2017

# A comparative study of the effects of river flow rates on decomposition

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# A COMPARATIVE STUDY OF THE EFFECTS OF RIVER FLOW RATES ON DECOMPOSITION

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in the partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Geography & Anthropology

by
Maddisen Paige Neuman
B.S., Oregon State University, 2014
May 2017

**Acknowledgements**

Foremost, I would like to thank Dr. Juliet Brophy for accepting to be my advisor. Dr. Brophy challenged me to perform to the best of my abilities, supported my interest in conducting a decomposition study, and assisted me with writing a thesis of which I am immensely proud. I thank Dr. Ginesse Listi, Dr. Kory Konsoer, and Dr. Rebecca Saunders for serving on my committee. Special thanks to Dr. Konsoer for assisting with site set up, pig deposition, and river data. I also thank Dr. Kent Mathewson, without whom I would never have been introduced to Dr. Brophy.

This research would not have been possible without several important people. Thanks to John Templet for the use of his private land. Additionally, thanks to Glen Gentry and Matt Capelle at the Bob R. Jones-Idlewild Research Station for their donation of feral hogs. I would also like to thank my colleagues Alyx Stanco and Kurt Dilores for their aid in the field and Marena Grondin for the assistance with the Onset HOBO temperature loggers. Generous thanks to the Department of Geography and Anthropology for awarding the Robert C. West and Materials awards which funded this study. I also want to thank Dana Sanders, Elizabeth Honeycutt, Amy Encinas, and Erika DeLeon, as well as my colleagues in the Department of Geography and Anthropology.

My family was extremely supportive of this project, for which I could never thank them enough. Thanks to my parents for always encouraging me to pursue my desire to learn. Particular thanks to my dad for helping me to condense the temperature logger data into an easy-to-comprehend graph. I thank my mother for cheering me on during the ups and downs of this research project. Thanks to my sister for helping me realize that I can do anything, and thanks to my aunt Lori and grandma for their unconditional support.

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## Abstract

While the general biological processes of decomposition are known to forensic anthropologists, data on aquatic decomposition is in need of refinement. Water composition varies in mineral content, temperature, flow rate, and scavengers; each of these elements can have an effect on the rate of decomposition. This study specifically focuses on the effects of river flow rates on decomposition by comparing the rate of decay of three feral pigs (*Sus scrofa*) on land (control specimen), in faster flowing water, and in slower flowing water. The hypothesis states that the pig placed in the faster section of the river will decompose more quickly due to increased water flow which would cause the flesh to deteriorate more quickly.

Three feral pigs weighing approximately 100 pounds each were deposited at their respective research sites on the Amite River at Galvez Landing in Prairieville, Louisiana. Each pig was protected from large scavengers by a thick wire cage equipped with a water temperature data logger. The river subjects were secured to the bank by an industrial chain kept afloat by boat bumpers.

Daily visits to the site revealed that the control pig was skeletonized in two weeks and both water pigs were reduced to a few bones by the end of three weeks. Maggot activity and the presence of fish differed between the two water specimens, but the pigs decomposed at similar rates. Based on the conditions in this study, the hypothesis was rejected as the observed river flow rates did not seem to impact the decomposition rates of the pigs. Further studies with stronger velocity differences should be performed to determine the rate at which water flow does impact decomposition. This study indicates that each environment is distinct and caution must be taken when managing aquatic forensic cases.

## Chapter 1: Introduction

In the United States, there are several distinct forensic facilities that study properties of decomposition using human donations and animal proxies, such as pigs (*Sus scrofa*). Research being done at these facilities is focused on better estimating the postmortem interval (PMI), or time since death (Anderson and Hobischak 2004). Forensic anthropologists relay this information to law enforcement personnel so they can establish a timeline for a forensic case. While the general process of decomposition is biologically universal, these research facilities are established to study the effects of a multitude of variables on the rate of decomposition. Studies at these facilities have shown that water can affect the rate of decomposition (Mann et al. 1990; O'Brien 1994; Ayers 2010).

Although it is widely accepted that water decomposition differs from terrestrial decomposition, relatively few studies have been done in this area of forensic taphonomy (Heaton et al. 2010). Previous studies on water decomposition compared decomposition in a single water environment to decomposition on land (Payne and King 1972; Anderson and Bell 2016; Hurst 2001; Farris 2014). Anderson and Bell (2016) studied the effects of deeply oxygenated water on decomposition. Anderson and Hobischak (2004) compared decomposition on land to decomposition in still and running water, but did not compare water flow rate.

Most published reports involving human decomposition in water stem from single case studies in which forensic investigators are involved (Cotton et al. 1987; Giertsen and Morild 1989; Kahana et al. 1999; Heaton et al. 2010). Such scenarios are more focused on the case and not on research related to water decomposition, providing little information about the effects of water on decomposition. Because of this, there is a growing need for more systematic studies of human decomposition in water environments (Heaton et al. 2010). Furthermore, water

composition varies throughout the United States in mineral content, pH, salinity, temperature, flow, and scavenging aquatic organisms. Therefore, this thesis project will focus on regionally specific effects of river flow rates on decomposition using feral pigs (*Sus scrofa*) as human proxies. Located on the Amite River in Prairieville, Louisiana, three sites were chosen: a land site for control; a "fast water" site along a turbulent, eroding bank; and a "slow water" site, located in a zone of recirculating flow just downstream of the "fast water" site. This study tests the hypothesis that pigs in rapidly moving water will decompose faster than in slower moving water. The proposition suggests that the increased water flow will cause the flesh to deteriorate more quickly than the slower water flow. If water flow has an effect on the rate of decomposition, then the specimens placed in the river will decompose at different rates.

The goal of this research project is to learn more about the effects of river flow rates on decomposition, contributing to the current literature about the impact that water can have on decomposition rates. While the exact water composition will vary seasonally and geographically, such studies are important for forensic cases so that recovery divers and forensic personnel may know what to expect and what to search for in water-recovery cases. At a minimum, referring to a water decomposition study for estimating PMI of a water-related case will be more precise than relying on land-based studies. This thesis will act as a model for future water-related decomposition research in different environments, seasons, and rivers. A greater understanding of the impacts of water on decomposition will lead to more accurate postmortem interval estimates.

## Chapter 2: Literature Review

### 2.1 Taphonomy and Decomposition

In forensic anthropology, taphonomy describes any of the processes that affect a biological organism postmortem (Haglund and Sorg 2002). Such processes include decomposition, scavenging, post-mortem transport, trampling, and natural chemical activity. Decomposition is specifically the breakdown of organic material into simpler forms. Upon the discovery of human remains, forensic anthropologists are tasked with determining the post mortem interval (PMI), or the time that has elapsed since death. Weather and geographic location have been shown to impact the rate of decomposition (Komar 1998). Understanding taphonomic processes and the rates of decomposition under controlled circumstances can reveal trends that can later be applied to recovered human remains in a forensic context (Christensen 2004).

Changes to the body begin immediately after death. Soft tissues of the body are among the first to undergo modification. Early visible stages include algor mortis, livor mortis, and rigor mortis (Christensen et al. 2014). Algor mortis is described as the cooling of the body that occurs after death. Because the body no longer needs to maintain an average temperature 37 degrees Celsius, it will attempt to reach equilibrium with its surroundings. The rate at which this cooling occurs depends on the differential temperature between the body and the environment, but as a general rule, the body cools about one degree per hour during the first twelve hours (Christensen et al. 2014). Livor mortis is the pooling of blood due to gravity after the cessation of blood circulation by the heart, which occurs a few hours after death and becomes most pronounced approximately twelve hours after death. If the body is disturbed or moved at this time, the blood will eventually re-pool in the parts of the body that are now nearest to the ground, due to gravitational pull. Rigor mortis, marked by body stiffness due to the muscle fibers binding

together, begins a few hours after death, peaks around twelve hours, and subsides over the next few days (Christensen et al. 2014).

Decomposition occurs through two primary chemical processes that often happen in tandem: autolysis (involving autolytic enzymes) and putrefaction (involving bacteria) (Roksandic 2002). Skin slippage, or the disassociation of the epidermis and the dermis, is also associated with early stages of decomposition (Christensen et al. 2014). While mummification may occur in arid climates, adipocere, a waxy substance that is the result of body fat hydration, is more likely to form in wet climates like river bottoms and lake beds (Byers 2011). Decomposition occurs in five general stages: Fresh, Bloat, Active decay, Advanced decay, and Dry or Skeletonized. Payne (1965: 595-597) elaborates:

> Fresh: Preliminary to bloating, the remains have been recently placed in the area. Insects take interest in minutes.
>
> Bloat: Remains, particularly the abdomen, begin to inflate. Liquids may seep out from the remains and a detectable odor is present. Maggots are concentrated around orifices.
>
> Active decay: Some areas, like the head, may be skeletonized, but the rest of the body continues to decompose.
>
> Advanced decay: A majority of the flesh has been consumed by necrophagus insects and the soft tissues begin to dry.
>
> Dry/Skeletonized: Only bones, skin, and cartilage are left. Beetles may remain.

Research that studies human decomposition reflects the multitude of variables that can affect the rate at which humans decompose (Bangs 2014). As such, it is important to conduct research that can be replicated in different scenarios. Stages of decomposition and the sequence of arthropod colonization of a body are well known in a terrestrial environment (Anderson and Hobischak 2004). In terrestrial environments, there is a predictable succession of events that are regularly used to determine an accurate PMI; however, there is no method of equivalent

precision for estimating PMI for water environments (Dickson et al. 2010). The most common approach is to base PMI or PMSI (postmortem submersion interval) on when a person was last seen alive; while this may be an accurate option in accidental water deaths, it may not be as successful in homicides (Dickson et al. 2010) because the date of deposition in the water may not occur at the same time as the death of the individual.

Much of what is known about forensic taphonomy and decomposition comes from outdoor research facilities that are often associated with universities. Several of these well-known facilities located in the United States include the Anthropology Research Facility at the University of Tennessee, Knoxville; the Forensic Anthropology Research Facility at Texas State University; the Southwest Texas Applied Forensic Science Facility at Sam Houston State University; the Complex for Forensic Anthropology Research at Southern Illinois, Carbondale; and the Forensic Investigation Research Station at Colorado Mesa University. Until quite recently, forensic literature has paid little attention to aqueous environments (Haglund and Sorg 2002) and current knowledge is derived from forensic casework (Dickson et al. 2010).

One aspect of understanding decomposition is forensic entomology, a highly specialized subdiscipline of entomology and forensic science (Rivers and Dahlem 2014). After death, animal and human tissue is attractive to a variety of insects and invertebrates (Smith 1986). Smith (1986) notes four ecological categories of insects that can be recognized on carrion: necrophagous species, predators and parasites on the necrophagous species, omnivorous species, and adventive species. Recognition of the species involved in the stages of succession paired with knowledge of their development can indicate the age of a corpse (Smith 1986). Flies generally emerge at about two weeks after maggot eggs are laid (Smith 1986). The transition from eggs to adults can take 10 to 25 days depending on temperature (Smith 1986).

Entomologists that are particularly adept at researching and understanding the phases of insect infestation and development may be called in to medico-legal circumstances to aid in establishing time of death. The first published works on entomology were by Jean Pierre Mégnin (1887, 1894) and were successful in aiding in some identifications (Smith 1986). Today, there are forensic entomologists, or medicocriminal entomologists, that specialize in the application of entomology to forensic and medico-legal contexts (Rivers and Dahlem 2014).

## 2.2 Water Decomposition

It is generally accepted that decomposition of bodies in water differs from that on land due to a large number of unique variables in an aquatic environment (Dickson et al. 2010). In particular, water temperature is one of the most important factors for determining the progression of decomposition. Human remains in water are subject to many potential actions reliant on the remains themselves and the characteristics of the water environment (Haglund and Sorg 2002). Depending on factors such water temperature, depth, oxygenation, and current, bodies in the water may float or sink, only to resurface later or remain submerged, accumulating sediment (Haglund and Sorg 2002). Bodies may be consumed by scavengers, become disarticulated, be cast upon shores, or carried by currents (Haglund and Sorg 2002). Thus, "bodies become modified due to their physical nature (an object that is transported), biochemical nature (a decomposing animal that becomes disarticulated and scattered), and biological nature (a source of food)" (Haglund and Sorg 2002: 202).

In 1972, Payne and King collaborated to write a primary article on water decomposition in South Carolina (Payne and King 1972). They used two stillborn pigs that had been frozen beforehand and submerged them in two metal tanks. The project began in June and ended in

November of 1966. Payne and King (1972: 154-161) defined six stages based upon the physical appearance of the body, smell, and presence of scavengers:

> First Stage: Submerged Fresh. Characterized as the stage in which the carcass is underwater. The carcass is no longer considered fresh when it rises to the surface. Pigs usually bloat in 1-2 days in the summer, but remain underwater for 2-3 weeks in the winter before bloating.
>
> Second Stage: Early Floating. The distended abdomen of the carcass is usually the first to emerge. Blowfly eggs of *Phaenicia caeruleiviridis* and *Cochliomyia macellaria* present.
>
> Third Stage: Floating Decay. The eggs hatched by the third day in the summer. Staphylinids and histerids were abundant at night.
>
> Fourth Stage: Bloated Deterioration. Characterized by the increased number of maggots. Most of the exposed tissue was gone and the maggots began to migrate under water.
>
> Fifth Stage: Floating Remains. Highly variable stage ranging from 4-14 days, depending on the number of remaining maggots and the rate of deterioration of the tissue and skin. Stage ended once the remains sank.
>
> Sixth Stage: Sunken Remains. Another variable stage ranging from 10-30 days. Bacteria and fungi complete the decomposition of the remains. Mosquito larvae are abundant and the water smells foul.

Anderson and Hobischak (2004) conducted a study to determine the rate of decomposition in a marine environment in British Columbia, Canada. They compared decomposition between pig carcasses submerged in still freshwater, running freshwater, and on land (Anderson and Hobischak 2004). Anderson and Hobischak (2004) used wild boars (*Sus scrofa* L.) weighing 20-25 kilograms each and submerged them at two depths, 7.6 meters and 15.2 meters. They found that while blow flies (Calliphoridae) penetrated the land carcass, they left the freshwater specimens alone (Anderson and Hobischak 2004). Table 1 contains information on their observations, broken up by stage of decompositions and elapsed time since death (ETSD) (Anderson and Hobischak 2004).

Table 1. Comparison of decomposition between carcasses submerged in still and running freshwater and those decomposed on land (modified from Anderson and Hobischak 2004)

| Stage | Freshwater, standing | Freshwater, running | Terrestrial |
|---|---|---|---|
| Fresh | 0-9 days ETSD<br>Mostly submerged. Larval caddis flies colonizing submerged areas. | 0-9 days ETSD<br>Mostly submerged, but some parts exposed. Fly eggs laid where body is exposed. | 0-1 days ETSD<br>Insect colonization, natural orifices first. |
| Bloat | 9-35 days ETSD<br>Still partially floating, Insect colonization on exposed tissue and under clothing. Aquatic colonization of submerged areas. | 9-35 days ETSD<br>Still partially floating, exposed skin pale in color, submerged skin dark. No insect colonization at orifices. Adipocere formation on head. Terrestrial vertebrate scavenging, resulted in sinking. | 2-10 days ETSD<br>Gases expand the abdomen first, then the rest of the body. Insect colonization continues. |
| Active | 42-105 days ETSD<br>Hair and skin sloughing off. Adipocere formation throughout. Still appears a little bloated, probably due to hardened outer tissue. Terrestrial insects no longer present. Exposed skin mummified. | 42-105 days ETSD<br>Hair sloughing. Some terrestrial insects present at first. Adipocere formation, outer skin hardened and mummified where exposed. Some further terrestrial vertebrate scavenging. | 11-16 days ETSD<br>Gases released, carcass deflates. Chemicals released give the body a “wet” appearance. Maggot masses present, concentrated around orifices and wounds. |
| Advanced | 105-280 days ETSD<br>Partially exposed. Submerged parts shredded by invertebrates. Torn tissue colonized by aquatic organisms. Submerged extremities and head skeletonized. Algal formation on submerged skin. | 105-182 days ETSD<br>Few organisms visible. Some disarticulation. Adipocere still present. | 17-42 days ETSD<br>Most flesh removed. Bones exposed. Maggots have left body, insect colonization continues. Discolored soil and dead vegetation around body. |
| Remains | 280-336 days ETSD<br>Skeletonized by aquatic organisms. | 280-336 days ETSD<br>Totally submerged. Typical sediment-dwelling fauna now present. | 43+ days ETSD<br>Only skin, bones and cartilage remain. Experiment terminated. |

Megyesi and colleagues (2005) developed an equation for calculating accumulated degree days (ADD) in terrestrial decomposition. Their system quantifies the process of decomposition as the summation of progressive numeric scores (dubbed the Total Body Score) based on the appearance of three regions: the head, trunk, and limbs (Megyesi et al. 2005). Heaton et al. (2010) suggest that the same principles from this method should also be applied to water-based decomposition scores and the accumulation of aquatic temperatures over time.

Recently, criminologists at Simon Fraser University tested the rates of decomposition of pigs placed in the Strait of Georgia, between the mainland of southern British Columbia and Vancouver Island (Anderson and Bell 2016). Using pig carcasses as human proxies, the researchers wanted to understand the impacts of biotic and abiotic factors in a deep coastal marine environment in order to apply such knowledge to a forensic context. Two pigs were deployed in the spring of 2012 and two additional pigs were placed in the fall of 2013; each pig weighed ~21-24 kilograms in order to approximate a human specimen as closely as possible (Anderson and Bell 2016). The researchers ultimately found that human-sized pig carcasses could be skeletonized in as little as four days in highly oxygenated deep waters, although bones could continue to be recovered for up to six months (Anderson and Bell 2016). Previous studies using whale carcasses showed that decomposition could take much longer, emphasizing the importance of using human-sized pig carcasses in this study (Anderson and Bell 2016).

Several students at Louisiana State University have also been involved in advancing research and understanding of decomposition in water environments. In 2001, Sherice LaVonne Hurst conducted a study that compared the rate of decomposition on land and in water. She used freshly euthanized domestic pigs weighing about 40 pounds (18 kilograms) (Hurst 2001). One site was a freshwater lake located at the Louisiana State University Aquaculture Center and the

other was a pecan grove less than a mile from the Aquaculture Center's manmade lake (Hurst 2001). Hurst (2001) placed her aquatic specimens in criminal situations: tied up at a dock, weighted with a cinder block, and kept afloat with a buoy. Water temperature, ambient temperature, and species of aquatic insects were recorded.

The land pig reached skeletonization between 21 and 62 days (Hurst 2001). The weighted pig and the buoyed pig decomposed at similar rates, reaching skeletonization between 37 and 94 days and 44 and 73 days, respectively; the pig at the dock reached the desiccated tissue stage between 72 and 106 days (Hurst 2001). Hurst (2001) noted that, despite the lack of entomological data, there was a shift in the ecology at the lake; scavengers could be used as pointers in locating the pigs because they swarmed densely around the carcasses. She suggests that water temperature, location, and scavenger activity might all have had an effect on the rate of decomposition (Hurst 2001). Hurst (2001) concluded that decomposition was slower in the aquatic environment compared to the land site.

In 2010, research was undertaken by Sophia Renke to understand the impact that algae have on the postmortem submersion interval (PMSI) (Renke 2010). Renke (2010) placed five previously frozen fetal pigs in Bayou Fountain in Baton Rouge during two seasons. The spring season study took place from May 12, 2009, to June 4, 2009, and the fall season study took place from November 12, 2009, to December 15, 2009 (Renke 2010). The specimens were caged and tied with rope to fence posts. The remains were allowed to float and sink with the rise and fall with the water without being removed from their cages (Renke 2010). Of the five specimens used in each season, two were clothed and three were unclothed.

Renke (2010) noted scavenging from fish and tadpoles, but also suggested that crawfish and turtles could have scavenged the remains as well. Renke (2010) found that, in the spring,

unclothed pigs were scavenged earlier in the study than clothed pigs. Spring specimens were all skeletonized between 16 and 24 days. In the fall, clothed pigs decomposed slower than the unclothed pigs; moreover, fall decomposition was overall slower than spring decomposition. At the termination of the fall study, the specimens were all in a stage of advanced decay at Day 34; skin was mostly intact and bone exposure was minimal (Renke 2010). Renke (2010) measured the concentration of cholorphyll *a* to determine algae growth. Algae growth occurred the fastest on the clothed specimens in the spring study due to more ideal growing conditions and available surface area for growth (Renke 2010). Renke (2010) ultimately showed that algae growth on a body can be used to determine PMSI by measuring the concentration of chlorophyll *a*.

In 2014, Rachael Farris completed a thesis research project related to decomposition in the swamp environments of southern Louisiana. Farris (2014) placed three fetal pigs on a dry land site and three fetal pigs in a nearby swamp site. She visited the sites twice daily to collect necrophagus insects, examine decomposition rates, and note other influential factors (Farris 2014). Despite the remains being placed in cages, scavengers like turtles and fish still consumed some of the remains (Farris 2014).

The remains of the pigs placed at the land site decomposed rapidly within a week (Farris 2014). Farris (2014) found that very few beetles visited the site due to the remains having skeletonized in mere days. At the swamp site, although all three pigs were placed on the same day, Farris (2014) observed different rates of decay for each pig; however, all were generally slower rates than those of the land pigs. Cage placement and rise and fall of water levels could have played a role in the varying rates of decomposition in the water (Farris 2014). Farris' (2014) study took only 19 days to complete.

Paul Bangs (2014) conducted research which compared the decompositional variability in three geographically distinct sites: the east bank of the Mississippi River in Baton Rouge; the "Red Pass" in the Bird Foot Delta near Venice, Louisiana; and the Grande Isle and Grand Terre Islands in the Gulf of Mexico. Bangs (2014) used six pigs weighing between 53 and 119 kilograms. Of these previously discussed theses, Bangs (2014) was the only project that utilized feral pigs, showing that they can be used as human surrogates.

At each site, Bangs (2014) recorded weather data, stage of decomposition, insect activity, and scavenging. Two pigs were placed at each site, and in the second week of the study, one of the pigs at each site was moved to land. Only the second Grande Isle pig and the first Baton Rouge pig made it to the dry stage of decomposition before the experiment ended on Day 37. Bangs' (2014) project shows that, although the average daily temperatures may vary within a few degrees, the succession of the stages of decomposition varied little as the pigs advanced through the Fresh to Bloat, and Bloat to Active stages. Bangs (2014) noted scavenging at every site; alligators and fish scavenged in the water, and coyotes scavenged on land. Alligators completely removed the remains at the Venice site by Day 10 and the Baton Rouge site was left with much of the original soft tissue at the end of the project (Bangs 2014).

## 2.3 River Morphology

Water flowing down a channel converts potential energy into kinetic energy as well as dispels energy (Wohl 2014). The rate and manner in which energy is expended depend on the arrangement of the channel, including the frictional resistance of the channel boundaries (Wohl 2014). Velocity is one of the most commonly measured variables due to its sensitivity to

frictional resistance (Wohl 2014). Both velocity distribution within a channel and average velocity are sensitive to boundary roughness that impedes flow (Wohl 2014).

Most natural rivers meander and erode the outer banks in their successive bends; engineering efforts have been undertaken on rivers to stabilize the banks (Blanckaert and Graf 2001). Such a pattern is observed in the Amite River at the site of this research. An abrupt change in the channel boundary or orientation can create separated flows, or portions of the channel in which there is little or no mean downstream flow (Robert 2003). Examples of such sites include sharp channel bends, channel expansions, and pools (Wohl 2014). The acceleration of flow around an obstacle can create a turbulent boundary layer to detach from the bank (Wohl 2014), resulting in a separate portion of water along the bank. The reattachment point occurs where the turbulent boundary meets back up with the bank downstream from the obstacle; the area between the separation and reattachment points is referred to as the zone of recirculating flow (Buffin-Bélanger et al. 2013). Sites of recirculating flow exhibit slower velocity than the main channel. Areas of recirculating flow are important for aquatic habitats by providing a low-velocity resting place for fish and other aquatic organisms (Wohl 2014).

## 2.4 Conclusion

Terrestrial decomposition differs from aquatic decomposition, yet relatively few studies have been conducted to understand the different ways in which water effects decomposition. Previous water decomposition studies compared the rate of decomposition in a single water environment to decomposition on land (Payne and King 1972; Hurst 2001; Bangs 2014; Farris 2014). Several students at Louisiana State University have been involved in advancing research of aquatic decomposition (Hurst 2001; Renke 2010; Farris 2014; Bangs 2014). While these

theses have contributed to understanding water decomposition in Louisiana, this study is the first to address the effects of river flow rates on decomposition.

## Chapter 3: Materials and Methods

This research project utilized three wild boars (*Sus scrofa*) weighing between 100 and 115 pounds (approximately 43 to 52 kilograms) as proxies for human subjects. Pigs have been shown to be adequate surrogates for researchers who do not have access to human remains. In addition to comparable bone shape and thickness to humans, pig skin and internal tissues have similar texture and percentages of fat as humans (Anderson and VanLaerhoven 1996). This study utilized pigs with weights comparable to smaller human adults. The boars were donated by the Bob R. Jones-Idlewild Research Station in Clinton, Louisiana, where wild boars are culled for studies relating to the economic damage from wild boars in the southeastern United States (LSU AgCenter and College of Ag New Sources 2017).

### 3.1 Study Area

The Amite River is located in southeastern Louisiana. The Amite watershed is approximately 5,700km$^2$ (Mishra and Deng 2009). The headwaters are located in southwestern Mississippi (Mossa and McLean 1997). The river flows approximately 117 miles and drains into Lake Maurepas in southeastern Louisiana (Watson et al. 2017). Multiple communities within the parishes of East Feliciana, St. Helena, East Baton Rouge, Livingston, Ascension, St. James, and St. John the Baptist are located along a 68-mile stretch of the Amite River, including Denham Springs, Port Vincent, French Settlement, and Maurapas (Watson et al. 2017: 9). The Amite River is a meandering, primarily sand-bed river (Gasparini et al. 2015). The average sediment concentration is 25mg/L (Mishra and Deng 2009: 846). Although the river has undisturbed areas, there are areas in which invasive sand and gravel mining has taken place (Mossa 1995; Mishra

and Deng 2009). Mossa and McLean (1997) have shown that a link exists between floodplain mining and channel change.

The U.S. Geological Survey (USGS) operates several streamflow-gaging stations on the Amite River (Watson et al. 2017: 9), including at Denham Springs and Port Vincent, that collect precipitation, discharge, and mean water velocity data. The mean water discharge available from USGS for the Amite River is approximately 2300cfs. At Big John's Galveztown Landing and Storage, the width of the Amite River is about 80 meters. The bankfull depth at this location averages approximately five meters based on bathymetric measurements taken by Dr. Kory Konsoer.

At approximately 10:30am on June 10, 2016, a researcher at the Bob R. Jones-Idlewild Research Station killed the pigs by administering a gunshot wound to their heads. The boars were picked up and loaded into a jon boat and taken immediately to their respective sites along the Amite River in Prairieville, Louisiana (Figure 1). The distance between the Bob R. Jones-Idlewild Research Station and the boat launch at Big John's Galveztown Landing and Storage is approximately 55 miles, and the drive took about two hours. Site 1 was named the Land Control Site and was chosen due to its proximity to the water sites; Site 2 was the Slow Water Site which was chosen due to the slow, recirculating current; Site 3 was the Fast Water Site, located nearer the main flow of the river. For the purpose of this study, the designations "Slow Water" and "Fast Water" were chosen to concisely describe the zone of recirculating flow and the downstream-oriented flow, respectively. The zone of recirculating flow is an area of slower flowing water, and the downstream-oriented flow is an area of faster flowing water. Placing the water sites near each other in the same river controlled for water temperature and composition. Permission was received by the Department of Wildlife and Fisheries to place the pigs in public

waters. John Templet, owner of Big John's Galveztown Landing and Storage, allowed deposition of the pigs on his private property.

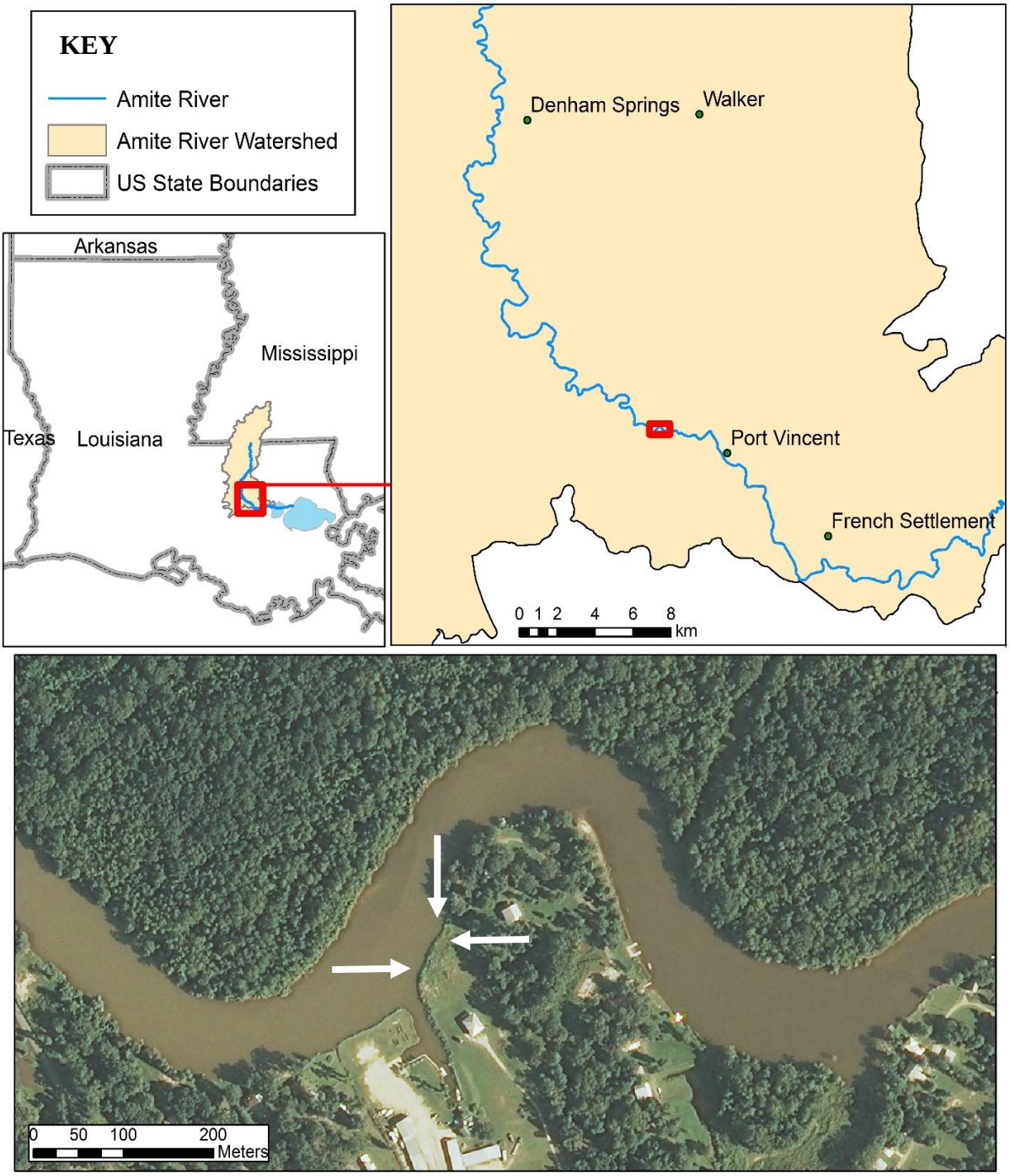


Figure 1. Location of the three sites on the Amite River.
Site 3, left arrow; Site 2, top arrow; Site 1, right arrow

The sites were accessible by driving up to and parking by a house nearby and walking about 120 meters to the edge of the river. John Templet, the landowner, mowed a path to the water's edge for easy access to the sites and visibility of potential venomous snakes, which neighbors had seen in the area downriver. Large metal dog crates were used as cages to protect the pigs from being carried away by large scavengers. Each pig was placed in its own wire cage that was secured with colored-coordinated zip ties to assist with distinguishing the pigs in photos. Every cage was equipped with an Onset HOBO temperature logger to monitor temperature changes in the air and water surrounding the cages. All of the pigs were positioned by 3:00pm on June 10, 2016, leaving as little time between death and deposition as possible. Deposition of the pigs marked Day 1.

The sites were visited regularly to check on the stage of decomposition. Cages were pulled up from the river, pictures were taken, and then the cages were put back. Insect activity was noted when possible, but was not a focus of this research due to the specialization of entomology. To remain consistent between the land control pig and the water specimens, Payne's (1965) general decomposition stages were used to describe the decomposition stages of all three specimens, but the water specimens were supplemented with more detailed information from Payne and King's (1972) water decomposition stages. In-depth descriptions of each of the three sites is presented in the following sections of this chapter.

## 3.2 Site 1: Land Control Site

The land control pig was deposited at 2:00pm. This pig is dubbed Site 1 even though it was deposited second. Site 1 is nearest to parking access, and therefore the first site encountered during data collection. The pig was placed inside an extra-large metal animal crate measuring 48

inches long and 33 inches high to protect it from any large scavengers that could drag it away from the site. The sides and door of the cage were reinforced with green zip ties. An Onset HOBO temperature logger was zip-tied to the cage near the back of the pig, as close to the pig's body as possible. This site was chosen because it was off the river bank about 15 meters and unable to be seen from the boat launch or the river; the site was located behind a pile of large cement blocks and similar debris that are reserved for reinforcing the eroding river bank. A sign stating the researcher's intention and contact information was placed nearby should anyone have any questions (Figure 2).


Figure 2. Land Control Site on Day 1

3.3 Site 2: Slow Water Site

The Slow Water pig was the first to be deposited. After being placed in a wire animal crate 42 inches in length and 30 inches in height, the cage was reinforced with purple zip ties and an Onset HOBO temperature logger was placed on the bottom front of the cage. Industrial metal

chain was looped through and around the front of the cage and secured with a padlock; similarly, the chain was looped around large cement blocks on the bank and also secured with a padlock. A rebar post was added to the bank to provide more support for the chain should the cement blocks on the bank slide into the water. Once secured, the cage was tipped into the water, sinking approximately seven meters based on the amount of chain that remained above water. Final deposition occurred at 1:45pm. This site was chosen as the Slow Water Site because of the eddy-like area that is formed from the main channel of water pushing away from the reinforced river bank, creating what Blanckaert and Graf (2001) referred to as a zone of recirculating flow with a lower velocity than that of the main channel (Figure 3).

Figure 3. Slow Water Site

3.4 Site 3: Fast Water Site

The Land Control site and Slow Water site are within 30 meters of each other, but to reach the Fast Water Site, the jon boat had to be moved approximately 60 meters up river, closer to the boat launch (Figure 1). Using the same methods as the Slow Water specimen, the Fast Water specimen was placed in a large wire animal crate measuring 42 inches in length and 30 inches in height, reinforced with blue zip ties, and equipped with an Onset HOBO temperature logger on the bottom front of the cage. Chain was looped through and wrapped around the cage and secured with a padlock; the cage was secured to the bank with rebar and chain wrapped around large cement blocks and locked with a padlock. Once secure, the cage was pushed into the water, sinking only one to two meters, more shallow than the initial depth of the Slow Water specimen. Final deposition occurred at about 2:50pm. This site was chosen as the Fast Water Site due to the main channel of water accelerating around the bend. Because this site is near the boat launch, wakes from boats also contributed to the turbulence of the water (Figure 4).

Figure 4. Fast Water Site

## Chapter 4: Results

The study began on June 10, 2016 and lasted 22 days. The weather the day the pigs were culled and taken to their sites was sunny and 29.6 degrees Celsius (Table 2). Regular visits became earlier than the time of the deposition day to try to avoid recreational boaters. Although the sites were typically visited late morning, recreational boaters were out on the river throughout the project. Occasionally, people pulled their boats as close to the bank as they could and asked what was happening, but no one showed any concern. Even the Ascension Parish Water Patrol Unit was excited to have witnessed a forensic research project. The specimens never appeared to be tampered with by curious people.

Figure 5 shows the relationship between rainfall and river discharge recorded by the Denham Springs gaging station located approximately 20 miles upriver from the boat launch at Big John's Galveztown Landing and Storage. This information is important because river flow is affected by rainfall; an increase in rainfall in cubic feet per second (cfs) can lead to changes in the river flow. Between June 10, 2016, and June 30, 2016, cumulative rainfall was recorded in inches and discharge was recorded in cubic feet per second. The discharge flow was stable for most of the test period and averaged approximately 1200cfs with two notable spikes. The first occurred around June 20, 2016, and lasted about two days. The discharge peaked at 3,000cfs - 2.5 times the average. The second spike in discharge occurred on June 29, 2016 and lasted one day. Only three days of the study experienced significantly elevated river flows which represented less than 20 percent of the test period; thus, flow patterns created by recreation and changes in cage location would have had a greater impact on the decomposition of the pigs than the flow spikes.

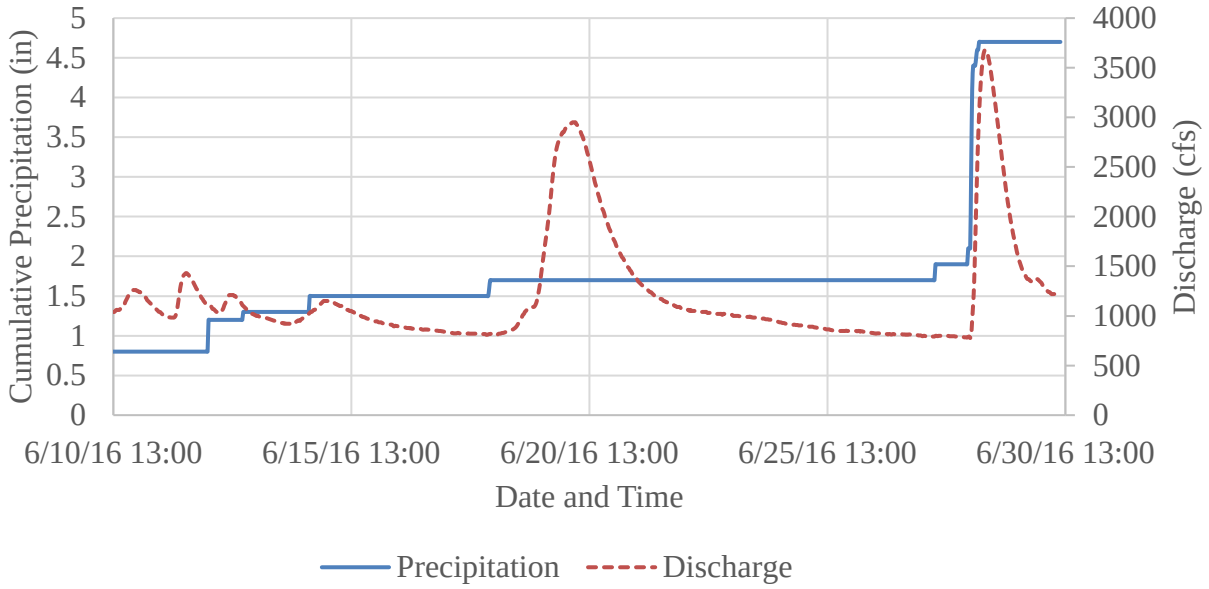


Figure 5. Precipitation and Discharge at Denham Springs from June 10 - Jue 30, 2016

Table 2 consolidates the results of the study into a single chart for comparison, listing the days and times visited as well as the stages of decomposition. Temperature at the time of the visit and any weather changes were also noted. Up to Day 12, the Slow Water specimen was slower to host maggots than the Fast Water specimen, but was further along in decomposition on Day 12 (Table 2). Over the next few days, the rates of decomposition slowed down for both specimens and evened out in rate. Each site will be discussed in detail in the sections to follow. Temperature results from the Onset HOBO temperature loggers are discussed in section 4.4.

Table 2. Decomposition stages for each of the three sites referencing Payne (1965) and Payne and King (1972)

| Day | Time | Temp (°C) | Site 1: Control | Site 2: Slow | Site 3: Fast | Notes |
|---|---|---|---|---|---|---|
| 1 | 1:45-3:00 | 29.6 | Fresh | Fresh, Submerged | Fresh, Submerged | Deposition day |
| 2 | 3:50pm | 31.1 | Bloat | Bloat, Early floating | Bloat, Early floating | Rained overnight |
| 3 | 3:45pm | 29.4 | Bloat | Bloat, Early floating | Bloat, Early floating | Rained overnight |
| 4 | 5:00pm | 28.3 | Active Decay | Bloat, Early floating | Bloat, Floating decay | Rained overnight |
| 5 | 3:30pm | 31.1 | Advanced Decay | Bloat, Floating decay | Bloat, Floating decay | Rained overnight |
| 6 | 12:15pm | 31.6 | Advanced Decay | Active, floating decay | Active, floating decay | |
| 7 | 11:45am | 31.6 | Advanced Decay | Active decay, Bloated deterioration | Active, floating Decay | |
| 8 | 11:15am | 30.5 | Advanced Decay | Active decay, Bloated deterioration | Active, floating Decay | |
| 9 | 12:00pm | 24.4 | Advanced Decay | Active decay, Bloated deterioration | Active, floating Decay | Rained overnight |
| 10 | 10:30am | 27.8 | Advanced Decay | Active decay, Bloated deterioration | Active decay, Bloated deterioration | Rained overnight |
| 11 | 11:45am | 24.1 | Advanced Decay | Active decay, Sunken remains | Active decay, Bloated deterioration | Rained overnight |
| 12 | 12:15pm | 24.1 | Advanced Decay | Active decay, Sunken Remains | Active decay, Bloated deterioration | |
| 13 | 11:45am | 22.6 | Advanced Decay | Active decay, Sunken remains | Active decay, Bloated deterioration | |
| 14 | 12:00pm | 22.2 | Skeletonized | Active decay, Sunken remains | Active decay, Sunken remains | |

Table 2. Decomposition Stages for each of the three sites, continued

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 1:00pm | 24.9 | Skeletonized | Advanced decay, Sunken remains | Active decay, Sunken remains | |
| 16 | 11:00am | 22.7 | Skeletonized | Sunken remains* | Sunken remains* | *Left in water |
| 17 | 10:15am | 30.5 | | Advanced decay, Sunken remains | Advance decay, Sunken remains | |
| 18 | N/A | | | | | Sites not visited |
| 19 | 10:15am | 23.6 | | Skeletonized | Advanced decay, Sunken remains | Rained overnight |
| 20 | N/A | | | Skeletonized | | Sites not visited |
| 21 | 10:30am | 22.4 | | Skeletonized | Skeletonized | Rained overnight |
| 22 | 10:15am | 23.2 | | | Skeletonized | |

4.1 Site 1: Land Control Site

The land pig was deposited approximately 15 meters from the bank of the Amite River at 2:00pm. The pig was in rigor mortis, beginning to bloat, and still expelling blood from the gunshot wound. By 3:50pm the next day, the carcass was bloated, and the orifices were bulging. Maggots surrounded the anus and gunshot wound in the head (Figure 6). Many flies were buzzing around the cage. On Day 3, bloat was still present and the maggots had grown in quantity; they now covered the head and mouth as well as the bottom of the cage, spilling to the ground outside. First instar maggot larvae, or maggots that had just hatched (Smith 1986), could easily be viewed. Rain from the night before (Figure 5) left water in the bottom of the cage and there was a strong odor about the carcass.


Figure 6. Land Control Specimen on Day 2

By Day 4 the land pig was almost completely covered in maggots. First, second, and third instar maggots overflowed into the bushes nearby (Figure 7). Flies and dragonflies clung to the surrounding foliage. Patches of fur were gone near the shoulders, back legs, mouth, and stomach. The strong odor persisted. By the afternoon of Day 5, insect activity on the pig had decreased significantly. Maggots were mostly in masses around and underneath the cage, but not on the carcass. The carcass itself was in an early stage of skeletonization; little skin remained and the fur had fallen to the bottom of the cage (Figure 8). Day 6 was similar to Day 5; the pig was in a late stage of decomposition. Rainwater was pooled in the bottom of the cage. Maggots were mostly underneath the pig and cage. Maggots were migrating in masses stretching downriver at least ten meters from the cage. On Day 7, the maggots were mostly gone; no maggot mass could be found. The bottom of the cage was wet, keeping the pig moist. Dragonflies and grasshoppers clung to the bushes nearby.

Figure 7. Land Control Specimen on Day 4

Figure 8. Land Control Specimen on Day 5

Day 8 mimicked Day 7; the carcass was still moist from rain water, but there were no maggots visible. The dragonfly and grasshopper numbers were reduced as well. The carcass still smelled, but much less so than Days 3 and 4. Day 9 was unchanged from Day 8. Days 10 and 11, however, saw a small resurgence of newly hatched flies in the surrounding foliage. The bottom of the cage was still holding water, keeping the carcass moist. On Day 12, the bushes around the control pig were black with newly emerged flies, consistent with the expectation that flies emerge from maggots in approximately two weeks (Smith 1986). Flies were also landing on the pig. Exposed bones were beginning to bleach from the sun. Day 13 showed little change from Day 12. By Day 14, the carcass was beginning to dry out. The carcass continued to dry out from Day 15 to Day 17. There were fewer and fewer flies around. Pupa casings were visible in the cage around the pig. Dragonflies reappeared on Day 17. Because very little changed in the subsequent days, the Land Control Site specimen was considered skeletonized between Days 14 and 16 (Figure 9).

Figure 9. Land Control Specimen on Day 15

4.2 Site 2: Slow Water Site

The Slow Water pig was the first pig to be deposited. On Day 1, the Slow Water specimen was beginning to bloat, in rigor mortis, and blood was still being expelled from the gunshot wound in the head. At 1:45pm, the caged pig was pushed into the Amite River. The cage sunk approximately seven meters based on the amount of slack left in the chain. On Day 2, the carcass was bloated, allowing the cage to float near the surface of the water. No insect activity was noted. The temperature logger on the front of the cage was submerged as intended, recording the temperature of the water around the specimen. Insect activity began on Day 3. Flies were seen on the cage and the exposed surface of the still bloated and floating pig. No other insect activity was visible.

On Day 4, bloating was diminished, but the carcass and cage were still floating; the cage was submerged about halfway (Figure 10). Flies were still present and the only insect activity noted. Debris, mostly small branches and leaves, were built up around the cage. Skin slippage was seen on the feet and nose. A dry, crusty spot was visible on the neck. Small fish were in the water surrounding the cage, probably eating the flies but potentially scavenging the pig remains. Three buoys were added to the chain on Day 4 so that the chain would not sink and catch on the rocky bank and river bottom. The buoys were light enough to keep the chain from sinking but not affect the flotation of the cage. Once pushed back into the river, the cage floated upstream with the rotating current.

On Day 5, the cage and pig remained floating. The flies had moved from the top of the carcass down the sides. First instar maggots could be seen near the head and gunshot wound. Skin slippage was occurring on the feet, and the face and legs were losing fur. Small fish were observed in the water nearby.

Figure 10. Slow Water Specimen on Day 4

Day 6 was similar to Day 5; the specimen was still floating, maggots were concentrated around the back, and fur was falling off the face and belly. The hooves were also falling off. At this time, the complete and waterlogged carcass was too heavy to lift out of the water to observe the submerged portion. The next day the specimen had floated upriver and the cage was mostly upside down. No attempt was made to right the cage to avoid unintentionally flipping the carcass, thus further interrupting a more natural mode of decomposition. Maggots were observed on the exposed surface of the carcass, and small fish were downstream eating the maggots that were washed off by the water. Skin continued to slip off the extremities.

Day 8 saw additional changes to the specimen, which was still floating at the top of the cage. The fur was almost gone and skin slippage continued on the face and feet. Maggots appeared more internally, and fish were present in the water nearby. A white, frothy substance floated around the carcass, possibly a result of decaying fat and tissue (Figure 11). The specimen

also possessed an odor that could be smelled from the bank. By Day 9, the specimen's feet were gone and little fur was left. Overall, the specimen was white and slimy-looking. Ribs were visible, and the intestines were bulging. No insect activity was visible. The specimen was still floating upstream. Small fish could be seen in the water nearby.

Figure 11. Slow Water Specimen on Day 8

By Day 10, enough of the specimen had decayed that the cage was lighter and easier to maneuver. The pig was still floating upriver and was a white and indistinguishable mass of flesh and bones. No fish were observed nearby. The Slow Water specimen sunk on Day 11. The pig was still upriver, but was pulled nearer the shore for observation. The limbs were gone, and distinguishing head from tail was difficult. Fish could be seen jumping in the main part of the river, but none were seen by the specimen. No insect activity was noted.

On Day 12, the submerged specimen was straight out into the river. The cage was sunk deep, past the first buoy on the chain; approximately three meters. The carcass was in a stage of

late decomposition; the skin was white and soft looking. The cage was pushed back out, and sunk about one meter down. No insects or fish were visible. The next day, the specimen had not moved much. The limbs were gone and the flesh was soft and white from loss of pigmentation. No insects, fish, or other scavengers were observed. On Day 14, the specimen was again sunk deep, approximately three meters. The cage was pulled up for observations before being pushed back out. Small fish were in the water around the pig, but the water was too muddy to see if the fish were scavenging on the flesh. The carcass was an indistinguishable mass of bone and flesh.

On Day 15, a large tree was caught on the cage (Figure 12). The carcass was a white, slimy mass with ribs exposed. No fish or scavengers were noted. While decomposition was slowing down, the cage was not pulled up on Day 16 to allow the pig to decompose without interference. Fish were observed in the water nearby. Little change was observed from Day 15 to Day 17; the pig was in a state of advanced decay as described by Payne (1965). Ribs were exposed through a mass of deteriorated flesh. The jaw was displaced. No fish were seen.

Figure 12. Slow Water Specimen on Day 15

The site was not visited on Day 18. Because the rate of decomposition had slowed down, the specimen was left to decompose without the disturbance of lifting the cage out of the water. The visit on Day 19 revealed a submerged specimen with a mass of skin and tissue floating nearby. Upon lifting, a mass of soft tissue floated to the top and loose bones sunk to the bottom of the cage (Figure 13). The mandible, cranium, some long bones, vertebrae, and os coxae were present in the cage. No fish or other scavengers were seen; the cage was replaced to allow the mass of tissue to continue to decompose.

Figure 13. Slow Water Specimen on Day 19

The site was visited again on Day 21. The flesh in the cage was completely gone and only a few bones remained in the cage: cranium, mandible, os coxae, one rib, and both femora. Fish swam around the cage. At this point, the pig at the Slow Water Site was considered completely

decomposed and skeletonized. The cage was pulled to land to dry, and the temperature logger was removed.

## 4.3 Site 3: Fast Water Site

The Fast Water pig was the final specimen to be deposited. The carcass was bloated and still expelling blood from the gunshot wound in its head. The pig was deposited into the Amite River near the boat launch at Big John's Galveztown Landing and Storage at 2:50pm. The pig and cage sunk approximately one to two meters. On Day 2, bloating caused the carcass and cage to float (Figure 14). The cage was floating near the bank with the door up, exposing the attached temperature logger to the air. Skin was beginning to slip on the pig's back. Not noticing any insect activity or other scavengers, the cage was left undisturbed. The temperature logger was left alone with the expectation that the cage would soon sink.

Figure 14. Fast Water Specimen on Day 2

On Day 3, the pig was still bloated, the cage was still floating, and the temperature logger was still exposed. A cottonmouth snake was curled up on the bank, so the cage was not pulled in for observation or to reposition the temperature logger. Other than a few flies hovering around the pig and some debris built up on the cage, no other changes could be seen. Flies covered the cement blocks supporting the eroding bank (Figure 15). Tenants living on the property went fishing earlier in the day, and, unaware of the ongoing project, dumped the gutted fish remains at the end of the path near the water's edge. Most of the flies were on the bank, but a few were on the pig.

Figure 15. Flies due to gutted fish near Fast Water Specimen

On Day 4, after struggling to unstick the chain from the river bottom, three buoys were added to keep the chain afloat. The buoys were light enough to keep the chain afloat but not impact the flotation of the cage. The temperature logger was moved down so it would be submerged when the cage was pushed back out. Skin slippage was noted on the feet and snout; a

small amount of maggots was concentrated on the head, probably in the gunshot wound. The pig floated downriver with the current when pushed back out.

On Day 5, boat wakes had pushed the cage closer to the bank. While the water flow near the bank was slower compared to the center of the river, water was still moving through the cage more quickly than in the Slow Water specimen. The carcass was still bloated. The skin was discolored on the body and slipping from the feet. Fur was falling off and maggots were observed around the ears. By Day 6 less fur remained, the hooves were falling off, and the intestines were bulging. The specimen was lighter and easier to maneuver, but still difficult to get a view of the underside of the pig. The third buoy gave the cage too much slack, allowing the cage to get stuck in a calm spot down river, and was pulled back to the bank on Day 7. A dead fish, unrelated to the fish skeletons from Day 3, was caught on the bank nearby. There were no visible insects or scavengers. The fur continued to fall off as did the feet. The cage was released back into the current after observation.

On Day 8, the support from the buoys positioned the cage in a good spot for water to flow past the pig (Figure 16). The pig was still bloated and pressed against the cage. The skin was holey and slipping off. No insect activity was noted. The cage was still floating on Day 9, more so than the specimen at Site 2, and had floated farther downstream. The feet were gone and skin slippage progressed. Some fur remained on the back, but was gone everywhere else. No insects or other scavengers were seen on the specimen. The visit on Day 10 revealed that the cage was near the bank, but still floating. Some fur still remained, but the limbs were gone. After observation, an effort was made to push the cage back out into the current.

Figure 16. Fast Water Specimen on Day 8

On Day 11, a lack of boaters allowed the cage to remain floating with the current of the river. Rain from the night before seemed to increase the current (Figure 5). There were some flies on the specimen, but no other scavenger activity was noted. The cage was stuck in shallow water on Day 12; the pig had room to float or sink and was still floating. Similarly to Day 11, fur and skin showed discoloration. After being pulled in for pictures, the cage was let back out with the third buoy so the cage could catch more of the river flow. On Day 13, the cage was again floating downstream in a calm spot, but this time it was stuck on a rock and unable to be moved. Small fish were visible nearby, and flies could be seen landing on the pig. The cage was no longer stuck the next day and had sunk about one meter. Dried flesh with fur could be seen on what little of the pig was exposed to the air (Figure 17). No fish or other scavengers were seen.

Figure 17. Fast Water Specimen on Day 13

The cage was sunk deep on Day 15. Only the third buoy could be seen above water, indicating that the specimen was sunk approximately nine meters based on how much of the chain was visible above water. The cage was pulled up for observation, revealing a pig in advanced decay according to Payne's (1965) decomposition stages. The carcass was a mass of white and slimy flesh. Fish were visible in the water nearby. The field was visited on Day 16, but the specimen was not pulled up for observation. The cage was sunk about six meters. On Day 17, the specimen was an indistinguishable mass of flesh in an advanced state of decay. Ribs were exposed, and the mandible was displaced. No fish, flies, or other scavengers were seen.

The specimen was allowed to decompose without disturbance through Day 18. Day 19 revealed a mass of soft tissue and loose bones stuck in the bottom of the cage. The mandible had fallen though the cage and there appeared to be no cranium. Long bones and vertebrae were beginning to disassociate from the bulk of the carcass. The specimen was again allowed to

decompose without disturbance through Day 20. On Day 21, the cage was stuck to the river bottom. The cage could not be freed from the riverbed despite vigorous efforts, so it was left alone. The next day, the cage had come unstuck on its own and was able to be lifted out of the water for observation. There were a lot of fish nearby, but only bones remained in the cage. The bones included a tibia, both scapulae, four vertebrae, and an os coxa, but no cranium. The gunshot wound and the unfused bones of the juvenile cranium probably allowed the it to fall to pieces small enough to fit through the cage wire. The cage was pulled up to dry, and the temperature logger was removed (Figure 18). The Fast Water specimen was considered skeletonized between Days 21 and 22.

Figure 18. Skeletal remains of the Fast Water Specimen on Day 22

## 4.4 Temperature Data

Temperature data were collected from the Onset HOBO temperature loggers placed on each of the three cages. The temperature was recorded by the logger in five minute intervals for

the duration of the research. The data collected represent temperature readings from 1:00pm CDT on June 10, 2016, to the approximate day of skeletonization, June 29 and July 1, 2016, for the Slow Water specimen and the Fast Water specimen, respectively. The results are displayed graphically in Figure 19.

Figure 19 shows that the ambient temperature of the Land Control specimen fluctuated significantly daily, as expected. On the first four days of the experiment, the temperature logger that was on the Fast Water specimen was exposed to the air, recording the ambient air temperature rather than the water temperature. Once that logger was submerged, the difference in temperature of the Slow Water specimen and Fast Water specimen was minimal. The greatest difference between the Slow Water specimen and the Fast Water specimen was 1.3 degrees Celsius where both temperature loggers were submerged. The average difference for the same range of data was 0.018 degrees Celsius.

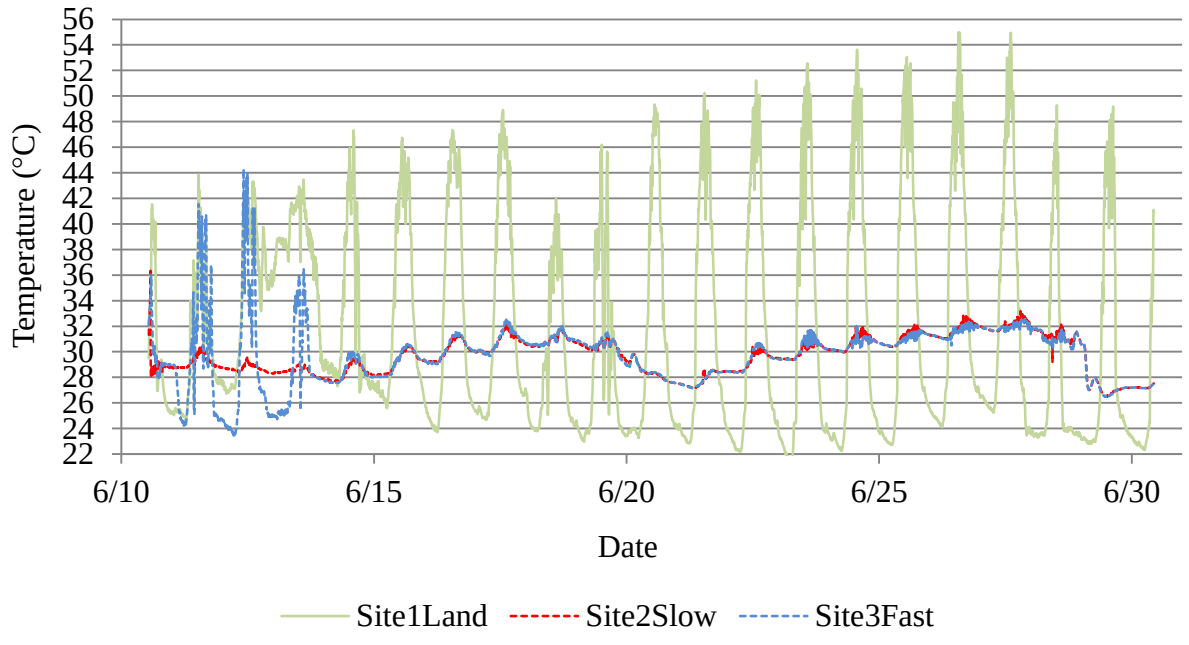


Figure 19. Temperature change over time

## Chapter 5: Discussion

The results of this research suggest that river flow rate has little effect on the rate of decomposition in this particular setting; therefore, the hypothesis that the pig in the faster section of the river would decompose more quickly due to increased water flow rate was rejected. These results are surprising. Despite controlling for many variables, such as water temperature and composition, this study shows that two sections of a river in close proximity to each other with different rates of flow did not have an effect on rates of decomposition in this environment. Although the Fast Water specimen had a tendency to be pushed against the shore and stuck on rocks, the river continued to flow past at a quicker pace than the water flowing around the Slow Water specimen. While the exact flow rate of the river was not measurable at each site, the river was consistently moving faster through the downstream-oriented flow around the Fast Water specimen than in the zone of recirculating flow around the Slow Water specimen. Even though the Slow Water specimen was slower to show maggot activity than the Fast Water specimen, the two ultimately decomposed at similar rates (Figure 20).

Because of the consistency in water temperature throughout the study at both of the aquatic sites, water temperature was inadvertently controlled. This constraint makes it clear that temperature could not have skewed the results, supporting the evidence that water flow rate has little effect on decomposition in this environment. Furthermore, because the water sites were close in proximity in the same river, other aforementioned variables such as mineral content and pH were also controlled. The possibility exists that factors such as oxygen levels, temperature, or a greater disparity in river flow rates play a stronger role in the rate of decomposition than the river flow rates at these sites. Because water flow was not found to be a factor in the rate of decomposition in this study, future research should focus on determining what other factors

might be significant in water decomposition. These factors might be a greater disparity in water velocity, water depth, or oxygen levels associated with water depth.

Figure 20. Comparison of the Slow Water Specimen, left, and the Fast Water Specimen, right, on Day 19

The Slow Water specimen was fresh on Day 1, but bloated quickly and stayed bloated for four days. The carcass did not begin to show signs of decay until Day 4. In the water, distinguishing between flotation caused by bloating or just lightness of the specimen was difficult. The line was drawn at Day 6, where bloat was considered diminished, but the specimen

continued to float for four days, sinking on Day 11. The specimen continued to actively decay for three days, slowing down on Day 15 in which it entered a more advanced state of decay marked by a lack of distinguishable body parts and ribs poking through the main mass of tissue. Decomposition slowed down for a few days, and only bones and some tissue remained in the cage on Day 19. The tissue completely separated from the bones by Day 21. This rate of decomposition was much faster than Anderson and Hobischak's (2004) specimen submerged in standing water in British Columbia. Their specimen was fresh for nine days, bloated for 26 days, actively decayed for another 63 to 70 days, and entered advanced decay for 77 to 175 days before skeletonizing around 280 days. Conversely, Farris' (2014) swamp study on decomposition in southern Louisiana was completed in under three weeks, similar to this study. Her fetal pig decayed in the swamp in 19 days.

The Fast Water specimen, also fresh on Day 1, began to decay before the Slow Water specimen. Unlike the Slow Water specimen, the Fast Water specimen entered a state of floating decay while still bloated on Day 4. The Fast Water specimen continued to be in a state of active decay, through bloating and sinking, until Day 17 when advanced decay was determined once the specimen was an indistinguishable mass of flesh. The specimen was considered skeletonized between days 21 and 22 after the remainder of the flesh separated from the bones. As with the Slow Water specimen, skeletonization occurred much sooner than Anderson and Hobischak's (2004) study. The waters of British Columbia are colder than the waters of southern Louisiana, retarding the rates of decomposition that Anderson and Hobischak (2004) observed compared to this study.

Unlike Payne and King's (1972) work on water decomposition, the water specimens in this study did not sink upon deposition in the water. Had the specimens been placed in the water

immediately after death, they may have sunk. Because the pigs became bloated on the trip from Clinton, Louisiana, to Prairieville, Louisiana, they entered rigor mortis and their state of bloat caused the carcasses to float initially; however, they sunk once bloat diminished. The results of this study corroborate previous findings that decomposition occurs at a faster rate on land than in water (Hurst 2001; Anderson and Hobischak 2004; Farris 2014).

The specimens were lifted out of the water for observation nearly every day for just over three weeks. This action may have contributed to a surprisingly quick rate of decomposition, but there was no other way to observe the stages of decomposition; the water was too turbid for terrestrial trail cameras or underwater cameras. On Day 14, there was some concern that the cages were keeping the specimens sunk, especially because the two cages sunk on different days; the Slow Water specimen on Day 11 and the Fast Water specimen on Day 14. The difference in sinking seemed to cause differences in the rate of deterioration of exposed skin, but ultimately was determined to have had little effect on the overall rate of decomposition.

The possibility exists that there may not have been enough discrepancy between the downstream oriented flow of the Fast Water pig site and the recirculating flow of the Slow Water pig site. Unfortunately, a greater disparity in river flow rates would invite a difference in aquatic organisms. Sites of recirculating flow provide a low-velocity resting place for fish and other aquatic organisms (Wohl 2014). If this study had used sites with a greater disparity in river flow rates, then distinguishing between decomposition due to river flow rate or scavenging of aquatic organisms would be difficult. Futures studies might eliminate scavengers altogether by performing a controlled laboratory test on the sheer force of water velocity and the impact it has on stripping organic material.

The decay of the Land Control specimen was not surprising. This specimen progressed through delineated stages of decomposition. The carcass was fresh for a day before and bloated for a couple of days. The specimen was in a state of active decay on Day 4 before quickly transitioning into advanced decay. The specimen continued to deteriorate more slowly in advanced decay for nine days before reaching skeletonization. This rate of decay is consistent with the first two stages of Anderson and Hobischak's (2004) findings on terrestrial decomposition. Their terrestrial pigs were fresh for one day and bloated for two to ten days. After that, the decomposition of their terrestrial specimens slowed down; skeletonization occurred 43+ days after death (Anderson and Hobischak 2004) - four weeks after the specimen in this study skeletonized. The decomposition rate of the land pig in this study is most similar to Hurst's (2001) study that took place in Louisiana; her land specimen skeletonized as early as 21 days. Table 3 compares the rates of decomposition observed in this study with the rates of decomposition observed in the other studies.

While the project is considered a success in that it tested whether pigs decomposed at a different rate in faster or slower flowing water, similar, future studies should include some minor modifications. Smaller, lighter cages might be considered in order to reduce the interference of cage weight in how much the specimens float or sink. A more remote section of river would be useful for limiting disturbance by recreational river-goers. Disturbing the specimens less would be a great advantage to future studies; however, the technology does not yet exist for clearly viewing underwater in turbid waters. Regardless, this project contributes to the current understanding of decomposition in water environments and provides a model with which further decomposition studies can be performed.

Table 3. Comparison of rates of decomposition

| Author(s), Location | Payne and King (1972), South Carolina | Anderson and Hobischak (2001), British Columbia | Hurst (2001) southeastern Louisiana | Renke (2010), southeastern Louisiana | Farris (2014), southern Louisiana | Bangs (2014), southern Louisiana | Neuman (2017), southeastern Louisiana |
|---|---|---|---|---|---|---|---|
| Subjects | Previously frozen stillborn pigs | Fresh pigs, 20-25 kg | Fresh pigs, 18 kg | Previously frozen fetal pigs | Previously frozen fetal pigs | Previously frozen feral pigs, 53-119 kg | Fresh feral pigs, 43-52 kg |
| Days to Skeletonization (Land) | | 43+ | 21-62 | | <7 | Baton Rouge: 22+<br><br>Grand Isle: 18+<br><br>Venice: scavenged before skeletonization | 14-16 |
| Days to Skeletonization (Water) | Barrels: 10-30 | Standing: 280-336<br><br>Running: 280-336 | Weighted: 37-94<br><br>Buoyed: 44-73<br><br>Dock: 72-106 | Spring: 16-24<br><br>Fall: 34+ | Swamp: <19 | Scavenged before skeletonization | Slow: 19-21<br><br>Fast: 21-22 |

## Chapter 6: Conclusion

This study began with the hypothesis that the pig placed in the faster downstream oriented section of the river would decompose more rapidly than the pig placed in the slower zone of recirculating flow due to increased water flow causing the flesh to deteriorate more quickly. Ultimately, that result was not the case for this particular environment. The Land Control specimen decomposed rapidly, skeletonizing in 14 to 16 days. The Slow Water specimen was slower to show maggot activity and entered Payne's (1965) stage of advanced decay on Day 15, earlier than the Fast Water specimen. The Slow Water specimen was considered skeletonized between Days 19 and 21. The Fast Water Specimen entered Payne's (1965) stage of advanced decay on Day 17, two days after the Slow Water specimen. This specimen was considered skeletonized between Days 21 and 22, overlapping with the Slow Water specimen. Fish were observed around both specimens throughout the study, but no other scavengers were noted.

Because the water specimens were placed in the same river in close proximity to each other, water temperature, pH, and mineral content were controlled for in this study. Onset HOBO temperature loggers were placed on each of the three cages to provide corroboration that the temperature of the water was similar for the two water specimens throughout the study.

While this study is only an introduction to the endless possibilities of water-related decomposition research, it offers some insight into what water decomposition looks like in the variously flowing waters of the Amite River in southeast Louisiana. With multiple trials performed in various geographic locations, this research can be expanded to better understand the effects of water on decomposition.

Research like this will prepare recovery divers and forensic personnel in what they can expect from water-recovery cases in certain environments. The number of boaters observed

during this study made it clear that the Amite River is a popular recreational area. In the event that someone goes missing in the Amite River, law enforcement can look to this data set for assistance. This research can not only estimate the PMI of a person that has gone missing in the Amite River, but can describe the state of remains with a known PMI.

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## Appendix A

Days of visits and corresponding dates

| | |
|---|---|
| Day 1 | 10 June, 2016 |
| Day 2 | 11 June, 2016 |
| Day 3 | 12 June, 2016 |
| Day 4 | 13 June, 2016 |
| Day 5 | 14 June, 2016 |
| Day 6 | 15 June, 2016 |
| Day 7 | 16 June, 2016 |
| Day 8 | 17 June, 2016 |
| Day 9 | 18 June, 2016 |
| Day 10 | 19 June, 2016 |
| Day 11 | 20 June, 2016 |
| Day 12 | 21 June, 2016 |
| Day 13 | 22 June, 2016 |
| Day 14 | 23 June, 2016 |
| Day 15 | 24 June, 2016 |
| Day 16 | 25 June, 2016 |
| Day 17 | 26 June, 2016 |
| Day 18 | 27 June, 2016 |
| Day 19 | 28 June, 2016 |
| Day 20 | 29 June, 2016 |
| Day 21 | 30 June, 2016 |
| Day 22 | 1 July, 2016 |

## Vita

Maddisen Paige Neuman was born in southeast Idaho to Dan and Cammie Neuman. She grew up in Soda Springs, Idaho, where she graduated from Soda Springs High School in 2010. Following her love of skeletal anatomy and osteology, she attended Oregon State University where she majored in anthropology. While at Oregon State University, Maddi interned with the Umm el-Jimal Osteological Research Collection curating human remains from Jordan. In June of 2014, Maddi proudly graduated with Cum Laude honors from Oregon State University with a Bachelor of Science in Anthropology.

Maddi began studying at Louisiana State University in 2015 where she is pursuing a Master of Arts degree in anthropology, advised by Dr. Juliet Brophy. After volunteering with the FACES Laboratory for a year and a half, Maddi accepted a graduate assistantship with the FACES Laboratory, assisting with a number of forensic cases and special projects like bioarchaeology cases and cemetery recovery. Maddi expects to complete her master's thesis on decomposition in river environments and graduate in May 2017. After graduation, she plans to pursue a career in forensic anthropology.