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Alluvial Sedimentation Associated with Logging in Low Gradient Watersheds in DeSoto National Forest, Mississippi

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ALLUVIAL SEDIMENTATION ASSOCIATED WITH LOGGING IN LOW GRADIENT WATERSHEDS IN DESOTO NATIONAL FOREST, MISSISSIPPI

by

Andrew W. Simmons

A Thesis
Submitted to the Graduate School
and the Department of Geography and Geology
of The University of Southern Mississippi
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for the Degree of Master of Science

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ABSTRACT

ALLUVIAL SEDIMENTATION ASSOCIATED WITH LOGGING IN LOW GRADIENT WATERSHEDS IN DESOTO NATIONAL FOREST, MISSISSIPPI

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Forestry and related businesses are an important factor of Mississippi's economy, contributing between $11 and $14 billion annually (Mississippi Forestry Commission, 2006). The timber industry is not only important in Mississippi but is an important sector of the economy throughout the Gulf Coast region. While providing positive economic benefits to the region, the forestry industry can also negatively affect soil properties, hillslope stability, and increase sedimentation rates in local streams and rivers. The aim of this research is to determine if forestry removal causes an increase of soil erosion and how it affects floodplain sedimentation in the low gradient watershed Whiskey Creek, located in DeSoto National Forest. Using the Revised Universal Soil Loss Equation (RUSLE) to model and predict sediment erosion, and the use of historical aerial photographs to determine exact locations of forestry removals, the RUSLE model predicted 10 times more erosion during periods of logging compared to natural conditions. Radiometrically dated sediment was used to determine the sediment accumulation rates of Whiskey Creek and was compared to a predicted sedimentation rate produced by three different land clearance scenarios using the RUSLE model. Of the three scenarios suggested, the most severe model provided the best results when compared to the measured sediment accumulation rate.

ACKNOWLEDGMENTS

Special thanks goes to my research advisor, Dr. Frank Heitmuller, and my other committee members, Dr. Omar Harvey and Dr. Carl Reese, for their advice and support throughout my project.

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LIST OF ABBREVIATIONS

ARS	Agricultural Research Service
BhD	Benndale-Smithdale Complex
BM	Bibb and Trebloc Soils
DEM	Digital Elevation Model
E	Total Storm Energy
EI	Rainstorm Parameter
GAP	Gap Analysis Program
GIS	Geographic Information System
I_{30}	30-Minute Intensity
K	Soil Erodibility
L	Slope Length
LiDaR	Light Detection and Radar
LsD	Lorman-Freest-Susquehanna Complex
MB	McLaurin and Benndale Soils
NWS	National Weather Service
R	Rainfall and Runoff
RUSLE	Revised Universal Soil Loss Equation
S	Slope Steepness
SDR	Sediment Delivery Ratio
ST	Susquehanna and Freest Soils
SWAT	Soil and Water Assessment Tool
USDA	United States Department of Agriculture

USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
WEPP	Water Erosion Prediction Project
WSS	Web Soil Survey

CHAPTER I

INTRODUCTION

The abundant pine forests of Mississippi have played a large role in the economic development of the State. The harvest of pine in Mississippi on a large scale began in the early 1800's, and pine products were being harvested for pitch pine and turpentine. The production of lumber increased as forestry removal technologies advanced such as the use of railroads and new milling techniques evolved, and allowed for more lumber to be processed. During the 1840's most mills were located at the mouth of rivers of south Mississippi to allow for the transportation of logs down major rivers of the region. Although the timber industry was strong during the 1800's, it was the introduction of railroads in the late half of the century which caused the industry to thrive. Because the railroads made the transportation of logs easier, larger sawmills became more financially viable. The timber industry peaked during the early 20th century when it ranked third in the nation in lumber production. Along with the production advantages of the railroads, logging technologies also advanced during the early 20th century, which allowed for more trees to be harvested. The technological advances brought great economic benefits but left many of the forests clear-cut and a dim forecast for the logging industry. By the 1930's, many of the sawmills within in the state were closed.

In recent times, forestry and related businesses in Mississippi have been revitalized, contributing between $11 and $14 billion annually to the State's economy (Mississippi Forestry Commission, 2006). However, forest-specific local economies are benefitting the greatest from the resurgence of Mississippi's forestry industry. For example, 62 percent of the economy in Perry County is reliant on the forestry industry

(Mississippi Tax Commission, 2012). Current logging industry economic trends forecast a continued growth in Mississippi due to the abundance of loggable forest lands within the state's six National Forest Districts.

There are six National Forest Districts in Mississippi which include; Bienville, Homochitto, Delta, Holly Springs, Tombigbee, and DeSoto (fig. 1). The DeSoto National Forest is the largest encompassing over 3,300 km^2 of forestland, which contains a large proportion of the State's longleaf pine resources (Oswalt 2011). Like many National Forests around the country, the DeSoto National Forest is subject to forestry activities such as logging. In addition to providing the many positive economic benefits associated with a thriving forestry industry, there is also the potential for negative environmental impacts. For example, unsustainable removal of trees can result in increased soil erodibility and increase sedimentation rates in local streams and rivers. Increased soil erosion and sediment accumulation due to land use changes can cause major impacts on the health of a watershed. Decreased soil productivity, hillslope failure, and increased sediment accumulation affect biological activity, reduce water quality, and cause sediment storage capacity problems.

To date, very little is known about how the extensive logging within the DeSoto National Forest has impacted key environmental changes to rivers such as sedimentation rates. This study seeks to quantify how historical and/or contemporary logging activity within the DeSoto National Forest has or may affect sedimentation in the low-gradient watersheds typical of the area. The Whiskey Creek watershed, located in southeastern Mississippi was used as an example of these low-gradient watersheds. Specifically, a variety of sedimentological techniques (including, grain size analysis, organic content, munsell color, and ^{210}Pb and ^{137}Cs analysis), spatial analysis tools, and the RUSLE model were integrated to assess how sedimentation rates within the Whiskey Creek watershed have been affected by logging activity.

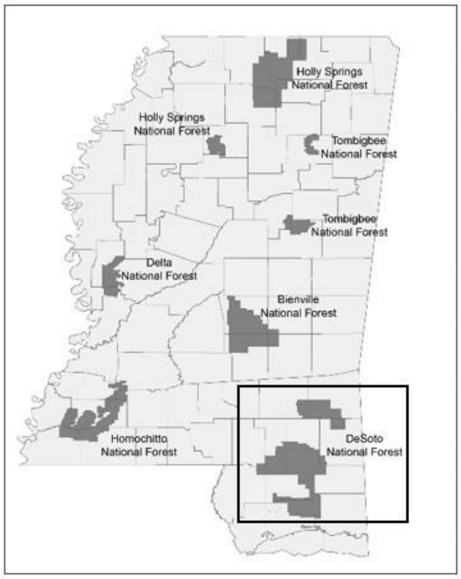


Figure 1. Location of National Forests in Mississippi.

1.1 Hypotheses and Research Questions

The hypotheses and research question are as follows:

Research Questions

R_1 – Using the Revised Universal Soil Loss Equation model under different parameters and potential sediment delivery ratios, under what spatial and temporal conditions is sediment erosion at its peak?

R_2 – How do the predicted rates of sedimentation using the Revised Universal Soil Loss Equation compare to observed rates using ^{137}Cs and ^{210}Pb to date alluvial floodplain profiles?

Hypotheses

H_1 – The Revised Universal Soil Loss Equation will predict higher annual sediment erosion when the percentage of the watershed cleared increases.

H_2 – The predicted rates of sedimentation will be lower than the observed rates obtained by dating sediment profiles using ^{137}Cs and ^{210}Pb.

CHAPTER II

LITERATURE REVIEW

2.1 Erosion

Water erosion of the soil surface is caused by raindrop impacts and surface flows, which can occur as sheet flow, or concentrated in rills (Horton 1945) and gullies (Charlton 2008). Erosion of soil is a complex process that depends on a number of physical and chemical properties of a soil, topography, vegetation, and climate. Falling raindrops possess kinetic energy and when enough energy from the falling raindrop is distributed to the soil, particles and grains of sediment can be dislodged and made available for transport (Bisal 1960, van Dijk and others 2002, Charlton 2008, Marzen and others 2015). The kinetic energy of the raindrop is dependent on the mass and velocity of the raindrop. The erosiveness of the impact of a raindrop increases as the mass and velocity of the falling raindrop increases.

Once enough precipitation has occurred in an area, water will begin to flow downhill in unconcentrated (sheetwash) and concentrated flows (rill and gully flow). These upland flow types are critical in moving sediment from upland areas of a basin to floodplains and streams (Bryan 2000). Sheet flow or sheetwash occurs as un-channelized, shallow water flowing over the land surface closely following topography. Sediment can only be directly eroded by sheetwash when the shear stress is great enough to overcome the resistance of the soil surface (Charlton 2008). Because sheetwash is typically too shallow to generate enough shear stress to erode sediment, sheetwash is most effective on steep slopes and bare ground (Morgan 2005). Raindrop splash and sheetwash are often associated together because the raindrop impact will have enough kinetic energy to dislodge soil particles and the sheetwash will be able to transport the fine sediment (Bryan 2000).

Rill erosion is a more concentrated flow regime than sheetwash and relies less on raindrop impact to erode sediment (Bryan 2000). The critical conditions by which rill erosion begins is considered in terms of critical shear stress after Horton's (1945) concept of slope erosion by overland flow. Horton's concept is based on the principle that shear stress increases with water depth, and as flow accumulates there must be a point when incision occurs (Charlton 2008, Bryan 2000). Rills are important geomorphic features in the evolution of a basin and are essential for the natural transportation of sediment downslope to streams and floodplains.

2.2 Forestry Removal and Soil Erosion

One of the primary environmental concerns of forestry removal is the potential for increased soil erosion and the deposition of the soil in nearby rivers and streams (Beschta and others 2004). Multiple factors play different roles on the amount of sediment eroded or the potential of sediment erosion following land clearance, including the type of logging, site preparation, and the overall topography of the area. There are two main types of conventional logging techniques that are presently common, ground-based and sky-based removal systems. Each system has a different effect on the potential to cause sediment erosion or damage the pre-logging soil conditions. Ground-based removal systems include skidding and cable winching which generally cause a larger disturbance than sky-based removal systems, such as helicopter and skyline yarding. (Klock 1975, Miller and Sirois 1986, Megahan and others 1995, Chase 2006). Even though the removal of lumber can cause major disturbances within the landscape, the soil may not erode if there are no rainstorms following the logging event (McIver and McNeil 2006). Even once logging has finished the site preparation for the next generation of lumber can cause major soil erosion (Slesak and others 2015). Site preparation techniques such as removal of logging slash, broadcast burning, and the control of competing vegetation can all lead to exposure of the bare mineral soil and leave it susceptible to erosion from falling raindrops (Brady and Weil 2002).

Clear cutting of a forest can also lead to soil erosion. Once a tree is cut, the root systems begin to decay reducing the shear strength of the soil mantle to the point of failure (Burroughs and Thomas 1977). This process likely has a greater effect on steeply sloped watersheds, but even in low gradient systems, reduced root density could play a major role of soil erosion. Increased soil erosion because of clear cutting practices is usually short lived. The recovery of shrubs and herbaceous vegetation is critical in reducing the increased erosion due to clear cutting.

Slash and burn practices are common among the logging industry. Once an area is logged, it is often burned to promote the growth of saplings to be logged in the future. The controlled burns in some cases can be too intense and leave a bare mineral soil, which is susceptible to erosion (Brown and Krygier 1971). When the organic material is burned from a soil, a hydrophobic layer can temporarily form and cause no infiltration and increase erosion. Another factor of slash and burn practices is once the area is logged canopy cover is dramatically decreased leaving an already erosion prone soil unprotected from raindrop erosion.

Commercial logging in southeastern Mississippi began in the 19th century and peaked in the early 20th century (Hickman 1962), but has maintained a strong presence to date. The methods and the technology of logging have greatly changed, from oxen-drawn carts and rafting to rail lines, heavy machinery, and road access. Road construction alone can provide a large sediment source that may not be eroded until many years after the initial logging took place. Beschta (1978) noted that a large increase in sedimentation in small low gradient streams due to the construction of logging roads did not occur until seven years after road construction. This could be due to a number of different factors, but reduced maintenance to logging roads after logging has been completed could lead to the failure of roads, thus providing a large sediment source to local streams.

2.3 Soil Erosion Models

Soil erosion models are used by a variety of soil conservation, water quality, and overall watershed management projects. The main two types of soil erosion models are either process or empirical based. Selecting the appropriate model for a particular study depends on the size of the study area, available background information, and the objective outcomes of the study. The following section briefly describes the most popular of available soil-loss/erosion models.

A soil erosion model developed by the United States Department of Agriculture (USDA), the Water Erosion Prediction Project (WEPP) was initiated in 1985 (Nearing and others 1989). The WEPP model is process based, considering the effects of physical processes of infiltration, surface runoff, plant growth, residue decomposition, hydraulics, tillage, management, soil consolidation, and erosion mechanics (Nearing and others 1989). The WEPP model is suitable for modeling soil erosion from hillslope profiles (1 to 200 m in length) or small watersheds (up to 260 ha) (Flanagan et al. 2013). The WEPP model was designed for small agricultural watersheds where the sediment yield is influenced by hillslope and channel processes, and is applicable up to a maximum area of 2.6 km^2 (Foster and others 1987).

Another soil erosion model is the Soil and Water Assessment Tool (SWAT). The SWAT model has been developed through the continuation of a number of different projects of the USDA Agricultural Research Service (ARS) (Gassman and others 2007). Unlike WEPP, SWAT is an empirical, basin-scale, continuous-time model designed to predict the impact of management of water, sediment, and agricultural chemical yields (Gassman and others 2007). Some of the factors included in the SWAT model are weather, hydrology, soil temperature, plant growth, nutrients, pesticides, land management, and bacteria and pathogens (Gassman and others 2007). The SWAT model has been used in a variety of different sized watersheds ranging from smaller than a square kilometer up to the Mississippi River watershed.

Arguably, the most widely accepted and used model is the Universal Soil Loss Equation (USLE). The USLE method provides the user a step-by-step process to calculate soil erosion caused by raindrop impact and surface run off for an area of interest and was first developed by Wischmeirer and Smith (1965, 1978). USLE predicts soil erosion by the product of six factors; rainfall and runoff erosiveness, slope steepness, slope length, soil erodibility, land cover, and land management practices. The six factors allow the user to tailor the equation to fit the region or environment that is specific to their study. As technology has progressed and new research has been complied on the six factors of USLE, the equation has been updated to the Revised Universal Soil Loss Equation (RUSLE).

The RUSLE is similar to USLE that it also includes six factors but the factors can now be better quantified through the use of multipliers and multiple step procedures to calculate unique factors for specific study areas. Both the USLE and RUSLE use the same equation to compute the average annual erosion expected as:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Where:

A = computed spatial average soil loss and temporal average soil loss per unit area, expressed in the units selected for K and for the period selected for R. In practice, these are usually selected so that A is expressed in ton $\cdot$ acre^{-1} $\cdot$ yr^{-1}, but other units can be selected.

R = rainfall-runoff erosivity factor – the rainfall erosion index plus a factor for any significant runoff from snowmelt.

K = soil erodibility factor – the soil-loss rate per erosion index unit for a specified soil as measured on a standard plot, which is defined as a 72.6-ft (22.1-m) length of uniform 9% slope in continuous clean-tilled fallow.

L = slope length factor – the ratio of soil loss from the field slope length to soil loss from a 72.6-ft length under identical conditions.

S = slope steepness factor – the ratio of soil loss from the field slope gradient to soil loss from a 9% slope under otherwise identical conditions

C = cover-management factor – the ratio of soil loss from an area with specified cover and management to soil loss from an identical area in tilled continuous fallow.

P = support practice factor – the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to soil loss with straight-row farming up and down the slope.

(Equation and description of factors from the Agriculture Handbook Number 703 issued 1997 page 15.)

2.4 Sediment Delivery Ratio

Gross erosion is the sum of erosion throughout the watershed including sheet, rill and gully, streambank, mass wasting, construction sites, and roads. Sediment yield is the quantity of sediment that is delivered to a specific location within that basin or the outlet of the basin. Sediment delivery ratio (SDR) is defined as the sediment yield from a basin divided by the gross erosion of the same basin. The SDR represents the efficiency of the basin in moving sediment from areas of erosion to the point where the sediment yield is being measured. The SDR by definition describes factors throughout the basin in which sediment can be stored for periods of time without leaving the basin. It is important to note that not every sediment particle that is removed from the land surface will reach the outlet of the basin. Examples of areas where sediment could be stored include floodplains, depressions, ponds, and even hillsides.

The SDR is usually presented as a percentage and in most cases is lower than 100%. It is possible however to have a SDR higher than 100% for specific storms or a particular year through remobilization of stored sediment (Walling 1983). In his study of Coon Creek, Wisconsin, Trimble (1983, 1999), found that during periods of severe erosion due to of changing land use practices only a small percentage of sediment was being transported out of the watershed and the rest was deposited in the valleys. Once land use practices changed and severe erosion decreased, the sediment yields for Coon Creek did not decrease and the sediment within the valleys had been remobilized and was transported out of the basin. Trimble's findings (1983, 1999) illustrate the difficulty in predicting an accurate sediment delivery ratio.

Sediment yield and the SDR are difficult values to accurately acquire without extensive monitoring of the basin. A number of empirical equations and models have been derived to estimate the SDR based on basin characteristics (Maner 1958, Roehl 1962, Williams and Berndt 1972, Mutchler and Bowie 1975, Walling 1983). Curves expressing the relationship between the sediment yield and the catchment area of a basin have also been produced for specific regions throughout the world (Fig. 2). Sediment yields for larger river systems have a lower sediment yield than would be expected due to higher sediment storage capacities than smaller systems (Milliman and Meade 1983). Choosing a SDR is an important factor when modeling sediment erosion and deposition within a watershed. The sediment delivery ratio will essentially predict the amount of sediment that is being deposited within the watershed and not transported out of the system.

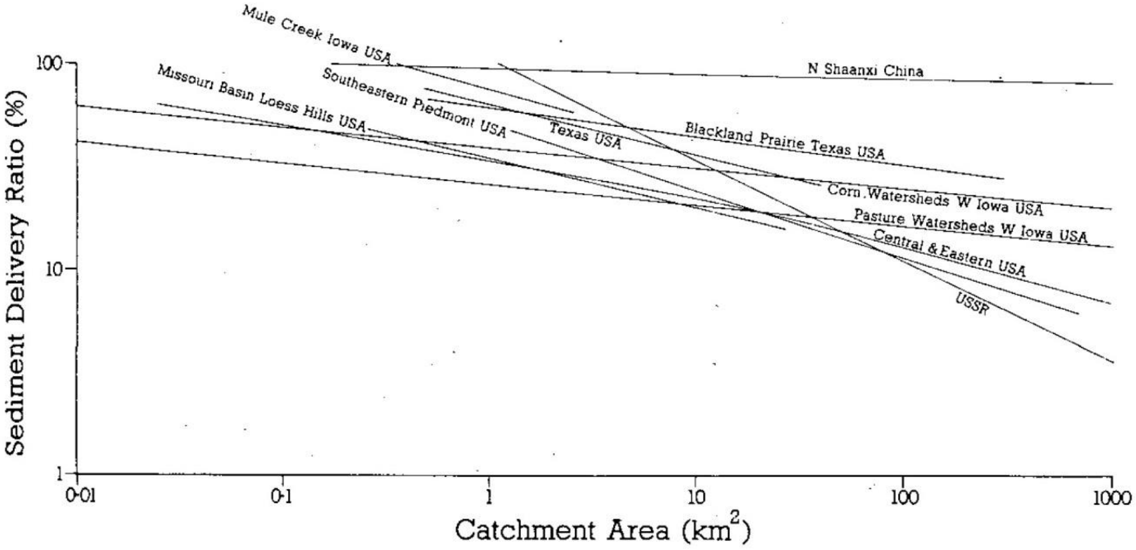


Figure 2. Sediment delivery ratios derived for several locales around the world. Figure from Walling (1983).

Mutchler and Bowie (1975) proposed a sediment delivery ratio equation for the area of Pigeon Roost Creek, Mississippi. This is an ideal equation to apply to the Whiskey Creek watershed since it is in a similar geographical and geological setting. The equation is expressed as:

$$DR = 0.488 - 0.006A + 0.010RO$$

Where DR equals the sediment delivery ratio, A equals the area of the basin in hectares, and RO represents the annual runoff in centimeters. Runoff value for Whiskey Creek is taken from the World Map Annual Runoff data from Fetke and others (2000). The Mutchler and Bowie (1975) equation predicts a sediment delivery ratio of 20%. Several SDR equations were applied and most estimate the SDR between 10 and 20 percent. Based on the USDA (1979) equation and the relationship between drainage area and SDR, Whiskey Creek is predicted to have a SDR of 18 percent.

2.5 Floodplain Sedimentation

Floodplains have allowed researchers to discover histories of rivers and watersheds throughout the 20th century including Fisk (1944), Trimble (1983), Saucier (1994), and Fitzpatrick and Knox (2000). Several arguments have been made on the topic of floodplain formation and evolution. Floodplains offer the ability to research a stream's history on both a geologic and an historic time scale. A geologic time scale includes events that have taken millions and minimally thousands of years to occur. An historic time scale most often refers to events in North America that have taken place since the major settlement of Europeans.

A variety of methods have been used to investigate changes in floodplain sedimentation in changing watersheds both by physical and chemical characteristics. Because floodplains are constructed by transported sediment, one of the most important characteristics of a floodplain is the grain size distribution. Changes in grain size throughout a soil profile can provide significant information on the depositional sedimentary environment. A variable grain size versus depth in the floodplain can represent many different factors in an evolving channel. Some possible changes are the lateral proximity to the channel, relative elevation of the channel bed and the floodplain surface, stream discharge, and sediment available for delivery (Walling et al 1997).

Wolman and Leopold (1957) argued that floodplains are constructed from lateral accretion, but more recent studies suggest that floodplains are constructed primarily from overbank deposition of fine grained material during flooding (Lewin 1978, Nanson and Young 1981, Magillgan 1992, Lecce 1997). Deposition of sediment on the floodplain can occur by different processes. During high flow events, flow within the main channel is faster and deeper than the floodplain, and capable of transporting higher concentrations of sediment (Pizzuto 1987). The velocity of flow across the floodplain decreases with distance from the channel, and as the flow becomes overloaded with sediment deposition occurs. This causes decreases in grain size and sediment thickness as the distance from the channel increases (Pizzuto 1987, Hudson and Heitmuller 2003).

Through published studies and model trials it has been well established that a fining upward sequence in overbank floodplain deposits is typical of a stable system (Wolman and Leopold 1957). However, in systems that have had major land use changes and other human induced interactions coarsening upward sequences are likely. Changes in grain size distributions from pre-settlement and post-settlement alluvium have been well documented (Knox 1987, Magilligan 1992). Changes in land use and cover can cause increased surface runoff, producing larger floods capable of transporting and eventually depositing larger grained material (Florsheim and Mount, 2003; Leece and Pavlowsky 2004).

CHAPTER III

DESCRIPTION OF STUDY AREA

Whiskey Creek watershed is 144 km^2, located 40 km southeast of Hattiesburg and part of the larger Pascagoula River Basin. With a stream gradient of 0.0020 the watershed is classified as a low order, low gradient stream system. The lack of major dam or diversion structures within the watershed makes it an ideal study location for sediment transport and accumulation.

3.1 Hydroclimatology

Currently, there are no gauging stations located within Whiskey Creek watershed, and data have been compiled from streams in the area that are similar in size and logging history. Cypress Creek, a stream also located within DeSoto National Forest, is being monitored by the United States Geological Survey (USGS). The monthly average flow data for this stream has been collected since 1965 and shows peak average flows during the months December to April, with the lower flows occurring during the summer months, May through November (Fig. 3). Black Creek, a larger stream in the DeSoto National Forest, also shows the highest monthly flows during December to April with the lowest flows occurring May through November (Fig. 3).

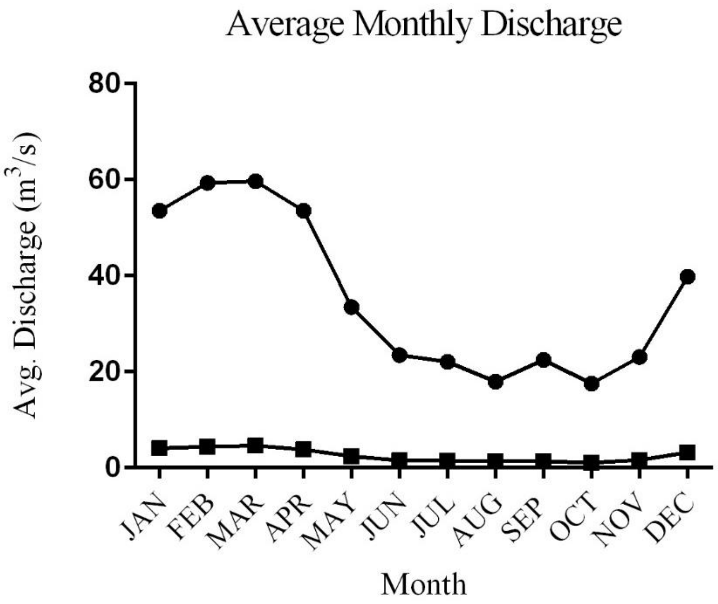


Figure 3. Mean monthly stream discharge for Black Creek, near Wiggins, MS USGS Stream gauge #02479160 (circle). Also average monthly discharge for Cypress Creek, near Janice, MS. USGS stream gauge #02479155 (square). (waterdata.usgs.gov/nwis/rt)

Precipitation data for southeastern Mississippi were compiled from the National Weather Service (NWS). Average monthly totals show the top three highest precipitation months on average are March, July, and February, respectively (Figure 4). It is interesting to note that the highest stream flow months and precipitation months are not the same. Possible reasons for this could be higher evapotranspiration rates and more dense vegetation during the summer months help minimize run-off. A climatological aspect of southeastern Mississippi that cannot be overlooked is the occurrence of tropical storms and hurricanes. Tropical storms can occur throughout the year but are most likely during June through November. Tropical storms have a large impact on average rainfall totals, the absence of a tropical storm during the year can dramatically reduce the amount of precipitation the region will receive.

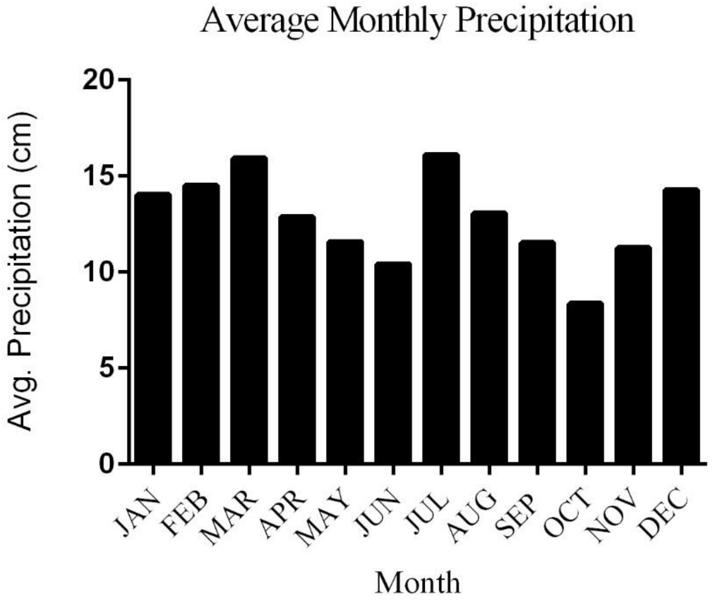


Figure 4. Average monthly rainfall totals recorded 1958 to 1987 at Richton, Mississippi. Perry County Soil Survey (2000)

3.2 Surface Geology

The Whiskey Creek watershed has developed mainly within the Hattiesburg and Citronelle Formations. The Hattiesburg Formation (Miocene) largely constitutes the substrate under the hills and beneath large portions of valley floors in southern Mississippi. The Hattiesburg Formation is described as a light bluish gray to medium olive, silty to clayey, marine deposit (Daniels and others 2000). The Citronelle Formation (Late Miocene to Mid Pliocene) consists of poorly indurated sands and gravels that lie upon the irregular, hilly surfaces developed on the Hattiesburg Formation (Daniels and others 2000). The Citronelle Formation was deposited by numerous migrating streams extending across the Gulf Coastal Plain. The Citronelle Formation is highly oxidized and is easily recognizable by its shades of red, orange, and yellow (Daniels and others 2000).

Soil type and distribution throughout a watershed is an important aspect of modeling sediment erosion within a watershed. Major soil formations within the watershed include the Lorman-Freest-Susquehanna complex, Bibb and Trebloc soils, McLaurin and Benndale soils, Susquehanna and Freest soils, and the Benndale-Smithdale complex. These soil complexes cover nearly 60 percent of the watershed and are directly affected by logging activities within the watershed.

The Lorman-Freest-Susquehanna complex (LsD) is the most widely distributed soil type within the watershed covering 22 percent. The LsD complex is described as a fine sandy loam in the upper soil profile and high clay percentages in the lower profiles, derived from clayey and loamy alluvium (U.S. Department of Agriculture NRCS, 2000). The LsD is also described as moderately well drained but susceptible to high runoff which makes it prone to erosion indicated by the K-factor value of 0.32 (U.S. Department of Agriculture NRCS, 2000).

The Bibb and Trebloc soils (BM) cover 10 percent of the watershed. The BM soils are described as a silt loam in the upper profile and a sandy loam in the lower profile and are associated with floodplains in the watershed that are frequently flooded U.S. Department of Agriculture NRCS, 2000). The BM soils are suitable for logging activities because of the low sloped areas where it is located but have k-factor value of 0.43 (U.S. Department of Agriculture NRCS, 2000).

The McLaurin and Benndale soils (MB) cover roughly 9 percent of the watershed and are described as loamy sand in the upper profile and sandy loam in the lower profile. The MB soils are found in the uplands of the watershed and are derived from loamy fluviomarine deposits. The MB soils are suitable to logging activities and have a k-factor value of 0.20 (U.S. Department of Agriculture NRCS, 2000).

The Susquehanna and Freest soils (ST) are another major soil type of the watershed covering 10 percent. The ST soils are described as a fine sandy loam in the upper profile and a clay in the lower profile and are also found in the upland areas of the watershed (U.S. Department of Agriculture NRCS, 2000). The ST soils are classified as a well suited soil type for forestry harvest but are susceptible to runoff and have a k-factor of 0.37 (U.S. Department of Agriculture NRCS, 2000).

The Benndale-Smithdale complex (BhD) covers 9 percent of the watershed and is located in the upland areas. The BhD complex is described as a fine sandy loam in the upper profile and a loam in the lower profile, and is derived from sandy loam alluvium deposits. Because it is found in the upland areas, it has potential for severe erosion due to runoff but has an average k-factor of 0.28 (U.S. Department of Agriculture NRCS, 2000).

3.3 Land Use and Cover

Another important physiological attribute of Whiskey Creek is the knowledge of the type of land cover and use within the watershed. Data from the USGS Gap Analysis Program (GAP) was used to determine the main land cover types within the watershed. Similar land use classes were merged to better quantify the overall land cover within the watershed. Pine forest dominates the land cover of the watershed, followed by floodplain forest, which is defined by the dominate tree species within the classes (Figure 5, Table 1). Agriculture only contributed a small percentage of land use for the watershed along with residential, roads, and water. The low row crop agricultural presence and low residential population within the watershed highlight the presence of the logging industry activities in the watershed.

Table 1

Percentages of land cover in Whiskey Creek watershed

Cover Type	Area (km^2)	Percentage
Forest	86.42	79.49
Floodplain Forest	19.09	17.56
Agriculture	1.02	0.94
Roads	1.91	1.75
Water	0.28	0.26

Note. Percentages of land cover were calculated using the GAP land analysis and ArcGIS version 10. Whiskey Creek watershed is highly forested with a low agricultural presence.

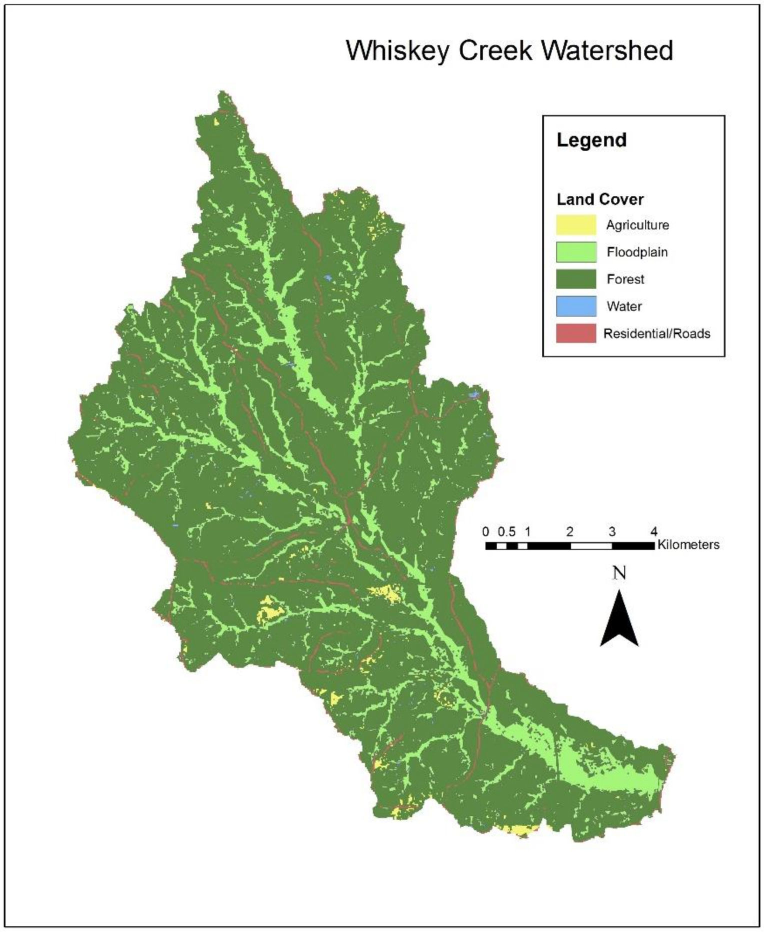


Figure 5. Map of the land cover types obtained for Whiskey Creek from the GAP Land Analysis 2006. High percentages of the watershed are classified and pine and floodplain forests.

CHAPTER IV

METHODS

4.1 RUSLE Model Factor Selection

The rainfall and runoff factor (R) quantifies the effect of raindrop impact and the amount and rate of runoff likely to occur with the rain. The R factor was first derived by Wischmeier (1959) and Wischmeier and Smith (1958) from research and data compiled from a number of different sources. The R factor is based on concept when all other RUSLE variables are held constant, soil losses are directly proportional to the rainstorm parameter (EI). The rainstorm parameter is the total storm energy (E) multiplied by the maximum 30-minute intensity (I_{30}) of the rainstorm (Agriculture Handbook Number 703). The EI parameter takes into account not only the total rainfall of a storm but also the intensity which is the maximum 30-minute intensity. The EI parameter improves on quantifying a storm's energy because a long, slow rain storm may produce the same amount of rainfall as a short, intense rainstorm that is more likely to detach soil by raindrop erosion. The R factor is defined as the average values of EI over a given period (Agriculture Handbook Number 703).

Isoerodent maps of the United States describing the R factor were created first by Wischmeier and Smith (1965) and updated as published weather data has been released. The isoerodent maps provide a quick and easy method of describing a study area's R factor. Modifiers can be applied to an R factor to fit the needs of the user in cases of mountainous terrain, flat slopes, and for locations where snowfall is a major form of precipitation. The R factor for Whiskey Creek was determined by using an isoerodent map developed for the United States (Figure 6). The relatively small size and low slope of the watershed meant that a single R factor could be used. A value of 575 was chosen.

Figure 6. Isoerodent map developed for the eastern United States. Units are hundreds ft · tons · in (ac·h·yr)$^{-1}$ (RUSLE Handbook)

The soil erodibility factor (K) is related to the effect of rainfall, runoff, and infiltration on soil loss. The K factor is determined by the physical, chemical, and mineralogical properties of a soil and how those properties interact with each other. Soils are widely varied and constantly changing from region to region which makes the K factor a difficult parameter to quantify. A number of studies have been produced to quantify the K factor and the most frequently used relationship is the soil-erodibility nomograph (Wischmeier and others 1971).

K factors for this study were compiled from published county soil surveys for the Whiskey Creek watershed which spans three different counties: Perry, George, and Greene. The soil shapefiles were downloaded from the Web Soil Survey (WSS). Once imported into ArcGIS v. 10.1, a new field was added for the K factor and the appropriate value was assigned to each soil class. The shapefile was converted into a raster using the Shapefile to Raster conversion tool (Figure 7).

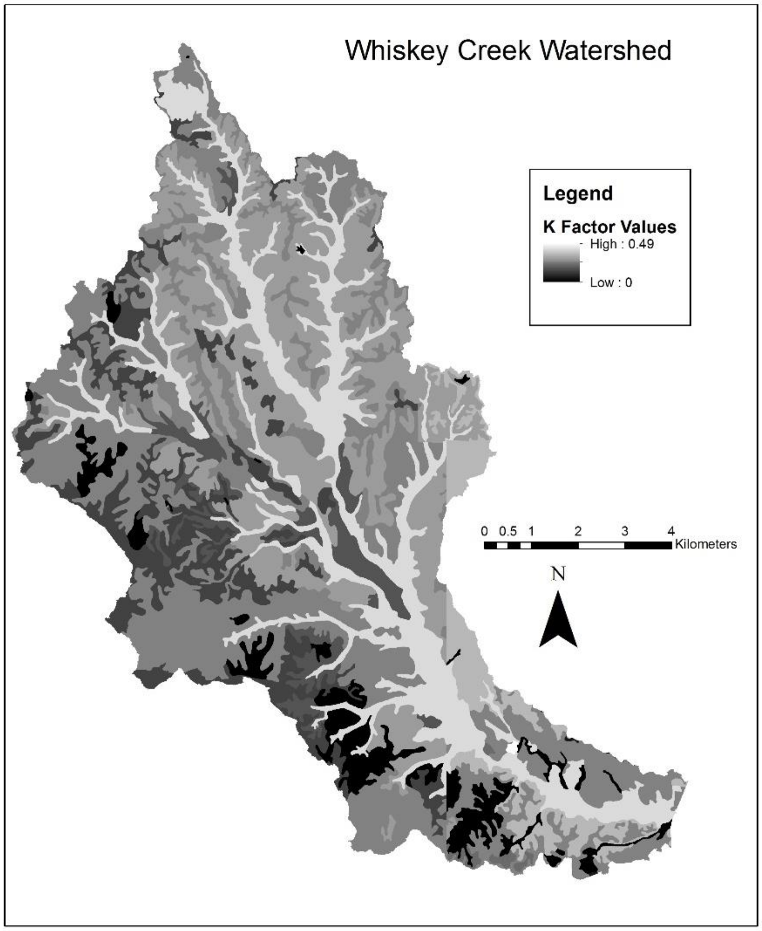


Figure 7. Map of K-factor value distribution throughout Whiskey Creek watershed.

RUSLE factors L and S are oftentimes associated with each other because of the similar nature of the factors. Slope length is represented by the L factor and, as the slope length increases so does erosion. Slope length is described as the horizontal distance from the origin of overland flow to the point where either the slope gradient decreases enough that deposition occurs or the runoff becomes concentrated into a defined channel (Wischmeier and Smith 1978). Slope steepness (S factor) describes the influence of slope gradient on erosion with steeper slopes yielding more erosion. The LS factor can be calculated a numerous ways and is much simpler if considering one specific hillside. In the case of this research the LS factor needed to be calculated for the entire watershed. The LS factor for this research was calculated by using ArcGIS and a digital elevation model (DEM) of Whiskey Creek.

The digital elevation model of Whiskey Creek watershed (Figure 8) was completed by using light detection and radar data (LiDaR). The LiDaR data were collected for Camp Shelby, MS, for the purposes of better defining flood prone areas near the base. The data were collected spring 2006 at an average spacing of 3 meters. The bare earth data set for the Whiskey Creek watershed was downloaded and processed in ArcGIS to create the base map for the LS factor calculations.

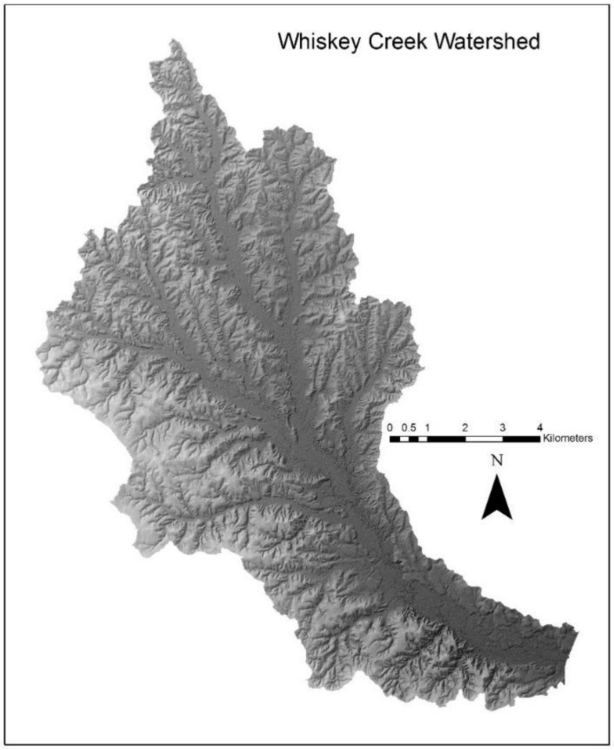


Figure 8. Whiskey Creek digital elevation model (DEM) with average spacing of 3 meters. The hillshade raster created from DEM is overlain expressing a three dimensional view of the topography of the watershed.

The flow direction of the watershed was calculated using the flow direction tool which determines the direction of flow from every cell in the raster. Next, the raster created from the flow direction was used to calculate the flow accumulation. The flow accumulation tool weights each raster cell and how many upstream cells would flow into a specific tool. Then the overall slope of the watershed was calculated using the DEM of Whiskey Creek. Finally the LS factor (Figure 9) was calculated using the raster calculator, the DEM, flow accumulation, and slope rasters.

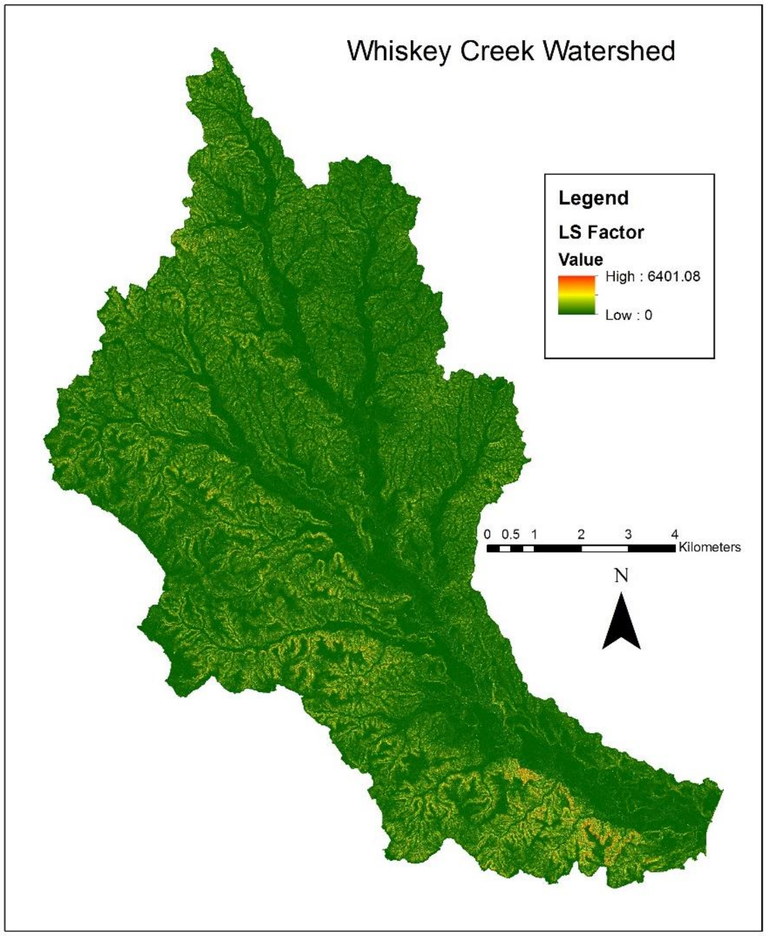


Figure 9. LS factor calcuations for Whiskey Creek watershed. Calculated using ArcGIS Version 10.1 and LiDaR data.

The C factor is the numerical description of the land cover and management practices. The C factor incorporates the impacts of previous land management, the protection of the soil surface provided by canopy, and how well the soil is protected by vegetation litter. Whiskey Creek watershed includes a limited number of different land cover types, most of which are forested. The dominant land cover is pine forests and floodplain forests with a minimal agricultural presence. For the purposes of the RUSLE model the forested land covers will be valued the same with the pine forests having sections of land being logged. Once an area is logged its C factor value will increase and decrease over time until the forests have completely regrown and the value is returned to its original value.

The locations of logged areas within the watershed were determined by using historical aerial photographs from various sources including GoogleEarth and USGS EarthExplorer. Images that were not already georeferenced were imported to ArcGIS so the images could be referenced and imported back to GoogleEarth for further analysis. Images used were dated from 1979 to 2013. The images were overlaid and areas where forest disturbances occurred were outlined so a shapefile could be created to import into the Whiskey Creek land cover raster. After analysis was completed it was estimated that since 1979, 25 percent of the watershed had been logged. Knowing the exact locations of logged areas is crucial in predicting an accurate soil production model since the other factors within the RUSLE equation are geographically dependent.

The final factor for RUSLE is the P factor, which represents support practices to minimize soil loss due to land management practices. The P factor is a product of individual sub-factors which include contouring, stripcropping, and the use of terraces.

The use of best management practices within Whiskey Creek watershed are minimal and the value inserted for P factor will be 1.

Several sediment cores were collected within the floodplains of Whiskey Creek watershed for sedimentological analysis. Coring locations along Whiskey Creek were chosen for their proximity to the stream, evidence of recent flooding such as sediment covered vegetation and high water marks, and clear from large trees for possible disturbance from large root systems. Cores were collected in 5 to 10 cm increments using a soil auger, bagged, and noted for any significant sedimentary features.

4.2 Floodplain Sediment

Grain size analyses were performed on the collected floodplain soils to determine grain size characteristics of the floodplain sediment in Whiskey Creek watershed. A number of different methods were used to determine the grain size including; hydrometer analysis method, sieve method, and laser diffraction. Samples that were analyzed using the hydrometer and sieve methods were air dried to a constant weight, ground using a mortar and pestle, and treated with a 5% sodium hexametaphosphate solution. Sediment samples were then mixed with a stand mixer for 5 minutes before the hydrometer test was begun. Samples were measured in pre-determined time intervals beginning at 40 seconds after initiation of the test and followed by 1, 1.5, 3, and 5 minutes, increasing until the end of the test at 4,320 minutes. Measurements at determined time intervals were used to determine multiple grain sizes for the silt and clay fractions of the sediment. The sand size fraction of the sediment was determined using a sieve method using sieves ranging from 2 to 0.065 mm.

Magnetic susceptibility is a measure of a sediment's magnetic mineral content which is dependent on concentrations of magnetite and other magnetic minerals (Mullins 1977). The concentration of magnetic minerals is dependent on the parent material and pedogenic processes which can either increase or decrease a soil's magnetic susceptibility. Nearly all naturally occurring minerals have some degree of magnetism, but ferrimagnetism is the most important among minerals in floodplain soils (Dearing and others 1985). Magnetic susceptibility is a tool that has long been used by geologists to fingerprint origin of sediment within a large basin, but can also help distinguish aggrading floodplain surfaces and buried soil horizons. Measuring magnetic susceptibility versus depth in the floodplain profile provides the opportunity to identify possible changes in the type of sediment delivered to the floodplains. Soil horizons with higher magnetic susceptibility are likely to be from material that has been exposed on the surface for a period of time and then eroded from the surface and deposited within the floodplains. A number of studies have also shown that magnetic particles are often associated with the coarser grain fraction of sediment due to the high specific gravity of magnetic minerals (Waythomas 1991). This implies that higher energy events will be able to transport and deposit the magnetic material derived from upland sources and magnetic horizons may possibly indicate depositional events during times of increased land cover changes within the watershed. Magnetic susceptibility of sediment samples were measured using a Bartington MS2B Dual Frequency Sensor and MS3 Magnetic Susceptibility meter.

The radionuclide isotope ^{137}Cs is a very useful isotope to help monitor sediment erosion and date sediment accumulation rates in the last 100 years. There are no natural sources of ^{137}Cs and is only produced from nuclear fission. The deposition of ^{137}Cs in the environment is only due to nuclear testing and releases from nuclear reactors (Wise, 1980; Walling and others, 1986). ^{137}Cs was not introduced into the environment until 1945, which was limited, and there was not global distribution of ^{137}Cs until 1952 due to thermonuclear tests (Carter and Moghissi 1977; Perkins and Thomas 1980). The ^{137}Cs that is distributed from nuclear testing is released into the stratosphere and circulates the globe until deposited on the land surface due to precipitation (Longmore 1982; Davis 1963). Peak nuclear testing in the northern hemisphere took place in 1962, correlating the largest ^{137}Cs spikes in accumulation profiles. ^{137}Cs strongly absorbs to clay and organic particles and is relatively nonexchangeable making it an ideal isotope for sediment accumulation analysis (Brisbin and others 1974). Although ^{137}Cs analysis is an ideal method for sediment dating in fine grained environments, Detriche and others (2009) related ^{137}Cs accumulation to grain size providing different curves for interpretation.

The natural radionuclide ^{210}Pb is a part of the ^{238}U radioactive chain and has a half-life of 22.23 ± 0.12 years (DDEP 2010). ^{210}Pb has been used in a number of studies dating and calculating accumulation rates in lacustrine, marine, estuarine, and alluvial environments. Unlike ^{137}Cs, which is a manmade and introduced radionuclide ^{210}Pb is a natural geogenic and excess atmospheric fallout of ^{210}Pb occurs nearly every year (Du and Walling 2012). Also, unlike ^{137}Cs dating methods rely on a peak of ^{137}Cs down core, ^{210}Pb sees a reduction in radioactive activity down core as the sediments age (Du and Walling 2012). Different sedimentation rates will affect the ^{210}Pb curve down core, rapid sedimentation will have a slow decease in ^{210}Pb activity, whereas a slow sedimentation rate will have the ^{210}Pb activity decrease more quickly (Du and Walling 2012).

Because ^{210}Pb concentrations decrease with depth which is caused by the natural radioactive decay, deeper levels in a core correspond to earlier dates. When ^{210}Pb concentrations are measured and plotted against depth, a line can be fitted to the ^{210}Pb profile and a sedimentation rate can be calculated. A variety of models have been developed to determine sediment accumulation rates using the radionuclide 210Pb depending on the type of depositional environment in the study. Most models were developed for the use in lacustrine sediments such as the; Constant Flux: Constant Sedimentation (CFCS) (Robbins 1978), the Constant Initial Concentration (CIC) (Appleby and Oldfield 1978) and the Constant Rate of Supply (CRS) models (Goldberg 1963, Krishnaswamy et al., 1971).

4.3 Model Trials

Several model trials were performed to estimate the sediment production within Whiskey Creek watershed. The first model performed was to estimate the differences between active logging and no logging activities within the watershed between 1979 and present. Sites of active logging were described as the areas chosen through the analysis of historical and current aerial photographs. The first run of the model was to estimate the sediment production assuming no logging was taking place during that year since the RUSLE model predicts sediment production on a yearly average. Because the purpose of the model is to estimate sediment production values based on a changing land cover and management practices, the only value that will change will be the C factor throughout the different runs of the model. The changing C factors were estimated using previously cited literature. The second run of the first model was to estimate the sediment production during active logging within the watershed. The C factor for areas that have undergone logging were chosen using the National Engineering Handbook Section 4 - Sedimentation. The model was performed under the assumption that all areas that have been logged since 1979, were logged at the same time to get a better overall understanding of the differences between active and non-active logging within the watershed. The first model provides the insight that the changing C factor does significantly alter the sediment production within the watershed during times of logging.

Although the first model provides useful estimates on background average soil loss per year, it does not accurately represent an actively logged watershed. Once an area of land is logged it will take several years for vegetation and erosion to return closer to pre-logging levels. The second model takes into account the regrowth period of logged areas on an eight year cycle. The first year C factor selected is based on the type of site preparation, mulch cover, and if the soil is covered by live vegetation. The year two C factor is calculated by taking the year one C factor multiplied by 0.7 to represent the regrowth of vegetation. Years three through five are calculated similarly, multiplying the year previous C factor by 0.7. The C factor for years six through eight are selected based on the canopy height of regrowth vegetation, percent coverage of the vegetation, and what type of litter is on the soil surface. After year eight the C factor will return to the background value to represent the logged area in the regrowth stage (appendix 2).

Three different trials of the second model were performed to estimate variances in different site preparations, canopy heights, and mulch cover. The three trials model different severities of logging events taking place in the watershed. The trials will be noted as severe, moderate, and minor. The model is performed over a 35 year period to better understand the sediment produced since 1979. The sediment produced over the trial period is converted to a volume using bulk density estimates obtained from the Perry County Soil Survey (2002), and compared to the estimated floodplain volume available within the watershed.

CHAPTER V

RESULTS

5.1 Estimated Sedimentation as Predicted by RUSLE

The RUSLE model predicts potential soil loss per year (A) by multiplying six factors including; rainfall erosivity (R), slope length (L), slope steepness (S), soil erodibility (K), land cover and management (C), and land support practice (P). The first model ran was to describe the potential soil loss per year of Whiskey Creek watershed during a period of no logging or a natural background rate. All forested areas within the watershed for this trial were given a C factor value of 0.003 to simulate undisturbed forested areas. The raster calculator in ArcGIS was used to multiply all the RUSLE appropriate rasters to create an output raster estimating soil loss per year for the watershed (Figure 10). The results of the first model indicate that the average rate of soil loss per year equals 2.69 t/ac/yr.

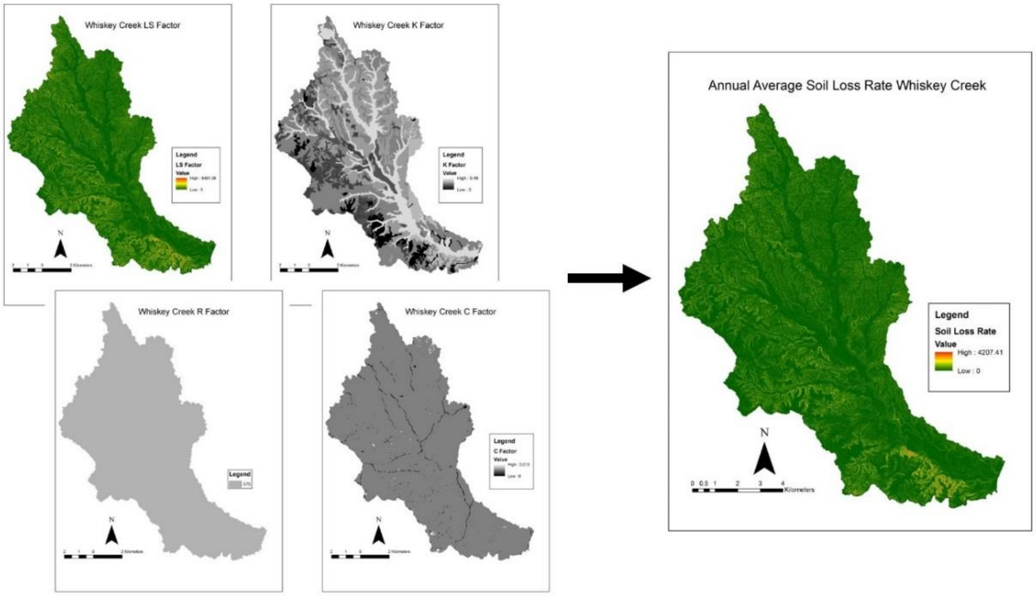


Figure 10. RUSLE rasters multiplied to calculate the average soil loss rate for Whiskey Creek during a period of no logging.

The next model trial was to test whether the RUSLE model for Whiskey Creek can detect when areas of the watershed are being logged. Logged areas are assigned a C factor value 0.031 and other forested areas have a C factor value of 0.003. The results from the model trial highlight the areas where logging has occurred and the model predicts an overall soil loss rate of 23.59 t/ac/yr (Figure 11).

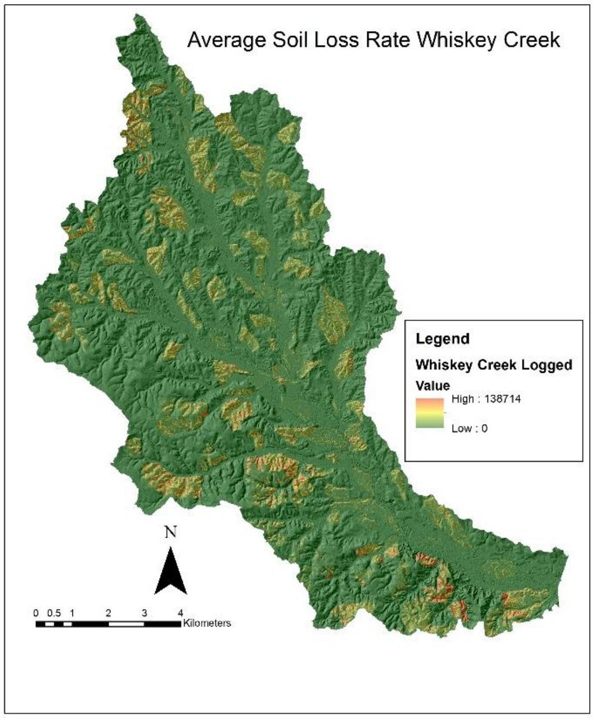


Figure 11. RUSLE model trial of Whiskey Creek highlighting the logged areas of the watershed for an overall soil loss rate of 23.59 t/ac/yr.

The first model trials were to test if the RUSLE model would detect logging events within the watershed, which the results clearly confirm. During the trial simulating a logging event the predicted soil loss rate is significantly higher than a period of no erosion. Although these model trials do not provide a very realistic long term look view of the watershed and the logging history, they still provide useful information and where sediment erosion is likely to occur given a change of land management.

The next model trials were performed on a 35 year period and include the different severities of logging. The trials include 35 years and simulate a logging event, the C factor is high once the area is cut, and gradually declines over an eight year period back to the background rate (Table 2). The results of the model trials include the average soil loss rate for logged areas and the average soil loss rate for the rest of the unchanging watershed to provide more detailed information about how logging affects the soil erosion rate.

Table 2

C factor values for three trials of RUSLE model

Year	Severe	Moderate	Minor
1	0.400	0.310	0.190
2	0.280	0.217	0.133
3	0.196	0.152	0.093
4	0.137	0.106	0.065
5	0.096	0.074	0.045
6	0.040	0.012	0.012
7	0.040	0.012	0.012
8	0.040	0.012	0.012
9	0.040	0.012	0.012
10-35	0.003	0.003	0.003

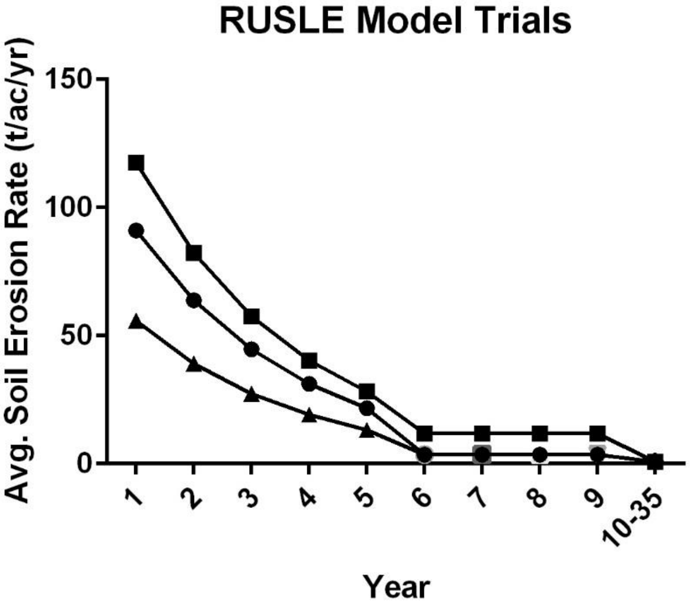


Figure 12. The RUSLE model trials for a severe (square), moderate (circle), and conservative (triangle) estimates of a changing C factor for logging activities within Whiskey Creek watershed.

Once the model trials were completed the results of the average soil erosion rate were converted into a volume using an average bulk density for floodplain soil types of Whiskey Creek. The purposes of converting the erosion rates to volumes of sediment is to compare radiometrically dated sediment within the watershed floodplains and if the depositional rates can be modeled through the RUSLE model. The floodplain was chosen through the FEMA project to delineate floodplains in south Mississippi and was associated with the project that collected the LiDaR data used in this project. The total floodplain area for the Whiskey Creek watershed measured to cover an area of 12.72 km^2. A floodplain volume can then be created using radiometrically dated sediment assuming even sedimentation throughout the watershed and floodplains. Once the volume of the sediment eroded, and the volume of the floodplain is known, an estimate for how long it would take to fill that floodplain volume is obtainable.

5.2 Estimation of Sedimentation Using Radiometic ^{137}Cs and ^{210}Pb

A sediment core collected from the Whiskey Creek floodplain was sampled in 5 cm intervals and tested for concentrations of ^{137}Cs at the Ozarks Environmental and Water Resources Institute (OeWRi) at Missouri State University. The complied concentration data of the radiometric isotope ^{137}Cs (Figure 11) shows a maximum peak buried 65 cm below the current floodplain surface.

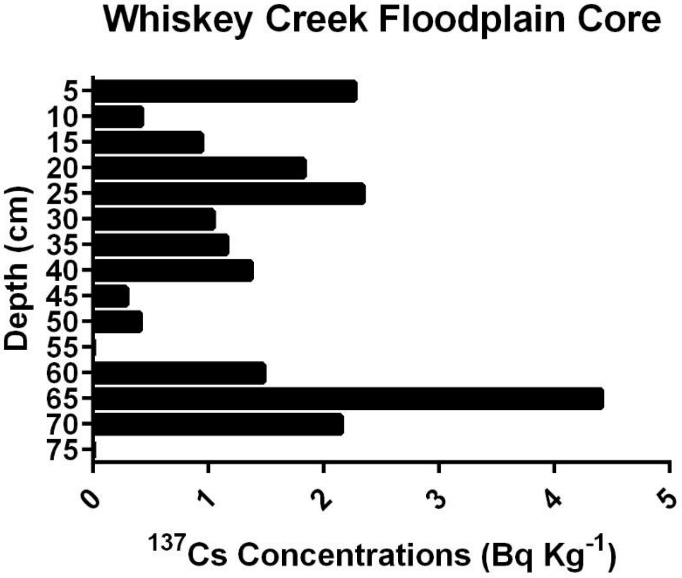


Figure 13. Floodplain sediment core collected in 5 cm intervals in the Whiskey Creek floodplain, showing the ^{137}Cs concentrations throughout the profile.

Through interpretation of the ^{137}Cs curve and comparisons to other published curves, the peak of the ^{137}Cs curve may not accurately represent the year 1961 as suggested by Ritchie and McHenery (1990). The ^{137}Cs however most likely represents a possible downward migration of ^{137}Cs particles due to the sandy substrate of the Whiskey Creek core. Although, the ^{137}Cs curve most likely over estimates the sedimentation rates of Whiskey Creek floodplains it does provide useful information on the type of depositional environment. The collected ^{137}Cs curve compared to those published by Detriche and others (2010) (Fig. 14). Their research describes ^{137}Cs curves in a sandy substrate floodplain and the typical curve profiles found in those locations. The collected Whiskey Creek floodplain curve is best represented by the type III curve. Type III curves indicate rapid sediment accretion during floods (Walling and He 1993) and the ^{137}Cs is mainly of sedimentary origin and not directly related from atmospheric fallout (Detriche and others 2010).

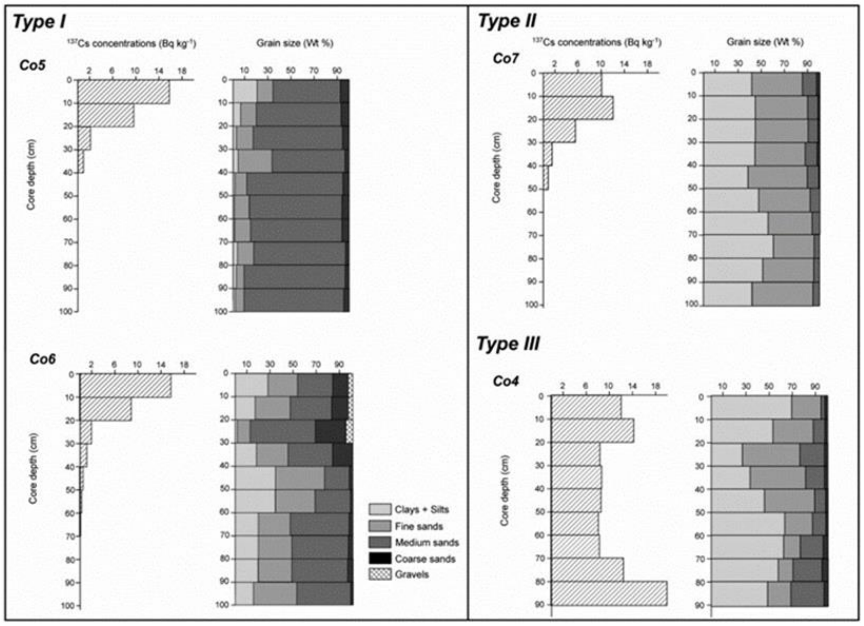


Figure 14. ^{137}Cs curves from sandy floodplain soils describing different sedimentary environments along a floodplain (Deriche and others 2010)

A ^{210}Pb core was also collected from Whiskey Creek floodplain to help determine sedimentation rates. The core was sampled in 10 cm intervals and was tested for ^{210}Pb concentrations by the Soils and Sediments Laboratory at the University of Texas at Austin. The compiled data were plotted against depth to display the general decay of ^{210}Pb with depth (fig. 15). Using the CIC and CRS methods the accumulation rates estimated for Whiskey Creek floodplain ranged from 0.72 cm/yr to 0.79 cm/yr. These calculated rates of deposition were used to back calculated the depth of 1979 for the RUSLE model and calculation of the floodplain volume. Assuming even and constant sediment accumulation throughtout the floodplains of Whiskey Creek the total floodplain volume for the RUSLE model trials was estimated at 3,339,000 cubic meters.

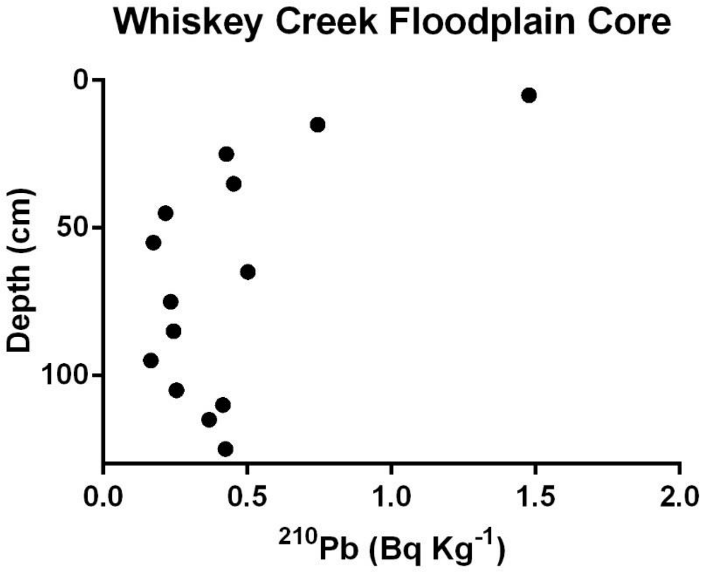


Figure 15. Floodplain sediment core collected in 10 cm intervals in the Whiskey Creek floodplain, showing the ^{210}Pb concentrations throughout the profile.

The results from the three trial models were converted into volumes and a modifier was placed on the total volumes to simulate the sediment delivery ratio for the watershed (Table 3). Again, the only areas to have a changing C factor were the logged areas and were simulated to have a regrowth period over nine years of the 35 year period of the model trial.

Table 3

Volume of sediment calculated by RUSLE model

Year	Severe	Sed Vol (m^3)	Moderate	Sed Vol (m^3)	Minor	Sed Vol (m^3)
1	0.400	529,811	0.310	417,820	0.190	236,399
2	0.280	380,489	0.217	302,095	0.133	165,471
3	0.196	275,964	0.152	221,213	0.093	115,821
4	0.137	202,548	0.106	163,973	0.065	81,104
5	0.096	151,529	0.074	124,154	0.045	55,968
6	0.040	81,846	0.012	14,905	0.012	14,905
7	0.040	81,846	0.012	14,905	0.012	14,905
8	0.040	81,846	0.012	14,905	0.012	14,905
9	0.040	81,846	0.012	14,905	0.012	14,905
10-35	0.003	930,947	0.003	930,947	0.003	930,947

Once the volumes of sediment were calculated and added for a 35 year period, the volume of sediment was compared to the volume of the floodplain. The number of years estimated to fill the volume represents how well the model was at predicting the floodplain sedimentation for Whiskey Creek (Table 4). The three models predicted different number of years to fill the floodplain volume with the severe model trial closely predicting the sedimentation within the floodplain.

Table 4

Estimated number of years to fill floodplain volume

Model	Severe	Moderate	Minor
Years to fill estimated floodplain volume	41	49	90

CHAPTER VI

DISCUSSION

Using the accumulation rate calculated by the ^{210}Pb dated core there may be some assumptions or projections that can be used to infer historical logging events within the watershed. There were a number of floodplain sediment cores collected from Whiskey Creek that were analyzed for grain size, organic material, and magnetic susceptibility. These cores throughout the watershed show an increase of grain size buried within the soil profile typically occurring in the range of 50 to 80 cm of depth (fig 16). Using the observed sediment accumulation rate and assuming there is a similar accumulation rate throughout the watershed there is an opportunity to back calculate and determine the age of these distinct increases in grain size. Using the average sediment accumulation rate of 0.75 cm/yr these buried peaks range from the years 1910-1930. During the early half of the 20th century, south Mississippi had a large increase in the number of sawmills and forestry removal (Hickman 1962). The grain size increases could be related to this increase of forestry removal activity and the large scale land cover changes.

Measured loss on ignition percentages of the sediment cores around the watersheds revealed limited significance. Typical sediment cores highlighted a peak in organic material near the surface and decreased towards the bottom with limited peaks of organics. Magnetic susceptibility measurements varied throughout cores.

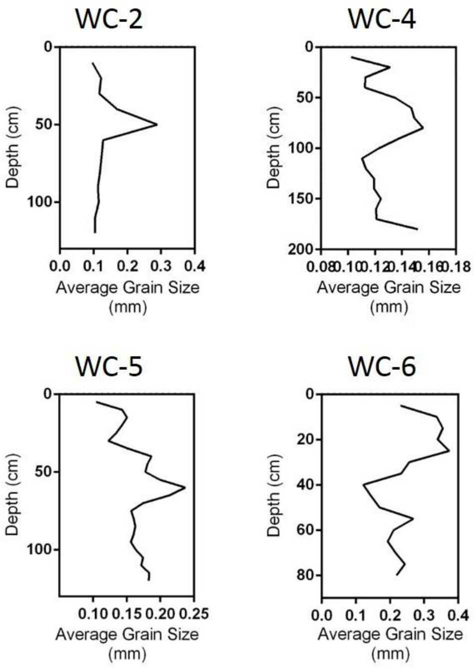


Figure 16. Collected floodplain sediment cores from various locations within the Whiskey Creek watershed highlighted the grain size increase buried at depth.

As the forestry industry continues to dominate the small county economies of south Mississippi and the DeSoto National Forest, research about upland erosion and downstream sedimentation will play a critical role in preserving the streams of the region. The RUSLE model generated for this research provides only the starting point for research need within the Whiskey Creek watershed. As stated previously the Whiskey Creek watershed is unique in that it has a very low agricultural and human population presence and provides a natural laboratory for the effects of logging in Gulf Coastal Plain watersheds. Considering that this current version of the model makes multiple assumptions about some of the geomorphic processes throughout the watershed, there are a few areas where the model can be improved for future research.

One inadequacy of the RUSLE model for this research is likely the input for the C factors. The C factors for most of the watershed were generalized and most areas of the watershed are unlikely to have the same value for the entirety of the watershed. Higher C factors for areas that have not been logged or even areas that have been previously logged would increase the overall generation of sediment. Another RUSLE factor that could be updated is the R factor, or the rainfall erosivity. The R factor is a long term average over several decades of collected precipitation data for the region. The influence of large storms may not be highlighted in this format and large tropical storms could play an influence in the erosive effect of rainfall.

Another area where the model could be improved is the selection and delineation of the floodplains and the successive calculation of floodplain volume. The floodplain area of Whiskey Creek was selected by FEMA and accounts for a 100 year flood zone. This floodplain area may be too large considering the time scale of 35 years of this project. A smaller floodplain area would drastically change the results predicted by the RUSLE model for Whiskey Creek. If considering a 50 year flood zone would cover an area half the size as the 100 year flood zone area the predicted results of the model are much closer to the observed dated sediment.

Because there are no current gauging stations within the watershed there is a lack of high quality hydrological data. Stream monitoring stations could provide need information to further correct the model for better results. Small scale erosion monitoring tests following logging events are also needed to help validate the predictions made by the model trials.

The most important area to further validate this study would be the collection of more radiometrically dated sediment cores. Due to the expensive nature of collecting and analyzing ^{137}Cs and ^{210}Pb this study was limited to one core for the use of research. The use of more cores throughout the watershed will help further describe the floodplain sedimentation rates of the watershed as a whole as logging will continue to play a role in the economies of the counties of south Mississippi.

CHAPTER VII

CONCLUSIONS

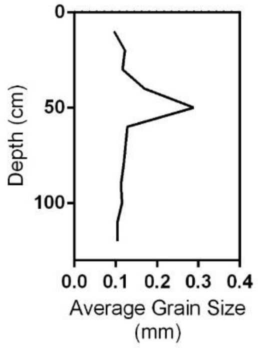
As the logging industry continues to have a major role in the economy of counties in southern Mississippi and the DeSoto National Forest, sediment production and floodplain sedimentation will continue. How the watersheds and streams will react to further sedimentation will affect downstream storage of floodplains and flood frequency. The primary objective of this study was to determine the floodplain sediment accumulation rates and compare the observed rates to a modeled sediment production prediction determined from the RUSLE model. The RUSLE model was generated using ArcGIS, historical aerial photos, and LiDaR generated digital elevation models to predict the overall volume of sediment produced over a 35 year period. The predicted eroded sediment volume was then compared to the observed and estimated floodplain volume of Whiskey Creek watershed to validate the accuracy of the RUSLE model. Three different RUSLE model trials were performed under different severities of forestry removal in the watershed during the 35 year model trial: severe, moderate, and conservative. The different severities of the models were determined by the changing C-factor during the initial forest removal, site preparation, and the regrowth of vegetation. Using the three model trials and comparing the results to the estimated floodplain volume calculated by the observed sedimentation rates, it is concluded that the severe model trial best represented the erosion and floodplain sedimentation rates within Whiskey Creek watershed.

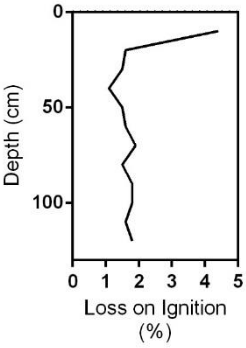
The RUSLE model implemented for watersheds impacted by land clearance provides a wealth of important information regarding sediment erosion. Land managers are able to determine which areas of the watershed will be most susceptible to erosion. With the knowledge of where erosion is likely to occur, better land management practices can be implemented in a cost-effective manner reducing the negative effects of forestry removal. Reducing the amount of top soil erosion will help not only the health of floodplains and streams but also preserve nutrients for the benefit of future tree growth.

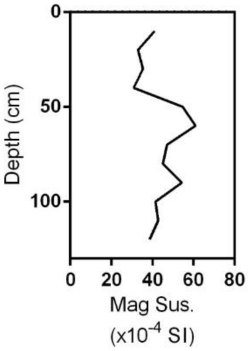
APPENDIX A

SEDIMENT CORE DATA

Location: Whiskey Creek 2	Date Collected: 10/15/2013
Latitude: 30.988912	Longitude: 88.859722







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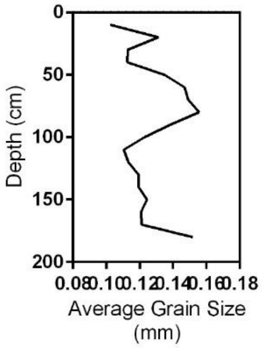
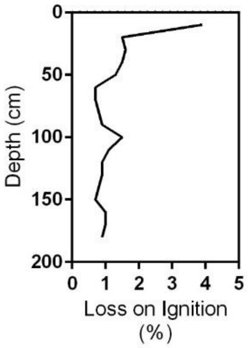
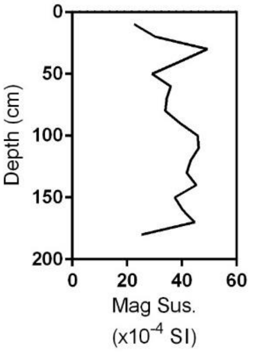
Latitude: 30.988598	Longitude: -88.859156







Location: Whiskey Creek 5	Date Collected: 7/18/2014
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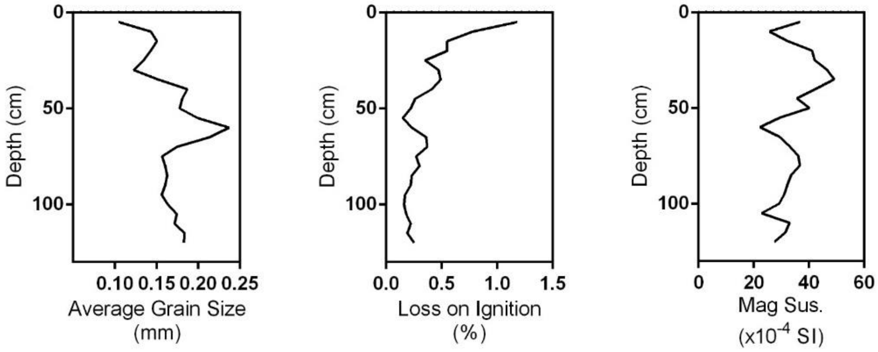
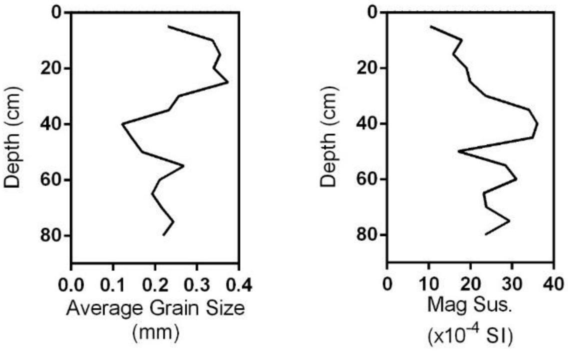


Location: Whiskey Creek 6	Date Collected:12/14/2014
Latitude: 30.969920	Longitude: -88.843742



Location: Whiskey Creek 7	Date Collected: 12/14/2014
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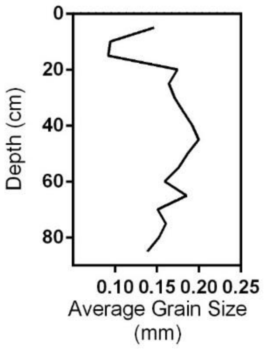
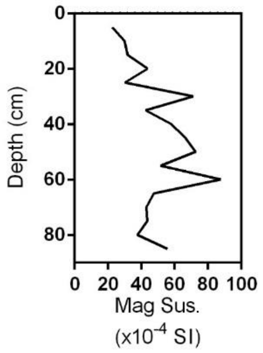
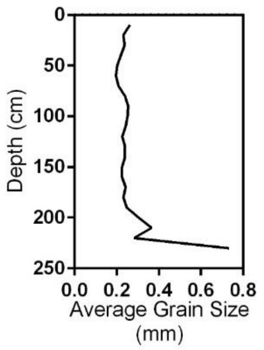
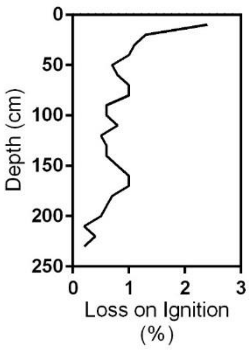
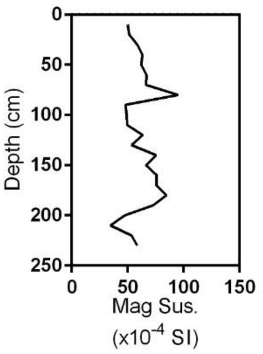




Location: Bridge Creek 2	Date Collected: 12/10/2013
Latitude: 31.066335	Longitude: -89.268605







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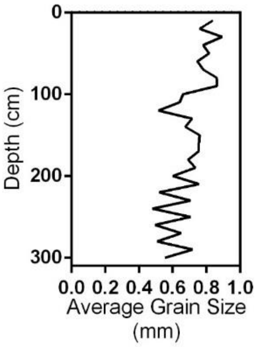

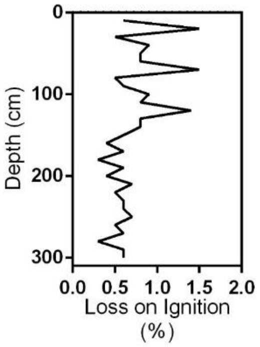

Location: RBC	Date Collected: 12/10/2013
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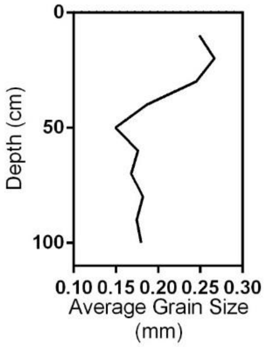

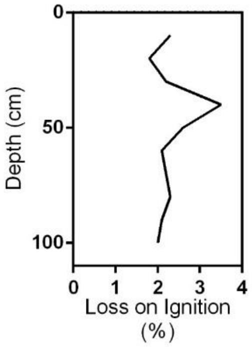

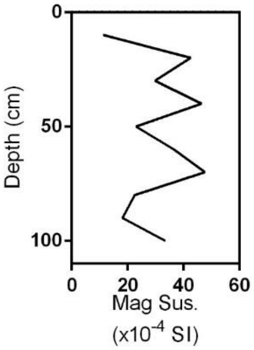

Location: UK Creek	Date Collected: 12/10/2013
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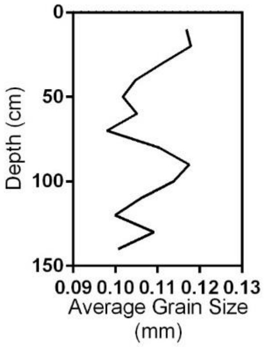

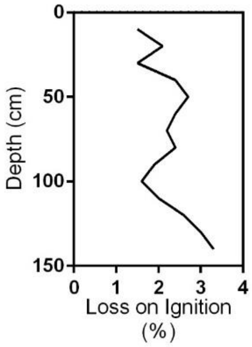

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