Spring 2020

The Economic Impact of Forest Harvest Practices on Washington State Park Visitation

Tyler Humphries

Central Washington University, Tyler.Humphries@cwu.edu

THE ECONOMIC IMPACT OF FOREST HARVEST PRACTICES

ON WASHINGTON STATE PARK VISITATION

A Thesis

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Cultural and Environmental Resource Management

---

by

Tyler Keith Humphries

June 2020

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

We hereby approve the thesis of

Tyler Keith Humphries

Candidate for the degree of Master of Science

APPROVED FOR THE GRADUATE FACULTY

______________ ____
Dr. Toni Sipic, Committee Chair

______________ ____
Dr. Charles Wassell

______________ ____
Dr. Jennifer Lipton

______________ ____
Dean of Graduate Studies

ABSTRACT

THE ECONOMIC IMPACT OF FOREST HARVEST PRACTICES

ON WASHINGTON STATE PARK VISITATION

by

Tyler Keith Humphries

June 2020

Washington State receives timber contributions from 34 out of its 39 counties, making it a top producer of timber in the United States. Because of the widespread and abundant number of harvests, many forests that society values are affected via diminished aesthetic appeal. Of these affected areas are Washington State Parks and the areas around them. This study seeks to estimate the economic impact that forest harvest practices have on the visitation of Washington State Parks. Through the use of GIS and fixed effect regression analysis, I estimate the impact that over 100,000 permitted forest cuts have on the visitation of 142 Washington State Parks and find statistically significant negative impacts of both even and uneven timber cutting methods. This study will benefit forest and park managers by evaluating forest harvest techniques with respect to recreation and hopes to inform the policy makers working to ensure the sustainability and prosperity of our Washington State Park System.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. INTRODUCTION

Washington is a top producer of timber in the United States. In 2017, Washington produced 2.7 billion board feet of timber and received contributions from 34 out of its 39 counties (Watts et al. 2018). As a state, Washington is the second largest employer in the logging industry and is the leader in annual mean wages as of May 2017 (Bureau of Labor Statistics 2017). Over 100,000 active forestry activities have been permitted in the state since 1995 (WADNR 2017). This permitted forestry activity is monitored by the Washington State Department of Natural Resources (WADNR) and outlines the methods utilized for each cut. Even-aged and uneven-aged are the most common timber harvest methods. The uneven-age method is a selective technique of tree harvesting in which a forest exists with many small trees and very few big trees (Wittwer, Anderson, and Marcouiller 2009). In other words, some trees may be selected for cutting while others may not, depending on their age. Conversely, even-aged forest harvesting is characterized by trees of around the same height and tree age structure (Kuuluvainen, Tahvonen, and Aakala 2012). A common type of even-age method is clearcutting, which reproduces a new even-aged forest by completely removing the old forest. It is viewed as controversial, but commercially efficient (Harvesting 2015).

Regardless of the method used, the aesthetic appeal of an area near a cutting site will be affected. After all, research from environmental studies and human psychology suggests that society places a great deal of value on landscape views (Poudyal et al. 2010). Because of the widespread and abundant number of timber harvests in the state, a number of these cuts occurred in or around places that society values for views and recreation, including Washington State Parks.

State park visitation is another great revenue source for the Washington State economy. The Washington State Park system consists of 142 developed sites in a variety of biophysical and cultural contexts. In fact, Washington State Park visits generate $1.4 billion in total economic contributions every year (Hoch et al. 2016). They have also provided 14,000 jobs to the people of Washington State (Mojica, Briceno, and Sundler 2015). According to the Washington State Parks and Recreation reporting system, there were over 37 million visitors in 2018. Nonetheless, changes in landscape views via forest cuts could greatly affect visitation to these State Parks. In return, this would have an effect on the economic value generated by these state park visits.

In this study, I examine the economic impacts of uneven and even-age forest practices on Washington State Park visitation. This research intends to bridge the data gap on economic valuation of state parks in our state. While previous research on economic values of state parks is abundant, including that of Mojica, Briceno, and Sundler (2015) and Genderen, Semler, and Dalbey (2010), a research gap remains on how logging impacts park economic values. This thesis combines literature on recreational visits to parks with forestry economics.

The purpose of this study is to evaluate the effects of forest harvest practices on the visitation of Washington State Parks. Specifically, I seek to analyze the impact of an additional acre of forest harvested on state park visitation. I hypothesize that additional cuts (especially even-age) made within the state park buffer zones decrease the amount of visitation, thus diminishing the economic value derived from state park visits. In other words, I am attempting to disprove the null hypothesis that forest harvest practices have no effect on the overall visitation and value derived from Washington State Parks. To do so I completed the following steps in my research:

1. Determined the incentives behind Washington State Park visitation via relevant literature
2. Examined the different forestry methods conducted in and around state park buffer zones
3. Overlaid datasets in GIS to detect cuts in accordance with buffer zones and park visits
4. Conducted regression analysis to determine significance of forest cuts on park visits
5. Used quantitative methods to determine the economic value affected by forest practices

Given the importance of outdoor recreation and forestry industries, it is essential to establish a firm grasp on the connection between timber harvest methods and state park visitation. Literature on the issue is sparse, thus forest and park managers can use this study to better inform forest management practices. In particular, they can determine what types of timber harvest methods affect the visitation of our parks most adversely and can work with park managers to ensure proper forestry techniques are applied that minimize such impacts. Additionally, this study will be useful to outdoor recreation managers and enthusiasts. Washington State Parks allow for a variety of activities in differing parts of the state. This study seeks to benefit those who visit parks and engage in outdoor recreation in Washington by providing research and useful results toward visitor preferences. In return, this study will identify appropriate foresting techniques for a longer, more sustainable future of our parks and timber industries.

CHAPTER II. LITERATURE REVIEW

The first half of this section begins with the discussion of relevant literature regarding forest management practices and methods of environmental valuation. The latter half introduces literature concerning the three predominant methods in economics used in nonmarket economic valuation, as well as previous state park valuation publications. This study focuses on the economic impact of forest harvest practices on state park visitation. Therefore, the literature surrounding this study is that of differing economic and forest management backgrounds. All in all, this section converges multiple sources to better understand the context behind this study.

2.1 Forest Harvest Methods

There are two methods of forest harvest examined in this study: even-aged and uneven-aged. Even-aged methods include three subcategories: clearcutting, shelter wood, and seed-tree regeneration (Dey et al. 2012). Uneven-aged methods include single-tree selection and group selection (Dey et al. 2012).

2.1.1 Even-Aged Cutting

In even-aged stands, trees are of a single class and the range in age does not exceed 20 percent of the rotation (Dey et al. 2012). Clearcutting is the cheapest and most commercially viable even-age harvest method (Dupler 2011). Clearcutting involves clearing an entire area of forest, and drastically altering the forest ecosystem (Dupler 2011). As a result, it can be viewed as controversial, but it is economically efficient. Seed tree is another method of even-aged cutting. This method is similar to clearcutting, but instead of clearing all the trees, a small number of mature trees are left standing (Dey et al. 2012). This will allow the mature trees to supply seed for natural regeneration (Dey et al. 2012). Shelter-wood cutting is a partial harvest of a stand in which mature trees are left to favor certain species by creating seeds and shelter for protection (Freedman 2014). Figure 1 illustrates an even-aged harvest that occurred in May 2013 at Schafer State Park in Elma, Washington.

Figure 1. Schafer State Park, May 2013, Strong evidence of Even-aged Clearing, Google Earth Pro

2.1.2 Uneven-Aged Cutting

Uneven-aged cutting method involves at least three distinct age classes of trees intermingled (Dey et al. 2012). The first subcategory is single tree selection. Single tree selection is the process of harvesting individual or small groups of trees (Dey et al. 2012). Trees are selected based on timber quality and its potential contribution to wildlife habitat, among other attributes (Dey et al. 2012). Group selection harvest method applies to small patches where all trees are cut, differing from single tree selection and clearcutting in the size of harvested area (Dey et al. 2012). The white box in Figure 2 illustrates an uneven-aged harvest that took place on June 2017 at Seaquest State Park, located in Castle Rock, Washington.

Figure 2. Seaquest State Park, June 2017, Evidence of Uneven-age Cutting, Google Earth Pro

2.2 Perceptions of Forest Harvesting

While there is little literature regarding the economic impact of timber harvest methods on park visitation, many studies have been published on forest management perceptions in recreation and residential areas. Consumer perceptions and preferences for park environmental quality drive visitation, making this literature important for this study. Kearney and Bradley (2011) evaluated forest aesthetic preferences in Western Washington with a survey sent to a diverse group of respondents (foresters, urban residents, rural residents, recreationalists, educators, and environmentalists). The survey showed pictures of Capitol State Forest, a 90,000 acre forest near Olympia, Washington that is managed by the WADNR. Overall, preference ratings tended to decline with each increasing evidence of clearing, with ratings being the highest with green scenery and the lowest for areas with large and/or recent clearings (Kearney and Bradley 2011). Eriksson et al. (2012) also analyzed visitor preferences by looking at a scene preference study of Swedish forest settings. The study received a sample survey size of 106 students, with 75 students coming from a social science background and 31 from forestry. These students were asked to reveal their preferences to different forest scenes, including “natural-looking”, “forest management; clear cut”, and “forest management: traces of forest machines”. While social science students preferred a recreation scene and forestry students preferred recreation and the natural-looking scenes equally, forest management scenes were less appreciated for both groups (Eriksson et al. 2012). Lastly, Taye (2017) examined preferences for variation in forest characteristics in recreational settings using a choice experiment. The choice experiment was used to elicit people's preferences for forest types on their next recreation visit (Taye 2017). In order to do so, respondents were asked to compose their ideal recreational forest by selecting differing tree species, height (age) and distance to the site (WTP) (Taye 2017). The study found that stands with varying tree heights (uneven-age) were preferred over stands of the same height (even-age) (Taye 2017). In conclusion, relevant literature has shown that people do have specific preferences towards forest management, with increasing evidence of clearing impacting perceptions of numerous types of sites.

2.3 Public Opposition to Clearcutting

Clearcutting is a method of harvesting and regenerating trees in which all trees are cleared from a site and a new, even-aged stand of trees is grown (Gorte 1998). Clearcutting is very common in the United States. In fact, between 1984 and 1997, clearcutting accounted for 59% of the area harvested in national forests (Gorte 1998). This technique contrasts to a wide variety of both traditional and modern cutting methods where only a proportion of the trees are cut at each logging event (Lundmark, Josefsson, and Östlund 2013). This distinction has brought significant negative attention, which poses an important question, why is clear cutting it so common? The answer stems from an economic perspective. Timber management in an even-aged forest is considered to be economically efficient since major operations require only one entry into a stand (Wittwer, Anderson, and Marcouiller 2009). This economic justification is up to debate to this day, however.

Social research focused on public aesthetic judgments of forest practices has overwhelmingly concluded that Americans find clearcutting aesthetically offensive (Bliss 2000). While there are empirical studies concluding this reality (discussed later), the reason behind the opposition of clear-cuts varies. Ribe and Matteson (2002) attempted to define these oppositions when they conducted a survey of six policy propositions to reflect often-proposed approaches. The results indicated that all respondents, except a small minority, thought clearcutting should be regulated (Ribe and Matteson 2002). Additionally, the responses showed that the public may simply dislike clear-cuts irrespective of their visibility, indicating that hiding clear-cuts is not sufficient (Ribe and Matteson 2002). On the other hand, in a 2002 survey of Washington voters, 69% agreed with the statement, "I don't always like how clear-cuts look, but if it means the land will remain in use for forestry rather than being converted to housing and commercial developments, then clearcutting is acceptable." (Murray and Nelson 2005). As a result, it can be inferred that while the general censuses of the public is that clearcutting is an unacceptable practice, the opposition of this practice stems from differing situations. While perceptions of clearcutting have illuminated a negative perception, empirical evidence has also backed up this claim. Palmer (2008) examined the perceived scenic effect of clearcutting in the White Mountains of New Hampshire. Survey results indicated that the intensity, size, and pattern of clear-cuts all had significant effects on scenic value (Palmer 2008). While these components influence preferences, the retention (or sustainability) of the trees being cut is also important. Ribe (2009) examined the in-stand scenic beauty of harvests and mature forests in the Pacific

Northwest. The results indicated that green-tree retention harvests (modification of traditional clearcutting) offer considerable potential gains in perceived scenic beauty compared to perceived traditional clear-cuts (Ribe 2009). As a result, prior literature has illustrated that while the public's perception of clearcutting is clearly negative, there are many components as to the degree of the opposition.

2.4 Open Green/Urban Spaces

While there are undoubtedly negative opinions towards clearcutting, prior literature has shown optimism towards open green/urban landscapes (Brander and Koetse 2011; Morancho 2003; Geoghegan 2002). The EPA (Environmental Protection Agency) defines open space as "any open piece of land that is undeveloped and is accessible to the public." This section provides an overview of open space literature by first defining the term(s) and alluding to prior empirical pieces of literature which demonstrate open space public perceptions.

Urban open spaces encompass a range of land uses including urban parks, forests, undeveloped land and agricultural land at the urban fringe (Brander and Koetse 2011). As a result, they can provide numerous benefits to not only ecosystems, but to the public as well. These open spaces can provide recreational opportunities, aesthetic enjoyment, and environment and agricultural functions (Brander and Koetse 2011). Therefore, preserving these areas is important, and yet not always a major priority. Brander and Koetse (2011) argue that urban open spaces have been recognized as a public good, and thus tend to be under-provided in the absence of public intervention. Additionally, urbanization has placed pressure on open spaces within and adjacent to cities, once again indicating the need for policy intervention. Regardless of these pressures, open green/urban spaces have been extremely beneficial, prompting empirical analysis.

Urban open spaces provide many benefits to the public as well as the ecosystem in which they are present. Consequently, numerous studies have been conducted to estimate the benefits of these areas. Morancho (2003) estimates the value of urban green areas using a hedonic pricing model. The study indicates that proximity to an open-space has a statistically significant effect on home selling price, indicating the value of these open space areas. Geoghegan (2002) estimates the value of open spaces in residential land use by using a theoretical model of how different types of open spaces are valued by residential landowners. The empirical results from a developing county in Maryland show that permanent open space increased land values over three time as much as developable open space (Geoghegan 2002). Permanent open spaces can be thought of as parks, or lands that have conservation easements while developable open spaces are privately owned land (Geoghegan 2002). Geoghegan's work is important because while it states the value of open spaces is evident, certain types of open spaces are more valuable than others. Additionally, the services of urban open spaces can be estimated. Brander and Koetse (2011) used both the contingent valuation and hedonic pricing method to examine which physical, socio-economic, and study characteristics determine the value of open space. It was determined that in both models there is a positive and significant relationship between the value of urban open space and population density, indicating the importance of both scarcity and crowdedness (Brander and Koetse 2011). The study also determines that urban parks are more highly valued than other types of urban open spaces such as agricultural and undeveloped land (Brander and Koetse 2011). All in all, it can be empirically estimated that not only are urban open spaces crucial for the public and ecosystems, they also provide value through their services, proximity to housing developments, and recreational capability.

2.5 Ecosystem Valuation

2.5.1 Hedonic Pricing Model (Viewshed Analysis)

The two reviews of literature examined in this section both involve the use of hedonic pricing models, a specialized type of regression. One also contains the use of viewshed analysis. Hedonic modeling is based on the idea that goods are valued based on their characteristic utility (Rosen 1974). As a result, hedonic models are used most frequently when analyzing home prices. Home value depends on characteristics such as the number of bedrooms, bathrooms, square footage, etc. A recent study by Poudyal et al. (2010) employs a hedonic pricing model to determine how visible forest area affected its residential housing price (Poudyal et al. 2010). The study found that the housing price was significantly and positively related to housing price (Poudyal et al. 2010).

Javier (2017) in his Central Washington University Master's thesis used hedonic modelling to analyze even-aged and uneven-aged cuts and their impact on Western Washington housing prices This example, is applicable in the context of this thesis, as my study area incorporates Western Washington, and is evaluating the same two types of cutting methods. Javier's study found negative and statistically significant impacts on home values for both cutting methods (Javier 2017). This has very important implications to forest managers, home buyers, and communities.

2.5.2 Contingent Valuation Method

Contingent Valuation Method (CVM) utilizes surveys where in which respondents are asked to indicate their willingness to pay (WTP) for a non-market good (Haefele et al. 2016). Bowie (2018) analyzed the recreational value of hiking in New England. They used contingent valuation method, surveying hikers and assessing their WTP for the hiking experience (Bowie 2018). While CVM is often plagued with various biases (selection bias and the idea that consumers are measured on their responses, amongst others), this method is crucial to the discussion of the valuation of non-market goods because it allows survey takers to demonstrate how much a particular resource means to them. Because it examines hypothetical markets, is also the preferred method when there is no observable market, and it is much more flexible than revealed preference methods.

2.5.3 Travel Cost Method

The Travel Cost Method (TCM), like the CVM, seeks to place a value on nonmarket goods such as beaches, parks, forests. However, the TCM uses actual consumption behavior from related recreational markets as its approach to the valuation of nonmarket goods. (Zandi et al. 2018). With the TCM, people's willingness to pay is estimated based on the quantity demanded at different prices (Jala et al. 2015). Zandi et al. (2018) conducted a study that determined the economic evaluation of a forest park in Northern Iran using an individual travel cost method. The consumption variables examined in this case were the common expenses used to make a trip to the park such as food, fuel, park fees, and time (opportunity costs) (Zandi et al. 2018). The study found that increasing the travel costs (living farther away), had a negative correlation with the number of visits (Zandi et al. 2018). As a result, it can be shown that travel costs play a critical role in determining the visitation and value of parks.

Other examples of the TCM include that of Fleming et al. (2007), which estimated the recreational value of Lake McKenzie in Queensland, Australia. The study yielded recreational values of the park ranging from $104.30 to $242.84 per person (Fleming et al. 2007). Iamtrakul et al. (2005) conducted public park valuations using the TCM in the area of Saga City, Japan. This study found that the information gathered from their research could play a significant role in generating information for local governments regarding suitable management plans for parks (Iamtrakul et al. 2005). Furthermore, Carr et al. (2003) valued Coral Reefs using a TCM of the Great Barrier Reef. The study examined domestic and international travel to the Great Barrier Reef in order to estimate the benefit that the area provides to its 2 million visitors each year (Carr et al. 2003). The study found that the domestic value is about 400 Million USD and internationally, it ranges from 700 million USD to 1.6 billion USD depending on distance and time spent (Carr et al. 2003). Once again, the TCM demonstrates its ability to value nonmarket goods, no matter the scale.

2.6 State Park Valuations

The aim of this study is to bridge the data gap that exists on the impact that forest harvest practices have on Washington State Park visitation. Previous park valuation studies, although they differ from the aims of this paper, are extremely important to the context of the study.

Mojica et al. (2015) examine the economic value derived from Washington State Park visitation. Consumer spending amounts to $1.5 billion each year (Mojica et al. 2015). The travel costs to state parks alone (gas, food, fees) amount to an astounding $803 million each year (Mojica et al. 2015). Not only does this benefit the park system, but it benefits the economy as a whole. Each item bought at the grocery store and every gallon of gas purchased at a gas station contributes to the overall well-being of the region's economy. Mojica et al. (2015)is essential literature in the context of my study, but it lacks the spatial and forestry impacts that could ultimately, affect the visitation.

The Statistical Report for the 2015/2016 fiscal year for California State Parks indicates numerous metrics regarding visitation and revenues. California State Parks had a total (camping and day use) of 74,393,798 visitors for the 2015/2016 fiscal year (Trute 2015). This amounted to $110,506,115 in user fees and the California State Park systems total revenue was about $130,644,343 (Trute 2015). These figures demonstrate that state parks can have an essential impact on the economies on the local, regional, and state level. Lastly, Montana State Parks carried out a 2010 economic impact survey of visitors to Montana State Parks. This report found that, based on 1,100 interviews at 27 state parks, that non-resident visitors spent 122.3 million dollars (Generen et al. 2010).

Again, these studies left out the effects that environmental practices could have on the visitation, further indicating the importance for this study.

2.7 Visitor Spending

In order to determine the economic value impacted by timber harvests on Washington State Park Visitation, it is essential to examine literature regarding visitor spending in park and trail settings For example, a recent report showed cyclists spending an average of $75 in Montana recreation sites (Rasker 2018). For national park visits, the average spending estimated by visitor segments indicated average spending of $136.44 per visit in 2017 (Cullinane 2018). More locally, a study estimated that the average spending per party of both mountain bikers and road bikers on the Columbia River Gorge trail system ranged from $43 on a day trip to nearly $600 for an overnight trip (Runyan 2014). These studies indicate both the visitors' willingness to pay for a variety of locations and indicate that visitors are willing to spend money towards recreation no matter the activity or distance. Mojica et al. (2015) studied activity based spending per visit in Washington State Parks. Table 1 shows the amount of spending per day with differing types of activities, gathered from Mojica et al. (2015). The study found that the average spending per visitor was just over $22, or a value of $24.22 in 2020 dollars, and that some visitors will spend up to $80 on a single visit (Mojica et al. 2015). I utilize these results in my assessment of economic benefits of park recreation.

Table 1. Spending Per Trip by Visit Type (Mojica et al. 2015)

	Visits	Percent of Total Visits	Expenditures	Per Visit
TOTAL	35,847,770	100%	$802,498,641	$22.39
Non-Water Related Recreation	35,280,847	98.42%	$785,710,593	$22.27
Local Day	22,488,922	62.73%	$359,089,712	$15.97
Non-Local Day	10,660,230	29.74%	$339,969,751	$31.89
Local Overnight	1,404,133	3.92%	$53,545,519	$38.13
Non-Local Overnight	727,562	2.03%	$33,105,611	$45.50
Water Related Recreation	566,923	1.58%	$16,788,048	$29.61
Water Local Day	362,097	1.01%	$8,266,147	$22.83
Water Non-Local Day	165,794	0.46%	$6,205,706	$37.43
Water Local Overnight	26,069	0.07%	$1,266,541	$48.58
Water Non-Local Overnight	12,963	0.04%	$1,049,654	$80.97

2.8 Determinants of Park Visitation

While the purpose of this study is to estimate the impact that forest harvest practices has on the visitation of Washington State Parks, there are undoubtedly other aspects that determine visitation. This study attempts to control for these other aspects by first identifying (via literature) common determinants of park visitation.

2.8.1 Time (Seasonality and Economic Cycle) Determinants

One of the main determinants of visitation modelled in previous studies is fluctuations in the economic cycle, indicating the need to control for time (Poudyal, Paudel, and Tarrant 2013; Ngure and Chapman 1999). Poudyal, Paudel, and Tarrant (2013) found that recessions were negatively related to national park visitation in the United States. While the scope of this study is much smaller, these results further suggest the need to control for temporal variation. Recessions can increase the unemployment rate and decrease average incomes. Other studies indicate that recessions caused no effect on visitation and in some cases, even increased National Park visitation levels (Loomis and Keske 2012; Davidson 2010). Furthermore, controlling for time will help account for seasonal weather fluctuations. (Hewer, Scott, and Fenech 2016; Scott, Gössling, and De Freitas 2008).

2.8.2 Income Determinants

Income is also important to control for since a trip to a park is costly. In fact, income is often the main constraint and/or perceived constraint measured in accordance to visitation (Green et al. 2009; More and Stevens 2000; Abercrombie et al. 2008). While Abercrombie et al. (2008) found that income had no significant effect on recreation, Green et al. (2009) found that low income populations were more likely to perceive they were constrained from participating in recreation. Additionally, a study by Burkett, Tyrrell, and Virden (2010) found the coefficient for both disposable income and income inequality to be negative, indicating two main factors. The first is that the rising inequality of wages has depressed park visitation and the second is that as per capita income rise, people may replace park visits with other activities previously deemed affordable (Burkett, Tyrrell, and Virden 2010). Income, along with seasonality and cyclicity, varies among studies, but will be included nonetheless in this analysis.

2.8.3 Population Determinants

Population is also essential to account for in this study with the assumption that the greater number of people in an area leads to higher visitation, on average. A study by Xiao et al. (2018) examined the impact of special accessibility and perceived barriers on visitation to the U.S. national park system. One of the main variables analyzed was the population of the United States, specifically nationwide measures of spatial access to National parks related to differing populations of race and ethnicity (Xiao et al. 2018). Additionally, population is often cited as a main part of the boosted demand for outdoor recreation (Cordell 1954; Douglass 1982). Because population is a key component to park visitation, it must be accounted for in this analysis.

2.9 Regression Analysis

The main goal of regression analysis is to construct a model which describes the relationship between two variables (Seber 2003). In the case for this study, I am examining the relationship between forest harvest practices and Washington State Park visitation. Regression analysis will allow me to determine if there is a significant correlation between the two. Although the data gap exists for regression analysis involving forest practices and state parks visitation, there is still valuable literature containing environmental regression analysis. Therefore, the literature discussed in this section is simply an example of regression analysis used in environmental settings.

Chhetri (2003) found a need for regression analysis in his research titled, "Mapping the Potential of Scenic Views for the Grampians National Park", when he realized that recent literature has given importance to scenic evaluations of natural landscapes (Chhetri 2003). Chhetri developed a spatial method in which he evaluated the predictability of scenic attractiveness of landscapes using GIS and multiple regression analysis. He found that certain areas of the park came out to be more attractive than others (Chhetri 2003). A different example, although still environmental, was published by Gibson (2016) regarding litter pollution in suburban parks. Gibson used linear multiple regression models to estimate the effect that income, home value, and the number of environmental programs in the area have on litter in suburban parks (Gibson 2016). Although her results weren't statistically significant, it can be concluded that regression analysis is an important statistical analysis technique to evaluate connections between variables, even in an environmental context. Lastly, Shelby et al. (2003) estimated the difference between six silviculture treatments using regression analysis. This research began with scenic evaluations obtained at six sites in the McDonald Research forest in Corvallis, Oregon. One of the sites consisted of old-growth Douglas fir trees with no harvest type, while the other five had differing harvest and stand types (Shelby et al. 2003). From 1990 to 2000, a group of students enrolled in a junior-level wildland recreation class were given a questionnaire asking them to judge scenic qualities at each of the six treatment locations. The results of the regressions showed the highest average ratings for the old growth forests and the lowest for the clear-cut site (Shelby et al. 2003).

2.10 Literature Gap

There have been no known studies using linear regression to estimate the economic impact of forest harvest practices on Washington State Park visitation. Having said that, there are many important relevant studies to this research. Table 2 illustrates the main studies used in the upbringing and development of this thesis. The work of Javier (2017) is extremely important for numerous reasons. First, Javier (2017) uses the same forest practices data and has a study area relevant to the area examined in this research. Additionally, although Javier (2017) examines housing prices as a proxy market for forest harvest practices, his study suggests negative impacts of cutting, especially even-aged forest management. This study follows a similar path, but the proxy market in this case is state park visitation rather than home sales, and this paper uses linear regression instead of hedonic modeling. Javier's results therefore only suggest the direction of impact that forest practices can have on markets. Mojica et al. (2015) also presents an extremely relevant study for this research. Their visitor spending values are used for analysis in this research. Their research, however, lacks the impacts of forest management practices and the effect that they can have not only on visitation, but on the recreation economy as well. While their values are essential for this research, my methods differ significantly from theirs. Lastly, Shelby et al. 2003 provided more insightful research by further solidifying negative perceptions with clearcutting and areas with downed trees. The study also indicated that while perceptions are extremely negative (especially for clear-cuts) moments after harvest, these perceptions improve over time (Shelby et al. 2003).

Table 2. Relevant Economic Studies

YEAR	STUDY	STUDY METHOD	IMPACTS
2017	Javier	HPM	Negative
2015	Mojica et al. 2015	Economic Contributions Model	N/A
2003	Shelby et al. 2003	Regression Analysis	Negative, but improving over time

CHAPTER III. GEOGRAPHIC INFORMATION SYSTEMS, STUDY AREA, AND DATA DESCRIPTIONS

This chapter describes the capabilities of a GIS (Geographic Information System), the study area for this research, and the data sets manipulated in my analysis. The first part of this section discusses how a GIS has been used in economic research and how this thesis incorporates GIS. The second section is a description of the study area and explanation as to why this specific area was chosen, along with a portrayal of both the Washington State timber industry as well as the State Parks system. The third and final section describes the data sets used in this thesis.

3.1 GIS and Economics

Natural resource economics has used GIS in numerous ways to examine resources both spatially and analytically. A GIS is computerized information systems that are designed around the use of geographic spatial data or information that is in some way tied to a location (Castle 1993). Unlike most statistical programming programs that economist's use, GIS allows for a spatial component that is essential when dealing with natural resource economics. GIS also allows for presentation mapping, the organization of large databases, and complex spatial techniques and analysis (Castle 1993). Most literature regrading GIS use and natural resource economics involves the use of hedonic modelling (Sander et al. 2010; Geoghegan et al. 1997; Cavailhes et al. 2009). For example, Noor et al. (2014) cites GIS as a main component of their research which estimates the value of green space in housing areas in Malaysia. Ready and Abdalla

(2005) estimate the positive and negative externalities from farmland and farming using hedonic pricing models and GIS.

3.1.1 Buffer Analysis

Determining the buffer zones that best capture the impact of timber harvests is very important. While there are no known studies that place GIS buffers around state parks and use them in accordance with forest practices, Hamstead et al. (2018) designated “residents” as those whose geocoded homes are within 1 mile of the city’s boundary in which the park is present. Additionally, buffering is often used in hedonic studies (Hjerpe, Kim, and Dunn 2016; Javier 2017). Hjerpe, Kim, and Dunn (2016) buffered each transacted property in their hedonic study with two buffering distances; one at 100 m and another at 500 m. On the other hand, Javier (2017) buffered the home sales in his study at distances of .5km, 1km, and 1.5km. Since my study deals with buffering parks of differing sizes that have a much greater area than a home, using a larger buffer zone than most hedonic studies is required. The challenge is to correctly implement buffer sizes that are not too small or too large. A buffer too small may not capture all of the necessary timber harvests and could be too small of a sample. Conversely, a buffer that is too large can cause a number of issues. One issue stems from the sheer ability of computing power within ArcGIS, Excel, and R. Another issue is that a buffer too large may take into account harvests that are not even within a viewing distance of visitors. One aspect that previous studies contained that is implemented into this analysis is the increase of buffer sizes to measure differences in harvest distance and visitation.

3.2 Study Area

The study area for this analysis is Washington State in its entirety, as my research will focus on timber cuts made in and around all of the Washington State Park boundaries. As a result, the culture, climate, cost, and overall experience of visiting a Washington State park will vary depending on the location in which you attend. Likewise, the amount of timber harvests and forest cover in the area may be drastically different. This section focuses in on relevant literature regarding the demographic and geological environments of Washington State Parks.

3.3 Brief Climate Introduction

The climate in the State of Washington varies greatly. The state experiences large amounts of precipitation each year and the geographic climate zones range from coastal rain forests to glaciated mountain ranges to arid scrublands (Salathé Jr et al. 2010). As a result, one Washington State Park may look quite different than another not only in terms of weather patterns, but in land cover as well. In terms of climate, generally speaking, areas west of the Cascades experience a mild, rainy climate for most of the year while areas east are characterized by cold winters, hot summers, and sparse rainfall (Washington 2012).

3.4 Washington State Park System and Visitation

According to the Washington State Park Website, there are 142 listed park sites. Because of the vast number of parks, the Washington State Park system divides their parks into 13 regions. Figure 3 shows the distribution of these regions.

Figure 3. Washington State Park Regions (parks.state.wa)

The majority of Washington State Parks are on the west side of the Cascades, with a large number in close proximity to the Puget Sound. According to the annual visitation report, Deception Pass State Park had the highest amount of visitation in 2018, with over 3 million visitors. Deception Pass State Park is located in Oak Harbor, Washington and falls into the Northwest Park Region. The park is located on two islands, Fidalgo to the north and Whidbey to the south, and is connected with a bridge that is heavily trafficked by visitors (Deception 2019). There is also a great concentration of park visitors on the Washington Coast, indicating visitors' willingness to travel to park sites. On the other side of the state, there are heavily trafficked areas as well. For example, Riverside State Park, located in Spokane, Washington has recorded around 4.5 million visitors from 2014-2018. This area is popular in the summer and winter, and boasts some of the best fishing, boating, snowshoeing, and snowmobiling east of the cascades (Riverside 2019). All in all, Washington State Parks can be heavily trafficked no matter the location or travel distance.

3.5 Washington's Timber Industry

The forests of Washington State are key ecological and economic resources. There are approximately 16.2 million acres classified as timberland in the state (Washington 2012). The two main types of timber harvests in Washington involve the Douglas-fir and Western Hemlock (Watts 2017). Forest lands differ in Western Washington and Eastern Washington. For example, 66 percent of forest that is older than 160 years is found in the western part of the state (Campbell et al. 2007). At the same time, forest lands in Western Washington are more productive than forest lands in Eastern Washington, producing two to four times the timber volume per acre (Washington's Forests). However, timber harvests are evident throughout the entire state. The top three timber producing counties are all located in South Western Washington. They include Lewis County, which accounts for 13% of timber harvest statewide, Grays Harbor County (11%), and Cowlitz County (10%) (Watts 2017). Figure 5 below shows the data used in this study regarding timber harvests (uneven and even-aged). This map was produced in a GIS and uses the forest practices application data from the WADNR along with county data. As Figure 4 illustrates, Lewis County has a large production of timber each year. Nonetheless, it can be shown that almost every county in Washington engaged in some sort of timber harvest.

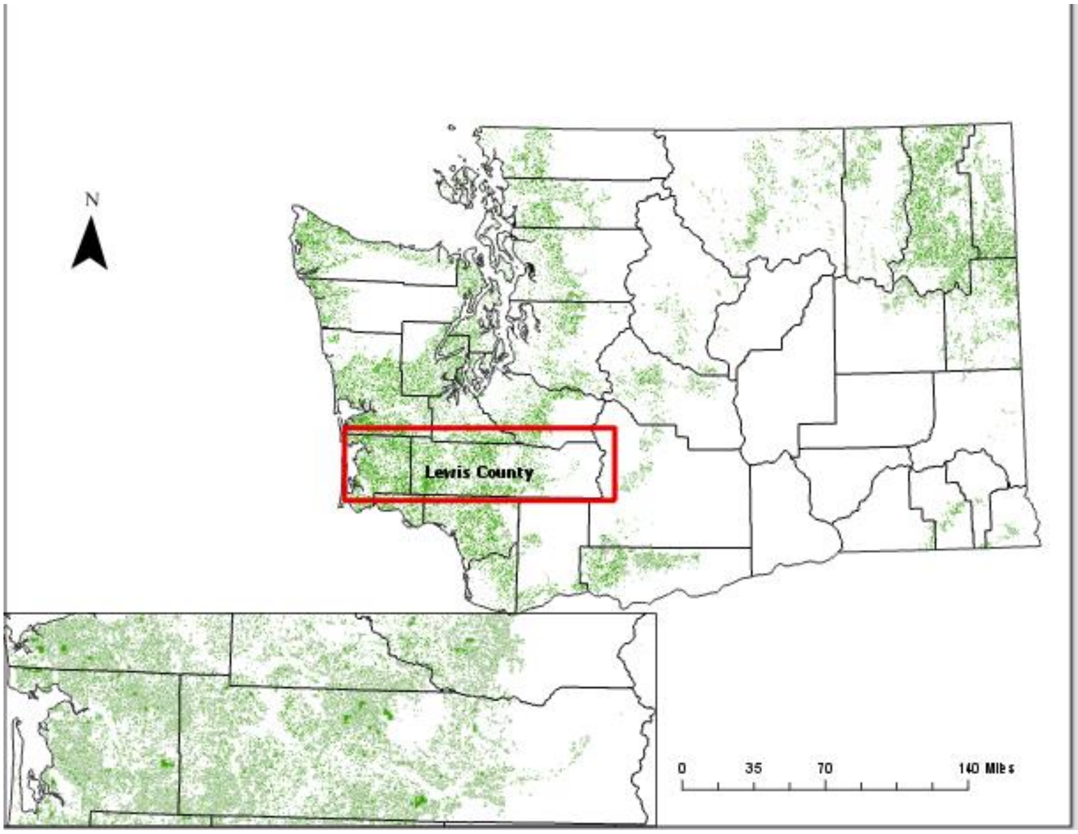

Figure 4. Uneven and Even-Aged Cutting Methods Mapped with County Data (GIS)

3.6 Population Growth in Washington State

Washington State has about 7.4 million people currently residing within its boundaries (OFM 2017). In fact, in the time period between 2010 and 2040, the population is expected to grow by about 2.5 million people, reaching over 9 million in 2040 (OFM 2017). Table 3 shows the total population in 2000, 2010, and 2018 from the U.S. Census, accompanied by the respective percentage change. As population increases, the visitation to our Washington State Parks and the use of key timber resources will be affected. This can have huge implications for forest and park managers regarding the appropriate forestry techniques as well as park management efforts. Population growth may lead to exceeding capacity of some recreation areas and result in user conflicts (Recreation 2015). This in return could diminish the visitation of parks due to overcrowding and the overuse of park resources such as fishing, hiking trials, boating, etc.

Table 3. Washington State Population by County in Census Year 2000, 2010, 2018 (OFM 2018)

County	2000	2000-2010 (%)	2010	2010-2018 (%)	2018
Adams	16458	13.79%	18728	5.51%	19759
Asotin	20546	5.24%	21623	4.56%	22610
Benton	143131	22.39%	175177	15.24%	201877
Chelan	66648	8.71%	72453	6.33%	77036
Clallam	64269	11.10%	71404	7.47%	76737
Clark	347208	22.51%	425363	13.28%	481857
Columbia	4069	0.22%	4078	-0.47%	4059
Cowlitz	92984	10.14%	102410	6.42%	108987
Douglas	32674	17.62%	38431	11.65%	42907
Ferry	7276	3.78%	7551	1.30%	7649
Franklin	49565	57.70%	78163	20.71%	94347
Garfield	2383	-4.91%	2266	-0.84%	2247
Grant	74918	18.96%	89120	9.21%	97331
Grays Harbor	67075	8.53%	72797	1.52%	73901
Island	71886	9.21%	78506	7.58%	84460
Jefferson	26414	13.09%	29872	6.22%	31729
King	1739009	11.05%	1931249	15.63%	2233163
Kitsap	232720	7.91%	251133	7.44%	269805
Kittitas	33537	22.00%	40915	15.76%	47364
Klickitat	19204	5.80%	20318	8.81%	22107
Lewis	68596	10.00%	75455	5.50%	79604
Lincoln	10143	4.21%	10570	1.61%	10740
Mason	49631	22.30%	60699	7.92%	65507
Okanogan	39566	3.93%	41120	2.46%	42132
Pacific	20939	-0.09%	20920	5.33%	22036
Pend Oreille	11672	11.39%	13001	4.62%	13602
Pierce	703993	12.96%	795225	12.08%	891299
San Juan	14120	11.68%	15769	8.62%	17128
Skagit	103420	13.04%	116901	9.67%	128206
Skamania	9895	11.83%	11066	7.75%	11924
Snohomish	609185	17.10%	713335	14.24%	814901
Spokane	418803	12.52%	471221	9.21%	514631
Stevens	40210	8.26%	43531	3.97%	45260
Thurston	208287	21.11%	252264	13.54%	286419
Wahkiakum	3835	3.73%	3978	11.26%	4426
Walla Walla	55178	6.53%	58781	3.64%	60922
Whatcom	167696	19.94%	201140	12.20%	225685
Whitman	40754	9.87%	44776	11.20%	49791
Yakima	222615	9.26%	243231	3.38%	251446

In terms of timber harvests, the rise in population will give greater rise to the amount of resources used. After all, the timber industry produces thousands of different products that meet a variety of human needs (Timber 2007). As this human need increases with population change, so will the need for timber harvest practices.

3.7 Dataset Descriptions

There are three primary datasets used in this study. The first is the permitted forest cuts GIS data from the Washington State Department of Natural Resources (WADNR) titled, "Washington State Forest Practices Application (FPA)". Data will be obtained that begins in the year 1987 and continues through present day. The second dataset incorporated into this study is the Washington State Park visitation data sent from the Washington State Parks and Recreation Commission covering the years 1987-2018. The third and final piece is the State Park boundaries data used in a GIS.

3.7.1 Forest Practices Applications Data from WADNR

The FPA data from the WADNR displays the permitted forest cuts from the years 1987 to present day. The FPA has about 240,000 forest cuts listed for the entire state of Washington, but just under 200,000 when filtered by strictly even-age and uneven-aged methods. The data provides the viewer with a wide variety of information regarding what the harvest entailed. However, not all of the variables are needed for this thesis. The four variables most important for the purpose of this study are the forest harvest type, forest harvest area, application effective date, and application decision. By eliminating other variables from the study, I can focus in on just the variables crucial for the purpose of this research. Also, it is important to note that there are a number of variables listed for forest cutting methods when this thesis is only focusing on the impacts of even-age and uneven-age cutting methods. As a result, I will query (through GIS) the observations so that the FPA data illustrates only uneven and even age cutting methods. A pre-check on the GIS data was conducted to ensure enough even-age and uneven-aged cuts were conducted in park buffer zones. Figures 5 and 6 illustrate the even and uneven-age harvesting areas on the Washington State Forest Practices Applications dataset (see Appendix Figures A1 and A2 and Tables A2-A4 for more statistics).

3.7.2 Washington State Park Visitation Data

The data gathered from the Washington State Parks and Recreation Commission dates back to 1987 and continues up until 2018. This thesis will examine park visitation from 2000 to 2018, to reflect more current forest management practices. The Microsoft Excel data contains a number of variables relating to park visits including the month and year of the visit, the park name, and whether or not the visit was day use or overnight. Within the overnight visitation section is subcategories containing utility, moorage, and ELC (Environmental Learning Center). For this research, the only variables from the visitation data necessary are the month, year, park name, and visitation numbers for total day and total overnight use (sum of utility, other, moorage, and ELC).

State Parks collect visitation at all parks and properties that meet the definition as an operational area. An operational area is one that is open for regular use by the visiting public at any level of development and has regular visits by agency staff during times of peak visitation. The primary way for recording visitation is through vehicle counts. These counters are places to focus on counting vehicles entering day use areas, and these counts are therefore attributed as day use visitors. A 3.5 multiplier is added to vehicle counts to obtain the estimated number of day use visitors to our parks. These multipliers were developed many years ago under a survey/visual observation project. These multipliers take into the occasional traffic from busses, passenger vans, and special events that would cause increases not apparent from using exclusively a vehicle counter. In areas where facilities are not appropriate for a vehicle counter, such as marine parks or other small properties, park staff will take estimated counts using visual observation.

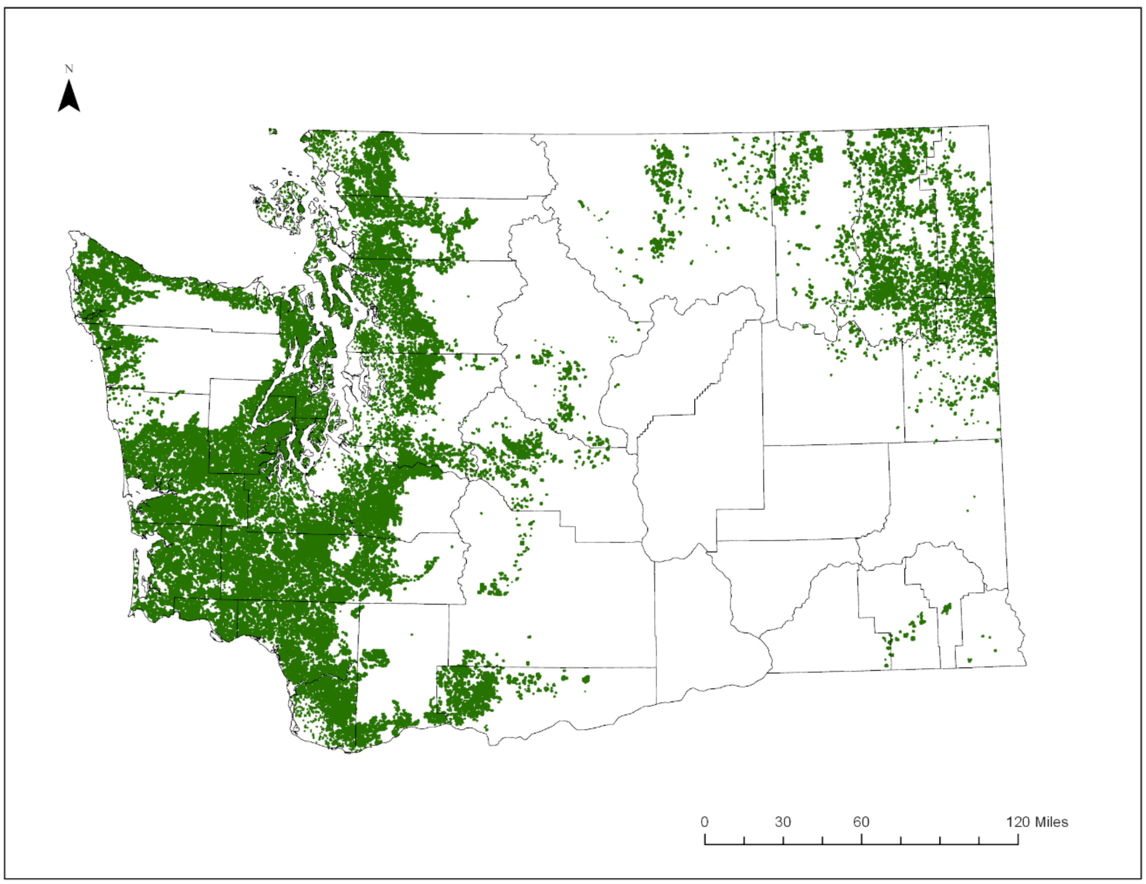

Figure 5. Even-age Washington State Forest Practices Application

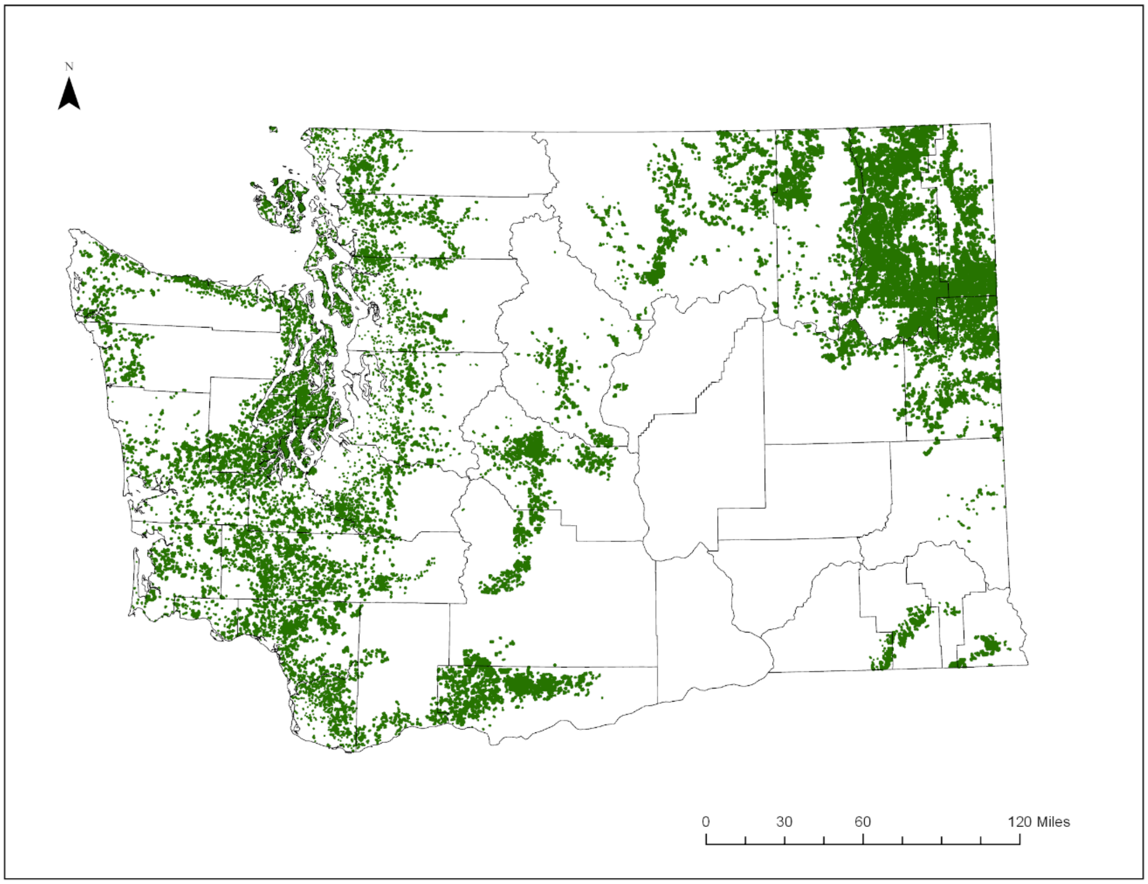

Figure 6. Uneven-age Washington State Forest Practices Application

Overnight accommodations are collected from the Washington State Park central reserve system, this data is for actual paid overnight accommodations and include the people count as provided by the visitor upon registration. It is important to note that of the 95 parks that provide overnight accommodations, 20 use an overnight multiplier (dictated by month) instead of the central reserve system. While this is only about 20% of the total, it is still important to include.

Park Closures are another aspect that must be considered for this study. These closures will appear as “0” for respective months and thus cannot be included in this study. After all, visitors cannot be affected by harvests if they do not have the chance to visit the park in the first place. Park closures can occur for several reasons. The most common reason happens annually for the winter season. Closures generally begin in mid to late October (depending on park) and end sometime in March or April. Figure 7 illustrates the annual visitation amounts of Washington State Parks in 2018 broken up into 200,000 visitor bins. As you can see, most parks have visitation under 200,000 annually, but there are few that surpass this range (see Appendix Table A1 for more visitation statistics).

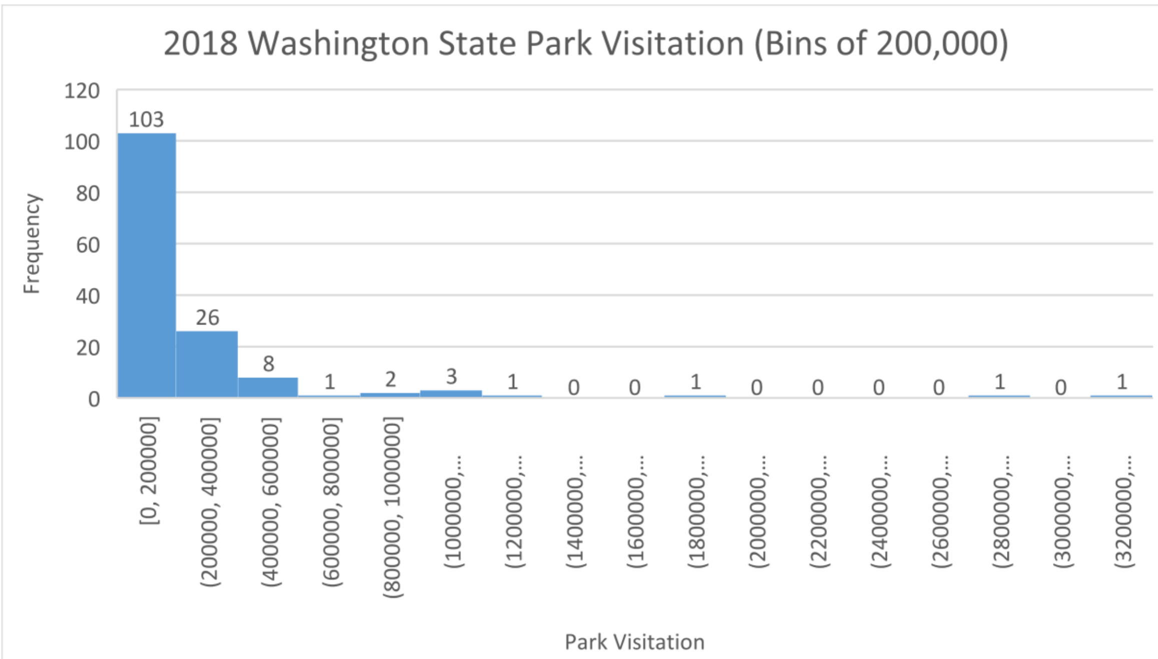

Figure 7. Annual Washington State Park Visitation in 2018

3.7.3 State Park Shapefile Data

The State Park boundaries data is gathered from the Washington Geospatial Open Data Portal. This vector data depicts the current boundaries for Washington State Parks and properties owned by the Washington State Parks and Recreation Commission. The data consists of 213 records and is available via spreadsheet, KML, Shapefile, and File Geodatabase. For the purpose of this project it will be downloaded as a shapefile. It is important to note this data represents only the approximate relative location of property boundaries. Figure 8 portrays these shapefiles on a Washington State County map.

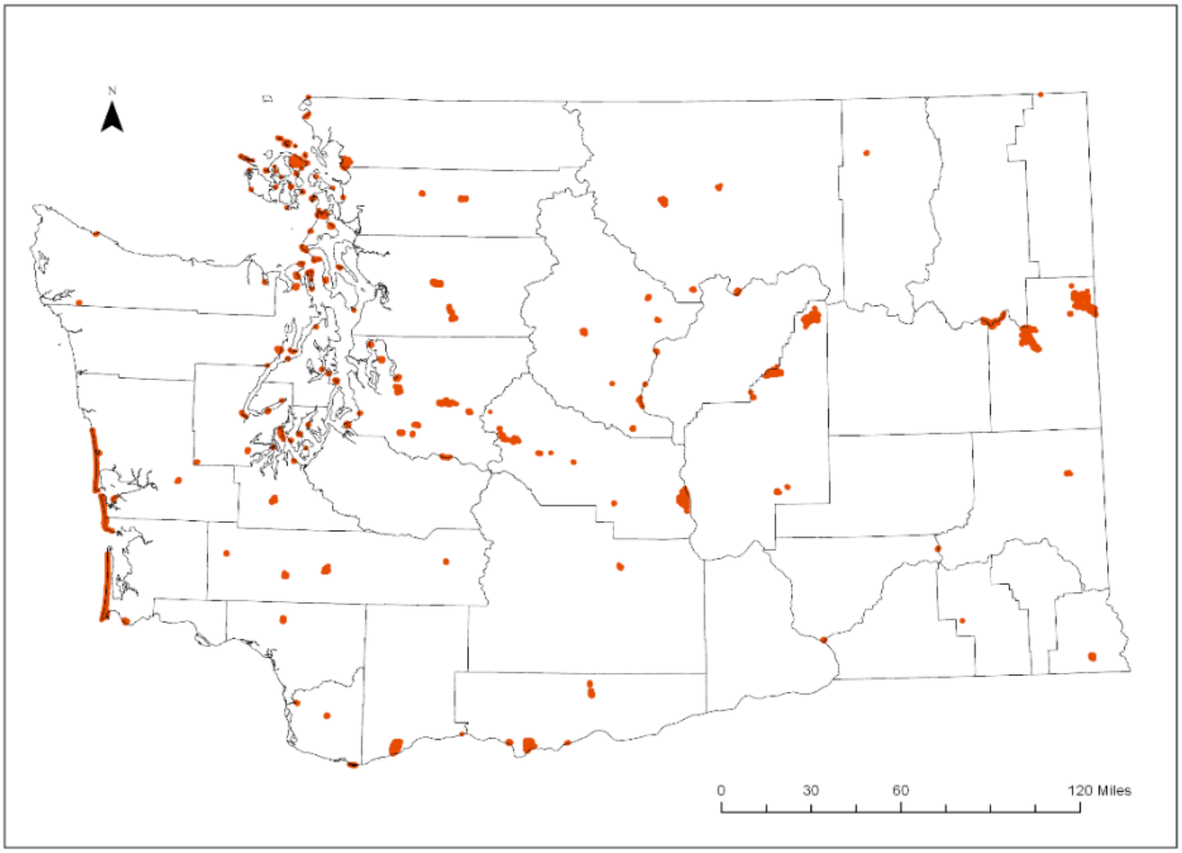

Figure 8. Washington State Park Shapefile

CHAPTER IV. METHODS

This section outlines the methods executed in order to arrive at results that forest and park managers can use for a more sustainable Washington State Park system. After all, the goal of this research is to empirically evaluate the impacts that even-age and uneven-age forest practices have on the visitation of Washington State Parks, while controlling to the best of my ability other determinants for park visitation. The first part of this section details how a GIS is used for this research, including relevant charts and maps. The second part of this section begins discussing the cleaning and data preparation needed, this includes the description of all components of the model. The last part dives into the techniques and how impacts are estimated in this study (see Appendix Figure A3 for a statistical workflow).

4.1 GIS Methods

In order to be able to measure the impacts that forest practices have on the visitation of Washington State Parks, two data layers must be overlaid in a GIS (Esri's ArcGIS Pro); one representing the Washington State Parks and the other representing the forest cuts. The first step in overlaying the data is to add both the forest practices application data and the state park boundaries shape file data layer to a blank GIS map. Because this thesis is only examining even and uneven-age cutting methods, a definition query was used to modify the FPA data such that only even-age and uneven-age cuts could be seen and/or analyzed. Figure 10 shows the query used to portray just those forest practices that are classified as uneven and even-age.

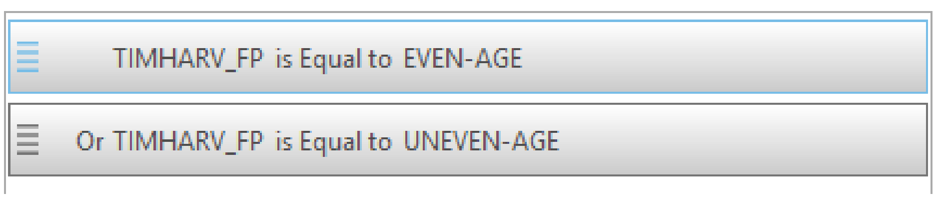

Figure 9. Definition Query in ArcGIS Pro

The same process was implemented for the State Park shape file data, as the "category" of this data was queried to equal "Park" rather than other land use such as museums, golf sites, and water access areas. Once both sets of data were filtered, the next step in the process is to use the buffer tool to draw buffers of 0.5, 1.0, and 1.5 mile(s) around each state park. As a result, each state park would have three separate buffers. Figure

10 shows an example of a Washington State Park with all three buffers drawn around it. The green shaded polygon under the text “Forest Harvest” indicates a forest cut that has occurred within the buffer zones drawn in the previous step. This particular forest harvest is completely within the 1.5 mile buffer, partially in the 1 mile buffer, and not at all within the .5 mile buffer. Figure 10 also shows numerous cuts completely out of range to these buffer parameters, and as a result, they are not a part of the analysis for this thesis.

Once all the buffers have been produced, the intersect tool was used to combine the attribute of each forest cut to the state park to produce the amount of area and the percentage that the forest cut had within each buffer zone. Figure 11 shows Squilchuck State Park with the intersect tool run. As you can see, only forest practices within the buffer zones are shown, producing the intersected park and forest harvest information needed for further analysis. The final step in the GIS process is then export the intersected data into comma separated values (csv) to use in Excel in accordance with the actual park visitation data. Figure 12 depicts the workflow with the querying of data all the way through the intersection and exporting of the data to csv files.

4.2 Data Cleaning in Excel

Once the data from GIS was exported into an Excel File, the data needed to be cleaned and made more accessible. Because the Washington State Park Visitation Data and the Washington State Park shapefile data are not from the same source, they often labeled the same park with different names.

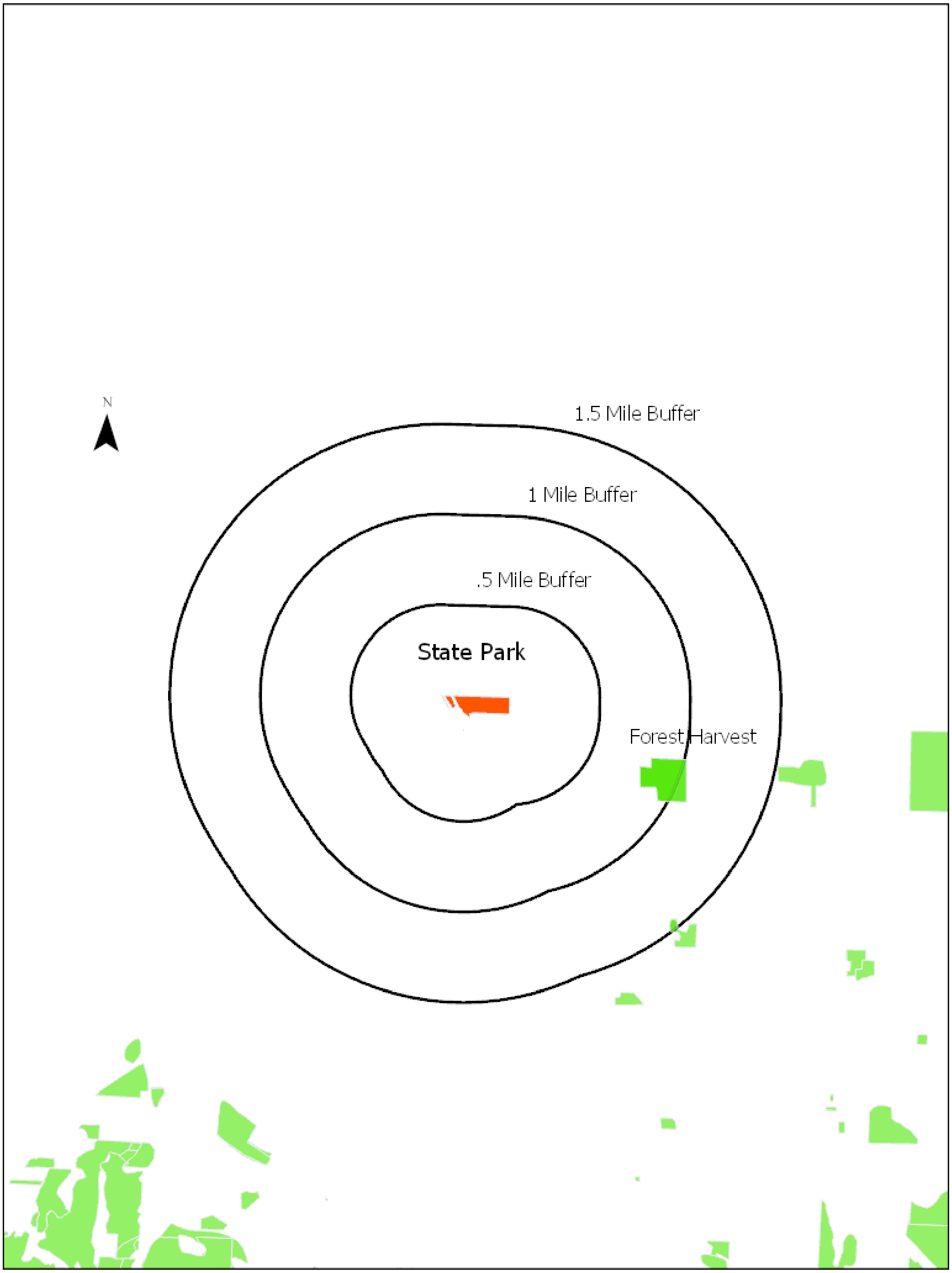

Figure 10. Washington State Park with buffer tool

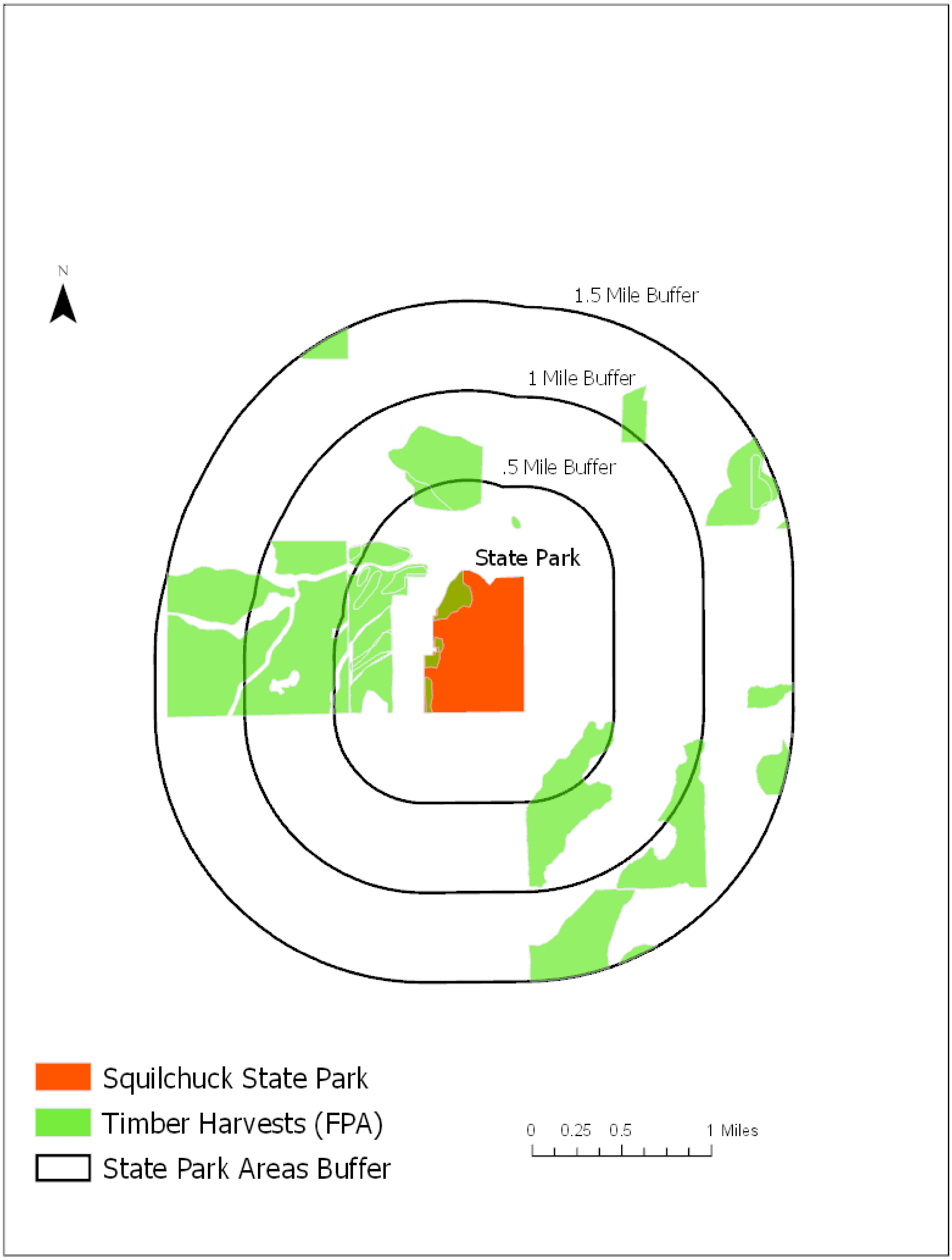

Figure 11. Squilchuck State Park with Buffers and Intersect Tool

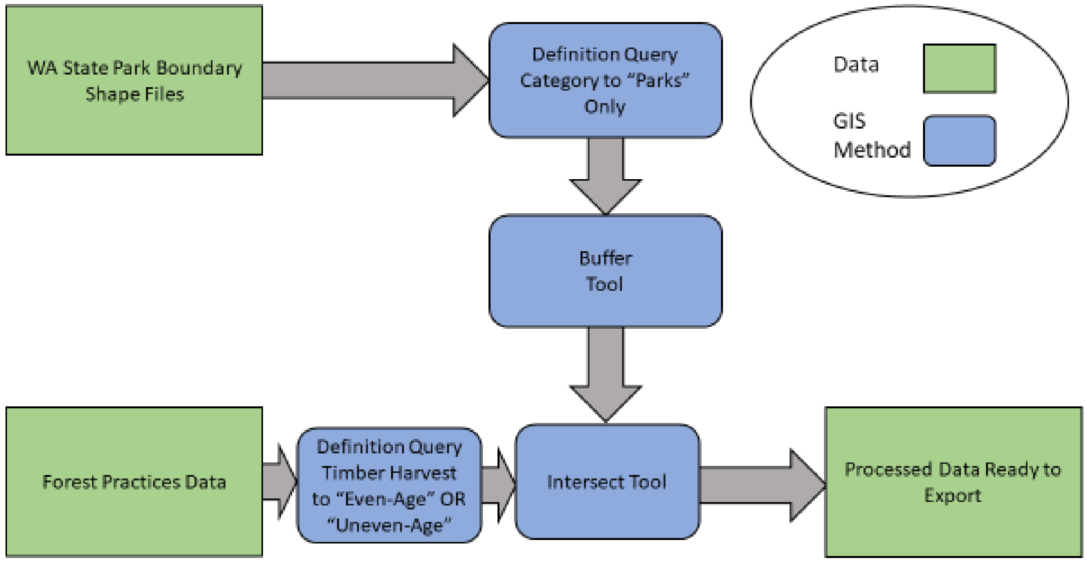

Figure 12. GIS Workflow

For example, while the visitation data may list a park as "Alta Lake", that same park may be labeled "Alta Lake State Park" in the GIS file. While both these sources are labeling the same park, the difference in names can cause the model not to be able to recognize the identical nature of the park. As a result, the find and replace feature in Excel allowed me to find parks with the "State Park" added onto then end of them so that they could be removed. It is also important to note that while the Washington State Parks website lists 142 park sites, the regressions estimated in this thesis only contain 82 parks for the half mile buffer, 91 for the one mile buffer, and 94 for the one and a half mile buffer. The difference between the amount on the website and the amount used in the models can be attributed to a variety of reasons:

1) The State Park is not listed as part of the GIS Shapefile

2) The State Park's visitation was not measured and/or recorded

3) The State Park no longer exists

4) The State Park has no forest practices within the designated buffer zones

4.3 Data Manipulation in R Studio

Once the data was cleaned in Excel, the data was loaded into R Studio, an integrated development environment for R, a programming language for statistical computing and graphics. From this point, the data was aggregated such that the acreage cut for each month and year is summed up, while still having the foresting method accounted for. The data is then merged by park name, and the difference in months between the effective harvesting date and the date of the visit is calculated. From this point, several binary (or dummy) variables are created.

4.3.1 Time-Elapsed Variable

The time elapsed variable is the difference (in months) between the FPA data's expiration date and the date of visitation. Since the purpose of the study is to examine how forest practices have affected park visitation, is it essential to identify how changes in time affect visitors' perceptions of timber harvests. Using the ifelse function in R, I created time bins of 0-1 year, 1-3 years, 3-5 years, and more than 5 years. These time bins were created if the uneven and even acreage cuts were greater than zero and if the difference in month's variable corresponded to the time bin. For example, a difference in months of 16 would fall into the 1-3 years category. The acreage cut in instances where the difference in months was less than 0 (cut occurred after the visit), did not qualify for this analysis.

4.3.2 Percentage Cut Dummy Variable

Another important variable is not only how much was harvested in a given buffer zone, but the percent in which was harvested. After all, state parks differ in size, making their respective buffer zones differ as well. This can especially become a problem when a park of little size has the same sized cut has a park of larger size. Therefore, this dummy variable attempts to control for fluctuations in park and buffer sizes. In order to determine buffer sizes, the Calculate Geometry feature was executed on ArcGIS pro and the associated timber harvests were divided by the total sizes of each buffer.

4.3.3 Time (Year and Month) Factors

As mentioned previously the model used in this study is a fixed effect regression. The two main aspects that are fixed are year and month, thus controlling for the time. This is extremely critical to the study because it is important to control for fluctuations in the business cycle as well as seasonality. These variables will be used in accordance with the as.factor function to encode a vector as a factor.

4.3.4 Income

There is no doubt income plays a major role in visitation, as this metric was previously discussed as a main variable in numerous recreational-based studies. As a result, it must be taken into account in this analysis as well. While income data isn't readily available at the census tract level for the timespan in this study, it is available at the county level. The Washington State Office of Financial Management (OFM) produces estimates of median household income from 1987 to 2017 and has projections for 2018. These estimations rely on the 1990 and 2000 census and are based on past relationships between available socioeconomic data and county-level median household income. With this data, both the Index and Match functions were used in Microsoft Excel to correctly match each county and year's income with the county and year of the park visit.

4.3.5 Population

Population, along with income, has been cited in numerous studies regarding recreational trends and demand (Xiao et al. 2018; Cordell 1954; Douglass 1982). As a result, it will be accounted for in this analysis. The United States Census and its data retrieval product, American Fact Finder, provide Intercensal resident populations for all counties in Washington dating back to the start of the park visitation data, or the year 2000. These estimates, like the income data, were imported into an Excel file where both the Index and Match functions were executed in order to correctly match each county and year's population with each county and year of the park visit.

4.4 Collapsing the Data

With the variables created and the population and income for each county and year matched, the next step in the data manipulation process was to collapse the data by park, month, and year using the group_by and summarize functions in R. Up to this point, the data is in a format in which every aggregated forest cut is repeated in order to match every single park's monthly visitation number. While this is what the data merging was intended to do, the fixed effect models cannot be run under this format. The group_by function in r groups a data frame based on certain frames, in this case, the park, month, and the year of the visitation data. From this point, the variables are outputted using the summarise function. The acreage cut time bins were summed and the population, income, and park visitation were averaged. In this way, the park, month, and year are listed only once, and each cut, population, income, and visitation are matched to the correct location.

4.5 Technique

With the data collapsed, numerous fixed effect regression models could be run. In total, six models are estimated in this paper. The six models are functionally the same, but differ in terms of buffer sizes and the number and harvesting method of the time bins. $TotalVisits_{\iota\tau}$ is the log of total visitation of park ι at time (month, year) τ. The visitation was logged to take into account the heteroscedasticity (high variability) of the visitation data. β_0 is the intercept or constant. $B_{month,buffer}$ is a vector of regression coefficients within a particular month range for a particular buffer. $X_{i\tau,month,buffer}$ is a matrix of observations of aggregated cuts for park *i* at time τ within a particular month range for a particular buffer. Columns correspond to park *i*; row correspond to time τ. β_2 and β_3 are the estimated coefficients for the logged income and population, respectively. υ_ι represents the dummy variable for each park. This will control for differing park characteristics such as bodies of water, trails, accessibility, and overall amenities. Whiting et al (2017) uses this same approach in their study regarding an outdoor recreation motivation and site preferences case study of Georgia State Parks. Each park is accounted for using the as.factor function in R as stated previously. ϕ_τ is the fixed effect controlling for time, including both the year and month of the visit.

Similarly, this is also represented using the as.factor function in R. Lastly, $\varepsilon_{\iota\tau}$ represents the individual error term.

$$lnTotalVisits_{i\tau} = \beta_0 + \sum_{buffer} \sum_{month\,range} \mathrm{B}_{month,buffer}\, \mathrm{X}_{i\tau,month,buffer} + \beta_2 lnIncome_{it} + \beta_3 lnPopulation_{it} + \upsilon_i + \phi_\tau + \varepsilon_{i\tau}$$

month range = {One to twelve months, thirteen to thirty-six, thirty-seven to sixty, over sixty}
buffer = {0.5 miles, 1.0 miles, 1.5 miles}

$$\iota = Park \qquad \tau = Time$$

4.6 Estimating the Impact

The coefficient on β_1 will be evaluated for all cutting time bins and harvesting methods. It will also be evaluated for its statistical significance. Statistical significance is the determination that results in the data are not explainable by chance alone. Statistically significant results are shown with asterisks for p-values of less than 0.1, 0.05 and 0.01. A negative coefficient indicates that each additional acre cut causes a β_1 percent negative impact on monthly visitation due to the logged nature of total visitation. This coefficient will be then multiplied by the median monthly visitation for each buffering distance and the resulting number is the amount of visitation affected on a monthly basis. Lastly, this number is multiplied by the 2020 inflation adjusted dollar amount calculated by Mojica et al. (2015) in their economic analysis of outdoor recreation at Washington State Parks, a value of $24.22.

CHAPTER V. RESULTS

5.1 Results

Table 4 shows the results for equations 1 and 2, Table 5 shows the results for equations 3 and 4, and Table 6 shows the results for equations 5 and 6. All equations show results for each buffering methods individually, with the even and uneven age cuts run separately. It is important to note, however, that all of these regression equations contain more variables than what is listed in this results section (park, month, and year).

5.1.1 Equations 1 and 2

Table 4 illustrates impacts from a buffering distance of 0.5 miles. The results illustrate the output of two separately estimated equations, one with even-age cutting methods only and the other with uneven-age cutting methods only. Both methods saw only significant results associated with only negative coefficients, but negative impacts were more prevalent with uneven-age cutting methods.

Equation 1, or the impact of even-age cutting at the 0.5 mile buffer, saw both positive and negative impacts. Negative impacts were present on two of the four time periods. The first negative impact occurred immediately post-harvest, but these impacts were not statistically significant. The other negative coefficient was statistically significant and occurred on the time bin of even age more than 5 years, with a decrease in monthly economic value of roughly $84.06 per acre cut.

For equation 2, or the impact of uneven-age harvesting methods in a buffering distance of 0.5 miles, we can see all negative impacts, with two out of four time bins containing statistical significance. These time bins, and their respective estimated economic losses per acre cut are 1 year or less ($-115.72) and 1 to 3 years ($-179.55).

These large negative impacts are significant at the 99.9% confidence level.

Table 4. Impact of Timber Activity within 0.5 Mile Buffer

Impact of Timber Activity within 0.5 Miles (Even and Uneven, Estimated Separately)

	Dependent variable:	
	Log(Total Visitation)	
	(1)	(2)
EVENonetotwelvemonths	-0.000034	
	(0.000280)	
EVENthirteentothirtysixmonths	0.000201	
	(0.000204)	
EVENthirtyseventosixtymonths	0.000251	
	(0.000194)	
EVENmorethansixtymonths	-0.000324***	
	(0.000052)	
UNEVENonetotwelvemonths		-0.000446***
		(0.000173)
UNEVENthirteentothirtysixmonths		-0.000691***
		(0.000122)
UNEVENthirtyseventosixtymonths		-0.000026
		(0.000118)
UNEVENmorethansixtymonths		-0.000056
		(0.000072)
log(Population)	-0.741394***	-1.061787***
	(0.216705)	(0.215559)
log(Income)	-0.505175***	-0.407890***
	(0.132646)	(0.132077)
Constant	21.051870***	23.460530***
	(2.287213)	(2.284984)
Observations	16,362	16,362
R2	0.761176	0.761284
Adjusted R2	0.759471	0.759580
Residual Std. Error (df = 16245)	0.699117	0.698959
Note:	*p<0.1; **p<0.05; ***p<0.01	

5.1.2 Equations 3 and 4

Table 5 illustrates the impacts of timber activity within 1.0 miles for uneven and even methods, estimated by separate regression equations. The estimated equations indicate all negative coefficients for even-age cutting methods and mostly negative for uneven age. Once again, both methods saw statistical significance only associated with negative coefficients.

Equation 3, or the impact of timber activity within 1.0 miles harvested with even-age practices, saw only negative coefficients. These ranged from -.000073 to -.000377. The significant coefficients on even 1 year or less (-0.000367), even three to five years (-0.000204), and even 5 or more years (-0.000188) saw estimated per acre economic losses of $81.02, $43.89, and $34.18, respectively. Because of the increasing buffer size, it is clear that the number of observations increased compared to the same regressions estimated at the 0.5 mile buffer.

Equation 4, or the impact of timber activity within 1.0 miles harvested with uneven-age practices, saw mostly negative impacts with significance and magnitude tapering off after 1 to 3 years. This regression saw two time bins contain both statistical significance and a negative coefficient. One year or less (-0.000217) and one to three years (-0.000340) had estimated per acre economic losses of $46.67 and $73.07, respectively.

Table 5. Impact of Timber Activity within 1.0 Mile Buffer

Impact of Timber Activity within 1.0 Miles (Even and Uneven, Estimated Separately)

	Dependent variable:	
	Log(Total Visitation)	
	(3)	(4)
EVENonetotwelvemonths	-0.000377**	
	(0.000169)	
EVENthirteentothirtysixmonths	-0.000073	
	(0.000123)	
EVENthirtyseventosixtymonths	-0.000204*	
	(0.000113)	
EVENmorethansixtymonths	-0.000159***	
	(0.000033)	
UNEVENonetotwelvemonths		-0.000217**
		(0.000095)
UNEVENthirteentothirtysixmonths		-0.000340***
		(0.000068)
UNEVENthirtyseventosixtymonths		-0.000030
		(0.000064)
UNEVENmorethansixtymonths		0.000026
		(0.000037)
log(Population)	-0.675457***	-0.929016***
	(0.210648)	(0.209774)
log(Income)	-0.577569***	-0.477919***
	(0.118831)	(0.118282)
Constant	21.004810***	22.693320***
	(2.239362)	(2.237844)
Observations	17,938	17,938
R2	0.828584	0.828940
Adjusted R2	0.827381	0.827740
Residual Std. Error (df = 17812)	0.697358	0.696634
Note:	*p<0.1; **p<0.05; ***p<0.01	

5.1.3 Equations 5 and 6

Table 6 states the regression results for two separately run regressions. Equation 5 portrays the regression results for even-age timber harvest activity within 1.5 miles while Equation 6 shows the regression results for uneven-age timber harvest activity within that same buffer. Along with equations 1 through 4, equations 5 and 6 contain statistical significance only for those coefficients that are negative. Most notably, both harvesting methods show only negative coefficients for this buffer zone.

Equation 5, or the impact of even-aged harvesting in 1.5 mile buffer, saw all negative and statically significant impacts for all time bins. Additionally, the economic impacts of these harvests decrease as the time bins increase. The coefficients range from -0.000405 to -0.000078, with varying amounts of statistical significance. The 1 year or less time bin, significant at the 1% level, saw estimated per acre economic losses of $89.45. One to three years, significant at the 5% level, saw estimated per acre economic losses of $43.87. Additionally, 3 to 5 years, significant at the 5% level, contained per acre losses of $35.31. Finally, more than 5 years, significant at the 1%, had per acre losses of $17.23. Furthermore, the number of observations increased to over 18,300 as the buffer zone increased another 0.5 miles.

Equation 6, the last equation estimated, portrays the impact of uneven-aged harvesting methods in a 1.5 mile buffer of qualifying Washington State Park zones. This equation estimated all time bins having negative coefficients, with one showing statistical significance. Uneven-aged cuts that occurred one to three years after visitation had a negative and statistically significant coefficient of -0.000246, and an estimated per acre economic loss of $-54.38.

Table 6. Impact of Timber Activity within 1.5 Mile Buffer

Impact of Timber Activity within 1.5 Miles (Even and Uneven, Estimated Separately)

	Dependent variable:	
	Log(Total Visitation)	
	(5)	(6)
EVENonetotwelvemonths	-0.000405***	
	(0.000118)	
EVENthirteentothirtysixmonths	-0.000198**	
	(0.000086)	
EVENthirtyseventosixtymonths	-0.000160**	
	(0.000079)	
EVENmorethansixtymonths	-0.000078***	
	(0.000022)	
UNEVENonetotwelvemonths		-0.000091
		(0.000066)
UNEVENthirteentothirtysixmonths		-0.000246***
		(0.000048)
UNEVENthirtyseventosixtymonths		-0.000046
		(0.000045)
UNEVENmorethansixtymonths		0.000008
		(0.000022)
log(Population)	-0.753460***	-0.956460***
	(0.210562)	(0.209952)
log(Income)	-0.516331***	-0.432423***
	(0.117588)	(0.116932)
Constant	21.211580***	22.519600***
	(2.236997)	(2.240471)
Observations	18,529	18,529
R2	0.829029	0.829189
Adjusted R2	0.827840	0.828001
Residual Std. Error (df = 18400)	0.699537	0.699210
Note:	*p<0.1; **p<0.05; ***p<0.01	

5.2 Discussion and Conclusion

The results show that, in general, Washington State Park visitation is affected by timber harvesting. This can be shown through both even and uneven-age cutting methods. Additionally, none of the regressions estimated have a statistically significant positive impact associated with either harvesting method. This section outlines each equation with a discussion on impact and validity. It then provides an overall conclusion compiling all of these results.

5.2.1 Equations 1 and 2

Table 7. Equation 1 Economic Impact

Harvesting Method and Time Since Harvest	Economic Impact (Bolded if Significant)
EVENonetotwelvemonths	-$8.72
EVENthirteentothirtysixmonths	$52.25
EVENthirtyseventosixtymonths	$65.23
EVENmorethansixtymonths	**-$84.06**

Table 7 estimated the impact of strictly even-aged harvesting methods at a buffering distance of 0.5 miles. The impacts start off negative post-harvest but begin to jump immediately to positive in 1 to 3 year and 3 to 5 year timespans. While these impacts are not significant, they are meaningful. After 5 years the impacts become negative and significant, with the largest magnitude coming in at -$84.06. While this is also meaningful, it shows that this estimated regression does not contain a significant explanation for the impacts of harvesting on visitation. One reasonable justification for this could be that at this low buffering distance, the impacts of clearcutting (even-age) are not being captured fully. With greater buffering distances comes more observations, so it might be an indication that a good portion of clear-cuts are outside this buffering zone. This can be shown through the other equations in this analysis.

Table 8. Equation 2 Economic Impacts

Harvesting Method and Time Since Harvest	Economic Impact (Bolded if Significant)
UNEVENonetotwelvemonths	**-$115.72**
UNEVENthirteentothirtysixmonths	**-$179.55**
UNEVENthirtyseventosixtymonths	-$6.74
UNEVENmorethansixtymonths	-$14.52

Table 8 shows the impact of strictly uneven-aged harvesting at a state park buffering distance of 0.5 miles. The results show strongly, in this case, that people do not prefer uneven-aged cutting nearby parks. This can be shown through not only all negative impacts, but through the statistical significance and large magnitude of the first two time bins.

5.2.2 Equations 3 and 4

Table 9. Equation 3 Economic Impact

Harvesting Method and Time Since Harvest	Economic Impact (Bolded if Significant)
EVENonetotwelvemonths	**-$81.02**
EVENthirteentothirtysixmonths	-$15.80
EVENthirtyseventosixtymonths	**-$43.90**
EVENmorethansixtymonths	**-$34.18**

Table 9 shows the impacts of even-aged harvesting at a state park buffering distance of 1.0 miles. The results show, strongly, that people prefer not to visit parks near clear-cutting sites. This can be demonstrated especially through the -$81.02 that is impacted within one year of the harvest. Additionally, all values are now negative, strongly contradicting equation (1) and indicating the buffering size plays a role in not only the number of observations, but the role of harvesting impacts.

Table 10 illustrates the economic impacts of uneven-aged harvesting at a buffering distance of 1.0 miles. Once again, we can see the first two time periods as significant and negative, with large magnitudes compared to the other time periods. The results also show that as the time post-harvest continues, the closer the impact gets to zero.

Table 10. Equation 4 Economic Impact

Harvesting Method and Time Since Harvest	Economic Impact (Bolded if Significant)
UNEVENonetotwelvemonths	**-$46.67**
UNEVENthirteentothirtysixmonths	**-$73.07**
UNEVENthirtyseventosixtymonths	-$6.40
UNEVENmorethansixtymonths	$5.64

5.2.3 Equations 5 and 6

Table 11. Equation 5 Economic Impact

Harvesting Method and Time Since Harvest	Economic Impact (Bolded if Significant)
EVENonetotwelvemonths	**-$89.45**
EVENthirteentothirtysixmonths	**-$43.87**
EVENthirtyseventosixtymonths	**-$35.31**
EVENmorethansixtymonths	**-$17.23**

Table 11 shows the impacts that even-aged harvesting methods have at a Washington State Park buffering distance of 1.5 miles. These results build upon the significance of equation 3 and illustrate the negative and significant nature across all time variables. These results are also consistent with Shelby et al. (2003) and Javier (2017), in which even-aged impacts have a diminishing effect over time. This is shown in Equation 5, which begins with one year or less post-harvest having an estimated per acre loss of $89.45 and diminishes all the way to $17.23 as time elapses to five or more years post-harvest. This is critical to this analysis and indicates that buffering size plays a major role in economic impacts and magnitudes.

Lastly, Table 12 illustrates the impacts that uneven-aged harvesting has on visitation at a buffering distance of 1.5 miles. Consistent with even-aged harvesting at the same buffering distance, all coefficients are negative. However, in this case only one is significant. In fact, visiting a state park one to three years post uneven-aged harvesting is significant and negative across all buffering methods. This equation also illustrates a diminishing effect as time elapsed past one to three years.

Table 12. Equation 6 Economic Impact

Harvesting Method and Time Since Harvest	Economic Impact (Bolded if Significant)
UNEVENonetotwelvemonths	-$20.07
UNEVENthirteentothirtysixmonths	**-$54.38**
UNEVENthirtyseventosixtymonths	-$10.08
UNEVENmorethansixtymonths	$1.66

5.2.4 Conclusion

Once again, these results show broadly that people do not like visiting Washington State Parks post-harvest. This can be demonstrated by persistently negative and statistically significant impacts shown for both harvesting methods. For uneven-aged harvesting, negative impacts were higher in magnitude at shorter buffer distances. Nonetheless, there were constantly significant and negative impacts shown for all buffering methods. In particular, visitation one to three years post uneven-aged harvesting was constantly impacted, with estimated per acre losses ranging from $179.55 to $54.38.

On the other hand, even-aged harvesting showed greater magnitude negative and statistically significant impacts as buffering distance increased. Equation 1, or the

0.5 mile buffer, saw one significant result, 1.0 mile buffer saw two significant results, and 1.5 mile buffer saw all four significant results. While significance is important, the increase in buffer sizes also brought forth more negative impacts. While the 0.5 mile buffer size only indicated two negative impacts, the other two buffer sizes contained only negative impacts.

I believe that these negative impacts have a few explanations. First, it can be shown through literature that forest harvesting is unaesthetic (Javier 2017; Poudyal et al. 2010; Shelby et al. 2003; Ribe and Matteson 2002; Bliss 2000). As a result, there is no surprise that this analysis follows suit. Additionally, harvesting is not a fast endeavor, the permit cutting time was around two years (Javier 2017). This extended period of time can put a damper on motivation to visit. All in all, these factors provide potential explanations for the consistently negative impacts on visitation.

5.3 Fitted Values

This section inputs the values set forth by the regression results to illustrate the fitted values for two parks, one with primarily uneven-age harvests and the other with primarily even-age harvests. These parks were chosen due their representativeness of the "average" park, as well as their location and evident harvest method presence. While actual visitation and harvesting amounts are examined for this section, these values are still rough estimates of economic impacts.

The first park examined is Lake Chelan State Park (Figure 13). Lake Chelan State Park is located in Chelan, Washington and offers an array of water activities as well as great opportunities for camping. The park has a median monthly visitation of 6,331 and has a strong presence of uneven age harvests. The average uneven-age harvesting area is about 15 acres.

Figure 13. Lake Chelan State Park (www.parks.state.wa.us)

Using the regression results for the one mile buffer, the economic impacts are shown below. This was calculated the same way as outlined in the methods section; however, the average acreage cut (15) is included and the median visitation (6,331) for only Lake Chelan was implemented. In Table 13 we can see major economic losses totaling around $500 one year or less post uneven age harvest and almost $800 one to three years post-harvest!

Table 13. Impact of Timber Activity within 1.0 Miles at Lake Chelan State Park

Harvesting Method and Time Since Harvest	Economic Impact of 15 Acres Harvested (Bolded if Significant)
UNEVENonetotwelvemonths	**-$499.34**
UNEVENthirteentothirtysixmonths	**-$781.79**
UNEVENthirtyseventosixtymonths	-$68.52
UNEVENmorethansixtymonths	$60.35

The other park examined is Lake Sylvia State Park, located in Montesano, Washington (Figure 14). The park is located in the hills between Olympia and the

Washington Coast and boasts hiking, camping, fishing, and biking. The park has a median monthly visitation of 13,534 and has a strong presence of even age harvests. The average even-age harvesting area is around 30 acres.

Figure 14. Lake Sylvia State Park (www.graysharbortalk.com)

Using the regression results again for the one mile buffer, the economic impacts are shown in Table 14. Once again, this was calculated in the same way as before, but this time the average acreage cut (30) is included and the median monthly visitation (13,534) for only Lake Sylvia was inputted. Table 14 shows massive economic losses with over $3,700 for zero to one year post even-age harvest, $2000 for one to three years post even-age harvest, and over $1,500 for more than five years post-harvest.

Table 14. Impact of Timber Activity within 1.0 Miles at Lake Sylvia State Park

Harvesting Method and Time Since Harvest	Economic Impact of 30 Acres Harvested (Bolded if Significant)
EVENonetotwelvemonths	**-$3,706.36**
EVENthirteentothirtysixmonths	-$722.59
EVENthirtyseventosixtymonths	**-$2,008.06**
EVENmorethansixtymonths	**-$1,563.57**

CHAPTER VI. POLICY, PROBLEMS, AND FURTHER WORK

6.1 Policy Implications

The Forest Practices Board, an independent state agency, was established by the 1974 Forest Practices Act and the rules it adopts are implemented by the Washington State Department of Natural Resources (Forest Practices Board 2020). The rules adopted by the Forest Practices Board establish standards for timber harvesting, road construction, pre-commercial thinning, and other applications. These rules are under constant review by the Adaptive Management Program (AMP). The Adaptive Management Program was created to "provide science-based recommendations and technical information to assist the Forest Practices Board in determining if and when it is necessary or advisable to adjust rules and guidance" (Adaptive Management 2020). Within the AMP is the Cooperative Monitoring Evaluation and Research Committee (CMER). The purpose of CMER is to "advance the science needed to support adaptive management (Guidelines 2013). The best available science for the AMP "is considered to be relevant science from all credible sources including peer-reviewed government and university research…" (Guidelines 2013).

I believe that this analysis fits right into the scope of the AMP, and more notably the CMER. This study is an evaluation of the harvesting policies set forth by the WADNR and regulated by the AMP. As a result, it deserves serious consideration by these parties. This paper shows statistically significant and negative economic impacts for both WADNR and AMP regulated harvesting methods and lands. While this paper was not assigned by the AMP, CMER, or WADNR, it provides additional and impactful research regarding the evaluation of forest practices.

The results of this analysis illustrate that timber harvests near Washington State Parks have negative aesthetic and economic impacts regardless of time and harvesting method. As a result, the CMER and AMP could use these findings to better manage the location and proximity of harvests to Washington State Park zones. This paper is not suggesting the ceasing of harvesting in Washington State, however. The analysis shows that visitors broadly do not prefer harvests near or inside their parks, building upon other research with similar findings. This research indicates that their may be an optimal harvesting distance from Washington State Parks, one where the benefits of harvests exceed the cost of lost visitation.

6.2 Problems

This analysis uses state park visitation data received from the Washington State Parks and Recreation Commission. In no way, shape, or form, is this data a completely accurate representation of the number of actual visitors. The Washington State Park website, under the Visitation Report section, states that “The visitor counts provided in these documents are derived through methodology and are not representing an exact number. No claims are made to the accuracy of this data or to the suitability of the data for a particular use.” (Visitation Reports 2020). As stated earlier, vehicle count multipliers, set by the agency, are used to determine day use visitors when applicable. Visual counts are also used in marine parks and other small properties, where vehicle counters are not appropriate. The agency member in communication was not able to speak further about the exact details of this multiplier justification, or the method behind visual observations. Also, it is important to note that the collection process for this visitation has improved greatly since 2014. What this means is that the data collection process has not entirely been consistently throughout all the years for this analysis. Furthermore, this analysis subsets months in which total visitation was greater than zero. This is to account for months in which parks are closed. All in all, a more accurate estimation of Washington State Park visitation would be extremely beneficial to this analysis.

This study also uses GIS data obtained from the Washington State Department of Natural Resources and Washington State Geospatial Open Data Portal. Neither of these shapefiles are a completely accurate representation of the exact area cut or the exact zones of Washington State Parks. As a result, key intersections between these variables are not perfect, leaving the ability for under or overestimations. Additionally, the forest practices application data did not include tree types or forest types, a similar problem dealt with by Javier (2017).

Besides the data itself, a number of the problems in this analysis occurred with the data management. The intersection of FPA data and Park zones caused massive datasets, ones that limited the amount of buffering sizes one could analyze. The computing power simply wasn't strong enough to analyze buffering sizes of more than 1.5 miles. This extended buffering is necessary to see how large buffering sizes, such as 5 miles, would impact the results. Additionally, population and income were added to regressions and were the best measure available for demographic information. Census tracts, a far better indicator, are not able to be implemented in this analysis due to their one-to-one relationship with parks. For example, because these census tracts are only available every 10 years, they would not fluctuate over time, meaning that each park was directly correlated with each census tract. Lastly, the collapsing of data left behind unaesthetic datasets, ones in which a value of 0 was very prevalent. This made it extremely hard to identify the correctly cleaned datasets that were ready for regression analysis.

6.3 Further Work

Further studies are essential to improve the understanding that timber harvests have not only on the economy, but on recreation. While this study showed statistically significant and negative impacts for all visitation time periods and harvesting methods, there is information that is needed for further analysis.

Further research should combine both qualitative and quantitative analysis. After all, there are many reasons why people choose to visit parks. Qualitative research such as surveys or interviews may help reveal the preferences of visitors, indicating just how influential harvesting is to visitors. We have seen other studies implementing survey or interview techniques and eliciting preferences on forest management. (Eriksson et al. 2012; Shelby et al. 2003; Kearney and Bradley 2011). A complete study would implement these qualitative tactics in addition to the quantitative methods shown in this analysis. I believe this would give forest managers the complete picture regarding appropriate foresting techniques.

Along with this qualitative and quantitative analysis is the need for viewshed analysis. This has been completed before in previous hedonic papers (Poudyal et al. 2010). This viewshed analysis could add greater detail to the estimates (Javier 2017). In this study, there was no indication that these state park visitors could indeed see the effects of clearcutting or uneven-aged cutting. These affects include downed trees, logging vehicles, debris, etc. A GIS would allow for this analysis, which would truly show which areas of the road or park could see certain harvests. Due to time and computing constraints, this paper did not include this type of analysis. Along with viewsheds, future research should examine impacts in greater time and buffering sizes. For example, with better computing power, a 5-mile buffer that shows impacts after 10 years would allow for a greater sample size and an indication on how long impacts last. While this study did show impacts after 5 years, it is not clear how long these visits occurred after harvests.

Apart from the addition of new data and methodologies, further research should incorporate more geographic areas. While negative impacts were seen with Washington State Parks and timber harvests, this analysis could be repeated in larger areas, different park settings, and numerous states. For example, this same analysis could be used for National Parks all over the United States. Additionally, this analysis could be implemented for other states who have accessible GIS and state park visitation data. Lastly, implementing this research to greater geographical areas would show not only if these impacts are widespread, but if they vary depending on region. All in all, understanding the impact of greater scales and different locations would contribute to the full understanding of the economic impact of forest harvest practices on recreation.

REFERENCES

Abercrombie, Lauren C., James F. Sallis, Terry L. Conway, Lawrence D. Frank, Brian E. Saelens, and James E. Chapman. 2008. "Income and Racial Disparities in Access to Public Parks and Private Recreation Facilities." *American Journal of Preventive Medicine* 34 (1): 9–15. https://doi.org/10.1016/j.amepre.2007.09.030.

"Adaptive Management: WA - DNR." WA. Accessed April 23, 2020. https://www.dnr.wa.gov/programs-and-services/forest-practices/adaptive-management.

Bliss, John C. 2000. "Public Perceptions of Clearcutting." *Journal of Forestry* 98 (12): 4–9. https://doi.org/10.1093/jof/98.12.4.

Bowie, Marina J. 2018. "Using Contingent Valuation to Measure the Economic Impact of Climate Change on Hiker Recreation during New England Peak Foliage The University of New Hampshire Department of Economics Using Contingent Valuation to Meas

Brander, Luke M., and Mark J. Koetse. 2011. "The Value of Urban Open Space: Meta-Analyses of Contingent Valuation and Hedonic Pricing Results." *Journal of Environmental Management* 92 (10): 2763–73. https://doi.org/10.1016/j.jenvman.2011.06.019.

Burkett, John, Tim Tyrrell, and Randy Virden. 2010. "National Park Service Visitation Trends: Exploring the Forces That Influence Visitation." *National Park Service*, no. July. https://doi.org/10.13140/2.1.4833.9848.

Campbell, Sally, Karen Waddell, and Andrew Gray. "Five-Year Forest Inventory and Analysis Report." 2007. Accessed February 7, 2019. https://www.fs.fed.us/pnw/pubs/pnw_gtr800.pdf.

Carr, Liam, and Robert Mendelsohn. "Valuing Coral Reefs: A Travel Cost Analysis of the Great Barrier Reef." AMBIO: A Journal of the Human Environment 32, no. 5 (2003): 353. Accessed January 24, 2019. doi:10.1639/00447447(2003)032[0353:vcratc]2.0.co;2.

Cavailhes, Jean, Mohamed Hilal, Thiery Brossard, Daniel Joly, Francois Tourneux, and Pierre Wavresky. “Landscape Metrics for Determining Landscape Prices,” 2009.

Castle, Gilbert. 1993. *Profiting From a Geographic Information System*.

Chhetri, Prem, and C. Arrowsmith. "Mapping the Potential of Scenic Views for the Grampians National Park." September 2003, 1859-871. Accessed January 23, 2019. doi:10.1080/02508281.2006.11081512.

Cordell, Ken. 1954. “The Latest Trends in Nature-Based Outdoor Recreation.” *Missouri Medicine* 51 (12): 1016–17.

Cullinane Thomas, C., L. Koontz, and E. Cornachione. 2018. 2017 national park visitor spending effects: Economic contributions to local communities, states, and the nation. Natural Resource Report NPS/NRSS/EQD/NRR—2018/1616. National Park Service, Fort Collins, Colorado.

Davidson, L. 2010. “National Park Visits Boom Amid Recession,” 2010.

"Deception Pass State Park." Sustainability | Washington State Parks and Recreation Commission. Accessed February 21, 2019. http://parks.state.wa.us/497/Deception-Pass.

Dey, Daniel C., John C. Brisette, Callie J. Schweitzer, and James M. Guldin. "Silviculture of Forests in the Eastern United State." Cumulative Watershed Effects of Fuel Management in the Eastern United States, July 13, 2012. Accessed January 22, 2019.

Douglass, Robert. 1982. *Forest Recreation*.

Dupler, Douglas. "Logging." In *Environmental Encyclopedia*, 4th ed., 1008-1010. Vol. 2. Detroit, MI: Gale, 2011. *Gale Virtual Reference Library* (accessed January 22, 2019).

Eriksson, Louise, Annika M. Nordlund, Olof Olsson, and Kerstin Westin. 2012. "Recreation in Different Forest Settings: A Scene Preference Study." *Forests* 3 (4): 923–43. https://doi.org/10.3390/f3040923.

Fleming, Christopher M., and Averil Cook. 2008. "The Recreational Value of Lake McKenzie, Fraser Island: An Application of the Travel Cost Method." *Tourism Management* 29 (6): 1197–1205. https://doi.org/10.1016/j.tourman.2008.02.022.

"Forest Practices Board: WA - DNR." WA. Accessed April 23, 2020. https://www.dnr.wa.gov/about/boards-and-councils/forest-practices-board.

Freedman, Bill. "Forestry." In *The Gale Encyclopedia of Science*, 5th ed., edited by K. Lee Lerner and Brenda Wilmoth Lerner, 1826-1830. Vol. 3. Farmington Hills, MI: Gale, 2014. *Gale Virtual Reference Library* (accessed January 22, 2019).

Genderen, Chas Van, Roger Semler, and Sue Dalbey. 2010. "2010 Economic Impact Survey of Visitors to Montana State Parks." Vol. 53. https://doi.org/10.1017/CBO9781107415324.004.

Geoghegan, Jacqueline. 2002. "The Value of Open Spaces in Residential Land Use." *Land Use Policy* 19 (1): 91–98. https://doi.org/10.1016/S0264-8377(01)00040-0.

Gibson, Ilanna. "Predictors of Litter Pollution in Suburban Parks." Master's thesis, University of Connecticut, 2016. Accessed January 23, 2019.

Gorte, Ross W. 1998. *Clearcutting in the national forests: background and overview*. [Washington, D.C.]: [Congressional Research Service, Library of Congress]. http://www.ncseonline.org/NLE/CRSreports/Forests/for-21.cfm?&CFID=8834248&CFTOKEN=4112860

Green, Gary, J Bowker, H Cordell, and Xiongfei Wang. 2009. "An Examination of Perceived Constraints to Outdoor Recreation." *Journal of Park and Recreation Administration* 32 (4): 1–36.

Guidelines for Adaptive Management Program, Guidelines for Adaptive Management Program § (2013). https://www.dnr.wa.gov/publications/fp_board_manual_section22.pdf?y8ttgi.

Haefele, Michelle, and John B. Loomis. "Total Economic Valuation of the National Park Service Lands and Programs: Results of a Survey of the American Public." SSRN Electronic Journal, 2016. Accessed January 23, 2019. doi:10.2139/ssrn.2821124.

Hamstead, Zoé A., Carson Farmer, and Timon Mcphearson. “Landscape-Based Extreme Heat Vulnerability Assessment.” *Journal of Extreme Events* 05, no. 04 (2018): 1850018. https://doi.org/10.1142/s2345737618500185.

"Harvesting Methods." UF-SFRC : 4-H : Common Persimmon. April 21, 2015. Accessed January 10, 2019. http://www.sfrc.ufl.edu/Extension/florida_forestry_information/forest_management/harvesting_methods.html.

Hewer, Micah, Daniel Scott, and Adam Fenech. 2016. “Seasonal Weather Sensitivity, Temperature Thresholds, and Climate Change Impacts for Park Visitation.” *Tourism Geographies* 18 (3): 297–321. https://doi.org/10.1080/14616688.2016.1172662.

Hjerpe, Evan, Yeon Su Kim, and Leah Dunn. 2016. “Forest Density Preferences of Homebuyers in the Wildland-Urban Interface.” *Forest Policy and Economics* 70: 56–66. https://doi.org/10.1016/j.forpol.2016.05.012.

Hoch, Don, Ken Bounds, Patricia Lantz, and Roger Schmitt. 2016. “2014-2019 State Parks Strategic Plan 2014-2019 State Parks Strategic Plan.” Olympia, WA. https://parks.state.wa.us/DocumentCenter/View/7663/2014-19-State-Parks-Strategic-Plan---May-2016-update-PDF.

Iamtrukal, Pawinee, Kardi Teknomo, and Kazunori Hakao. "PUBLIC PARK VALUATION USING TRAVEL COST METHOD." Proceedings of the Eastern Asia Society for Transportation Studies 5 (2005): 1249-264. 2005. Accessed January 24, 2019. doi:10.4337/9781843767152.00015.

Javier, Kaleb. 2017. “The Economic Impacts of Forest Timber Methods in Washington State: A Hedonic Approach.” Master’s thesis, Central Washington University.

Kearney, Anne R., and Gordon A. Bradley. 2011. “The Effects of Viewer Attributes on Preference for Forest Scenes: Contributions of Attitudes, Knowledge, Demographic Factors, and Stakeholder Group Membership.” *Environment and Behavior* 43 (2): 147–81. https://doi.org/10.1177/0013916509353523

Kuuluvainen, Timo, Olli Tahvonen, and Tuomas Aakala. 2012. “Even-Aged and Uneven-Aged Forest Management in Boreal Fennoscandia: A Review.” *Ambio* 41 (7): 720–37. https://doi.org/10.1007/s13280-012-0289-y.

"Logging Workers, All Other." U.S. Bureau of Labor Statistics. March 30, 2018. Accessed March 07, 2019. https://www.bls.gov/oes/current/oes454029.htm#st

Loomis, John, and Catherine Keske. 2012. “Did the Great Recession Reduce Visitor Spending and Willingness to Pay for Nature-Based Recreation? Evidence from 2006 and 2009.” *Contemporary Economic Policy* 30 (2): 238–46. https://doi.org/10.1111/j.1465-7287.2011.00277.x.

Lundmark, Hanna, Torbjörn Josefsson, and Lars Östlund. 2013. “The History of Clear-Cutting in Northern Sweden - Driving Forces and Myths in Boreal Silviculture.” *Forest Ecology and Management* 307: 112–22. https://doi.org/10.1016/j.foreco.2013.07.003.

Mojica, Johnny, Tania Briceno, and Greg Sundler. 2015. “Economic Analysis of Outdoor Recreation at Washington ’ s State Parks.” https://parks.state.wa.us/DocumentCenter/View/5910/State-Parks-Economic-Analysis---Earth-Economics-9-9-15-PDF?bidId.

Morancho, Aurelia Bengochea. 2003. “A Hedonic Valuation of Urban Green Areas.” *Landscape and Urban Planning* 66 (1): 35–41. https://doi.org/10.1016/S0169-2046(03)00093-8.

More, Thomas, and Thomas Stevens. 2000. “Do User Fees Exclude Low-Income People from Resource-Based Recreation?” *Journal of Leisure Research* 32 (3): 341–57. https://doi.org/10.1080/00222216.2000.11949920.

Murray, Sarah, and Peter Nelson. 2005. “How the Public Perceives Forestry (and Why It Matters),” no. November 2004: 1–12.

Ngure, Njoroge, and Duane Chapmen. “Demand for Visitation to U.S. National Park Areas: Entrance Fees and Individual Area Attributes .” cornell.edu. Cornell University, October 1999. http://publications.dyson.cornell.edu/research/researchpdf/wp/1999/Cornell_Dyson_wp9925.pdf.

Noor, Norzailawati Mohd, M.zainora Asmawi, and Alias Abdullah. “Sustainable Urban Regeneration: GIS and Hedonic Pricing Method in Determining the Value of Green Space in Housing Area.” *Procedia - Social and Behavioral Sciences* 170 (2015): 669–79. https://doi.org/10.1016/j.sbspro.2015.01.069.

Palmer, James F. 2008. “The Perceived Scenic Effects of Clearcutting in the White Mountains of New Hampshire, USA.” *Journal of Environmental Management* 89 (3): 167–83. https://doi.org/10.1016/j.jenvman.2007.01.064.

Poudyal, Neelam C., Donald G. Hodges, John Fenderson, and Ward Tarkington. 2010. “Realizing the Economic Value of a Forested Landscape in a Viewshed.” *Southern Journal of Applied Forestry* 34 (2): 72–78. https://watermark.silverchair.com/sjaf0072.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAmQwggJgBgkqhkiG9w0BBwagggJRMIICTQIBADCCAkYGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMOVKtdT3Ku7wCbNcbAgEQgIICF8ikkaF7RMNdY2Vl0I9NYkcXGdDpH1QIqZoSXl1GsrPP5j.

Poudyal, Neelam C., Bamadev Paudel, and Michael A. Tarrant. 2013. “A Time Series Analysis of the Impact of Recession on National Park Visitation in the United States.” *Tourism Management* 35: 181–89. https://doi.org/10.1016/j.tourman.2012.07.001.

Rasker, Ray. "Montana's Outdoor Recreation Economy." Headwaters Economics. December 17, 2018. Accessed March 05, 2019.

Ready, Richard C., and Charles W. Abdalla. “The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model.” *American Journal of Agricultural Economics* 87, no. 2 (2005): 314–26. https://doi.org/10.1111/j.1467-8276.2005.00724.x.

Recreation, Outdoor, and J Fox. 2015. “Washington State Population Trends and Implications For Outdoor Recreation,” no. November 2013.

Rosen, Sherwin. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." The Journal of Political Economy 82, no. 1 (January/February 1974): 34-55.

Ribe, Robert G. 2009. "In-Stand Scenic Beauty of Variable Retention Harvests and Mature Forests in the U.S. Pacific Northwest: The Effects of Basal Area, Density, Retention Pattern and down Wood." *Journal of Environmental Management* 91 (1): 245–60. https://doi.org/10.1016/j.jenvman.2009.08.014.

Ribe, Robert G., and Mollie Y. Matteson. 2002. "Views of Old Forestry and New among Reference Groups in the Pacific Northwest." *Western Journal of Applied Forestry* 17 (4): 173–82. https://doi.org/10.1093/wjaf/17.4.173.

"Riverside State Park." Sustainability | Washington State Parks and Recreation Commission. Accessed February 21, 2019. http://parks.state.wa.us/573/Riverside.

Runyan, Dean. "Columbia River Gorge Bicycle Recreation: Economic Impact Forecast for the Communities Along the Historic Columbia River Highway." Headwaters Economics. 2014. Accessed March 05, 2019.

Salathé, Eric P., L. Ruby Leung, Yun Qian, and Yongxin Zhang. "Regional Climate Model Projections for the State of Washington." Climatic Change102, no. 1-2 (2010): 51-75. doi:10.1007/s10584-010-9849-y.

Sander, Heather, Stephen Polasky, and Robert G. Haight. "The Value of Urban Tree Cover: A Hedonic Property Price Model in Ramsey and Dakota Counties, Minnesota, USA." *Ecological Economics* 69, no. 8 (2010): 1646–56. https://doi.org/10.1016/j.ecolecon.2010.03.011.

Scott, Daniel, Stefan Gössling, and C. R. De Freitas. 2008. “Preferred Climates for Tourism: Case Studies from Canada, New Zealand and Sweden.” *Climate Research* 38 (1): 61–73. https://doi.org/10.3354/cr00774.

Seber, George A. F. Linear Regression Analysis, 2nd Edition. John Wiley & Sons, 2003. Accessed January 23, 2019.

Shelby, Bo, Jonanthan Thompson, Mark Brunson, and Rebecca Johnson. 2003. “Changes in Scenic Quality after Harvest: A Decade of Ratings for Six Silviculture Treatments.” *Journal of Forestry* 101 (2): 30–35.

Taye, Fitalew Agimass. “Valuation of Non-Market Ecosystem Services of Forests: Preferences for Recreation, Effect of Childhood Experience, and the Role of Environmental Attitudes,” 2017.

United States. Bureau of Business and Economic Research. Montana State Parks. 2010 Economic Impact Survey of Visitors to Montana State Parks. By Chas Generen, Roger Semler, and Sue Dalbey. December 2010. Accessed January 24, 2019.

United States. California State Parks. Statistical Report 2015/16 Fiscal Year. By Barry Trute. Accessed January 24, 2019.

“Visitation Reports.” Visitation reports | Washington State Parks and Recreation Commission. Accessed April 23, 2020. https://parks.state.wa.us/1165/Visitation-reports.

"Washington." In *Worldmark Encyclopedia of U.S. and Canadian Environmental Issues*, edited by Susan Bevan Gall and Margaret K. Antone, 483-492. Detroit, MI: Gale, 2012. *Gale Virtual Reference Library* (accessed February 6, 2019).

"Washington's Forests, Timber Supply, and Forest-Related Industries." Accessed February 7, 2019. http://file.dnr.wa.gov/publications/em_fwfeconomiclow1.pdf.

Watts, Andrea, Kristoffer Larson, Bob Redling, Jim Yeager, and Andrea Watts. 2018. "2017 Washington Timber Harvest Report." Olympia, WA. https://www.dnr.wa.gov/publications/em_obe_wa_timber_harvest_2017_final3.pdf?wx099uz.

Wittwer, R F, S Anderson, and D Marcouiller. 2009. "Even and Uneven-Aged Forest Management." http://www.forestry.ok.gov/Websites/forestry/Images/Even and Uneven-Aged Forest Management.pdf.

Xiao, Xiao, Lisa Aultman-Hall, Robert Manning, and Brian Voigt. 2018. "The Impact of Spatial Accessibility and Perceived Barriers on Visitation to the US National Park System." *Journal of Transport Geography* 68 (April): 205–14. https://doi.org/10.1016/j.jtrangeo.2018.03.012.

Zandi, Solmaz, Soleiman Mohammadi Limaei, and Neda Amiri. "An Economic Evaluation of a Forest Park Using the Individual Travel Cost Method (a Case Study of Ghaleh Rudkhan Forest Park in Northern Iran)." Environmental & Socio-economic Studies 6, no. 2 (2018): 48-55. doi:10.2478/environ-2018-0014.

APPENDIXES

Appendix A – Supplemental Tables and Figures

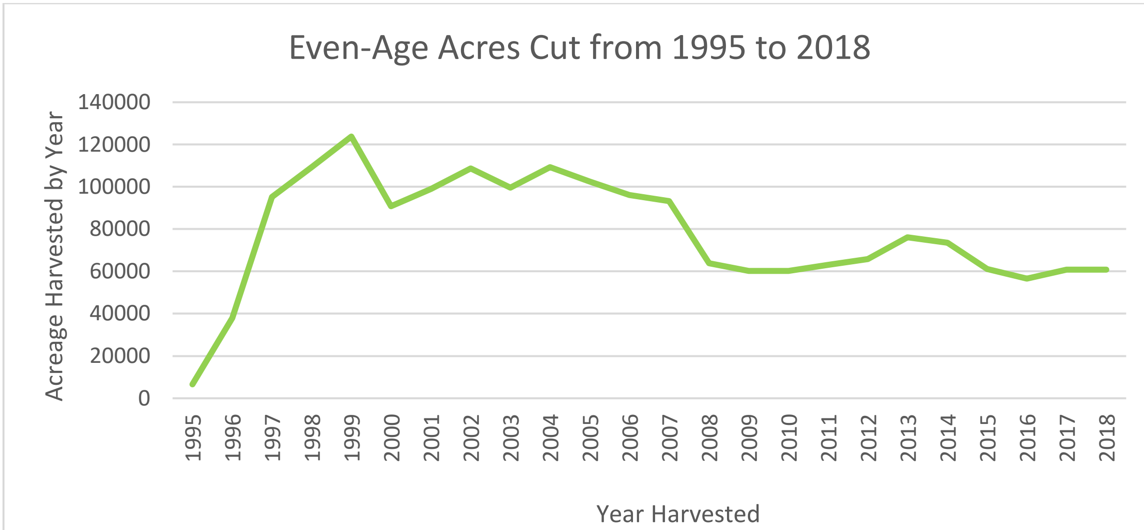

Figure A1. Even-aged Harvests from 1995 to 2018

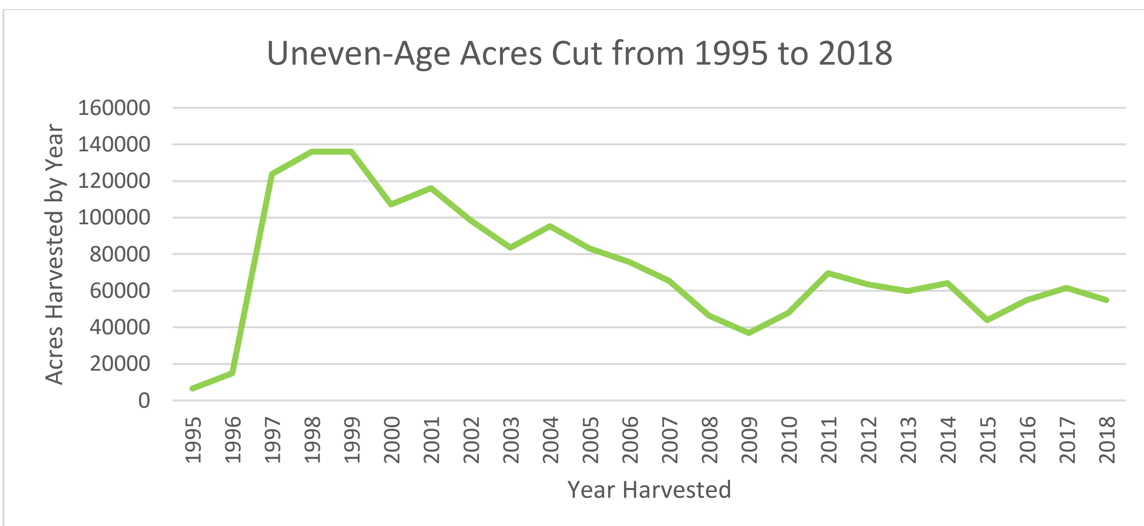

Figure A2. Uneven-aged Harvests from 1995 to 2018

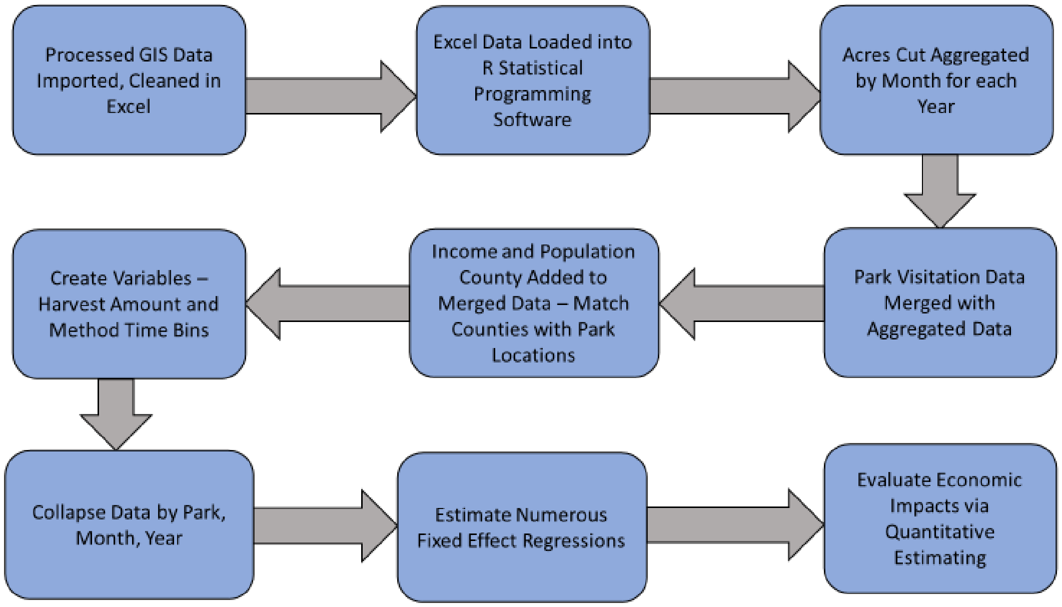

Figure A3. Statistical Workflow

Table A1. Washington State Park Visitation Data Statistics from 2000-2018

Washington State Park Total Visitation (2000-2018)	
Mean	18202
Median	4572
Mode	60
Standard Deviation	41773
Range	855057
Minimum	2
Maximum	855059
Sum	315916910
Count	17356

Table A2. 0.5 Mile Buffer Summary Statistics

0.5 Mile Buffer					
	Number of Parks	Sum Acres Harvested	Average Acres Harvested	Min Acres	Max Acres
EVENonetotwelvemonths	82	129201.81	7.24	0	410.01
EVENthirteentothirtysixmonths	82	266653.67	14.95	0	475.69
EVENthirtyseventosixtymonths	82	267792.01	15.01	0	475.69
EVENmorethansixtymonths	82	1254754.30	70.37	0	2684.53
UNEVENonetotwelvemonths	82	107310.98	6.09	0	717.62
UNEVENthirteentothirtysixmonths	82	258184.89	14.67	0	1694.01
UNEVENthirtyseventosixtymonths	82	273685.28	15.55	0	1694.01
UNEVENmorethansixtymonths	82	1419589.59	80.64	0	3383.91

Table A3. 1.0 Mile Buffer Summary Statistics

1.0 Mile Buffer					
	Number of Parks	Sum Acres Harvested	Average Acres Harvested	Min Acres	Max Acres
EVENonetotwelvemonths	91	283522.49	14.44185441	0	717.9303
EVENthirteentothirtysixmonths	91	566296.38	28.84557741	0	824.9323
EVENthirtyseventosixtymonths	91	579316.95	29.50880973	0	824.9323
EVENmorethansixtymonths	91	2835114.38	144.4129167	0	3463.121
UNEVENonetotwelvemonths	91	229466.19	11.68837563	0	1327.345
UNEVENthirteentothirtysixmonths	91	522139.12	26.5963282	0	2539.828
UNEVENthirtyseventosixtymonths	91	575187.95	29.29848991	0	2789.682
UNEVENmorethansixtymonths	91	3064347.36	156.0894131	0	6777.894

Table A4. 1.5 Mile Buffer Summary Statistics

1.5 Mile Buffer					
	Number of Parks	Sum Acres Harvested	Average A	Min Acres	Max Acres
EVENonetotwelvemonths	94	514992.16	25.34909	0	1289.164
EVENthirteentothirtysixmonths	94	1040674.98	51.2244	0	1008.47
EVENthirtyseventosixtymonths	94	1068037.87	52.57127	0	1008.47
EVENmorethansixtymonths	94	5118994.19	251.9686	0	4840.58
UNEVENonetotwelvemonths	94	381274.79	18.98023	0	1915.151
UNEVENthirteentothirtysixmonths	94	842329.69	41.93198	0	3927.827
UNEVENthirtyseventosixtymonths	94	928575.96	46.22541	0	4177.68
UNEVENmorethansixtymonths	94	4829925.85	240.4384	0	10138.33

Appendix B – Restricted Regression Tables: Regression contained parks that had a treatment applied at any point. If the park did not, it was left out.

Table A5. Half Mile Restricted Regression Results (Even-age)

Half Mile Buffer (Even-age)	
	(1)
VARIABLES	lntotal
evenonetotwelvemonths	-0.000033
	-0.000273
eventhirteentothirtysixmonths	0.000205
	-0.000200
eventhirtyseventosixtymonths	0.000260
	-0.000190
evenmorethansixtymonths	-0.000345***
	-0.000050
population	3.55e-07**
	0.000000
income	-1.03e-05***
	-0.000003
Constant	7.152***
	-0.409000
Observations	15,362
R-squared	0.760
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table A6. Half Mile Restricted Regression Results (Uneven-age)

Half Mile Buffer (Uneven-age)	
	(1)
VARIABLES	lntotal
unevenonetotwelvemonths	-0.000428**
	-0.000169
uneventhirteentothirtysixmonths	-0.000709***
	-0.000120
uneventhirtyseventosixtymonths	-0.000046
	-0.000116
unevenmorethansixtymonths	-0.000097
	-0.000072
population	3.09e-07**
	0.000000
income	-8.08e-06***
	-0.000003
Constant	8.254***
	-0.101000
Observations	13,614
R-squared	0.788
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table A7. One Mile Restricted Regression Results (Even-age)

One Mile Buffer	
	(1)
VARIABLES	lntotal
evenonetotwelvemonths	-0.000322**
	-0.000164
eventhirteentothirtysixmonths	-0.000067
	-0.000121
eventhirtyseventosixtymonths	-0.000178
	-0.000111
evenmorethansixtymonths	-0.000175***
	-0.000033
population	2.72e-07**
	0.000000
income	-5.83e-06**
	-0.000002
Constant	6.972***
	-0.404000
Observations	16,514
R-squared	0.831
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table A8. One Mile Restricted Regression Results (Uneven-age)

One Mile Buffer (Uneven-age)	
	(1)
VARIABLES	lntotal
unevenonetotwelvemonths	-0.000181*
	-0.000093
uneventhirteentothirtysixmonths	-0.000319***
	-0.000067
uneventhirtyseventosixtymonths	-0.000010
	-0.000063
unevenmorethansixtymonths	0.000040
	-0.000035
population	4.29e-07***
	0.000000
income	-8.68e-06***
	-0.000002
Constant	8.198***
	-0.091800
Observations	16,433
R-squared	0.826
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table A9. One and a Half Mile Restricted Regression Results (Even-age)

One and a Half Mile Buffer (Even-age)	
	(1)
VARIABLES	lntotal
evenonetotwelvemonths	-0.000405***
	-0.000116
eventhirteentothirtysixmonths	-0.000215**
	-0.000085
eventhirtyseventosixtymonths	-0.000165**
	-0.000078
evenmorethansixtymonths	-9.46e-05***
	-0.000022
population	3.53e-07***
	0.000000
income	-1.15e-05***
	-0.000003
Constant	8.533***
	-0.198000
Observations	17,333
R-squared	0.830
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table A10. One and a Half Mile Restricted Regression Results (Uneven-age)

One and a Half Mile Buffer (Uneven-age)	
	(1)
VARIABLES	lntotal
unevenonetotwelvemonths	-0.000079
	-0.000064
uneventhirteentothirtysixmonths	-0.000247***
	-0.000047
uneventhirtyseventosixtymonths	-0.000059
	-0.000044
unevenmorethansixtymonths	-0.000001
	-0.000022
population	4.63e-07***
	0.000000
income	-1.13e-05***
	-0.000002
Constant	8.298***
	-0.092200
Observations	17,248
R-squared	0.821
Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	