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# Impacts of consumer horticulture on stormwater and nutrient management: Investigating public perception, knowledge, and practices in the Shenandoah River Watershed

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Impacts of consumer horticulture on stormwater and nutrient management: Investigating public  
perception, knowledge, and practices in the Shenandoah River Watershed

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A dissertation submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

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## Abstract

The South Fork Shenandoah River is a tributary to the Chesapeake Bay that is a significant contributor to nitrogen and phosphorus that enter the Bay and leads to increased eutrophication. These nutrients also cause problems in the South Fork Shenandoah River. The United States Environmental Protection agency has implemented strict regulation to reduce nutrients entering the Bay by developing the Chesapeake Bay TMDL. While the TMDL has strict regulation on wastewater treatment, agriculture, and industry, there are still sources of nutrients entering the Bay through unregulated sources. Urban/suburban runoff is one of these sources, particularly runoff from home owner's lawns. This research investigated the consumer horticulture and runoff management practices and knowledge of individuals living in the South Fork Shenandoah River watershed. This was done to gain an understanding of the rates of sustainable practices and knowledge in the South Fork Shenandoah River watershed as well as provide a basis for educating people about consumer horticulture and runoff management Best Management Practices (BMPs) in the watershed. Research was conducted by surveying the faculty and staff at James Madison University through the implementation of an online questionnaire.

The questionnaire found that large numbers of people were not actively using many of the BMPs for the purpose of nutrient management. Nearly half did not think about their lawn from a conservation perspective and didn't use any consumer horticulture BMPs identified in the survey. There were also low rates of runoff management BMP use as only one of the practices identified was used by a significant number of people. These numbers could be linked to the lack of sustainability knowledge demonstrated by the respondents. These results show that while the residence of the South Fork Shenandoah are not using sustainable nutrient management practices. There is potential to increase sustainability through educational programs that discuss the concerns associated with nutrient management and offers education on BMP use.

## 1. INTRODUCTION

The Chesapeake Bay is the largest estuary in the United States and has significant ecological importance. Over the last several decades the Chesapeake Bay has had problems with increased rates of eutrophication and there have since been efforts to restore the Chesapeake Bay. This research aims to review the history of nutrient management within the Chesapeake Bay as a whole and then to analyze survey data that has been collected from individuals who primarily reside in the South Fork Shenandoah River watershed.

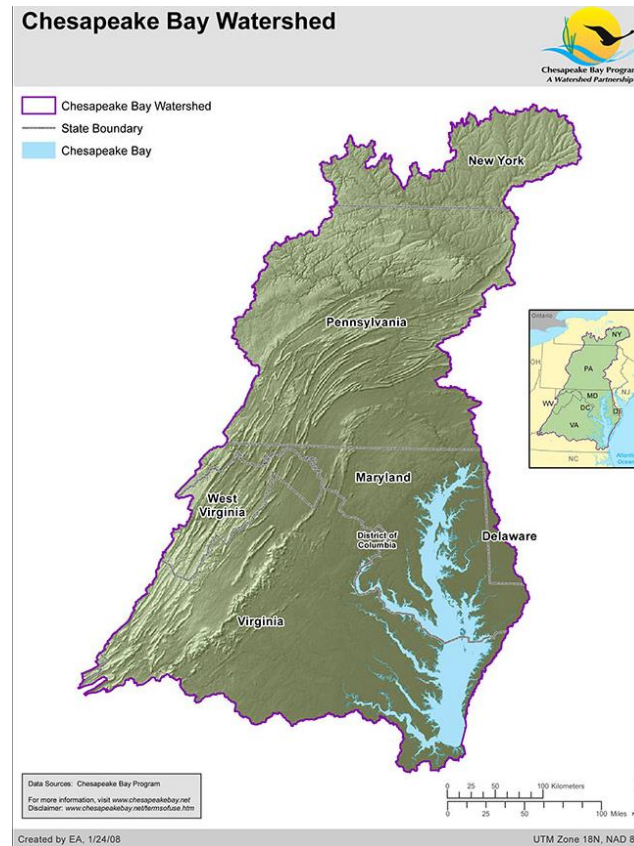
This research will focus on identifying the lawn management practices of individuals in the Shenandoah River Valley, with a focus on consumer horticulture. It will also identify their knowledge on how common practices impact nutrient inputs to the Chesapeake Bay. This will give a picture about the current state of the public attitude towards nutrient management in the Shenandoah River valley based on the demographical information that will also be collected.

### 1.1 Background

The Chesapeake Bay watershed (pictured in figure 1.1) spans more than 64,000 square miles and is home to over 17 million people. Virginia, Maryland, West Virginia, Delaware, Pennsylvania, New York, and Washington D.C. all have land within the bay's watershed. The biodiversity of the bay includes 348 species of finfish and 173 species of shellfish as well as 3,600 species of plant and animal life. Some of the economic value of the bay includes, but is not exclusive to, 500 million pounds of seafood harvested annually (Chesapeake Bay Watershed Geographic Facts, undated). The land to water ratio in the bay is 14:1. This is the largest of any coastal waterbody in the world. Because of this, the health of the bay is impacted more significantly by actions within its watershed relative to other coastal waters around the world (Chesapeake Bay Watershed Geographic Facts, undated). The Bay has been negatively impacted



by anthropogenic activities that have increased the nutrients entering the bay, in particular nitrogen and phosphorus.



*Figure 1.1, Chesapeake Bay watershed*

(Chesapeake Bay Watershed Geographic Facts, undated) <http://www.cbf.org/about-the-bay/more-than-just-the-bay/chesapeake-bay-watershed-geography-and-facts>

Nutrient pollution is currently one of the most costly problems that faces the United States in order to clean up the environment (“The Problem”, undated). Nutrients are a natural and essential part of aquatic ecosystems; however, excess nutrients can lead to nutrient pollution that can degrade the ecosystem. Nitrogen and phosphorus are nutrients that are a common by-product of human activities that can have a negative impact on ecosystems. The anthropogenic sources of these nutrients are mainly generated through agriculture, industry, human wastewater, and urban/suburban runoff (Rabalais, 2002). These nutrients are required for growth. However,

when a large amount of excess nutrients enter an aquatic ecosystem over an extended period of time, it leads to rapid eutrophication in that ecosystem (Murphy, Kemp, and Ball, 2011).

Anthropogenic sources of nutrients have led to a current eutrophication problem in the Chesapeake Bay.

Degradation in the Bay began when European settlers to America began clearing timber for agriculture which caused erosion and sedimentation of the Bay. Conversion of this land for agricultural purposes led to pollution of the Bay and its upstream watershed from increased runoff. Nutrient pollution began to become more serious with the development of chemical fertilizers which led to increased nutrients entering the Bay (U.S. Environmental Protection Agency, 2010). Another major contributor leading to this problem was poor livestock management practices where nutrients entered the water through animal waste and erosion caused by the animals in pastures.

By the 1970s the Bay was rapidly losing aquatic life and Maryland Senator Charles Mathias sponsored a Congressionally funded five-year study in order to determine the cause. This study concluded that excess nitrogen and phosphorus were the main contributors to the Bay's decline (U.S. Environmental Protection Agency, 2010). This led to the Chesapeake Bay agreement in 1983 where the Governors of Maryland, Virginia, and Pennsylvania, the mayor of the District of Columbia and the chairman of the Chesapeake Bay Commission signed the agreement which acknowledged the decline in the Bay's health and agreed to establish the Chesapeake Executive Council. This agreement had little effect and in 1987 the same signers came up with another agreement that had more quantifiable goals. They set a goal to reduce point source and non-point source nutrients entering the Bay by 40% by 2000. The Chesapeake Bay Program (CBP) was also established at this time (Chesapeake Bay Program, 2014). The CBP was established in order to coordinate Federal and State efforts as well as monitor the Chesapeake Bay.

By 2000 the goal of 40% reduction had not been met and the EPA began setting up the framework to establish the Chesapeake Bay Total Maximum Daily Load (TMDL) for nitrogen, phosphorus and sediment. A TMDL is the maximum amount of a substance that can enter a water body. The Chesapeake Bay TMDL was established in 2010 and details plans to reduce nutrient inputs by 2025 to the point where the Bay will be fully restored over time, 60% of these reductions are to be met by 2017 (U.S. Environmental Protection Agency, 2010). There are seven Jurisdictional zones under the TMDL which are Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia. Each of these areas was required to submit a watershed implementation plan in 2010 (WIP I) and another one (WIP II) in 2012. A third watershed implementation plan (WIP III) is due in 2017 (U.S. Environmental Protection Agency, 2010).

One of the nutrient sources of concern that is addressed by the TMDL is from urban and suburban runoff. Runoff occurs after a rain event. The water that does not evaporate or infiltrate into the groundwater runs off the surface. Since there are many impermeable surfaces in urban and suburban areas, runoff is a significant volume of water. In most cases in urban and suburban areas this runoff is collected in the storm water system and dealt with according to EPA regulations. However, because of cost, water treatment facilities often do not treat water for nutrients unless it is over the limit for human consumption, which is 10mg/L for nitrates. This is much higher than the ambient level of 0.6mg/L for nitrates (Virginia Department of Conservation and Recreation, 2008). The CBP estimates that, in 2009, urban and suburban development and runoff contributed to 16 percent of the sediment loadings, 15 percent of the phosphorus loadings, and 8 percent of the nitrogen loadings to the Bay (U.S. Environmental Protection Agency, 2014).

The Shenandoah River's South Fork is a significant area for study in regards to nutrient pollution. Much of the land in the South Fork Shenandoah River watershed is in the top 50% contributor and above for urban nitrogen sources entering the Bay from Virginia. This is further

discussed in section 2.4 where figure 2.8 can be found which shows this trend. The contribution from urban and suburban development will continue to increase at a higher rate than other sources as development expands (Stormwater Runoff, undated). In accordance with Virginia's watershed implementation plans, the state has made some important progress in reducing nutrient loads into the Chesapeake Bay from urban and suburban runoff. This includes legislation that requires that no phosphorus be in lawn maintenance fertilizer as well as significant investments in storm water infrastructure (U.S. Environmental Protection Agency, 2014). However there are still obstacles that make nutrient management of urban and suburban areas difficult. For example, these areas include many private residences that are difficult to bring under regulatory control for nonpoint source pollution.

## 1.2 The Research Question and Justification

Excess nutrients continue to enter the Chesapeake Bay from storm water runoff that is generated from privately owned residences in urban and suburban parts of the Chesapeake Bay watershed. In order to develop strategies to help reduce nutrient loads, it is important to have an understanding of the households of the specific area by knowing how households manage their lawns, and to determine whether or not they understand the issues. This is because a large portion of nutrients that enter the Bay from storm water is from land owner practices, such as application of fertilizer to lawns and gardens (Schueler, 2011).

The following list of questions are the research questions that were considered when designing the survey and when interpreting the results of this research:

- What are the current consumer horticulture practices in the Shenandoah River watershed with respect to stormwater management and nutrient management?
- What is the current knowledge on how consumer horticulture practices impact nutrient management and water quality in the Shenandoah River Valley?

- Does overall environmental awareness and concern impact knowledge or practices on nutrient management?
- Is there any way to predict nutrient management practices or knowledge through demographic information?
- Do knowledge and practices vary in different geographic regions of the Shenandoah River watershed and between individuals living in the watershed and those outside of it?

The preamble to the 2014 Chesapeake Bay Watershed Agreement concisely describes why it is important to restore the Chesapeake Bay:

*The Chesapeake Bay watershed is one of the most extraordinary places in America, spanning six states and the District of Columbia. As the nation's largest and most productive estuary, the Chesapeake Bay and its vast network of more than 180,000 miles of streams, creeks and rivers, holds tremendous ecological, cultural, economic, historic and recreational value for the nearly 18 million people who live, work and play in the region.*

After reviewing the Chesapeake Bay TMDL and the EPA's WIP evaluations for Virginia, there is a trend where the EPA is focused on the reduction of nutrient inputs through traditionally high input sources such as agriculture and wastewater. While this is important, there is also a substantial amount of nutrients entering the bay from nonpoint source storm water runoff. A potential reason that this area has a lower focus is that there are many private land owners in urban and suburban areas where the runoff is generated. However, regardless of the reason, this demonstrates an area for potential nutrient reduction that has not been sufficiently addressed.

Common practices such as garden and lawn fertilization increase the amount of nutrients in the runoff. Another potential concern from storm water is that in the case of a large rain event excessive runoff can cause erosion that will release more nutrients (Schueler, 2011). A

combination of high cost and potential public resistance makes strict regulation of these properties impractical. Public outreach and education has been embraced as an important part of improving the health of the Chesapeake Bay; for example the Chesapeake Bay Foundation (CBF) uses many resources to educate students on the issues (Stewardship and Meaningful Watershed Educational Experiences, 2001). Before actions are taken in an area, it is important to understand characteristics of the population that may allow future strategy development to help reduce future nutrient runoff. This research aims to identify the potential for expanded public outreach and education if it is found that homeowners are not informed about nutrient management issues.

### 1.3 Methodology and Data

The data that collected for this research was through an online questionnaire that identifies the respondent's lawn management habits involving consumer horticulture. The questionnaire also identified the respondent's knowledge on how different lawn management practices affect nutrient loadings to the Chesapeake Bay. Basic demographic information questions were also included in the survey. The survey was administered to the faculty and staff at James Madison University through Qualtrics, an online surveying resource that was available through JMU.

The demographic data was used to determine the habits of different individuals based on their social standing. Responses will be analyzed to identify any groups that tend to be more environmentally conscious and or environmentally literate out of the sampled population. Data was also used to gain a general understanding of the current status of people's practices and knowledge of how they can reduce their own impact on the Bay. Also, zip codes were collected from the respondents for spatial analysis.

The rest of this thesis will go into further depth and expand on the ideas that were touched on in this introductory chapter. Chapter 2 will discuss nutrients and relate them to the issues impacting the Chesapeake Bay as a whole and the South Fork Shenandoah River

specifically. It will also look at policy considerations and conservation considerations. Chapter 3 will discuss the methodology used for this research which was a survey. It will also discuss how the survey was designed and why this design was chosen. Chapter 4 discusses the results of the survey through descriptive statistics, GIS analysis and cross tabulations. Chapter 5 will conclude with the implications of key findings as well as recommendations and options for future study.

## 2. ENVIRONMENTAL TRENDS & WATER CONSERVATION POLICY

This chapter contains two primary themes. The first is regarding how nutrients cycle in the environment and the current state of nutrient pollution within the study area. The second theme involves public policy implementation as well as other water conservation efforts. The first theme will discuss how environmental processes function naturally with respect to nutrients and how human activities have altered these processes. How consumer horticulture impacts nutrient pollution will be specifically investigated. It will also discuss the current status of nutrient pollution in the Chesapeake Bay as a whole and then focus more specifically on the South Fork Shenandoah River. The second theme will focus on policy development over the years including the various Chesapeake Bay Agreements and the development and implementation of the Chesapeake Bay TMDL. Water conservation will also be discussed in this section through consumer horticulture BMPs and as well as how these BMPs can be best implemented through public outreach.

### Theme 1: The environment, nutrient cycling, and nutrient contamination

#### 2.1 What are nutrients and why do they matter

When considering nutrients and their role in environmental degradation the two nutrients that are most important are nitrogen and phosphorus. Each of these nutrients function differently in the environment and have individual pathways of entering aquatic ecosystems. Before we can manage nutrients in an ecosystem, it is important to understand and quantify how they move through ecosystems. Nitrogen is an essential element for life because it is found in the amino acids, proteins and nucleic acid of living organisms (Pidwirny, 2011). Nitrogen moves through the biosphere in a cycle that is shown in the following figure 2.1.



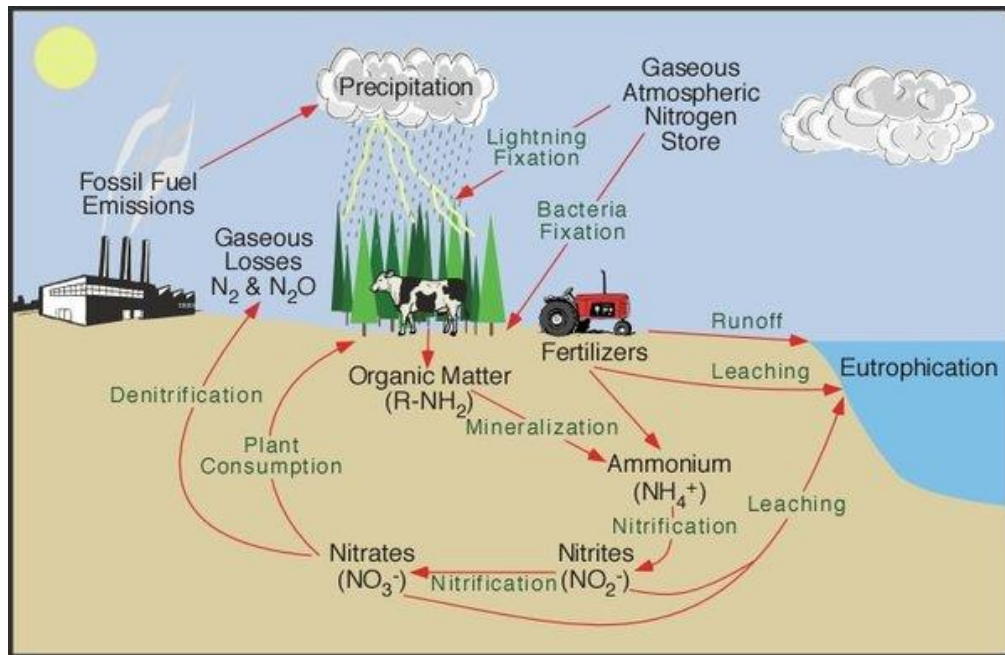


Figure 2.1, Nitrogen Cycle

(Pidwirny, 2011), <http://www.eoearth.org/view/article/154864>.

The largest store of nitrogen that is part of the nitrogen cycle is present in the atmosphere as nitrogen gas ( $N_2$ ).  $N_2$  gas is not useable by plants and animals so it must first be converted into ammonium ( $NH_4^+$ ) or nitrate ( $NO_3^-$ ) by a process called fixation. About 90% of the nitrogen fixation that occurs naturally is done by bacteria converting nitrogen gas into ammonium (Rosswall, 1981). Another form of nitrogen fixation is through lightning strikes where nitrogen gas and water react to form ammonia ( $NH_3$ ) and nitrate which are then transported to the ground by precipitation where they can be used by plants. Animals get the nitrogen they need when eating plants. Most nitrogen in ecosystems is stored in living and dead organic matter (Pidwirny, 2011). Dead organic matter is decomposed by bacteria and fungi and the nitrogen is converted back into ammonium through a process called mineralization. An important medium in the nitrogen cycle is soil because clay particles in soil have a negative charge. Since ammonium is positively charged it attaches to soil and is held in place and can be stored on the clay particles. Ammonium is released from the soil particle through exchange with another cation (a cation is an ion with a positive charge). Once released from clay particles the ammonium is free to react and

is converted into nitrite ( $\text{NO}_2^-$ ) and nitrate by bacteria through a process called nitrification (Rosswall, 1981). Since nitrite and nitrate are negatively charged, they do not attach to clay and move more freely through the soil. The nitrogen is removed from the soil back into the atmosphere as nitrogen gas by denitrification. This can occur by bacteria in anaerobic soils (soil that lacks oxygen). Also, the nitrites and nitrates can leach from the soil into waterbodies since they are highly mobile. Once in water they make their way to the ocean and are eventually return to the atmosphere as nitrogen gas through denitrification (Pidwirny, 2011).

The other important cycle to understand is the phosphorus cycle. In most ecosystems, phosphorus is the limiting factor for growth (Falconer, undated). The majority of phosphorus is stored in mineral form in rocks and sediment, only a small fraction is in an organic form. Phosphates ( $\text{PO}_4^{3-}$ ) are made available to plants through the weathering of rocks. Animals then eat the plants or other animals to get the phosphorus they need, much like in the nitrogen cycle. The process that causes phosphates to be incorporated into living organisms is called immobilization (Hogan 2012). Phosphorus from organism's urine and feces or decaying organisms is converted back to phosphate by bacteria through mineralization. In soil, phosphorus is stored in insoluble phosphates. These insoluble phosphates do not leach from the soil and therefore the loss of phosphorus through leaching is not a problem like it is for nitrogen (Espinoza, L., Norman, R., Slaton, N., and Daniels, M., undated). Phosphorus slowly makes its way to the ocean through gradual leaching and soil erosion where it settles into sediment. Over long periods of time the sediment will form rocks and the phosphorus will reenter the geological cycle (Hogan, 2012). The phosphorus cycle is shown in figure 2.2.

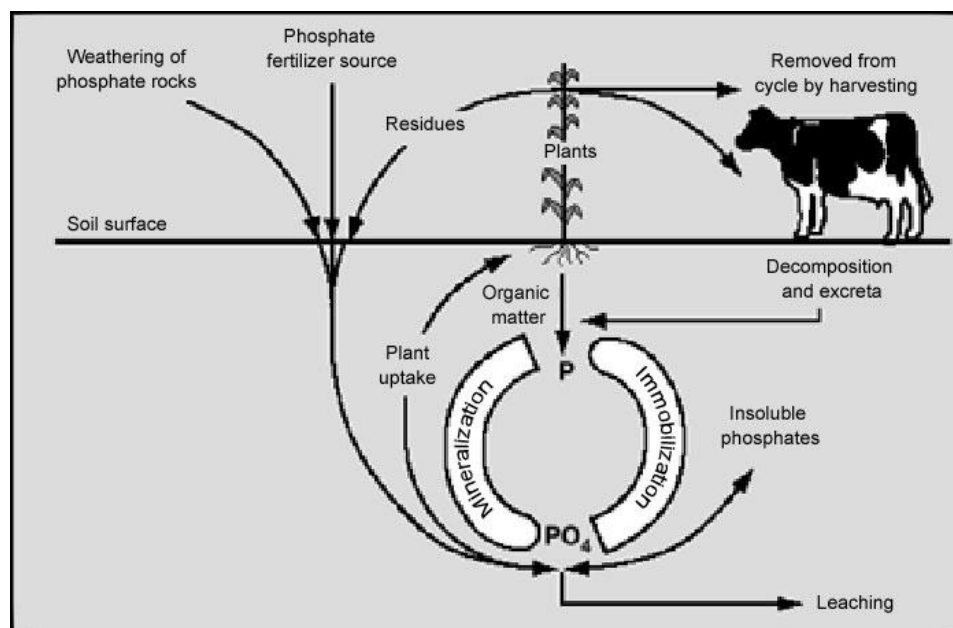


Figure 2.2, Phosphorus Cycle

(Biogeochemical Cycling in Ecosystems, undated)

[https://www.learner.org/courses/envsci/unit/text.php?unit=4&secNum=4#phosphorus\\_cycle](https://www.learner.org/courses/envsci/unit/text.php?unit=4&secNum=4#phosphorus_cycle)

The current problem is that human activities have changed the nitrogen and phosphorus cycle and changed the balance of ecosystems. There are several pathways that these nutrients have that were not previously available. First, the amount of erosion that takes nutrients to waterbodies has increased. Agriculture has greatly increased the amount of nutrient entering water through livestock feces and crop fertilization which introduce nutrients through both runoff and leaching (U.S. Environmental Protection Agency, 2010). Human waste from sewage treatment plants and storm water runoff are other anthropogenic sources of these nutrients. The combustion of fossil fuels is an additional source of nitrogen entering ecosystems. Combustion of any material will react with nitrogen gas forming nitrogen oxides ( $NO_x$ ) in the atmosphere, in a rain event these nitrogen oxides will be deposited on the earth's surface and continue in the nitrogen cycle.

Once nitrogen and phosphorus enter water bodies in bioavailable forms, they contribute to eutrophication. Eutrophication is the process where ecosystems that are rich in nutrients have

excessive algae growth. As the algae decomposes, it consumes the oxygen in the water and other species that require that oxygen die (Eutrophication, undated). This can lead to large fish kills that damage the environment as well as reduce the ecosystem services that are provided by that particular ecosystem. Eutrophication is a natural process. However, anthropogenic activities can greatly accelerate the process which does not allow the ecosystem to gradually adapt to the change and can cause extensive ecological damage. Figure 2.3 shows a photograph taken of an experiment conducted in 1973 that visually demonstrates how an ecosystem can be impacted. Excess phosphate was added to the south part of the lake which is separated from the northern part by a barrier (Falconer, undated).



*Figure 2.3, Eutrophication caused by excess phosphate*

(falconer, undated) <http://www.visionlearning.com/en/library/Earth-Science/6/The-Phosphorus-Cycle/197>.

## 2.2 Nutrient issues associated with consumer horticulture

There are several ways that consumer horticulture and lawn management practices contribute to nutrient pollution when improperly managed. The ways that nutrients are exported from lawns are from runoff and to a much lesser degree leaching and volatilization of nitrogen into the atmosphere as gas. Leaching is generally not a problem since soil will naturally remove nutrients. The primary time that this can become a problem is when a lawn is fertilized that is in close proximity to a waterbody and there is not time for the nutrients to be removed before they enter the waterbody.

Runoff can become a significant pathway that nutrients are lost from a lawn. In a natural ecosystem, some of the rain will be absorbed by the soil and some will runoff until it reaches a waterbody. Even in a natural ecosystem, a certain amount of nutrient will be “picked up” through the runoff. There are many impermeable surfaces on and surrounding a house. These include the roof of the house, driveways, sidewalk, patios, etc. Since water cannot be absorbed by these, it increases the amount of runoff since the ratio of amount of water falling on the land to the amount of soil that can absorb the water is significantly decreased. The increased amount of runoff will run into the stormwater system or to nearby waterbodies, forest, etc. In addition to the way properties are designed increasing the amount runoff from a lawn, there are aspects of consumer horticulture that increase the excess nutrients that are available to be carried away in the runoff.

If fertilizer is inappropriately applied to a lawn or gardens this could result in excess nutrient loss. For example, failing to clean fertilizer off impermeable surfaces, or applying chemical fertilizer right before a large rain event. Also, nutrients can be exported from a yard in the form of organic material. This can be through lawn clippings that are not cleaned off of impermeable surfaces. In addition, in areas that do not have appropriate ground cover, erosion can occur and organic and inorganic nitrogen and phosphorus can be carried off the lawn with the eroded soil. Inappropriate land cover could include things such as exposed soil on the lawn or

poorly maintained flower beds or vegetable gardens. The best ways to manage these nutrient losses will be discussed through BMPs later in this paper.

### 2.3 Current Nutrient Pollution trends

Urban and suburban areas account for 15 percent of the phosphorus loadings, and 8 percent of the nitrogen loadings to the Bay (U.S. Environmental Protection Agency, 2014). When data on nutrients loadings are collected and models are used to determine the sources of nutrients, there is some variation in how the sources of nutrients are allocated. However, a common source allocation for reporting that was used in the Chesapeake Bay TMDL is reporting nutrients from point-source, agriculture, forest, stormwater runoff, septic, and non-tidal deposition (U.S. Environmental Protection Agency, 2010). Point source pollution is defined in the CWA as “discernable, confined, and discrete conveyance, including...any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, or vessel or other floating craft, from which pollutants are or may be discharged” (Clean Water Act of 1972, 502(14), 40 CFR 122.2).

All of the sources listed in figures 2.4 and 2.5 are considered non-point source except the category labeled as point source. Non-point sources are any water that enters the Bay that does not fit the legal definition of point source given by the CWA (U.S. Environmental Protection Agency, 2010). The agricultural portion comes from any agricultural activities including nutrients that may runoff after fertilizing crops or nutrients generated from animal waste for farmers that own livestock. Much of the nutrients that come from the forest source do not originate from the forest, but rather from some of the other sources. For example, runoff from a yard that doesn’t enter the stormwater system, but instead runs into a nearby forest, will be sourced to forest rather than point source or stormwater runoff. For this reason, the forest source is sometimes allocated differently and is grouped with other sources (Restoration and Protection Efforts, undated). Stormwater runoff refers to nonregulated stormwater since stormwater that is

regulated by MS4 (Municipal Separate Stormwater Sewer System) permitting and combined sewer systems are considered point sources. The septic source refers to the nutrients that comes from the septic systems that are prevalent in the Chesapeake Bay watershed. Non-tidal deposition refers to nitrogen deposited on the land in the bay's watershed that eventually enters the bay. The amount of phosphorus from non-tidal deposition is negligible.

This categorization demonstrates how complicated nutrient pollution source allocation can become. The categories are all designated into land use categories rather than listing their ultimate source. A likely reason that these nutrient source categories are selected by the EPA is because it allows for more clear regulation methods. For example, regulation of farming operations and point source nutrient pollution is much more easily regulated than runoff from an individual's yard that goes to a forest and then into a nearby stream. The contribution of each source at the time of the Chesapeake Bay TMDLs implementation in 2010 is shown for nitrogen in figure 2.4 and for phosphorus on figure 2.5 for each jurisdictional zone.

<b>Jurisdiction</b>	<b>Agriculture</b>	<b>Forest</b>	<b>Stormwater runoff</b>	<b>Point source</b>	<b>Septic</b>	<b>Nontidal deposition</b>
Delaware	3%	1%	1%	0%	2%	1%
District of Columbia	0%	0%	1%	5%	0%	0%
Maryland	16%	14%	28%	27%	36%	27%
New York	4%	7%	3%	3%	5%	5%
Pennsylvania	55%	46%	33%	25%	30%	42%
Virginia	20%	27%	33%	39%	24%	25%
West Virginia	3%	4%	2%	1%	2%	1%
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Note: Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters.

*Figure 2.4, Percent of total nitrogen delivered to the Bay from each jurisdiction by pollutant source sector*

(U.S. Environmental Protection Agency, 2010)

<b>Jurisdiction</b>	<b>Agriculture</b>	<b>Forest</b>	<b>Stormwater runoff</b>	<b>Point source</b>	<b>Septic</b>	<b>Nontidal deposition</b>
Delaware	4%	1%	1%	0%	0%	0%
District of Columbia	0%	0%	1%	2%	0%	0%
Maryland	19%	14%	28%	21%	0%	27%
New York	5%	7%	3%	5%	0%	5%
Pennsylvania	24%	25%	16%	28%	0%	27%
Virginia	42%	45%	50%	42%	0%	38%
West Virginia	6%	7%	2%	3%	0%	2%
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Note: Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters. Although the percentage contribution of phosphorus from nontidal deposition is provided here, the overall amount of phosphorus contributed from nontidal deposition is considered to be insignificant.

*Figure 2.5, Percent of total phosphorus delivered to the Bay from each jurisdiction by pollutant source sector*

(U.S. Environmental Protection Agency, 2010)

While the Chesapeake Bay TMDL has its method of reporting the sources of nutrients, there are other ways they can be reported. The nutrient contribution from consumer horticulture to the Bay spans over several of these sources and exact numbers on how much it contributes to nutrient pollution are not available. The Bay TMDL seems to allocate sources in such a way so that it can regulate large industries and sectors such as agriculture, water treatment and point source discharge from specific businesses. While this method is effective from a regulatory perspective, it may miss some opportunities for nutrient pollution reduction in areas such as consumer horticulture that would require implementation of policies that aim to increase public awareness and improve consumer horticulture BMP usage.

Since there is currently no method for determining the amount of nutrient entering the Bay from consumer horticulture, the next part of this section will discuss the following topics to give an idea of how much consumer horticulture impacts nutrient pollution. First, the total amount of nitrogen and phosphorus entering the Bay will be discussed. Then turf grass coverage in both the Bay's watershed as a whole and Virginia specifically will be discussed. Finally, the amount of fertilizer used in the Bay's watershed as well as nutrient dynamics in managed turf grass will be discussed.



Regulators use an array of models in order to help implement management policies to restore the Chesapeake Bay. The following data was generated by the phase 5.3 watershed model which describes the transport and fate of nutrients in the Chesapeake Bay watershed (Modeling, undated). This model uses land use, fertilizer applications, wastewater plant discharges, septic systems, air depositions, farm animal populations, weather and other variables to derive nutrient loads entering the Bay. The total amount of nitrogen entering the Bay each year in 2013 was 262.38 million pounds from agricultural runoff and discharges, wastewater treatment plant discharges, urban and suburban runoff, septic tank discharges, and air deposition. Virginia's contribution to this amount was 60.86 million pounds. In order to meet the TMDL standards this needs to be reduced to 52.59 million pounds by 2025. Approximately 16% (40.76 million pounds) of the 262.38 million pounds of nitrogen that entered the Bay in 2013 was from urban and suburban runoff (Restoration and Protection Efforts, undated). Similarly agricultural runoff and discharges, wastewater treatment plant discharges, urban and suburban runoff contributions to phosphorus inputs into the bay accounted for 17.19 million pounds in 2013. Virginia contributed 7.66 million pounds to this and needs to reduce inputs to 6.40 million pounds by 2025. 2.81 million pounds of the 17.19 million pounds of phosphorus that entered bay in 2013 was from urban and suburban runoff (Restoration and Protection Efforts, undated).

A technical bulletin issued by the Chesapeake Stormwater Network looked at the extent of turf grass cover in the Bay's watershed using GIS analysis, statewide turf grass industry statistics, and impervious surface/turf cover regression. The impervious surface/ turf cover regression estimated turf cover by relating it to the fractional extent of impervious surface area derived from night time lights radiance, road density, and Landsat-derived urban land cover values. In 2004 there were 1,702,000 total acres of turf grass in Virginia, 55% of this was in the Chesapeake Bay watershed (Schueler and Claggett, 2010). 1,048,000 acres were attributed to privately owned home lawns. Additionally, this number had increased to 1,702,000 total acres of

turf grass from 617,923 total acres of turf grass in Virginia in 1972 (Virginia's Turfgrass Industry, 2006). Virginia currently has over 1.2 million acres of turf grass in the Chesapeake Bay watershed, compared to the 15.3 million acres of land in the Bay watershed in Virginia. According to Virginias WIP, 500,000 of these acres must implement nutrient management plans in order to reach compliance with the bay TMDL by 2025 (Urban Nutrient Management, undated).

It is relatively easy to determine the amount of fertilizer used and where it is used for agricultural applications because of the availability of sales data. This data is not as readily available for fertilizer applied to turf grass on urban and suburban land because of the difficulty determining where and when fertilizer is applied; this makes it a low priority for the EPA. It is estimated that 215 million pounds of nitrogen are applied to lawns in the Chesapeake Bay watershed each year (Why Stormwater Management Matters, undated). While specific data on nutrient inputs into the Bay from turf grass is limited, there have been studies conducted to understand nitrogen and phosphorus dynamics in turf grass.

Less than 1% to 18% of phosphorus applied to a lawn through fertilization is lost depending on the conditions. Factors that may increase phosphorus loss from a lawn include steep slopes, compacted soils, frozen ground, and low turf density (Soldat and Petrovic, 2008). This highest potential for phosphorus loss occurs in winter months when the turf is dormant and the ground is frozen (Soldat and Petrovic, 2008). Most cases of phosphorus loss if from runoff because phosphorus leaching does not occur frequently or in significant amounts. Phosphorus loss also increases as the rate of fertilizer containing phosphorus increases (Shuman, 2004). Turf grass clippings have been measured to contain between 2.0% and 5.0% phosphorus. This can be another source of phosphorus if poor lawn management practices causes these clippings to be removed in run off. Also, phosphorus can be removed from a lawn in runoff as organic phosphorus attached to eroded sediment.

Nitrogen naturally enters lawns through mineralization of nitrogen in the soil, atmospheric deposition and can be artificially added through fertilization (Schueler and Lane, 2013). Similar to phosphorus, nitrogen loss from lawns is highly variable and depends largely on factors that increase the amount of runoff from a lawn. Loss rates can be increase by steep slopes, compacted soils, frozen ground, low turf density (Schueler and Lane, 2013). Unlike phosphorus, leaching can be a significant source of nitrogen export from turf grass. Nitrate leaching is generally not a problem on turf grass where fertilizer is not applied, but it can become significant depending on the timing and the rate of the fertilizer application as well as the soil type. Figure 2.6 was generated by the Chesapeake Storm Network after they reviewed multiple studies about nitrate leaching. It demonstrates that increasing rates of nitrogen fertilization also increases the amount of nitrogen that is lost through leaching. A study conducted in Glyndon, Maryland found that the average homeowner uses about 85 pounds of fertilizer per acre, this is consistent with other national data (Lawn, Band and Grove, 2010). This is on the lower end of leaching risk in figure 2.6 however depending on the soil characteristics leaching can be a problem. The same study conducted in Glydon found that 53% of their nitrogen budget was from lawn fertilization. Therefore the combination of nutrient leaching and runoff can be problematic.

<b>Table 8: N Losses from Turf Grass as a Function of Fertilizer Application Rate</b>				
N Load Exported (lb/ac)	N Fertilizer Input (lb/ac)	% of Fertilizer Exported <sup>1</sup>	Reference	Notes
0.17	85	0.20%	Mancino & Troll, 1990	In 10 weekly apps
0.28	87.5	0.32%	Namcino & Troll, 1990	In 5 biweekly apps
0.06	93.7	0.06%	Spence et al. 2012	High Maintenance Fescue lawn
0.13	76.75	0.17%	Spence et al 2012	Low Maintenance Fescue Lawn
0.87	87.45	1%	Frank et al. 2006	Lo input <i>leaching losses</i>
1.78	131	1.36%	Guillard & Kopp 2004	Organic fertilizer
1.8	43.6	4.13%	Mancino & Troll, 1990	Single application
3.3	131	2.52%	Guillard & Kopp, 2004	PCSCU slow release
2.68	268	1%	Quiroga-Garza et al. 2001	Semi-arid, Warm season Bermuda grass
3.66	268	1.37%	Erickson 2001	<i>Leaching loss</i>
6.25	79	7.91%	King et al. 2001	<b>Hi Risk:</b> Watered to maintain 85% FC with tile drains
10.7	1071	1%	Quiroga-Garza et al 2001.	<b>Hi Risk:</b> Hi Input semi-arid Bermuda grass
23.02	131	17.55%	Guillard & Kopp 2004	<b>Hi Risk:</b> Highly soluble ammonium nitrate
24.05	219	11%	Frank et al. 2006	<b>Hi Risk:</b> Hi Input
68.02	412.3	16.5%	Roy et al 2000	<b>Hi Risk:</b> 3x sod grower practice overwhelms turf, fall <i>leaching losses</i> .
87-222	312	28%-71%	Pare et al 2006	<b>Hi Risk:</b> 80:20 sand peat media, applied 25kg/ha biweekly over 7 month growing season. Multiple cultivars.
<sup>1</sup> Export is calculated as % fertilizer inputs. This overestimates turf <i>system</i> exports for field studies with atmospheric inputs in precipitation. Not all studies measured all species of nitrogen, and some may have measured only surface or subsurface N losses				

Figure 2.6, Rates of fertilizers exported from lawns based on application rates

(Schueler and Lane, 2013)

The areas where this turf grass occurs are golf courses, athletic fields, community and business parks, common areas in developed communities, and residential lawns. Voluntary reduction of nutrients applied to residential lawns would be a good way to reduce nutrient loads; however this requires an educated public. Nutrient management plans will consider more than just the fertilizer that is applied. It will also include other BMPs that will be discussed in a later section.

## 2.4 South Fork Shenandoah River

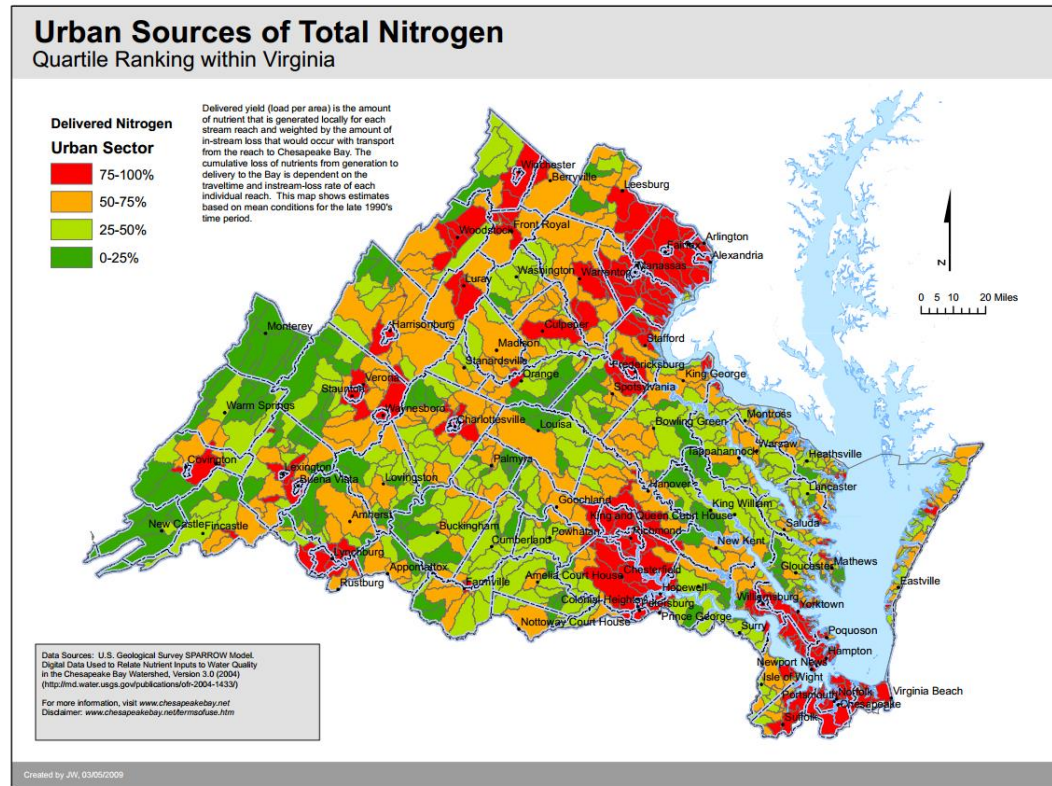
The South Fork Shenandoah River watershed (shown in figure 2.7) was chosen as the region for study for several reasons. First is its significance to nutrient pollution in the Bay.

Figure 2.8 shows the amount of nitrogen entering the Chesapeake Bay from urban sources in Virginia's section of the Chesapeake Bay watershed. This demonstrates that the urban and suburban contribution to nitrogen in the Shenandoah River's South Fork is high with much of it in the top 50% contributor and above. This is especially relevant considering that this is a rural area. Also the environmental history of the Shenandoah River is compelling as there have been large algae blooms as well as large fish kills (these fish kills were not necessarily related to nutrient management issues). The other primary reason was because of convenience as James Madison University is located within this watershed so the study population in this area was more accessible than any other area would have been.



*Figure 2.7, South Fork Shenandoah River location*

(Virginia Department of Conservation and Recreation, 2008)



*Figure 2.8, Urban sources of total nitrogen delivered to the Bay in Virginia*

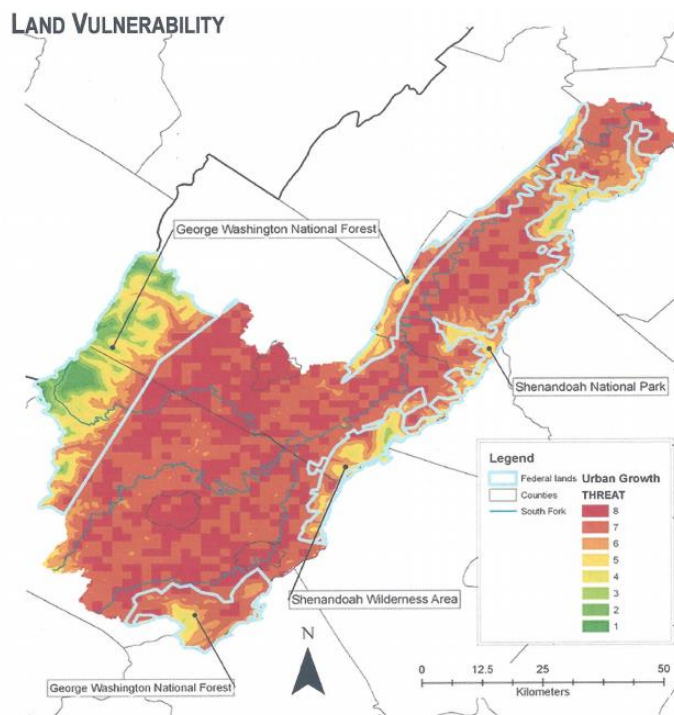
(Urban Sources of Total Nitrogen – Quartile Ranking within Virginia)

[http://www.chesapeakebay.net/images/maps/cbp\\_34545.pdf](http://www.chesapeakebay.net/images/maps/cbp_34545.pdf)

The questionnaire that was developed for this research was given to individuals who primarily reside in South Fork Shenandoah River watershed. The watershed for the Shenandoah River's South Fork is 1.1 million acres. This watershed is a largely rural area; however it has experienced significant growth. From 1990 to 2005 the watershed's population increased by 20% to 220,000. By 2030 the population is predicted to be between 255,000-275,000 (Virginia Department of Conservation and Recreation, 2008).

The land cover that contributes to nutrient runoff in the watershed is 38% agricultural and 4% residential or urban. The remaining 58% is forested and does not contribute significantly to nutrients entering the South Fork Shenandoah River. Residential and urban land cover is expected to increase as the population increases. Figure 2.9 shows the areas within the watershed that are vulnerable to development (Virginia Department of Conservation and Recreation, 2008).

This rates urban growth threat on a scale from 1-8. More than 65% of the watershed is either 6 or higher while only 2.5% of the watershed is a 1.



*Figure 2.9, Vulnerability of land to development*

(Virginia Department of Conservation and Recreation, 2008)

The ambient concentration of nitrate in aquatic ecosystems with no stress from humans is 0.6mg/L according to the EPA. While Virginia does not have an ambient water quality standard, it has a drinking water standard of 10mg/L. Monitoring conducted by Friends of the Shenandoah River showed that two tributaries to the North River violated this water quality standard more than 10% of the time and therefore had TMDLs created (Virginia Department of Conservation and Recreation, 2008). Several tributaries to the South River are well above the EPA ambient concentration of 0.6mg/L and still increasing. For example, the Wheat Spring Branch is now above 3mg/L for nitrate, however it is not listed as impaired because it is well within the drinking water quality standards (Wayne Webb, 2014). Like nitrogen, phosphate does not have an ambient level in Virginia. It is worth noting that data collected by Friends of Shenandoah River

show that phosphate levels are decreasing in the South River and its tributaries (Virginia Department of Conservation and Recreation, 2008).

As of 2012 there were TMDLs for 11 tributaries to the South Fork Shenandoah River. Many of them were for sediment and phosphorus, none were for nitrogen (Virginia Department of Environmental Quality, 2012). Algae blooms are currently prevalent throughout the Shenandoah River; however the river as a whole is not listed as impaired since it is not technically in violation of any water quality standards throughout much of the river. Some groups, such as the Shenandoah Riverkeeper, are pushing for the entire river to be listed as impaired so measures can be taken to reduce algae blooms which are a nuisance for those who recreate in the river as well as a hazard for the potential of creating dead zones (Potomac RiverKeeper, Inc., 2014). Not only do the nutrients that cause these algae blooms negatively impact the Shenandoah River, but they will be carried downstream and eventually contribute to the nutrient problems in the Chesapeake Bay.

Historically the major source of nutrient pollution in the watershed has been from agriculture. There has been recognition of agriculture as a problem to nutrient pollution and many programs have been implemented to reduce this pollution. For example, the creation of state and federal cost share programs that cover up to 75% of cost for farmers who implement practices to keep livestock out of streams (Virginia Department of Conservation and Recreation, 2008). While there are still agricultural practices that need to be improved to reduce nutrients, urban and suburban nutrient runoff is emerging as a problem in the Shenandoah River (Potomac RiverKeeper, Inc., 2014).

This section has outlined the nitrogen and phosphorus cycles. It has also described how anthropogenic activities from agricultural practices to urban and suburban development have disrupted the natural cycles and increased the nutrients entering the Chesapeake Bay. This has led to eutrophication problems that threaten the aquatic life within the Bay. This paper also



outlines how nutrient accounting is conducted for regulatory purposes as well as discuss nutrient dynamics in turf grass. While exact numbers on nutrients entering the Bay from consumer horticulture are not available, the data in this area that is available has been used to demonstrate the potential for nutrient reduction in the Bay from this source. Finally, the significance of the South Fork Shenandoah River watershed was discussed. It was shown that the nitrogen contribution from the South Fork Shenandoah River watershed was high relative to other rural areas. This is of particular concern since figure 2.9 demonstrated that much of the watershed is expected to see increased urban growth. This means there is potential for educational programs to be implemented on BMPs in consumer horticulture to help reduce nutrient pollution within the watershed.

The next theme of this chapter will transition from nutrient dynamics and go further into policy development within the Bay watershed. Even though nutrient pollution was identified as the main problem in the Bay in the early 80s and several interstate agreements were made to reduce nutrient inputs, only modest improvements occurred. This led to Federal intervention in the form of the Chesapeake Bay TMDL. The next section discusses this public policy development as well as outlining some of the lesser used policy tools such as public education. It will discuss the tools that are particularly relevant to this research by discussing which consumer horticulture and lawn management BMPs could be implemented by homeowners to reduce nutrient runoff as well as look at some examples of how public education has influenced citizen behaviors in other studies.

## Theme 2: Public Policy and Water Quality Conservation

### 2.5 Chesapeake Bay Watershed Policy History

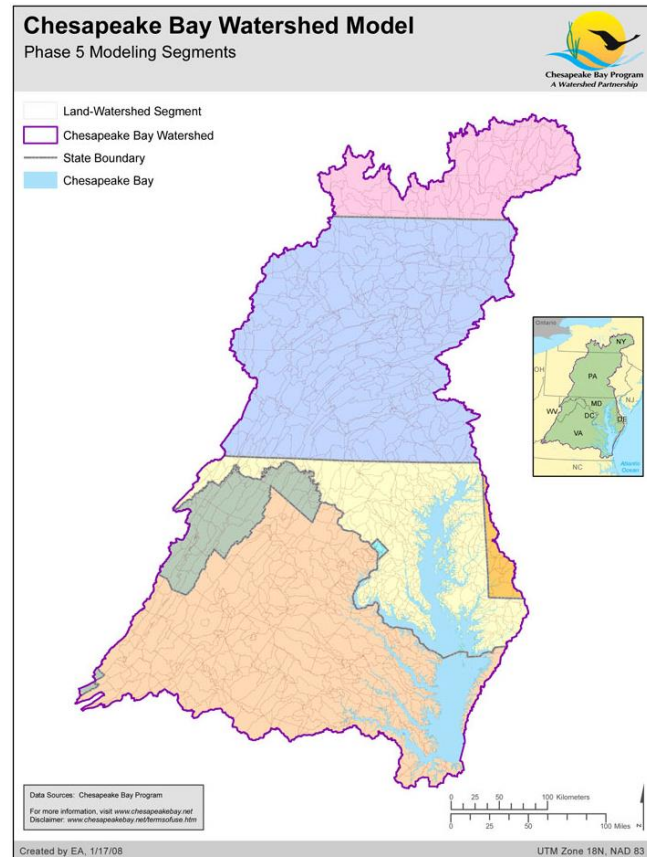
Current regulatory efforts within the Bay's watershed were established by the Chesapeake Bay TMDL in 2010. However, there is a history of degradation and restoration efforts that occurred before the TMDL that have required the development and implementation of

the Chesapeake Bay TMDL. There were many other environmental concerns emerging across the country in the 1960s and early 1970s which, among other environmental legislation, led to the Clean Water Act (CWA) establishment in 1972. The CWA set a goal for all waters in the United States to be fishable and swimmable (Clean Water Act of 1972, 2002). The CWA requires states to establish appropriate uses for all their waterbodies and come up with water quality standards so those uses can be protected. The CWA also requires that a list of waterbodies that do not meet the set standards be generated every two years. Soon after the CWA became law, the Congressionally funded study that was discussed in the introduction identified nitrogen and phosphorus as the causes of decline in the Bay (U.S. Environmental Protection Agency, 2010).

A series of agreements between the states in the Chesapeake Bay watershed have taken place in an attempt to restore the Bay. The Congressionally sponsored study prompted the first Chesapeake Bay agreement in 1983. This was a simple agreement signed by the governors of Virginia, Pennsylvania, and Maryland, the mayor of Washington D.C., the EPA administrator and the chair of the Chesapeake Bay Commission. It stated that cooperation was needed to solve the problems faced by the Bay and the restoration efforts involved. Little action was taken after the first agreement, and a second agreement was signed in 1987. It was decided that to restore the Bay, the amount of nitrogen and phosphorus entering the bay needed to be reduced by 40% by the year 2000. This goal was not met, but a third agreement was made in 2000 that was much more extensive than the previous two agreements (Chesapeake Bay Program History, undated). This was the first agreement that included New York Delaware and West Virginia. They do not contribute as heavily to nutrient inputs but they still have some land in the Chesapeake Bay watershed. This agreement set a goal of living resource protection and restoration, vital habitat protections and restoration, water quality protection and restoration, sound land use and stewardship and community engagement (Chesapeake 2000, 2000). In order to attain this, 102 specific goals were set; for example, in order to achieve water quality restoration the agreement

stated that “by 2002, complete a public process to develop and begin implementation of revised Tributary” (Chesapeake 2000, 2000).

While the series of Chesapeake Bay Agreements had some success in improving the conditions of the Bay, they were not effective enough to achieve restoration. By 2000, the EPA realized that goals for the Chesapeake Bay would not be attained without additional oversight. This is when the development of the Chesapeake Bay TMDL began (U.S. Environmental Protection Agency, 2010). A TMDL is a “pollution diet” that states the maximum amount of a specific pollutant can enter a waterbody and it still meet the CWA criteria for not being impaired. The EPA gets its authority for enforcing TMDLs from the CWA (Frequently Asked Questions about the Bay TMDL, undated). The Chesapeake Bay TMDL was established on December 29, 2010 and sets limits on nitrogen, phosphorus and sediment that enter the bay. Seven jurisdictional zones are recognized by the TMDL; they are Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia. These jurisdictional zones are shown in figure 2.10. The smaller image on the right of this images shows a map of the region with the Bay watershed outlined and the abbreviated jurisdictional zone names. The larger image shows only the watershed and the zones without labels.



*Figure 2.10, Jurisdictional zones in the Chesapeake Bay watershed*

(Andrew, E., 2008)

After using years of data collected and watershed models that had been developed it was determined nitrogen inputs must be reduced by 25%, phosphorus reduced by 24%, and sediment reduced by 20% between all the jurisdictions by 2025 (U.S. Environmental Protection Agency, 2010). These reductions will ensure the long term restoration of the bay. Each jurisdiction is allocated a maximum amount of nitrogen, phosphorus and sediment that it can release into the bay and has been required to submit a series of watershed implementation plans (WIPs) that state their goals for pollution reduction and how they will achieve attainment of their goals.

WIP I was submitted by each jurisdictional zone in November of 2010. The WIPs were sent in before the TMDL was established because they were used to provide information to the EPA when deciding where to allocate needed nutrient reductions. This way, the jurisdictional areas that contributed the most to each nutrient would be required to reduce the most. WIP I was

also designed for the jurisdictional areas to say what actions and control measures would be taken to reduce nutrients as well as set up authorities to oversee the progress (U.S. Environmental Protection Agency, 2010). The Chesapeake Bay TMDL requires that 2 year goals be set so that attainment of these goals can be tracked. The jurisdictional areas are allowed to work independently from the EPA in many ways unless they fail to meet these goals. If inadequate progress is made on the goals then federal action may be taken (How does it Work? Ensuring Results, undated).

The major areas for nutrient reduction that are addressed by Virginia's phase I WIP are agriculture, urban stormwater, and wastewater (EPA Evaluation of Virginia Final Phase I Watershed Implementation Plan, 2010). These reductions are to be attained largely by upgrades in wastewater treatment facilities, improvements in urban stormwater programs, and by expanding agricultural programs, this could result in more regulation of agriculture if voluntary programs are not successful (EPA Evaluation of Virginia Final Phase I Watershed Implementation Plan, 2010). The issue that Virginia's WIP I addresses that is relevant to this research is the MS4 program.

There are two primary types of sewer systems. They are sanitary sewers and stormwater sewers. Sanitary sewers transport waste water from homes and commercial buildings to wastewater treatment plants. After treatment water is typically discharged to local waterbodies. Stormwater sewers collect runoff from rain events. The water from these sewers often goes untreated before being discharged. There are also combined sewers where water from sanitary sewers and stormwater sewers are combined. The water from combined sewers is treated (Stormwater Management Program, 2015). MS4s are stormwater sewer systems that are operated by the Federal, state or a local government that help reduce nutrient loads. They do not include systems that transport sewage or a combination of sewage and rainwater (Virginia Department of Environmental Quality, 2010).

A permit is required to discharge water MS4s into natural waterbodies. Phase 1 permits are for larger cities and counties where the MS4 serves more than 100,000 people. Phase 2 are for smaller counties and cities and have less stringent requirements since small areas will not have as many resources for treatment of the water (Municipal Separate Storm Sewer System (MS4), 2014). One requirement for all MS4 permits is that public education and outreach be conducted on the impacts of stormwater. This relates as nutrient management should be a part of public education (Virginia Department of Environmental Quality, 2010). A major area of concern for all jurisdictional zones involved in the TMDL is the economic cost of the required nutrient reductions. According to Virginia's WIP I "urban nutrient management represents a cost-effective approach to reduce nutrient loss from land use. Virginia intends to maximize the implementation of urban nutrient management through a combination of actions." Virginia plans to use a combination of voluntary and regulatory actions to reduce nutrients in urban areas. Due to difficulty and public resistance that would come from regulation, the importance of public education and outreach is increased if the goals of Virginia's phase 1 WIP are to be achieved.

Phase II WIPs were submitted to the EPA by each jurisdictional zone in 2012. The primary purpose of phase II is to involve local governments, watershed organizations, conservation districts, citizens and other key stakeholders in the effort to reduce nutrient pollution (U.S. Environmental Protection Agency, 2010). It also serves to review the progress in nutrient reductions since the phase I WIP (Virginia Department of Environmental Quality, 2012). Some of the important steps that were taken in Virginia were during the 2011 Virginia General Assembly session when House Bill (HB) 1831 was passed. This advanced many of the strategies that were addressed in the phase I WIP. Some of the important urban nutrient management strategies included a prohibition on the sale and distribution of general lawn maintenance fertilizer containing phosphorus. Also the prohibition for the sale of any deicing agents containing urea, nitrogen, or phosphorus intended for application on parking lots, roadways, and

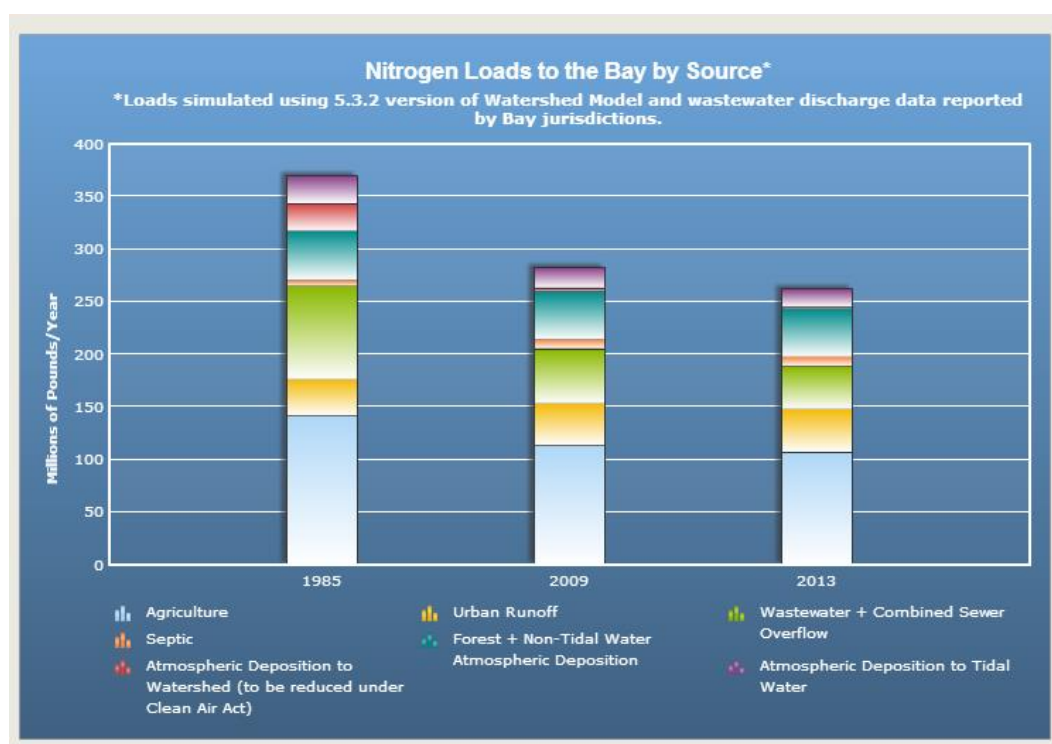
sidewalks, or other paved surfaces. It also required a report for contractors who planned to apply lawn fertilizer to more than 100 acres of nonagricultural lands annually (Virginia Department of Environmental Quality, 2012).

The phase II report did outline several public education outreach possibilities for urban nutrient management; however it failed to allocate funds for these projects which will inhibit implementation of these ideas (Virginia Department of Environmental Quality, 2012). In an EPA review of Virginia's phase II WIP, there was an emphasis on the operation and maintenance of stormwater treatment facilities as well as permitting (U.S. Environmental Protection Agency, 2014). A lack of the EPA citing urban horticulture practices and public education in Virginia's phase I and II WIP reviews, as well as limited allocation of funds by Virginia, shows that there has been limited focus in this area. This is potentially missing out on an opportunity as voluntary efforts by an educated public can prove to be one of the most cost efficient ways to reduce nutrient inputs into the bay. WIP III is due in 2017 and will be focused on ensuring that all the practices are in place by 2025 in order to fully restore the Chesapeake Bay and its tidal waters.

An example of the efforts in reducing nutrient pollution from consumer horticulture to the Chesapeake Bay is occurring in Harrisonburg, which is in the Southfork of the Shenandoah River watershed. As required by the MS4 permitting program, Harrisonburg has outlined public outreach that aims to educate the general public on how they can alter their behavior to reduce their contribution to nutrient pollution. This is being done primarily through several events held each year which include Blacks Run Clean-Up Day, household hazardous waste collection, school river field trips, and rain barrel workshops (City of Harrisonburg, 2014). Since the Chesapeake Bay TMDL is the largest TMDL that has been developed and requires much new regulation there may need to be additional help in order to improve effectiveness of programs. The Chesapeake Bay Foundation contracted the Williamsburg Environmental Group, which is a part of Stantec, to assist the city of Lynchburg, Va in meeting the public outreach mandate of the

MS4 permit (Chesapeake Bay Foundation, 2014). One of the major things that was focused on by this coop was the importance of feedback that analyzes the effectiveness of the public campaign and designing ways to improve the effectiveness of reaching the target audience as a result of any feedback.

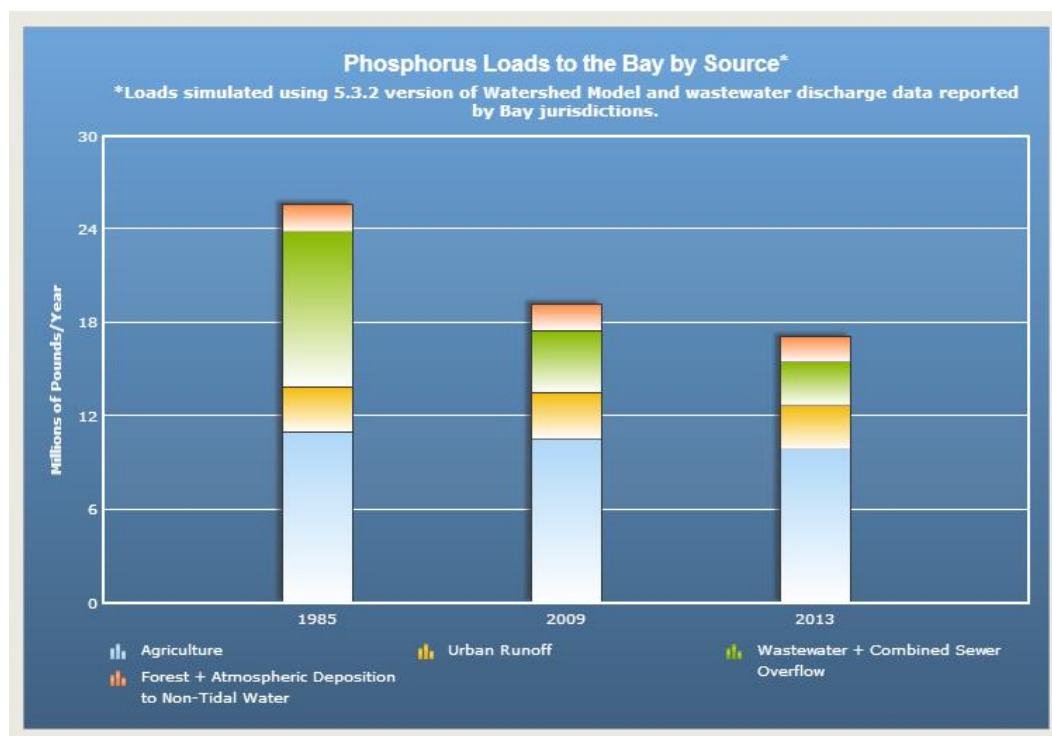
Some of the success in nutrient reduction that has been achieved through the Chesapeake Bay Agreements as well as progress since the implementation of the Chesapeake Bay TMDL is demonstrated by the following figures. Figure 2.11 and figure 2.12 show the reduction in nitrogen loading into the bay by source for nitrogen and phosphorus respectively.



*Figure 2.11, Nitrogen loads to the Bay by source*

(Restoration and Protection Efforts, undated) <http://www.chesapeakebay.net/track/restoration>





*Figure 2.12, Phosphorus loads to the Bay by source*

(Restoration and Protection Efforts, undated) <http://www.chesapeakebay.net/track/restoration>

## 2.6 Consumer Horticulture BMPs

Best Management Practices (BMPs) is a term that is used across various disciplines that uses a set of methods, measures, or structural controls to achieve a set goal. The BMPs used will often be specific to the discipline in question (Best Management Practices, 2014). An example of a specific area that uses BMPs is stormwater pollution management. A BMP for stormwater pollution management would be an action that can be taken that has the effect of reducing pollution in stormwater. Another aspect to account for in BMPs is not only the overall effect of achieving the goal, but also how efficiently resources are used to achieve the goal.

There are many consumer horticulture BMPs and general landscaping BMPs that homeowners can use to reduce pollution that is caused by their lawn. Some practices are not expensive or time consuming and the main barrier for these practices is getting the information to the public so they know to use these practices. BMPs like this include managing fertilizer use. Since fertilizer can be a large source of nutrients leaving a homeowners lawn, use can be reduced

or eliminated. For homeowners that choose to fertilize, Virginia Extension Services recommend that 1 pound of nitrogen be used per 1000 square feet (or about 45 pounds per acre) annually. However, this will vary depending on the lawn. In order for homeowners to determine if their lawn should be fertilized and how much, they should have a soil test conducted to see if their lawn is nutrient deficient (Home Lawn Fertilization in Virginia: Frequently Asked Questions, 2009). Since phosphorus has been banned in lawn fertilizers in Virginia there is no longer any consideration for phosphorus fertilizers. It is also important to fertilize at the right time of year. Fertilizing when the plants in a lawn are dormant can lead to significant nutrient loss (Homeowner Guide for a more Bay friendly property, 2014). It is also important to maintain a dense cover of grass or conservation landscaping. This will help to reduce runoff and erosion. Fertilization is not always negative since in nutrient deficient lawns, fertilizing may help improve cover which will increase nutrient retention (Home Lawn Fertilization in Virginia: Frequently Asked Questions, 2009).

Another important practice is to sweep any excess fertilizer and lawn clipping off impermeable surfaces. For example, lawn clippings on driveways or near storm drains will enter the storm drain in runoff if it is not swept away and will contribute to nutrient pollution (Lawn and Garden Care, undated). A cost saving BMP that can be used is to reduce or eliminate irrigating the lawn as this can lead to unnecessary runoff. One of the most important practices will not be employed by all homeowners. For individuals that have lawns on or near a waterbody, it is important not to fertilize near the water and also to maintain the area as a conservation landscape (Homeowner Guide for a more Bay friendly property, 2014). Areas like this on the edge of water features are known as riparian buffers and are one of the most important features for nutrient reduction into waterbodies from nonpoint sources. The width and type of vegetation within the buffer are important factors in removing nutrients. One study showed that when compared to a control with no buffer, a 23 foot buffer of switch grass removed 80% of total

nitrogen and 78% of total phosphorus. A 53ft wide buffer of switch grass and woody plants removed 94% of total nitrogen and 91% of total phosphorus (Lee, Isenhardt, and Shultz, 2003). While this is not a comprehensive list, it is some of the more common practices used and promoted by various education outreach groups.

There are also some BMPs that require significant investments in either time or money that can reduce nutrient pollution. Many of these are focused on water management. Planting trees can reduce runoff. Also, using rain barrels that collect water from the roofs of builds so it can be used at a later time for irrigation purposes. Rain barrels also reduce the volume of water running over the lawn in rain events and therefore reduces runoff. Permeable hard surfaces also increases water infiltration and reduces runoff. This can be used on surfaces such as driveways or sidewalks. A rain garden is an area that collects water from areas of the lawn that water commonly runoffs off, such as roofs or driveways. Natural soils in rain gardens are replaced with sandier ones and native plants are used to allow infiltration of water that may contain nutrients. Conservation landscaping is planting mulch beds with perennial plants shrubs and small trees in order to retain rainfall and absorb runoff from adjacent turf or paved surfaces (Homeowner Guide for a more Bay friendly property, 2014). BayScaping is a term that has been coined to describe conservation landscapes within the Chesapeake Bay that consist of planting plants indigenous to the bay area (RiverSmart Homes, undated).

The EPA has a “menu” of about 130 BMPs related to stormwater management and more are always being developed, though not all are directly related to nutrient management (Madge, B, 2006). It is unreasonable to expect the average homeowner to know even a fraction of these without education tools. Even with existing public outreach and education programs, other support programs to work with homeowners implementing BMPs are needed (Madge, B, 2006). Since every piece of property is different, some different management strategies may need to be employed as some lawns may be at higher risk for nutrient loss than others. An example of a

program like this that could be expanded is the DDOE River Smart Homes program available to Washington DC residents that credits them up to \$1,200 for using one or more of the following BMPs: shade tree planting, rain barrels, pervious paving, rain gardens, or BayScaping (RiverSmart Homes, undated). The next section will look more into considerations involving public outreach and some of the impacts BMPs have had in these areas.

## 2.7 Public Outreach Considerations

This research focuses on investigating the current knowledge and practices of individuals within the Shenandoah River watershed and how these relate to various demographics. One of the valuable things about gathering this sort of data is how it can be applied to create educational programs since awareness of environmental issues is important in order to improve behavior. This section will discuss some areas of social science that will not be focused on in the analysis of this research; however, these concepts are important for those developing policy or implementing programs to improve BMP use for homeowners.

If a stakeholder is made more aware of how their community is impacted by their behavior, this can be useful to improve sustainable practices. A study conducted in Minnesota surveyed homeowners to determine their knowledge of lawn care BMPs and practices they used in their own lawns. This study showed that individuals who are knowledgeable about BMPs are more likely to implement them on their own lawn (Martini and Nelson, 2014). While this connection may seem intuitive, it is important to note that a significant number of individuals who were knowledgeable about BMPs still demonstrated poor implementation of them. Since some people know the correct practices but don't implement them, other strategies outside of education are required to develop solutions. Campaigns that change people's awareness and views may be useful in improving and increasing use of BMPs in lawns. An example where this was done in environmental sustainability is the history of recycling. Recycling programs have

gradually improved since the establishment of the EPA in the 1970s. Programs like those in schools can be effective over time in changing attitudes (Recycling, undated).

A final point to consider is ensuring that resources are used efficiently. A lack of efficient use of resources was demonstrated in a study in Connecticut aimed at seeing how nutrients could be decreased through BMP educational programs. Even though the educational programs were effective in improving BMP use by homeowners, there was not reduction in nitrogen in local waterbodies. The researchers said that they had likely not correctly identified how homeowner's habits impacted nitrogen pollution in that ecosystem (Dietz, Clausen and Filchak, 2004). By correctly identifying the sources of nutrients within a specific watershed, effective strategies can be developed to reduce nutrient pollution. Some cases may require educating homeowners on the impacts of urban and suburban stormwater runoff while others will need to focus on other nutrient management strategies.

This literature review has demonstrated that there is a current problem with nutrient pollution that has developed over time within the Chesapeake Bay. Management of this problem has seen limited success in restoring the Bay. The Chesapeake Bay TMDL is the most aggressive action ever taken in cleaning up the Bay and defines a clear path to restoring the Bay. However, there are areas that are potentially overlooked by the Bay TMDL as ways to reduce nutrients entering the Bay which may inhibit the realization of the TMDLs goal of restoration. One area that is currently largely overlooked is public outreach and education involving consumer horticulture BMPs. The research involved in this thesis involves conducting a survey to determine the degree to which households in the South Fork Shenandoah River use the consumer horticulture BMPs that were discussed in this chapter and the factors that influence BMP usage. The reason that the South Fork watershed was chosen was given in section 2.4. The following chapter will discuss the survey design in depth.

### 3. METHODOLOGY AND RESEARCH DESIGN

This chapter explains, discusses, and justifies the research design and method used in this study, which incorporated a social survey implemented through an online anonymous questionnaire to all faculty and staff at James Madison University. The research questions, variables, and hypotheses are introduced, then the discussion moves into the operationalization of the variables into the survey instrument. The chapter concludes with a summary of the sampling strategy and human subjects research approval protocol.

#### 3.1 Research Questions and Hypotheses

The research questions that were listed in section 1.2 were used as a guideline to develop the dependent and independent variables for the survey. The first two questions asked about consumer horticulture practices and knowledge with respect to stormwater management and nutrient management in the Shenandoah River watershed:

1. What are the current consumer horticulture practices in the Shenandoah River watershed with respect to stormwater management and nutrient management?
2. What is the current knowledge on how consumer horticulture practices impact nutrient management and water quality in the Shenandoah River Valley?

These questions were used as a basis to develop the dependent variables. The four dependent variables that derive from these research questions are (a) runoff management practices, (b) consumer horticulture practices with respect to nutrient management, (c) stormwater runoff knowledge, and (d) knowledge regarding fertilization practices. The dependent variables were selected based on an understanding of nutrient dynamics in the environment as well as consumer horticulture BMPs which were both discussed within the literature review in Chapter 2. Not all BMPs mentioned in the review were mentioned in the questionnaire. Instead the questionnaire aimed to identify types of behaviors that were exhibited by the study group.

Three research questions were used to help generate a list of independent variables that could describe the dependent variables:

3. Does overall environmental awareness and concern impact knowledge or practices on nutrient management?
4. Is there any way to predict nutrient management practices or knowledge through demographic information?
5. Do knowledge and practices vary in different geographic regions of the Shenandoah River watershed and between individuals living in the watershed and those outside of it?

A number of independent variables derive from these research questions that can potentially explain the dependent variables. These independent variables are (a) common environmental practices, (b) traditional demographics (e.g. age, income), (c) nontraditional demographics (e.g. outdoor recreational activities), and (d) location (i.e. zip code).

Since this research was exploratory in nature there was no formal hypothesis. However, the literature review that was presented in Chapter 2 was used to demonstrate a set of ideas that helped understand and generate the research questions and variables used as well as to inform the interpretation of the results. For example, when looking at the education demographic, it would be expected that higher education would increase knowledge of consumer horticulture BMPs. Another example is that someone who says that they participate in a larger number of outdoor activities may be more likely to participate more in consumer horticulture as well. Ideally their consumer horticulture practices would be sustainable. However, outside of these seemingly obvious relationships, the researcher was open to finding unexpected patterns and associations in the data.

### 3.2 Methodology and Survey Principles

The primary methodology of this research is a survey methodology using an online questionnaire as the data gathering instrument. There are two broad categories of social survey

methods, which are questionnaires and interviews. A questionnaire consists of the subject answering a set of questions without any interaction with the person(s) conducting the research. In an interview survey, the subject is directly asked questions by the researcher which allows interaction between them. These broad categories can be broken down further into the specific instruments that are used to conduct the survey. For example, common practices for interview surveys are phone calls and face to face interviews. The benefit of this type of survey is that it allows for follow up questions and question clarification. The disadvantages are that skilled interviewers are needed as well as increases in cost and time.

Questionnaires are commonly administered as paper surveys through traditional postal mail, or online via email or web-based questionnaire forms. Some advantages are cheaper and faster data gathering and it allows anonymity. A disadvantage may be a lower response rate that may introduce bias (Blakstad, O., undated). Surveys can also be broken down into cross sectional studies which collect data from the study group in a specific point in time. There are also longitudinal studies that collect data from the study group over a span of time.

Questionnaires are a common tool that is used in the social sciences and is useful for gaining insights on the behaviors, attitudes, values, perceptions, of the populations of interest. However, the development of such surveys can be challenging as it is time consuming and can also have a high monetary cost. The questionnaire typically consists of a series of close ended questions that each have a set of given responses. Open ended questions can be used for exploratory research to investigate the responses given. Online questionnaires have become one of the more common tools used by survey designers due to the relatively low cost, ease to administer, and flexibility within the design (Blakstad, O., undated).

The design and implementation of surveys has been researched heavily and is a systematic process by which questions are designed and administered to a representative population. Once data is obtained, the results are generalized to the overall population within that



group (Office of Quality Improvement: University of Wisconsin-Madison, 2010). It is therefore important to ensure a reliable questionnaire design method, sampling method for data collection and validation of results to ensure that false generalizations about the target population are not made.

There are many things to consider when determining how data collection will be done for a particular survey. In many cases, the collection may be limited by resources that are available for the project. The design of the questionnaire will be influenced by the data collection method. For example, if the surveyor is interviewing the respondents, they can clarify questions that can't be clarified in a self-administered survey. Since this research used a self-administered survey, this was taken into consideration when designing the questions. While there are many styles of designing questions, the primary goal is to ensure that every potential respondent will interpret what is being asked in the same way that allows them to answer it accurately. Respondents also need to be willing to answer the question (Dillman, 2007).

There are many specifics that go into designing a questionnaire. For example, question wording, question order and aesthetic design of the questionnaire are all important. It is important to design the survey in a manner that maximizes response and completion rate for the survey. This is especially important in survey design as the current trend in data collection is moving towards increased self-administration. Sampling is important because in most cases it is impossible to sample an entire population. Instead, a sample group that is supposed to be representative of the population as a whole is surveyed. The sample group must be representative of the population as a whole for the results to be valid. There are many different sampling methods, but the two broad categories of sampling methods are probability sampling or non-probability sampling (Survey Sampling Methods, undated). In probability sampling methods, each member of the population has a known, non-zero chance of being chosen for being sampled.

In non-probability sampling methods the chance that a member of the population will be chosen is not known.

There are several sources of error associated with survey design and implementation. These include coverage error, non-response error, sampling error and measurement error. There is no current method for reducing these sources of error that has a combined, measured effect (Dillman, 2007). Coverage error is how much the statistics are incorrect in regards to the population being generalized due to the sample group being unlike the population as a whole. There is no standard formula for success in reducing coverage error. Some methods are being developed. For example, in today's information age, massive lists of entire populations can be compiled so the entire target population can be known. There are ethical and legal issues that come with this as well (Dillman, 2007). Sampling error is made by collecting data from only a subset of the population rather than the entire population.

There are more developed methods of reducing this type of error and is the easiest source of error to control. This type of error can be controlled through methods such as ensuring a sufficient size of the sample population as well as sample methods that ensure each member of the population has an equal chance of being selected (Dillman, 2007). Non-response error is caused from surveys that are not answered, generally due to members of the selected survey group being unable, unavailable, or unwilling to respond to the survey. Some common methods to reduce this type of error are issued reminders to complete the survey, offering incentives, and oversampling (Miller, undated). Finally, measurement error is caused by imperfections in the way statistics are collected. They are often caused by issues like poor question words, faulty assumptions by researcher and imperfect scales (Stanley, 2011). This can be controlled by methods such as pretesting the survey before it is distributed. Validation of survey results is an important part of determining how useful the results are. An example of survey research validation is comparing the individuals sampled to the overall population using census data.

### 3.3 Research Design and Variable Operationalization

#### 3.3.1 Variable Operationalization

The data collection for this research was done through developing a questionnaire that aimed to gather information on the consumer horticulture knowledge and practices as well as demographic information from respondents. The survey consisted of 26 questions that focused on lawn care management methods such as nutrient management and runoff management practices as well as questions about the perceived environmental impacts of consumer horticulture practices and basic demographical information. The questions were generated from the variables shown in table 3.1.

Research Question Used to Measure Variables	Dependent Variables	Independent Variables
What are the current consumer horticulture practices in the Shenandoah River watershed with respect to stormwater management and nutrient management?	<ul style="list-style-type: none"> <li>- Runoff management practices</li> <li>- Consumer horticulture practices</li> </ul>	None
What is the current knowledge on how consumer horticulture practices impact nutrient management and water quality in the Shenandoah River Valley?	<ul style="list-style-type: none"> <li>- Stormwater/runoff knowledge</li> <li>- Consumer horticulture knowledge</li> </ul>	None
Does overall environmental awareness and concern impact knowledge or practices on nutrient management?	<ul style="list-style-type: none"> <li>- Runoff management practices</li> <li>- Consumer horticulture practices</li> <li>- Stormwater/runoff knowledge</li> <li>- Consumer horticulture knowledge</li> </ul>	Common environmental practices used
Is there any way to predict nutrient management practices or knowledge through demographic information?	<ul style="list-style-type: none"> <li>- Runoff management practices</li> <li>- Consumer horticulture practices</li> </ul>	-Demographics Traditional – (education, age, sex, income) Nontraditional – (home description, outdoor

	- Stormwater/runoff knowledge - Consumer horticulture knowledge	recreational activities, home ownership rate)
Do knowledge and practices vary in different geographic regions of the Shenandoah River watershed and between individuals living in the watershed and those outside of it?	- Runoff management practices - Consumer horticulture practices - Stormwater/runoff knowledge - Consumer horticulture knowledge	Location (zip code)

*Table 3.1, Dependent and independent variables used to measure research questions*

After the variables were determined, they were operationalized by developing questions that allowed them to be measured. For both dependent and independent variables, there was a question asked followed by a set of responses. Either only one or a combination of multiple responses could have been selected depending on the question. There were several survey items within the questionnaire that were developed to measure stormwater management and consumer horticulture practices as dependent variables. Figure 3.1 and 3.2 show example questions used to measure the four dependent variables in this study.

**Which of the following best describes how you landscape your yard or property?  
(Check all that apply)**

- ☐ I make landscaping choices that reduce the amount of lawn I need to take care of
- ☐ I make landscaping choices or select plants that reduce the need for watering my lawn or gardens
- ☐ I make landscaping choices or select plants that reduce the need for fertilizing my lawn or gardens
- ☐ I really don't think about my yard or property like this

*Figure 3.1, Example 1, dependent variable operationalization*

**Which of the following statements about water runoff do you agree with, if any? (Check all that apply)**

- ☐ Urban runoff has a similar water quality to water that is in streams and rivers
- ☐ Water that enters a storm drain is treated before being release into nearby water bodies
- ☐ It is not possible to significantly reduce the amount of water that runs off your property
- ☐ I am not sure or do not agree with any of these statements

*Figure 3.2, Example 2, dependent variable operationalization*

While both of these examples have responses that allow the respondent to check all that apply, there were other questions that required only one answer to be chosen. For example, a question asked involving consumer horticulture practices about if the respondent fertilized their lawn and they had to select “yes”, “no” or “Not Sure”. All of the data collected for the dependent variable were categorical.

Of the 26 question on the survey, 12 of them served to assess dependent variables. They included questions on both landscape management and fertilizing knowledge and water conservation management and runoff knowledge. Referring to the questionnaire, which is found in appendix A, consumer horticulture practices were assessed using questions 6-11. Runoff management practices were measured using questions 12-15. Sustainable consumer horticulture knowledge was assessed through question 23 and Stormwater/runoff knowledge was assessed using question 24.

Independent variables were similarly operationalized. For example, the independent variable related to environmental awareness and concern was measured as the respondent’s actual use of common environmental practices. There was only one item within the questionnaire developed to measure this variable, shown in figure 3.3. The respondent may pick multiple responses for this question.

Please check all of the statements that are true about you.

- ☐ I have switched products for environmental reasons
- ☐ I regularly try not to waste water or leave lights on around the house
- ☐ I regularly recycle
- ☐ I compost
- ☐ I feel good when I take steps to help the environment

*Figure 3.3, Example 1, independent variable operationalization*

The standard demographic variables measured in the survey include age, household income, sex, and level of education. One non-traditional demographic variable used was an indicator of the respondent's level of engagement with the outdoors (figure 3.4). For this question any combination of the first seven answers may be chosen and "other" allows for the respondents to fill it in. Or they may pick only the eighth response "None of the above". Most of the data collected for the independent variables were categorical. The exceptions were for age, income and education which were ordinal.

Of the 26 questions in the survey, 12 were used to assess independent variables in order to predict the landscaping and runoff management knowledge and practices of the respondents. The location was assessed through question 3 in the questionnaire requesting the respondent's zip code. The common environmental practices used were assessed through question 25. The traditional demographics were assessed through questions 20-22 and 26. The nontraditional demographics were assessed using questions 2, 4, 5, 16, 17, and 19.

**Which of the following outdoor activities (if any) do you regularly engage in? (Check all that apply)**

- ☐ Boating, kayaking or canoeing
- ☐ Bicycling
- ☐ Fishing
- ☐ Walking/Hiking
- ☐ Picnicking
- ☐ Camping (tents, cabins, or RVs)
- ☐ Other (Please explain)
- ☐ None of the above

*Figure 3.4, Example 2, independent variable operationalization*

The ideal responses for the dependent variables within questionnaire would be those that demonstrate higher rates of knowledge and implementation of sustainable practices with regards to consumer horticulture and stormwater runoff management. For example, referring back to figure 3.1 about landscaping practices, each of the first three responses is an example of a common BMP that could be implemented. It would be preferable that one or more of the first three responses would be chosen. Also, the fourth response is a less ideal choice since it indicates that the homeowner is not managing their property by using consumer horticulture BMPs. All questions that gathered data on the dependent variables were similar to this in that they had responses that indicated higher or lower levels of sustainability knowledge and behavior.

### 3.3.2 The study and sample populations

For this study, the population of interest are the residents of the Shenandoah River Valley, which includes the South Fork, North Fork, and Mainstem subwatersheds. There is a particular interest in the South Fork Shenandoah River sub watershed, because it is located in the agricultural center of Virginia. Because of the survey sampling design, residents of the Mainstem Shenandoah River were not included in the study, and the survey respondents also included many individuals living in the North Fork watershed. The counties included in the South Fork are Augusta, Warren and Rockingham. The cities included in the South Fork are Harrisonburg, Staunton and Waynesboro. The sample population had to be chosen out of this region while considering that the group being

surveyed and how they were surveyed involved many different constraints. These include the amount of time available to develop and administer the survey, the amount of money/funding available for the research. There must also be available access to the sample population. Also, researcher expertise impacts what type of data may be collected based on planned analysis.

The sample population that was selected for this study was the JMU faculty and staff. This group was chosen because it minimized or eliminated the constraints listed in the previous paragraph. In other words, the JMU faculty and staff were chosen somewhat as a convenience sample. Convenience sampling is a non-probability sampling method where the sample group is chosen based on how easily they can be surveyed. This could be for reasons such as their proximity or accessibility for the researcher, or other issues such as ease of access due to less funding being required. The benefits of this type of sampling are that it reduces the constraints that typically come with surveys. However, a disadvantage is the potential for sample bias to be introduced. (Blakstad, O., undated). For example, since only the faculty and staff at JMU are being surveyed, the demographics may be more narrow than the actual population of the Shenandoah Valley. However, because this research is exploratory, the sample population was assumed to be representative of the study population, and the assumption was tested in the analysis by comparing demographics of those surveyed to census data from the cities and counties that are in the South Fork Shenandoah River watershed.

Some other important considerations are that a high enough response and completion rates must be attained in order to improve the validity of the results. An assumption will also be made that important predictor variables were accounted for in determining a relationship between knowledge of environmental impacts of consumer horticulture and implementation of BMPs.

### 3.3.3 Survey Implementation

The questionnaire was administered using Qualtrics, an online survey tool. The survey was sent to all JMU faculty and staff through a bulk email request on January 14, 2015, and included



3,782 individuals. A reminder to take the survey was sent on January 21, 2015 and the survey was closed on January 26, 2015. Of 547 individuals who began the survey, 515 surveys were completed. This is a response rate of 14.5% and a completion rate of 94%.

Analysis of the data included descriptive statistics of the questions answered. Also, cross tabulations were included. The chi squared test was used to analyze the cross tabulations and a P value of 0.1 was used as the significance level for rejecting the null hypothesis. ArcGIS was used for analysis of zip codes. Census data for the cities and counties within the South Fork Shenandoah River watershed was used to compare respondents to members of the general population. For the surveys that were not completed, all questions answered were still used for analysis. Skip logic was included within the survey so not all questions were answered by all respondents that completed the survey

Respondents to the survey were totally anonymous. There was nothing to stop respondents from taking the survey more than once; however, a request was made in the reminder email to not retake the survey if the individual had already responded. Since there are members of the JMU faculty and staff that do not live in the Shenandoah Valley, a question was added asking for the respondent's zip code so that those living within the Shenandoah River watershed could be identified. This also allowed for potential analysis to differentiate between responses of those who live in the valley against those who do not.

### 3.4 IRB and Human Subjects Research

Research that is conducted using human subjects requires Institutional Review Board (IRB) approval. At JMU, the IRB is the committee that oversees all the research that involves human subjects. In order to obtain IRB approval for this research, a form that discussed what the research involved and how the survey would be conducted was completed and submitted for review after the questionnaire was developed and before the survey was conducted. It also included information about the researcher. Before the researcher could submit an IRB request, an

online course was completed involving training on ethical guidelines and regulations for research on human subjects. Approval from the IRB to conduct this research was received on January 13, 2015 and extended through May 1, 2015.

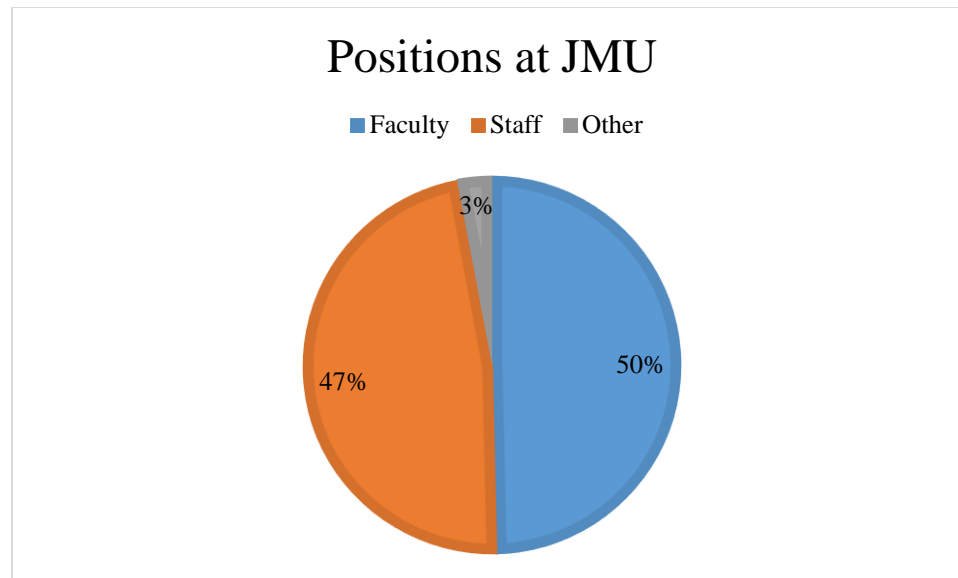
This chapter has outlined the principles of survey research and discussed the particular methodology used to develop the questionnaire for this research as well as the specifics of the questionnaire. Once the questionnaires were all completed, the results were analyzed. The following chapter discusses the data analysis and the results that were obtained from the questionnaire.

## 4. DATA AND ANALYSIS

This chapter discusses the data and how it was analyzed and provides discussion and interpretations for the results of the analysis. It will discuss descriptive statistics for dependent variables, then independent variables. The discussion will then move to the analysis which included spatial analysis using ArcGIS, and finally cross tabulations in or to discover relationships between the variables.

### 4.1 Validity of Responses

Some of the questions in the survey were not directly used in the analysis but rather served as a filter in the survey in order to eliminate some respondents from the survey. The researcher only wanted faculty and staff to respond to the questionnaire, so a question was included to make sure data being used was from faculty and staff. 269 of the respondents answered that they were faculty, 257 answered that they were staff. An additional response was added to the survey to identify if anyone inappropriately completed the survey that was not JMU faculty or staff. 16 individuals designated other as their position but in a fill in section associated with this response, it was found that these 16 people fit the criteria of being either faculty or staff. These response rates are demonstrated in figure 4.1. Also, a question was included to insure that respondents were from Virginia. Of the 524 people that answered the question on whether or not they currently resided in Virginia, 520 answered that they did.

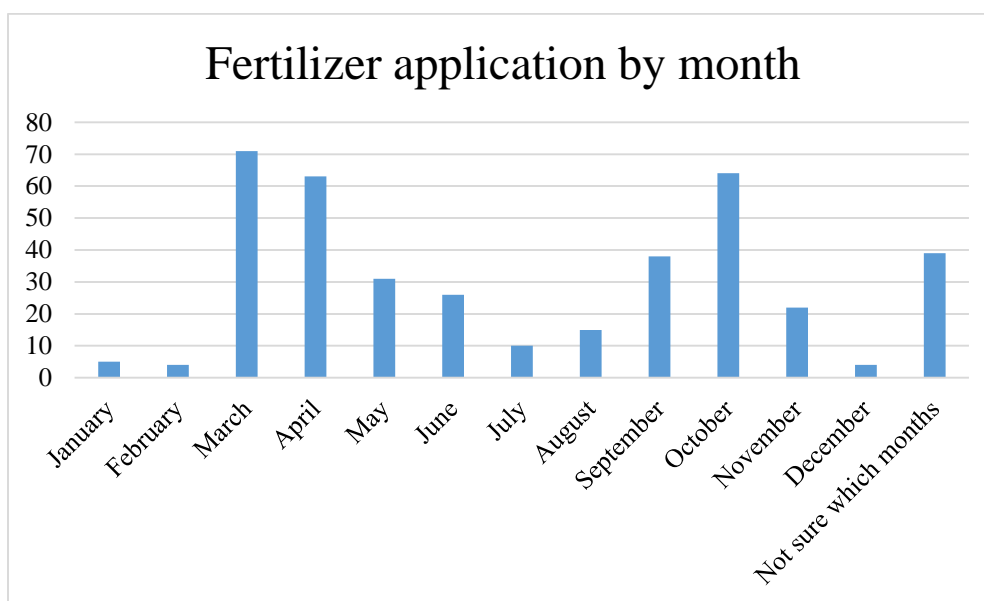


*Figure 4.1, Employee positions at James Madison University*

#### 4.1.1 Dependent variables

Respondents were asked a series of questions about their lawn fertilization practices. Out of 507 responses, 205 (40%) said that they fertilize. These 205 were asked additional questions on their fertilizing practices. 12% of these respondents only fertilize once every 2 or 3 years, 60% fertilize 1 or 2 times per year, 23% fertilize 2-4 times per year, and 5% fertilize 5 or more times per year. Most people who fertilize do so multiple times per year. Lawn fertilization should correct nutrient deficiencies but would only be sustainable when over fertilization does not increase nutrient loss. The sustainability of annual fertilizer applications will depend on several factors that contribute to nutrients being transported from the lawn to waterways. Frequent applications of fertilizer will typically lead to increased nutrient runoff because they likely exceed the amount required to correct nutrient deficiencies. Ultimately these rates of fertilization would not be considered sustainable practices. This implies that many homeowners are not taking environmental issues into consideration in their consumer horticulture choices, or these environmental issues are not a priority when they make these choices.

Respondents were also asked what type of fertilizer they used. The most common responses were that 37% used a standard commercial mix, 24% used a slow or extended release commercial mix, and 24% were not sure. Additionally, 76% of individuals who fertilize their lawn have never had a soil nutrient test conducted. In order to increase sustainability, a larger number would have a soil nutrient test conducted to determine if fertilizer was needed on their lawn. Also, sustainability would increase if more people made sure they knew the type of fertilizer being used on their lawn and switched to slow or extended release fertilizers instead of making multiple applications.



*Figure 4.2, Number of respondents who applied fertilizer by month*

Figure 4.2 shows the number of individuals that apply fertilizer to their lawns by month. The two times of year that show increased rates of fertilizer application are in March (36%) and April (32%) as well as September – November. Some areas of concern are that 11% of individuals fertilize in November which is late, even for cool-season turf grasses. Applications of fertilizer in October also precedes turf dormancy by only a few weeks. Also, the highest rate of fertilizing is in March (36%) when most grass in the region is still dormant so there is high

potential for significant nutrient runoff. Fertilization in these months when the grass is dormant or about to become dormant is when a large portion of nutrient runoff will occur.

The final question involving consumer horticulture practices asked about personal landscape management choices. Table 4.1 shows the possible responses as well as how many people selected that response. Those who selected #4 did not select any of the other responses.

Question number	Answer	Response count	%
1	I make landscaping choices that reduce the amount of lawn I need to take care of	163	33
2	I make landscaping choices or select plants that reduce the need for watering my lawn or gardens	129	26
3	I make landscaping choices or select plants that reduce the need for fertilizing my lawn or gardens	84	17
4	I really don't think about my yard or property like this	242	49

*Table 4.1, Response rates for consumer horticulture BMP use*

Almost half of respondents do not use any of these practices. The first three responses were chosen because many of the consumer horticulture BMPs are focused on total area of turf grass in the overall lawn or yard, water management, and fertilizer management. The low rates of use of these practices relative to those not using them indicates that there is a possibility to decrease nutrient runoff through education that may increase implementation of consumer horticulture BMPs.

The next series of questions investigated runoff management practices. This line of questions found that only 17% of respondents watered their lawn. Of this 17%, 73% of them only water during long dry periods. The amount of people watering their lawn on a regular basis in this region is small and will not contribute to a significant portion of the total runoff and therefore will not contribute significantly to nutrient loss. It is not necessary to explore these watering practices further since their impacts to nutrient pollution is likely negligible. Another question that was asked in this series about what time of day respondents watered their lawn. The

times were split evenly between evening and morning. During the analysis, it was determined that this question related to water conservation but not to runoff management, therefore it will not be discussed further in this report.

The final question in this series was relevant to water runoff management practices. There was an error in the survey's branch and skip logic. The error was that everyone that had a lawn was supposed to answer this question; however, the typo made it so that only individuals who watered their lawn answered this question and therefore there were only 83 responses to this question. The practices and numbers of people who selected each practice are shown in table 4.2. Those who selected #6 did not select any of the other responses.

<b>Question Number</b>	<b>Answer</b>	<b>Response Count</b>	<b>%</b>
<b>1</b>	Rain barrel(s)	14	17
<b>2</b>	Rain garden(s)	3	4
<b>3</b>	Pervious paving (allows water to flow through driveways and sidewalks)	7	8
<b>4</b>	Ground cover on bare soil (plants, mulching, etc.)	47	57
<b>5</b>	Other	2	2
<b>6</b>	I use none of these	31	37

*Table 4.2, Response rates for use of common runoff management practices*

A large number of people said they used ground cover on bare soil. It is possible that some of the people selected this practice for aesthetic appeal or some other reason than for runoff management since this received so many more responses than the other practices listed. Only 37% use no practices which was a lower number than expected. Overall, there is a general lack of utilizing sustainable runoff management practices outside of ground cover on bare soils.

Finally, two questions were asked to determine runoff management knowledge and consumer horticulture knowledge. Questions asked whether respondents agree with statements

related to consumer horticulture, particular fertilization topics, and runoff management.

Responses are displayed in tables 4.3 and 4.4 respectively.

<b>Answer Selection</b>	<b>Response Count</b>	<b>%</b>
<b>1. Fertilizing at least once per year will improve lawn health or appearance</b>	257	50%
<b>2. Cleaning fertilizer off driveways and sidewalks helps protect water quality</b>	158	31%
<b>3. It is important to water the lawn after applying fertilizer</b>	115	23%
<b>4. It is best to fertilize a lawn during its growing season</b>	81	16%
<b>5. The month in which fertilizer is applied will not affect the quality of water runoff</b>	13	3%
<b>6. I am not sure or do not agree with any of these statements</b>	211	41%

*Table 4.3, Response rates for consumer horticulture knowledge*

<b>Answer Selection</b>	<b>Response Count</b>	<b>%</b>
<b>1. Urban runoff has a similar water quality to water that is in streams and rivers</b>	25	5%
<b>2. Water that enters a storm drain is treated before being release into nearby water bodies</b>	30	6%
<b>3. It is not possible to significantly reduce the amount of water that runs off your property</b>	42	9%
<b>4. I am not sure or do not agree with any of these statements</b>	400	82%

*Table 4.4, Response rates for runoff management knowledge*

The dynamics of nutrient management and nutrient pollution are complex, making it is difficult to create a simply true or false statement. Some statements from these questions may tend to be true or false most of the time, but the questions were designed not only to get a preferred response correct, but to get a general understanding of the attitudes of the respondents. Since these questions are rather complex, two lists are provided here of the dynamics to consider for interpreting each response choice for both questions. The list will also include comments and interpretation of each response. The survey taker may not have been aware of the complexity of these questions.



List 1: Considerations and comments for answer selections in table 4.3, sustainable consumer horticulture knowledge:

1. Fertilizing at least once per year will improve lawn health or appearance – This may or may not be true and depends on the nutrients available to the turf grass in each individual lawn. There are some other complex dynamics to consider as well, i.e. does the individual export nutrient away from his lawn in the fall by raking and bagging leaves. 50% believe this is true, which is consistent when considering the amount of people who fertilize.
2. Cleaning fertilizer off driveways and sidewalks helps protect water quality- This is almost always true particularly when in close proximity to the storm water system or a water body. 31% selected this to be true, this also relates to the question about storm water runoff and shows a lack of understanding about runoff management.
3. It is important to water the lawn after applying fertilizer- This is not important and can be detrimental to water quality if the amount of watering causes runoff. Although not a part of the question, individuals should not fertilize before a rain event. 23% chose this which shows a good understanding regarding this part of fertilizer application.
4. It is best to fertilize a lawn during its growing season- This is always true, if a plant is dormant it cannot use nutrients available and significant runoff will occur. A 16% response rate here shows not only a lack of knowledge regarding nutrient management, but plant growth dynamics as well, both of which are considerations in fertility management for environmental sustainability.
5. The month in which fertilizer is applied will not affect the quality of water runoff – This is false as fertilizer should only be applied in the growing season. Only 3% agreed with this; however, when comparing this to the months that people actually apply fertilizer, it

show that a higher percent are unaware of which months they should make fertilizer applications.

6. I am not sure or do not agree with any of these statements- Since there are both true and false options in this set, 41% selected this option, which shows at least some lack of knowledge regarding fertilizing practices and limited knowledge regarding sustainable consumer horticulture practices.

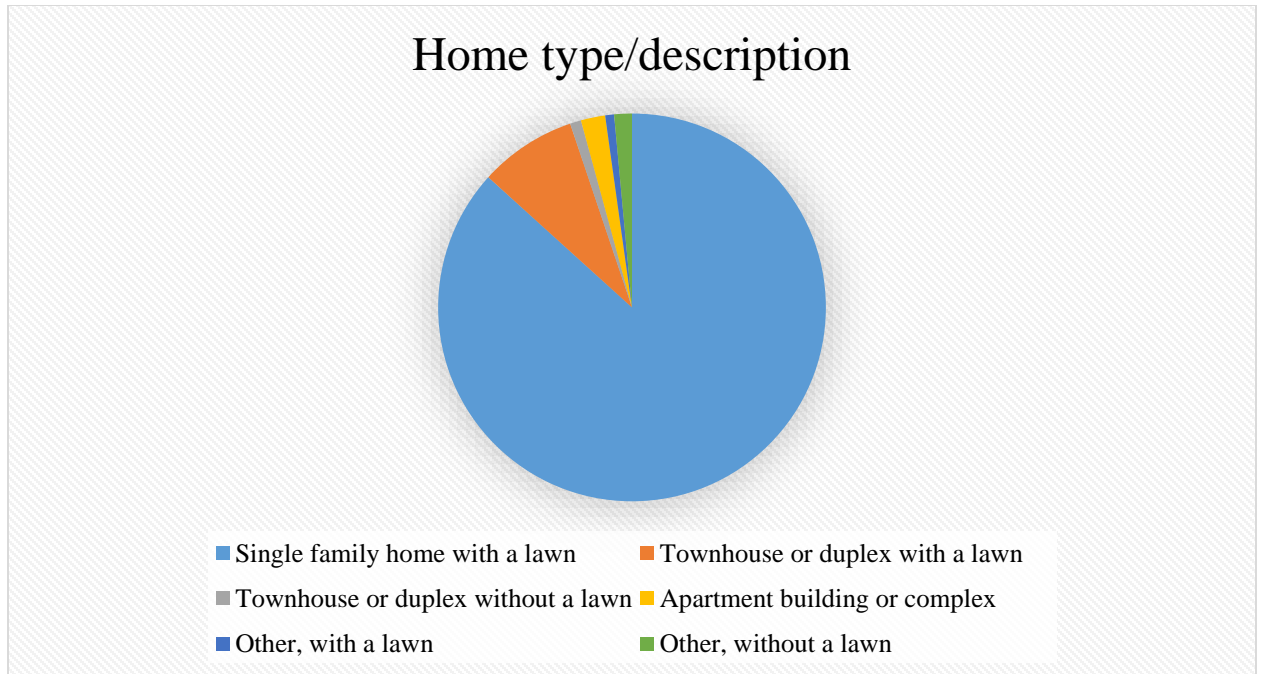
List 2: Considerations and comments for answer selections in table 4.4, sustainable runoff management knowledge:

1. Urban runoff has a similar water quality to water that is in streams and rivers- This will depend on where the runoff is coming from but it is generally not true, especially if the stream or river is considered pristine.
2. Water that enters a storm drain is treated before being release into nearby water bodies- This is typically false but in certain cases may be true. The only time storm water must be treated is if it is part of a combined sewer system where waste from a sanitary sewer and storm water are mixed.
3. It is not possible to significantly reduce the amount of water that runs off your property- This is false.
4. I am not sure or do not agree with any of these statements- Since most of the questions here are either sometimes or always false, selecting this answer could mean that the survey taker has almost no knowledge about storm water runoff or considerable knowledge. It is likely that many 82% of people chose this response did so because this did not know whether the others were true or not, this conclusion is drawn because there were significant runoff management knowledge gaps shown in the questions that were asked in the previous question regarding fertilizing knowledge.

With respect to the dependent variables, this analysis found that there was a lack of sustainability through BMP from respondents. Individuals who fertilized their lawns often did so without conducting soil nutrient tests to see if their lawn was nutrient deficient, and there were significant numbers of people who fertilize in the winter months. Also, there were a lot of respondents who used either no BMPs or a limited number of BMPs. This could be linked to the fact that the knowledge of consumer horticulture and runoff management BMPs was low. Further questioning that would be interesting would include questions regarding who fertilizes and when do they fertilize?, what factors contribute to increased BMP usage?, and what factors contribute to consumer horticulture and runoff management knowledge?. The next section outlines descriptive statistics for the variables used to explain the dependent variables.

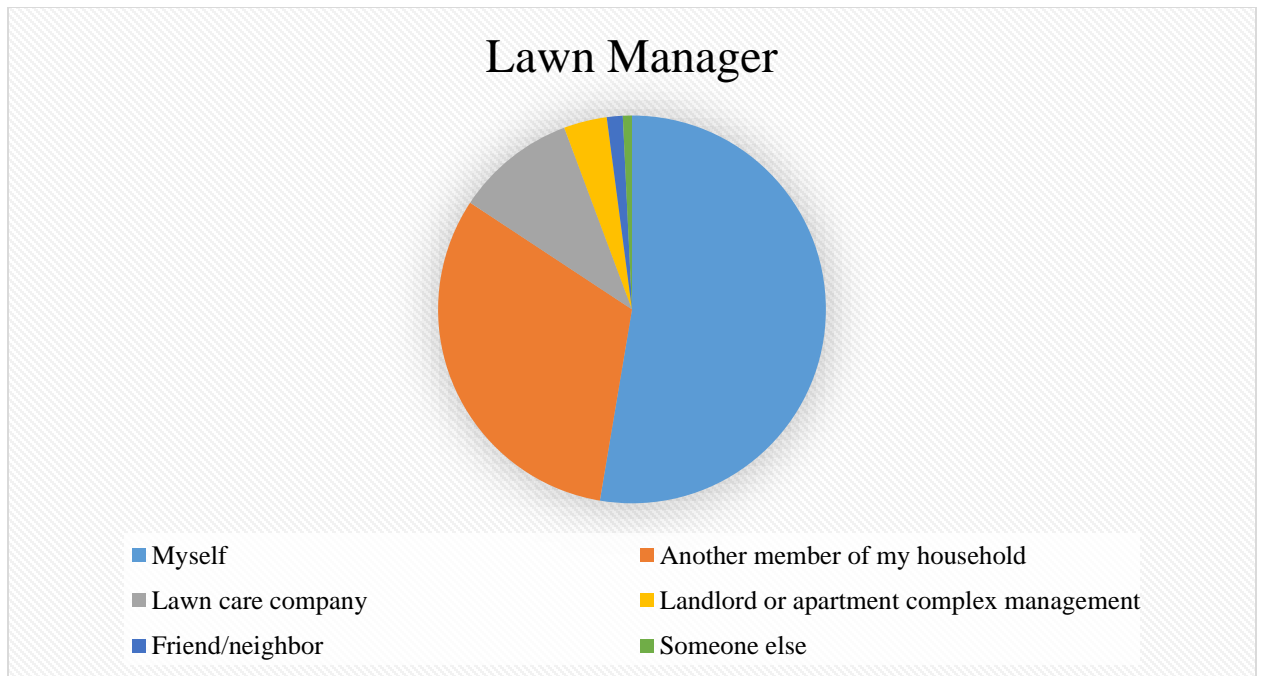
#### 4.1.2 Independent variables

Participants were asked whether they owned or rented where they lived. Of 541 respondents, 467 (86%) said that they owned, 67 said that they rented and 7 designated other. Zip codes were collected from the participants for spatial analysis. There were 59 unique values that were entered for zip codes. In order to determine whether or not the respondent could answer questions on what their landscaping practices were, two questions were asked. One was on the description of the respondent's home and the other was on who primarily took care of the lawn. For the home description, the majority of the respondents lived in single family home with a lawn; figure 4.3 fully details the responses. The largest two groups are the most significant for this research. These groups are those with a single family home with a lawn (87% of responses), and those with a townhouse or duplex with a lawn (8% of responses). If the respondent selected an answer that indicated that they did not own a lawn, they were not asked to respond to questions involving landscaping practices or questions involving watering or runoff management practices.



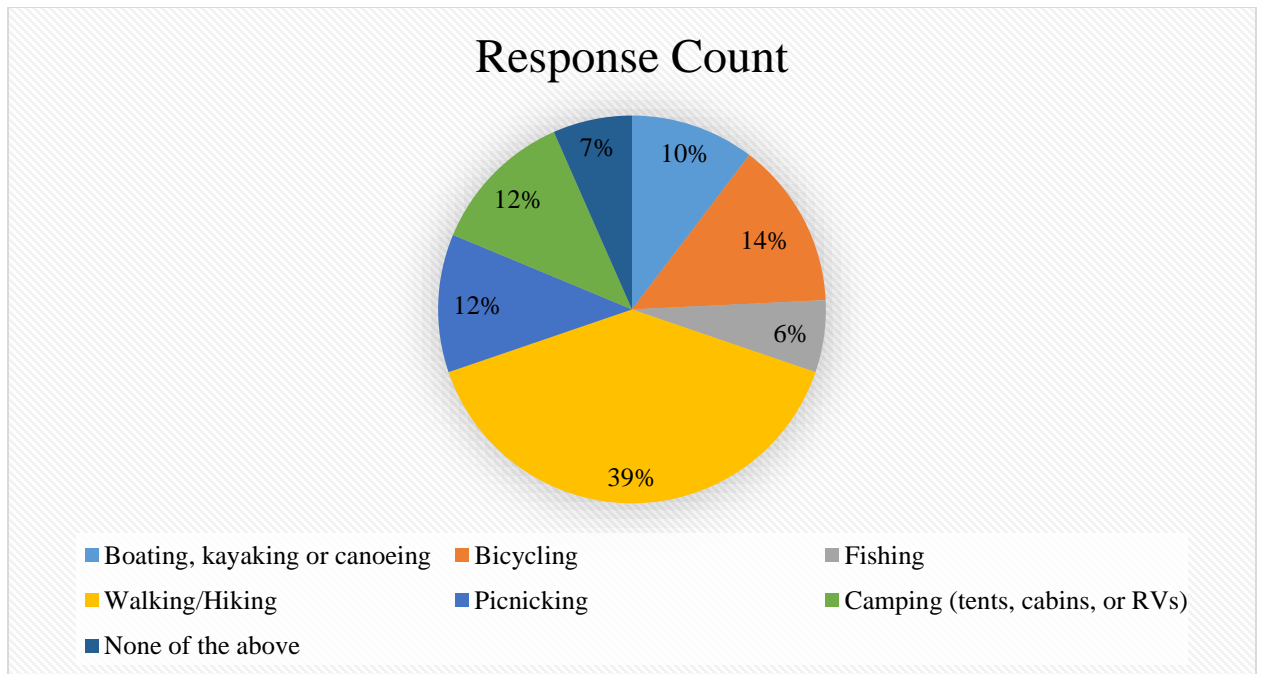
*Figure 4.3, Response Rates for home description*

The next question asked who took care of the lawn. It should be noted that respondents could only select one answer, while in reality there could have been more than one answer to this question as different people could take care of different aspects of lawn management. Because of this, there could be some slight discrepancies in the results and how people actually manage their lawns. Most respondents answered that either they took care of their lawn, followed by another member of the household or a lawn care company. The results are detailed in Figure 4.4. If respondents said that a landlord or complex manager primarily took care of the lawn or if they weren't sure, they were not asked to respond to questions involving landscape practices or questions involving watering or runoff management. The important responses for the analysis were "myself" (53% of responses), "Another member of my household" (32% of responses), and "Lawn care company" (10% of responses).



*Figure 4.4, Response rates for who takes care of the lawn*

A question was designed to determine whether an individual's outdoor recreational activities may impact landscape and runoff management. Several possible activities that may be common in the region were selected and used for the survey. The possible responses were boating, kayaking or canoeing, bicycling, fishing, walking/hiking, picnicking, and camping. Another field was left open as other and allowed respondents to fill in answers. Figure 4.5 shows the responses for this question.



*Figure 4.5, Response rate of Outdoor recreational activities*

Figure 4.5 showed that for people who engage in outdoor activities, the ranking in order of prevalence was walking/hiking, bicycling, camping, picnicking, boating, kayaking or canoeing, and fishing.

Table 4.5 was generated to show activities that were manually filled in by people that selected other. It shows the activities that were entered by 3 respondents or more.

Activity	Count
Running/Jogging	24
Gardening	14
Golf	13
Hunting	12
Horseback Riding	7
Swimming	6
Tennis	3
Rock climbing	3
Total	82

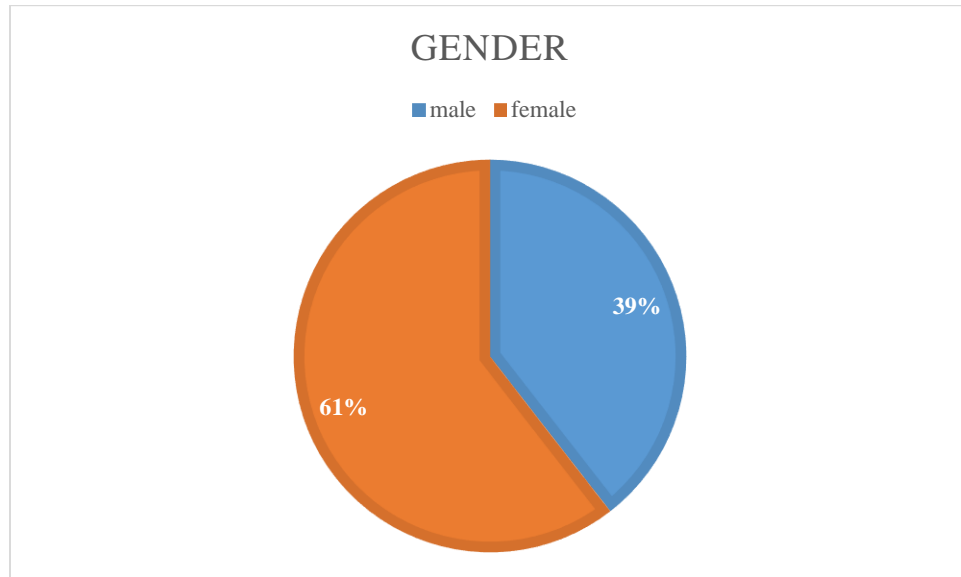
*Table 4.5, Open ended responses for outdoor activities*

For the cross tabulation analysis, the researcher was interested in how the number of outdoor activities impacted the various dependent variables rather than investigating each specific activity. To do this analysis, number categories were generated from 0 to 7 to indicate the respondents “activity score”. If the respondent selected none of the above for their outdoor recreational activities they received a 0 and. For every activity selected by the respondent out of the 7 options, they received 1 point. For example, if a respondent marked 2 activities, they would have an activity score of 2, or if they selected all 7 activities, they would get the maximum activity score of 7. An activity score of 0, 1, 2, 3, 4, 5, 6, or 7 was possible. A higher score indicates a larger number of outdoor recreational activities in which the respondent engages. In other words, it shows a broader range of interest in different types of outdoor activities and in some cases may indicate an increased rate of participation as well. Rather than making each response by respondents who selected “other” a unique value, they were given 1 point for selecting “other” since the response rate for this answer was consistent with the other responses designated in the survey. The number of people in each category that was created can be found in table 4.6.

<b>Category</b>	<b>Count</b>
<b>0</b>	65
<b>1</b>	151
<b>2</b>	147
<b>3</b>	89
<b>4</b>	44
<b>5</b>	22
<b>6</b>	5
<b>7</b>	3
<b>Total</b>	526

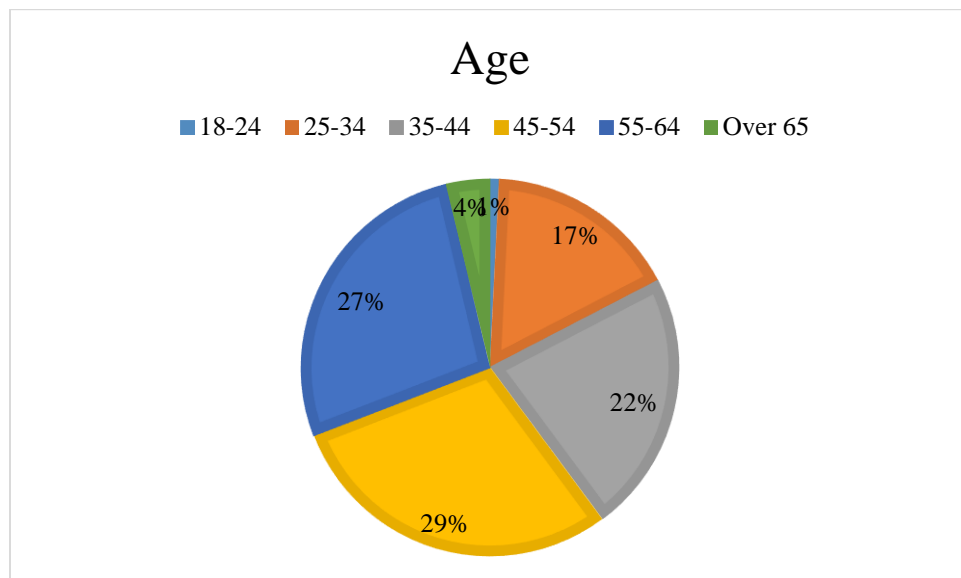
*Table 4.6, Outdoor activity score response rates*

Some standard questions were asked to collect demographic information on gender, age, education and income. The following part of this section will show several charts (Figures 4.6, 4.7, 4.8, and 4.9) with a brief description of what that chart is showing.



*Figure 4.6, Gender response rates*

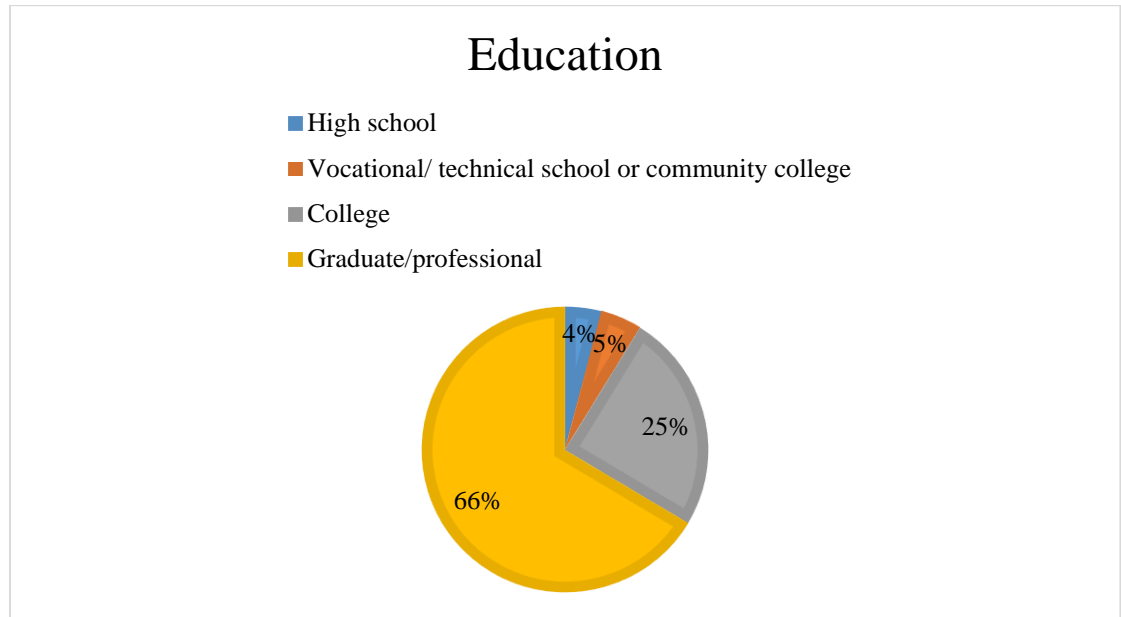
Of 509 respondents, 201 were male and 308 were female.



*Figure 4.7, Age response rates*

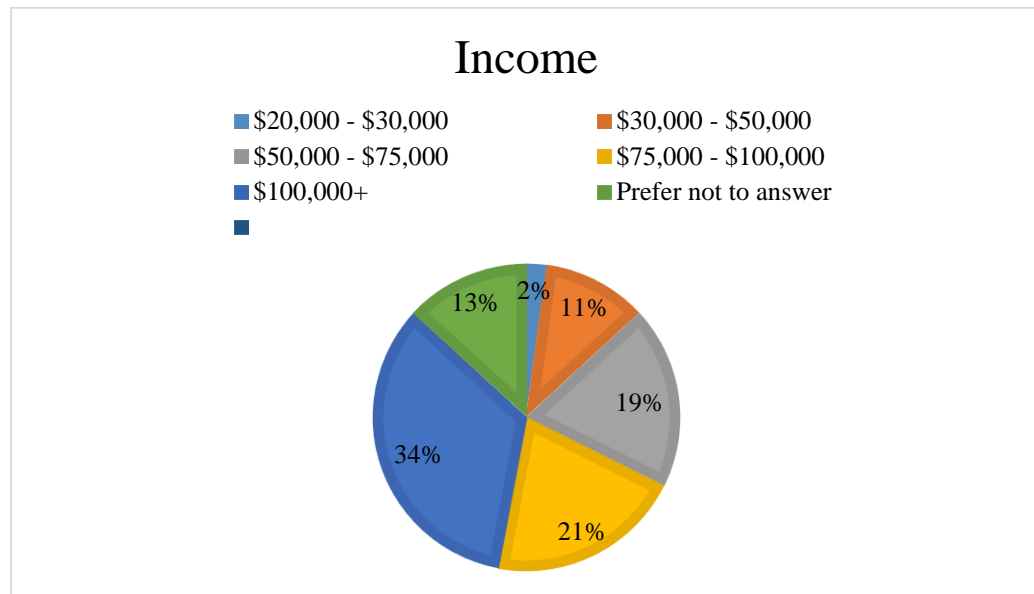


Most of the respondents were between the ages of 25 and 64 and were evenly distributed over this range as 85 were between the ages 25-34, 115 were from 35-44, 150 were from 45-54, and 139 were between the ages 55-64.



*Figure 4.8, Education response rates*

The respondents were well educated as 100% had completed at least high school and 91% had completed at least college. 66% had completed graduate or professional school.



*Figure 4.9, Income response rates*

Of the 445 people who answered what their household income was, 24% made over \$100,000 and 13% made \$50,000 or less.

Tables 4.7 and 4.8 show census data that is available from the cities and counties that are located in the South Fork Shenandoah River watershed. There are some discrepancies between the general population and the faculty and staff at JMU that responded to the survey. A higher rate of female responded to the survey than are in the general population. Also, education and income are significantly higher for survey respondents. These results were expected since the survey was given to individuals who work at a university where higher education would be expected. Also home ownership rates of 86% are a bit higher than the general population. The increased number of people who are of working age in the survey is expected since the survey was given to people who are working.

<b>Location</b>	<b>Population, 2010</b>	<b>Female population, 2013</b>	<b>Education, % with high school or higher 2009-2013</b>	<b>Education, % with bachelors or higher 2009-2013</b>	<b>household income, 2009-2013</b>	<b>Home ownership rate, (2009-2013 %)</b>
<b>Augusta County</b>	73,750	49.5%	84.2	19.9	\$52,027	80.9
<b>Page County</b>	24,042	50.6%	75.6	11.4	\$42,906	72.0
<b>Rockingham County</b>	76,314	51.1%	80.7	23.4	\$52,195	76.8
<b>Warren County</b>	37,575	50.2%	84.0	20.5	\$61,610	72.5
<b>Harrisonburg City</b>	48,914	53.4%	81.5	35.1	\$38,048	36.2
<b>Staunton City</b>	23,746	54.7%	84.6	28	\$38,501	57.7
<b>Waynesboro City</b>	21,006	52.4%	83.6	19.1	\$44,847	58.2

*Table 4.7, South Fork Shenandoah demographics*

<b>Location</b>	<b>Age, % 20-24</b>	<b>Age, % 25-34</b>	<b>Age, % 35-44</b>	<b>Age, % 45-54</b>	<b>Age, % 55-64</b>	<b>Age, % 65+</b>
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<b>Augusta County</b>	5.0	10.7	13.4	16.6	14.3	16.6
<b>Page County</b>	5.2	10.9	13.2	15.6	13.8	17.6
<b>Rockingham County</b>	5.8	10.9	12.8	15.5	12.7	15.6
<b>Warren County</b>	5.7	11.1	14.0	17.0	12.4	12.6
<b>Harrisonburg City</b>	28.1	12.7	8.2	7.9	6.2	9.3
<b>Staunton City</b>	6.6	12.7	11.3	13.7	13.3	19.8
<b>Waynesboro City</b>	5.9	14.1	11.7	14	11.7	16.9

*Table 4.8, South Fork Shenandoah demographics cont.*

The final questions that were used here involved environmental sustainability. The first was to determine the amount of environmental sustainability work that was involved in the individual's job at JMU. 6% of respondents said their job involved a lot of work with environmental stewardship and sustainability, 17% said their job involved some. 76% said their job involved little or no environmental stewardship or sustainability. A question was also asked to determine some of the environmental practices of the respondents. This allows for further analysis to see if some common environmental practices people use will relate to an increased knowledge about lawn management as well as influence their habits. Table 4.9 shows the sustainability practices that were asked about in this question as well as the results.

<b>Answer Selection</b>	<b>Response Count</b>	<b>%</b>
<b>I have switched products for environmental reasons</b>	252	50%
<b>I regularly try not to waste water or leave lights on around the house</b>	476	94%
<b>I regularly recycle</b>	453	89%
<b>I compost</b>	212	42%
<b>I feel good when I take steps to help the environment</b>	411	81%

*Table 4.9, Response rates for common sustainable environmental practice*

These results show that there is a higher amount of people that use practices such as recycling and conserving water and electricity. These practices may be more established in our culture and may not show as much environmental awareness as using some of the less used practices like composting and changing products for environmental reason.

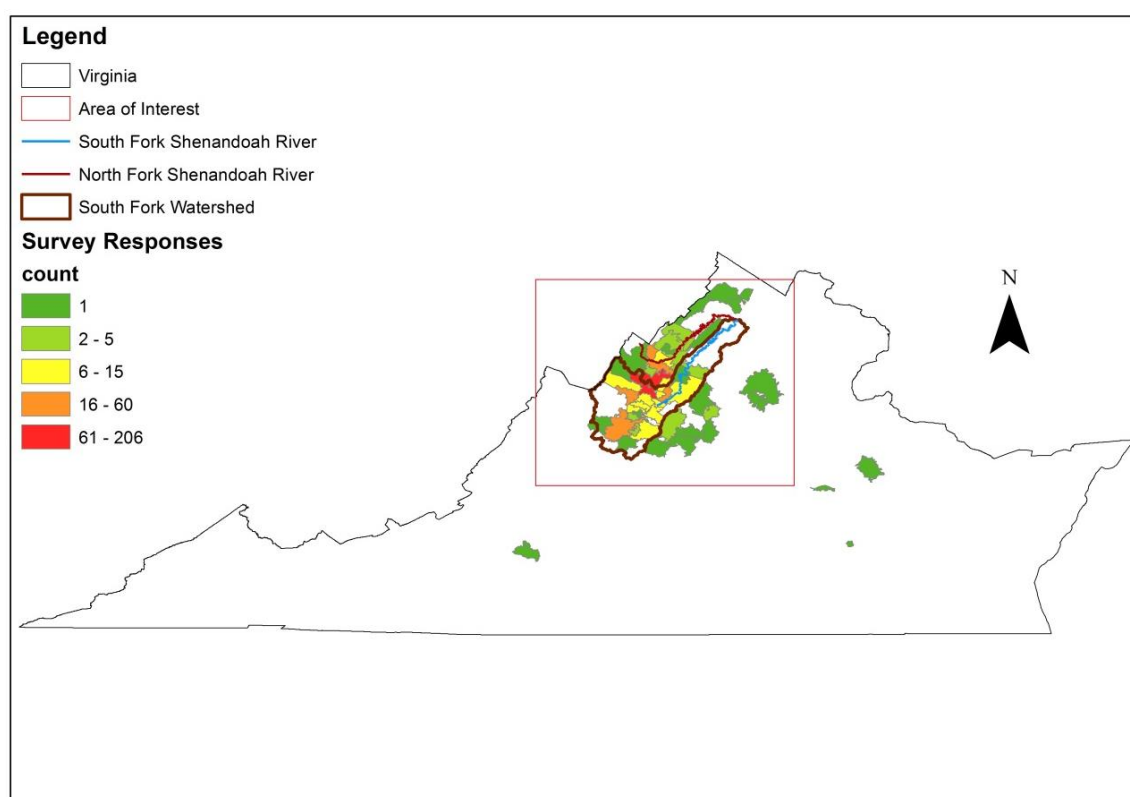
#### 4.2 GIS zip code analysis

ArcGIS was used for analysis of the zip codes collected for the survey. There were a total of 56 unique zip codes from the surveys answered. Of these 50 were Virginia zip codes. Since only 4 people answered that they did not currently live in Virginia, it seems that there were some incorrect zip code entries, but this was not for more than 2 entries total. Figure 4.10 shows a map of Virginia with all of the zip codes that respondents live in. They are colored based on how many responses were given for each zip code. Zip codes that only had 1 respondent were removed from further parts of the zip code analysis (i.e. they are not used in figures 4.11, 4.12, and 4.13). This left 26 of the zip codes that were designated as populated zip codes, which means there was at least 2 surveys from that zip code, table 4.10 shows the zip codes that were used in the analysis.

<b>Zip code</b>	<b>Respondent Count</b>	<b>Zip code</b>	<b>Respondent Count</b>
<b>24486</b>	10	22844	5
<b>24482</b>	4	22842	3
<b>24471</b>	7	22841	8
<b>24467</b>	8	22840	19
<b>24441</b>	6	22834	3
<b>24401</b>	29	22832	7
<b>22980</b>	11	22827	15
<b>22968</b>	2	22824	3
<b>22939</b>	4	22821	13
<b>22932</b>	2	22815	30
<b>22853</b>	6	22812	20
<b>22851</b>	2	22802	80
<b>22846</b>	11	22801	206

*Table 4.10, Zip codes used in analysis*

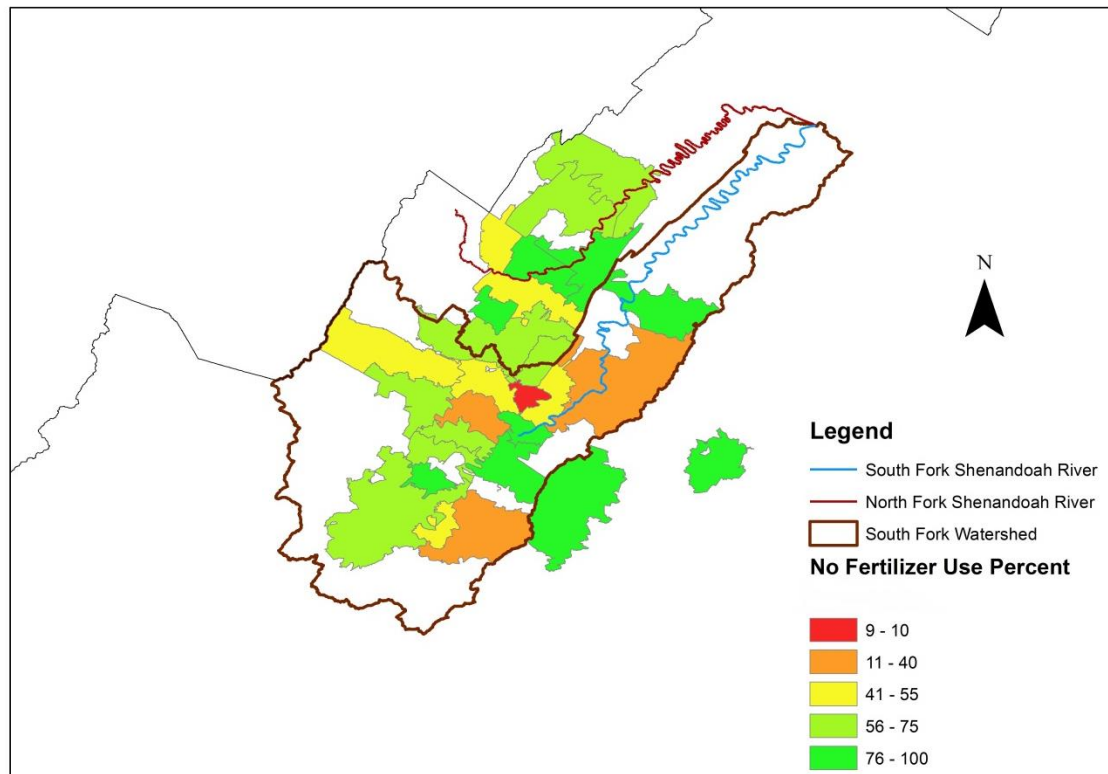
The map also shows an outline of the South fork Shenandoah River watershed. 16 of the 26 populated zips are fully contained within this area with 373 of 514 respondents living within these zip codes. Harrisonburg has the most responses as 286 of the 514 respondents live there. Some of the other zip codes have some of the land within the watershed but it is impossible to tell how many of the people actually live in the watershed so they were not counted as living within the watershed. Many of the other respondents still live within the Shenandoah River watershed, but they are part of the north fork. For the populated zip codes, cross tabulations were made. The remaining 3 maps in this section will show maps for interesting trends that were found from these cross tabulations and will be focused on the area of figure 4.10 marked as “Area of Interest”.



*Figure 4.10, Zip codes in Virginia that had responses and area of interest for the study*

Figure 4.11 shows the percent of respondents in each zip code that do not use fertilizer. The map shows that many of the higher rates of fertilizer use are by regions within the South Fork

Shenandoah River watershed. For all comparisons in the spatial analysis, the zip codes were treated as categorical data and a chi square test was run. The 6 highest rates of fertilizer use are all within the South Fork watershed and all of them have rates higher than 50% of people fertilizing their lawn. The P value for this comparison is 0.01, this means the null hypothesis is rejected which means that the comparison will accurately predict the actual trends.



*Figure 4.11, Percent who don't use fertilizer in populated zip codes*

Figure 4.12 refers to the question about landscape management practices that are mentioned about in Section 4.1.2. It shows the percent of people in each zip code that answered “I really don't think about my property like this” on that question. The P value on this comparison is quite high at 0.34, and it is therefore the null hypothesis is accepted. However, the purpose of this map is not to link a specific lack of practices to specific area. It is rather to visually demonstrate a wide spread lack of property management mindset that does not make consideration for nutrient management practices as most regions show high rates of people saying that they do not think of their property from a conservation perspective.

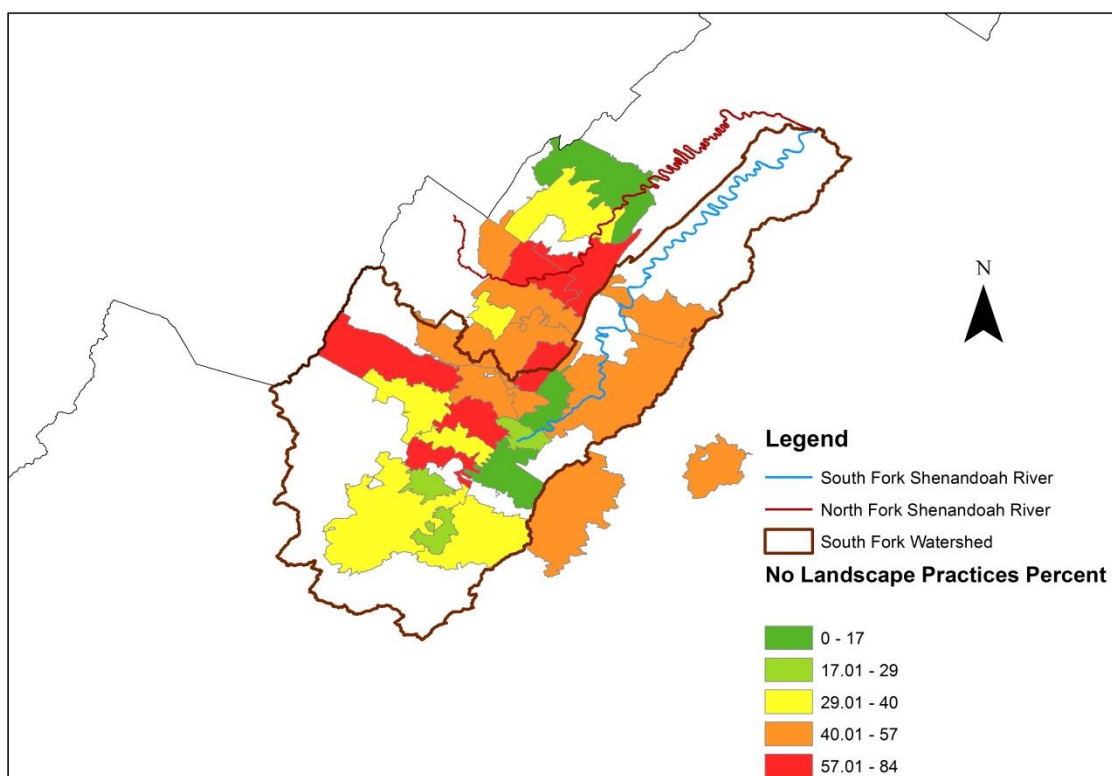
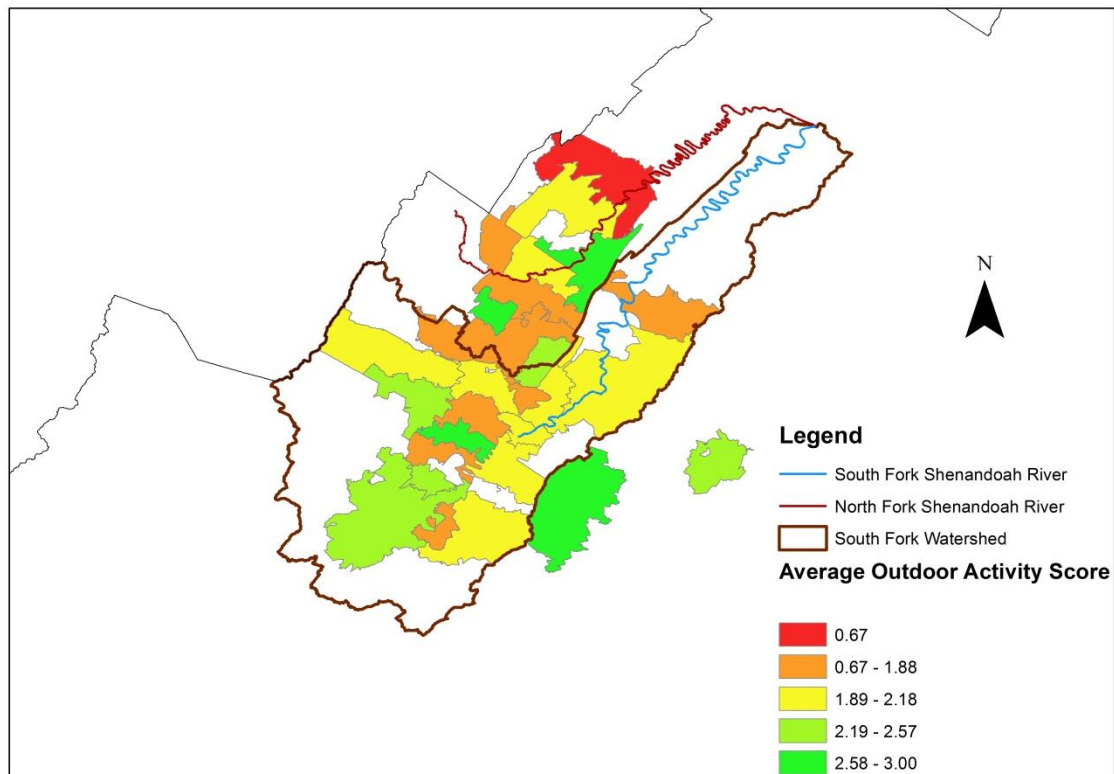


Figure 4.12, Percent who don't use BMPs in their landscape practice in populated zip codes



*Figure 4.13, Average outdoor activity score in populated zip codes*

Figure 4.13 shows the average outdoor recreational activity score for each zip code.

The average outdoor recreational activity score was calculated by taking all scores for residents within a particular zip code and averaging the responses when that zip code. The resulting averages were then mapped to visually show the trends. This on its own is not relevant for the study, but some interesting trends in outdoor activity and nutrient management come up further in the analysis that make this map more relevant. Later analysis will demonstrate how increased outdoor activity score is related with increase in BMP use. The average score for the South Fork watershed is 2.07; the average score for areas outside was slightly higher at 2.20. The range of scores is from 0.67 to 3.00 and is evenly distributed over space.

#### 4.3 Cross tabulations

Each independent variable was taken and cross tabulated with each dependent variable in order to identify any trends that were present. This section will list all of the trends that were



discovered. A later section will go further into the implications of what the findings may mean. Most of the cross tabulations were run using Qualtrics main website that allows for analysis of categorical data. Since a new category was made out of the outdoor recreational activities, cross tabulations of these results were done using Microsoft Excel. Tables for all the cross tabulations discussed can be found in appendix B, only some tables will be included in the text in the case they are needed to add clarity to the variables that are being discussed. For every table shown, the independent variable is found in the rows and the dependent variables are in the columns.

There was a relationship found for people that owned or rented their property and whether or not they fertilize. 44% of the people that own their home fertilize their lawn while only 13% of people that rent their home fertilize their lawn. For the relationship between for people that owned or rented their property and whether or not they fertilize, the Chi Square ( $\chi^2$ ) is = 26.26, and  $P = 0.00002$ . Since it is less than 0.1, which is the significance level for rejecting the null hypothesis in this study, the null hypothesis is rejected. People likely fertilize their lawn if they own the property because they have a vested interest in their residence, not because of any views that are associated with the use of fertilizer.

Table 4.10 shows an interesting trend on how home ownership influences knowledge regarding fertilizing practice knowledge. There are several similar tables in this analysis. The number in black indicates the count of respondents who selected both the dependent and independent variables being measured by that table. For example, in table 4.11, 22 people select that that they rent and that they believe fertilizing at least once per year will improve lawn health or appearance. The percent shown in red underneath the count is the amount of individuals who selected both the dependent and independent variables as a percent of all the individuals who selected just the independent variable. 63 people rent in total. Therefore 35% of everyone who rents also believes fertilizing at least once per year will improve lawn health or appearance.

Further analysis will show that a similar relationship was found between other dependent variables and fertilizing knowledge. The trend seen in table 4.11 is that people who rent are less likely to give a positive response, or in other words select one of the first 5 responses. Also, they are more likely to say that they are unsure or don't agree with any of the other responses. They are less likely to select one of the first 5 responses regardless of whether it is a true statement or not. The same trend was found when comparing fertilizer knowledge statements with the type of house the person had. Those living in a single family home with a lawn were less likely to select one of the first 5 responses compared to those living in a townhouse or duplex with a lawn. Also, 40.3% of those living in a single family home said they didn't know or didn't agree with any of the statements while 34.1% of those living in a duplex or townhouse selected that they didn't know or didn't agree with any of the statements.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						Total
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	
Do you own or rent the home where you live?	Rent	22 34.92%	14 22.22%	12 19.05%	11 17.46%	1 1.59%	34 53.97%	63 100.00%
	Own	233 52.95%	143 32.50%	100 22.73%	69 15.68%	11 2.50%	173 39.32%	440 100.00%
	Neither	2 33.33%	1 16.67%	3 50.00%	1 16.67%	1 16.67%	3 50.00%	6 100.00%
	Total	257 50.49%	158 31.04%	115 22.59%	81 15.91%	13 2.55%	210 41.26%	509 100.00%

*Table 4.11, Comparison of whether property is owned or rented with consumer horticulture knowledge (Chi Square = 16.54 P- value = 0.09)*

Some trends were also found when comparing who takes care of the lawn to some of the dependent variables. For the relationship between who takes care of the lawn and whether or not they fertilize,  $\chi^2 = 23.79$ , and  $P = 0.0002$ . 40% of people who take care of their own lawn say that they fertilize. However, 57% of people who had a landscaper take care of their lawn fertilized. People who have landscapers take care of their lawn could possibly have higher rates of fertilizer use due to some marketing that is done by the landscaping company to those whose lawns they

manage. Since landscapers can be expensive, this could also be related to a relationship that will be shown later between income and whether or not the lawn is fertilized.

Table 4.12 shows another relationship that people who fertilize themselves are more likely to know the type of fertilizer is being used on their lawn compared to people who have others manage their lawn. 15% of people who managed their own lawn didn't know what type of fertilizer was used on their lawn 27% of people who had another member of the household manage the lawn didn't know and 54% of people that used a lawn care company didn't know.

		What type of fertilizer do you normally use for your lawn?					Total
		Organic mix	Standard commercial mix	Slow or extended release commercial mix	Low or no-phosphorus commercial mix	Not sure	
Who takes care of your lawn?	Myself	13 12.15%	50 46.73%	25 23.36%	3 2.80%	16 14.95%	107 100.00%
	Another member of my household	7 11.86%	16 27.12%	17 28.81%	3 5.08%	16 27.12%	59 100.00%
	Lawn care company	3 10.71%	5 17.86%	4 14.29%	1 3.57%	15 53.57%	28 100.00%
	Landlord or apartment complex management	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 100.00%
	Friend/neighbor	0 0.00%	1 50.00%	1 50.00%	0 0.00%	0 0.00%	2 100.00%
	Someone else	1 100.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	1 100.00%
	Not sure	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 100.00%
Total		24 12.18%	72 36.55%	47 23.86%	7 3.55%	47 23.86%	197 100.00%

Table 4.12, Comparison of who takes care of the lawn to what type of fertilizer is used (*Chi Square = 32.31 P- value = 0.009*)

A comparison between who manages the lawn and what months lawn fertilization takes place shows that those who fertilize the lawn themselves are more likely to know when fertilization takes place by a significant margin. 6% of people who fertilize themselves don't know when they fertilize while 32% of those who have another member of the household fertilize don't know what months their lawn is fertilized. 43% of those who use a lawncare company don't know. The lack of knowledge about when their lawn is fertilized is shown by homeowners

who use lawncare companies or have another member of the household care for the lawn shows a similar trend shown in table 4.10 which is that people who don't take care of their own lawn tend to not inquire about fertilization practices that are occurring on their lawn. The survey responses also suggest that lawncare companies do not fertilize in the winter and typically start to fertilize after the grass is no longer dormant. Figure 4.14 shows that people who fertilize themselves sometimes fertilize in the winter and many begin to fertilize when the grass is still dormant (i.e. November through March). There are particularly high numbers of individuals fertilizing in March and November.



*Figure 4.14, The number of people who personally fertilize their lawn for each month*

When comparing outdoor recreational activity scores to the dependent variables, relationships were found with landscaping habits and runoff management practices. Table 4.13 shows the relationship with landscaping habits, detailing the percent of people in each outdoor recreation category that selected the respective landscaping practices. The numbers in the column headers represent the following statements:

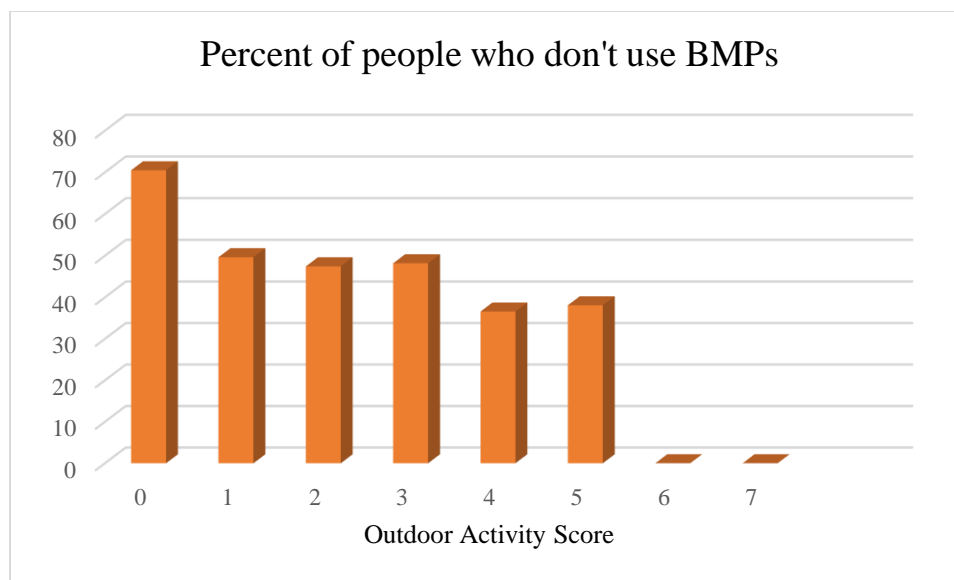
1. I make landscaping choices that reduce the amount of lawn I need to take care of.

2. I make landscaping choices or select plants that reduce the need for watering my lawn or gardens.
3. I make landscaping choices or select plants that reduce the need for fertilizing my lawn or gardens
4. I really don't think about my property like this

Outdoor recreational activity score	1	2	3	4	Total
0	18.03	14.75	6.56	70.49	100
1	32.37	20.86	15.11	49.64	100
2	35.77	27.01	13.87	47.45	100
3	34.94	24.10	20.48	48.19	100
4	41.46	41.46	34.15	36.59	100
5	28.57	47.62	28.57	38.10	100
6	80.00	60.00	40.00	0	100
7	66.67	100	33.33	0	100
<b>Total</b>	33.26	26.12	17.14	48.98	100

*Table 4.13, Comparison of outdoor recreational activity score with consumer horticulture practices (Chi Square = 58.19 P- value = 0.00002)*

Table 4.13 demonstrates that increased outdoor recreational activity increases the use of landscape management practices. People who don't use consumer horticulture BMPs decrease significantly as outdoor recreational activity score increases. Also, use of every practice mentioned tends to increase as outdoor activity score increases. Figure 4.15 shows that as outdoor activity score increases, the percent of people who don't use BMPs decreases.



*Figure 4.15, Percent of people who don't use BMPs vs outdoor activity score*

Potential reasons that increased outdoor activity is related to increased use of landscape management practices could be that increasing outdoor activity could increase interest in environmental stewardship as a closer connection to the environment is felt. Also, other outdoor activities mean that people may enjoy some of these landscaping practices so it is not difficult to go outside and manage their lawn in environmentally friendly ways since they already enjoy the outdoors.

Table 4.14 shows the outdoor recreational activity compared to runoff management practices. Similar to Table 4.13, it shows the percent of people in each outdoor recreation category that selected the respective runoff management practices out. The numbers in the column headers represent the following statements:

1. Rain Barrel(s)
2. Rain Garden(s)
3. Pervious paving (allows water to flow through driveways and sidewalks)
4. Ground cover on bare soil (plants, mulching, etc.)
5. Other

6. I use none of these

<b>Outdoor recreational activity score</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>Total</b>
<b>0</b>	20	0	10	50	0	50	100
<b>1</b>	16.67	6.67	10	56.67	0	33.33	100
<b>2</b>	0	5.26	5.26	52.63	0	47.37	100
<b>3</b>	13.33	0	6.67	53.33	6.67	40	100
<b>4</b>	75	0	0	75	0	0	100
<b>5</b>	50	0	25	75	0	25	100
<b>6</b>	0	0	0	0	0	0	0
<b>7</b>	0	0	0	100	100	0	100
<b>Total</b>	16.87	3.61	8.43	56.63	2.41	37.35	100

*Table 4.14, Comparison of outdoor recreational activity score with runoff management practices (Chi Square = 64.79 P- value = 0.0002)*

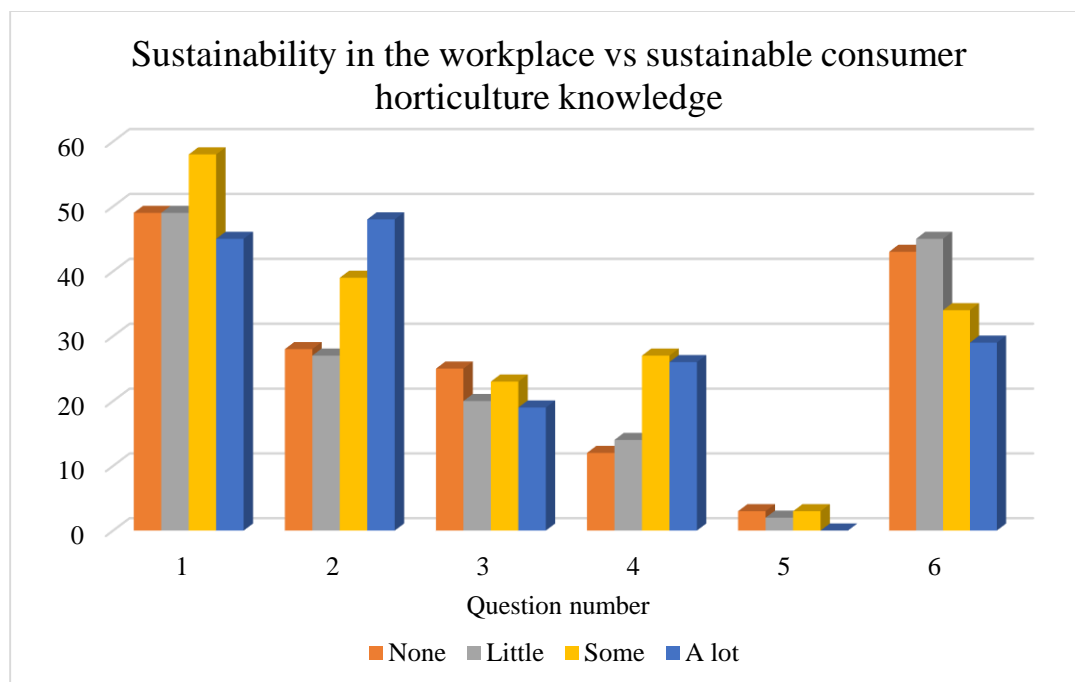
Due to the error in the survey mentioned earlier, only people who water their lawn answered this question. While table 4.14 may be able to predict the behaviors of people in this group well, there are no real conclusions that can be drawn about how outdoor activity impacts runoff management for those that water their lawn. It would be interesting to see if runoff management was impacted by outdoor activity in those who don't water their lawn as they may be more concerned about water management and conservation than those that water their lawn.

		What type of fertilizer do you normally use for your lawn?				
		Organic mix	Standard commercial mix	Slow or extended release commercial mix	Low or no-phosphorus commercial mix	Not sure
How much does your job at JMU involve environmental stewardship and sustainability?	None	8 10.67%	29 38.67%	17 22.67%	0 0.00%	21 28.00%
	Little	8 11.94%	25 37.31%	14 20.90%	1 1.49%	19 28.36%
	Some	7 17.07%	13 31.71%	11 26.83%	6 14.63%	4 9.76%
	A Lot	1 7.69%	5 38.46%	5 38.46%	0 0.00%	2 15.38%
	Total	24 12.24%	72 36.73%	47 23.98%	7 3.57%	46 23.47%
						196 100.00%

*Table 4.15, Comparison of job sustainability with type of fertilizer used on lawn (Chi Square = 26.12 P- value = 0.01)*

The amount of sustainability and environmental stewardship involved in an individual's job described several of the dependent variables. Table 4.15 shows how much an individual's job involving sustainability impacts the type of fertilizer that was used was influenced. For people whose job required a lot of sustainability and environmental stewardship, 38% of those who fertilized used slow or extended release compared to 23% among the other groups that had none to some. Also, of those with some to a lot of sustainability and environmental stewardship in their job, only 11% didn't know the type of fertilizer that was used. 28% of those with little to no sustainability and environmental stewardship didn't know the type of fertilizer used. The relationship between increased job sustainability in the workplace and fertilizer use shows that increased sustainability in an individual's job can transfers to how they treat the environment.





*Figure 4.16, how sustainability involved in the workplace impacts sustainable horticulture knowledge*

Figure 4.16 demonstrates that sustainability and environmental stewardship in an individual's job also showed an increased knowledge in fertilizing practices. The answer numbers in this chart represent the same answer choices that were shown back in table 4.3. There were higher rates of correct responses for those with a lot of sustainability involved in their job, and fewer were unsure about the answer choices. Those who answered a lot for this question recognized that cleaning fertilizer off impermeable surfaces protective water quality at a response rate of 48%. This is compared to a response rate of 30% for all the other groups. Also 26% of those that answered some or a lot recognized that it was best to fertilize in the growing season compared to the 13% of those that answered little or none. This trend makes sense because individuals with sustainability requirements in their job likely encountered sustainability topics in their formal education and may have educated themselves on certain topics outside of a formal setting.

The gender of the respondents showed some interesting relations with some of the independent variables. First, 48% of males fertilize their lawn while only 34% of females

fertilize their lawn. Also, females are more likely to not know the type of fertilizer used on their lawn. This could indicate that for females, someone other than themselves is fertilizing their lawn as earlier analysis showed that people are more likely to know what fertilizer is being used if they are the ones applying the fertilizer. This expectation is confirmed by figure 4.17 which shows that 82% of males who responded take care of their own lawn while 34% of females take care of their own lawn.

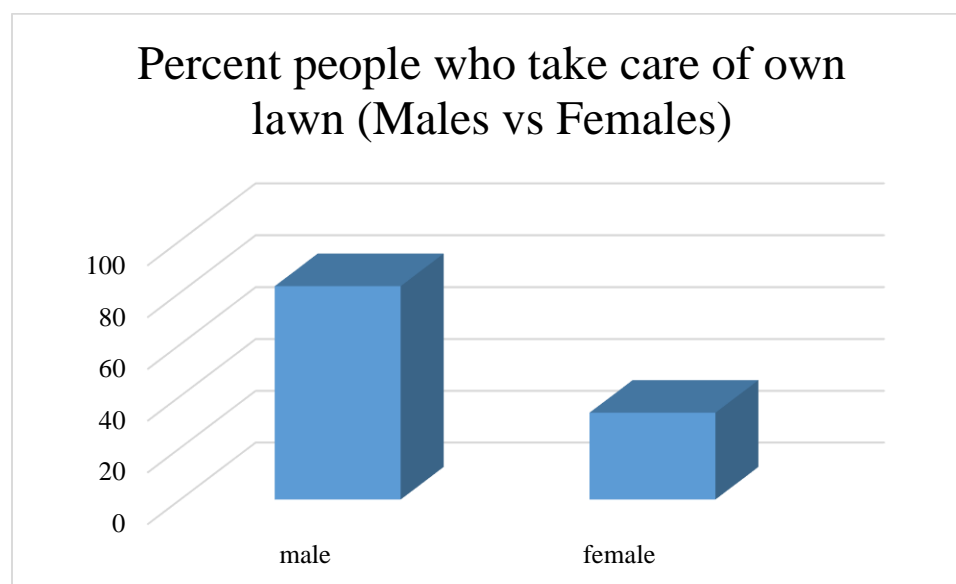


Figure 4.17, Percent of males vs females who take care of their own lawn

Table 4.15 shows the months fertilizer as applied both for men and women. It also shows that men are more likely to fertilize in the winter and summer months while women are more likely to be unsure what months fertilizer is applied to their lawn.

		In what months do you fertilize your lawn? (Check all that apply)													Total
		January	February	March	April	May	June	July	August	September	October	November	December	Not sure which months	
What is your sex?	Male	3 3.19%	3 3.19%	43 45.74%	38 40.43%	15 15.96%	18 19.15%	8 8.51%	9 9.57%	26 27.66%	32 34.04%	15 15.96%	4 4.26%	8 8.51%	94 100.00%
	Female	1 1.04%	1 1.04%	26 27.08%	25 26.04%	14 14.58%	7 7.29%	2 2.08%	6 6.25%	11 11.46%	32 33.33%	5 5.21%	0 0.00%	27 28.13%	96 100.00%
	Total	4 2.11%	4 2.11%	69 36.32%	63 33.16%	29 15.26%	25 13.16%	10 5.26%	15 7.89%	37 19.47%	64 33.68%	20 10.53%	4 2.11%	35 18.42%	190 100.00%

Table 4.16, Comparison of gender with months fertilized (Chi Square = 44.76 P- value = 0.00)

For fertilization knowledge, the same trend that was mentioned earlier was found. That is that males were more likely to select one of the first 5 answers, regardless if the answers were true or false. 49% of females selected that they were unsure or didn't agree with any of the statements. 30% of males selected the same option.

The number of people that fertilize their lawn increases with each age group from 18 until 54, then it levels off. This may be because as people become established in their careers they gain more disposable time and income. Age also has the same impact the variable regarding fertilization knowledge that keeps coming up. Younger age groups are more likely to say they are unsure or don't agree with any of the statements while older groups are more likely to select one of the responses regardless if the statements are true or false.

For the question that had some basic environmental practices listed, relationships were found with landscaping and property management as well as fertilizer knowledge. Table 4.17 shows this relation with landscaping and property management. It shows that those who have switched products for environmental reasons and those who compost are more likely to use the management strategies listed. Turning lights and water off in your house also have economic incentives and recycling is an environmentally friendly practice that has become a social norm. Feeling good about helping the environment is relatively vague and doesn't necessarily require any action. Switching products for environmental reasons and composting require some additional form of action and I suggest these choices require a more environmentally conscious individual. It therefore follows that respondents who selected that they have switched products for environmental reasons and compost would be the ones who are more likely to follow other environmentally friendly practices such as conservation landscaping.

		Which of the following best describes how you landscape your yard or property? (Check all that...)				Total
		I make landscaping choices that reduce the amount of lawn I need to take care of	I make landscaping choices or select plants that reduce the need for watering my lawn or gardens	I make landscaping choices or select plants that reduce the need for fertilizing my lawn or gardens	I really don't think about my yard or property like this	
Please check all of the statements that are true about you.	I have switched products for environmental reasons	95 40.95%	83 35.78%	62 26.72%	85 36.64%	232 100.00%
	I regularly try not to waste water or leave lights on around the house	150 33.86%	122 27.54%	80 18.06%	211 47.63%	443 100.00%
	I regularly recycle	143 33.97%	114 27.08%	76 18.05%	202 47.98%	421 100.00%
	I compost	78 39.00%	67 33.50%	49 24.50%	79 39.50%	200 100.00%
	I feel good when I take steps to help the environment	133 34.82%	108 28.27%	70 18.32%	177 46.34%	382 100.00%
	Total	156 33.05%	123 26.06%	83 17.58%	231 48.94%	472 100.00%

*Table 4.17, Comparison of common environmentally sustainable practices with consumer horticulture practices (Chi Square = 49.26 P- value = 0.00)*

For lawn fertilization knowledge compare to the environmental practices listed, the P-value was 0.12 and therefore the relationship was not significant. However it is mentioned here because it shows the same trend again where those who compost and have switched products for environmental reasons are more likely than the other groups to say they are unsure or disagree with the other statements. Also, those that have switched products of environmental reasons were less likely to select the answers that were false. The final variable to consider of income showed that as income increases, rate of fertilizing increases. Households with incomes greater than \$100,000 fertilize 50% of the time while households that make less than this fertilize 30% of the time. Since it cost money to apply fertilizer, it would be expected that those with higher incomes would fertilize more. However, it is somewhat surprising that the large jump in fertilization rates does not occur until a household income of over \$100,000 is reached.

This chapter has discussed important descriptive statistics and all the significant relationships that were found between the variables. The following points show the key findings from this chapter that will then be discussed in the concluding chapter.

- More people use consumer horticulture BMPs than water management, but still do not employ BMPs to a sustainable level.
- Limited water management BMP use.
- Nearly half of individuals fertilize their lawn.
- Some understanding shown on specific consumer horticulture practices, but most issues were still not understood or known.
- There was a significant lack of knowledge regarding water runoff.

## 5. CONCLUSIONS

Comparing the demographics of those that were surveyed showed some significant difference to the general population. This means that extrapolating data to general population is limited. It will mostly apply to the higher income and higher education demographics within the region. This is because 24% of people who took the survey made over \$100,000 and 13% made \$50,000 or less. The average household income in all the cities and counties in the South Fork Shenandoah River ranges from \$38,048 - \$61,610, which is much lower than those surveyed. Also, 91% of those surveyed had completed at least a Bachelor's degree. The percent of people who have completed at least a Bachelor's degree in all the cities and counties in the South Fork Shenandoah River ranges from 11.4% - 35.1%.

Even still, these results can prove useful in understanding the dynamics of nutrient management knowledge and practices within the region since people in these demographics are more likely to own a property with a lawn than other demographics. Since private citizens are in a position to help solve some of the nutrient issues involved in the Shenandoah watershed and on a larger scale the Chesapeake Bay watershed, insuring that individuals are educated about the issues can help reduce nutrient inputs. This research has focused on looking at people's knowledge and practices regarding nutrients involved with storm water runoff and nutrient management on private property. 81% of those who answered the survey said that they felt good when they took steps to help the environment. This shows that there is potential willingness for people to alter some of their landscape management practices in order to reduce the nutrient runoff from their property.

### 5.1 Implications of Key Findings

The analysis showed that a large number of people were not actively using many of the BMPs for the purpose of nutrient management. For water runoff management practices, most people either used none or only used groundcover on bare soils. It is possible that the ground

cover was only for aesthetic appeal rather than water runoff management since other water runoff management practices were used at low rates. However, an additional line of questioning would be required to determine the reasons why groundcover was selected more frequently than other practices.

On the question that investigated peoples landscaping practices, nearly half did not think about their lawn from a conservation perspective. When comparing common environmental practices with landscaping practices, it was seen that people who are more thoughtful about their environmental practices, such as changing products for environmental reasons rather than just feeling good about helping the environment, will be more likely to use the conservation practices listed. So, while many people who use landscape management practices for environmental reasons, there are likely others who use these practices of convenience of lawn management, such as placing a flowerbed so there is less lawn to mow.

Nearly half the people fertilize their lawn. However, this is something that could be considered overall an environmentally neutral practice from a runoff management standpoint since how it impacts the environment really depends on the individual lawn in question. However, some of the other practices such as fertilizing when plants are dormant and not having a soil nutrient test conducted show that many people in this region are not thinking about their lawn from a conservation standpoint. Since many of the people have high rates of using some typical environmental practices, this indicates that the problem has to do with not having an educated public.

41% of individuals said they didn't know or didn't agree with the statements about lawn fertilization, some of which were true statements. Only 16% recognized the need to only fertilize in the growing season and 31% knew that it was important to clean excess fertilizer off impermeable surfaces. 82% of individuals said they didn't know or didn't agree with the statements about runoff management knowledge. Since all the answers were either partially or

completely false this could mean that they did understand the dynamics. However, considering the lack of runoff management practices used and knowledge about fertilizing practices, it is probable that many the people that selected this answer did not know whether the other responses were true or false. Since the problem seems to be a lack of knowledge rather than an unwillingness to use conservation practices, this presents an opportunity for public outreach and education programs to increase the number of BMPs used. One of the primary problems is funding that would be needed for any program.

## 5.2 Recommendations

Independent variables from the study can be used to determine what groups have the largest potential for improvement in nutrient management practices. This will allow for the most impactful strategies to be developed to increase BMP use in the general public and reduce nutrients entering the South fork Shenandoah through lawns.

In order to have a larger impact across the Chesapeake Bay watershed to improve nutrient practices would take a significant amount of funding. However, there are some steps that can be taken locally in the South Fork Shenandoah River. The urban areas represented by the cities in the watershed have the ability to implement educational programs. For example, I would recommend that Harrisonburg increase educational efforts that are outlined in their MS4 permit since their current commitments are limited and likely has a minor impact in changing behavior.

Some of the cross tabulations can be used to identify the groups that would be more effective to target for any educational program that is theoretically implemented. Since homeowners rather than renters as well as men and individuals over 45 years old are more likely to fertilize their lawn. Education programs could target groups such as homeowner associations or groups that have exclusively or larger numbers of males for education on fertilization BMPs. Also, individuals that do not participate in outdoor activities or participate at lower rates are more likely to not use BMPs. People that do not go outdoors for recreational activities may be using



communication tools like the internet and social media. This could demonstrate an effective and low cost option of something like a social media campaign to educate people. Many education programs include things like workshops where the individual must already have an interest in the issue. Research like this allows for specific groups to be targeted in order to maximize efficiency and focus education efforts where they will be most impactful.

### 5.3 Future Study

There are several options for future research on nutrient management in the South Fork Shenandoah River watershed. If funding was provided, a questionnaire similar to this one could be developed and administered only to individuals living in the South Fork watershed. Also, a true random sample of the population could be taken so that all demographics are included. This would give better information about the general population so that more effective measures could be taken to improve BMP use in the watershed. There would also be a possibility for the study to be expanded to investigate other trends involving nutrient management, such as surveying those whose house was near a riparian buffer. This would be important because these people's individual practices have the highest impact on water quality. If an education campaign was used in this demographic, an alternative study could be performed on the same study group afterwards to determine how successful the campaign was. Monitoring success is important because it allows methods to be developed and perfected that can be used by people living in other parts of the Chesapeake Bay watershed as well.

## APPENDIX A: QUESTIONNAIRE

This survey asks you questions about lawn care and rainwater management practices at your home as well as questions about your perceptions of water quality. If you are willing, please take 10-12 minutes to complete the survey. To take the survey, please review and click the consent box below. If you choose not to take this survey, simply close your browser window. The survey is anonymous and voluntary. You can quite the survey at any time simply by closing your browser.

- ☐ I acknowledge that I have been given the opportunity to ask questions about this study, that I have read the consent in the email and understand what is being requested of me as a participant. I am at least 18 years of age.

1. What is your position at JMU?

- ☐ Faculty  
☐ Staff  
☐ Other (please note) \_\_\_\_\_

2. Do you own or rent the home where you live?

- ☐ Rent  
☐ Own  
☐ Neither

3. Please enter the zip code for your current residence below:

\_\_\_\_\_

4. Which of the following best describes where you live?

- ☐ Single family home with a lawn  
☐ Townhouse or duplex with a lawn  
☐ Townhouse or duplex without a lawn  
☐ Apartment building or complex  
☐ Other, with a lawn  
☐ Other, without a lawn

5. Who takes care of your lawn?

- ☐ Myself
- ☐ Another member of my household
- ☐ Lawn care company
- ☐ Landlord or apartment complex management
- ☐ Friend/neighbor
- ☐ Someone else
- ☐ Not sure

6. Do you fertilize your lawn?

- ☐ Yes
- ☐ No
- ☐ Not sure

7. What type of fertilizer do you normally use for your lawn?

- ☐ Organic mix
- ☐ Standard commercial mix
- ☐ Slow or extended release commercial mix
- ☐ Low or no-phosphorus commercial mix
- ☐ Not sure

8. How many times per year do you fertilize your lawn?

- ☐ About once every 2 or 3 years
- ☐ 1 to 2 times a year
- ☐ 2 to 4 times a year
- ☐ 5 or more times a year
- ☐ Not sure

9. In what months do you fertilize your lawn? (Check all that apply)

- ☐ January
- ☐ February
- ☐ March
- ☐ April
- ☐ May
- ☐ June
- ☐ July
- ☐ August
- ☐ September
- ☐ October
- ☐ November
- ☐ December
- ☐ Not sure which months

10. Have you ever had a soil nutrient test conducted to determine if you should fertilize your lawn or how much fertilizer to use?

- ☐ Yes
- ☐ No
- ☐ Not sure

11. Which of the following best describes how you landscape your yard or property? (Check all that apply)

- ☐ I make landscaping choices that reduce the amount of lawn I need to take care of
- ☐ I make landscaping choices or select plants that reduce the need for watering my lawn or gardens
- ☐ I make landscaping choices or select plants that reduce the need for fertilizing my lawn or gardens
- ☐ I really don't think about my yard or property like this

12. Do you water your lawn?

- ☐ Yes
- ☐ No
- ☐ Not sure

13. How often do you usually water your lawn during the growing months?

- ☐ Only during long dry periods
- ☐ Once a week
- ☐ Several times per week
- ☐ Once per day
- ☐ Several times per day
- ☐ Not sure

14. What time of day do you usually water your lawn?

- ☐ Before 10 am
- ☐ Between 10 am and 5 pm
- ☐ After 5 pm
- ☐ Not sure

15. Do you use any of the following water runoff management practices at your home? (Check all that apply)

- ☐ Rain barrel(s)
- ☐ Rain garden(s)
- ☐ Pervious paving (allows water to flow through driveways and sidewalks)
- ☐ Ground cover on bare soil (plants, mulching, etc.)
- ☐ Other \_\_\_\_\_
- ☐ I use none of these

16. Which of the following outdoor activities (if any) do you regularly engage in? (Check all that apply)

- ☐ Boating, kayaking or canoeing
- ☐ Bicycling
- ☐ Fishing
- ☐ Walking/Hiking
- ☐ Picnicking
- ☐ Camping (tents, cabins, or RVs)
- ☐ Other (Please explain) \_\_\_\_\_
- ☐ None of the above

17. How much does your job at JMU involve environmental stewardship and sustainability?

- ☐ None
- ☐ Little
- ☐ Some
- ☐ A Lot

18. Do you currently live in Virginia?

- ☐ Yes
- ☐ No

19. How long have you lived in Virginia?

- ☐ Less than 2 years
- ☐ 2 - 7 years
- ☐ 8-15 years
- ☐ More than 15 years

20. What is your sex?

- ☐ Male
- ☐ Female

21. What is the highest level of education that you have completed or are currently undertaking?

- ☐ Less than high school
- ☐ High school
- ☐ Vocational/ technical school or community college
- ☐ College
- ☐ Graduate/professional

22. How old are you?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ Over 65

23. Which of the following statements about lawn fertilization do you agree with, if any? (Check all that apply)

- ☐ Fertilizing at least once per year will improve lawn health or appearance
- ☐ Cleaning fertilizer off driveways and sidewalks helps protect water quality
- ☐ It is important to water the lawn after applying fertilizer
- ☐ It is best to fertilize a lawn during its growing season
- ☐ The month in which fertilizer is applied will not affect the quality of water runoff
- ☐ I am not sure or do not agree with any of these statements

24. Which of the following statements about water runoff do you agree with, if any? (Check all that apply)

- ☐ Urban runoff has a similar water quality to water that is in streams and rivers
- ☐ Water that enters a storm drain is treated before being release into nearby water bodies
- ☐ It is not possible to significantly reduce the amount of water that runs off your property
- ☐ I am not sure or do not agree with any of these statements

25. Please check all of the statements that are true about you.

- ☐ I have switched products for environmental reasons
- ☐ I regularly try not to waste water or leave lights on around the house
- ☐ I regularly recycle
- ☐ I compost
- ☐ I feel good when I take steps to help the environment

26. What is the average yearly income of your household?

- ☐ \$12,000 or Less
- ☐ \$12,000 - \$20,000
- ☐ \$20,000 - \$30,000
- ☐ \$30,000 - \$50,000
- ☐ \$50,000 - \$75,000
- ☐ \$75,000 - \$100,000
- ☐ \$100,000+
- ☐ Prefer not to answer

## APPENDIX B: CROSS TABULATIONS

This section includes a numbered list of tables with captions of all cross tabulations where the P value is significant. For these tables, the number in black represents the count of individuals who selected that response. The red number is percent that the count in that box represents out of the total count of that column. The blue number is percent that the count in that box represents out of the total count of that row.

1. Comparison of whether people own or rent and if they fertilize their lawn.

		Do you fertilize your lawn?			Total
		Yes	No	Not sure	
Do you own or rent the home where you live?	Rent	6 13.04% 2.94%	39 84.78% 13.27%	1 2.17% 14.29%	46 100.00% 9.11%
	Own	198 43.81% 97.06%	249 55.09% 84.69%	5 1.11% 71.43%	452 100.00% 89.50%
	Neither	0 0.00% 0.00%	6 85.71% 2.04%	1 14.29% 14.29%	7 100.00% 1.39%
	Total	204 40.40% 100.00%	294 58.22% 100.00%	7 1.39% 100.00%	505 100.00% 100.00%

Chi Square = 26.76 P- value = 0.00002

2. Comparison of whether people own or rent and their consumer horticulture knowledge.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						Total
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	
Do you own or rent the home where you live?	Rent	22 34.92%	14 22.22%	12 19.05%	11 17.46%	1 1.59%	34 53.97%	63 100.00%
	Own	233 52.95%	143 32.50%	100 22.73%	69 15.68%	11 2.50%	173 39.32%	440 100.00%
	Neither	2 33.33%	1 16.67%	3 50.00%	1 16.67%	1 16.67%	3 50.00%	6 100.00%
	Total	257 50.49%	158 31.04%	115 22.59%	81 15.91%	13 2.55%	210 41.26%	509 100.00%

Chi Square = 16.54 P- value = 0.09

3. Comparison of home description with if people fertilize their lawn.



		Do you fertilize your lawn?			Total
		Yes	No	Not sure	
Which of the following best describes where you live?	Single family home with a lawn	189 40.73% 92.65%	270 58.19% 91.53%	5 1.08% 71.43%	464 100.00% 91.70%
	Townhouse or duplex with a lawn	14 38.89% 6.86%	21 58.33% 7.12%	1 2.78% 14.29%	36 100.00% 7.11%
	Townhouse or duplex without a lawn	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
	Apartment building or complex	0 0.00% 0.00%	2 100.00% 0.68%	0 0.00% 0.00%	2 100.00% 0.40%
	Other, with a lawn	1 25.00% 0.49%	2 50.00% 0.68%	1 25.00% 14.29%	4 100.00% 0.79%
	Other, without a lawn	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
	Total	204 40.32% 100.00%	295 58.30% 100.00%	7 1.38% 100.00%	506 100.00% 100.00%

Chi Square = 18.70 P- value = 0.005

#### 4. Comparison of home description with consumer horticulture knowledge.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						Total
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	
Which of the following best describes where you live?	Single family home with a lawn	226 50.90%	138 31.08%	97 21.85%	68 15.32%	12 2.70%	179 40.32%	444 100.00%
	Townhouse or duplex with a lawn	27 65.85%	17 41.46%	16 39.02%	12 29.27%	1 2.44%	14 34.15%	41 100.00%
	Townhouse or duplex without a lawn	0 0.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	5 100.00%	5 100.00%
	Apartment building or complex	3 30.00%	0 0.00%	1 10.00%	0 0.00%	0 0.00%	7 70.00%	10 100.00%
	Other, with a lawn	1 50.00%	0 0.00%	0 0.00%	0 0.00%	0 0.00%	1 50.00%	2 100.00%
	Other, without a lawn	0 0.00%	3 37.50%	1 12.50%	1 12.50%	0 0.00%	5 62.50%	8 100.00%
	Total	257 50.39%	158 30.98%	115 22.55%	81 15.88%	13 2.55%	211 41.37%	510 100.00%

Chi Square = 39.67 P- value = 0.03

#### 5. Comparison of who takes care of the lawn with if lawn is fertilized.

		Do you fertilize your lawn?			Total
		Yes	No	Not sure	
Who takes care of your lawn?	Myself	110 39.71% 53.66%	167 60.29% 56.61%	0 0.00% 0.00%	277 100.00% 54.64%
	Another member of my household	62 37.35% 30.24%	100 60.24% 33.90%	4 2.41% 57.14%	166 100.00% 32.74%
	Lawn care company	30 56.60% 14.63%	21 39.62% 7.12%	2 3.77% 28.57%	53 100.00% 10.45%
	Landlord or apartment complex management	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
	Friend/neighbor	2 28.57% 0.98%	4 57.14% 1.36%	1 14.29% 14.29%	7 100.00% 1.38%
	Someone else	1 25.00% 0.49%	3 75.00% 1.02%	0 0.00% 0.00%	4 100.00% 0.79%
	Not sure	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
Total		205 40.43% 100.00%	295 58.19% 100.00%	7 1.38% 100.00%	507 100.00% 100.00%

Chi Square = 23.79 P- value = 0.002

#### 6. Comparison of who cares for the lawn with type of fertilizer used

		What type of fertilizer do you normally use for your lawn?					Total
		Organic mix	Standard commercial mix	Slow or extended release commercial mix	Low or no-phosphorus commercial mix	Not sure	
Who takes care of your lawn?	Myself	13 12.15% 54.17%	50 46.73% 69.44%	25 23.36% 53.19%	3 2.80% 42.86%	16 14.95% 34.04%	107 100.00% 54.31%
	Another member of my household	7 11.86% 29.17%	16 27.12% 22.22%	17 28.81% 36.17%	3 5.08% 42.86%	16 27.12% 34.04%	59 100.00% 29.95%
	Lawn care company	3 10.71% 12.50%	5 17.86% 6.94%	4 14.29% 8.51%	1 3.57% 14.29%	15 53.57% 31.91%	28 100.00% 14.21%
	Landlord or apartment complex management	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
	Friend/neighbor	0 0.00% 0.00%	1 50.00% 1.39%	1 50.00% 2.13%	0 0.00% 0.00%	0 0.00% 0.00%	2 100.00% 1.02%
	Someone else	1 100.00% 4.17%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	1 100.00% 0.51%
	Not sure	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
Total		24 12.18% 100.00%	72 36.55% 100.00%	47 23.86% 100.00%	7 3.55% 100.00%	47 23.86% 100.00%	197 100.00% 100.00%

Chi Square = 32.31 P- value = 0.009

#### 7. Comparison of who takes care of the lawn with month fertilized.

		In what months do you fertilize your lawn? (Check all that apply)												Not sure which months	Total
		January	February	March	April	May	June	July	August	September	October	November	December		
Who takes care of your lawn?	Myself	3 2.78% 60.00%	2 1.85% 50.00%	49 45.37% 69.01%	42 38.89% 66.67%	21 19.44% 67.74%	17 15.74% 65.38%	7 6.48% 70.00%	9 8.33% 60.00%	31 28.70% 81.58%	35 32.41% 54.69%	14 12.96% 63.64%	3 2.78% 75.00%	7 6.48% 17.95%	108 100.00% 54.27%
	Another member of my household	1 1.67% 20.00%	1 1.67% 25.00%	16 26.67% 22.54%	13 21.67% 20.63%	9 15.00% 29.03%	6 10.00% 23.08%	1 1.67% 10.00%	4 6.67% 26.67%	3 5.00% 7.89%	23 38.33% 35.94%	5 8.33% 22.73%	1 1.67% 25.00%	19 31.67% 48.72%	60 100.00% 30.15%
	Lawn care company	1 3.57% 20.00%	1 3.57% 25.00%	5 17.86% 7.04%	6 21.43% 9.52%	1 3.57% 3.23%	3 10.71% 11.54%	2 7.14% 20.00%	1 3.57% 6.67%	4 14.29% 10.53%	6 21.43% 9.38%	3 10.71% 13.64%	0 0.00% 0.00%	12 42.86% 30.77%	28 100.00% 14.07%
	Landlord or apartment complex management	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
	Friend/neighbor	0 0.00% 0.00%	0 0.00% 0.00%	1 50.00% 1.41%	1 50.00% 1.59%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	1 50.00% 2.56%	2 100.00% 1.01%
	Someone else	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	1 100.00% 1.59%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	1 100.00% 6.67%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	1 100.00% 0.50%
	Not sure	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 0.00% 0.00%	0 100.00% 0.00%
	Total	5 2.51% 100.00%	4 2.01% 100.00%	71 35.68% 100.00%	63 31.66% 100.00%	31 15.58% 100.00%	26 13.07% 100.00%	10 5.03% 100.00%	15 7.54% 100.00%	38 19.10% 100.00%	64 32.16% 100.00%	22 11.06% 100.00%	4 2.01% 100.00%	39 19.60% 100.00%	199 100.00% 100.00%

Chi Square = 74.32 P- value = 0.009

#### 8. Comparison of outdoor recreational activity score with consumer horticulture practices.

Outdoor recreational activity score	1	2	3	4	Total
0	18.03	14.75	6.56	70.49	100
1	32.37	20.86	15.11	49.64	100
2	35.77	27.01	13.87	47.45	100
3	34.94	24.10	20.48	48.19	100
4	41.46	41.46	34.15	36.59	100
5	28.57	47.62	28.57	38.10	100
6	80.00	60.00	40.00	0	100
7	66.67	100	33.33	0	100
Total	33.26531	26.12245	17.14286	48.97959	100

Chi Square = 58.19 P- value = 0.00002

#### 9. Comparison of outdoor recreational activity score with runoff management practices.

Outdoor recreational activity score	1	2	3	4	5	6	Total
0	20	0	10	50	0	50	100
1	16.66667	6.66667	10	56.66667	0	33.33333	100
2	0	5.263158	5.263158	52.63158	0	47.36842	100
3	13.33333	0	6.66667	53.33333	6.66667	40	100

4	75	0	0	75	0	0	100
5	50	0	25	75	0	25	100
6	0	0	0	0	0	0	0
7	0	0	0	100	100	0	100
<b>Total</b>	16.86747	3.614458	8.433735	56.62651	2.409639	37.3494	100

Chi Square = 64.79 P- value = 0.0002

#### 10. Comparison of environmental sustainability in job with type of fertilizer used.

		What type of fertilizer do you normally use for your lawn?					
		Organic mix	Standard commercial mix	Slow or extended release commercial mix	Low or no-phosphorus commercial mix	Not sure	Total
How much does your job at JMU involve environmental stewardship and sustainability?	None	8 10.67% 33.33%	29 38.67% 40.28%	17 22.67% 36.17%	0 0.00% 0.00%	21 28.00% 45.65%	75 100.00% 38.27%
	Little	8 11.94% 33.33%	25 37.31% 34.72%	14 20.90% 29.79%	1 1.49% 14.29%	19 28.36% 41.30%	67 100.00% 34.18%
	Some	7 17.07% 29.17%	13 31.71% 18.06%	11 26.83% 23.40%	6 14.63% 85.71%	4 9.76% 8.70%	41 100.00% 20.92%
	A Lot	1 7.69% 4.17%	5 38.46% 6.94%	5 38.46% 10.64%	0 0.00% 0.00%	2 15.38% 4.35%	13 100.00% 6.63%
	<b>Total</b>	24 12.24% 100.00%	72 36.73% 100.00%	47 23.98% 100.00%	7 3.57% 100.00%	46 23.47% 100.00%	196 100.00% 100.00%

Chi Square = 26.12 P- value = 0.01

#### 11. Comparison of environmental sustainability in job with consumer horticulture knowledge.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	Total
How much does your job at JMU involve environmental stewardship and sustainability?	None	105 48.84%	61 28.37%	54 25.12%	25 11.63%	6 2.79%	93 43.26%	215 100.00%
	Little	86 49.43%	47 27.01%	34 19.54%	24 13.79%	4 2.30%	78 44.83%	174 100.00%
	Some	52 57.78%	35 38.89%	21 23.33%	24 26.67%	3 3.33%	31 34.44%	90 100.00%
	A Lot	14 45.16%	15 48.39%	6 19.35%	8 25.81%	0 0.00%	9 29.03%	31 100.00%
	<b>Total</b>	257 50.39%	158 30.98%	115 22.55%	81 15.88%	13 2.55%	211 41.37%	510 100.00%

Chi Square = 24.39 P- value = 0.06

#### 12. Comparison of sex with if lawn is fertilized.

		Do you fertilize your lawn?			Total
		Yes	No	Not sure	
What is your sex?	Male	94 48.21% 49.47%	101 51.79% 35.94%	0 0.00% 0.00%	195 100.00% 40.88%
	Female	96 34.04% 50.53%	180 63.83% 64.06%	6 2.13% 100.00%	282 100.00% 59.12%
	Total	190 39.83% 100.00%	281 58.91% 100.00%	6 1.26% 100.00%	477 100.00% 100.00%

Chi Square = 12.79 P- value = 0.00

### 13. Comparison of sex with type of fertilizer used.

		What type of fertilizer do you normally use for your lawn?					Total
		Organic mix	Standard commercial mix	Slow or extended release commercial mix	Low or no-phosphorus commercial mix	Not sure	
What is your sex?	Male	9 9.68% 40.91%	43 46.24% 60.56%	24 25.81% 52.17%	2 2.15% 28.57%	15 16.13% 34.88%	93 100.00% 49.21%
	Female	13 13.54% 59.09%	28 29.17% 39.44%	22 22.92% 47.83%	5 5.21% 71.43%	28 29.17% 65.12%	96 100.00% 50.79%
	Total	22 11.64% 100.00%	71 37.57% 100.00%	46 24.34% 100.00%	7 3.70% 100.00%	43 22.75% 100.00%	189 100.00% 100.00%

Chi Square = 9.15 P- value = 0.06

### 14. Comparison of sex with months of fertilizing.

		In what months do you fertilize your lawn? (Check all that apply)												Total
		January	February	March	April	May	June	July	August	September	October	November	December	
What is your sex?	Male	3 3.19% 75.00%	3 3.19% 75.00%	43 45.74% 62.32%	38 40.43% 60.32%	15 15.96% 51.72%	18 19.15% 72.00%	8 8.51% 80.00%	9 9.57% 60.00%	26 27.66% 70.27%	32 34.04% 50.00%	15 15.96% 75.00%	4 4.26% 100.00%	94 100.00% 49.47%
	Female	1 1.04% 25.00%	1 1.04% 25.00%	26 27.08% 37.68%	25 26.04% 39.68%	14 14.58% 48.28%	7 7.29% 28.00%	2 2.08% 20.00%	6 6.25% 40.00%	11 11.46% 29.73%	32 33.33% 50.00%	5 5.21% 25.00%	0 0.00% 0.00%	96 100.00% 50.53%
	Total	4 2.11% 100.00%	4 2.11% 100.00%	69 36.32% 100.00%	63 33.16% 100.00%	29 15.26% 100.00%	25 13.16% 100.00%	10 5.26% 100.00%	15 7.89% 100.00%	37 19.47% 100.00%	64 33.68% 100.00%	20 10.53% 100.00%	4 2.11% 100.00%	190 100.00% 100.00%

Chi Square = 44.76 P- value = 0.00

### 15. Comparison of sex with consumer horticulture knowledge.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						Total
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	
What is your sex?	Male	120 60.30% 47.24%	91 45.73% 57.96%	45 22.61% 39.82%	43 21.61% 53.09%	13 6.53% 100.00%	59 29.65% 28.10%	199 100.00% 39.33%
	Female	134 43.65% 52.76%	66 21.50% 42.04%	68 22.15% 60.18%	38 12.38% 46.91%	0 0.00% 0.00%	151 49.19% 71.90%	307 100.00% 60.67%
	Total	254 50.20% 100.00%	157 31.03% 100.00%	113 22.33% 100.00%	81 16.01% 100.00%	13 2.57% 100.00%	210 41.50% 100.00%	506 100.00% 100.00%

Chi Square = 67.11 P- value = 0.00

16. Comparison of age with if lawn is fertilized.

		Do you fertilize your lawn?			Total
		Yes	No	Not sure	
How old are you?	18-24	0 0.00% 0.00%	1 100.00% 0.35%	0 0.00% 0.00%	1 100.00% 0.21%
	25-34	17 22.97% 8.90%	56 75.68% 19.86%	1 1.35% 16.67%	74 100.00% 15.45%
	35-44	33 31.43% 17.28%	71 67.62% 25.18%	1 0.95% 16.67%	105 100.00% 21.92%
	45-54	74 50.68% 38.74%	70 47.95% 24.82%	2 1.37% 33.33%	146 100.00% 30.48%
	55-64	58 42.96% 30.37%	75 55.56% 26.60%	2 1.48% 33.33%	135 100.00% 28.18%
	Over 65	9 50.00% 4.71%	9 50.00% 3.19%	0 0.00% 0.00%	18 100.00% 3.76%
	Total	191 39.87% 100.00%	282 59.87% 100.00%	6 1.25% 100.00%	479 100.00% 100.00%

Chi Square = 21.89 P- value = 0.02

17. Comparison of age with consumer horticulture knowledge.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						Total
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	
How old are you?	18-24	1 25.00% 0.39%	0 0.00% 0.00%	1 25.00% 0.88%	0 0.00% 0.00%	0 0.00% 0.00%	3 75.00% 1.42%	4 100.00% 0.79%
	25-34	37 44.05% 14.45%	18 21.43% 11.46%	15 17.86% 13.16%	15 17.86% 18.52%	3 3.57% 23.08%	43 51.19% 20.38%	84 100.00% 16.50%
	35-44	45 39.13% 17.58%	27 23.48% 17.20%	19 16.52% 16.67%	12 10.43% 14.81%	0 0.00% 0.00%	61 53.04% 28.91%	115 100.00% 22.59%
	45-54	87 58.00% 33.98%	58 38.67% 36.94%	42 28.00% 36.84%	27 18.00% 33.33%	2 1.33% 15.38%	48 32.00% 22.75%	150 100.00% 29.47%
	55-64	74 54.01% 28.91%	46 33.58% 29.30%	32 23.36% 28.07%	25 18.25% 30.86%	8 5.84% 61.54%	51 37.23% 24.17%	137 100.00% 26.92%
	Over 65	12 63.16% 4.69%	8 42.11% 5.10%	5 26.32% 4.39%	2 10.53% 2.47%	0 0.00% 0.00%	5 26.32% 2.37%	19 100.00% 3.73%
	Total	256 50.29% 100.00%	157 30.84% 100.00%	114 22.40% 100.00%	81 15.91% 100.00%	13 2.55% 100.00%	211 41.45% 100.00%	509 100.00% 100.00%

Chi Square = 47.76 P- value = 0.00

18. Comparison of common sustainable environmental practices used with consumer horticulture practices.

		Which of the following best describes how you landscape your yard or property? (Check all that...)				Total
		I make landscaping choices that reduce the amount of lawn I need to take care of	I make landscaping choices or select plants that reduce the need for watering my lawn or gardens	I make landscaping choices or select plants that reduce the need for fertilizing my lawn or gardens	I really don't think about my yard or property like this	
Please check all of the statements that are true about you.	I have switched products for environmental reasons	95 40.95% 60.90%	83 35.78% 67.48%	62 26.72% 74.70%	85 36.64% 36.80%	232 100.00% 49.15%
	I regularly try not to waste water or leave lights on around the house	150 33.86% 96.15%	122 27.54% 99.19%	80 18.06% 96.39%	211 47.63% 91.34%	443 100.00% 93.86%
	I regularly recycle	143 33.97% 91.67%	114 27.08% 92.68%	76 18.05% 91.57%	202 47.98% 87.45%	421 100.00% 89.19%
	I compost	78 39.00% 50.00%	67 33.50% 54.47%	49 24.50% 59.04%	79 39.50% 34.20%	200 100.00% 42.37%
	I feel good when I take steps to help the environment	133 34.82% 85.26%	108 28.27% 87.80%	70 18.32% 84.34%	177 46.34% 76.62%	382 100.00% 80.93%
	Total	156 33.05% 100.00%	123 26.06% 100.00%	83 17.58% 100.00%	231 48.94% 100.00%	472 100.00% 100.00%

Chi Square = 49.26 P- value = 0.00

19. Comparison of common sustainable environmental practices used with consumer horticulture knowledge.

		Which of the following statements about lawn fertilization do you agree with, if any? (Check all...)						Total
		Fertilizing at least once per year will improve lawn health or appearance	Cleaning fertilizer off driveways and sidewalks helps protect water quality	It is important to water the lawn after applying fertilizer	It is best to fertilize a lawn during its growing season	The month in which fertilizer is applied will not affect the quality of water runoff	I am not sure or do not agree with any of these statements	
Please check all of the statements that are true about you.	I have switched products for environmental reasons	99 39.29% 38.98%	71 28.17% 45.51%	44 17.46% 39.29%	38 15.08% 47.50%	3 1.19% 23.08%	126 50.00% 60.00%	252 100.00% 49.80%
	I regularly try not to waste water or leave lights on around the house	237 50.00% 93.31%	149 31.43% 95.51%	105 22.15% 93.75%	73 15.40% 91.25%	11 2.32% 84.62%	196 41.35% 93.33%	474 100.00% 93.68%
	I regularly recycle	220 48.78% 86.61%	143 31.71% 91.67%	97 21.51% 86.61%	69 15.30% 86.25%	11 2.44% 84.62%	191 42.35% 90.95%	451 100.00% 89.13%
	I compost	84 40.00% 33.07%	76 36.19% 48.72%	39 18.57% 34.82%	33 15.71% 41.25%	6 2.86% 46.15%	102 48.57% 48.57%	210 100.00% 41.50%
	I feel good when I take steps to help the environment	209 51.10% 82.28%	137 33.50% 87.82%	90 22.00% 80.36%	68 16.63% 85.00%	10 2.44% 76.92%	165 40.34% 78.57%	409 100.00% 80.83%
	Total	254 50.20% 100.00%	156 30.83% 100.00%	112 22.13% 100.00%	80 15.81% 100.00%	13 2.57% 100.00%	210 41.50% 100.00%	506 100.00% 100.00%

Chi Square = 27.41 P- value = 0.12

20. Comparison of income with if lawn is fertilized.

		Do you fertilize your lawn?			
		Yes	No	Not sure	Total
What is the average yearly income of your household?	\$12,000 or Less	0 0.00% 0.00%	1 100.00% 0.36%	0 0.00% 0.00%	1 100.00% 0.21%
	\$12,000 - \$20,000	0 0.00% 0.00%	1 100.00% 0.36%	0 0.00% 0.00%	1 100.00% 0.21%
	\$20,000 - \$30,000	1 11.11% 0.52%	8 88.89% 2.85%	0 0.00% 0.00%	9 100.00% 1.88%
	\$30,000 - \$50,000	13 29.55% 6.77%	31 70.45% 11.03%	0 0.00% 0.00%	44 100.00% 9.19%
	\$50,000 - \$75,000	27 28.72% 14.06%	67 71.28% 23.84%	0 0.00% 0.00%	94 100.00% 19.62%
	\$75,000 - \$100,000	33 34.02% 17.19%	61 62.89% 21.71%	3 3.09% 50.00%	97 100.00% 20.25%
	\$100,000+	86 50.89% 44.79%	81 47.93% 28.83%	2 1.18% 33.33%	169 100.00% 35.28%
	Prefer not to answer	32 50.00% 16.67%	31 48.44% 11.03%	1 1.56% 16.67%	64 100.00% 13.36%
Total		192 40.08% 100.00%	281 58.66% 100.00%	6 1.25% 100.00%	479 100.00% 100.00%

Chi Square = 29.19 P- value = 0.01



## APPENDIX C: SAMPLE CALCULATION FOR CHI SQUARE

Most of the chi square calculation were done by Qualtrics automatically when cross tabulations were done. However, when the outdoor activity score was generated and cross tabulated with the dependent variables, the chi square had to be calculated using excel. This shows a sample calculation of how this was done with the comparison of outdoor activity score with if people fertilize.

The formula used to calculate the chi square is:

$$\chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

n = number of cells

$O_i$  = number of observations in cell i

$E_i$  = expected number of observations in cell i

$E_i$  is calculated for each cell by multiplying the column total by row total and then dividing by the total number of observations.

The calculation  $O_i$  and  $E_i$  for each cell is shown below.

	A	B	C	D	E	F	G	H
4				Yes	No	Don't kno	Total	
5								
6			0	22	38	1	61	
7			1	59	78	2	139	
8			2	60	78	2	140	
9			3	31	53	0	84	
10			4	12	28	1	41	
11			5	10	10	0	20	
12			6	3	2	0	5	
13			7	1	2	0	3	
14			Total	198	289	6	493	
15								
16								
17			$O_i$	$E_i$	$(O_i - E_i)^2 / E_i$			
18			22	24.49899	0.254906			
19			59	55.82556	0.18051			
20			60	56.22718	0.253155			
21			31	33.73631	0.221938			
22			12	16.46653	1.211543			
23			10	8.032454	0.481949			
24			3	2.008114	0.489932			
25			1	1.204868	0.034834			
26			38	36.87221	0.034495			
27			78	84.02028	0.43137			
28			78	84.62475	0.51861			
29			53	50.77485	0.097515			
30			28	24.78296	0.417599			
31			10	12.08925	0.361062			
32			2	3.022312	0.345802			
33			2	1.813387	0.019204			
34			1	0.742394	0.089388			
35			2	1.691684	0.056192			
36			2	1.703854	0.051473			
37			0	1.022312	1.022312			
38			1	0.498986	0.503051			
39			0	0.243408	0.243408			
40			0	0.060852	0.060852			
41			0	0.036511	0.036511			
42								

Once  $O_i$  and  $E_i$  are known, plug them into the formula and then sum the results for all cells to get the chi square, for this relationship chi square = 7.42

To determine the P – value for this relationship first calculate the degrees of freedom.

Degrees of freedom = (number of variables in row - 1)\*(number of variables in column - 1) = (7-1)\*(3-1) = 12

You then need to go to look at a chi-square distribution table and find P- value when chi square = 7.42 with 12 degrees of freedom. For this relationship,  $P = 0.83$

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