2013

A Preliminary Study for Estimating Postmortem Interval of Fabric Degradation in Central Florida

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A PRELIMINARY STUDY FOR ESTIMATING POSTMORTEM INTERVAL OF FABRIC DEGRADATION IN CENTRAL FLORIDA

by

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A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Anthropology
in the College of Sciences
and in the Burnett Honors College
at the University of Central Florida
Orlando, Florida

Fall Term 2013

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Abstract

Forensic anthropologists rely on forensic evidence to estimate the postmortem interval of a decedent. This may include the study of the degree of deterioration of the human body, the life stage of insects, and the degradation of associated material evidence. Material evidence comes in many forms, and certain taphonomic processes will affect the material and must be considered when making inferences about a PMI. These include variables such as the characteristics of the soil, microorganisms, and the presence of a decaying organic material. Previous research has undertaken studies in how fabric degrades over time; however, there is no standard methodology in use. The purpose of this research project is to establish a comprehensive scoring system and description standard after analyzing the degradation of four different fabric types. This will be useful for future studies in need of a standard methodology. In addition, the methods used in this project can be applied to actual forensic cases. After retrieval, the fabric type with the highest degradation was the cotton with about 1/3 of all cotton fabric swatches demonstrating more than 50% total degradation. For all fabric types, swatches that were positioned flat tended to degrade more than those that were positioned crumpled. Cotton fabric swatches degraded more in Trench 1 and Trench 2 than the Ground Surface, however, all other fabric types demonstrated slightly more degradation on the Ground Surface than the other two Areas. Soil moisture fluctuated the most on the Ground Surface while Trench 1 and Trench 2 were able to retain more water in the soil. Overall, cotton was the only fabric type to degrade significantly enough to show how it degrades over time, while the other fabric types have longer degradation intervals that must be studied further.

Dedication

This thesis is dedicated to my friends and family who so graciously supported me through this time with words of encouragement and comic relief.

Acknowledgements

I would like to thank the Departments of Civil, Environmental, and Construction Engineering at the University of Central Florida for providing access to the Deep Foundations and Geotechnical Research Site. Also, thanks to the Department of Anthropology for the use of The Bone Isotope Lab. I want to thank Dr. Schultz for his guidance and direction for the many months I had undertaken this project. Thank you to Dr. Williams for her encouragement and assistance in the development of the method of fabric degradation analysis. I also would like express my appreciation to my friends Jennifer Dewey, Megan Franken, Phillip Mondelli, and Heather Zimmerman for braving the Florida heat and mosquitos during the field site construction and data collection processes. A special thanks goes to my boyfriend, Martin O'Steen, who always seemed to find the elusive cotton/polyester sample from Trench 1. Last but not least, I want to express thanks to Patricia Reynolds who helped me take the perfect picture.

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Chapter 1: Introduction and Purpose

Forensic anthropologists are physical anthropologists who specialize in the skeletal analysis of human remains involved in a medicolegal context (Schultz and Dupras, 2008). An important role of the forensic anthropologist is determining the postmortem interval or time since death of a decedent. There are many characteristics of a crime scene that are useful in aiding the forensic anthropologist in this discovery; the degree of deterioration of the human body based on quantifying the presence of soft tissue (Hunter et al., 1996; Forbes, 2008; Dirkmaat and Adovasio, 1997), the types of insects present and at what stage of life (Hunter at al., 1996; Forbes, 2008; Amendt et al., 2004; Dirkmaat and Adovasio, 1997), and the degree of degradation of associated material evidence (Hunter et al., 1996; Morse et al., 1983; Morse and Dailey, 1985; Janaway, 2008). These variables give information as to the length of time an individual has been at the particular burial site.

Material evidence found at a crime scene is referred to as trace evidence and can be categorized as man-made or natural (Rowe, 1997; Singer and Rowe, 1989). Some examples of typical trace evidence found at a crime scene are paper money, leather wallets, bond receipts, decedent's clothing, metals, etc. (Janaway, 2008; Rowe, 1997; Singer and Rowe, 1989). Because trace evidence such as textiles are susceptible to deterioration, they can help in the determining time since death (Morse et al., 1983; Morse and Dailey, 1985; Janaway 2008; Rowe 1997; Dirkmaat and Adovasio, 1997; Mitchell et al. 2012). Biodeterioration is stated by Huek (1965, 1968) as "any undesirable change in the properties of a material cause by the vital activities of organisms." The composition of material evidence varies, producing differences in deterioration. Natural materials are either cellulosic, deriving from plants, or proteinaceous, deriving from animals, and proteinaceous fabrics are more resistant to decay than cellulosic fabrics (Janaway, 2008; Peacock, 1994). Typically, natural materials deteriorate at a faster rate than synthetic materials (Rowe, 1997; Janaway, 2008).

Soil has a large influence on the rate of deterioration. The pH of the soil, depth of the soil, soil type, soil temperature, soil moisture, and microorganisms present all affect the rate of deterioration of remains (Lawson et al., 2000; Wilson et al., 2007; Janaway, 2008; Peacock, 1994; Morse and Dailey, 1985; Hunter et al., 1996). Therefore, considering the soil at a crime scene and its effect on material evidence can help lead the forensic anthropologist to a successful determination of the post-mortem interval.

Purposes and Goals

The goal of this thesis is to establish a comprehensive scoring system and description standard after compiling data of the degradation of trace evidence. This information will be a useful aid in determining the post mortem interval of an individual. This can be accomplished by first choosing a location that warrants further evaluation. Florida's environment offers a unique perspective into this area of research as bodies tend to deteriorate much faster at this locality. A series of experiments would be conducted to observe the deterioration of specific fabrics, as well as the associated depths, pH, temperature, and rainfall. The significance of this experiment lies in the applicability of the results to forensic anthropologists in Florida and other regions with a similar environment. Questions to be answered include:

1. How do four fabric types (cotton, cotton/polyester blend, rayon, denim) degrade over a six month period?

2. How do certain variables affect the degradation of the fabric?
3. How can the materials be analyzed post burial? What methods of evaluation are most useful?
4. Can a more comprehensive scoring system be established? Is it useful to create a condition score that is fabric specific?

Chapter 2: Background and Literature Review

The main resources for information about the degradation of associated material remains include experiments conducted by Tigg (2005), Rowe (1997), Singer and Rowe (1989), Wilson et al. (2007), Morse et al. (1983), Morse and Dailey (1985), Bell et al. (1996), Terry (1996), and Peacock (1994).

Tigg (2005) conducted an experiment which focused on the effect of metals on the preservation of different types of jean material buried at three select locations in the United Kingdom. A summary of this experiment in provided in Table 1. The swatch sizes were 30 cm by 30 cm on which was sewn metal zippers, rivets, and buttons. Location 1 was a humic topsoil that changed to yellow clay at a 40 cm depth. Some discrepancy lies in the soil type for Location 1 being described as both orange clay and yellow clay. Material was buried at 30 cm and at 60 cm at this location. Location 2 and 3 included well-tilled garden top soil and a surface of conifer needles respectively. Location 2 had material buried at 30 cm, and Location 3 had material at 0 cm. The experiment lasted 15 weeks, after which, the materials were removed for analysis. Analyzing evidence once after 15 weeks is problematic because it does not allow for a thorough capture of all the stages of degradation for each material buried. Therefore, it will be impossible to know the true total degradation interval of a textile. Analysis included visual assessment of damage and descriptive terminology was used to provide results. The denim material buried at Location 2 showed the highest degree of deterioration, almost total. Deterioration of the fabric buried at a 60 cm depth at Location 1 was less advanced than at 30 cm. Deterioration at

Location 3 was least apparent. There is no mention as to how many swatches were buried at each location; an increase in sample size would strengthen their conclusions.

Singer and Rowe (1989) conducted an experiment focusing on the techniques useful for identifying man-made fabrics. Six samples were selected of cellulose acetate, cellulose triacetate, acrylic, nylon, polyester, and rayon. The cellulose materials were cut into 2 cm squares, while the others were cut into 1 cm squares. Three soil types were used; undisturbed forest soil with a pH of 3.9, urban soil with a pH of 4.0, and agricultural soil with a pH of 5.7. Materials were buried in plastic flower pots filled with the different soils. The methodology does not include how many flower pots were used, how many of each swatch were buried in each pot, the positioning of the fabric buried, or how deep the material was buried. The materials were exhumed for examination monthly for at least five months, but the entire length of the study was not mentioned in the chapter by Singer and Rowe (1989). However, Rowe (1997) discusses their experiment as spanning nine months. Singer and Rowe (1989) only provide the degradation results for the cellulose materials and the rayon. Analysis of the fabrics included qualitative descriptive terms and different types of microscopic analysis. The stereomicroscope was used to look for changes in weave of knit. The polarized light microscope was used to measure fiber diameter and birefringence. Solubility tests were conducted to identify the material by comparing it to a known sample. Of the material tested, rayon demonstrated the highest degree of degradation, but at different rates depending on the soil type. By the end of the first month, rayon showed deterioration in the urban and agricultural soil types. The forest soil inhibited rayon deterioration until the second month. Rayon in all soil types were almost completely degraded by the fifth month. Changes were noted by a decrease in birefringence of the rayon post burial via light microscope. The cellulose materials did not show significant signs of deterioration throughout the experiment. Microscopic observations were most useful in making comparisons between control fabrics and buried fabrics; macroscopically there was little change.

Wilson et al. (2007) conducted an experiment near Bradford University to test the effect of pig cadavers on the environment in which they were buried and the buried material in their vicinity. The experiment took place at three different locations, the results for the pasture location is provided in Table 2. The moorland site included peat soil with a fluctuating water table. The woodland site had brown colored soil covering Millstone grit and was more easily draining. The pasture site had brown colored soil with iron influence and was also freely draining. Burial pits at each site had dimensions of 100 cm by 180 cm with depths of 60 cm; one pit per time interval. The distance between graves was about 150 cm. Pig carcasses were placed in each pit at a depth of about 30 cm. Five different textiles were buried in sets of three above and below the carcass (30 cm and 60 cm). Control graves of similar size were dug at each site to only include the textile samples. Each textile strip was 3 cm by 15 cm. Manual temperature was logged weekly at the woodland site but not as consistently at the others. However, automated temperature was taken daily at the moorland site. The water table for each location was measured using piezometer pipes. The only results discussed in detail are of the materials recovered from the pasture site of the pilot experiment after 24 months. After 24 months, the wool, cotton, and denim materials from the control grave were completely degraded, while the polyester remained well intact. The graves containing the pig carcasses both slowed deterioration of the associated materials. Materials buried below the pig at 60 cm demonstrated the least amount of deterioration. The materials in the other sites were both recovered after 6 months and then after 12 months, however, their results are not present. All that is concluded is that the moorland site had the least severe deterioration and that amongst the control pits, materials of the same kind had less degradation at 60 cm than at 30 cm. Also, results revealed that the pig carcasses produced an anaerobic environment, especially at 60 cm, which inhibited the deterioration of the associated materials as compared to the control (Wilson et al., 2007). The undyed cotton was the least resistant to deterioration followed by wool, denim, and polyester. With the results provided from the pasture site, degradation was measured in a qualitative manner. Some of the results focus on the percentage of loss of fabric, but no explanation is given as to how this was obtained, whether microscopically, visually, or by other means.

Morse at al. (1983) published preliminary results from experiments performed in Florida and Georgia. The final results of the experiment were published at a later time and will be discussed in conjunction with the initial experiment (Morse and Dailey, 1985). A summary of the results of the first three months can be found in Tables 3 and 4. The project included numerous experiments and was completed by Florida State University. The purpose was to obtain more information about time of death using crime scene material. The studies focused on the biodegradation of a number of fabrics buried in nine trenches, eight with acidic soil and one with alkaline soil. The depths of the trenches are provided at surface (0 cm), and about 30 cm and 60 cm depending on the trench, however, length and width were not described. Each of the trenches housed 10 compartments with a set of materials inside each compartment. Each compartment would then be exhumed after 1, 2, 3, 5, 7, 10, 25, 35, 48, and 60 months. The materials chosen were cotton (with resin), rayon, triacetate, nylon, cotton/polyester, and acrylic.

The swatches of material buried were cut 10 cm by 15 cm. Fabrics were analyzed for degradation using high and low power microscope, scanning electron microscope, breaking and bursting strength tests, soft x-rays, and chemical tests. Qualitative analysis and percent loss of fabric was attributed to each of the materials from each compartment of each trench. However, there was no explanation as to how these were obtained. Results of the bursting and breaking strength tests are provided in pounds per inch, but the equipment or procedure used was not described. The cotton showed limited signs of loss until the second month in trench five and eight. Total loss of cotton was observed after the tenth month in the majority of the trenches. Heavy deterioration was observed at all trenches containing rayon. Total degradation of rayon was observed after three months in the majority of the trenches. Triacetate demonstrated limited deterioration throughout the entire experiment, only showing loss after 48 months. Cotton/polyester did not begin to show signs of deterioration until month ten and severe loss was observed after 35 months. Nylon showed the most deterioration in trench four beginning at month ten. Acrylic remained in good condition for the entirety of the experiment. Morse et al. (1983) and Morse and Dailey (1985) focus on how the results of their experiment can provide information of time since death and time since buried.

A unique experiment began in the United Kingdom to analyze the effects of long term burial on textiles. The Experimental Earthworks Project was initiated between 1958 and 1960, with intentions of gathering data at intervals of 1, 2, 4, 8, 16, 32, 64, and 128 years (Bell at al. 1996). These experiments have contributed greatly to different avenues of anthropological research, but are more focused on long-term degradation and, therefore, have less forensic applications. Bell et al. (1996) discussed the recovery of five different types of fabric; linen, plain cotton, dyed khaki cotton, wool contrast, and wool worsted gabardine at the Overton site. Six of these materials were buried in each soil environment; turf and chalk. Each fabric size was 0.46 m by 80 mm and then folded to an 80 mm square. Excavations were completed and results provided after 2, 4, 8, 16, and 32 years. The materials' degradation was qualified by use of a condition score ranging from 0-4 (Bell et al., 1996). The scoring system is based on subjective terms such as "general degradation," which is problematic when making comparisons to other experiments that use condition scores. Overall, fabrics buried in the turf were less resistant to decay than those buried in the chalk. Plain cotton showed initial signs of degradation after two months in the chalk. Total loss of cotton was observed after eight months in the chalk. The khaki remained well preserved until month eight in the chalk. Contrast and gabardine wool and linen degraded throughout the experiment in the chalk environment, but never were completely lost. Cotton and khaki showed total loss after the second month in the turf environment. Contrast wool was completely lost after 32 months and gabardine wool showed total loss after 16 months in the turf. Linen was degraded completely after month four in the turf. Analysis of the materials included scanning electron microscopy, Fourier Transform Infrared Microscopy, and fiber diameter using the Wool Textile Organization Method and a projection microscope.

Terry (1996) in Bradford, like Tigg (2005), focused on the degradation of different types of denim: commercial denim, Indranthan Blue dyed, indigo dyed, and undyed. Three different soil environments were used; garden, moors, and cellar. There are not details as to the depths of the burials, but time intervals are stated to be 70 and 140 days. Three swatches of each material of unknown size were buried in each soil type. The dyed and undyed denim showed 30 percent loss in the moorland soil after 70 days, while commercial denim at this location showed no loss.

After 70 days in garden soil, the undyed denim demonstrated the most degradation, followed by the indigo dyed, commercial, and Indranthan Blue. After 140 days in the garden soil, all fabrics showed severe loss, but there was some inconsistencies. A separate commercial denim of the same interval and location showed no loss. After 140 days in the moorland soil, Indranthan Blue, indigo, and undyed denim all exhibited mild loss. After 140 days in cellar soil, all dyed and undyed denim were totally lost; only commercial denim exhibited no loss. Results were not given for the materials buried in the cellar soil after 70 days. To qualify the aforementioned results, a condition score ranging from 0-5 was assigned to each material post-burial as compared to each control sample. The scoring is based on percentage of the fabric destroyed.

Peacock (1994) tested the biodegradation of textiles in different soils in a laboratory setting. This poses a problem because, although it allows for a more controlled experiment, it can never replicate real world conditions. Cotton, linen, wool, and silk were buried in two soil compositions of garden peat and sandy loam. The fabric was cut into swatches of 10 cm by 5 cm. Forty-five liters of soil was sifted into storage containers 60 cm by 30 cm by 30 cm. There were two bins per soil type. Prior to burial the following measurements were taken: areal density, cross sectional analysis via light microscopy, and color analysis based on the Munsell Color System and the Natural Color System. Areal density measures the weight of the dry fabric in mg/cm^2. Samples were buried vertically, 10 cm below the surface of the soil with a distance of 2-3 cm between each fabric sample. One bin contained wool and silk, and the other bin contained cotton and linen. A set of each fabric type (8 samples) was buried in each bin. The materials were removed after 0.5, 1, 2, 4, 8, 16, and 32 weeks. Upon removal, the samples were rinsed with deionized water and then allowed to dry before analysis. After 0.5 weeks the linen was initially degraded in the loam soil and completely lost after four weeks. After one week, the cotton began to degrade and was completely degraded after eight weeks. The silk and wool began degradation at week four and were still visible after 32 weeks. All fabrics in the peat soil had retarded deterioration beginning at week four. Cross sectional morphology was analyzed again to compare initial fabric with post burial fabric. Scanning electron microscopy (SEM) revealed reduced areal density and fabric shrinkage. Color change and value (changes in lightness or darkness) were also used for analyzing the fabrics, but only by assigning objective terminology. Color was not compared by using Munsell or Natural Color Systems before and after burial. Changes in pitting, corrosion, splitting, and fibrillation were noted by SEM. Peacock (1994) reported that there was variation in the deterioration of the sets of samples including cotton and linen more than the wool and silk as well as considerable variation in the fabrics buried in loam more than peat. The proteinaceous fabrics were more resistant to decay than the cellulosic fabrics. Also, the loam environment activated more decay and a faster decay than the peat soil.

Issues with Previous Research

The research experiments are lacking in multiple areas. Firstly, the methodology is different in every experiment and, therefore, no standard reference exists as a foundation for making future replications. Also, the inconsistent methodology and incomplete reporting of methods make it difficult to create comparisons between experiments. Janaway (2008) acknowledges when critiquing an inconclusive experiment by McGrath (1999), that the same soil types can cause variability in results of the same fabric causing problems with reproducibility. Each experiment has its own limitations and areas that need improvement. These issues will be discussed in further detail with comparisons on fabric type, field methods, and analysis among the experiments.

Fabric Type

There is a general agreement on the materials used in each experiment as polyester, rayon, cotton, and denim, or some type of blend of these materials (Morse et al., 1983; Morse and Dailey, 1985; Tigg, 2005; Wilson et al., 2007; Terry, 1996; Peacock, 1994; Bell, 1996; Rowe, 1997). There are inconsistencies in the size of each sample of fabric which makes it difficult for using any of these experiments as models. The majority of the experiments do not detail how the materials were placed in the soil. Bell et al. (1996) folds each swatch into 80 mm squares before burying. Peacock (1994) buries each swatch vertically. There is also no information as to the horizontal distance between each swatch except in Peacock (1994) which is difficult to replicate because it was conducted in a laboratory where all variables were controlled.

Field Methods

The majority of the experiments use similar burial depths: below ground at 30 cm and 60 cm and on the surface (Tigg, 2005; Morse et al., 1983; Morse and Dailey, 1985; Wilson et al., 2007). However, there are inconsistencies in the number of pits, and the length and width of the pits. These decisions are dependent on how many different materials are being used, the length of the experiment, how many of each fabric type, and how many different ways the swatches are buried; all of which are different between experiments.

Analysis

Most of the experiments use some form of microscopy, usually scanning electron and/or light to analyze the material, and all assign a condition score or descriptive term as a way of describing the degree of degradation (Morse et al., 1983; Wilson et al., 2007; Tigg, 2005; Terry, 1996; Bell et al., 1996; Peacock, 1994; Singer and Rowe, 1989). However, there is no standard for what is deemed "degradation." This study will consider degradation of fabric to be any declination in quality from its original condition. Other studies focus on color change, percent loss, or visual cues such as fraying or fibrillation (Tigg, 2005; Singer and Rowe, 1989; Wilson et al., 2007; Morse et al., 1983; Morse and Dailey, 1985; Bell et al., 1996; Terry, 1996; Peacock, 1994). Other studies look at quantifiable methods such as tensile tests (Morse et al., 1983; Morse and Dailey, 1985; Mitchell et al. 2012). These tests compare breaking and bursting strength of the buried fabric to the control. However, this method is not useful for forensic cases as it destroys crime scene evidence and is not replicable.

Bell et al. (1996) concludes that condition scores are the most useful method for degradation analysis because it does not harm the evidence and it provides a quantity that can be compared. However, the scoring systems are not consistent. Bell et al. (1996) uses a scale from 0-4 to make comparisons of degradation based on descriptive terms. Terry (1996) uses a scale from 0-5 that compares percent loss of fabric. Morse et al. (1983) and Morse and Dailey (1985) use a condition score with letters to compare percent loss of fabric.

Furthermore, there is discrepancy in the time intervals in which to analyze the textiles ranging from weeks to months to years. Detailed, step by step procedures and explanations of analysis are lacking in the literature making replication difficult.

A standard needs to be created by which other experiments can be modeled, but more importantly, that has forensic application. A quantitative scoring method with minimal subjectivity and high end microscopy would be the most optimal standard for analysis of material degradation. This experiment would be directed to forensic anthropologists working in central Florida because very little research has been conducted in this area other than Morse et al. (1983) and Morse and Dailey (1985) which was conducted in the panhandle. By creating an experiment that tests different types of fabric at different depths in Florida soil will be advantageous because it will offer a standard for forensic crime scene materials to be compared. Furthermore, knowing the variables affecting degradation, as well as the stages of degradation for each material will aid in the determination of the post mortem interval of a decedent.

Table 1: Denim fabric swatches buried with metal elements at 3 different locations for 15 weeks (Tigg, 2005)

	Location 1	**Location 2**	**Location 3**
Soil Type	Humic topsoil and orange clay subsoil	Humic topsoil	Shed conifer needle (surface)
pH	6	5-6	_____
Depth	HT: 30 cm OCS: 60 cm	30 cm	0 cm
Denim	HT: Some degradation OCS: Extreme degradation	Almost total degradation	Little to no degradation
Brass zipper	Severe surface corrosion	Severe surface corrosion	Little to no corrosion
Nickel Plating	HT: Some loss of plating OCS: Almost total loss of plating	Some loss of plating	Little to no loss of plating
Aluminum Zipper	Slight corrosion	Slight corrosion	Little to no corrosion
Length of time buried	15 weeks	15 weeks	15 weeks

Table 2: Various fabric swatches buried at 2 different depths at each of three sites (Wilson et al., 2007)

	Pasture Control		Pasture with cadavers	
Location	140 m above sea level		140 m above sea level	
pH	4.6		4.6	
Depth	30 cm	60 cm	30 cm	60 cm
Duration	24 months		24 months	
Dyed polyester	No loss	No loss	No loss	No loss
Undyed wool	Total loss	Total loss	60-90% loss of area	No loss
Undyed cotton	Total loss	Total loss	Total loss	60-90% loss of fabric area
Indigo dyed denim	Total loss	Total loss	~60% loss of fabric area	No loss

Table 3: Characteristics of the 9 trenches used in the experiments by Morse and Dailey (1985)

	Trench 1	Trench 2	Trench 3	Trench 4	Trench 5	Trench 6	Trench 7	Trench 8	Trench 9
pH	Acid	Acid	Acid	Acid	Alkaline	Acid	Acid	Acid	Acid
Depth (inches)	63.5 cm	30 cm	28 cm	surface	30 cm	30 cm	30 cm	30 cm	30 cm
Soil type	leon	leon	Fresh water swamp	leon	Sand and clam shells	lakeland	Orange-burg	Leon?	lakeland
drainage	poor	poor	Poor	poor	Fair to good	good	Fair to good	poor	good

Table 4: Biodegradation of a variety of fabrics buried in 9 trenches of different depths (Morse and Dailey, 1985)

	Trench 1	Trench 2	Trench 3	Trench 4	Trench 5	Trench 6	Trench 7	Trench 8	Trench 9
Cotton (with resin)									
1 month	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
2 months	No loss	No loss	No loss	No loss	Mild damage	No loss	No loss	Severe damage	No loss
3 months	No loss	No loss	Mild damage	No loss	Mild damage	Mild damage	Mild damage	Severe damage	No loss
Rayon									
1 month	Severe damage	Severe loss	Total loss	Mild damage	Mild damage	Severe loss	Severe damage	Severe damage	Not recovered
2 months	Severe damage	Severe loss	Total loss	Mild damage	Severe damage	Severe loss	Severe damage	Total loss	Severe damage
3 months	Total loss	Severe loss	Total loss	Moderate damage	Severe damage	Severe loss	Total loss	Total loss	Total loss
Triacetate									
1 month	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
2 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
3 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
Nylon									
1 month	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
2 months	no loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
3 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
Cotton/ Polyester									
1 month	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
2 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
3 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
Acrylic									

	Trench 1	Trench 2	Trench 3	Trench 4	Trench 5	Trench 6	Trench 7	Trench 8	Trench 9
1 month	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
2 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss
3 months	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss	No loss

Chapter 3: Methodology

Field Site

The experiment was conducted at the Arboretum at the University of Central Florida main campus in the semi-urban area of Orlando, FL. The research area was within a locked and gated location of the Deep Foundation and Geotechnical Research Site (Schultz and Martin, 2012). The specific area chosen was an overgrown field surrounded by woods which was also secured with a fence and lock (Schultz and Martin, 2012). It is unknown when trees were initially cleared away from this field; however, before experimentation could be conducted, it required additional clearing due to its overgrown state. This was undertaken using garden trimmers and a rake. The research site has a humid, subtropical climate. According to Climate-Zone.com (2012), the total yearly rainfall is 122.2 cm with an average monthly temperature of 22.4 °C. A Green Space Research Permit was obtained by the Arboretum office which granted access to the aforementioned location.

The soil at this location was classified as Spodosols, specifically part of the Pomella series (Doolittle and Schellentrager, 1989). The soil profile is described in detail in Schultz and Martin (2012).

Three areas were constructed representing three different depths. At the depths studied, the soil consisted of fine sand. Trench 1 was ~30 cm below ground surface and Trench 2 was ~60 cm below ground surface, and the Ground Surface was the surface location; these were created based on common burial depths used in previous research (Tigg, 2005; Morse et al., 1985; Wilson et al., 2007). The two trenches were ~288 cm long by ~65 cm wide. See Figures 1 and 7 for a display of how the trenches were constructed.

In addition, soil samples were collected from each of the trenches and at different depths to be analyzed for soil pH. The results will be discussed in the Chapter 4: Results.

Figure 1: Construction of the research site: Ground Surface (left), Trench 2 (middle), and Trench 1 (right).

A HOBO weather station, Part #: H21-001, was set up and mounted about 1 m south of the three areas (Figures 1 and 2). The station continuously logged information for the duration of the research project. According to HOBO Weather Station User's Guide (2006), HOBO's rain gauge smart sensor measured a maximum rate of 1 inch of rain per hour. The weather station also measured temperature with a range of -40°C to 75°C. Additionally, there were three soil moisture smart sensors that measured soil water content in each of the burial locations (Figure 3). One soil moisture sensor's probe was pushed into the side of the bottom of each of the two trenches (Figure 4). The soil moisture sensor measuring the surface location was placed under a small layer of dirt to measure surface soil moisture. According to the HOBO Weather Station User's Guide (2006), the soil moisture sensors measured the volume of water per volume of soil (m^3/m^3) by measuring the soil dielectric constant. The dielectric constant is an electrical property of soil that is influenced by water content (NRCan.gc.ca, 2008). Dry soil is indicated by values of 0 to 0.1 m^3/m^3 while wet soil is indicated by values at or higher than 0.3 m^3/m^3 (HOBO Weather Station User's Guide, 2006).

Figure 2: HOBO weather station at the research site includes a temperature smart sensor, a rain gauge smart sensor, and three soil moisture smart sensors.

Figure 3: Soil moisture smart sensor prior to burial.

Figure 4: Soil moisture smart sensor with probe placed horizontally into the bottom of the trench.

<u>Fabric Samples</u>

Four different fabric swatches were chosen for this experiment; 100% cotton, 60% polyester/40% cotton, 100% rayon, and 100% cotton denim. Cotton and denim were chosen because they represent the most common fabric types used in previous experiments (Morse and Daily, 1985; Tigg, 2005; Morse et al., 1983; Wilson et al., 2007; Terry, 1996; Peacock, 1994; Bell et al., 1996). Additionally, a cotton/polyester blend and rayon were chosen because their relevance to forensic scenarios have been indicated in other experiments (Morse and Daily, 1985; Morse et al., 1983; Wilson et al., 2007; Rowe, 1997). Materials were cut into swatches 15 cm by 15 cm. Because the swatch size for each type of material used varies with each previous experiment, this size was chosen to be the standard size.

After the fabric was cut, it was washed and dried one time based on the experiment conducted by Mitchell et al. (2012) who concluded that clothing found at a crime scene is unlikely to be unlaundered and brand new. Comparison samples were also retained from burial including unwashed and washed and dried (Figure 5). All swatches were ironed on suggested settings for their fabric type; this was to ensure that they would lie flat on the bottom of the three areas. The frayed edges of each fabric were then trimmed. Care was taken to not mix-up the pure cotton and the cotton/polyester blend materials as they were similar in color.

For this experiment the fabric swatches were buried in two different positions: flat (horizontal) and crumpled. Previous research has not utilized a uniform position for the fabric. For example, Peacock (1994) buried materials vertically while Bell et al. (1996) folded materials into 80 mm squares. Therefore, it was important to also study fabrics in a different position other than positioned flat. It was decided that crumpled fabric was more typically recovered at a crime scene, since folded fabrics are not commonly found in this context.

Fabric was laid out in six groups at each area, each group representing one month. Each group included eight swatches of fabric, two of each type of fabric with one positioned flat and one crumpled.

Between each group of fabric was ~20 cm of space, ~1 cm between fabrics of the same month, and ~1 cm between the fabric swatch and the outer edges of the area. The majority of previous experiments did not mention horizontal distances between fabrics and edges of the trench, except for Peacock (1994) who used horizontal distance between vertically buried swatches making it inapplicable to this experiment. See Figure 6 and 7 for the appropriate layout of fabric at each area. The 20 cm space was needed between each group to remove the fabric swatches.

Fabric samples were unearthed at intervals of about one month for a period of six months based on the intervals used by Singer and Rowe (1989). Peacock (1994) and Morse et al. (1983) were not consistent in their time intervals, both increasing their intervals throughout their experiments. The procedure to unearth the fabrics included the removal of all eight swatches from the corresponding month's group of all three areas.

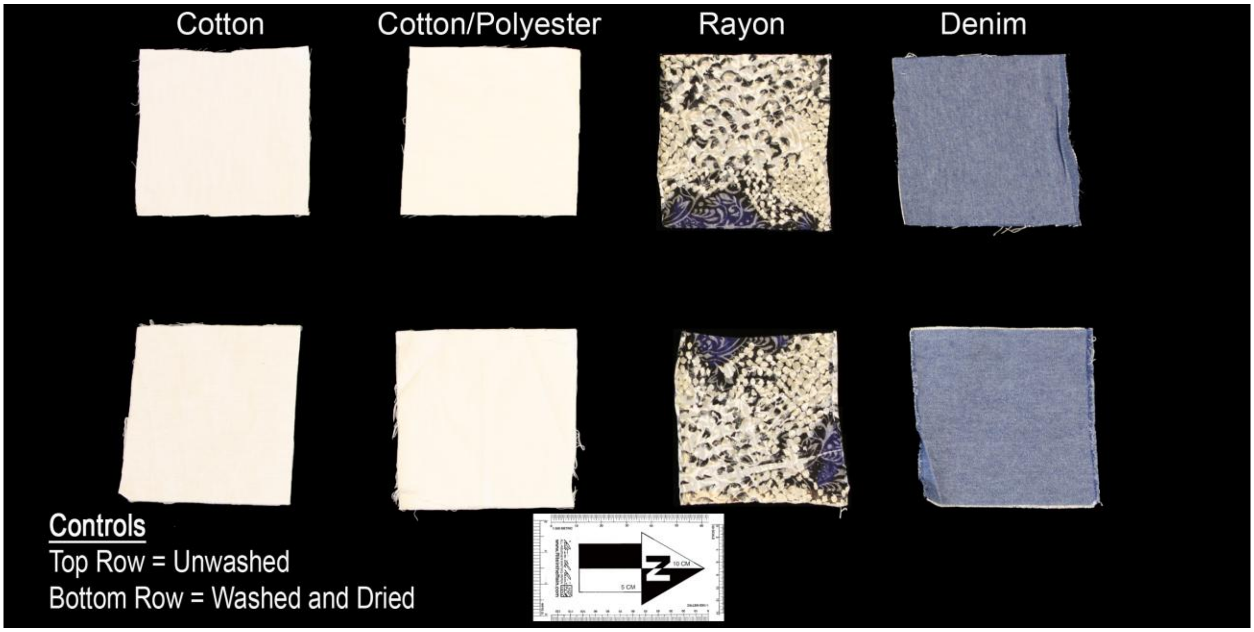

Figure 5: Comparison samples that were not buried but retained for future comparisons to buried fabric swatches.

Figure 6: Trench 2 (60 cm) showing the layout of fabric swatches and distance between each group and edge of pit. For example, one month of samples is marked by the red box.

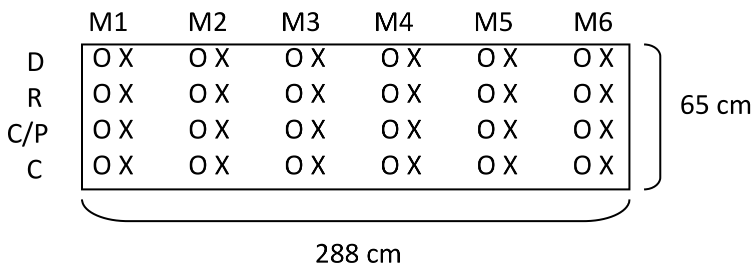

Figure 7: Position of fabric samples for the three areas (Ground Surface, Trench 1, and Trench 2). O= flat material, X= crumpled material, M= month, C= cotton, C/P= cotton/polyester, R= rayon, D= denim. There is 20 cm between each group (month), 1 cm between each sample, and 1 cm between the sample and the edge of the Area.

Utilizing a meat source in this experiment will more accurately reflect the degradation process of fabrics found in conjunction with a decomposing body at a crime scene. Most studies, however, did not use meat in their experiments. Pork picnic was chosen to represent muscle tissue and cow liver was chosen to represent organ tissue. Pork was chosen based on the experiment performed by Wilson et al. (2007) which observed the effects of pig cadavers on the deterioration of buried fabrics. Pigs are often chosen as replacements for humans in experimentation because they decompose similarly (Haglund, Conner, and Scott, 2001; Payne, 1965). The meat sources were obtained from a Publix butcher, and they were cut into cubes of approximately 1 in^{3}. A cube of each was placed in the center of each fabric sample, crumpled and flat, before burial (Figure 8). Because of the inclusion of meat, Yard Guard's Hardware Cloth ¼ inch was placed over the surface and 30 cm locations to prevent animal activity and stakes were used to hold the wire in place. Overlapping the hardware cloth was necessary because it was not wide enough to cover the pit in one sheet. Furthermore, zip ties served to hold the overlapping sheets together so that animal scavengers could not penetrate the gaps (Figure 9).

Figure 8: Ground Surface showing the placement of the cubes of meat. Both pork and liver cubes are placed in the center of the fabric swatch.

Figure 9: Shows the placement of the hardware cloth on the Ground Surface (top) and Trench 1 (bottom), and the exclusion of it on Trench 2 (middle). Zip ties are indicated by the red arrow.

<u>Exhumation Process</u>

At the end of each month, one of the six groups was unearthed to collect one all of the samples from each of the three areas. Upon removal, each swatch was cleaned of loose dirt with a soft bristle brush. Then, each fabric swatch was placed in an open zipper seal sandwich bag which was properly labeled with the date of exhumation, the month number, the area, the type of fabric, and if it was flat or crumpled. After about three days of drying, a small label was placed in each bag before sealing; Table 5 describes the label notation. Then the bags for each area were placed in a larger plastic bag labeled with the area and the date of exhumation. Finally, the bags samples were placed in a refrigerator to halt further degradation or molding until examination was conducted.

Table 5: Notation for labeling fabric swatches recovered from Month 1 as an example.

Fabric Swatches for month 1	Area	Specimen Notation
Cotton (flat)	Ground Surface	1
Cotton (crumpled)	Ground Surface	2
Cotton/Polyester (flat)	Ground Surface	3
Cotton/Polyester (crumpled)	Ground Surface	4
Rayon (flat)	Ground Surface	5
Rayon (crumpled)	Ground Surface	6
Denim (flat)	Ground Surface	7
Denim (crumpled)	Ground Surface	8
Cotton (flat)	Trench 1	9
Cotton (crumpled)	Trench 1	10
Cotton/Polyester (flat)	Trench 1	11
Cotton/Polyester (crumpled)	Trench 1	12
Rayon (flat)	Trench 1	13
Rayon (crumpled)	Trench 1	14
Denim (flat)	Trench 1	15
Denim (crumpled)	Trench 1	16
Cotton (flat)	Trench 2	17
Cotton (crumpled)	Trench 2	18
Cotton/Polyester (flat)	Trench 2	19
Cotton/Polyester (crumpled)	Trench 2	20
Rayon (flat)	Trench 2	21
Rayon (crumpled)	Trench 2	22
Denim (flat)	Trench 2	23
Denim (crumpled)	Trench 2	24

Analysis

Previous studies have used a range of microscopy to aid in visual examination of the degradation of materials. Scanning electron microscopy (SEM) is the most common type used for comparison of color changes, cross sectional morphological changes, fiber diameter, and birefringence (Carroll, 1992; Singer and Rowe, 1989; Morse et al., 1983; Morse and Dailey, 1985; Bell et al., 1996; Peacock, 1994). In addition, all of the studies focus on qualitative manners of analyzing degradation either by a condition score, descriptive terms, or color changes (Bell et al., 1996; Peacock, 1994; Morse et al., 1983; Wilson et., 2007; Tigg, 2005; Terry, 1996; Mitchel et al. 2012). Prior to analysis, each fabric will be rinsed with distilled water which will remove dirt and prevent microbial activity and then allowed to dry.

Microscopy

Although previous studies have used SEM to analyze fabric degradation, the equipment is expensive and not useful in evaluating degradation according to Morse et al. (1983) and Morse and Dailey (1985). Therefore, stereomicroscopy will be used to analyze changes in warp and weft, color, and loss of surface area (Petraco and Kubic, 2004; Singer and Rowe, 1989). Petraca and Kubic (2004) established the standard for analyzing fabric characteristics. Therefore, an adapted textile data sheet and fabric analysis sheet will be used to record observations made during the microscopy analysis. In addition to microscopy, a light board will be used to highlight areas of degradation which will be shaded and then measured for percent degradation.

Color Score

Peacock (1994) grades each fabric using the Munsell Color System and the Natural Color System. Although Peacock (1994) discussed the initial scores of each fabric according to each color system, there was not an assigned score after exhumation. There is only a broad discussion of changes in color due to the degradation process. A printed sample of the Munsell Color

System and the New Munsell Student Color Set will be used to establish changes in color with each fabric over the entire period of six months.

Percent Loss

Morse et al. (1983), Morse and Dailey (1985), Terry (1996), and Wilson et al. (2007) evaluate their material evidence by determining percent loss of the fabrics. Unfortunately, none of the experiments described how they determined percent loss of fabrics. Therefore, a method was developed that is more quantitative and reduces subjectivity.

The method will involve creating a transparency sheet that will be overlaid onto each fabric swatch in order to trace degradation. A blank 14 cm by 14 cm grid with 49, 2 cm by 2 cm squares and a 0.5 cm edge will be created on Microsoft PowerPoint and then printed onto a transparency sheet. Each 2 cm square of the grid will be analyzed in regards to degradation and weakening using a stereomicroscope and a light table. Degradation will be defined as complete loss of fabric. Weakening will be defined as any deterioration in the fabric from its initial state, with the fabric still being completely present. Each grid square will be observed and any degradation will be traced onto the blank grid sheet (Figure 10) while any weakening will be shaded lightly on this sheet. After tracing, the degradation and weakening can be measured by drawing the simplest shapes around these shadings from which an area can be calculated. For this study, triangles, squares, and rectangles were traced around the areas of degradation and weakening and then their areas were calculated in millimeters squared.

The total area of the fabric swatch that will be analyzed is 19,600 mm^2. This is not including the 0.5 cm edges because they were cut with scissors to make the 15 cm by 15 cm fabric swatch. Therefore, the edges should not be included in the calculation of percent loss because they were treated differently and will not represent the swatches' pattern of degradation. The total percent loss of the entire fabric swatch can be considered by Formula A:

$$\frac{\text{Sum of calculated areas of degradation in mm}}{19{,}600\ \text{mm}^2} \ \text{X}\ \ 100 \ = \ \text{total \% degraded}$$

In addition, a smaller section of each fabric swatch will be evaluated separately in terms of degradation. This section is called the Center Value and consists of the center nine squares on the grid outlined in red with an area of 3,600 mm^2. (Figure 10). The percent loss in regards to degradation of the Center Value can be calculated by Formula B:

$$\frac{\text{Sum of calculated areas of degradation for the CV in mm}}{3{,}600\ \text{mm}^2} \ \text{X}\ \ 100 \ = \ \text{\% degraded of CV}$$

Finally, the entire fabric swatch will be analyzed in terms of weakening. The percent of the fabric that is weakened will represent fabric that is not yet degraded and can be calculated by using Formula C:

$$\frac{\text{Sum of calculated areas of weakening in mm}}{19{,}600\ \text{mm}^2 - \text{sum of calculated areas of degradation in mm}^2} \ \text{X 100} \ = \ \text{\% weakened}$$

If the yarns running in a certain direction appear to be more degraded than those running in the opposite direction, a separate blank grid sheet will be used to record how the warp and weft are degrading (Figure 11).

Condition Score

Condition scores are used by Terry (1996), Bell et al. (1996), Morse et al. (1983), and Morse and Dailey (1985). Terry (1996) uses a system ranging from 0-5 based on percent loss.

Bell (1996) uses a system ranging from 0-4 based on descriptive terms. Morse et al. (1983) and Morse and Dailey (1985) do not use a numbered score, instead letters are assigned based on percent loss. Because there is no standardization, one will be developed for this experiment. Pictures of each fabric swatch after each month's exhumation will be documented and accompanied with a detailed description of the appearance of the fabric, noting any changes that have occurred. In addition, each picture will have an assigned score in which comparisons can be made in future experiments or case studies.

The range for the condition scores will be 0-11based the results of Formula A and can be found in Table 6.

Table 6: Condition Scores for each fabric swatch based on the total percent degradation calculated from Formula A.

Condition Score	Total Percent Degradation
0	0%
1	>0% to 10%
2	>10% to 20%
3	>20% to 30%
4	>30% to 40%
5	>40% to 50%
6	>50% to 60%
7	>60% to 70%
8	>70% to 80%

Condition Score	Total Percent Degradation
9	>80% to 90%
10	>90% to <100%
11	100%

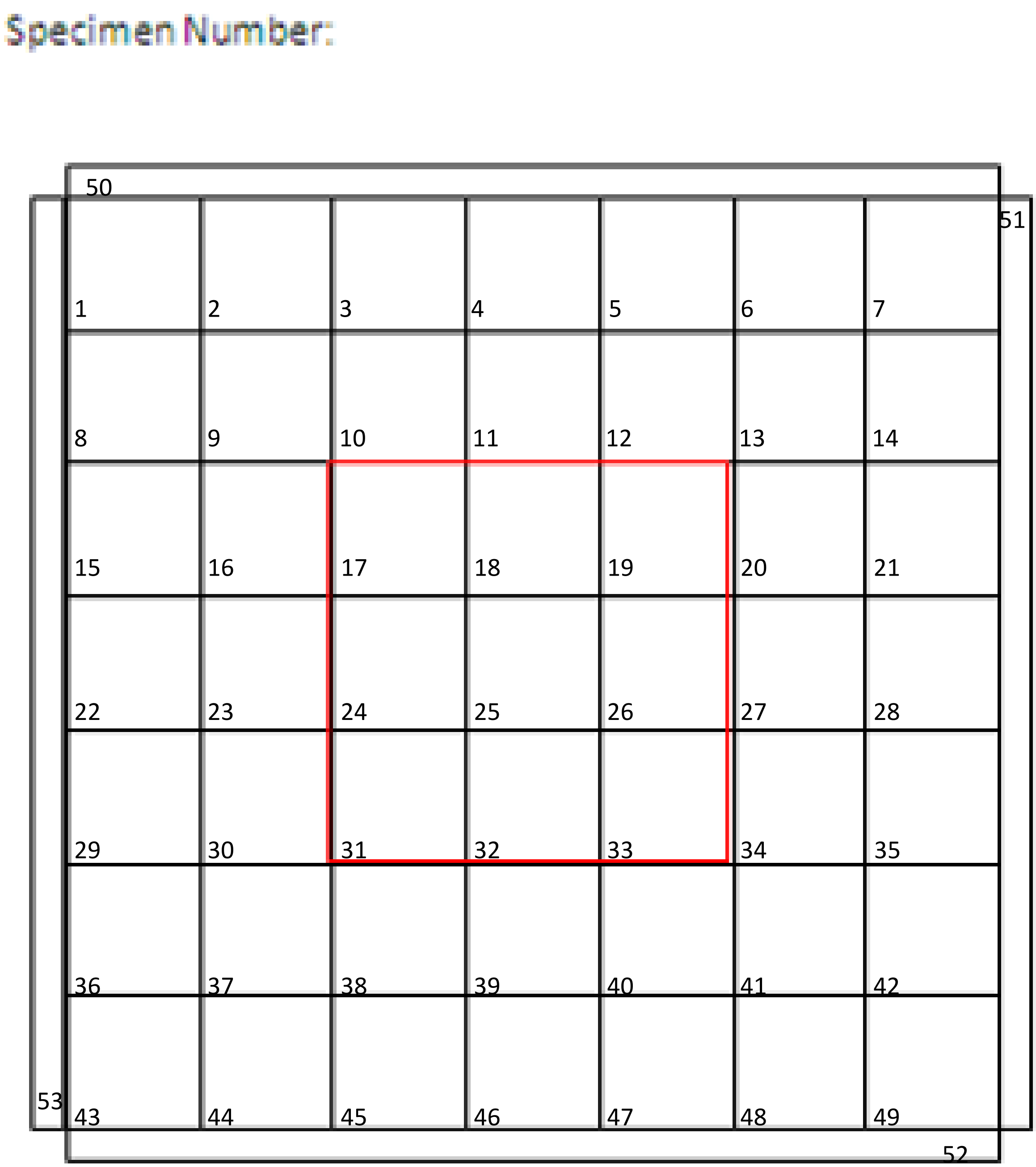

Figure 10: Grid pattern created on Microsoft PowerPoint used to record degradation and weakening. Numbers 1-49 represent the area of fabric that will be analyzed (19,600 mm^2). Numbers 17-33 represent the Center Value. Numbers 50-53 represent the edges of the fabric.

Specimen Number:

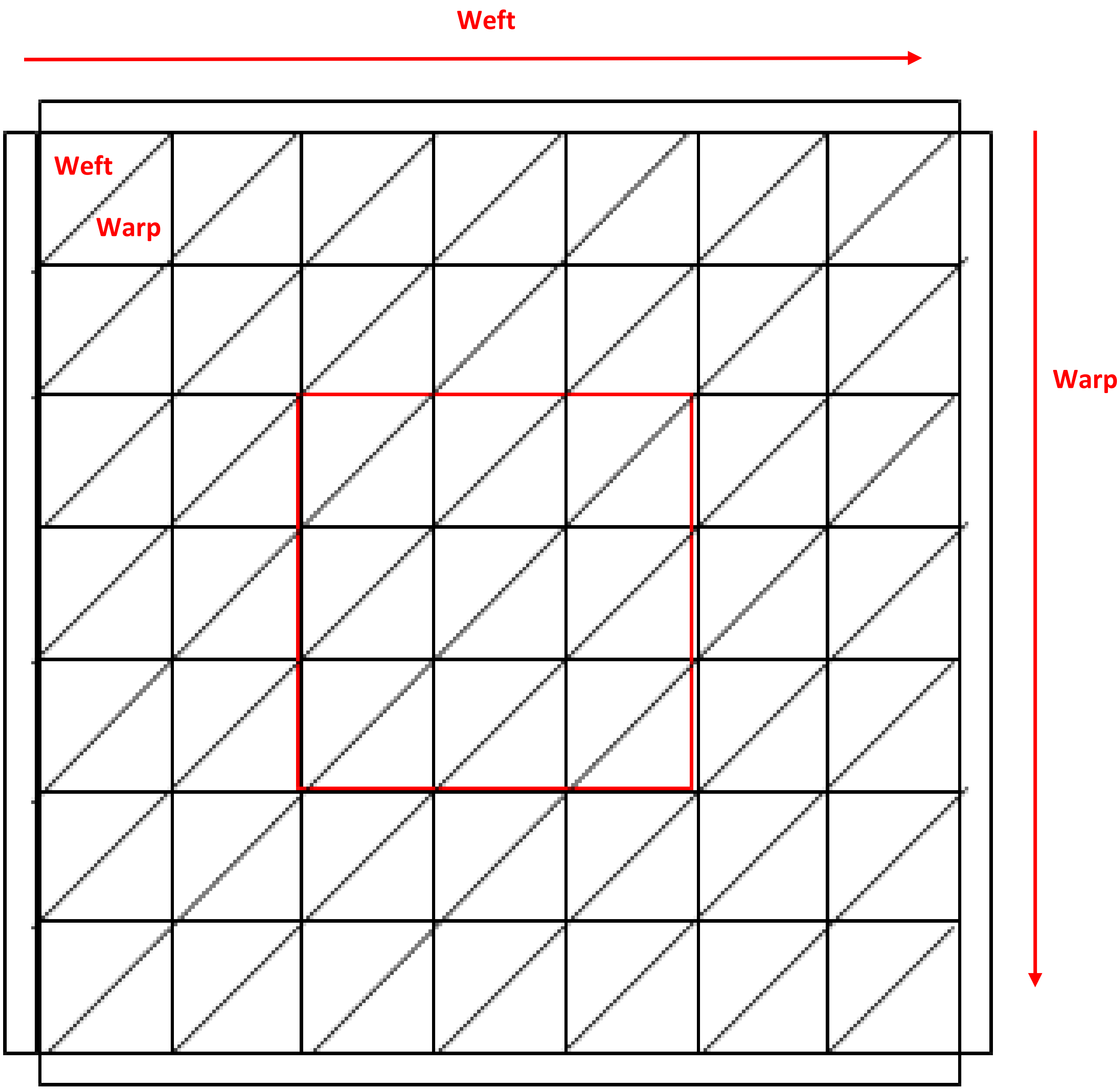

Figure 11: Grid pattern used for recording changes in warp and weft of fabric swatches. The 49, 2cm squares are divided by a diagonal line to isolate degradation of warp and weft. Warp yarns are oriented from top to bottom, while weft yarns are oriented from left to right. The Center Value is represented by the center square outlined in red. The edges are above, below, right, and left of the 49 squares.

Chapter 4: Results

Observations were recorded when returning to the research site to obtain data from the weather station or to collect that month's fabric swatches. After three days into the experiment, insect activity was noticed on the Ground Surface samples; including ants. After 12 days, the fabric swatches at the Ground Surface Area had noticeable meat stains located in the center of the fabric with an accumulation of organic material and insect activity. Collection became more increasingly difficult for the cotton samples in Trench 1 and 2 as these degraded the fastest. Below is a picture summary of the fabric swatches recovered each month from each Area (Figures 12-23). It is evident that the fabric swatches are being altered in phases; first is discoloration, next is weakening, and last is degradation. This change in the fabric is begins in where the meat was placed on the fabric. Therefore, the fabric swatches positioned flat with the meat placed in the center are beginning to degrade from the center and outward, while the fabric swatches positioned crumpled with the meat placed in the center are degrading in different sections where the fabric overlapped under the meat.

Results of the pH testing that was obtained from soil samples during Month 4 of the experiment are found in Table 7. A number of the soil samples from the Ground Surface resulted in an acidic pH, while the majority tested a neutral 7. According to the Orange County IFAS Extension, the pH results correlated with what is likely to be found in the Central Florida soils.

Table 7: Location of where the soil sample was collected and the results of the pH test for each sample.

Location of Soil Sample	pH
Control	4.5
Surface of the Ground Surface (border)	4.5
Surface of the Ground Surface (middle)	7
Surface of Trench 1 (wall)	7
Surface of Trench 1 (disturbed soil)	7
15 cm deep in Trench 1 (wall)	7
15 cm deep in Trench 1 (disturbed soil)	7
30 cm deep in Trench 1 (wall)	7
30 cm deep in Trench 1 (disturbed soil)	7
Surface of Trench 2 (wall)	7
Surface of Trench 2 (disturbed soil)	7
30 cm deep in Trench 2 (wall)	7
30 cm deep in Trench 2 (disturbed soil)	7
60 cm deep in Trench 2 (wall)	7
60 cm deep in Trench 2 (disturbed soil)	7

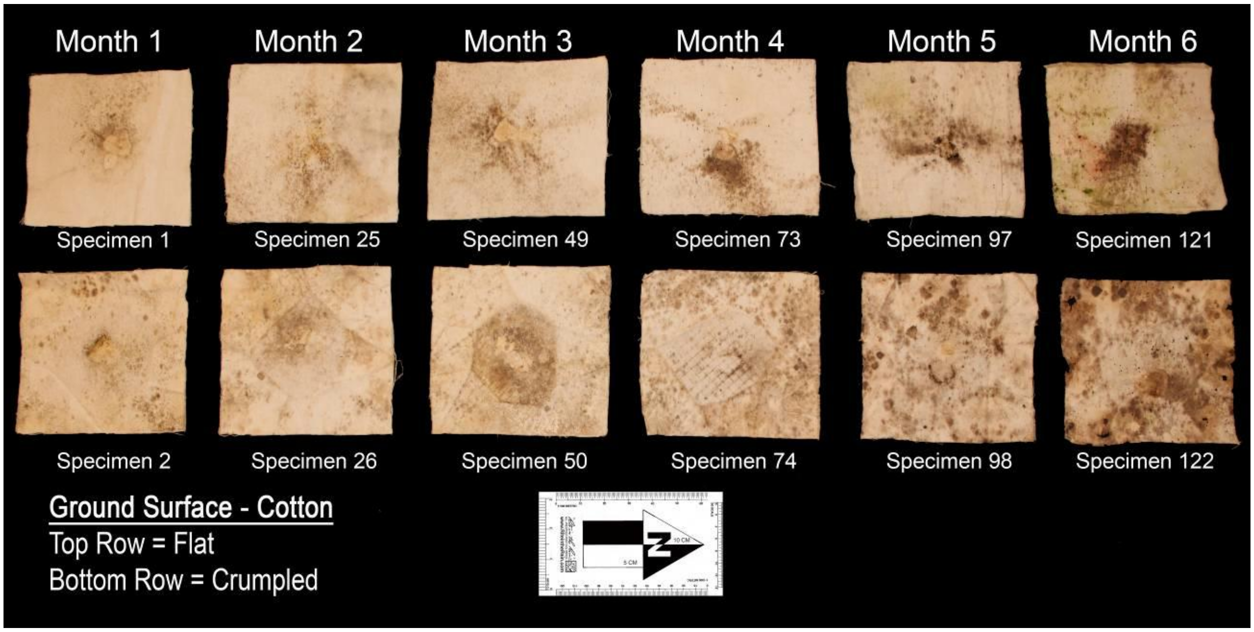

Figure 12: Cotton fabric swatches collected from the Ground Surface for the duration of 6 months.

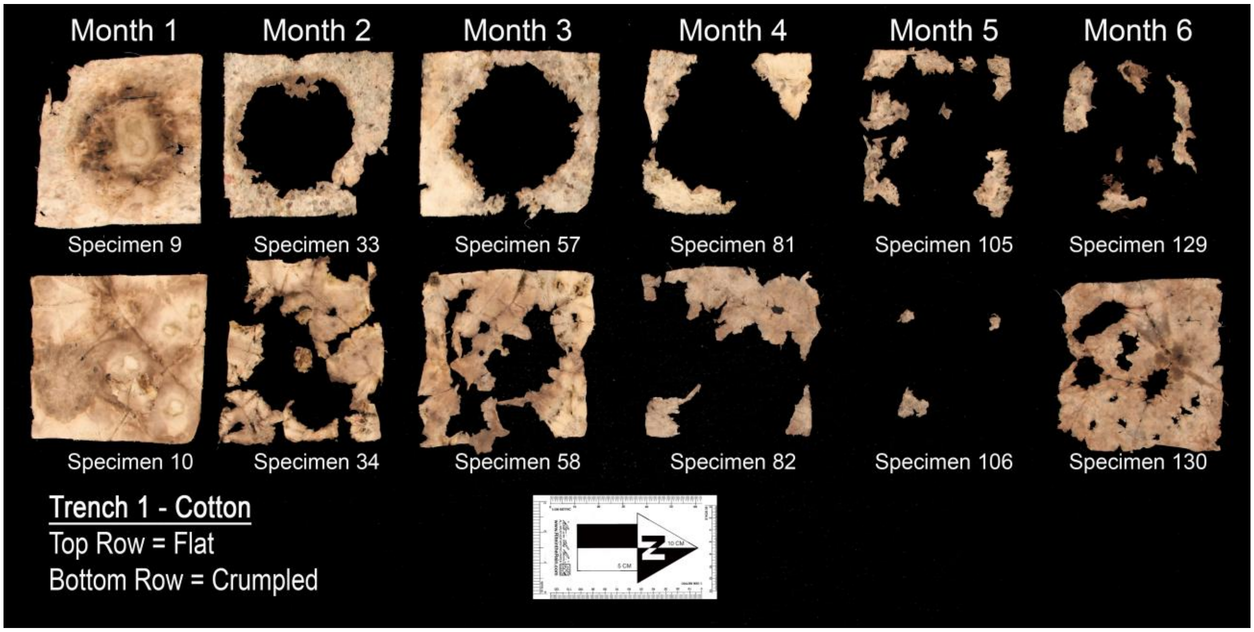

Figure 13: Cotton fabric swatches collected from Trench 1 for the duration of 6 months.

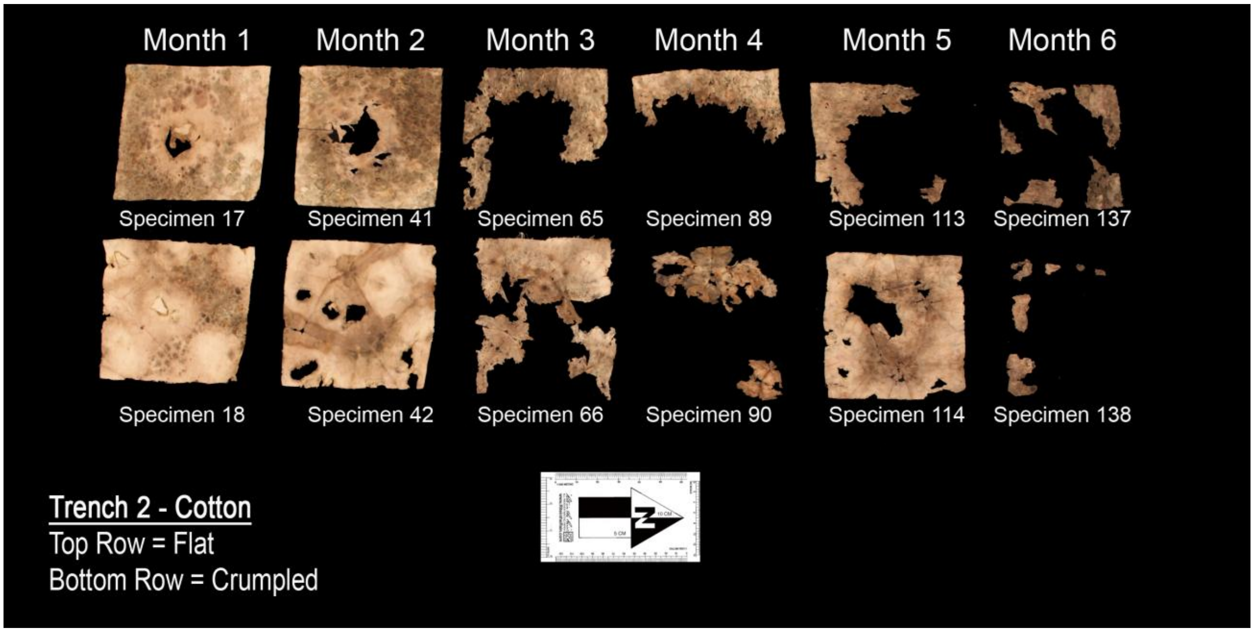

Figure 14: Cotton fabric swatches collected from Trench 2 for the duration of 6 months.

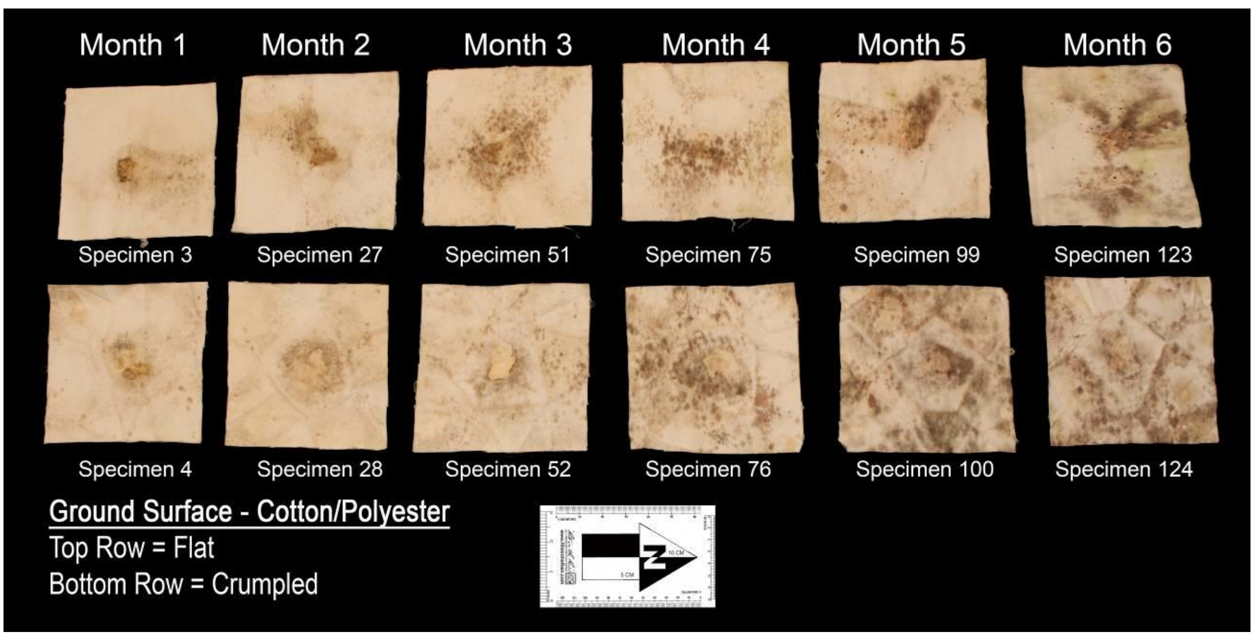

Figure 15: Cotton/polyester fabric swatches collected from the Ground Surface for the duration of 6 months.

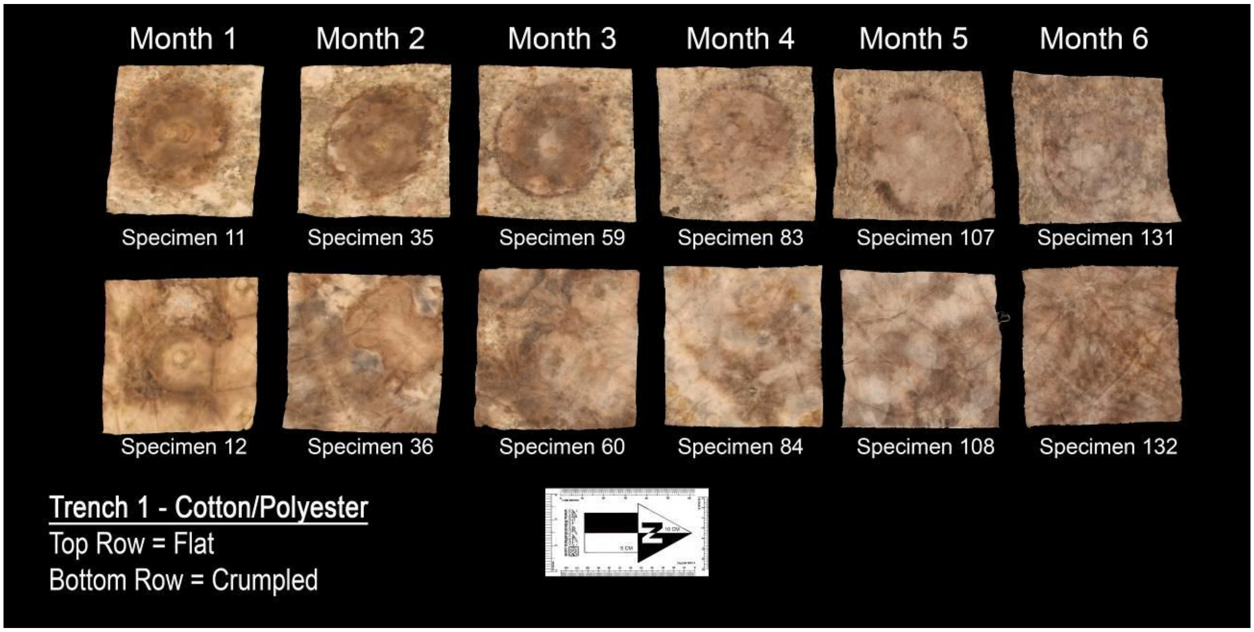

Figure 16: Cotton/polyester fabric swatches collected from Trench 1 for the duration of 6 months.

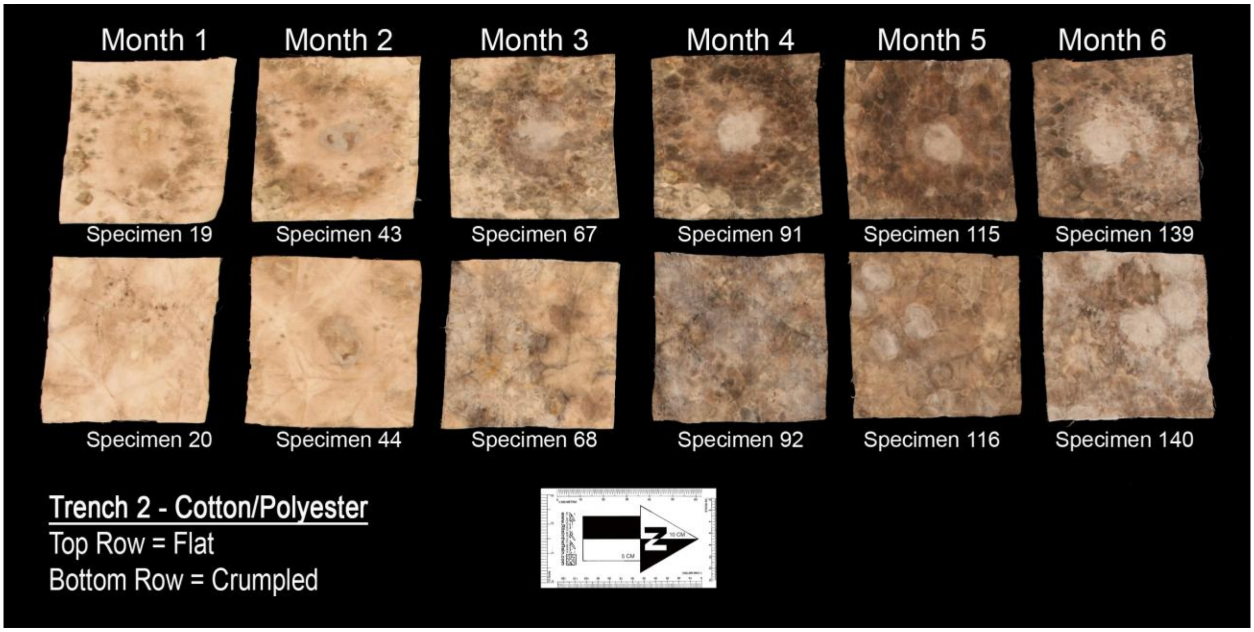

Figure 17: Cotton/polyester fabric swatches collected from Trench 2 for the duration of 6 months.

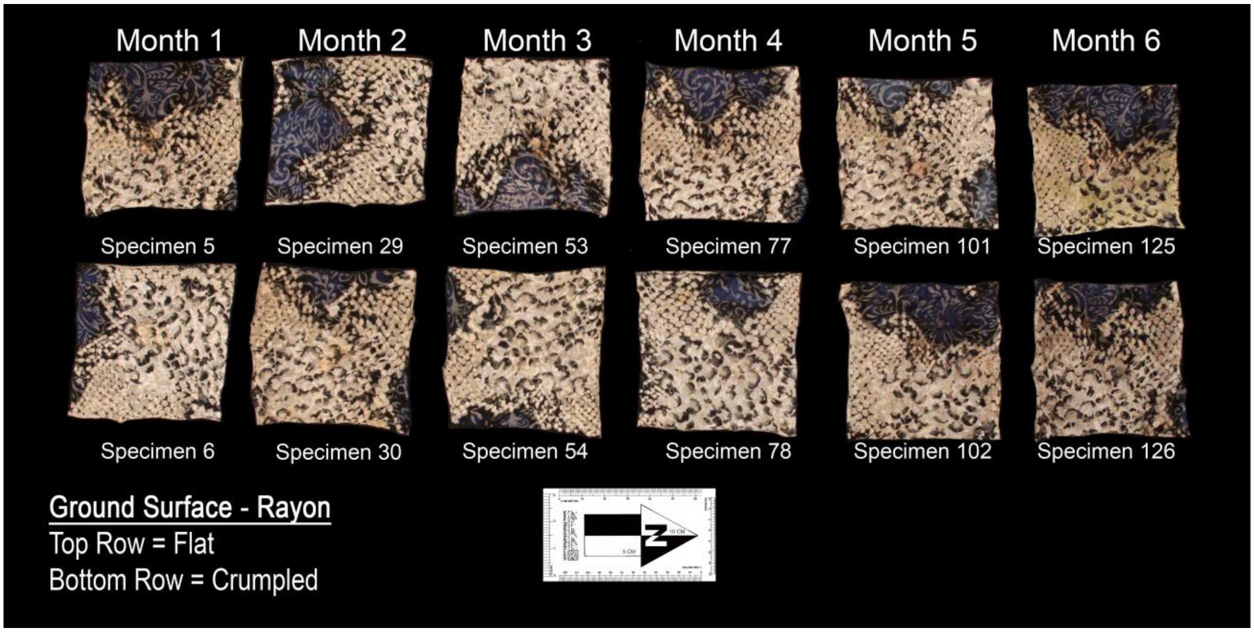

Figure 18: Rayon fabric swatches collected from the Ground Surface for the duration of 6 months.

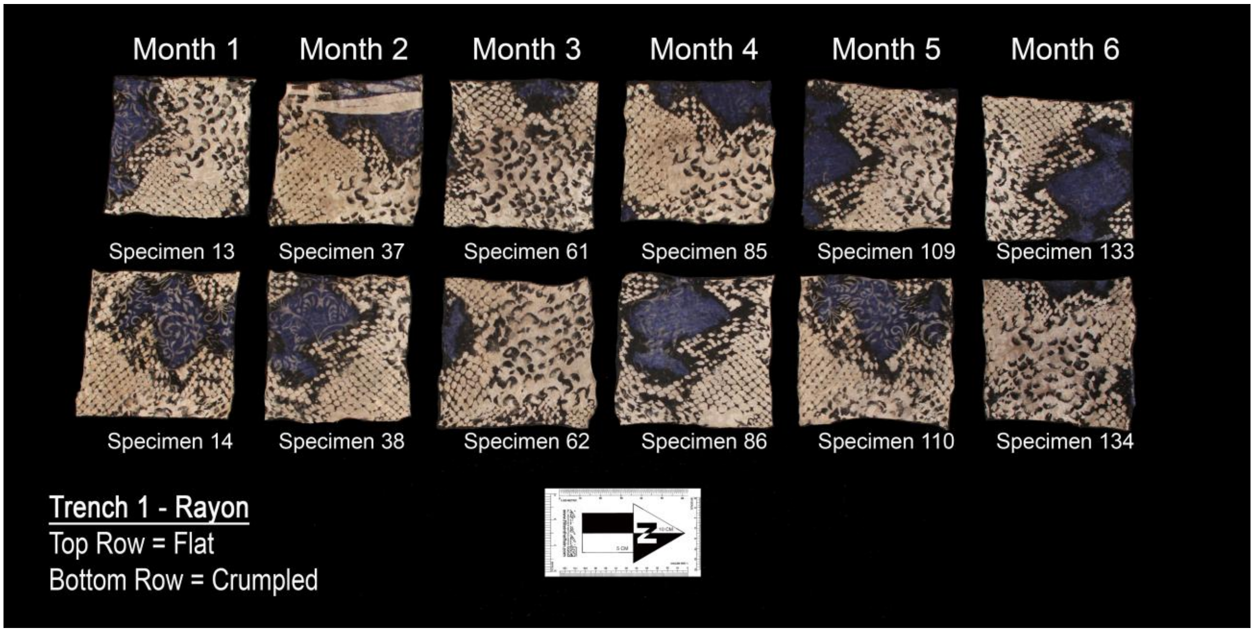

Figure 19: Rayon fabric swatches collected from Trench 1 for the duration of 6 months.

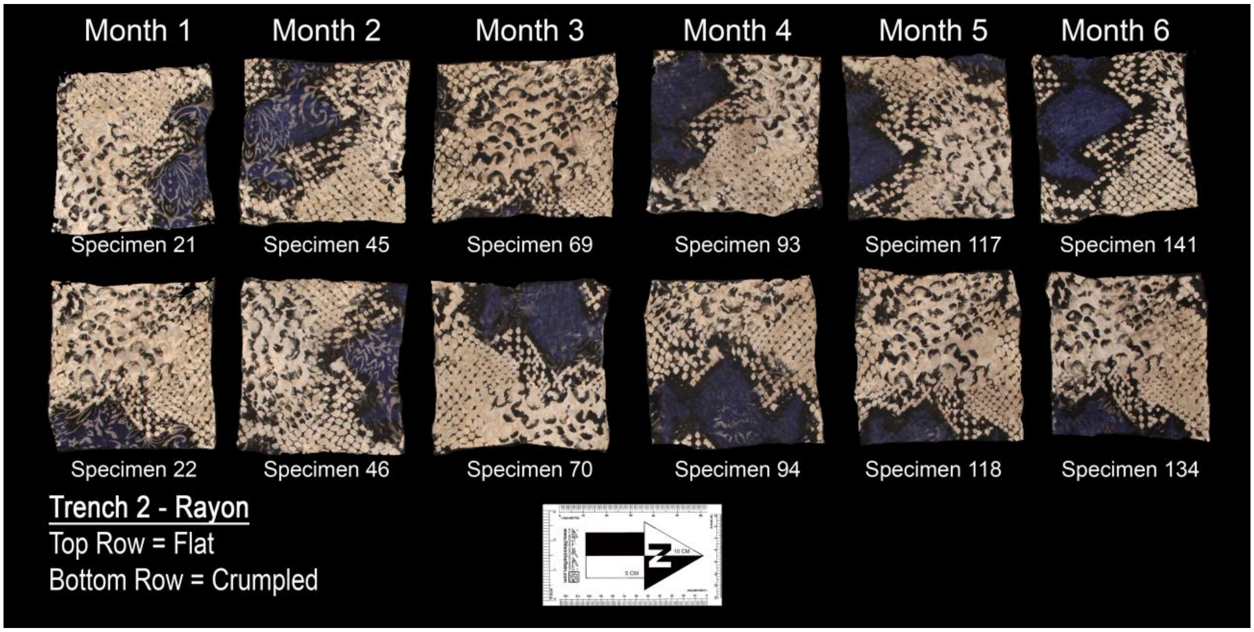

Figure 20: Rayon fabric swatches collected from Trench 2 for the duration of 6 months.

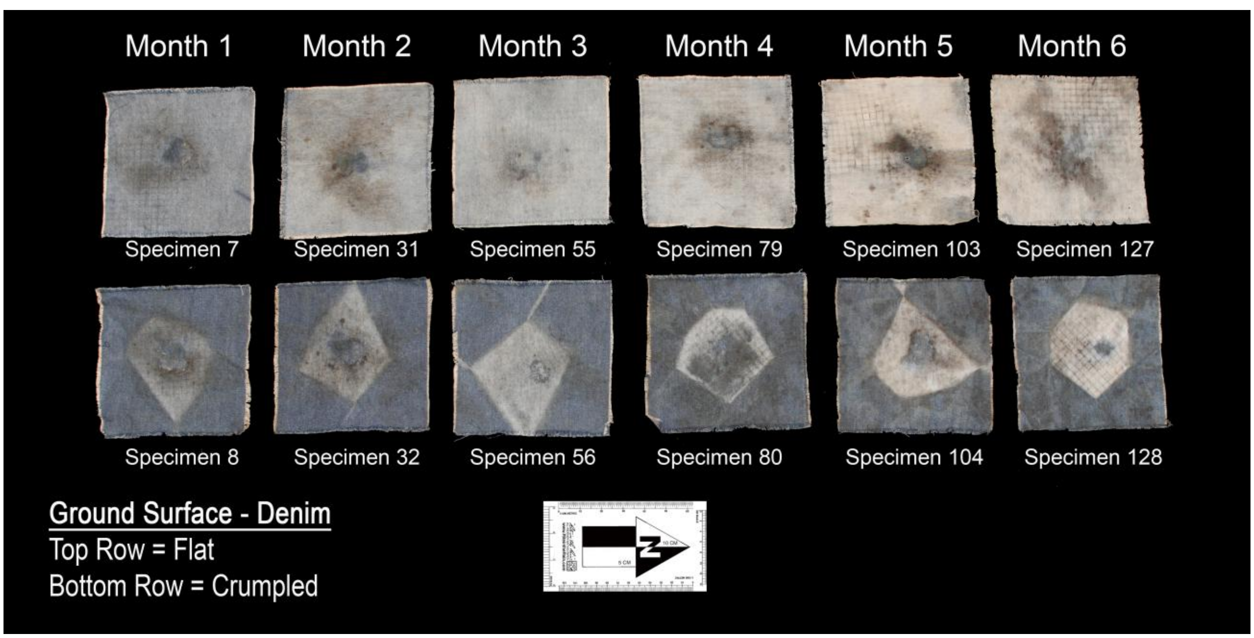

Figure 21: Denim fabric swatches collected from the Ground Surface for the duration of 6 months.

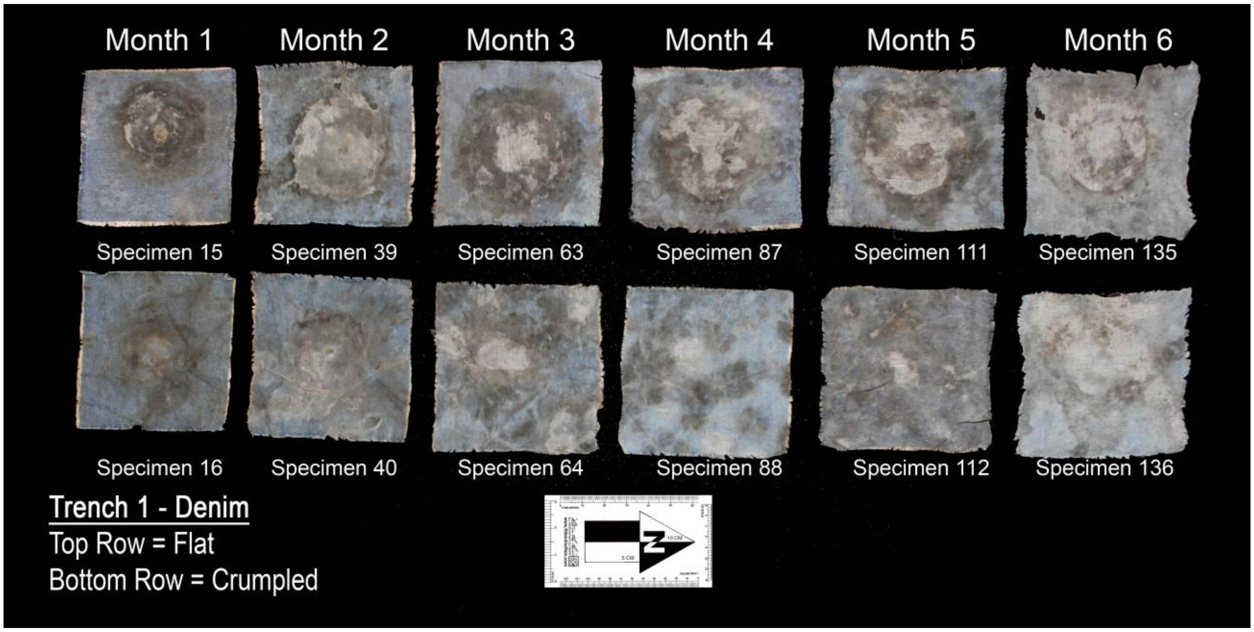

Figure 22: Denim fabric swatches collected from Trench 1 for the duration of 6 months.

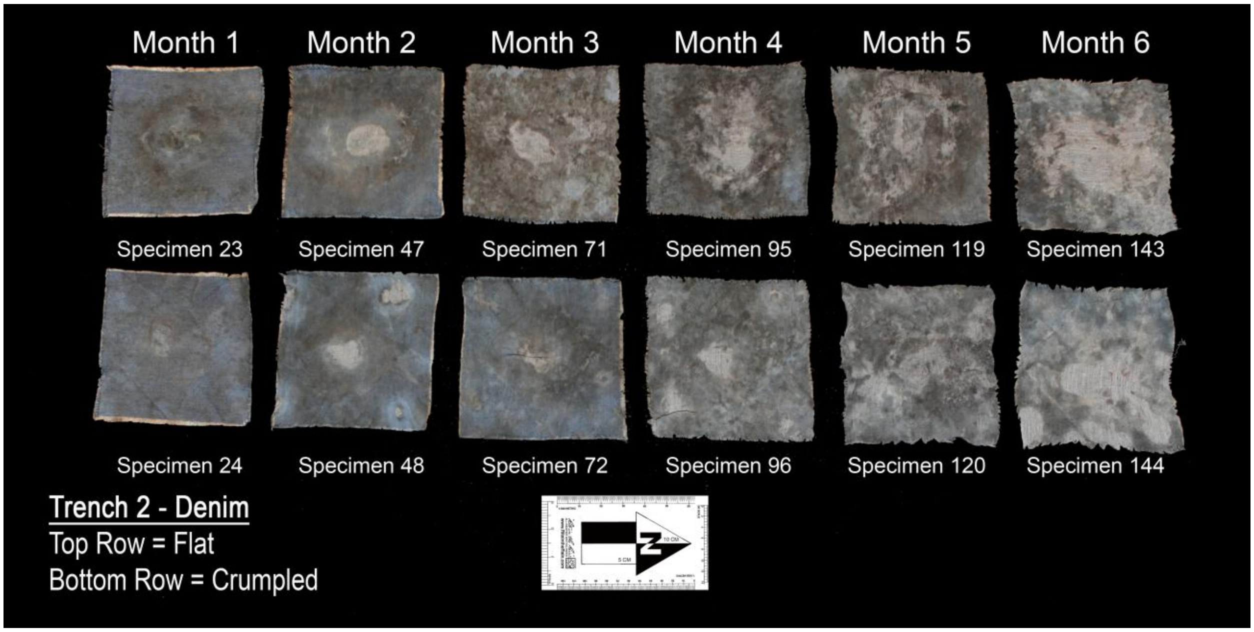

Figure 23: Denim fabric swatches collected from Trench 2 for the duration of 6 months.

Cotton

Flat

Results for the degradation of cotton fabric swatches positioned flat can be found in Table 8. For the duration of the 6 months, cotton fabric swatches positioned flat that were retrieved from the Ground Surface were best preserved with less than 1% total degradation.

After 6 months, there was a significant increase in the degradation of cotton fabrics positioned flat in Trench 1 and Trench 2. By Month 3, more than 50% of the fabric swatches were degraded.

Crumpled

Results for the degradation of cotton fabric swatches positioned crumpled can be found in Table 9. Fabric swatches positioned crumpled that were retrieved from the Ground Surface after six months demonstrated little to no degradation, less than 1%.

Fabric swatches in Trench 1 and Trench 2 that were positioned crumpled demonstrated an increase in degradation for the duration of the experiment. By Month 3, less than 50% of the fabric was degraded.

Comparison

Cotton fabric swatches that were positioned flat and crumpled both demonstrated very little degradation at the Ground Surface (Figure 26). Fabric swatches positioned both flat and crumpled which were collected from Trench 1 and Trench 2 were more degraded than the samples from the Ground Surface. Flat and crumpled fabric swatches retrieved from Trench 1, however, began to significantly degrade by Month 2. In comparison, those in Trench 2 had more delayed degradation, with fabric swatches demonstrating close to 50% total degradation by Month 3 (Figures 24 and 25). Cotton fabric swatches that were positioned flat began degrading faster than those positioned crumpled in all three Areas, especially after Month 3 (Figures 26-28).

Table 8: Total percent degradation of cotton fabric swatches that were positioned flat in the three studied areas for a duration of 6 months.

	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
Ground Surface	0.04%	0%	0.01%	0.31%	0.37%	0.84%
Trench 1	4.8%	46.93%	50.65%	73.01%	68.51%	81.19%
Trench 2	2.83%	8.49%	55.40%	72.24%	66.44%	70.26%

Table 9: Total percent degradation for cotton fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
Ground Surface	0%	0%	0%	0.04%	0.32%	0.99%
Trench 1	0.13%	30.29%	34.39%	73.52%	96.1%	17.21%
Trench 2	0.17%	6.33%	40.52%	72.93%	12.9%	90.77%

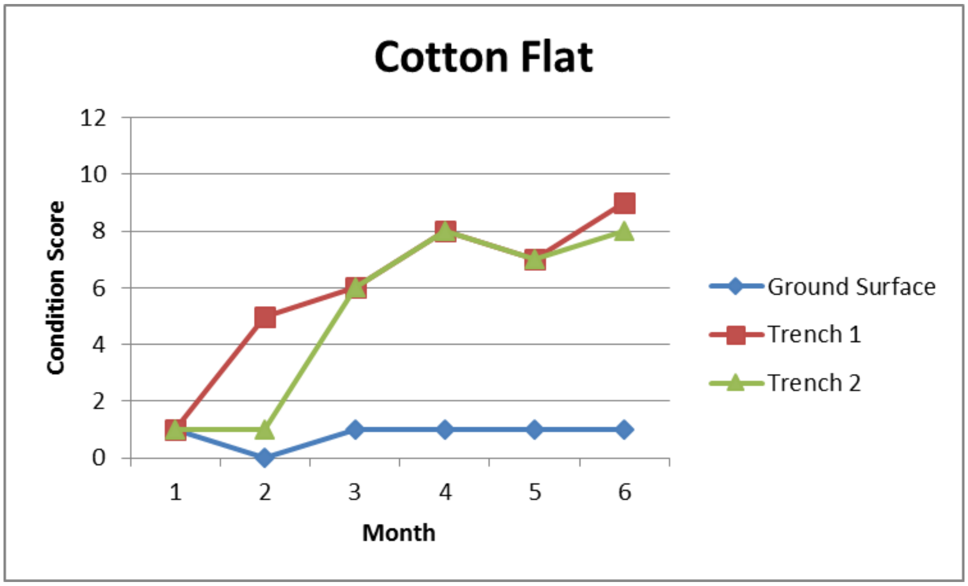

Figure 24: Condition scores of cotton fabric swatches that were positioned flat in all three studied areas for a duration of 6 months.

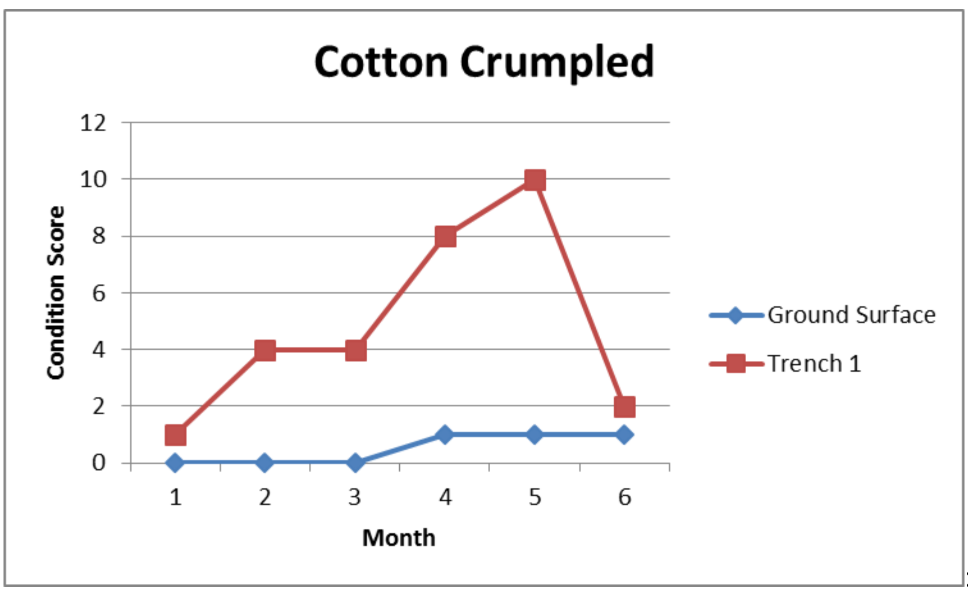

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Figure 25: Condition scores for cotton fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

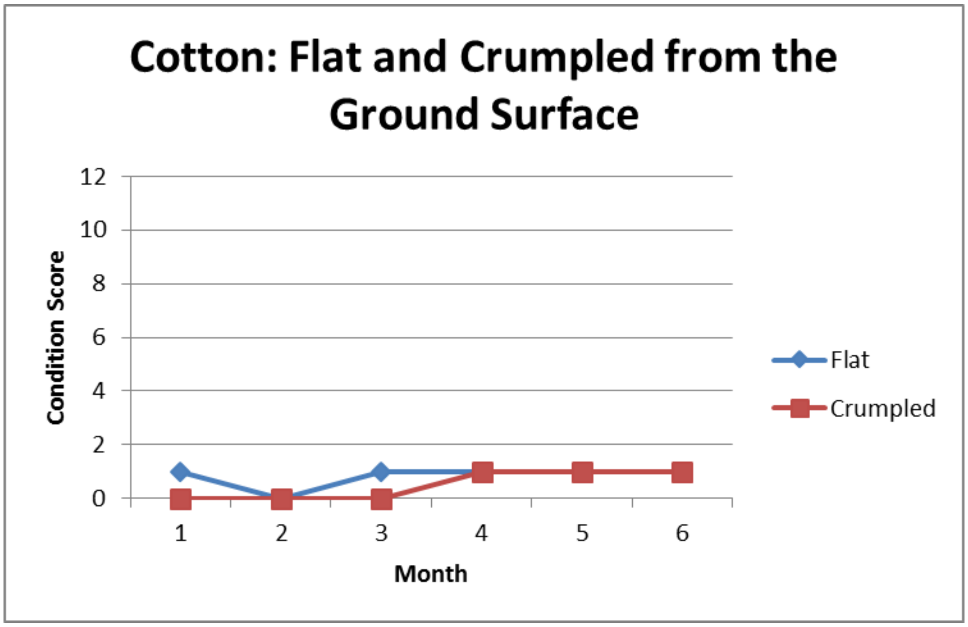


Figure 26: Condition scores of cotton fabric swatches that were positioned flat and crumpled from the Ground Surface for a duration of 6 months.

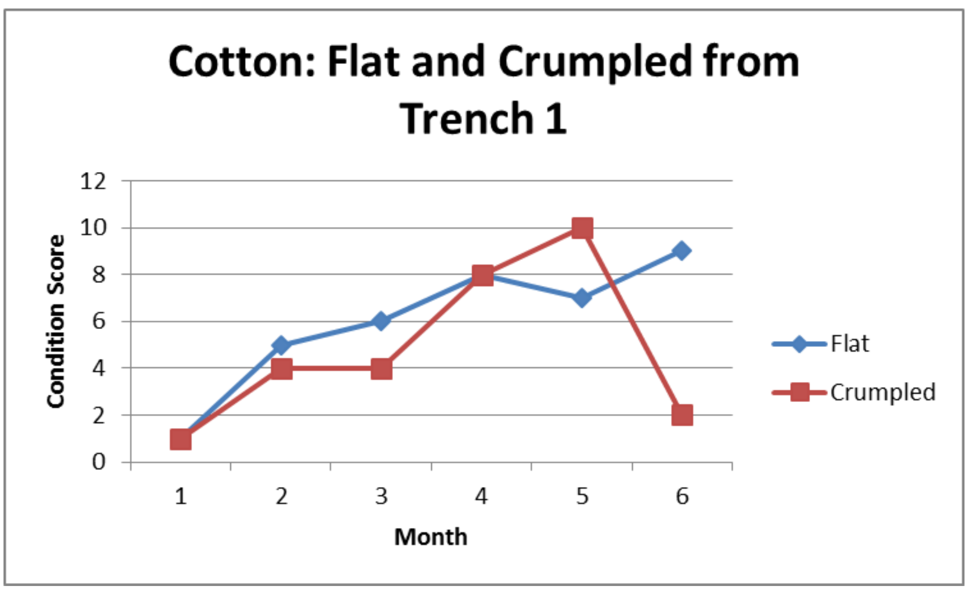


Figure 27: Condition scores for cotton fabric swatches that were positioned flat and crumpled from Trench 1 after a duration of 6 months.

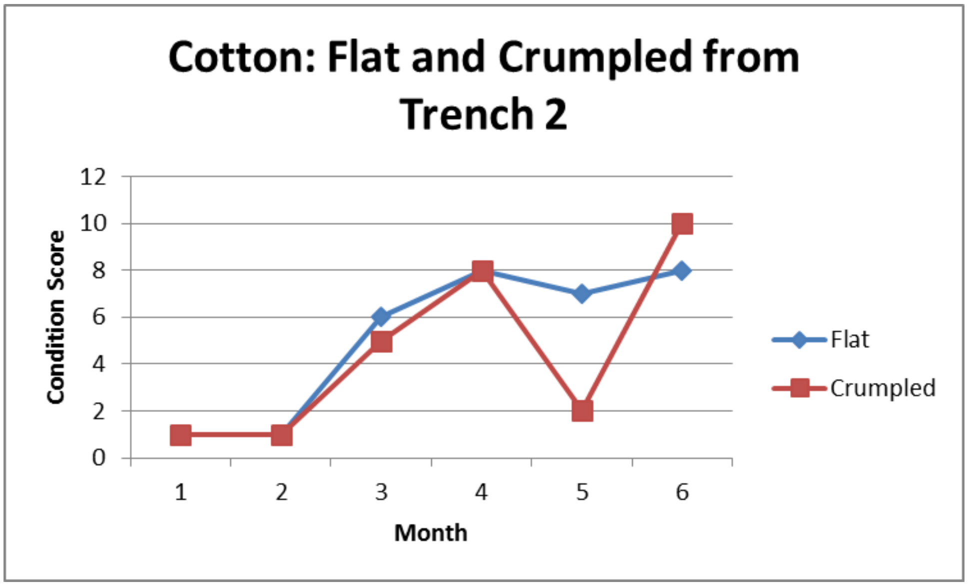


Figure 28: Condition scores for cotton fabric swatches that were positioned flat and crumpled in Trench 2 after a duration of 6 months.

Cotton/Polyester

Flat

Results for the degradation of cotton/polyester fabric swatches positioned flat can be found in Table 10. For the duration of the 6 months, cotton/polyester fabric swatches positioned flat from all three studied Areas preserved well with less than 1% total degradation.

Crumpled

Results for the degradation of cotton/polyester fabric swatches positioned crumpled can be found in Table 11. After the duration of 6 months, all but one fabric swatch had 0% total degradation.

Comparison

Although all cotton/polyester fabric swatches from all three studied Areas demonstrated very little degradation, those positioned flat had more degradation between 0% - 1%; therefore they received higher condition scores (Figures 31-33).

Table 10: Total percent degradation of cotton/polyester fabric swatches that were positioned flat in the three studied areas for a duration of 6 months.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0%	0.04%	0.01%	0%	0.72%	0.5%
Trench 1	0.02%	0%	0%	0%	0.02%	0%
Trench 2	0.01%	0%	0%	0.01%	0.01%	0.02%

Table 11: Total percent degradation for cotton/polyester fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0%	0%	0%	0%	0%	0.03%
Trench 1	0%	0%	0%	0%	0%	0%
Trench 2	0%	0%	0%	0%	0%	0%

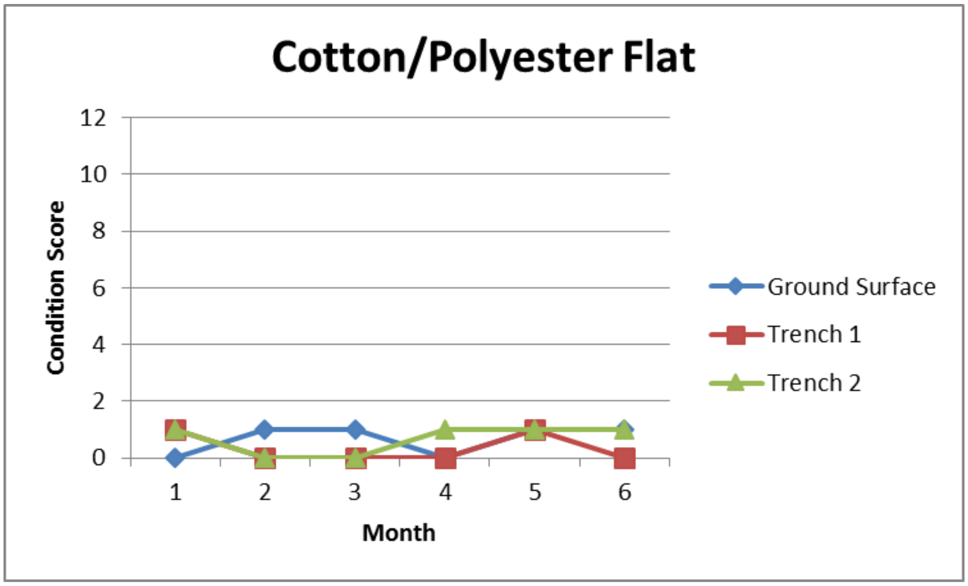


Figure 29: Condition scores of cotton/polyester fabric swatches that were positioned flat in all three studied areas for a duration of 6 months.

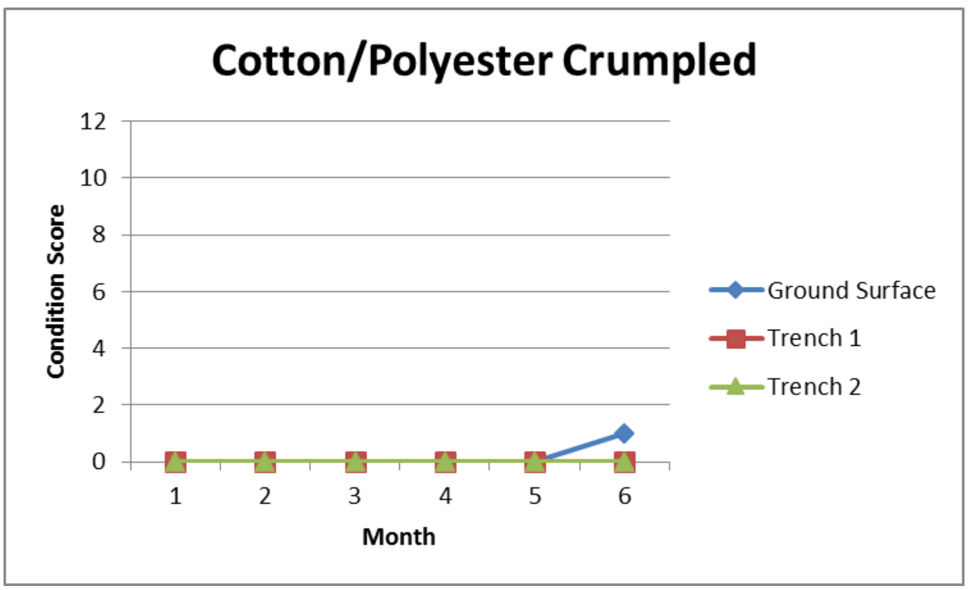


Figure 30: Condition scores for cotton/polyester fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

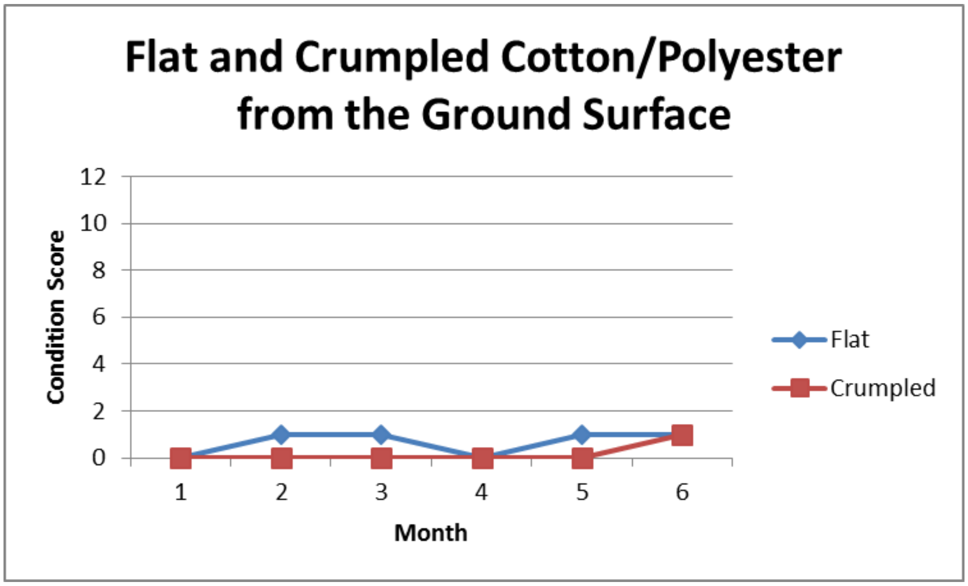


Figure 31: Condition scores for cotton/polyester fabric swatches that were positioned flat and crumpled on the Ground Surface after a duration of 6 months.

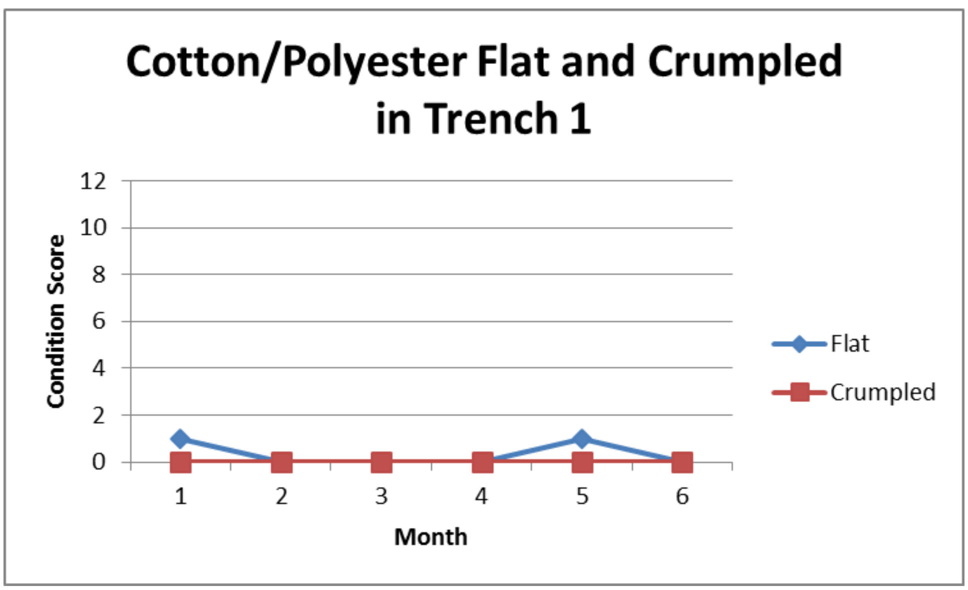


Figure 32: Condition scores for cotton/polyester fabric swatches that were positioned flat and crumpled in Trench 1 for a duration of 6 months.

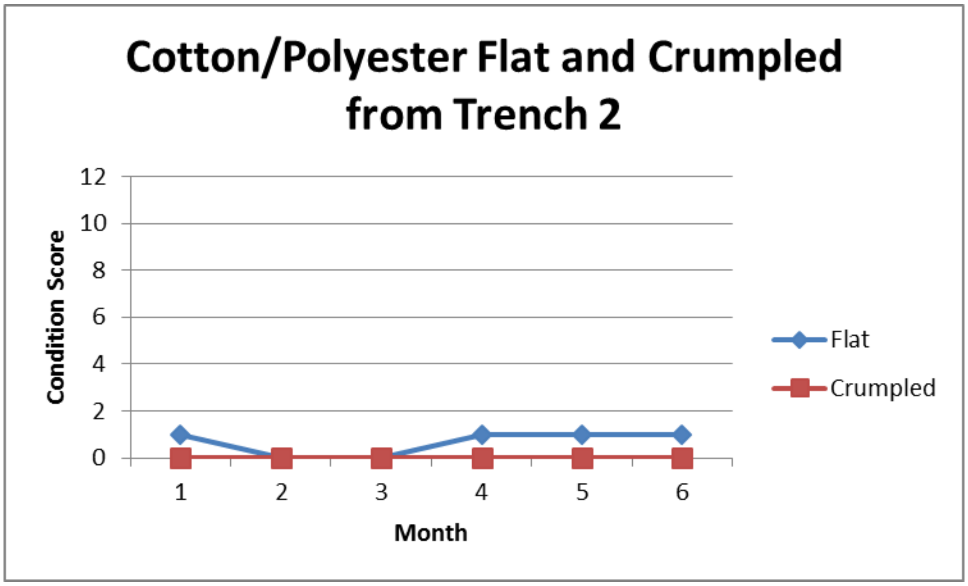


Figure 33: Condition score for cotton/polyester fabric swatches that were positioned flat and crumpled in Trench 2 for a duration of 6 months.

<u>Rayon</u>

Flat

Results for the degradation of rayon fabric swatches positioned flat can be found in Table 12. For the duration of the 6 months, fabric swatches positioned flat from all three studied Areas demonstrated less than 1% total degradation. Those collected on the Ground Surface demonstrated between 0% and 1% total degradation. Fabric swatches retrieved from Trench 1 and Trench 2 had 0% total degradation.

Crumpled

Results for the degradation of rayon fabric swatches positioned crumpled can be found in Table 13. For the duration of the experiment, fabric swatches positioned crumpled that were retrieved from all three studied Areas showed less than 1% total degradation. The fabric swatches collected from the Ground Surface showed degradation higher than 0% but less than 1%, while the fabric swatches from Trench 1 and Trench 2 demonstrate 0% total degradation.

Comparison

All rayon fabric swatches in all three studied Areas demonstrated less than 1% total degradation. However, fabric swatches that were positioned flat and crumpled on the Ground Surface degraded more than the other Areas, receiving higher condition scores (Figures 34 and 35).

Table 12: Total percent degradation of rayon fabric swatches that were positioned flat in the three studied areas for a duration of 6 months.

	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
Ground Surface	0.23%	0.02%	0.13%	0.16%	0.2%	0.21%
Trench 1	0%	0%	0%	0%	0%	0%
Trench 2	0%	0%	0%	0%	0%	0%

Table 13: Total percent degradation of rayon fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
Ground Surface	0%	0.06%	0.03%	0.06%	0.06%	0.02%
Trench 1	0%	0%	0%	0%	0%	0%
Trench 2	0%	0%	0%	0%	0%	0%

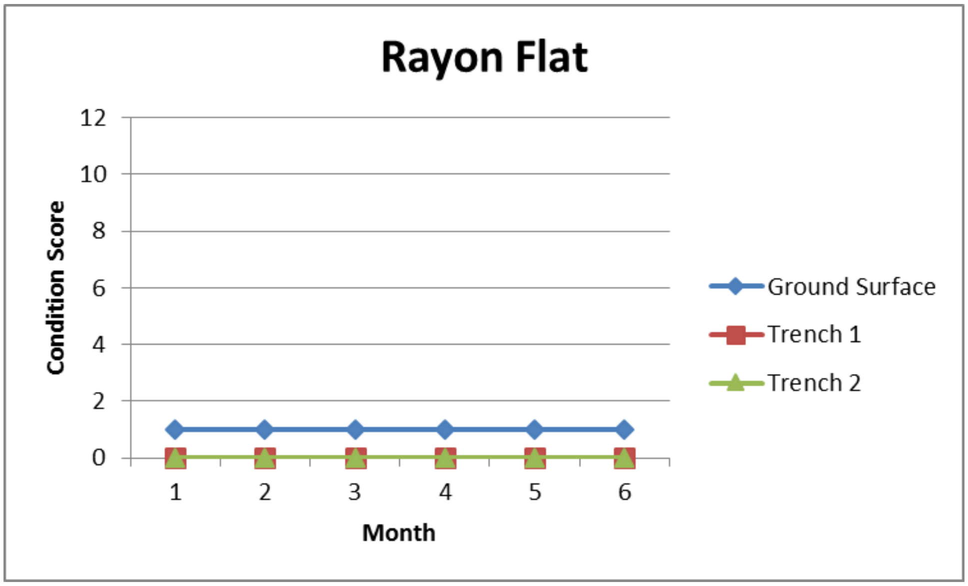


Figure 34: Condition scores of rayon fabric swatches that were positioned flat in all three studied areas for a duration of 6 months.

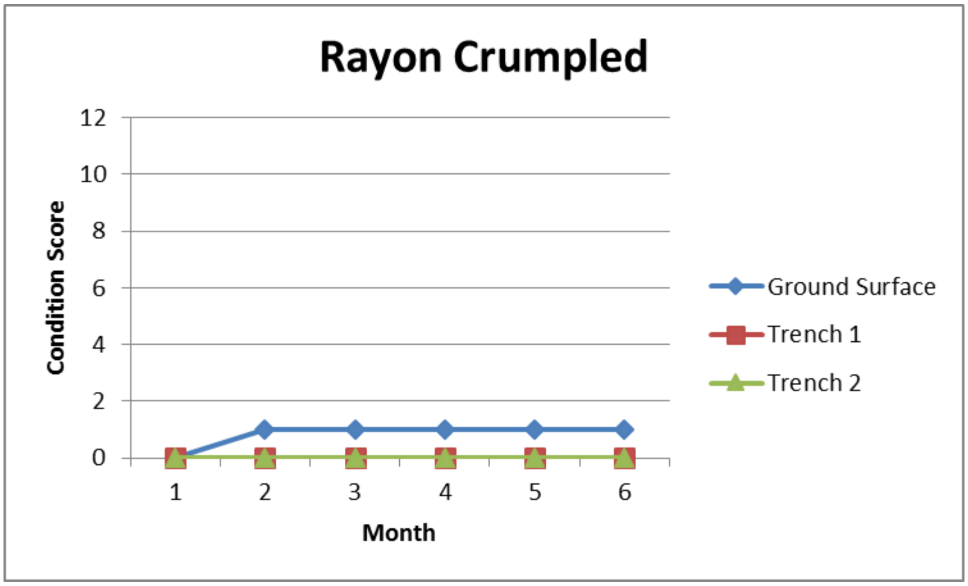


Figure 35: Condition scores of rayon fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

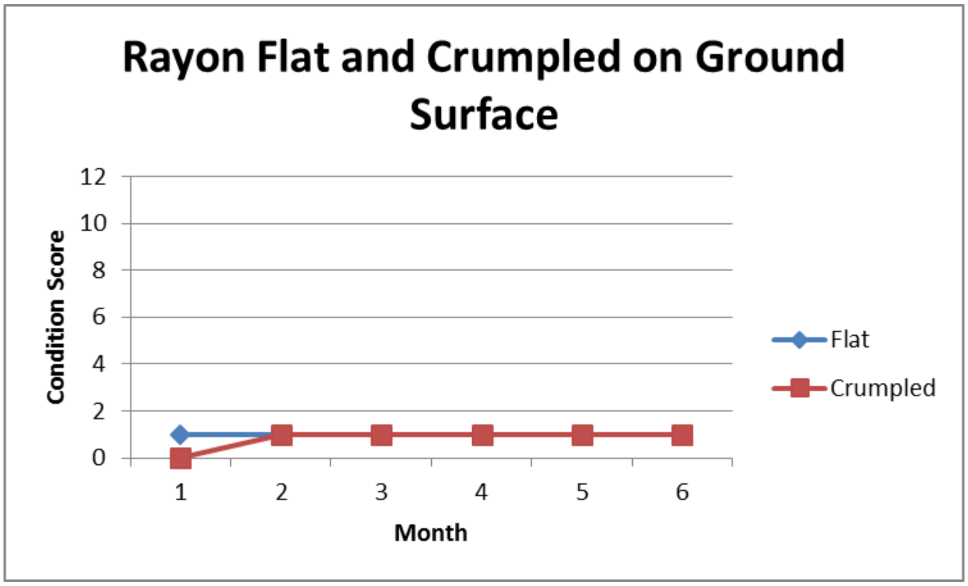


Figure 36: Condition scores for rayon fabric swatches that were positioned flat and crumpled on the Ground Surface for a duration of 6 months.

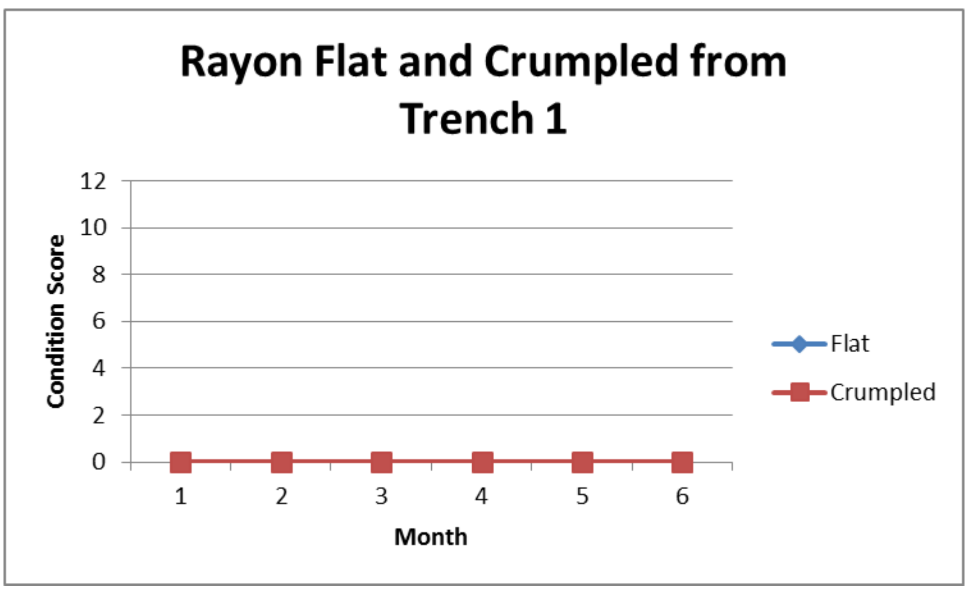


Figure 37: Condition scores for rayon fabric swatches that were positioned flat and crumpled in Trench 1 for a duration of 6 months.

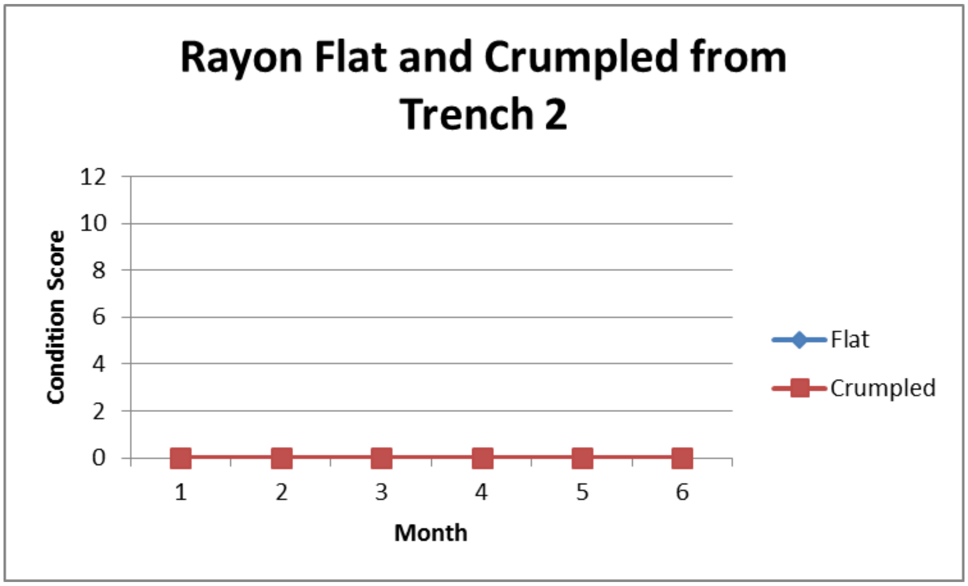


Figure 38: Condition scores for rayon fabric swatches that were positioned flat and crumpled in Trench 2 for a duration of 6 months.

<u>Denim</u>

Flat

Results for the degradation of denim fabric swatches positioned flat can be found in Table 14. For the duration of the 6 months, denim fabric swatches positioned flat from all three studied Areas demonstrated less than 1% total degradation.

Crumpled

Results for the degradation of denim fabric swatches positioned crumpled can be found in Tables 15. All fabric swatches positioned crumpled in the three studied Areas show less than 1% total degradation.

Comparison

Denim fabric swatches positioned both flat and crumpled in all three studied Areas demonstrate less than 1% total degradation (Figures 39 and 40).

Table 14: Total percent degradation of denim fabric swatches that were positioned flat in the three studied areas for a duration of 6 months.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0%	0%	0%	0%	0.09%	0.43%
Trench 1	0.04%	0%	0.03%	0%	0.25%	0%
Trench 2	0%	0%	0%	0%	0.08%	0.06%

Table 15: Total percent degradation of denim fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0%	0%	0%	0.01%	0%	0%
Trench 1	0%	0%	0%	0%	0.05%	0%
Trench 2	0%	0%	0%	0%	0%	0%

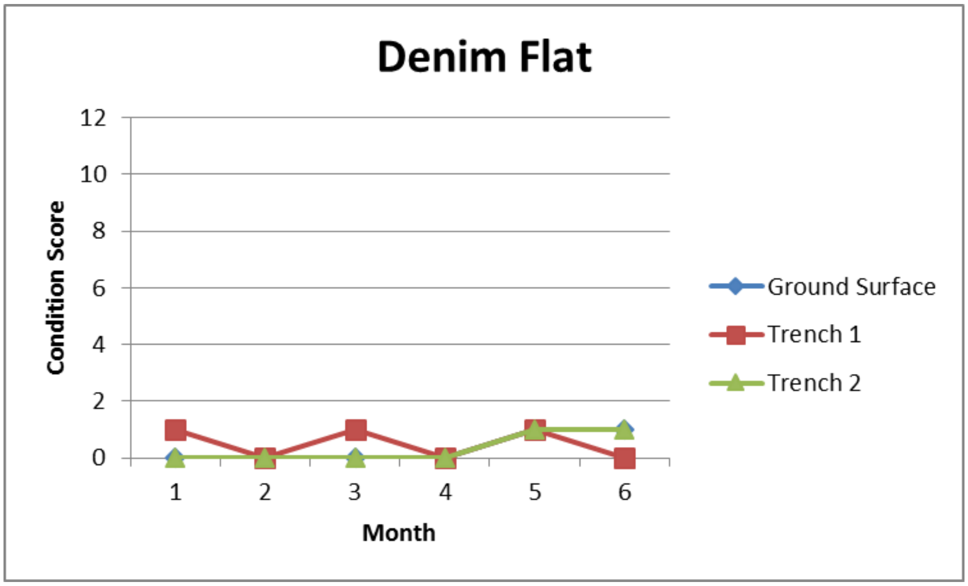


Figure 39: Condition scores of denim fabric swatches that were positioned flat in all three studied areas for a duration of 6 months.

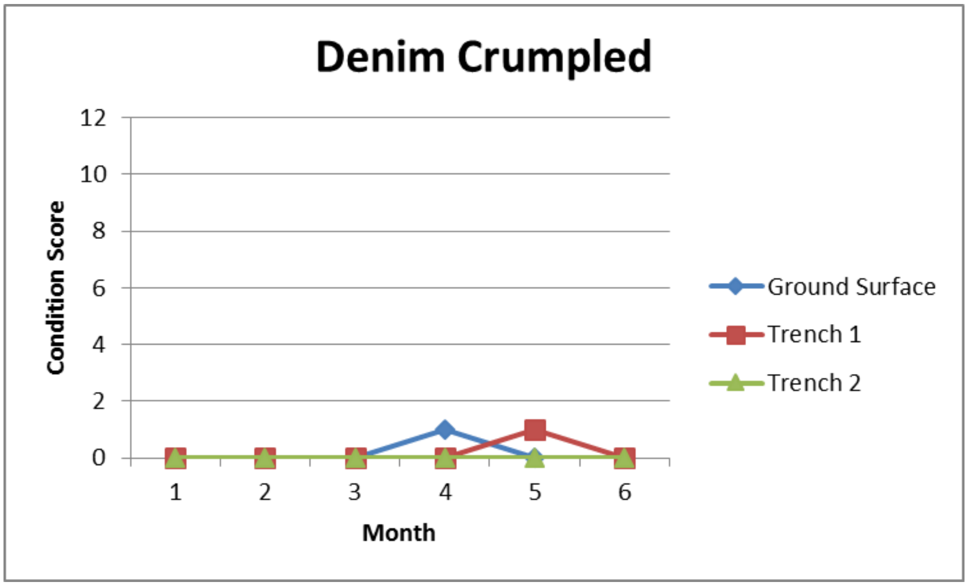


Figure 40: Condition scores of denim fabric swatches that were positioned crumpled in all three studied areas for a duration of 6 months.

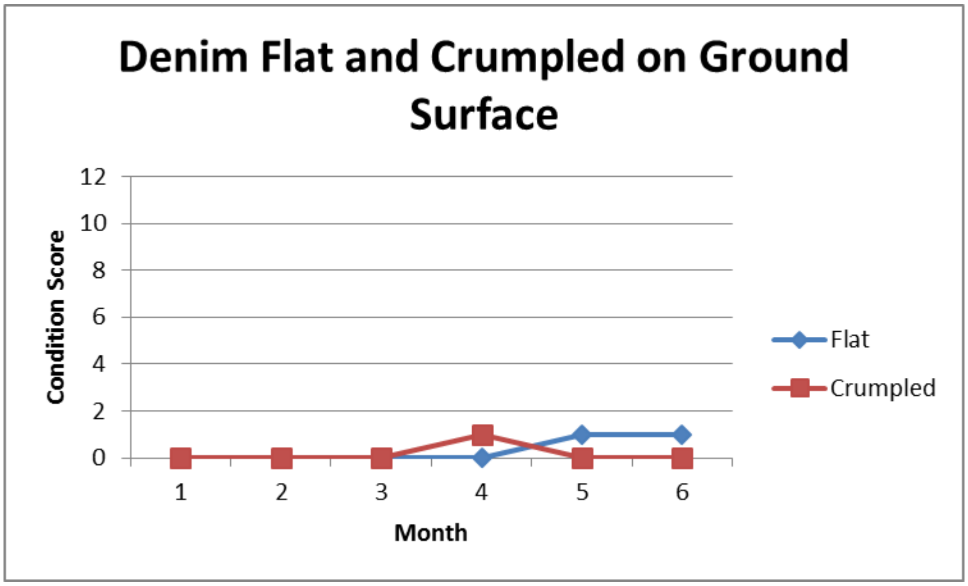


Figure 41: Condition scores for denim fabric swatches that were positioned flat and crumpled on the Ground Surface for a duration of 6 months.

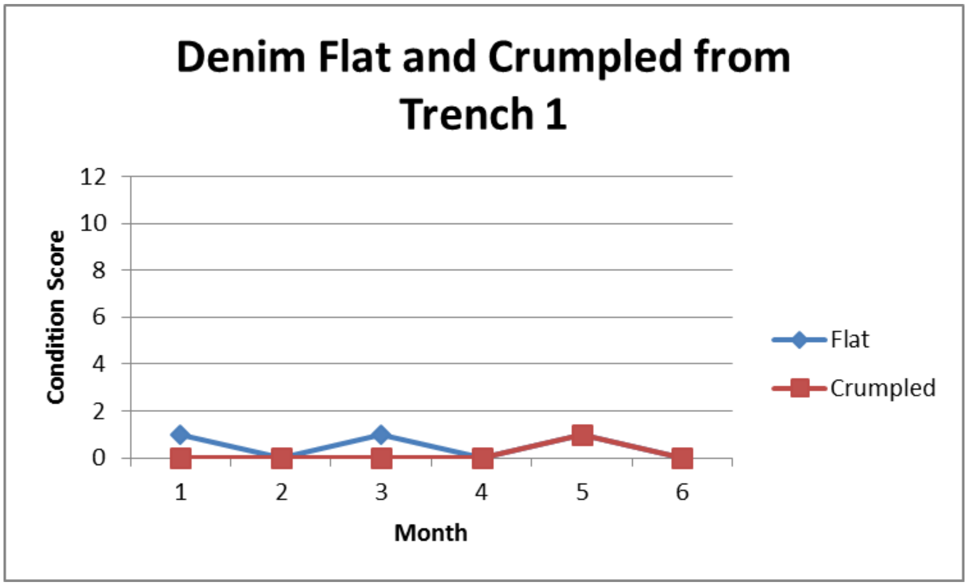


Figure 42: Condition scores for denim fabric swatches that were positioned flat and crumpled in Trench 1 for a duration of 6 months.

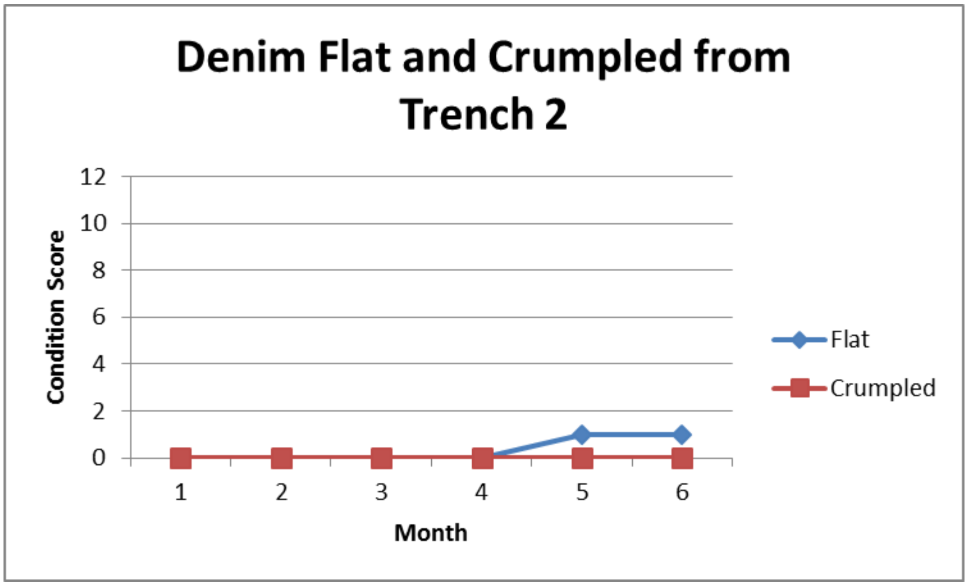


Figure 43: Condition scores for denim fabric swatches that were positioned flat and crumpled in Trench 2 for a duration of 6 months.

Rainfall

Results for the rainfall from the research site for the duration of 6 months can be found in Figure 45.

Area

Rainfall at the research site was about 0.5 inches or more for Months 3-6 of the experiment. The Ground Surface was the Area directly affected by the rainfall. This caused new plant growth in which blades of grass penetrated some of the fabric swatches. This event did not occur in Trench 1 or Trench 2.

Fabric Type

Cotton fabric swatches positioned flat and crumpled on the Ground Surface had less total percent degradation than the fabric swatches recovered from Trench 1 and Trench 2 (Figures 24 and 25). The cotton fabric swatches at this Area demonstrated less than 1% total degradation due to grass growth. Cotton/polyester, rayon, and denim fabric swatches positioned flat and crumpled also demonstrated less than 1% total degradation on the Ground Surface, and their damage can be attributed to new grass (Figures 46 and 49). Therefore, the degradation of cotton/polyester, rayon, and denim fabric swatches may be related to plant growth rather than soil moisture as in the case of cotton fabric swatches.

Soil Moisture

Results for the soil moisture of all the three studied Areas for the duration of 6 months can be found in Figure 44.

Area

The soil moisture fluctuated most on the Ground Surface. In this Area, the soil moisture would reach a maximum and then slowly decrease over a period of 1 to 2 weeks. It appeared to repeat this pattern for the duration of the 6 months. For a total of about 6 weeks, but not consecutively, the Ground Surface had a soil moisture content close to 0 m^3/m^3. This occurred during Months 2-5. According to the HOBO Weather Station User's Guide (2006), soil moisture at or below 0.1 m^3/m^3 is considered dry soil, while soil moisture at or above 0.3 m^3/m^3 is considered wet soil. Soil moisture rarely reached above 0.3 m^3/m^3 for the Ground Surface location.

The soil moisture in Trench 1 remained consistent at ~0.1 m^3/m^3 for the first three months of the experiment. Then it began to follow a similar pattern to that of the Ground Surface in which the soil moisture would reach a maximum and then decrease in the following weeks. The soil moisture in Trench 1 reached over 0.3 m^3/m^3 a few times during the last 2 months of the experiment.

The soil moisture in Trench 2 decreased slowly from ~0.2 m^3/m^3 to ~0.05 m^3/m^3 over the first four months. Then, the soil moisture increased to a maximum of ~0.47 m^3/m^3 during the fifth and sixth months before decreasing again. The soil moisture in Trench 2 was above 0.3 m^3/m^3 for ~20 days during the last 2 months of the experiment.

Soil moisture in both Trench 1 and Trench 2 reached levels above 0 m^3/m^3 more consistently than the Ground Surface location which may be related to the increased degradation of cotton fabric swatches at these Areas. The constant fluctuation of soil moisture on the Ground Surface with periods of 0 m^3/m^3 of moisture, may have decreased the degradation of cotton fabric swatches at this Area.

Fabric Type

The fabric type that seemed most influenced by soil moisture was cotton. Most of the cotton fabric swatches that were positioned flat and crumpled demonstrated decreased or retarded degradation in Month 5 which may be related to the increase in soil moisture at all three studied Areas, especially in Trench 1 and Trench 2 (Figures 46-51). Because the Ground Surface could not retain a constant soil moisture, this may have allowed for better preservation of cotton fabric swatches placed at this Area (Figures 46 and 49). The soil moisture at the Ground

Surface has direct contact with the sun and air which allow for periods of drying in which moisture is removed almost completely.

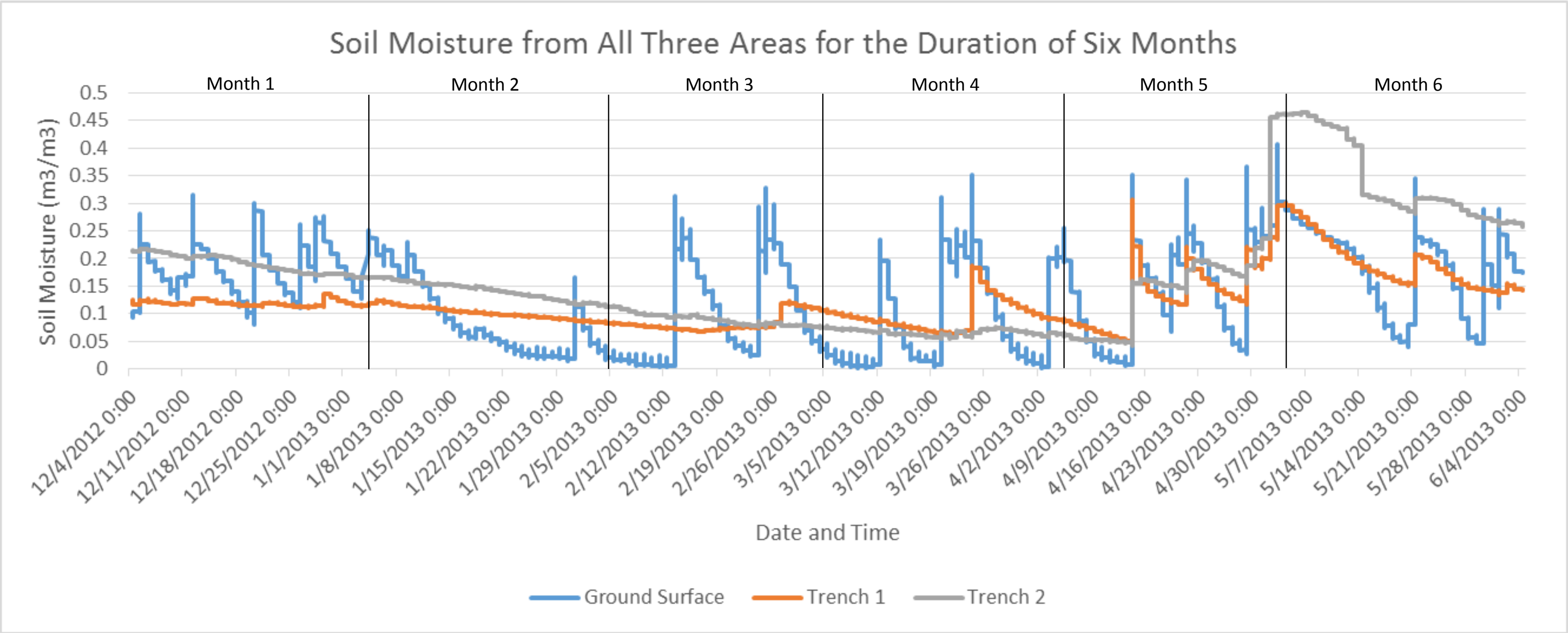


Figure 44: Soil moisture from all three studied Areas for the duration of six months.

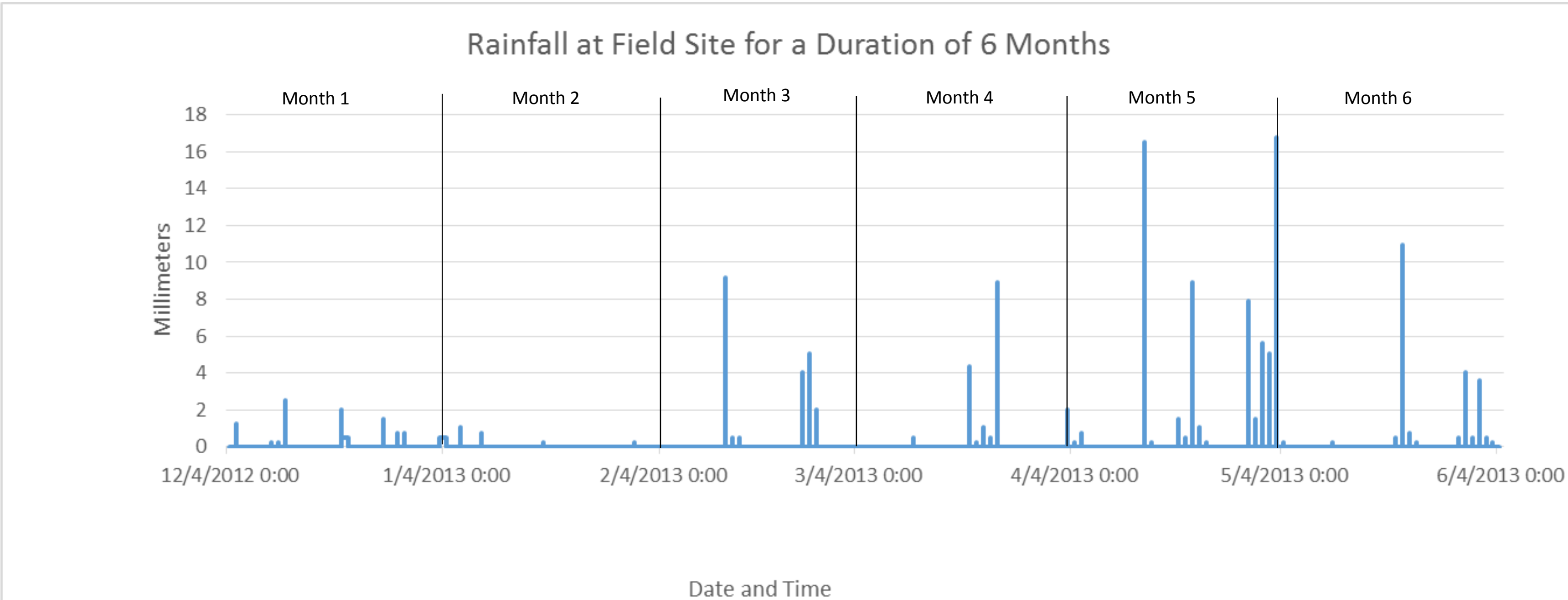


Figure 45: Rainfall for all three studied Areas after a duration of six months.

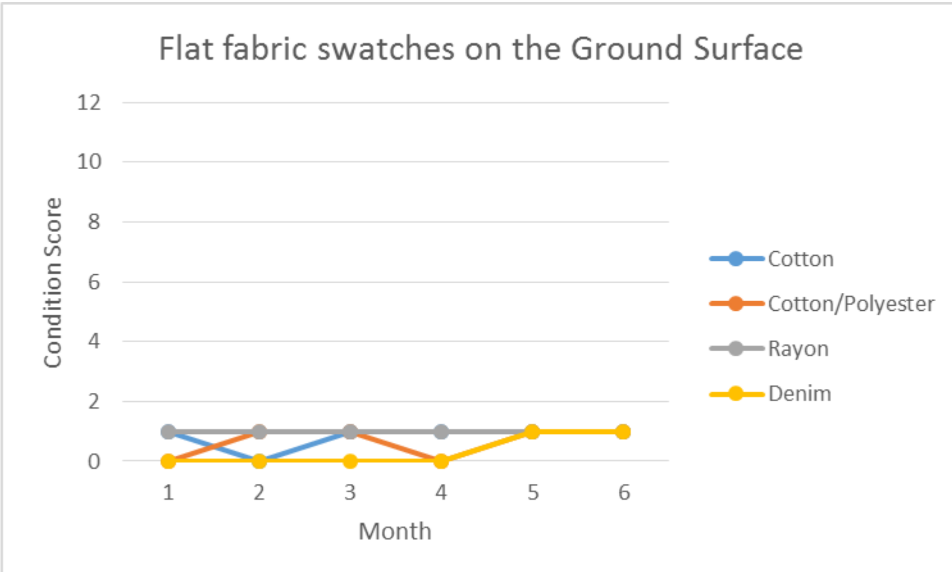


Figure 46: Cotton, cotton/polyester, rayon, and denim fabric swatches that were positioned flat on the Ground Surface after a duration of 6 months.

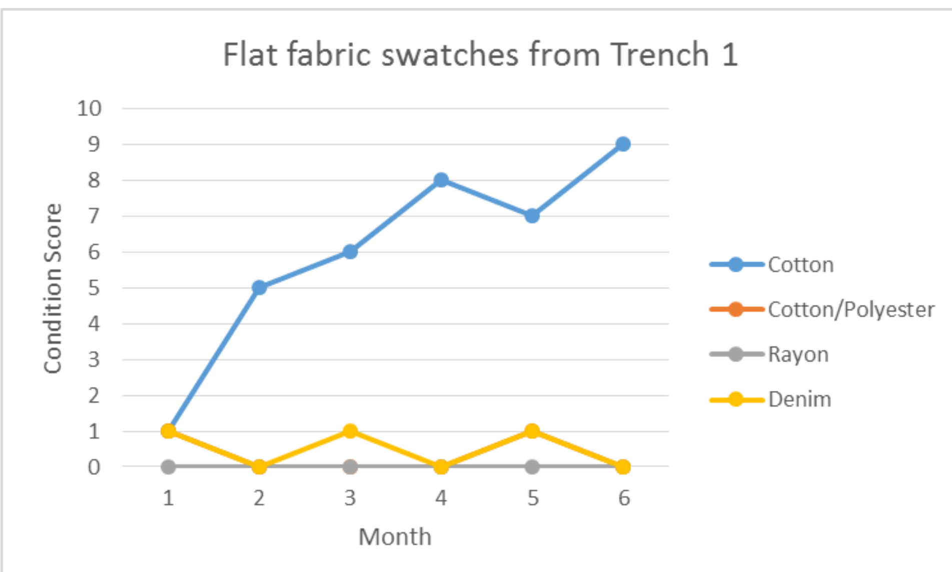


Figure 47: Cotton, cotton/polyester, rayon, and denim fabric swatches that were positioned flat in Trench 1 after a duration of 6 months.

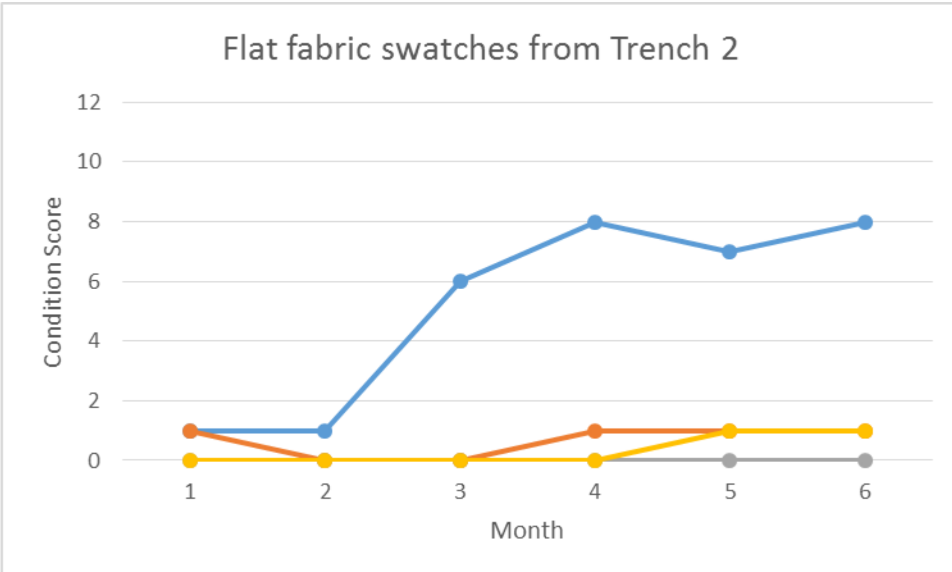


Figure 48: Cotton, cotton/polyester, rayon, and denim fabric swatches positioned flat in Trench 2 after a duration of 6 months.

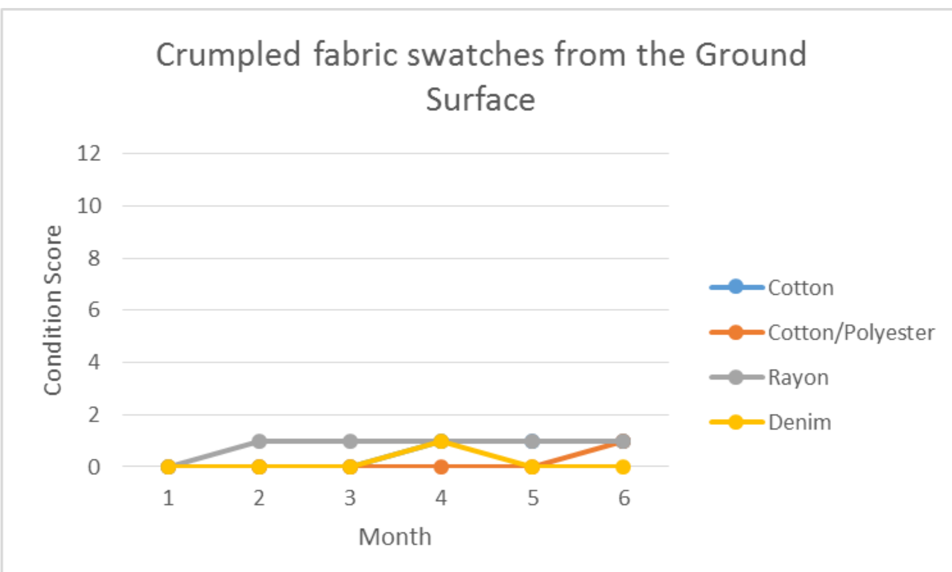


Figure 49: Cotton, cotton/polyester, rayon, and denim fabric swatches that were positioned crumpled on the Ground Surface after a duration of 6 months.

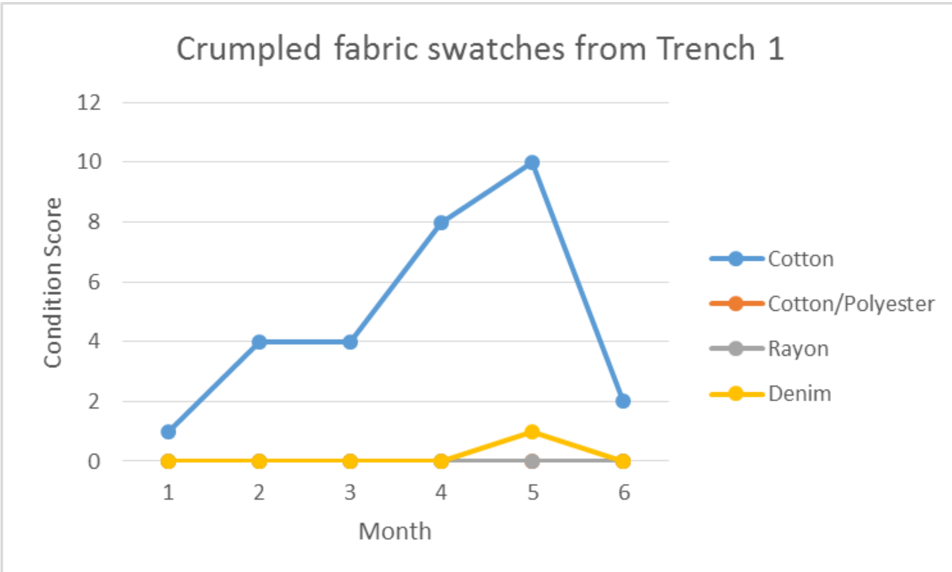


Figure 50: Cotton, cotton/polyester, rayon, and denim fabric swatches that were positioned crumpled in Trench 1 after a duration of 6 months.

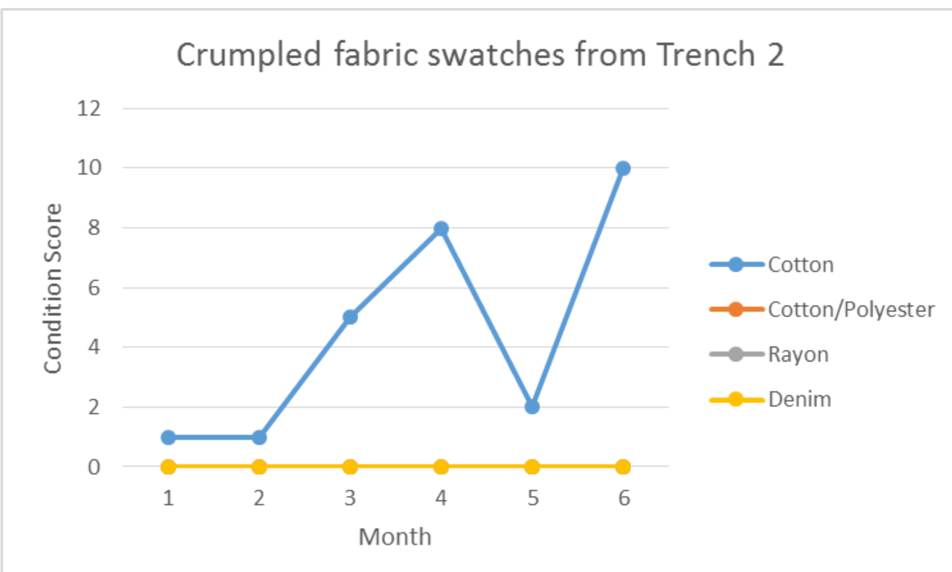


Figure 51: Cotton, cotton/polyester, rayon, and denim swatches that were positioned crumpled in Trench 2 after a duration of 6 months.

Final comparisons

Fabric type

The cotton fabric swatches degraded the most for the duration of the six months, in which about 1/3 of the fabric swatches demonstrated more than 50% total degradation (Tables 8 and 9). Cotton/polyester, rayon, and denim fabric swatches all showed less than 1% total degradation at the three Areas that were studied (Tables 10-15).

Position

Of the cotton fabric swatches, about ½ of the fabric swatches that were positioned flat demonstrated more than 50% total degradation (Table 8). In comparison, only 10% of the cotton fabric swatches positioned crumpled demonstrated over 50% total degradation (Table 9). More cotton/polyester fabric swatches that were positioned flat had total degradation closer to 1% than those positioned crumpled (Tables 10 and 11). The same pattern is demonstrated for both rayon and denim (Tables 12-15).

Depth

In regards to the cotton, fabric swatches degraded the most in Trench 1 (30 cm), followed closely by Trench 2 (60 cm). Cotton fabric swatches placed on the Ground Surface (0 cm) showed the least total degradation of less than 1% (Figures 24 and 25). Cotton/polyester fabric swatches degraded most on the Ground Surface, however less than 1% (Tables 10 and 11). Cotton/polyester fabric swatches placed in Trench 1 and Trench 2 followed closely, both demonstrating similar amounts of total degradation (Figures 29 and 30). The only Area in which rayon fabric swatches showed degradation was the Ground Surface, although still less than 1%

(Figures 34 and 35). More denim fabric swatches showed degradation in Trench 1, though not a significant amount more than in Trench 2 and the Ground Surface (Figures 39 and 40).

Time

Cotton was the only fabric type to demonstrate significant increases in total degradation (Figures 47, 48, 50, 51). Therefore, this will be the only fabric type discussed in regards to the month that showed the most degradation. Cotton fabric swatches recovered from Trench 1 and Trench 2 after Months 4-6 demonstrated more than 50% total degradation (Tables 8 and 9).

Percent Weakened

Data showing the percent of weakened fabric for each fabric swatch can be found in the Appendix D.

Cotton fabric swatches positioned flat on the Ground Surface did not show any weakening for the duration of 6 months. However, cotton fabric swatches positioned flat in Trench 1 and Trench 2 weakened more than 50% by Month 3 and about 100% by Month 6. Cotton fabric swatches positioned crumpled on the Ground Surface demonstrated less than 3% weakening by Month 6. Cotton fabric swatches positioned crumpled in Trench 1 and Trench 2 weakened about 30% by Month 3, but had reduced weakening in Month 6 at 0%.

Cotton/polyester fabric swatches positioned flat on the Ground Surface showed less than 1% weakening for the duration of 6 months. Cotton/polyester fabric swatches positioned flat in Trench 1 and Trench 2 were less than 50% weakened by Month 3. By Month 6, the flat fabric swatch was 100% weakened in Trench 1, but the flat fabric swatch in Trench 2 was only about

50% weakened. Cotton/polyester fabric swatches positioned crumpled on the Ground Surface showed no weakening for the duration of 6 months. After Month 6, the crumpled fabric swatch from Trench 1 showed more than 50% weakening, while the crumpled fabric swatch from Trench 2 showed about 30% weakening.

Rayon fabric swatches positioned flat were not weakened for the duration of the 6 months. Rayon fabric swatches positioned crumpled demonstrated less than 1% weakening for the duration of 6 months.

Denim fabric swatches positioned flat were less than 2% weakened by Month 6. Denim fabric swatches positioned flat in Trench 1 and Trench 2 were more than 50% weakened by Month 4. By Month 6, the flat fabric swatch from Trench 1 is almost 100% weakened, while the fabric swatch from Trench 2 is more than 50% weakened.

Percent Degradation of the Center Value

Data showing the percent degradation of the Center Value of each fabric swatch can be found in the Appendix E.

Cotton fabric swatches positioned flat on the Ground Surface showed less than 2% degradation of their Center Value for the duration of 6 months. The flat fabric swatches from Trench 1 and Trench 2 demonstrated about 100% degradation of their Center Value from Month 3 through Month 6. Cotton fabric swatches positioned crumpled on the Ground Surface showed less than 2% degradation of their Center Value for the duration of 6 months. Crumpled fabric swatches in Trench 1 and Trench 2 demonstrated about 50% degradation of their Center Value by Month 3. By Month 6, the crumpled fabric swatch from Trench 1 reduced to less than 50%

degradation of its Center Value, while the crumpled fabric swatch from Trench 2 increased to almost 100% degradation of its Center Value. Cotton/polyester fabric swatches positioned both flat and crumpled in the three Areas that were studied demonstrated less than 1% degradation of their Center Value for the duration of 6 months. Rayon fabric swatches positioned flat on the Ground Surface showed less than 2% degradation of their Center Value. Flat fabric swatches from Trench 1 and Trench 2 demonstrated no degradation of their Center Value for the duration of 6 months. Rayon fabric swatches positioned crumpled on the Ground Surface showed less than 1% degradation of their Center Value, while those from Trench 1 and Trench 2 demonstrated no degradation of their Center Value for the duration of 6 months. Denim fabric swatches positioned flat in all three of the Areas that were studied showed less than 2% degradation of their Center Value for the duration of 6 months. Denim fabric swatches positioned crumpled in all three of the Areas that were studied demonstrated less than 1% degradation of the Center Value for the duration of the 6 months.

Chapter 5: Discussion and Conclusion

In order to understand the importance of the results of the current experiment, the findings must be compared to that of previous studies. Having little standardization in methodology of the previous experiments makes them difficult to compare with the current study because certain conditions were not replicated in previous experiments, and some experiments used different variables. However, a number of the previous studies did use similar variables which will be compared. Comparisons will be made in regards to the following variables: fabric type, position, depth, time, soil moisture, and presence of decaying tissue. A number of these variables have been summarized in Table 9.

Fabric Type

In the current experiment the natural fabric type of plain cotton degraded the most, while the heavier cotton denim and the blended cotton/polyester became weakened and altered in color. However, the heavier the fabric and the more chemically altered or synthetic the fabric, such as rayon or cotton/polyester, the more resistant to degradation.

The fabric type that degraded the least in the current experiment was rayon, which showed less than 1% total degradation on the Ground Surface and no degradation in Trench 1 and Trench 2 (Tables 12 and 13). No other study found similar results to the present experiment. In contrast, previous studies demonstrated that rayon was the fabric that deteriorated the most (Morse and Dailey, 1985; Singer and Rowe, 1989). Rayon is a cellulose-based fabric that has been chemically modified and regenerated into a semi-synthetic fabric. Because it comes from a natural source it is susceptible to degradation in soils with a pH range of acidic to neutral (Janaway, 2008) and will degrade similarly to natural cellulose like cotton (Rowe, 1997).

However, the strength of the rayon can be increased with the use of high wet modulus (HWM) rayon which resists damage from washing and drying more than regular rayon (Charankar et al., 2007). Rayon can also be blended with other fabrics to increase its strength.

The reason for different results from that of the current study may be due to the use of different blends and strengths of rayon fabrics. For example, one study used only man-made fabrics to compare degradation (Singer and Rowe, 1989) and because rayon is not as resistant to degradation as other synthetic textiles (Rowe, 1997) it may have appeared to be the most degraded relative to the other fabric types. In addition, different soil types may cause differential degradation; the previous experiments used more acidic soils that may have increased the degradation of rayon (Morse and Dailey, 1985; Singer and Rowe, 1989).

Cotton/polyester degraded less than 1% in the current experiment (Tables 10 and 11). A previous study demonstrated similar results in that cotton/polyester preserved well (Morse and Dailey, 1985). The similarity in the preservation of cotton/polyester may be because the blend of natural cellulose with synthetic polyester makes this fabric type more resistant to microbial activity (see subsection on the Composition of Decomposing Tissue with Associated Fabric) and degradation than pure cotton (Janaway, 2008). Cotton/polyester may be affected by mildew formation and fabric staining (Hardie and Pratt, 1996) as was shown in the current experiment (Figures 15-17). Other studies did not use this blend of fabric type making comparisons impossible (Bell et al., 1996; Peacock, 1994; Singer and Rowe, 1989; Terry, 1996; Tigg, 2005; Wilson et al., 2007).

Because denim is made from cotton, it is vulnerable to degradation, but to a lesser degree (Janaway, 2008). In the current experiment, denim fabric degraded less than 1% (Tables 14 and

15). One study did show similar, yet varying results in that denim demonstrated little to no degradation at one particular depth, and about 60% degradation at another depth (Wilson et al., 2007). Other studies did not exhibit similar results. Instead, these experiments describe denim as severely degraded (Terry, 1996; Tigg, 2005). The reasons for differential degradation of denim may be the inclusion of metal artifacts on the fabric and different soil environments, such as acidic soils (Tigg, 2005; Wilson et al., 2007). Because denim is composed of cotton, it is subject to degradation in soils with a low pH (Janaway, 2008). The use of pig cadavers in another study proved to slow the degradation process of the denim (Wilson et al., 2007). However, in that study, the pig analogues had formed adipocere which was not observed in the current study.

The fabric type that degraded the most in the current experiment was the 100% cotton fabric, which had degraded over 50% by Month 4 in Trench 1 and Trench 2 (Tables 8 and 9). Cotton fabric also degraded significantly in other experiments (Bell et al., 1996; Peacock, 1994; Wilson et al., 2007). These experiments had similar results to the current study since it is expected for cotton to be susceptible to degradation as it is a natural cellulosic textile. This is especially evident in soil with moisture and microbial activity (Janaway, 2008). Because cotton is less robust than denim and more natural than the cotton/polyester and rayon, it is inclined to degrade more. The presence of the meat on the cotton fabrics inhibited degradation slightly in the Wilson et al. (2007) experiment as compared to the control cotton due to different burial environments with increased water retention and adipocere formation. But because there are no pictures provided by Wilson et al. (2007) to compare to the current experiment it is difficult to determine similarities in preservation or degradation. In addition, the present study did not bury control samples without meat to compare to the samples that included meat.

One study in particular used cotton that had been treated with resin (Morse and Dailey, 1985) which has been shown to increase resistance of cotton to decay and mildew (Goldthwait et al., 1951) altering its normal tendency toward degradation.

Position

The current study shows that fabric swatches that were positioned flat degraded more than those that were positioned crumpled (Figures 46-51). The reason for this differential degradation is because the flat fabric swatches have more surface area exposed to the environment while the crumpled fabric swatches are protected. The position of the fabric swatches was not discussed in many of the previous experiments (Morse and Dailey, 1985; Morse et al., 1983; Singer and Rowe, 1989; Terry, 1996; Tigg, 2005; Wilson et al., 2007). However, one experiment folded the fabric swatches (Bell et al., 1996), while another positioned the fabric swatches flat and vertically into soil (Peacock, 1994). The current experiment varies so greatly from the previous studies because fabric swatches were placed both flat and crumpled in order to determine if the position of the fabric swatch would produce differential degradation. Because none of the other studies use two methods of positioning their fabric swatches, the results obtained in this experiment cannot be compared properly.

Depth

In this experiment, cotton fabric swatches degraded the most in Trench 1, with similar degradation results in Trench 2 (Tables 8 and 9). The cotton fabric swatches placed on the Ground Surface preserved the best because they were not impacted by the deteriorating effects of soil environment and the microbes within it. In regards to the other fabric types which demonstrated less than 1% total degradation, most degradation occurred from the fabric swatches on the Ground Surface because of grass growth that did not occur in Trench 1 and Trench 2 (Tables 10-15).

A number of experiments did not discuss the depths used (Bell et al., 1996; Singer and Rowe, 1989; Terry, 1996) which makes comparisons impossible.

Some experiments used similar depths and showed similar results as the current study in that the 30 cm location preserved fabrics the least (Morse and Dailey, 1985; Tigg, 2005; Wilson et al., 2007). Although, it is important to consider that in the current study, these degradation results applied to cotton only, while in other studies it applied to denim (Tigg, 2005), cotton and denim (Wilson et al., 2007), or cotton and rayon (Morse and Dailey). In contrast, the denim and rayon preserved well at the 30 cm location in the current study. It is evident that differential results can be obtained between experiments with similar depths. This may have occurred because conditions in the experiments vary such as types of fabrics used, soil type, or soil moisture.

Duration

The duration of the current study was 6 months, and fabric swatches were removed in one month intervals from each of the three Areas that were studied. Cotton fabric swatches were more than 50% degraded by Month 4, and were almost completely degradation by Month 6 (Tables 8 and 9). All other fabric types demonstrated less than 1% total degradation for the duration of the 6 months (Tables 10-15).

A number of previous studies removed their fabric swatches at similar intervals but demonstrated different results from the current study (Morse and Dailey, 1985; Singer and Rowe, 1989). For example, rayon degraded more than cotton in these previous studies. The reason for the differential preservation of rayon has been discussed previously.

Some experiments did not remove fabric swatches at monthly intervals making comparisons difficult (Bell et al., 1996; Peacock, 1994; Terry, 1996; Tigg, 2005; Wilson et al., 2007). The experiment by Tigg (2005) lasted a duration of 15 weeks in which denim fabric swatches were significantly degraded, whereas the denim in the current study preserved well for the duration of 6 months. In another experiment using denim, the fabric swatches were recovered after 70 and 140 days with different degrees of degradation (Terry, 1996). A separate study recovered fabric swatches after 24 months in which cotton and denim were completely degraded (Wilson et al., 2007), while in the current study, the cotton degraded significantly, but not the denim, although this was only after 6 months. The study by Bell et al. (1996) provided results that show that cotton began degrading after the second month in one soil environment, while in another it had completely degraded by the second month. In contrast, the cotton in the current study began degrading after the first month and was not yet completely degraded by the sixth month. Finally, Peacock (1994) recovered fabric swatches after a range of weeks increasing exponentially for a duration of 32 weeks. In the previous experiment, cotton was completely degraded after week eight which is different from the current study.

Because cotton is the only fabric type to demonstrate significant degradation in the current experiment, its degradation interval can be expected based on the results of previous studies with longer durations than 6 months. However, it is important to remember that degradation intervals are location-specific due to differences in soil pH, soil type, and soil moisture. Bell et al. (1996) found that after 8 months, cotton was completely degraded in the chalk environment. Results of the study by Wilson et al. (2007) showed that cotton was completely or close to completely degraded after 24 months in both the 30 cm and 60 cm locations. Morse and Dailey (1985) discovered that cotton degraded completely in the majority of the trenches by the tenth month. Therefore, it is expected that cotton will degrade completely sometime after six months and definitely by 24 months in a location similar to central Florida. It is more difficult to determine the degradation interval of the cotton/polyester, denim, and rayon fabrics in the current experiment because they all degraded less than 1%; the denim and cotton/polyester demonstrating discoloration and weakening, while the rayon remained the most unaltered.

Denim fabric degraded earlier than 6 months in prior studies while it was well preserved in the current study. Therefore, the degradation interval of denim is greater than 6 months. A cotton/polyester blend is discussed in the study by Morse and Dailey (1985), in which it was reported that cotton/polyester began deteriorating by the tenth month, and was not severely affected until month 35. This time table may be useful for predicting the degradation interval of cotton/polyester in the current study. Finally, the rayon demonstrated the least amount of degradation, weakening, and discoloration, remaining well preserved after 6 months in the current experiment. However, previous studies show that rayon can degrade earlier than 6 months. Because of these discrepancies, rayon fabric warrants further testing to determine its true degradation interval.

Soil Moisture

In the current study, the Ground Surface dried the fastest and most frequently, while Trench 1 and Trench 2 retained water longer making drainage quality poorer than on the Ground Surface (Figure 44). Most of the degradation of cotton occurred in Trench 1 and Trench 2, while it was most preserved on the Ground Surface. Although most of the other three fabric types showed less than 1% degradation, most of the degradation is demonstrated on the Ground Surface. According to Carter, Yellowlees, and Tibbett (2010), extremely dry or wet soils are not preferred by microoganisms because of decreased supply of nutrients, difficult mobility, and restricted gas diffusion. The soil in the current study was neither too dry nor too wet. Because of the high percent loss of cotton and the discoloration and weakening in the other fabric types, it is evident that microbes were active in the soil environment of the current study. Trench 1 and Trench 2 retained moisture in the soil at above 0.1 m^3/m^3 for the entirety of the experiment, while the Ground Surface was the most easily drained and demonstrated more periods of soil dryness.

Soil moisture, rainfall, or drainage is not discussed in all of the experiments making it a difficult variable to compare (Bell et al., 1996; Peacock, 1994; Singer and Rowe, 1989; Terry, 1996; Tigg, 2005). No experiments demonstrated results similar to the current study. In previous experiments, fabric swatches were more degraded from locations that were more easily drained (Wilson et al., 2007). Differing results may be due to having different soil types that offered better drainage of water and more microorganism activity. In addition, seasonal changes affect soil moisture which may increase or decrease the preservation of textiles (Janaway, 2008).

Composition of Decomposing Tissue with Associated Fabric

Natural textiles are susceptible to gradation by soil microbes (Janaway, 2008). Using meat as an additional variable to this experiment alters this soil environment, and influences the degradation of the associated materials placed in the soil. Decomposing meat creates a cadaver decomposition island (CDI) adding nutrients to the soil, and thus, increasing the microbial activity and pH of the surrounding soil (Janaway, 2008; Carter and Tibbett, 2008). Microbes are agents in the breakdown of organic material such as textiles and decomposing tissue. Bacteria and fungi are among the most important microorganisms in the soil environment and are also found with decomposing cadavers (Janway, 2008). It should be expected that the presence of meat on the fabric samples will increase degradation of the fabric swatches in the current experiment. The placement of the meat in the center of the fabric swatches caused a three step sequence of events: discoloration, weakening, and finally degradation of the fabric from the center and outward (Figures 12-23). Discoloration and weakening was observed in the cotton/polyester and denim fabrics, while the cotton demonstrated the final phase of degradation (Figures 13 and 14). The rayon fabric was the least affected (Figures 18-20).

The experiment conducted by Wilson et al. (2007) shows a variation of the effects of meat on the preservation of associated textiles. The fabric swatches buried without the pig cadaver demonstrated total loss of wool, cotton, and denim at both depths and no loss of polyester. The fabric swatches buried above the pig cadaver demonstrated slightly less loss than the control graves, while the fabrics below the pig were well preserved because of adipocere formation. In this experiment, there were periods in which the water level rose above the pig which would inhibit degradation of the cadaver and buried textiles (Janaway, 2008). This experiment shows that cadaver decomposition and fabric degradation can be inhibited if the soil moisture content is high. Also, the cadaver can inhibit fabric degradation if adipocere formation occurs in an anaerobic environment with anaerobic microorganisms which are not as efficient metabolizers as aerobic microorganisms (Swift, Heal, and Anderson 1979).

Analysis

The present study primarily used a light table and the aid of a stereomicroscope to analyze the degradation and weakening of each fabric swatch. A standard was then developed which attempted to eliminate the arbitrary and qualitative scoring methods used in previous experiments in order to establish a quantitative methodology. Although the majority of the previous experiments used microscopy, assigned condition scores or descriptions as to the degradation quality of the fabric swatches, they all approach the analysis differently, such as how they arrived at the percent loss of fabric or the way in which they assigned condition scores, while excluding the details behind their analysis (Bell et al, 1996; Morse and Dailey, 1985; Peacock, 1994; Singer and Rowe, 1989; Terry, 1996; Tigg, 2005; Wilson et al., 2007). The current study's analysis is developed to be a future standard that can be repeated in future experiments.

Table 16: Summary of all experiments. Highlights the fabric type that degraded the most, the position of the fabric type that degraded the most, the depth of that fabric swatch, and the amount of time it took for the fabric to exhibit significant degradation.

Experiment	Fabric type	Position	Depth	Duration
Current study	Cotton	Flat	Trench 1 (30 cm)	Months 4-6
Tigg (2005)	Denim	?	30 cm	~4 months
Singer and Rowe (1989)	Rayon	?	?	5 months
Wilson et al. (2007)	Cotton	?	30 cm 60 cm	24 months
Morse and Dailey (1985)	Rayon	?	~60 cm (Trench 1) ~30 cm (Trenches 3, 7, 8, 9)	2-3 months
Bell et al. (1996)	Cotton and Khaki	?	? (turf)	2 months
Terry (1996)	Dyed and undyed denim	?	? (cellar soil)	~4.5 months
Peacock (1994)	linen	vertical	10 cm	2 months

Future Areas and Research

The benefit of this research experiment is that it is the first study to explore a standard methodology for the experimentation and analysis of fabric degradation in the central Florida area. This study can serve as a foundation for future studies in fabric degradation because it has developed a methodology and research design that is replicable. However, this experiment should be considered a pilot study with areas of improvement and considerations for future studies.

In future studies, more replication is needed within the experiment design in which there are multiple trenches at the depths of 30 cm and 60 cm as well as Ground Surface locations. This will increase the sample size in order to produce more accurate results and trend analysis. In addition, there should be a number of samples buried at each location with and without meat in order to observe fabric degradation differences due to the inclusion of meat. It would be beneficial to a future study to research each fabric type to determine if it was treated with any resins or dyes or if it was blended with other fabrics as this can affect the degradation process.

Future studies will also use the data collected on the weakening of the fabric swatches as well as the Center Value degradation as an additional method to analyze fabric degradation. Future studies should also explore longer durations than 6 months in order to understand the true degradation interval of the more resistant fabric types. In addition, it may be beneficial to collect fabric swatches at more frequent intervals than monthly in order to more thoroughly understand the degradation interval of the fabric type as it applies to the PMI.

Summary

Textiles are material evidence which is a type of trace evidence that can be found at a crime scene. Therefore, a deceased individual is likely to be found in conjunction with textiles. Because textiles degrade over time, they can be useful in estimating time since death of the victim in which they are associated. Therefore, experimentations involving the analysis of fabric degradation are important to the field of forensic science and other forensic workers on the case. Unfortunately, there are limited studies which focus on fabric degradation and even fewer concerned with the central Florida burial environment. This study challenged the issues presented in previous studies and worked to develop a standard methodology for experimenting and analyzing degraded fabrics. It was found that the total percent degradation was useful in evaluating the degradation of the fabric swatches, as it was quantitative and less subjective than previous methods used. Although further studies should be conducted, this pilot study highlights the importance of standardization of methodology and develops a useful technique that is better for evidence evaluation that might need defending in court.

Fabric analysis in conjunction with the processing of other crime scene evidence would be useful for estimating the PMI of a deceased victim. However, if soft tissue is no longer present or if there are no insects at the crime scene, clothing or other fabrics may be the only clues as to how long the individual has been deceased. Therefore, after further experimentation, the results of this type of experiment could potentially be used to predict a PMI for a deceased individual. An example of PMI estimation developed from the fabric degradation results of the current study can be found in Tables 10 and 11. The prediction is created for a victim wearing fabric such as: cotton, cotton/polyester, rayon, and denim. Their body is found in the central Florida area with sandy soils and a neutral pH. The location in which the victim is found could be the ground surface or a shallow grave between 30 cm and 60 cm. The PMI of the individual is between 1 month and 6 months based on the discoloration, weakening, and degradation of the fabric.

Table 17: Prediction for estimated PMI of victim buried above ground using four different fabric types over a range of 6 months, based on results of the degradation of fabric swatches that were positioned flat.

	Post mortem interval in months					
Fabric type worn by victim found on the ground surface	1	2	3	4	5	6
Cotton	Small, light brown discoloration with meat stain in the center	Blotchy, light brown discoloration in the center moving outward; meat stain in the center	Medium brown discoloration in the center; meat stain in the center	Dark brown discoloration in the center; meat stain in the center	Black and brown blotchy discoloration; meat stain in the center	Dark brown, black, green, and red discolorations; meat stain in the center
Cotton/ polyester	Small, light brown discoloration in the center; meat stain in the center	Larger medium brown discoloration in the center; meat stain in the center	Blotchy medium brown discoloration radiating from the center; meat stain in the center	Blotchy dark brown discoloration with meat stain in the center	Holes from grass, blotchy dark brown, green, and red discoloration; meat stain in the center	Holes from grass, blotchy dark brown, green, and red discoloration; meat stain in the center
Rayon	Meat stain in center	Meat stain in center	Meat stain in center	Meat stain in center	Meat stain in center	Brownish tint over whole swatch with meat stain in the center

Fabric type worn by victim found on the ground surface	1	2	3	4	5	6
Denim	Medium blue with dark grey discoloration and meat stain in the center	Light blue with dark grey discoloration and meat stain in the center	Pale blue with small, light grey discoloration and meat stain in the center	Pale blue with larger grey discoloration and meat stain in the center	White-blue with black discoloration and meat stain in the center	White-blue with blotchy, black discoloration and meat stain in the center

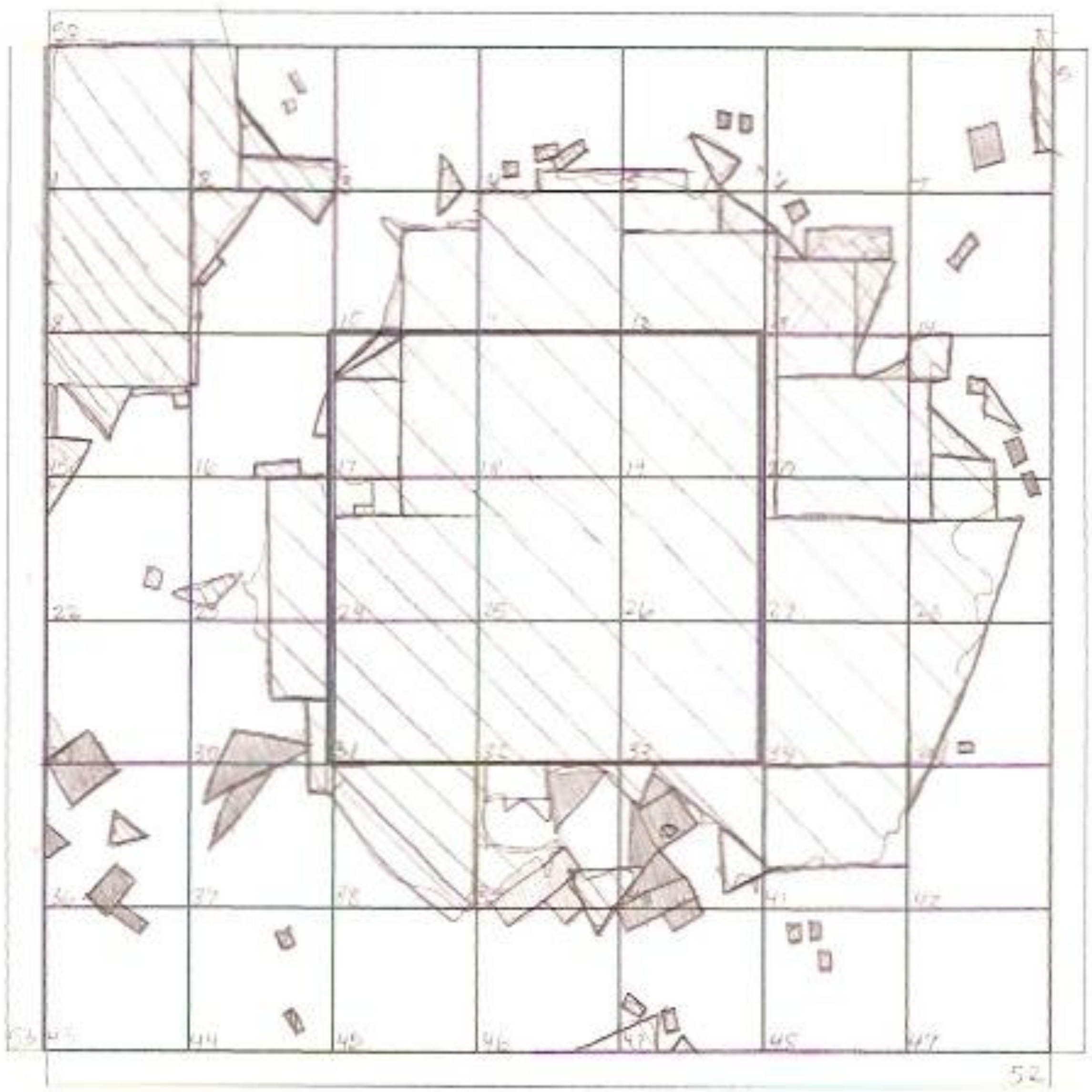
Table 18: Prediction for estimated PMI of victim buried below ground using four different fabric types over a range of 6 months, based on results of the degradation of fabric swatches that were positioned flat.

	Post mortem interval in months					
Fabric type worn by victim found below ground	1	2	3	4	5	6
Cotton	Dark brown circle of discoloration in the center with degradation	Circular center of swatch is degraded with a weakened perimeter; overall brown discoloration	Larger circular center of swatch is degraded with a weakened perimeter; overall brown discoloration	Large fragments of fabric with brown discoloration	Medium fragments of fabric with brown discoloration	Fewer medium fragments with roots attached and brown discoloration
Cotton/polyester	Medium brown circle of discoloration in the center with meat stain in the center	Medium brown circle of discoloration in the center with a dark brown outline and meat stain in the center	Medium brown circle of discoloration in the center with a dark brown outline and meat stain in the center	Weakened circle of brown discoloration in the center of the fabric with a meat stain	Weakened circle of brown discoloration in the center of the fabric with a meat stain	Entire fabric swatch is weakened with circle of brown discoloration
Rayon	Light brown discoloration	Medium brown discoloration	Grey discoloration	Medium brown discoloration	Light brown discoloration	Light brown discoloration

Fabric type worn by victim found below ground	1	2	3	4	5	6
Denim	Weakened, black circle of discoloration in the center; overall fabric is light blue	Weakened, grey discoloration in the center; overall fabric is light blue	Weakened, white center with black outline; overall fabric is light blue	Weakened, white and black center; overall fabric is light blue	Weakened white and black center; overall fabric is light blue	Entire swatch is weakened and whitish with black discoloration

APPENDIX A: DATA FORMS

Specimen Number: 33



Textile Data Sheet

Specimen Number: Observations

Fiber Class	Genera	
Overall Appearance	Luster	
	Texture	
	Color	
	Surface	
	Crimps/inch	
	Other	
Fiber type	Staple filament	
Yarn Type	Single ply	
	Cord	
	Combed	
	Worsted	
	Stretch	
	Spun	
	Other	
Twists/inch		
Fiber/thread count		
Pile	Uncut/cut	
	W	
	V	
	Other	
Knit	Warp or weft	
	Plain stitch	
	Purl stitch	
	Miss Stitch	
	Tuck stitch	
Weave Pattern	Face side	
	Back side	
Printed/dyed design		

Fabric Analysis

Specimen Number:

1. Determine overall appearance overall appearance of fabric (color, luster, texture)

2. Determine the fiber composition:
   a. Is the yarn composed of synthetic or natural fibers?

   b. If synthetic, what is the generic classification?

   c. If natural, is the material hair, wool, or vegetable fiber?

   d. Is the yarn made of a single fiber type or is it a blend?

   e. How many plies? Single or multiple-ply yarn?

   f. Is the yarn composed of tow, filament, or staple lengths?

   g. How are the fibers held together? Are they crimped, twisted, other?

3. Can the warp direction be determined?
   a. Selvage runs in warp direction
   b. Reed marks run parallel to warp
   c. Warp yarns usually have higher twists
   d. Warp yarns are normally finer in diameter
   e. Stripes usually run in warp direction
   f. Fabric is harder to tear in the warp direction

4. Can the weft direction be determined?
   a. Novelty yarns are usually in the filling direction
   b. Bulkier yarns are in the filling direction
   c. Ridges usually run in the weft direction
   d. Weft direction usually has more stretch

5. Determine face side of the fabric

6. Determine basic type of weave (plain, basket, twill, satin)
   a. Note fabric finish (print design, dyed, mechanical texturing, coating)
   b. Hold the fabric face up with the warp yarns running toward you
   c. Pull out one end of the warp yarn with a tweezer and determine how it is woven from the first pick down
   d. Continue examining the fabric until you are certain that you have completed one repeat
   e. As a check, make sure you examine and determine several repeats of the weave

7. Prepare a graphic representation of the fabric. All collected data and observations should be noted on a textile data sheet.

8. Use the data compiled on the data sheet to examine, identify, and compare questioned and known textile specimens.

APPENDIX B: PERCENT WEAKENED AND PERCENT DEGRADED OF THE CENTER VALUE

Specimen Number	Percent Weakened	Percent Degraded of the Center Value
1	0	0.25
2	0	0
3	0	0
4	0	0
5	0	1.25
6	0	0
7	0	0
8	0	0
9	0	1.18
10	2.11	0.11
11	13.85	0
12	5	0
13	0	0
14	0	0
15	21.56	0.22
16	1.41	0
17	4.5	14.78
18	0.72	0.58
19	0	0.06
20	1.82	0
21	0	0
22	0	0
23	2.97	0
24	0.82	0
25	0	0
26	0	0
27	0	0.22
28	0	0
29	0	0.08
30	0	0.31
31	0	0
32	0	0
33	4.38	98.86
34	6.66	56.81
35	42.46	0
36	8.11	0
37	0	0
38	0	0
39	46.5	0

40	26.85	0
41	10.2	36.46
42	3.26	12.5
43	7.74	0
44	12.19	0
45	0	0
46	0	0
47	11.75	0
48	5.93	0
49	0	0.03
50	0	0
51	0	0.03
52	0	0
53	0	0.56
54	0	0.14
55	0	0
56	0.05	0
57	66.12	99.89
58	37.14	59.64
59	42.59	0
60	31.69	0
61	0	0
62	0	0
63	19.81	0
64	23.18	0
65	58.31	95.06
66	20.14	45.85
67	22.29	0
68	13.94	0
69	0	0
70	0	0
71	32.56	0
72	6.72	0
73	0	0.42
74	0	0.22
75	0.03	0
76	0	0
77	0	0.72
78	0	0.33
79	0.02	0
80	0	0.03
81	22.1	100

82	100	94.67
83	67.6	0
84	20.02	0
85	0	0
86	0	0
87	55.62	0
88	8.28	0
89	39.56	100
90	58.73	85.5
91	31.48	0.03
92	48.83	0
93	0	0
94	0.03	0
95	62.05	0
96	72.96	0
97	0	1.64
98	0	0.36
99	0	0.61
100	0	0
101	0	0.2
102	0	0
103	1.89	0.67
104	0	0
105	45.41	99.56
106	100	0
107	52.88	0
108	40.1	0
109	0	0
110	0	0
111	34.45	1.22
112	27.41	0.25
113	15.62	100
114	7.15	29.76
115	63.49	0
116	13.08	0
117	0	0
118	0	0
119	51	0
120	76.22	0
121	0	1.86
122	2.73	1.11
123	0.44	0.97

124	0	0.06
125	0	1
126	0	0
127	0.74	1.64
128	1.73	0
129	86.09	100
130	0	26.04
131	100	0
132	62.39	0
133	0	0
134	0	0
135	99.41	0
136	58.01	0
137	100	100
138	0	96
139	43.27	0.03
140	36.73	0
141	0	0
142	0	0
143	55.5	0.28
144	42.36	0

APPENDIX C: SUMMARY OF DATA COLLECTION

Control Samples

Fabric Type	Munsell Color System	% Degraded	Condition Score
Cotton	GLEY1 8/N	0	0
Cotton/Polyester	GLEY1 8/N	0	0
Rayon	10YR 6/3 10YR 8/1 GLEY1 2.5/N 5PB 4/10	0	0
Denim	5PB 7/2	0	0

Summary of data collected for Month 1

Fabric swatch number	Munsell Color System (face side)	% degraded	Condition Score
1	2.5Y 7/3 2.5Y 3/1 GLEY 1 8/N	Total: 0.04 CV: 0.25	1
2	2.5 Y 3/1 10YR 7/6 10YR 7/2 GLEY 1 8/N	Total: 0 CV: 0	0
3	10 YR 2/1 10 YR 3/2 10 YR 7/2 GLEY 1 8/N	Total: 0 CV: 0	0
4	2.5 Y 7/3 2.5Y 2.5/1 10YR 6/3 10YR 5/2 10YR 5/6 GLEY 1 8/N	Total: 0 CV: 0	0
5	10YR 7/6 10YR 7/2 10YR 8/1 GLEY 1 2.5/N	Total: 0.23 CV: 1.25	1
6	2.5Y 7/4 10YR 6/3 10YR8/1 10YR 2/2 GLEY 1 2.5/N	Total: 0 CV: 0	0
7	10YR 4/1 10YR 6/3	Total: 0 CV: 0	0
8	10YR 2/1 10YR 8/4 GLEY 2 7/10B	Total: 0 CV: 0	0

9	10 YR 8/1 (44%) 10 YR 4/2 (25%) 10 YR 6/3 (25%) 2.5 Y 5/3 (5%) 5 Y 5/1 (1%)	Total: 4.8 CV: 1.18	1
10	2.5Y 7/3 (47%) 10YR 4/2 (40%) 10YR 2/2 (10%) 2.5Y 5/3 (3%)	Total: 0.13 CV: 0.11	1
11	10YR 5/3 (50%) 10YR 2/2 (10%) 2.5Y 4/1 (25%) 2.5Y 7/6 (3%) 2.5Y 8/1 (12%)	Total: 0.02 CV: 0	1
12	10YR 2/1 (5%) 10YR 4/2 (25%) 2.5Y 7/3 (55%) 2.5Y 5/3 (10%) GLEY2 6/10BG (5%)	Total: 0 CV: 0	0
13	GLEY1 4/N (20%) GLEY1 2.5/N (25%) 10YR 8/1 (30%) 5PB 4/10 (25%)	Total: 0 CV: 0	0
14	GLEY1 2.5/N GLEY1 4/N 10YR 8/2 5PB 4/10	Total: 0 CV: 0	0
15	5Y 2.5/1 (25%) 2.5Y 7/3 (1%) 10YR 8/1 (10%) 5PB 7/2 (64%)	Total: 0.04 CV: 0.22	1
16	10YR 2/1 (3%) 2.5Y 3/3 (5%) 10YR 3/2 (20%) 5PB 7/2 (72%)	Total: 0 CV: 0	0
17	10YR 6/3 (29%) 10YR 4/6 (3%) 7.5YR 5/2 (5%) GLEY1 5/10Y (40%) 10YR ¾ (3%) 10YR 8/1 (20%)	Total: 2.83 CV: 14.78	1
18	10YR 2/1 (5%) 10YR 6/6 (1%) 10R 5/2 (1%) GLEY1 4/10Y (30%) 10YR 6/3 (30%) 10YR 8/1 (33%)	Total: 0.17 CV: 0.58	1
19	GLEY1 4/10Y (15%) 10YR 5/2 (10%) 10YR 6/3 (15%) 10YR 8/1 (60%)	Total: 0.01 CV: 0.06	1
20	10YR 5/3 (40%) 2.5Y 3/1 (3%) 10YR 8/1 (56%) 10 R 5/2 (1%)	Total: 0 CV: 0	0
21	GLEY 4/N GLEY 2.5/N 10YR 6/3 10YR 8/1 5PB 4/10	Total: 0 CV: 0	0
22	10YR 7/3 GLEY2 2.5/5 PB 10YR 8/1 GLEY1 5/N 5PB 4/10	Total: 0 CV: 0	0

23	10YR 2/1 (5%) 10YR 3/2 (25%) 10YR 8/1 (5%) 5PB 7/2 (65%)	Total: 0 CV: 0	0
24	10YR 3/2 (25%) 10YR 8/1 (3%) 5PB 7/2 (72%)	Total: 0 CV: 0	0

Summary of data collected for Month 2

Fabric swatch number	Munsell Color System (face side)	% degraded	Condition Score
25	10YR 5/6 (1%) 10YR 3/2 (10%) 10YR 6/3 (20%) 2.5Y 5/1 (10%) GLEY1 8/N (58%) 5Y 7/6 (1%)	Total: 0 CV: 0	0
26	10YR 2/1 (20%) 10YR 6/6 (15%) 10R 7/1 (1%) GLEY1 8/N (50%) 2.5Y 5/2 (14%)	Total: 0 CV: 0	0
27	10YR 2/1 (3%) 10YR 7/2 (20%) 10YR 4/4 (5%) 5Y 6/8 (1%) GLEY1 8/N (71%)	Total: 0.04 CV: 0.22	1
28	10YR 2/1 (10%) 10YR 8/2 (70%) 10YR 5/6 (1%) 10YR 8/1 (19%)	Total: 0 CV: 0	0
29	GLEY2 2.5/5PB GLEY1 6/N 2.5Y 7/2 10YR 8/1 10YR 6/6 5PB 4/10	Total: 0.02 CV: 0.08	1
30	GLEY1 5/N 10YR 6/3 10YR 6/6 10YR 8/1 5PB 4/10	Total: 0.06 CV: 0.31	1
31	10YR 2/1 (3%) 10YR 4/1 (15%) 10YR 6/6 (1%) 5PB 8/2 (76%) 5PB 7/8 (5%)	Total: 0 CV: 0	0
32	GLEY1 2.5/N (3%) 10YR 6/2 (1%) 10YR 3/2 (15%) 5PB 8/2 (20%) 5PB 5/10 (61%)	Total: 0 CV: 0	0
33	2.5Y 3/3 (10%) 2.5Y 6/2 (40%) 2.5Y 5/2 (40%) 2.5Y 6/6 (3%) 10R 5/4 (7%)	Total: 46.93 CV: 98.86	5

34	10YR 6/3 (40%) 10YR 5/2 (40%) 10R 6/6 (1%) 2.5Y 5/4 (19%)	Total: 30.29 CV: 56.81	4
35	10YR 4/2 (50%) 10YR 8/1 (5%) 5Y 4/1 (40%) 5Y 5/6 (3%) 2.5Y 5/6 (1%) 10R 6/6 (1%)	Total: 0 CV: 0	0
36	10YR 8/2 (10%) 10YR 5/3 (30%) 10YR 5/2 (40%) 2.5Y 4/1 (20%)	Total: 0 CV: 0	0
37	10YR 5/2 10YR 8/1 10YR 2/1 GLEY1 2.5/N 5PB 4/10	Total: 0 CV: 0	0
38	GLEY1 2.5/N 10YR 5/3 10YR 7/1 GLEY1 4/N 5PB 4/10	Total: 0 CV: 0	0
39	GLEY1 7/N (15%) 10YR 2/1 (15%) 5Y 5/1 (25%) 10YR 7/3 (3%) 5PB 7/2 (42%)	Total: 0 CV: 0	0
40	10YR 2/1 (20%) 10YR 8/1 (10%) 10YR 5/1 (50%) 5PB 7/2 (20%)	Total: 0 CV: 0	0
41	10YR 6/3 (25%) 10YR 6/8 (5%) 5Y 4/2 (20%) 5Y 3/1 (40%) 10YR 8/1 (10%)	Total: 8.49 CV: 36.46	1
42	10YR 7/2 (40%) 10YR 5/3 (25%) 10YR 2/1 (5%) 10YR 5/8 (1%) GLEY1 3/5G (1%) 10YR 8/2 (28%)	Total: 6.33 CV: 12.5	1
43	10YR 8/1 (25%) 10YR 7/3 (40%) 10YR 4/3 (10%) 5Y 3/2 (20%) 10YR 7/8 (3%) GLEY1 7/N (2%)	Total: 0 CV: 0	0
44	10YR 7/2 (75%) 10YR 8/2 (15%) 10YR 3/3 (3%) 10YR 5/4 (5%) 10YR 8/1 (2%)	Total: 0 CV: 0	0
45	GLEY1 5/N GLEY1 2.5/N 10YR 6/3 10YR 8/2 5PB 4/10	Total: 0 CV: 0	0
46	GLEY 2.5/N 5PB 4/10 GLEY 5/N 10YR 6/3 10YR 8/1	Total: 0 CV: 0	0

47	10YR 8/1 (15%) 10YR 4/1 (15%) 10YR 3/2 (5%) 10YR 2/1 (3%) 5PB 7/6 (62%)	Total: 0 CV: 0	0
48	10YR 3/2 (50%) 10YR 8/1 (15%) 10YR 5/2 (15%) 5PB 7/2 (20%)	Total: 0 CV: 0	0

Summary of data collected for Month 3

Fabric swatch number	Munsell Color System (face side)	% degraded	Condition Score
49	10YR 8/3 (5%) 10YR 2/2 (20%) GLEy1 8/N (75%)	Total: 0.01 CV: 0.03	1
50	10YR 5/4 (5%) 2.5Y 8/2 (5%) 2.5Y 4/1 (25%) 10YR 2/2 (20%) 10YR 4/4 (3%) GLEY1 8/N (42%)	Total: 0 CV: 0	0
51	10YR 4/3 (3%) 10YR 6/4 (5%) 10YR 3/1 (10%) 10YR 5/6 (1%) GLEY1 8/N (40%) 10YR 8/1 (41%)	Total: 0.01 CV: 0.03	1
52	10YR 2/2 (5%) 10YR 3/1 (10%) 2.5Y 8/2 (10%) 10YR 8/2 (30%) GLEY1 8/N (45%)	Total: 0 CV: 0	0
53	5PB 4/10 GLEY1 2.5/N 10YR 5/6 (5%) 10YR 7/2 10YR 8/1 GLEY1 5/N	Total: 0.13 CV: 0.56	1
54	5PB 4/10 GLEY1 2.5/N 10YR 7/6 GLEY1 5/N 10YR 6/3 10YR 8/1	Total: 0.03 CV: 0.14	1
55	GLEY1 7/10B (96%) 10YR 4/4 (1%) 10YR 3/2 (3%)	Total: 0 CV: 0	0
56	5PB 7/6 (69%) GLEY2 6/10B (25%) 10YR 7/6 (1%) 10YR 3/1 (5%)	Total: 0 CV: 0	0
57	10YR 6/8 (10%) 10YR 7/4 (20%) 10YR 8/1 (30%) 10YR 5/1 (40%)	Total: 50.65 CV: 99.89	6

58	2.5Y 7/4 (30%) 10YR 4/2 (50%) 5Y 3/2 (10%) 5Y 4/4 (10%)	Total: 34.39 CV: 59.64	4
59	10YR 4/1 (20%) 10YR 4/2 (20%) 10YR 3/1 (20%) 10YR 5/6 (5%) 2.5Y 4/1 (20%) 10YR 7/1 (5%)	Total: 0 CV: 0	0
60	10YR 4/2 (40%) 10YR 3/1 (10%) 10YR 6/2 (20%) 10YR 7/2 (30%)	Total: 0 CV: 0	0
61	GLEY 2.5/N GLEY 4/N 5PB 4/10 10YR 5/3 10YR 8/1	Total: 0 CV: 0	0
62	GLEY 2.5/N 5PB 4/10 10YR 6/3	Total: 0 CV: 0	0
63	5PB 7/2 (30%) 10YR 3/1 (40%) 10YR 4/2 (15%) 2.5Y 8/1 (15%)	Total: 0.03 CV: 0	1
64	5PB 7/2 (20%) 5PB 8/4 (20%) 2.5Y 8/1 (25%) 10YR 6/2 (15%) 10YR 3/1 (20%)	Total: 0 CV: 0	0
65	10YR 4/1 (70%) 10YR 8/3 (10%) 5Y 4/2 (10%) 10YR 3/1 (10%)	Total: 55.40 CV: 95.06	6
66	10YR 8/2 (20%) 10YR 6/2 (70%) 10YR 2/1 (10%)	Total: 40.52 CV: 45.85	5
67	10YR 4/2 (20%) 10YR 5/8 (3%) 5Y 4/2 (50%) 10YR 2/2 (10%) 10YR 8/1 (10%) 10YR 7/1 (5%) 10R 6/3 (2%)	Total: 0 CV: 0	0
68	10YR 6/3 (50%) 10YR 5/3 (15%) 10YR 5/8 (5%) 10YR 2/1 (15%) 10YR 5/1 (5%) 10YR 7/1 (10%)	Total: 0 CV: 0	0
69	GLEY1 2.5/N 5PB 4/10 10YR 3/1 10YR 6/3	Total: 0 CV: 0	0
70	5PB 4/10 GLEY1 2.5N GLEY1 3/N 10YR 6/3	Total: 0 CV: 0	0

71	5PB 8/2 (5%) 10YR 3/1 (80%) 10YR 8/1 (15%)	Total: 0 CV: 0	0
72	5PB 7/4 (45%) 10YR 2/1 (15%) 10YR 3/1 (20%) 10YR 6/1 (20%)	Total: 0 CV: 0	0

Summary of data collected from Month 4

Fabric swatch number	Munsell Color System (face side)	% degraded	Condition Score
73	10YR 3/2 (15%) 10YR 8/3 (3%) 5Y 6/4 (1%) GLEY1 8/N (81%)	Total: 0.31 CV: 0.42	1
74	10YR 5/2 (25%) 10YR 6/3 (25%) 10YR 3/2 (5%) GLEY1 8/N (45%)	Total: 0.04 CV: 0.22	1
75	10YR 5/3 (3%) 10YR 8/3 (5%) 10YR 2/1 (50%) GLEY1 8/N (87%)	Total: 0 CV: 0	0
76	10YR 3/1 (30%) 10YR 6/2 (10%) 10YR 8/6 (1%) 10YR 8/3 (5%) 5YR 7/3 (5%) GLEY1 8/N (49%)	Total: 0 CV: 0	0
77	5PB 4/10 GLEY1 2.5/N GLEY1 4/N GLEY1 8/N 10YR 6/3 10YR 3/2 10YR 7/6	Total: 0.16 CV: 0.72	1
78	5PB 4/10 GLEY1 2.5/N GLEY1 4/N GLEY1 8/N 10YR 6/8 10YR 6/3	Total: 0.06 CV: 0.33	1
79	GLEY2 8/10B (82%) 5PB 7/2 (5%) 10YR 2/1 (3%) 10YR 4/1 (10%)	Total: 0 CV: 0	0
80	GLEY2 8/5PB (25%) 5PB 7/6 (15%) 10YR 3/1 (20%) 10YR 8/4 (5%) GLEY2 7/10B (25%)	Total: 0.01 CV: 0.03	1
81	2.5Y 8/4 (60%) 10YR 5/1 (15%) 2.5Y 5/1 (10%) 2.5YR 6/4 (1%) 10YR 3/1 (5%) 10YR 6/8 (9%)	Total: 73.01 CV: 100	8

82	10YR 5/2 (45%) 10YR 5/3 (45%) 2.5YR 6/4 (10%)	Total: 73.52 CV: 94.67	8
83	10YR 6/2 (20%) 10YR 5/2 (20%) 10YR 2/1 (10%) 2.5Y 8/2 (5%) 2.5Y 4/1 (20%) 2.5 Y 6/4 (10%) 10YR 7/2 (15%)	Total: 0 CV: 0	0
84	10YR 3/1 (20%) 10YR 5/3 (15%) 10YR 2/1 (5%) 2.5Y 7/6 (10%) 10YR 8/1 (50%)	Total: 0 CV: 0	0
85	GLEY1 2.5/N 5PB 4/10 10YR 6/3 10YR 5/2	Total: 0 CV: 0	0
86	5PB 4/10 GLEY1 2.5/N GLEY1 3/N 10YR 6/3	Total: 0 CV: 0	0
87	5PB 7/2 (45%) 10YR 3/1 (15%) GLEY2 5/5B (15%) GLEY1 8/N (25%)	Total: 0 CV: 0	0
88	5PB 7/2 (60%) GLEY1 8/N (10%) 10YR 2/1 (30%)	Total: 0 CV: 0	0
89	10YR 4/2 (10%) 10YR 7/4 (20%) 5Y 5/2 (50%) 2.5Y 3/1 (20%)	Total: 72.24 CV: 100	8
90	10YR 5/8 (20%) 10YR 7/4 (20%) 5Y 3/1 (20%) 5Y 4/2 (40%)	Total: 72.93 CV: 85.5	8
91	10YR 8/1 (15%) 2.5Y 7/6 (5%) 10YR 6/3 (15%) 10YR 5/3 (15%) 10YR 2/1 (25%) 5Y 3/1 (25%)	Total: 0.01 CV: 0.03	1
92	10R 5/4 (1%) 10YR 5/1 (80%) 10YR 3/1 (10%) 10YR 8/1 (9%)	Total: 0 CV: 0	0
93	5PB 4/10 GLEY1 2.5/N 10YR 4/1 10YR 6/3 10YR 8/1	Total: 0 CV: 0	0
94	5PB 4/10 GLEY1 2.5/N GLEY1 5/N 10YR 6/3	Total: 0 CV: 0	0
95	5PB 7/2 (20%) 10YR 3/1 (25%) 10YR 8/1 (30%) GLEY2 5/10B (25%)	Total: 0 CV: 0	0

96	5PB 7/2 (10%) 5PB 8/2 (30%) GLEY2 3/10B (30%) 10YR 3/1 (30%)	Total: 0 CV: 0	0

Summary of Data collected from Month 5

Fabric swatch number	**Munsell Color System (face side)**	**% degraded**	**Condition Score**
97	5Y 6/3 (10%) 10YR 3/2 (15%) 10YR 6/4 (3%) 10YR 6/8 (1%) 10YR 8/1 (71%)	Total: 0.37 CV: 1.64	1
98	10YR 8/4 (3%) 10YR 3/2 (25%) 10YR 8/1 (12%)	Total: 0.32 CV: 0.36	1
99	10YR 3/1 (20%) 10YR 8/2 (5%) 7.5YR 7/3 (5%) 10YR 8/1 (70%)	Total: 0.72 CV: 0.61	1
100	10YR 4/2 (20%) 10YR 8/3 (10%) 10YR 4/1 (10%) 10YR 8/1 (60%)	Total: 0 CV: 0	0
101	10YR 6/3 GLEY1 2.5/N GLEY1 6/N 5PB 7/2 10YR 8/1	Total: 0.20 CV: 0.20	1
102	GLEY1 2.5/N 5PB 4/10 10YR 6/3 GLEY1 5/N 10YR 4/2	Total: 0.06 CV: 0	1
103	GLEY2 8/10B (90%) 5PB 7/8 (5%) 10YR 2/2 (5%)	Total: 0.09 CV: 0.67	1
104	GLEY2 8/10B (25%) 5PB 7/8 (65%) 10YR 2/2 (10%)	Total: 0 CV: 0	0
105	10YR 6/3 (40%) 10YR 4/1 (60%)	Total: 68.51 CV: 99.56	7
106	10YR (100%)	Total: 96.10 CV: 100	10
107	10YR 6/2 (40%) 10YR 2/1 (5%) 5Y 4/1 (30%) 10YR 8/1 (25%)	Total: 0.02 CV: 0	1
108	10YR 3/2 (15%) 10YR 4/1 (70%) 10YR 7/2 (15%)	Total: 0 CV: 0	0

109	5PB 4/10 GLEY1 2.5/N 10YR 6/3	Total: 0 CV: 0	0
110	5PB 4/10 GLEY1 2.5/N GLEY1 4/N 10YR 6/3	Total: 0 CV: 0	0
111	5PB 8/4 10YR 3/1 10YR 8/1	Total: 0.25 CV: 1.22	1
112	5PB 7/2 (20%) GLEY2 5/10B (40%) 10YR 3/1 (20%) 10YR 8/1 (10%) 10YR 5/3 (10%)	Total: 0.05 CV: 0.25	1
113	10YR 6/3 (45%) 10YR 6/2 (45%) 10YR 4/6 (1%) 10YR 4/1 (9%)	Total: 66.44 CV: 100	7
114	10YR 7/3 (74%) 10YR 3/2 (25%) 5YR 6/3 (1%)	Total: 12.90 CV: 29.76	2
115	10YR 3/1 (25%) 10YR 4/2 (50%) 10YR 8/1 (10%) 10YR 6/3 (15%)	Total: 0.01 CV: 0	1
116	10YR 6/3 (75%) 10YR 8/1 (15%) 10YR 3/1 (10%)	Total: 0 CV: 0	0
117	5PB 4/10 GLEY1 2.5/N 10YR 5/2 10YR 6/3	Total: 0 CV: 0	0
118	5PB 4/10 GLEY1 2.5/N GLEY1 4/N 10YR 6/3	Total: 0 CV: 0	0
119	GLEY2 4/10B (25%) 5PB 7/2 (5%) 10YR 8/1 (25%) 10YR 2/1 (45%)	Total: 0.08 CV: 0	1
120	GLEY2 5/10B (40%) 10YR 8/1 (40%) 10YR 2/1 (20%)	Total: 0 CV: 0	0

Summary of data collected from Month 6

Fabric swatch number	Munsell Color System (face side)	% degraded	Condition Score
121	10YR 3/2 (20%) 10YR 8/1 (55%) 5GY 8/4 (10%) 5GY 7/4 (5%) 2.5YR 7/4 (10%)	Total: 0.84 CV: 1.86	1
122	10YR 3/2 (25%) 10YR 5/4 (10%) 10YR 7/3 (20%) 10YR 8/1 (45%)	Total: 0.99 CV: 1.11	1
123	10YR 3/2 (20%) 10YR 8/1 (70%) 2.5YR 7/7 (5%) 5GY 8/4 (5%)	Total: 0.50 CV: 0.97	1
124	10YR 3/2 (20%) 2.5YR 7/4 (2%) 2.5Y 7/3 (5%) 10YR 8/1 (73%)	Total: 0.03 CV: 0.06	1
125	GLEY1 2.5/N GLEY1 8/N 5GY 8/2 GLEY1 5/N 5P 4/10	Total: 0.21 CV: 1	1
126	5P 4/10 GLEY1 2.5/N GLEY1 8/N 10YR 4/2	Total: 0.02 CV: 0	1
127	GLEY2 8/5PB (80%) 5PB 8/4 (10%) 10YR 3/2 (10%)	Total: 0.43 CV: 1.64	1
128	GLEY2 8/5PB (30%) 5PB 7/2 (70%)	Total: 0 CV: 0	0
129	10YR 2/2 (90%) 10YR 7/2 (10%)	Total: 81.19 CV: 100	9
130	10YR 5/3 (95%) 10YR 3/2 (5%)	Total: 17.21 CV: 26.04	2
131	10YR 5/1 (95%) 10YR 3/2 (5%)	Total: 0 CV: 0	0
132	10YR 5/2 (95%) 10YR 3/2 (5%)	Total: 0 CV: 0	0
133	5P 4/10 GLEY1 2.5/N 10YR 5/2	Total: 0 CV: 0	0
134	5P 4/10 GLEY 2.5/N 10YR 7/1	Total: 0 CV: 0	0

135	GLEY2 8/5PB (40%) GLEY2 5/10B (55%) 10YR 3/2 (5%)	Total: 0 CV: 0	0
136	GLEY2 8/5PB (25%) 5PB 8/4 (70%) 10YR 3/2 (5%)	Total: 0 CV: 0	0
137	10YR 7/4 (5%) 10YR 3/2 (30%) 10YR 5/2 (65%)	Total: 70.26 CV: 100	8
138	10YR 6/3 (90%) 10YR 3/2 (10%)	Total: 90.77 CV: 96	10
139	10YR 5/4 (3%) 10YR 8/1 (10%) 10YR 3/1 (87%)	Total: 0.02 CV: 0.03	1
140	10YR 8/1 (25%) 10YR 5/2 (5%) 10YR 3/2 (70%)	Total: 0 CV: 0	0
141	5P 4/10 10YR 7/1 GLEY1 2.5/N	Total: 0 CV: 0	0
142	5P 4/10 GLEY1 2.5/N 10YR 4/1 10YR 6/3 10YR 8/1	Total: 0 CV: 0	0
143	GLEY2 8/5PB (40%) GLEY2 5/10B (60%)	Total: 0.06 CV: 0.28	1
144	GLEY2 8/5PB (25%) GLEY2 4/10B (70%) 10YR 3/2 (5%)	Total: 0 CV: 0	0

APPENDIX D: DATA FOR PERCENT WEAKENED OF THE FOUR FABRIC TYPES

Percent weakened of cotton positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0	0
Trench 1	0	4.38	66.12	22.1	45.41	86.09
Trench 2	4.5	10.2	58.31	39.56	15.62	100

Percent weakened of cotton positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0	2.73
Trench 1	2.11	6.66	37.14	100	100	0
Trench 2	0.72	3.26	20.14	58.73	7.15	0

Percent weakened of cotton/polyester flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0.03	0	0.44
Trench 1	13.85	42.46	42.59	67.6	52.88	100
Trench 2	0	7.74	22.29	31.48	63.49	43.27

Percent weakened of cotton/polyester positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0	0
Trench 1	5	8.11	31.69	20.02	40.1	62.39
Trench 2	1.82	12.19	13.94	48.83	13.08	36.73

Percent weakened of rayon positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0	0
Trench 1	0	0	0	0	0	0
Trench 2	0	0	0	0	0	0

Percent weakened of rayon positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0	0
Trench 1	0	0	0	0	0	0
Trench 2	0	0	0	0.03	0	0

Percent weakened of denim positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0.02	1.89	0.74
Trench 1	21.56	46.5	19.81	55.62	34.45	99.41
Trench 2	2.97	11.75	32.56	62.05	51	55.5

Percent weakened of denim positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0.05	0	0	1.73
Trench 1	1.41	26.85	23.18	8.28	27.41	58.01
Trench 2	0.82	5.93	6.72	72.96	76.22	42.36

APPENDIX E: DEGRADATION OF THE CENTER VALUE OF ALL FOUR FABRIC TYPES

Degradation of Center Value of cotton positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0.25	0	0.03	0.42	1.64	1.86
Trench 1	1.18	98.86	99.89	100	99.56	100
Trench 2	14.78	36.46	95.06	100	100	100

Degradation of Center Value of cotton positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0.22	0.36	1.11
Trench 1	0.11	56.81	59.64	94.67	0	26.04
Trench 2	0.58	12.5	45.85	85.5	29.76	96

Degradation of Center Value of cotton/polyester positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0.22	0.03	0	0.61	0.97
Trench 1	0	0	0	0	0	0
Trench 2	0.06	0	0	0.03	0	0.03

Degradation of Center Value of cotton/polyester positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0	0.06
Trench 1	0	0	0	0	0	0
Trench 2	0	0	0	0	0	0

Degradation of Center Value of rayon positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	1.25	0.08	0.56	0.72	0.2	1
Trench 1	0	0	0	0	0	0
Trench 2	0	0	0	0	0	0

Degradation of Center Value of rayon positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0.31	0.14	0.33	0	0
Trench 1	0	0	0	0	0	0
Trench 2	0	0	0	0	0	0

Degradation of Center Value of denim positioned flat

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0	0.67	1.64
Trench 1	0.22	0	0	0	1.22	0
Trench 2	0	0	0	0	0	0.28

Degradation of Center Value of denim positioned crumpled

	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Ground Surface	0	0	0	0.03	0	0
Trench 1	0	0	0	0	0.25	0
Trench 2	0	0	0	0	0	0.0

APPENDIX F: ORANGE COUNTY IFAS SOIL REPORT

Orange County/University of Florida IFAS Extension
Division of Health & Community Services
6021 S. Conway Rd., Orlando, FL 32812
Tel: 407-254-9200
Fax: 407-850-5125
http://ocextension.ifas.ufl.edu

UF UNIVERSITY of FLORIDA IFAS Extension

ORANGE COUNTY GOVERNMENT FLORIDA

SOIL ANALYSIS REPORT

Date: 4/11/2013

NAME Lorraine Humbert STREET 4000 Central FL Blvd

CITY Orlando STATE FL ZIP 32826 TEL# 407-547-6529

Sample No.	What are you trying to grow?	Your pH	To Adjust pH Use	To Adjust pH lbs. per	Suggested Fertilizer* lbs. per	Suggested Fertilizer* Analysis	FOR OFFICE USE ONLY
							Fabric samples buried
1		4.5					at: surface
2		4.5					30cm
3		7					60cm
4		7					pH of each location
5		7					

*Fertilizers listed are only suggestions. Products of a similar analysis may be substituted. For example: 25-5-10, 15-0-15,and 12-4-8 could be used in place of a 16-4-8 at the manufacturer's suggested rates.

Agent/Master Gardener Signature: [illegible]

W B AI/AK H A/PI F

(11/10)

APPENDIX G: RESEARCH PERMIT

University of Central Florida Green Space Research Permit

www.green.ucf.edu

Please print and carry with you at all times.

Permit Number: R2012-06 Issued Dates: April 2012 – December 2012

Authorized Time: Sunrise - Sunset

Site: Geotechnical Engineering Site located within the Arboretum

Authorized Vehicles: Vehicle use is permitted to the study site (see *Note below)

Permit Issued To: Dr. John J. Schultz

Authorized Activities: This permit authorizes the above personnel along with one student to study the deterioration of clothing fibers to collect information for time since death estimates. Clothing swatches of different fabrics will be buried (and placed on the ground surface), then monitored monthly for data collection and analysis.

*Note: Please use caution with vehicles in traveling on the dirt trails to the study site. There are active Gopher Tortoise (including hatchlings) in this area of the Arboretum.

Issued by: Jennifer Pudewell; 4/11//2012
Disturbance of vegetation and creation of new trails is not permitted. All materials must be removed at the end of the issued date. If you have any questions or problems please contact Alaina Bernard or Jennifer Pudewell, UCF Land Management Program at 407-823-3146 and 407-823-4702, respectively.

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