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Evaluating the Current Status of Chestnut-Present Forest Systems: Integrating GigaPan as a Tool for Site Assessment

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Evaluating the Current Status of Chestnut-Present Forest Systems: Integrating GigaPan as a Tool for Site Assessment

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ABSTRACT

Evaluating the Current Status of Chestnut-Present Forest Systems: Integrating GigaPan as a Tool for Site Assessment

The field of environmental science can directly benefit from a society driven by advances in technology. The loss of the American chestnut (*Castanea denata*) has had a significant negative environmental and economic impact throughout the Appalachian region. However, using an integrated approach utilizing recent advances in science and technology, we may be able to promote the re-introduction of a very similar species within this region. Using GigaPan as a tool for site assessment and data storage, and previous methods of biological field surveying within the critical detritus layer of the forest floor, we will assess the status of forest ecosystems currently retaining native *C. dentata* sprouts, and systems absent of *C. dentata*. Once this process is complete, we will gain knowledge on developing a protocol to implement plantings of the newly acquired hybrid American chestnut (*Castanea denata x mollissima*). If followed through properly, this work could provide background research towards the introduction of a keystone resource in forest ecosystems that will affect many different levels of ecosystem functionality.

INTRODUCTION

American chestnut

The American chestnut (*Castanea denata*) once dominated the eastern forests of the United States (Hebard et al., 2006). “Once, their creamy June bloom so festooned the eastern hardwood forests that they looked from afar “like a sea with white combers plowing across the surface,” wrote the naturalist Donald Culross Peattie (Horton, 2010, p. 32). The American chestnut positively impacted the area both economically and ecologically (Barakat et al., 2009). This species grew up to sizes of 100 feet in height and over 12 feet in diameter (Horton, 2010). Also after being harvested, the American chestnut grew rapidly compared to other hardwoods, and its soft yet durable wood was perfect for producing anything from fence posts to furniture (Horton, 2010). With this being said, the American chestnut was of great importance economically due to its vital role in the early timber industry, especially in the Appalachian region in which it is estimated that the chestnut once comprised of one in every four species within the forest stand (United States Forest Service, n.d., www.fs.fed.us).

The impacts of the American chestnut are ecologically and economically significant. The nut crop produced by this species is a story within itself. This remains a part of American folklore to this day because of the famous “chestnuts roasting on an open fire” line in Tormé and Wells’ 1944 song titled “The Christmas Song.” However, these lyrics mean more than what we tend to think. The sweet-tasting nuts produced from the American chestnut were once a vital food source for the early settlers and their livestock and for wildlife species ranging from squirrels to bear; thus, it was a key component to the food chain within a forest system (Horton, 2010). Also, due to its vast canopy and leaf litter, it would have likely provided sufficient shading and habitat for the forest floor. With a more suitable habitat for forest floor organisms, nutrient cycling and availability would increase and provide nourishment to all of the plant-life within the system and in turn, restoring diversity within a forest. Another key concept of ecological importance of the American chestnut would be its ability to sequester carbon (Jacobs, 2007). Years of greenhouse gas emissions have manipulated the earth's atmosphere, resulting in an overall warming of the earth. This global warming can have many serious impacts on the environment that include, but are not limited to, the loss of key flora and fauna and most importantly an increase in health risks to the human population. However, many studies suggest a strong correlation between carbon storage and proper land management techniques within a terrestrial system (Niu and Duiker, 2006). As mentioned previously, the American chestnut grows much larger and faster than other hardwoods, which would allow it to sequester more carbon over time and become a key factor in climate mitigation (Jacobs, 2007). With all of these above mentioned positive ecological impacts, it is obvious that the American chestnut species has the ability to benefit not only our forests, but our entire world as a whole.

Region of Concern

West Virginia has been historically economically dependent on the extraction of coal, gas, and timber resources. However, over-utilization of the region's natural resources has resulted in the degradation of the land that we once prided ourselves upon. Mountaintop mining and other extensive timbering practices have been carried out for many years without proper restoration practices. One article supports this fact by saying, "Hundreds of thousands of reclaimed strip mines throughout the central Appalachians are experiencing arrested succession. They remain in the same grassland state produced immediately following reclamation and do not appear to be succeeding back to hardwood forest, the original condition prior to the disturbance" (McCarthy et al., 2008, p. 32). This occurrence seems to remain true in most cases.

The Meadow River Lumber Company was once the largest hardwood mill in the world (Bagdon, 2002). In 1906, brothers Thomas and John Raine of Ironton, Ohio "caught wind of 32,000 acres of land in Fayette and Greenbrier county West Virginia" (Bagdon, 2002, p. 3). In a time when un-touched timber was hard to find, the Raine brothers found fortune. This excerpt from Phillip Bagdon's book sums it up best, "This retrospective was penned by John Raine in 1931: Twenty-five years ago your president came into this wilderness and discovered on the headwater of the Meadow River, where elevation, climate and soil ministered to their growth and perfect development the cream of the Appalachian hardwoods" (Bagdon, 2002, p.3). The reason this land was yet to be timbered was due to its inaccessibility (Bagdon, 2002). This area, like a lot of West Virginia consisted of a vast mountainous terrain that seemed off limits to most timber industries but not to the Raine brothers. They planned a rail system to access this timber and then followed through with the plan in 1910. Over 18,000 loads of hardwood came to Rainelle (a town in Greenbrier County) between 1910 and 1971, making it the longest running forest related rail operation in the history of the state. However, the events associated with this deforestation resulted in severe economic decline and produced an environment degraded in overall quality and lower biodiversity.

Loss of the American chestnut

Unfortunately, with the exception of sprouts soon to be overcome by disease, the American chestnut species has become almost totally extirpated (Paillet, 2002.) Mining and timber activities (such as the Meadow River Lumber Company) have significantly reduced the population of American chestnut in the past, but these activities are not the main culprit in the extirpation of the species; rather, it was an introduced disease known as the chestnut blight. Chestnut blight (*Cryphonectria parasitica*) was first discovered on the American chestnut species in 1904 at the Bronx Zoo in New York City and is thought to have been carried into this country on previously infected Japanese chestnuts (*Castanea crenata*) sometime in the late 1800's (Sisco, 2003). Chestnut blight is a yellow-orange fungus that affects the above ground biomass of the tree by entering splits and cracks within the bark (USFS, n.d, www.fs.fed.us). Once the fungus enters a wound in the tree, it girdles the tree and eliminates everything above the point of infection (Davelos and Jarosz, 2004).

This disease began to spread quickly through the Appalachian Mountains where chestnut comprised the majority of the forest stand (Sisco, 2003). Once this disease hit so rapidly, it was only a matter of time before the species would become extirpated within the region. By 1960, the disease had spread throughout the entire American chestnut population and had killed an estimated 4 billion trees (Jacobs, 2007). This occurrence is considered to be one of the greatest environmental disasters to be recorded and a significant loss to American history (Colleran, 2008).

Hope for the Future

Recent scientific discoveries and innovations provide us with many opportunities that lead to a more sustainable environment for all living organisms. A blight resistant hybrid variety of the American chestnut (*Castanea denata x mollissima*) is one such innovation. The method of backcross breeding is the underlying source in restoration attempts of the American chestnut (Jacobs, 2007). After decades of failed attempts to restore this species, a corn geneticist named Charles Burnham learned that the U.S. Department of Agriculture had shut down their study of the American chestnut (Horton, 2010). After reading the USDA's published results, Burnham discovered that their scientists had overlooked a key concept in breeding resistance into crops, the concept of backcrossing (Horton, 2010). Up to this point, the USDA had been crossing American to Chinese (a species resistant to blight) chestnuts for many years but had not attempted backcrossing methods (Horton, 2010). With previous methods, the USDA almost succeeded with a hybrid species known as the "Clapper" tree in 1976, but, after reaching a height of 76 feet, the tree became infected with the blight and hope of restoration seemed to be lost. However, after learning of the absence of backcrossing in the USDA's methodology, Burnham took action. He, along with other scientists, developed an organization known as The American Chestnut Foundation in 1983 (Horton, 2010). This organization obtained land for their study and began right away. Although very promising, the method of backcrossing was no easy task (Horton, 2010). First, a parent stock was derived from cloned offspring of the USDA Clapper tree, and then the trees had to be hand pollinated while keeping the female flowers away from undesired pollen (Horton, 2010). Scientists then had to wait several years for the trees to grow and would eventually select approximately 1 out of every 150 trees that appeared to be most resistant and phenotypically similar to the American chestnut (Horton 2010). After repeating this process for many years, The American Chestnut Foundation has created hybrids that appear to be capable of resisting blight and succeeding in forest systems; however, experimental studies must be followed through to truly determine this hybrid species' resistance/survival rate and the overall effect this species may have on forest ecology.

The importance of assessment of chestnuts to forest diversity has been demonstrated by recent funding of a study comparing diversity and sustainability of forest canopy and soil litter organisms between stands of transgenic and hybrid American chestnuts at the State University of New York (Powell et al., 2008). In this study, they are comparing a new transgenic American chestnut with a resistance-enhancing transgene known an oxalate oxidase with wild-type chestnuts and hybrid American chestnuts (*Castanea denata x mollissima*) (Powell et al., 2008). As one of SUNY's objectives, they will examine the relationship between the transgenic American chestnut and multiple herbivorous feeding guilds of soil litter organisms to determine soil nutrient activity that occurs within the site (Powell et al., 2008). Although my particular study will examine only Collembolan presence within stands of native chestnuts, many fundamental ideas were drawn from this study. Particularly, how will the re-introduction of chestnuts impact overall forest diversity within the leaf litter zone? Progress has been made as far as implementation of the transgenic trees for this study, but no results on the effect on soil organisms have been released at the time.

Multiple studies at Mammoth Cave National Park, Kentucky have provided us with crucial information on the restoration of the American chestnut. In one particular study, chestnut habitat suitability was mapped by locating chestnut sprouts and then determining what environmental parameters were associated with the area (Fei et al., 2007). In this study, it was determined that chestnuts sprouts were "strongly associated with geological formation, slope steepness, elevation, and topographic position (Fei et al., 2007, p. 201)." Also, in a closely related study in Edmonson County Kentucky (which encompasses most of Mammoth Cave National Park), historical data were examined to determine possible restoration areas by determining other species positively associated with the American chestnut in the past (McEwan et al., 2005). 575 randomly selected settlement era land deeds, spanning a 53 year period during the settlement of West Central Kentucky, were obtained (McEwan et al., 2005). "This time period preceded the arrival of the chestnut blight by approximately 60 years" (McEwan et al., 2005, p. 276). Using these deeds, species composition was measured in areas where chestnuts previously existed, and in areas where chestnut had been absent (McEwan et al., 2005). Comparisons were made by using the relative importance value (relative density + relative frequency), and then Spearman's rank correlation to determine relationships between chestnuts and co-occurring species (McEwan et al., 2005). Based on the data from this study, it was determined that chestnut was positively associated with white oak (*Quercus alba*) and black oak (*Quercus velutina*) and negatively associated with post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) (McEwan et al., 2005). Assessments from these two studies (environmental parameters, occurring species, etc.) at Mammoth Cave National Park allow us to have some existing idea on whether chestnuts will exist within future study areas, making them both valid framework studies to the implementation of my particular project.

Bioindicator of Terrestrial Systems

Soil arthropods are important, but often neglected, bioindicators in forest systems (van Straalen, 1998). Soil arthropods are classified into categories based on their function within the soil; these categories are shredders, predators, herbivores, and fungal feeders (Moldenke, n.d.).Shredders, often located on the surface of the soil, chew up dead plant matter as they consume bacteria and fungi on the surface of plant matter which increases the rate of decomposition within this zone (Moldenke, n.d.). Predators' functional role in the soil is just as the their name portrays, they feed upon other arthropods or insects within the soil, sometimes reducing the number of arthropods in the soil; however, depending on their prey of choice, shredders may also act as a method of bio-control by eating crop pests (Moldenke, n.d.). Herbivores live most of their life within the soil and may consume roots or plants (can be a crop pest in excess) but still benefit terrestrial systems by mineralizing plant nutrients as they graze (Moldenke, n.d.) Finally, fungal feeders contribute by consuming bacteria and fungi off of root surfaces, resulting in an increase of available plant nutrients through nutrient release (Moldenke, n.d.). Although soil arthropods are crucial to health of the forest floor, no set bioindicator system is in place to assess current forest ecosystem status by means of arthropod abundance and diversity (van Straalen and Verhoef, 1997). However, the recovery of native arthropod fauna in relation to restoration activities could be an important goal in forest conservation (Longcore, 2003).

One particularly useful group of soil arthropods is the Collembola (Springtails). Collembola can be used as soil bioindicators for many reasons. First of all, it is suggested that Collembola are the second most populous group of soil arthropods found within the soil (Nardi, 2007). Also, it is known that Collembola play a significant role in two key stages of ecosystem functioning, soil organic matter dynamics and nutrient mineralization (Cassagne et al., 2004). With this being said, Collembola hold great potential in determining the health of current forest ecosystems.

It is known that certain fauna, such as salamanders, prey primarily and are dependent on soil arthropod biomass, and soil arthropod activity provides plant nutrient availability (Moldenke, n.d.) Healthy chestnut systems were known for a large canopy cover and heavy leaf fall density (optimal habitat for forest floor organisms). Consequently, the diversity, numbers, and mass of soil arthropods associated with chestnut trees are directly linked to the overall biomass and diversity of a forest system.

Future of Environmental Assessment

"GigaPan is a simple robotic platform for capturing very high-resolution (gigapixel and up) panoramic images from a standard digital camera (Carnegie Mellon University, n.d., www.cs.cmu.edu)." GigaPan allows the user to take a series of images by mounting a standard digital camera onto the robotic device and programming this device to capture an entire scene. Once the images have been taken, the user can then use the GigaPan software to upload the individual photos, and stitch them together to create a panorama. Once the panorama has been created you can then zoom into any area for a closer look. In a society that has become obsessed with advances in technology, GigaPan allows us to create a means of successfully exploring environmental issues from our laptop, iPad, or iPhone. This occurrence may be what it takes to influence the future generations to explore environments and collect data promoting environmental sustainability; furthermore, GigaPan may have the possibility to be an important scientific tool for on-site habitat assessments in the future (Shoen and Stevenson, 2010).

For each location in this study, I will 1) assess the current physical status of the region by means of GigaPan technology and 2) determine the abundance of a crucial forest bioindicator group (Collembola) and relate this occurrence to the chemical and physical make-up of the region.

METHODS

Site Selection

In this study, sites were chosen based on the presence/absence of American chestnut sprouts, and accessibility. My goal was to locate one site currently holding pure American chestnut sprouts and two sites that were absent of chestnut sprouts. This goal was accomplished by locating sites in three separate counties in West Virginia. My sites included the Huntington Museum of Art (HMA) Trail (Cabell County, WV), Meadow River Park (MRP- Greenbrier County, WV), and Old Fork Rd. (Wayne County, WV). The Huntington Museum of Art and Meadow River Park locations (region previously described as a land that has suffered environmentally and economically due to resource extraction) acted as control sites for the study (absent of chestnut sprouts), whereas the Old Fork Rd. location served as my area retaining recurring chestnut sprouts.

Study Area

Figure 1: 3 chosen study sites marked on WV county map (Source: Taylor Brewer, 2011).

HMA Trail (Cabell County)

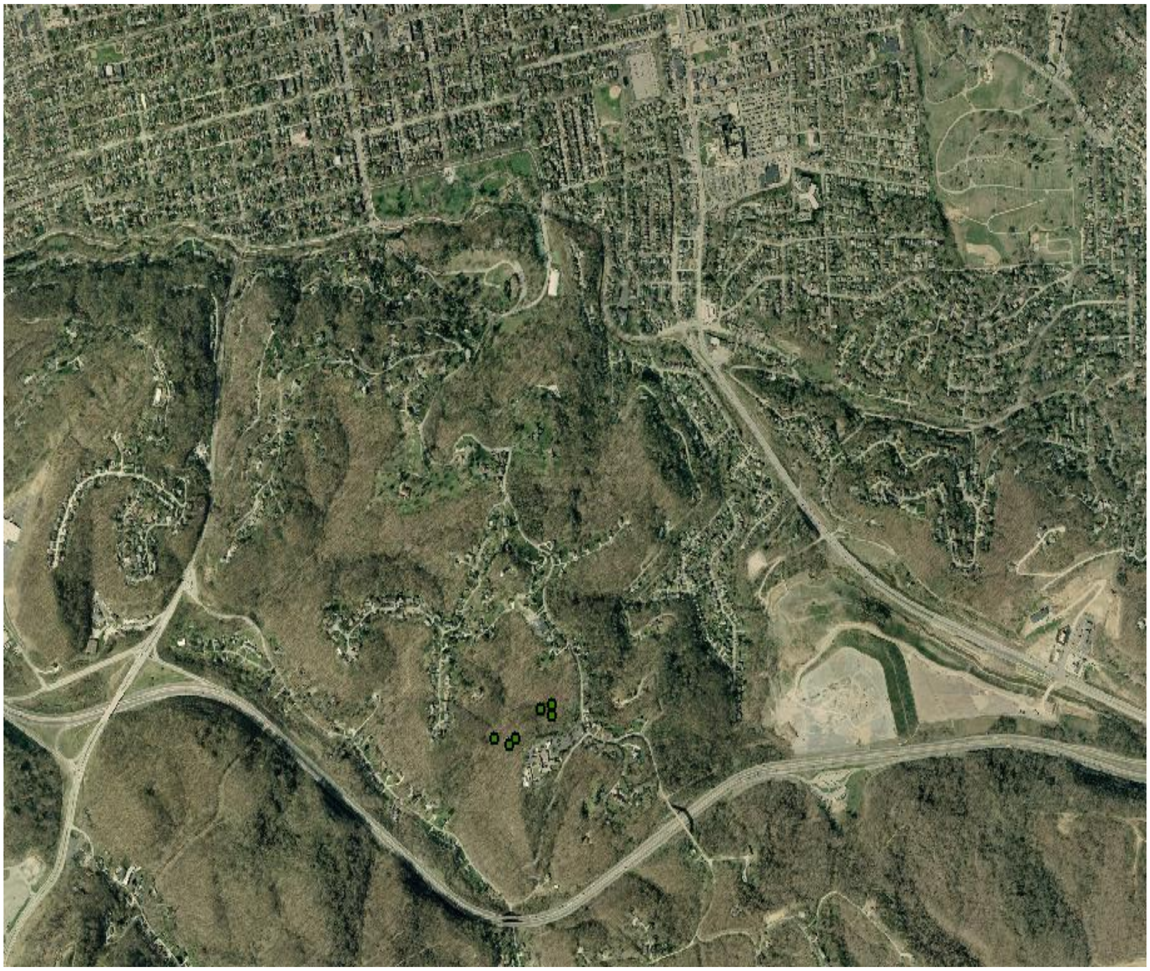

Figure 2: Aerial view of site with sampling events marked (Source: Taylor Brewer, 2011).

MRP (Greenbrier County)

Figure 3: Aerial View of site with sampling events marked (Source: Taylor Brewer, 2011).

Old Fork Rd. (Wayne County)

Figure 4: Aerial View of site with sampling events marked (Source: Taylor Brewer, 2011).

Site Descriptions

HMA Trail (Cabell County)

The Huntington Museum of Art trail is located on 8th street hill above Ritter Park in Huntington WV. Below the art museum, a walking trail was constructed and the surrounding forested area was minimally obstructed in doing so, thus creating an optimal environment for nature walks. Within this area, cover objects are abundant, being composed primarily of a mixed-oak composition. This site was chosen mostly due to its accessibility. Being a student at Marshall's Huntington campus, I could easily gather equipment and test field techniques with a minimal amount of travel required. Also, this forest type was absent of American chestnut sprouts, allowing it to act as a "control" site for my study.

HMA Walking Trail

Figure 5: GigaPan panorama of HMA walking trail (Source: Taylor Brewer, 2011).

MRP (Greenbrier County)

The second site chosen for this study was in a forested area beside the Meadow River Community Park located near Rupert/Rainelle in Greenbrier County WV. This area was chosen because of several factors. First of all, as a part of my graduate assistantship funded by the Rahall Transportation Institute (RTI), I was then helping to develop GIS database systems for the newly created Meadow River Watershed Association. Because of this occurrence, I was able to meet multiple members of the Meadow River community who were genuinely interested in creating a more sustainable environment for the area. After meeting with these group members, I was given permission to conduct soil sampling in an area that has been somewhat degraded in quality due to extensive mining and timber operations. My project advisor and I agreed that such an area would be useful for comparison in this study.

To add to the validity of this site location, we were given permission to create an experimental plot (10 trees) of hybrid American chestnuts to determine their success/ survival rate in existing soil types. Concurrently, at a nearby location, hybrid American chestnuts were being planted on large scale for the same purpose. Therefore, we could not only provide useful information about the current state of this region, but also make a prediction on whether these chestnuts were for the area. The general make-up of this region was a typical mixed-oak forest with the presence of a significant amount of evergreens as well.

MRP Location

Figure 6: GigaPan panorama of Meadow River Park Location. Park Located just across road from this forested area. (Source: Taylor Brewer, 2011).

Old Fork Rd. (Wayne County)

Old Fork Road is located near the town of Crum WV. As the final, and most important study area, this location was said by many of the locals (friends of the family) to have recurring chestnut sprouts throughout a general area. After hearing of this occurrence, I made a trip to see for myself. As they had thought, there were indeed sprouts of American chestnuts within the region, and remnants of larger chestnuts that had previously fallen to the chestnut blight. With this being said, I chose to make this my final soil sampling region and compare certain parameters within this region to my other two locations that were absent of chestnut sprouts.

Old Fork Rd.

Figure 7: GigaPan panorama of chestnut location, near Crum WV (Source: Taylor Brewer, 2011).

Experimental Design

Soil litter is primarily a resource that is not randomly distributed along steep hillsides with non-random cover objects that serve as traps for leaf fall. Consequently, we propose stratified sampling to be used within homogenous sites chosen to have maximum leaf fall density and, therefore, maximum habitat for soil arthropods.

Following protocol from a study of soil extraction methods by the Department of Entomology at Ohio State University, we used bulb planters (Garden Plus #0057704) to extract soil samples from our chosen locations (Bater, n.d.). However, we chose to develop our own pattern of sampling that best suits the specific equipment that we have. For each sample site, using the stratified sampling technique, I plotted 3 eastern points (E1-E3) and 3 western points (W1-W3) that were at the least separated by 30 meters east to west and north to south for arthropod extraction. At each point, I collected 3 contiguous samples with bulb planters to make one full sample. The reason we chose to collect 3 contiguous samples with the bulb planters is that this provides us with an optimal final sample size to place on our Berlese funnels in the lab, thereby giving us a full sample. The dimensions of our bulb planters are 6 cm in diameter, and 10 cm deep. Consequently, each full sample was approximately 18 cm (3 times the original) in diameter and 10 cm in depth. This sampling pattern was conducted in the spring and fall of 2011 for both the HMA and MRP locations, and, due to time constraints, repeated twice only in the fall for the Old Fork location. Finally, using a handheld GPS device, coordinates and corresponding elevations were recorded for each location for further research.

To add to the biological survey of soil arthropods within my study areas, pH readings were obtained from the collected soil samples using the YSI pH 10 EcoSense pH probe. The entire process will be outlined in the next section. Again, due to time constraints, these readings were only conducted in the fall, but readings were obtained for each sampling site. Because pH is believed to be an influential factor in the presence of American chestnut sprouts and in the presence of certain keystone arthropod groups, this data may provide useful information to the future introductions of the newly developed hybrid chestnut.

Along with arthropod/pH sampling at each study site, a GigaPan panorama was shot for the area. This goal was achieved by using the GigaPan EPIC, with a Canon Powershot A3100 IS camera, and a simple tripod. Within each site, I positioned myself to develop a view of a portion of my sampling area that would allow me to tag information about the make-up (physically and biologically) of the region. In the end, I would then be able to possibly correlate these factors to arthropod abundance and soil pH and then draw conclusions from there.

GigaPan Equipment

Figure 8: A picture of myself setting the GigaPan for a shoot at HMA (Source: Steve Beckelhimer, 2011).

Data Analysis

The Berlese funnel method of arthropod extraction was used in this study. This was achieved by taking the soil samples that I obtained from each site (6 per location), and placing them into a funnel with a mesh bottom. This funnel was then attached to a container of ethyl alcohol. After this snap together system was in place, a simple gooseneck lamp with a 40 watt light bulb was placed over the soil sample and left on for a week. The purpose of this mechanism was to desiccate the soil, making the arthropods within escape through the mesh bottom where they would then be preserved by the alcohol and ready for identification. Then, using John R. Meyer's Kwik-Key to Soil Dwelling Invertebrates and a MEJI EMZ scope, arthropods falling under the order of Collembola (springtails) were counted for each of the 6 samples for each study area. This method was repeated for each area twice (giving me 36 samples for comparison). The purpose of this part of the study was to determine a difference (if one existed) in Collembola abundance between the systems; thus, higher or lower proportions of what I believe to be as a crucial soil bioindicator.

With the leftover soil from each sample area, I then tested existing pH levels for the soil. To accomplish this goal, I sieved the soil using mesh to eliminate as much of the other existing organic matter as possible (to get a "true" soil reading). Then I created a 50/50 distilled water and soil mix and stirred for 3 minutes. Once the mixture settled, I used a YSI pH10 EcoSense pH probe to determine the pH reading for each sample, and the results were recorded.

Berlese Funnel Apparatus

Figure 9: Example of Berlese set-up in lab; soil would go on mesh and the container below would be filled with alcohol for arthropod preservation (Source: Taylor Brewer, 2011).

For the final part of my data analysis, I obtained GigaPan imagery by using the GigaPan EPIC with a Canon Powershot A3100 IS camera. Our primary goal for this portion of the study was to determine different ways to incorporate this new robotic software application with previous methods of biological field surveying, thus, combining new technology with proven methods to provide a well-rounded study. To do this, I went to each of the 3 chosen study sites and found an area within the forest cover in which I could shoot a general panorama of the region. Based on the size/view of the region, I shot a series of images (approximately 150-180 images) that portrayed the general landscape and biological make-up of the area. Once these images were shot, I took them to the lab. In the lab, I downloaded the GigaPan Stitch 1.0.0805 software for use. This software was very simple and easy to use. To do so, I uploaded the series of images that I shot for each region, and then modified the number of rows and columns until the panorama looked "most natural." When first uploading the imagery, the panorama will be distorted, and it is up to the user to modify it to make it aesthetically pleasing. Once the panorama was ready, I just chose the option to save and stitch the image, and then the software did its work (taking up to a couple hours at a time).

After the software stitched the images, I uploaded each one onto my personal GigaPan website for further examination/use. Once loaded onto the page, the user has the ability to zoom in on very high definition imagery. Using this feature, I surveyed the area and tagged different features such as tree types, land characteristics, land use, etc. to examine the overall similarities/differences of each study area. Combining this electronic data with the previously collected biological and chemical data would then allow us to make further assumptions on the status of the region. For instance, is there a correlation between American chestnut presence, Collembola presence, pH, elevation, and the presence of other existing flora within the region? Some of these parameters are assumed to be connected (such as low pH and chestnut presence), but this study could help shed light on the big picture and determine the overall status of systems with recurring chestnut sprouts, which would allow us to determine areas in which the newly developed hybrid chestnuts may succeed/not succeed.

As previously mentioned, a major goal of this study was to determine different ways to incorporate GigaPan into the field of environmental science. In exploring these efforts, I developed somewhat of a digital key for soil arthropods. Using the same GigaPan unit with a close-up camera, I shot a few panoramas of some of my arthropod samples on petri dishes. I then uploaded them into the GigaPan software and stitched them just as I had previously done for my study areas. Using the zoom feature in the software, I examined the different arthropod groups/characteristics and tagged them accordingly, thus, creating somewhat of a digital arthropod key for further use. Furthermore, I developed two types of electronic data storage for this study; 1) GigaPan for on-site assessment and 2) a digital key for arthropod identification.

RESULTS

Site 1 (HMA)

GigaPan Assessment

HMA

Figure 10: Panorama of entire HMA sampling site (Source: Taylor Brewer, 2011).

For a general overview of the area, a GigaPan panorama was shot to later view and determine different characteristics within the region. Some of the different features that I thought were worth noting follow.

Species Composition

Figure 11: Maple leaves and acorns (Source: Taylor Brewer, 2011).

The most dominant tree species within this region were maples and oaks. Found within the region are the Sugar Maple (*Acer saccharum*) and the Red Maple (*Acer rubrum*). Also, a wide variety of oaks (many hybridizing) exist within this site, and the acorns from these trees provide an abundant mast to support the majority of the wildlife with the region (squirrels, deer, etc.) The American Beech (*Fagus grandifolia*) is also prominent within the region.

Walking Trail

Figure 12: HMA walking trail (Source: Taylor Brewer, 2011).

As previously mentioned, a walking trail has been constructed in this region for the use of the general public. However, the walking trail has caused minimal disturbance to the ecosystem as a whole. The trail also acts as a walking path for the nearby fauna such as deer (generally like to follow paths), increasing wildlife activity within the area. Also, as you can see in the following image, an abundance of leaf litter in the region provides optimal habitat for soil litter organisms (interest of the study).

Habitat for Arthropods

Figure 13: Leaf litter collecting around downed trees provides optimal habitat for soil arthropods (Source: Taylor Brewer, 2011).

Collembola Counts

The following tables and figures display the results from my arthropod collection, extraction, and identification procedures. As previously mentioned, the order of Collembola was the group of interest for this study. Also included are soil pH readings and corresponding elevations

HMA Spring 2011

Location	Lat	Long	Collembola Count	Elevation
E1	38.394018	-82.433992	12	827 ft.
W1	38.393373	-82.435494	22	814 ft.
E2	38.394308	-82.433999	27	818 ft.
W2	38.393209	-82.435768	14	835 ft.
E3	38.394175	-82.434494	22	808 ft.
W3	38.393358	-82.436372	16	759 ft.
Total			113	

Table 1: Results from site in Spring 2011 (Source: Taylor Brewer, 2011).

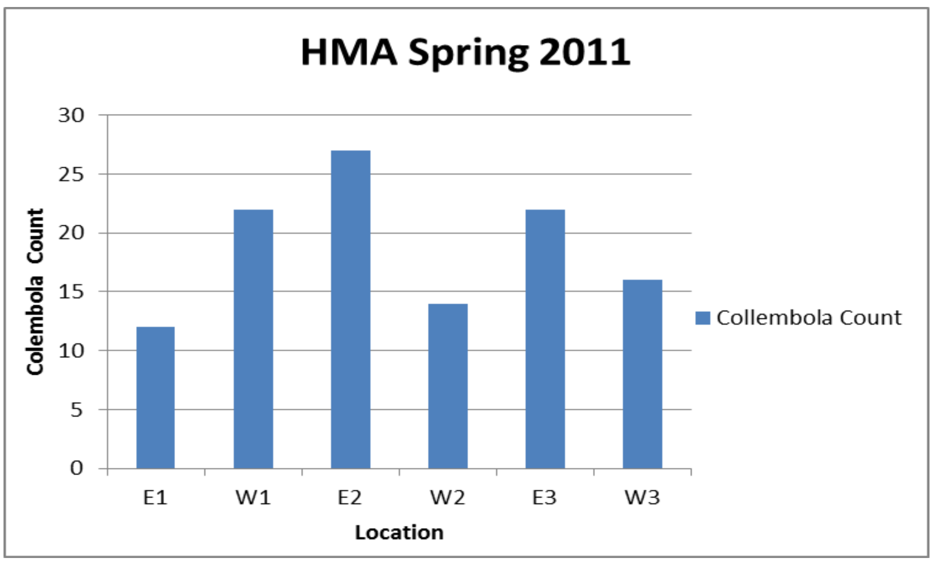

Figure 14: Results from site in Spring 2011 (Source: Taylor Brewer, 2011).

HMA Fall 2011

Location	Collembola Count	pH	Elevation
E1	21	7.22	827 ft.
W1	17	6.65	814 ft.
E2	18	6.14	818 ft.
W2	9	6.38	835 ft.
E3	16	5.84	808 ft.
W3	15	5.71	759 ft.
Total	96		

Table 2: Results from site in Fall 2011(Source: Taylor Brewer, 2011).

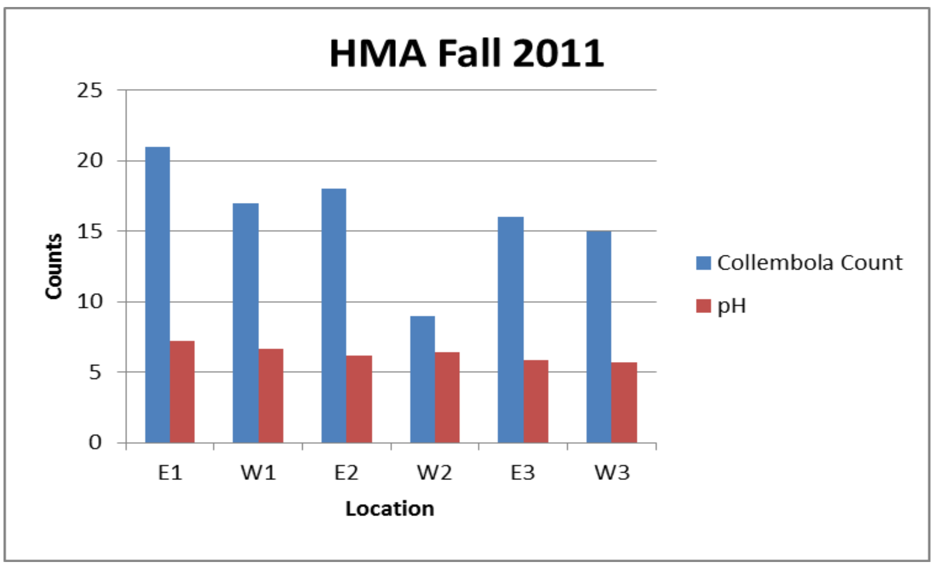

Figure 15: Results from site in Fall 2011 (Source: Taylor Brewer, 2011).

Site 2 (MRP)

GigaPan Assessment

MRP

Figure 16: Panorama of entire sampling site (Source: Taylor Brewer, 2011).

Species Composition

Figure 17: Oak leaf (Source: Taylor Brewer, 2011).

American Beech

Figure 18: American Beech (*Fagus grandifolia*) (Source: Taylor Brewer, 2011).

Evergreen

Figure 19: Evergreens (Source: Taylor Brewer, 2011).

The most dominant species within this sampling site seemed to be the oak group. Following the oaks, there was an abundance of American Beech (Figure 18). Finally, one very noticeable occurrence in this region was the abundance of evergreens (Figure 19) as opposed to site 1. Although some evergreens existed within site 1 (HMA), they appeared to be much more prominent within sampling site 2 (MRP).

Meadow River Park

Figure 20: Meadow River Community Park is located just across from sampling site (Source: Taylor Brewer, 2011).

The park was constructed by local community members and organizations that are a part of creating a more sustainable environment in a region that has suffered both environmentally and economically due to resource extraction. Within this park, we created a plot of 10 hybrid American chestnuts in order to test their ability to adapt/survive in unfavorable soils (clay, etc.). These trees have the potential of somewhat replacing the pure American chestnut if they prove to succeed.

Collembola Counts

The following tables and figures display the results from my arthropod collection, extraction, and identification procedures. As previously mentioned, the order of Collembola was the group of interest for this study. Also included are soil pH readings and corresponding elevations.

MRP Spring 2011

Location	Collembola Count	Elevation
E1	14	2520 ft.
W1	43	2458 ft.
E2	51	2499 ft.
W2	25	2450 ft.
E3	48	2431 ft.
W3	55	2431 ft.
Total	236	

Table 3: Results from site in Spring 2011 (Source: Taylor Brewer, 2011).

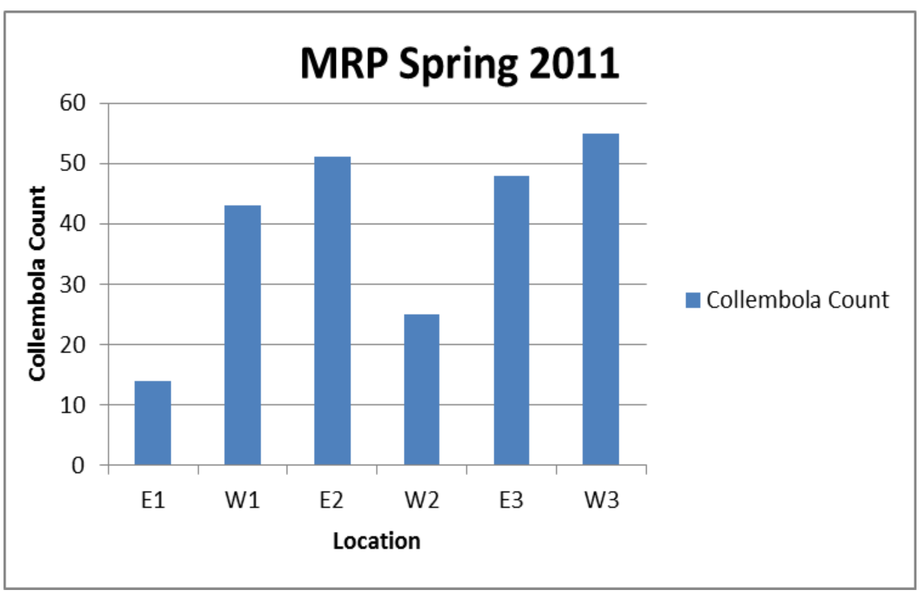

Figure 21: Results from site in Spring 2011(Source: Taylor Brewer, 2011).

MRP Fall 2011

Collembola Count	pH	Elevation
64	4.88	2520 ft.
13	4.33	2458 ft.
42	4.77	2499 ft.
42	4.49	2450 ft.
55	4.73	2431 ft.
70	5.06	2431 ft.
286		

Table 4: Results from site in Fall 2011 (Source: Taylor Brewer, 2011).

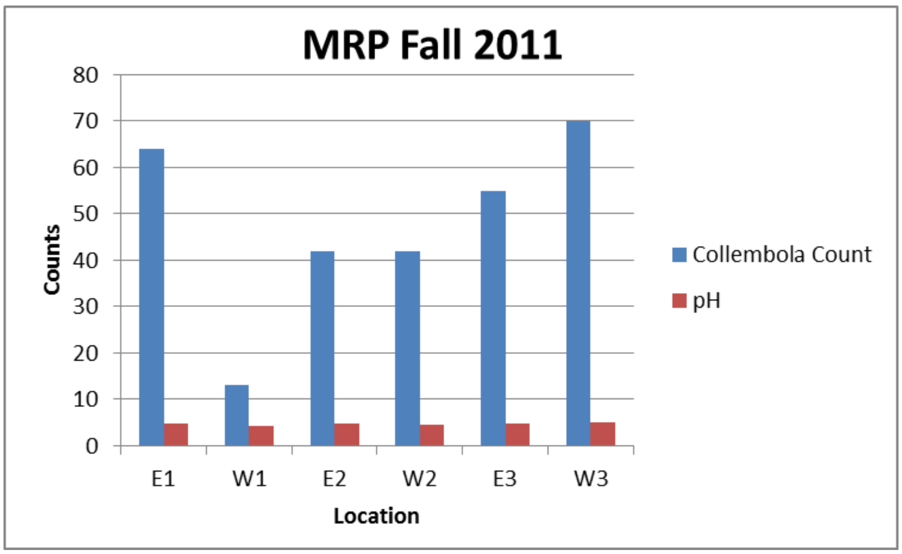

Figure 22: Results from site in Fall 2011 (Source: Taylor Brewer, 2011).

Site 3 (Old Fork, WV)

GigaPan Assessment

Old Fork Road, Crum WV

Figure 23: Panorama of entire sampling site (Source: Taylor Brewer, 2011).

Old Fork Road (inside canopy)

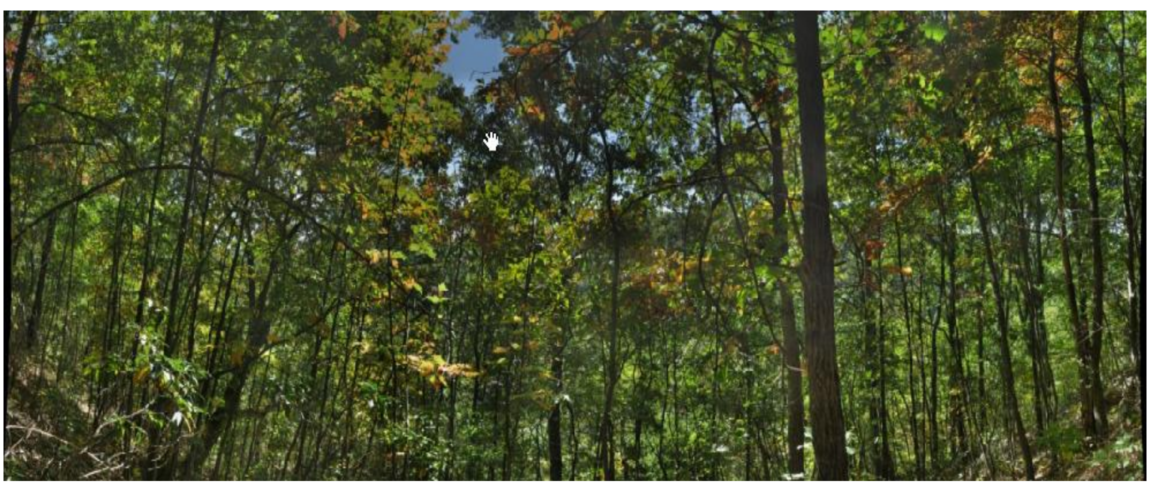

Figure 24: Panorama shot inside the canopy of sampling site (Source: Taylor Brewer, 2011).

Species Composition

Figure 25: American chestnut (*Castanea denata*) sprout (Source: Taylor Brewer, 2011).

C. dentata

Figure 26: *C. dentata* leaves from a live sprout, and a nearby dead sprout from which it was derived

More Sprouts

Figure 27: Another set of *C. dentata* sprouts within the sampling site (Source: Taylor Brewer, 2011).

Maples

Figure 28: Maple leaves (Source: Taylor Brewer, 2011).

Sycamore

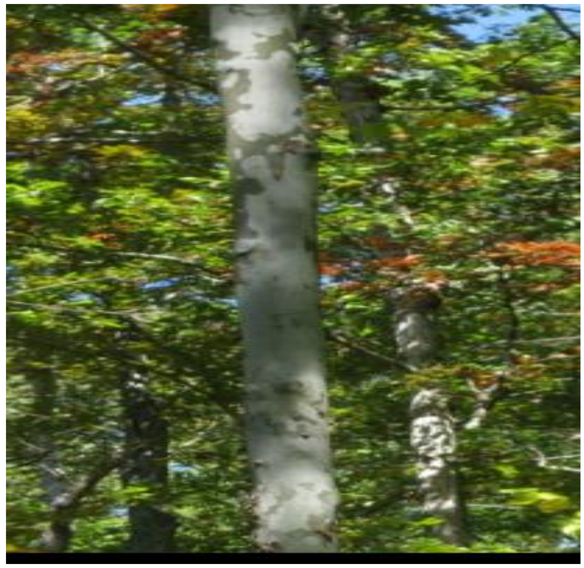

Figure 29: Sycamores were fairly numerous at this location (Source: Taylor Brewer, 2011).

As you can see from the previous GigaPan imagery, this location was my chestnut sampling site. Within the site, multiple sets of surviving *C. dentata* sprouts were located. At each occurrence, multiple dead sprouts (as seen in figure 26) were found close by. This further proves the fact that these pure chestnuts do sprout from the previously fallen trees and that the root systems must stay healthy. Most of the sprouts were relatively small (2-4 ft.); however, one tree was located that was an estimated 22-24 ft. high. A chestnut of this size is rare, but it was not bearing fruit.

Other flora within the region were fairly consistent with the previous locations. Red Maples (*Acer rubrum*) and Sugar Maples (*Acer saccharum*) were present within the area. Other notable species within the region were the American Beech (*Fagus* *grandifolia*) and the American Sycamore (*Platanus occidentalis L*). However, as opposed to the other non-chestnut sampling locations, evergreens were not as abundant.

Collembola Counts:

The following tables and figures display the results from my arthropod collection, extraction, and identification procedures. As previously mentioned, the order of Collembola was the group of interest for this study. Also included are soil pH readings and corresponding elevations.

Old Fork Fall (1)

Location	Collembola Count	pH	Elevation
E1	17	4.99	1067 ft.
W1	14	4.26	1065 ft.
E2	99	6.22	1062 ft.
W2	24	4.55	1054 ft.
E3	21	5.95	1012 ft.
W3	29	5.4	1051 ft.
Total	204		

Table 5: Results from first sampling in Fall 2011 (Source: Taylor Brewer, 2011).

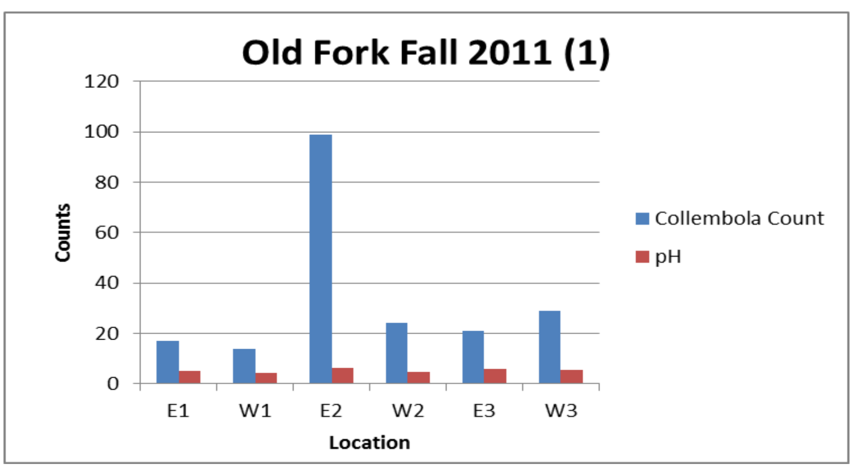

Figure 30: Results from first sampling in Fall 2011 (Source: Taylor Brewer, 2011).

Old Fork Fall 2011 (2)

Location	Collembola Count	pH	Elevation
E1	29	4.99	1067 ft.
W1	32	4.26	1065 ft.
E2	17	6.22	1062 ft.
W2	18	4.55	1054 ft.
E3	16	5.95	1012 ft.
W3	19	5.4	1051 ft.
Total	131		

Table 6: Results from second sampling in Fall 2011 (Source: Taylor Brewer, 2011).

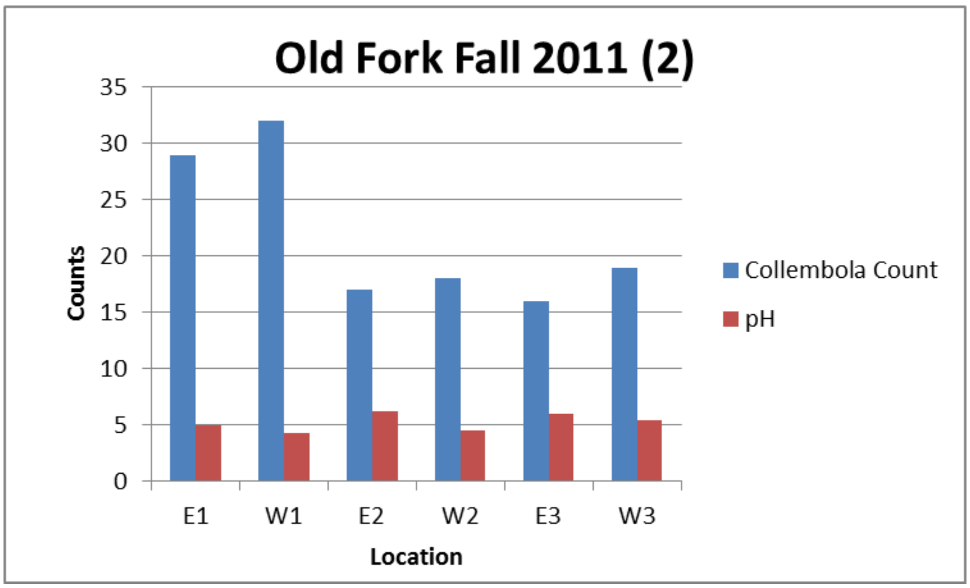

Figure 31: : Results from second sampling in Fall 2011 (Source: Taylor Brewer, 2011).

DISCUSSION

Site 1 (HMA)

The HMA location consisted of an area of minimal environmental disturbance. The walking trail did not seem to create any great amount of habitat disturbance; rather, it attracts fauna such as deer to the region. Adequate canopy cover existed, creating habitat for soil litter organisms by means of leaffall. The flora composition of the region consisted primarily of the mixed-oak type, with other species typical to the region being somewhat abundant (Maples and Beech).

Results from my Spring 2011 arthropod sampling (Collembola in particular) were rather low (as it seemed to be throughout the study). Collembola counts ranged from 12 (E1) to 27 (E2). Elevations at this site were generally low ranging from 759 ft. (W3) to 835 ft. (W2). Furthermore, no significant correlation between Collembola abundance and elevation seemed to exist during this sampling event. Overall, 113 Collembola species were collected between the 6 plots at this location.

Results from the Fall 2011 sampling event were even lower than the Spring counts with Collembola numbers ranging from 9 (W2) to 21 (E1). During this sampling event, pH readings were collected for further evaluation. These data also did not seem to prove any major correlation, but it is worth noting that the highest pH (E1- 7.22) did render the greatest Collembola count (21). However, the lowest Collembola count (9) at point W2 had a pH of 6.38 (above the average for the region). Finally, the overall Collembola count for the region was 96, while the average pH as a whole was 6.32 and the average elevation was approximately 810 ft.

Site 2 (MRP)

This site was located in a region known historically for environmental degradations by means of resource extraction (coal and timber). However, the location in which I collected my soil samples did have significant hardwood canopy cover in place (although some areas were more undergrowth as opposed to others). Similar to the previous location, the most common group of flora were the oaks with other similar species (beech, poplar, maple) being present as well. However, differing from the previous location, evergreens were noticeably more plentiful at this site. The newly constructed Meadow River Park was across the road from the sampling area, creating no disturbance towards my sampling procedures.

Results from my Spring 2011 sampling at this location ranged from14 Collembola specimens (E1) to 55 specimens (W3). Elevations ranged from 2431 ft. (W3) to 2520 ft. (E1). Furthermore, the lowest elevation resulted in the highest number of Collembola and the highest elevation resulted in the lowest number of Collembola. However, numbers in between fluctuated and this occurrence did not stay consistent throughout. Overall, 236 Collembola specimens were collected at this time.

Collembola counts were a bit higher during my Fall sampling at this location, producing 286 total Collembola specimens. Numbers ranged from 13 (W1) to 70 (W3); thus, making it evident point W3 again had the most Collembola. Also, a pattern still seems to exist in that as elevation went down, Collembola specimens became more plentiful. For my Fall sampling, pH data were collected as I did in site 1 (HMA). Numbers were significantly lower at this site, ranging from 4.33 (W1) to 5.06 (W3); thus, the highest pH recording rendered the highest Collembola count, further indicating a pattern in the data. This pattern stayed fairly consistent throughout this sampling event. Overall, the average pH of the region was 4.71, and the average elevation was 2464 ft.

Site 3 (Old Fork Road)

This location near Crum, WV, acted as my chestnut-present study location. This general region is known for mining and timbering activities; however, within my sampling area very little disturbance had occurred over the years. Within this site, multiple sets of American chestnut (*Castanea denata*) sprouts were located and recorded. These chestnut sprouts ranged from approximately 2-4 ft. in height, with one isolated tree reaching 20 – 24 ft. in height and 3 ½ inches in diameter at breast height (dbh). Other notable flora within the region were the maples, beech, and sycamores with evergreens being less abundant than the previous sites.

Due to time constraints with the project, I had to collect two sets of Fall data only for this location, which could have produced somewhat lower Collembola counts as opposed to Spring data (chestnuts were hard to locate in a timely manner). For the Old Fork Fall (1) sampling, Collembola results varied significantly ranging from 14 (W1) to 99 at point E2. Elevations for this site ranged from 1012 ft. to 1067 ft. The pH recordings for this location ranged from 4.26 to 6.22, with the lowest pH rendering the lowest Collembola count. The overall Collembola count for this sampling event was 204 specimens.

The second set of arthropod sampling, Old Fork Fall (2), produced less Collembola overall (131 specimens). Collembola numbers ranged from 16 (E3) to 32 (W1). At this time, the highest number actually came from the site that previously rendered the lowest number of Collembola (W1). The average elevation for this location was 1052 ft., and the average pH of the region was 5.23.

CONCLUSION

In general, the goals of this project were to 1) develop ways to integrate a new form of digital imagery analysis (GigaPan technology) into environmental field and lab studies and 2) to compare certain environmental parameters in a region currently retaining C. dentata sprouts to regions absent of this occurrence. In doing so, I believe that this project has expanded the use of new technology in environmental monitoring, and has the ability to reach out to a wide group of people interested in the loss of the C. dentata. At the same time I have included basic background data portraying certain biological characteristics associated with these regions to promote future research and implementation of the newly acquired *C. dentata x mollissima* into forest ecosystems.

Using GigaPan technology, I stitched panoramas of my study areas and tagged contents such as flora located in the region, noticeable physical changes in the terrain (slope, rock formations, etc.) and other general parameters that could have an effect on arthropod habitat within the region (walking trails, human impacts, etc.). Also, by use of close up lenses, I determined that it is possible to create somewhat of a digital soil arthropod key as of a means of data storage, adding yet another important factor in the use of GigaPan technology. After I uploaded these panoramas to my personal GigaPan website, they were then available to the general public. To me, this is probably the most important factor. As Shoen and Stevenson stated, GigaPan provides ways to "share information about plants, geology and landscapes of regions in both formal and informal education settings (Shoen and Stevenson, 2010, p.1)." As modern day environmental issues are on the rise, the promotion of these issues to the general public seems to be just as important as the development of scientific data relevant to such issues. Furthermore, we must incorporate methods that catch the eye of a world fascinated with new technology and at the same, time develop useful scientific data. Also, GigaPan's ability to capture high resolution imagery of land features seems to be unmatched by any other software applications that I have used in the past. By zooming in to the full extent on the digital camera and then using the zoom feature within the GigaPan site, the user has the ability to explore even the smallest of organisms (insects, fungi, etc.). Thus, GigaPan provides users with the opportunity to explore ecosystem functions at the macro and micro levels. With this being said, GigaPan does indeed have the ability to provide both "formal and informal" educational tools and to promote the awareness of important environmental issues such as the loss of the American chestnut; thus, this project further enforces Shoen and Stevenson's previous statement.

As for the biological assessment of the region, some trends seem to be evident, but, due to the fact that my study was limited to a two-year time frame, and "healthy" native chestnut sprouts were difficult to locate, these data should be used with some caution of course. However, in general I have seen that the region with the lowest average pH (MRP - 4.71) rendered the highest number of total Collembola counts (522 specimens), and the region obtaining the highest average pH reading (HMA – 6.32) rendered the lowest overall Collembola counts (209 specimens). Consequently, my chestnut location (Old Fork) had an average pH of 5.23, and the middle number of total Collembola (335 specimens). Along the same line, the higher the elevation of each site, the lower the pH, and the higher the number of Collembola within the region.

With all this being said, what do these data show? As I previously stated, these data should be used with some caution because the data were not gathered at each location for each season due to a time constraint. For example, the chestnut location was verified later than my other control sites, leaving me with time to only collect two rounds of fall data (as opposed to spring and fall at the other sites). However, what I believe these data do show is that regions that may be considered to be environmentally "damaged" may hold promise towards developing a different type of successful forest ecosystem. Seeing that chestnuts are able to flourish in lower pH ranges (according to previous data and data from this study) and that Collembola counts increase in such areas, we may begin to develop a protocol to implement the plantings of the hybrid American chestnuts into these same regions. In doing so, we may be able to reclaim regions that have suffered from natural resource extraction and lowered soil pH by re-introducing a crucial tree species with the ability to support an abundance of wildlife species. Futhermore, these regions obtaining such a low pH would still sustain high populations of crucial soil litter organisms (Collembola) that would hold the ability to maintain optimal nutrient cycling within the forest floor and fuel the system as a whole.

In conclusion, I believe that data from this project provide background information showing that areas suffering from past environmental disturbance hold the opportunity to create a uniquely successful habitat in regards to terrestrial systems, thus, providing us with the possibility of re-introducing a very similar species to the fallen native American chestnut, and creating unique but successfully functioning forest ecosystems on lands of previous environmental degradation. Such chestnut plantings are currently being followed through within the Meadow River watershed region that I discussed earlier in this document. The data from this study further supports plantings within this area and areas with similar physical and biological structure.

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Career Aim

To develop a professional career in the field of environmental science.

Education

August 2010 – May 2012: Marshall University, Huntington, West Virginia
M.S. Candidate, Physical and Applied Science: Geobiophysical Modeling
Thesis Study: Evaluating the Current Status of Chestnut-Present Forest Systems: Integrating GigaPan as a Tool for Site Assessment
Anticipated Graduation Date: May 2012
Current Graduate GPA: 4.0

August 2005 - May 2010: Marshall University, Huntington, West Virginia
Degree Earned: B.S. Integrated Science and Technology: Environmental Assessment and Policy
Cumulative GPA: 3.66 Magna Cum Laude

May 2010: Marshall University, Huntington, West Virginia
Certificate Earned: Geographic Information Systems (GIS) Certificate, Geography Department
Description: Earned upon the completion of at least 21 course hours in the field of GIS.

Grants Submitted

Fall 2011 EPA Science to Achieve Results (STAR) Fellowships for Graduate Environmental Studies
Funding Opportunity Number: EPA-F2011-STAR-J2
Topic: Ecosystem Services: Terrestrial Systems Soil and Plant Ecology
Proposed Project Title: Hybrid American Chestnuts and the Restoration of Sustainability in Appalachia: A Study of Soil Litter Organisms
Funding Amount Requested: $ 42,000

Work Experience

August 2010–Current: Marshall University, Huntington, West Virginia
Job Title: Full-Time Graduate Assistant: Research, Department of Integrated Science and Technology
Paid Experience: Funding provided by the Rahall Transportation Institute (RTI)

Duties:
On Campus: Assisting professors in various class related research projects and GIS database management
In Greenbrier County, WV: Assisting the Meadow River Watershed Association (Rupert WV) with the development and management of geospatial data models to store water quality information, and coordinating with Greenbrier West High School in an effort to educate young scholars on environmental problem solving methods and data collection/management.

February 2009 - Current: Cabell Huntington Health Department, Huntington West Virginia
Job Title: GIS Technician
Part Time/Full Time: Paid Experience
Duties: Worked in the CHHD environmental health and threat preparedness department collecting county-wide field data for the mosquito control program, conducted lab procedures to identify mosquito specimens, developed and maintained CHHD Geographic Information Systems, and collected Global Positioning System (GPS) data that located key features related to the health of the public and the environment. Also, I worked with surveillance equipment to monitor illegal dumpsites throughout Cabell County, and corresponded with sanitarians and local law enforcement to ensure the clean-up of these occurrences.

Professional Skills

- **Stream Bio-Assessment**
  1. Benthic Macro-invertebrate Collection/Identification
  2. Fish Collection/Identification
  3. Water Chemistry Analysis
- **Terrestrial Systems Assessment**
  1. Wildlife and Land Management
  2. Soil Ecology/Soil Arthropods
  3. Public Health Related Issues
- **Technology**
  1. GIS Software Applications: ArcGIS, ERMapper, IDRISI, DNR Garmin, GPS Track Maker, Map Windows GIS, Quantum GIS, Gigapan
  2. GPS devices (mapping)
  3. Microsoft Word, Excel, and Access (attribute data storage and management)

Professional Interests and Activities

Meadow River Watershed Association - Participating in group projects to restore an area that has suffered severe economic and environmental decline.

Personal Interests and Activities

I enjoy hunting, fishing, camping, and generally anything to do with the outdoors.

References

Marshall University Educational Advisor
Ralph Oberly, Ph.D.
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Marshall University Faculty Advisor
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