AN ECONOMIC ANALYSIS OF THE SMITH RIVER FLOAT LOTTERY

by

Chase Nelson Walker

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Applied Economics

MONTANA STATE UNIVERSITY
Bozeman, Montana

April 2020

ACKNOWLEDGEMENTS

I would like to thank my girlfriend, Mariah, and my family first and foremost for their constant support throughout my time at Montana State. Finally, I would also like to thank my thesis committee: chair Dr. Randy Rucker, Dr. Richard Ready, and Dr. Bryan Leonard for their guidance and comments during the thesis writing process. Their feedback and thoughts provided a substantial amount of value to this thesis project.

TABLE OF CONTENTS

1. INTRODUCTION 1

Smith River Background and Management 6
Smith River History and Management Evolution 13

2. LITERATURE REVIEW 18

3. THEORY ON LOTTERY APPLICATION RATES 25

Applicant Tradeoffs and Strategy 25
Application Equilibrium 28
Discussion of Supply vs. Outfitter Effects 34

4. DATA 39

5. EMPIRICAL STRATEGY 55

Outfitter vs. Supply Testing Model 59

6. RESULTS 62

Total Season Results 64
Peak Season Results 66
Shoulder Season Results 70
Early Shoulder Season 71
Late Shoulder Season 73
Test of Supply vs. Outfitter Effects 79
Robustness Checks 82
Discussion of Results 88

7. POST APPLICATION ANALYSIS 92

Data 93
Empirical Model and Results 99

8. CONCLUSION 105

REFERENCES CITED 109

TABLE OF CONTENTS CONTINUED

APPENDICES 113

APPENDIX A: Smith River Lottery Application...114
APPENDIX B: Smith River Outfitter Calendar 117
APPENDIX C: Predicted Flow and Temperature Discussion....................................119
APPENDIX D: Additional Tables and Results 122

LIST OF TABLES

Table Page

1. Variable Descriptions....44
2. Summary Statistics - Total Season Data (April - July)....45
3. Summary Statistics - Peak Season Data (May 15th - July 15th)....45
4. Summary Statistics - Total Shoulder Season (April - May & July) 46
5. Summary Statistics - Early Shoulder Season (April 1st - May 14th) 46
6. Summary Statistics for Late Shoulder Season (July 16th - July 31st)....47
7. Correlation Matrix of Variables....48
8. Total Season Results (April - July)....65
9. Peak Season Results (May 15th – July 15th)....69
10. Total Shoulder Season Results (April – May & July) 76
11. Early Shoulder Season Results (April 1st – May 14th)....77
12. Late Shoulder Season Results (July 16th – July 31st)....78
13. May and July Tests 80
14. Robustness Check 1 86
15. Robustness Check 2 87
16. Post Application Variable Descriptions....96
17. Summary Statistics: Total Season....97
18. Summary Statistics: Peak Season 97
19. Summary Statistics: Total Shoulder Season 97
20. Summary Statistics: Early Shoulder Season 98

LIST OF TABLES CONTINUED

Table Page

21. Summary Statistics: Late Shoulder Season..98

22. Post Application OLS Analysis 104

23. Post Application Quadratic Inflections 123

24. Main Analysis Quadratic Inflections 123

25. Main Analysis OLS Results...124

LIST OF FIGURES

Figure Page

1. Smith River Float Map with Campsites 8
2. Smith River Location Map 9
3. Smith River State Park Fees 13
4. Smith River Yearly Applications 17
5. Lottery Equilibrium 31
6. First Choice Applications by Float Season - Daily 40
7. Average number of First Choice Applications - Daily 48
8. Average Number of April Applications, Yearly 49
9. Average Number of May Applications, Yearly 49
10. Average Number of June Applications, Yearly 50
11. Average Number of July Applications, Yearly 50
12. Average April Flows (cfs), Yearly 51
13. Average May Flows (cfs), Yearly 51
14. Average June Flows (cfs), Yearly 52
15. Average July Flows (cfs), Yearly 52
16. Average April Temperature (Fahrenheit), Yearly 53
17. Average May Temperature (Fahrenheit), Yearly 53
18. Average June Temperature (Fahrenheit), Yearly 54
19. Average July Temperature (Fahrenheit), Yearly 54

LIST OF FIGURES CONTINUED

Figure Page

20. Daily Average Usage Rate, 2007 - 2018 98

ABSTRACT

Outdoor recreation is a popular pastime for many and provides an opportunity to unwind and take a break in nature and on public resources. In recent years, overcrowding and commercial use have been highlighted in the media for taking away from the recreational experience and stressing some of the resources. To explore this issue, I collect data on float permit application numbers over 15 years for the Smith River, which is a popular lottery accessed recreational river in Montana that receives over 10,000 float applications per year and also allows private commercial guiding. To attempt to gain insights into whether commercial use is viewed negatively, I use variation in the number of outfitted trips that are permitted to launch each day within the float season to identify how outfitter use impacts application rates. I find that application rates during the peak season decrease by an average of 11 percent on days in which two outfitters launch compared to days when only one outfitter can launch. Because outfitter launch allocations effect the supply of permits available in the lottery, this result could be attributed to either an outfitter effect or supply effect. Further analyses that test the differences between the early season when outfitter use is low, and the peak season when outfitter use is high, indicates that there is a combination of both effects, but that the impact of outfitter use is large and significant.

CHAPTER ONE

INTRODUCTION

Recreational use of public lands and resources is a popular activity in the United States, and encompasses a wide variety of activities such as hunting, fishing, hiking, camping, and rafting. Outdoor recreation is generally perceived to have positive economic impacts, as it is estimated to generate $887 billion in consumer spending and to currently support 7.6 million American jobs (Outdoor Industry Association, 2017). Despite the economic benefits, there are many issues that arise from high use that present policy makers with challenges on how to address them. People often search for tranquil experiences and undisturbed habitats when traveling to natural places and public lands, but these places are becoming progressively harder to find. User conflict and habitat degradation naturally result from overcrowding and overuse.

Overcrowding is becoming more widespread throughout the West, with more people flocking to public resources and participating in outdoor recreation. National parks and monuments have seen massive increases in use, creating problems such as traffic congestion, negative ecosystem interactions, conflict among resource users, and limited resources to maintain facilities and enforce regulations (Simmonds, 2018).

Overuse is an issue on popular rivers as well. For example, Flathead River managers are considering changes in management, given the river's designation as a "Wild and Scenic River", which requires it to be managed to maintain its diverse and intact ecosystem, and the values that make it unique. Recent use studies have shown that more people are using the river, and fish populations and streamside vegetation may be suffering. New management plans for use are being considered, and a permitting system is not being ruled out (Byron, 2019).

Many other popular recreational rivers already have commercial use restrictions throughout the West. In Montana, the Upper Bitterroot, Blackfoot, Big Hole, Beaverhead, and Alberton Gorge of the Clark Fork River all require special use permits for commercial or non-resident use. Specific commercial use limitations include closing certain sections of rivers to outfitters on certain days of the week during high use seasons, which is the case for the Upper Bitterroot River (Montana FWP, 2020). Commercial use restrictions and permit systems can also be found on Bureau of Land Management (2020) managed rivers such as the Deschutes, Rogue, and John Day Rivers in Oregon, Salmon River in Idaho, and Colorado River in Utah. The Grand Canyon of the Colorado River in Arizona is also managed with a lottery and commercial permitting system (National Park Service, 2020).

Perhaps the most publicized and recently debated issue has been newly proposed management on the Madison River in southwest Montana. Historically, the Madison has been one of the premier trout fishing rivers in the country as a result of the high numbers and size of fish, combined with the scenic beauty of the Madison Valley and generous public access. Because of these desirable traits, the river has seen continually rising recreational use over time, and is now the most fished river in Montana with 207,000 angler days estimated in 2017 (Montana FWP, 2019). The heavy use on the river has led to conflict among groups that use the river, with many locals believing that outfitters and nonresidents are overcrowding and abusing it. To address these issues Montana Fish, Wildlife, and Parks proposed new regulations, primarily targeting commercial use, in April 2018 to help manage the river into the future. Some examples of these proposed regulations include closing certain sections of the river to any type of boats or watercraft and capping the number of commercial outfitters. This initial proposal was, however, quickly voted down (Wright, 2018).

After the initial proposal failed, a Madison River Committee made up of a variety of stakeholders on the river was formed in 2019. This committee was created with the intent to come up with a new rule proposal to present to the Montana Fish and Wildlife Commission. Over months of meetings the committee was not able to come to a consensus, and eventually disbanded in May 2019 (Wright, 2019a). Most recently, Montana FWP released a comprehensive survey to gauge the public's opinion on four issues: commercial outfitter use, social conflict, angler use on the upper section of river, and recreation on the lower section of the river. Survey respondents were asked about the possibility of prohibiting guided fishing on certain sections of the river on certain days, banning boats on the two wade fishing only sections, capping non-resident use, and potentially requiring anglers to buy a Madison River stamp to be able to fish the river (Wright, 2019b). The survey recently closed, and no rule has yet been made regarding survey responses and future management.

The challenges facing the management for the Madison River are not unique, with many other rivers and public resources seeing steadily increasing use in other places as well. As these places continue to become stressed by overuse, policy makers will be searching for information and sound research on best management strategies. Recently, the Madison/Gallatin Chapter of Trout Unlimited submitted a letter to the commissioners of the Montana Fish & Wildlife Commission recommending that regulation decisions on the Madison be based on science as well, rather than just a survey. Trout Unlimited suggests that the commission create a panel of biologists, University social scientists, and economists to provide input on the regulation process. Despite the clear demand for research on the impacts of overcrowding and outfitter use, there is little empirical evidence in the economics literature that identifies these impacts.

Although data are lacking on fairly unregulated rivers such as the Madison, lotteries and permit systems are commonly used to ration access to other rivers and public resources and provide valuable resource use statistics that have been underutilized in the context of outdoor recreation in the economics literature. There are currently 13 rivers that have lottery systems in the United States, and many more that require users to obtain a permit before floating or accessing the river (American Whitewater, 2019). One of the most popular rivers in the country with a lottery system - and the focus of this thesis - is the Smith River, which is located in Central Montana and can only be floated by acquiring a permit won via a highly competitive lottery. In addition to the lottery, people desiring to float the Smith River may also hire a commercial outfitter to guide them on a trip down the river. Commercial outfitters are allotted a certain number of launches throughout the season, with the number of commercial launches allowed varying across days of the week.

There has been a substantial amount of research on outdoor recreation in the economics literature, however the focus of much of the literature is concentrated on quantifying the value of outdoor recreation, which is not the goal of this thesis. My research is more focused on identifying variables and characteristics that impact the quality of recreation, and how changes of these characteristics impact recreation decisions. Most of the similar literature looking at lotteries for recreational use permits is focused on hunting lotteries (Nickerson, 1990; Scrogin et al., 2000, 2003, 2005, 2018; and Boxall, 1995). These articles generally identify how characteristics such as hunt type, harvest probability and type of firearm used impact lottery application choices and utility. A similar approach is taken in this thesis, however, because this analysis is focused on a river lottery, I use river and float characteristics to examine effects on application rates.

The only other similar paper that examines river lotteries is by Yoder et al. (2014), who primarily attempt to measure the impact of river characteristics on lottery application rates and calculate marginal rates of substitution between these characteristics, for example, the marginal rate of substitution between flow and air temperature. Additionally, they attempt to estimate the impacts of congestion on application rates and find that it is viewed negatively, however they acknowledge that they have limited variation within river sections and are likely not identifying the full impacts of congestion. This research extends Yoder et al's. (2014) by identifying the impacts of river characteristics, as well as commercial outfitting on lottery applications using within season variation in both river characteristics and exogenous outfitter use allocations. Additionally, this research is the first to develop a theoretical equilibrium analysis with comparative statics predictions for an outdoor recreation lottery.

In this thesis I use the variation in outfitter launches from day to day within the season to identify the impact of high outfitter use days on lottery application rates for the Smith River Lottery with daily level data from 2004-2018. Additionally, data on flows and air temperature will provide information on preferences for expected river and weather characteristics during the application period. Results show that application rates decrease on days where more than one outfitter can launch, which could be attributed to either an outfitter effect or supply effect due to outfitter launch allocations changing the number of permits available in the lottery. The outfitter effect can be defined as the effect of outfitter use that negatively affects the recreation experience for private resource users. Some examples of negative outfitter effects may be competition for fishing spots or campsites, or a feeling of the river being slightly more crowded. The supply effect is defined as the impact on application rates that could be attributed to the fact that outfitter launch allocations affect the supply of permits available in the lottery.

Further tests of how the outfitter effect and supply effect impact application rates allow these two effects to be definitively separated using the lottery structure in the early and late parts of the season, specifically in May and July, where each of these months contain half peak season dates where outfitter use is high and half shoulder season dates where outfitter use is nearly non-existent. These tests indicate that the impact of outfitter allocations may be attributed to some level of supply effects, and that the outfitter effect is fairly large and significant, providing some evidence that outfitter use is viewed negatively. I also find that application rates correspond with expected flow and temperature in ways that make economic and intuitive sense. Two methods of robustness checks confirm the validity of the findings with respect to the impact of outfitter days, and a post application analysis using data on actual usage rates yields similar results for river characteristic preferences as the main analysis.

The rest of this chapter will include a background of the Smith River and its management history. Following chapters include a review of previous literature, a theoretical model of lottery applications with comparative statics predictions, a data section, empirical models and results, and a discussion. The paper will end with a conclusion chapter.

Smith River Background and Management

Documented recreational use on the Smith River dates back to the 1950s, and today, it is one of the most heavily regulated rivers in the West, and certainly the most heavily regulated in Montana. Its striking views and steep canyon walls, good fishing, remoteness, and gentle flow attract potential visitors from across the country. Most applicants are from Montana, but states like Colorado, Washington, Idaho, Utah, California and Oregon generally have several hundred applicants, and there is at least one application from nearly all 50 states in the most recent lottery. The Smith River has two primary access points for the lottery managed section of the river, a put-in at Camp Baker and take out at Eden Bridge, with approximately 59 remote river miles in between. Figures 1 and 2 below display the location of the river within Montana as well as a more detailed map of the campgrounds on the Smith River. Floaters generally take three to five days on a trip, depending on river flows at the time.

Figure 1. Smith River Float Map with Campsites (from Smith River State Park website)

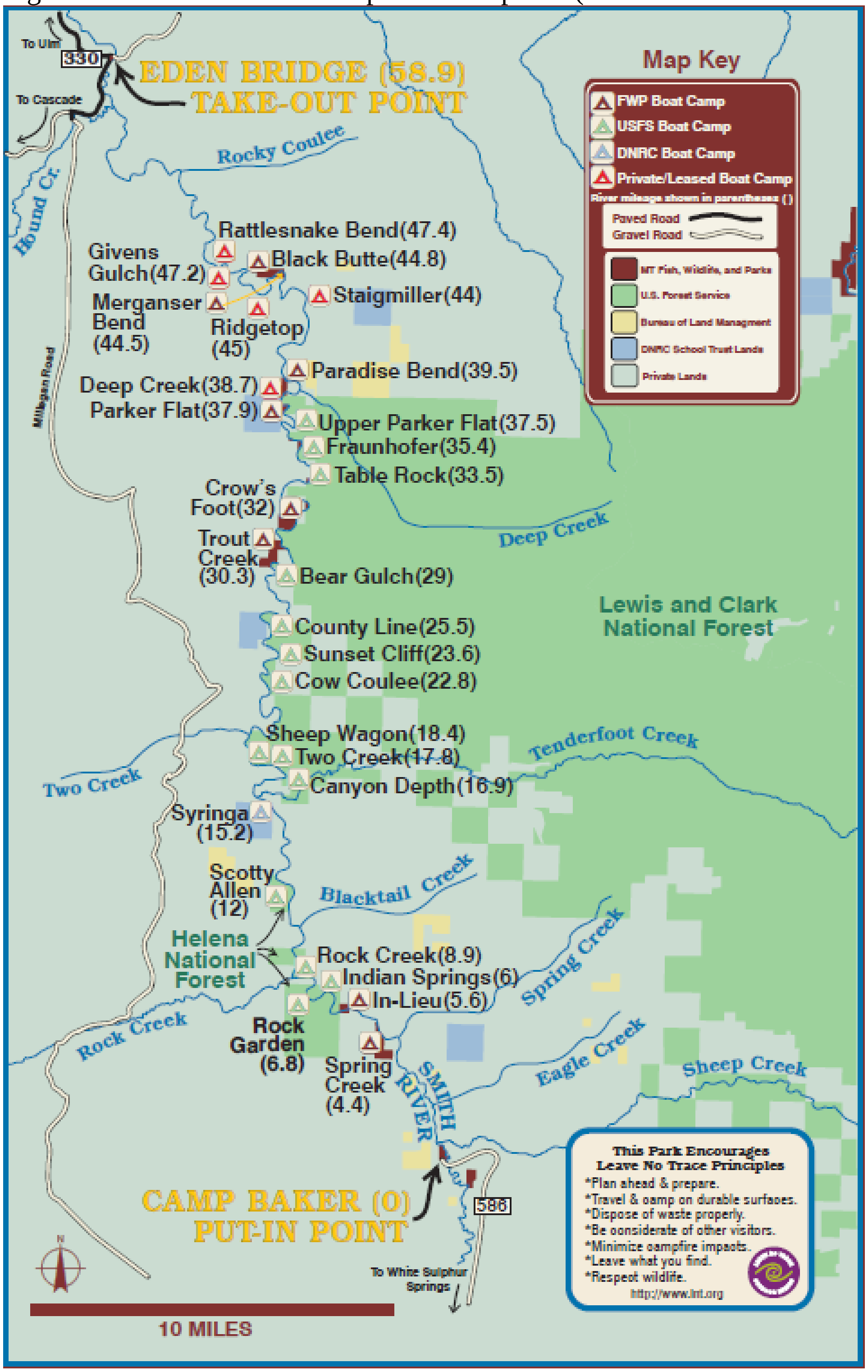
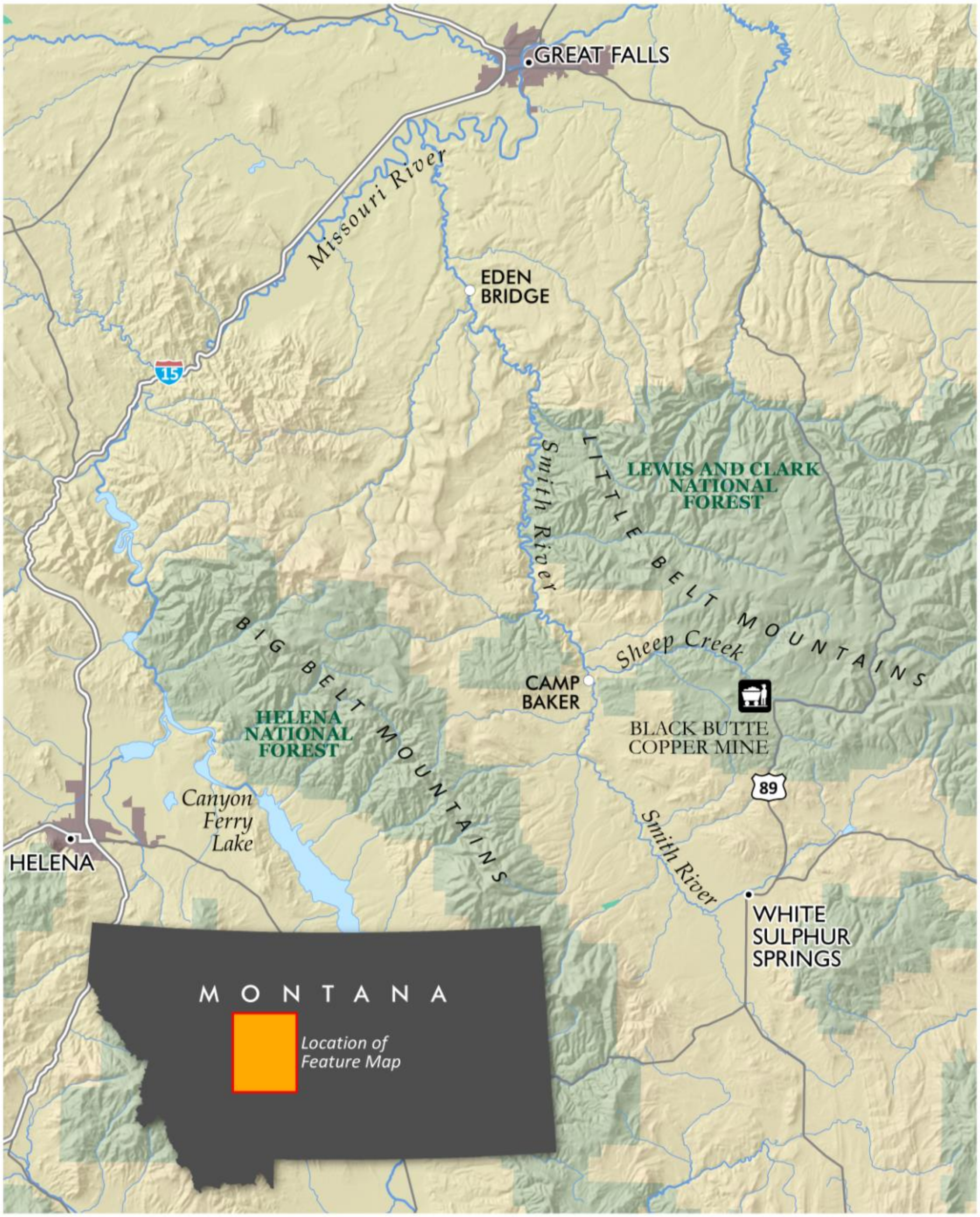


Figure 2. Smith River Location Map (from American Rivers website)



The structure of the Smith River lottery is fairly straightforward. The float season runs from April 1-October 31, although peak season is May 15-July 15 because that is when flows and weather are typically most favorable for floating. The peak season is defined by the Smith River State Park and requires floaters to finish their trips in a maximum of four nights/five days. The application period for a permit runs from the beginning of January to mid-February each year, and permit drawing results are posted near the beginning of March. Applicants are allowed to list three choices of launch dates, although first choices have a higher chance of winning than second choices, and second choices have a higher chance of winning than third choices. To explain, if there are more first choice applications than permits available on a given day, then all of the permits will be randomly allocated amongst the first choice applications in the lottery, with second and third choice applications having no chance to win on that day. If there are less first choice applications than are available, applications will be allocated to all of the applicants that listed first choices, and then the lottery will randomly allocate the remaining permits to the second choice applications until there are no longer permits available for that day.

The lottery is unweighted in the sense that an individual's probability of winning a permit does not increase if she was unsuccessful in the previous year. In addition to the general lottery, there is also a lottery for a single super permit. The super permit allows applicants to enter an unlimited number of times, for a $5 per entry fee. Only one super permit is awarded per year, but it allows the winner to choose any launch date she prefers. For those who are unsuccessful in the lottery, a reservation hotline opens up in mid-March, which allows people to call and reserve any remaining launch dates that were not allocated in the lottery. Peak season dates generally fill up, but shoulder seasons often have unfilled dates, allowing opportunistic floaters a chance to access the river without going through the lottery system.

Commercial outfitting is also allowed on the river, although a limited number of outfitters are authorized to guide on the Smith, and launch dates are limited. There are currently seven authorized outfitters, and a total of 73 launches authorized per year that are allocated among those outfitters (Smith River Management Plan, 2009). Outfitters are required to finalize launch dates one week prior to the lottery drawing, although outfitter spots are put on-hold for outfitter use up to 29 days before the launch date if they are not initially reserved. Within 28 days of the launch date these on-hold spots become available via the reservation hotline to both the general public and commercial outfitters. The allowance of commercial outfitters gives the public an opportunity to float and see the river without going through the lottery system, although at a substantially higher cost. Because trips are limited, advanced booking is usually necessary, and trips are not cheap - people can expect to pay between $3,400 and $4,800 per person for a five day outfitted trip, and this does not include travel costs to get to the Smith River.

A maximum of nine total groups are allowed to launch per day during the float season. A maximum group size of fifteen is allowed for all private and outfitted launch parties, and this number includes guides and other commercial staff on outfitted trips. The only exception to the maximum number of launches allowed per day is for the winner of the super permit, who is allowed to choose any launch date she pleases.

Landowners with property along the Smith River may also float without acquiring a lottery permit, if they launch directly from their property. Fees associated with the lottery include a non-refundable application fee of $10 and launch fees for lottery winners and all members of their float party. Montana residents are required to pay launch fees of $25, and non-residents pay $60. Commercial outfitters pay $200 per float trip, $25 per staff member, and $100 per client.[1] These fees are outlined in figure 3 below. To prevent speculators from entering the lottery and reselling permits at a higher price, lottery permits are non-transferrable, and the permit winner must be present with the launch party on their designated launch date.

Throughout the river corridor, there are 52 designated campsites that floaters are required to stay at on their trips. These campsites are chosen at the Camp Baker launch on a first come, first served basis. Launch party members may show up to camp at 7:30 a.m. the day before their launch to register and choose their campsites for the trip. This can become a fairly competitive process, as there are certain campsites that are highly desired, so users who arrive early may benefit, although they incur a time cost of having to wait for a whole day to launch after arriving. Discussions with a user of the river in the past year indicated that commercial outfitters often send a member of their crew to Camp Baker on the day before their launch date to claim campsites. This crew member reportedly sleeps on a cot at the door of the ranger cabin to be the first to sign up. Apparently, if clients are willing to pay nearly $5,000 for a trip, claiming prime campsites is quite important.

[1] Individuals acquiring permits through the reservation hotline do not pay an application fee but are still required to pay launch fees.

Figure 3. Smith River State Park Fees

SMITH RIVER STATE PARK USER FEES

PRIVATE FLOAT TRIPS	
Item	**Fee**
Permit Application	$10 (nonrefundable)
Super Permit Lottery	$5 per chance (unlimited chances)
Private Float Trip	$0 per resident or nonresident child (less than 6 years old) $15 per resident or nonresident youth (age 6 through 12) $25 per resident (age 13 and above) $60 per nonresident (age 13 and above)

LANDOWNER FLOAT TRIPS (DAY FLOATS ONLY)	
Item	**Fee**
Landowner Float Trip	$0 per landowner & immediate family member $0 per agent, assignee, or guest within landowner's fee title $7.50 per non-immediate family member, agent, assignee, or guest outside of landowner's contiguous fee title property boundaries

COMMERCIAL OUTFITTER FLOAT TRIPS	
Item	**Fee**
Commercial Outfitter Float Trip	$200 per float trip $25 per commercial outfitter staff or contractor $100 per commercial outfitter client
Commercial Business Transfer	$200 per transfer transaction

Note: Landowners who have property along the river may float from their property without acquiring a launch permit. The Commercial Business Transfer is the fee for when an outfitter transfers or sells their business to a different outfitter to be able to guide on the Smith River.

Smith River History and Management Evolution

The Smith River is well known by outdoor enthusiasts for its consistently scenic float, and outstanding fishing that can occur in favorable water conditions. Flowing through a deep canyon in the Little Belt Mountains, floaters have the opportunity to see unique geologic features, and observe a variety of wildlife throughout. For those that fish, the Smith holds abundant populations of rainbow and brown trout, frequently reaching 16 to 18 inches, with the opportunity for an occasional larger fish. The Smith is popular within the fishing community and draws attention nationally as a fantastic trout river located in a spectacular and remote setting. The Smith has been enjoyed for many years by recreationists, but because of conflicts between landowners and river users, highly regulated management has also been a part of the Smith River history.

In 1970, the process that has led to the current management of the river began, when the Governor's Council on Natural Resources and Development recommended legislation designating the Smith as a State Recreational Waterway. That year was also the first time there was a documented meeting between Fish, Wildlife and Parks (FWP) and landowners along the Smith, to discuss the recreational use and future management of the river (Smith River Management Plan, 1996). Issues expressed by ranchers as a result of recreational floating included trespassing, vandalizing, littering, as well as human waste issues. Floaters had difficulty finding campsites and navigating around fences across the river to contain livestock. FWP was attempting to acquire small tracts of land along the river as well, to provide floaters with places to camp on their trips. Landowners were concerned about the impacts that future recreational use and management would have on their land into the future, and unanimously opposed any increase in recreational use of the river (Petersen, 1995).

Despite obvious conflicts, landowners and recreationists were able to find some common ground on the steadily increasing use and management of the river. Both parties agreed that future development, such as subdivisions, along the river were undesirable. Additionally, too much recreation was viewed by both as detrimental. Landowners were concerned about trespassing and waste issues, and recreationists were concerned that too many people would negatively impact the fishery and the serene experience of the float. It is clear that the “unique quality” and untouched remoteness are among the most important and valued attributes of the river (Petersen, 1995).

As recreation continued to rise through the 1970s, management of the river evolved as well. In 1980, FWP and the Bureau of Land Management (BLM) hired seasonal employees to patrol the river, and the first Smith River map and floater’s guide were published. Additionally, to gather more information about river use and perceptions of management, landowner and floater surveys were beginning to be conducted. Throughout the 1980s, FWP continued to implement ways to help manage recreation on the river, including instituting a floater log as a method of voluntary registration, building a seasonal ranger cabin, installing latrines at high use campsites, and purchasing more land along the river corridor (Smith River Management Plan, 1996).

By the mid-1980s, recreation continued to increase, and major steps towards future management were being made. In 1984 the Smith River Ad Hoc Committee was formed, which was made up of floaters, outfitters and landowners that represented the multiple viewpoints in how the river should be managed. In 1986, perhaps the most influential aspect of Smith River management began, a formal recreation use survey called the Smith River Study. FWP contracted with a consultant named Joel Shouse, who completed the study over a three-year period, and proposed a management plan that FWP eventually adopted and outlined in the Smith River Management Plan of 1988 (Petersen, 1995).[2]

Shouse's management plan was based on usage levels, and included five stages. His recommendation was essentially to implement a new stage as the agency saw fit based on usage levels and the determined carrying capacity of the river. These stages are outlined below (Petersen, 1995):

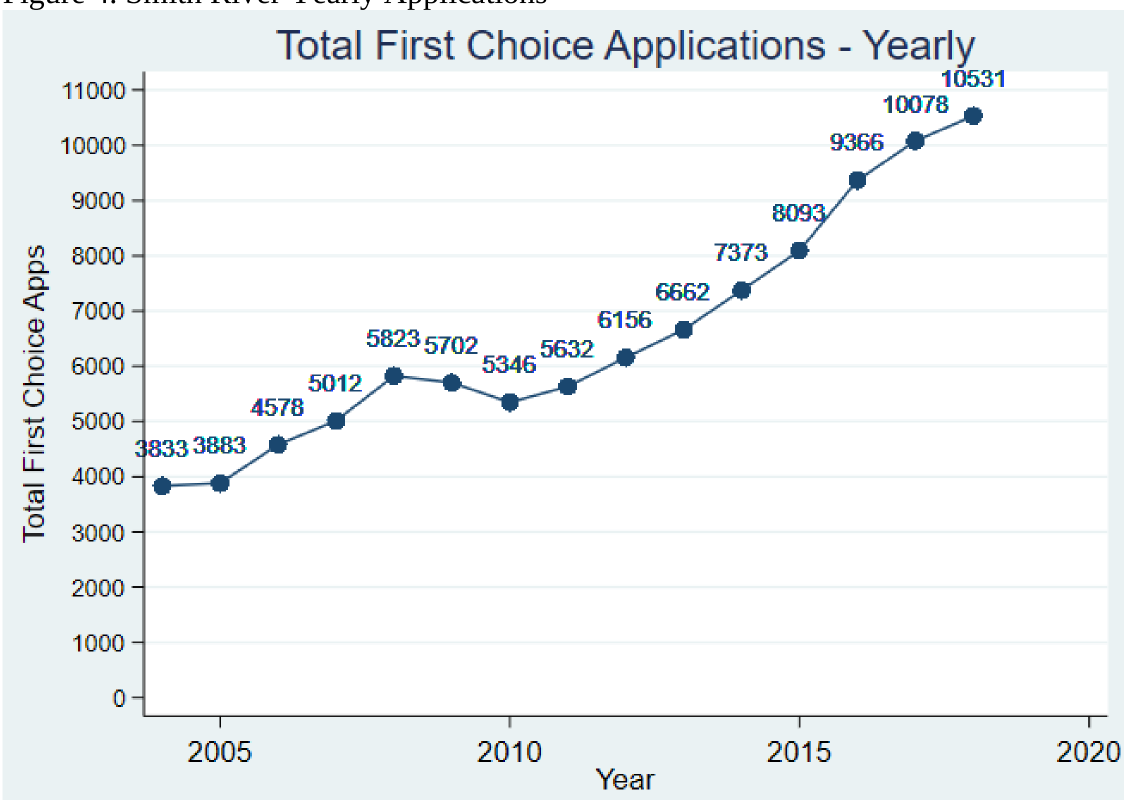
1. The present stage of management at the time of the study. This included voluntary registration, a seasonal river ranger, and voluntary boat camp declarations which would help managers understand most popular campsites along the river.
2. Continue the voluntary registration system but add a mandatory registration at Camp Baker to track river use, and a floater's log that was required to be turned in at the Eden Bridge takeout.
3. Require mandatory reservations for a set number of permits for peak float season, between Memorial Day and the Fourth of July.
4. Require mandatory reservations for the entire float season.
5. Initiated when total user demand exceeded total annual user permits. Implement a competitive system to allocate the limited number of floater permits per season.

It did not take long to get to Stage 5 of this plan; beginning in 1993, permits were allocated by random draw for days that had more applications than the set amount of launches available. Despite the newly implemented lottery system, visitation continued to

[2] I do not have access to Shouse's study, but the Smith River Management Plan of 1988 incorporates essentially all recommendations of the study.

increase, likely as a result of larger group sizes and increased use of the shoulder seasons. Today, the lottery system remains in place, although management has continued to evolve, and there have been policy changes to adjust to issues that have arisen over time. As indicated in figure 4, applications continue to increase - in each of the past seven years, the lottery has set records for permit applications.

Figure 4. Smith River Yearly Applications



CHAPTER TWO

LITERATURE REVIEW

Over time, demand for outdoor recreation has tended to continually increase, and there has consequently been substantial economics research dedicated to this field. Despite the wide reach of the outdoor recreation literature, relatively little research has been conducted on river lottery systems, with most of the literature to date focusing on hunting lotteries.

Historically, hunting lotteries have been used to allocate licenses for popular big game hunts in most western states. Because overharvesting can easily become an issue if unregulated, especially for trophy game, lotteries provide managers the easiest and most fair way of allocating licenses. Nickerson (1990) provides one of the first studies that estimates demand for hunting lottery permits, using data from big game lotteries in the state of Washington. He controls for a variety of hunting characteristics such as probability of success, type of firearm (rifle, muzzleloader, bow) used, and game management unit using a log-linear OLS regression specification.

Scrogin et al. (2000, 2003, 2005, 2018) have published a series of papers using data from a variety of big game hunts in New Mexico and analyzed policy changes in the lotteries to measure a variety of welfare and demand changes. These policy changes include a non-resident supply quota that allocated at least 78 percent of the lottery licenses to residents, a lowered fee for elk licenses, and a change in fee structure that only required applicants to submit an entry fee (rather than both an entry and license fee, where the license fee would be refunded if the applicant did not win the lottery). After these amendments were made, there was a 58 percent increase in resident lottery applications for elk licenses. In their initial paper using these data published in 2000, Scrogin et al. estimate welfare measures such as Marshallian surplus, using a count modeling approach. Because of the count data nature of lottery applications, the authors use a generalized negative binomial model. This model handles over dispersed and heterogeneous data well and has been shown to produce unbiased parameter estimates while accounting for dates with zero observations (or applications). The lottery application data tends to be over dispersed, in that there is a high number of applications during peak season, and people tend to try to coordinate on application dates if they are planning to go in a group. While this thesis is estimating a model with a different lottery structure, and is not examining policy changes within the lottery, Scrogin et al. (2000) provide the basis for the use of a count model, as the Smith River Lottery data take on a similar form.

In their 2003 study, Scrogin and Berrens develop a two-stage random expected utility model (REUM) for a demand and welfare analysis of the New Mexico hunting lottery system. They estimate expected access probabilities by modeling observed outcomes of the lottery participants, using four different regression specifications: standard and skewed logit models, and standard and heteroskedastic probit models. They find that the heteroskedastic probit model outperforms all other models, and thus is used to generate expected access probabilities needed to estimate REUMs. Independent variables include measures of travel costs, license fees, past probability of winning, harvest ratios and a variety of indicator variables that control for type of hunt, location, and time.

Scrogin (2005) estimates another REUM model to see how lottery participation is affected by types and timing of tariff payments (entry and license fees). This analysis is based on the changes in lottery policy discussed earlier that lowered fees and increased resident chances if more non-residents enter in the New Mexico hunting lottery. The author finds that the types and timing of the tariff payments significantly affects participation, choices over rationed and open access alternatives, and the benefits derived from changes in the quantity and quality of lottery-rationed access opportunities (Scrogin, 2005).

In a 2018 study, Scrogin estimates risk preferences over multi-attribute public lotteries, once again using data from the New Mexico big game lottery. To estimate risk preferences, he uses a conditional logit model to estimate expected utility of entering the lottery. Variables in the model include lottery characteristics such as fees, travel cost, and indicators of hunt type, location and time. Of primary interest is a risk aversion coefficient that is conditioned upon individual characteristics of lottery participants such as age and gender. Scrogin (2018) finds that, in general, lottery participants are risk averse, with females exhibiting a higher degree of risk aversion than males.

Random Utility Models (RUMs) have also been applied frequently in work on lottery rationed recreation as well, most generally applied to hunting lotteries. Boxall (1995) extends work by Loomis (1980, 1982a, 1982b) on estimating benefits from lottery rationed hunting licenses and river recreation using the travel cost method. Loomis (1980, 1982a, 1982b) used a zonal travel cost model, with the dependent variable being applications per capita, and where the expected costs of traveling between origin and hunting sites was used as the independent variable as an alternative for price. The travel cost variable was constructed using automobile costs from the U.S. Department of Transportation, the permit fee, and travel time (a fraction of the minimum wage). Boxall (1995) applies the travel cost method discussed above to a discrete choice or random utility model, which had previously been used to estimate benefits for a variety of recreational activities in the travel cost literature. He finds that the random utility model is superior to earlier travel cost models because of its ability to better represent the process of selecting one site (for antelope hunting in Alberta) from a set of alternate hunting sites. Variables included in the model include travel cost, a measure for hunter density, a measure for antelope density, and dummy variables representative of site characteristics.

Another study by Akabua et al. (1999) further explores the use of Random Utility Models (RUMs) in nonmarket valuation studies using data from a moose hunting lottery in Newfoundland. They compare the RUMs developed by Boxall (1995) and Rouwendal (1989) to conditional Multinomial Logit Models (MNLs) to test which models perform best when choices made may not be realized with certainty, which is the case in lotteries. They find that the results from the previous RUM models give significantly different results than the MNLs, and are preferred to the MNLs as well.

As can be seen, RUMs are commonly employed in this literature because they examine the probability that an alternative choice set, which is stated to be preferred to the others, will be chosen by a consumer based on the perception of the utility that can be obtained from a bundle of its attributes (Akabua, 1999). Because RUMs display probabilities of choices that can be interpreted as demand functions, they can be used to measure welfare, particularly in lottery settings where consumers must choose a date to apply for based on the utility they expect to receive from the characteristics of the specific resource on that given day. The use of RUMs in the literature have provided information for what types of characteristics may be important to include in this lottery analysis, however, this specific model is not employed for this thesis because of a lack of more detailed individual level applicant data and travel costs.

Hedonic pricing models have also been used, although less frequently, to value lottery rationed permits or applications. Bushena et al. (2001) apply a hedonic pricing regression to value elk hunting permits in Colorado, in which applicants can build preference points for that allow them to become more competitive in winning a future permit for each year they do not win one. The preference point system is essentially a weighted lottery, where applicants will earn a preference point for each year they do not win a permit, and then have their preference points reset once a permit is eventually won. So for example, an applicant with seven preference points has a higher probability of winning the lottery than an applicant with three preference points. They use a hedonic regression analysis to estimate how various hunting characteristics such as probability of success, type of firearm used, trophy hunts, proximity to a metropolitan area, public land, and a variety of indicator variables impact permit value. A Poisson regression specification was used, although they also tested a negative binomial regression, but found that it did not offer a significant improvement in fit over the Poisson model. In this analysis, a Poisson was also tested, although a negative binomial proved to fit the data better.

It is clear that hunting lotteries have provided a valuable way to study nonmarket valuation and demand for recreation, but these techniques can also be applied to other public lotteries that remain fairly understudied to this point. Lotteries are commonly employed to allocate permits to access popular rivers throughout the West, which are used for whitewater rafting, fishing, and casual floating. Yoder et al. (2014) provide the first, and only, previous research focused on a river lottery, with a study on the popular 4 Rivers Lottery in Idaho. They employ a negative binomial regression specification with number of applicants on a given river day as the dependent variable, and forecasts for water flow and maximum air temperature, as well as year dummy variables being the independent variables. Additionally, using their regression specification, they are able to estimate the marginal utilities of river characteristics, and thus calculate and map marginal rates of substitution between water flows and temperature.[3]

Finally, Yoder et al. (2014) also attempt to quantify the effects of congestion in the 4 Rivers Lottery by using changes in number of permits available. They find that the congestion variable is negative and statistically significant, which indicates that congestion is viewed negatively. The authors acknowledge, however, that because they lack variation within river sections, that changes in the number of permits available are likely picking up the variation across river sections and that the congestion effect should

[3] This allows for the tradeoffs that applicants make between flow and temperature to be displayed and understood.

be interpreted as the relationship between the number of permits and unobserved river characteristics.[4] It is unclear how congestion would affect river management policy and how outfitters may impact application rates or a river user's utility, which is something that this thesis improves upon.

[4] Two out of the four rivers in the lottery (the Selway and the Snake) have a constant number of permits available every day of the season.

CHAPTER THREE

THEORY ON LOTTERY APPLICATIONS

An equilibrium analysis is used to model how individuals choose dates on which to apply for a first-choice application for a float permit. I begin this chapter with a brief discussion of the tradeoffs that applicants must consider between the probability of winning and desired float and river characteristics. Next, the equilibrium analysis is developed, and comparative statics predictions are derived. A graphical visualization of the equilibrium in the lottery is also included in the analysis. Finally, because days in which two outfitters can launch also decreases the supply of permits available to lottery applicants, it is unclear whether supply changes or outfitter presence affect the number of applications. I will therefore discuss the tradeoff and challenge of distinguishing the difference between outfitter use and supply and rewrite the comparative statics predictions for these variables taking into account the fact that they are not independent of one another.

Applicant Tradeoffs and Strategy

The Smith River float lottery is a highly competitive lottery where applicants must make their application decision based on a variety of expectations about their probability of winning and what the river conditions will be like on the day for which they apply. This is an interesting decision, because the Smith River has highly variable conditions from year to year and within each float season, and there is generally only a short window of each season where conditions would be considered “prime” for floating and fishing, which generally falls in mid to late June.[5] Of course, the mid to late June window is also when application rates are the highest, and thus the probability of winning a permit is the lowest. The problem with applying outside of the peak time is the risk of the river conditions being so dangerous or poor that floating is undesirable or impossible. In the earliest part of the season, the river could potentially still have ice flows if cold weather lasts into early spring. On the other hand, if it is a warm spring, snowmelt and rainfall could make the water level so extreme on the river that floating becomes dangerous. In the later part of the season, flows generally become so low that boats cannot make it down the river. Depending on snowpack and springtime precipitation, these low flows may occur as early as July, or as late as mid-August.

I assume that all individuals generally prefer warmer temperatures and water flows that are high enough to make floating enjoyable. The tradeoff they must make is whether they want to sacrifice the expected most desirable floating conditions for a day in which there is a higher probability of winning but less desirable conditions. Some applicants are likely willing to be more flexible on their application choice if they are not as concerned with conditions and simply want the opportunity to float the river. Others may only want to do a trip if they think that the conditions will be good, so they would be unlikely to change their application choice much for a date with a higher win probability but less desirable conditions.

[5] It is not uncommon, however, for mid and late June dates to display undesirable or dangerous conditions for floating. Weather conditions are highly variable and not known with certainty during the application period. The mid to late June time frame offers favorable conditions in most years, which is why the application rates are always highest then.

I have discussed application choices with several former river applicants and individuals familiar with the lottery structure, and there appears to be a fairly wide range of strategies that are used. One such strategy is getting a group together and having each person apply for the same date, which would increase the probability that your group would win a permit on that day. If one person in the group wins a permit on that date, then the whole group can go on the trip. Another strategy is to attempt to apply for a permit before runoff occurs, which is generally in late April to early May. This strategy seems to be used by applicants whose focus on the trip is fishing. Late April and early May can provide some great early season fishing if conditions are right and may also offer a much higher probability of winning. Many people also apply for their desired launch date and will then attempt to obtain a launch through the reservation hotline if they do not win a permit in the lottery. The reservation hotline is useful for picking up shoulder season dates that are not allocated in the lottery, if conditions turn out to be good on those shoulder season dates.[6]

In the absence of detailed individual level application data, these strategies are difficult to test from an empirical standpoint. Regardless, a discussion of the tradeoff and strategizing that occurs is important and interesting because it highlights the complexity of the decision process for this lottery.

[6] Available shoulder season dates in the reservation hotline are becoming progressively rarer as more individuals enter the lottery. Nearly all shoulder season dates now receive more than nine applications, making the lottery increasingly more competitive.

Application Equilibrium

Lottery applicants make their application decision based on their preferences and the features of the lottery, about which applicants are assumed to be fully informed. These features include - lottery winners are chosen randomly, there is a known fixed supply of permits available each day, lottery applicants have a general understanding of the probability of winning, a person may enter for a first-choice application only once, and lottery permits are non-transferrable. Additionally, lottery applicants will attempt to choose a launch day to apply for that provides them the highest expected benefit based on expected river characteristics and probability of winning of which they are assumed to be fully informed. Some examples of these characteristics include weather and water conditions, and social conditions such as interactions with other private parties and commercially outfitted groups. Finally, applicants are assumed to have homogeneous preferences for river characteristics.

Before the equilibrium is discussed, it is important to note that the number of applicants in each lottery season has been trending upward over time, which is not accounted for in the model below, but was displayed graphically in figure 4 within Chapter 1 of this thesis. The general upward trend implies that the demand for floating the Smith River has been increasing over time, which could be attributed to a variety of factors such as increases in income, increases in population, or even a change in tastes and preferences for outdoor recreation. These factors, however, are unobserved within the Smith River data. Additionally, the equilibrium analysis and empirical model are not testing why application rates are increasing over time. The goal of this thesis is to identify why application rates differ within the float season due to variation in outfitter use and river characteristics over the float season. Although application numbers have generally increased over time, the peak season and highest number of applications within float seasons has remained fairly constant, with the peak application period falling consistently from late May into early July.

In equilibrium, expected benefits on day *i* for individual *j* will be equal to expected costs of applying, that is the $10 application fee, represented in equation (1):

$$E[B_{ij}] = P_A = \$10$$

$$E[B_{ij}] = \frac{S_i}{N_i} \cdot V_{ij}(F_i, T_i, O_i) + \left(1 - \frac{S_i}{N_i}\right) \cdot 0 = P_A \quad (1)$$

Where $\frac{S_i}{N_i}$ is the ratio of the supply of permits available on day *i* to the number of applicants on day *i*, which represents the probability of winning. The value of the float starting on day *i* for individual *j*, $V_{ij}(\cdot)$, is a function of river characteristics such as water flow, F_i, and air temperature, T_i, and conflict with commercially outfitted groups, O_i.[7] The $10 cost of applying is represented by P_A. If the expected benefits from entering the lottery on any day *i* are greater than P_A, then individual *j* will choose to enter the lottery and will then select the day that is representative of the greatest expected benefit to her.

The market clearing conditions will occur as each N_i adjusts until the individual is indifferent between entering the lottery and applying for any day, or not entering the

[7] An increase in river characteristics such as flow and air temperature are generally assumed to increase the expected benefit, so $\frac{\partial V_{ij}}{\partial T_i, F_i} > 0$. An increase in the number of outfitters is assumed to decrease the expected benefit of applying, so $\frac{\partial V_{ij}}{\partial O_i} < 0$.

lottery at all. The equilibrium number of applicants N_i^* will be determined by the parameters of the model – supply of permits on float day *i*, S_i, Outfitter presence, O_i, expected water flow and air temperature on float day *i*, F_i and T_i , and application price, P_A:

$$N_i = N_i^*(S_i, F_i, T_i, O_i, P_A) \quad (2)$$

Rearranging equation (1) and substituting in N_i^* creates the identity that clears the market for any set of parameters:

$$N_i^*(\cdot) \equiv \frac{S_i}{P_A} \cdot V_{ij}(F_i, T_i, O_i\,)\;\; for\ all\ i = 1 \ldots n \quad (3)$$

This identity allows for comparative statics to be derived for the five parameters of the model F_i, T_i, P_A, S_i and O_i.

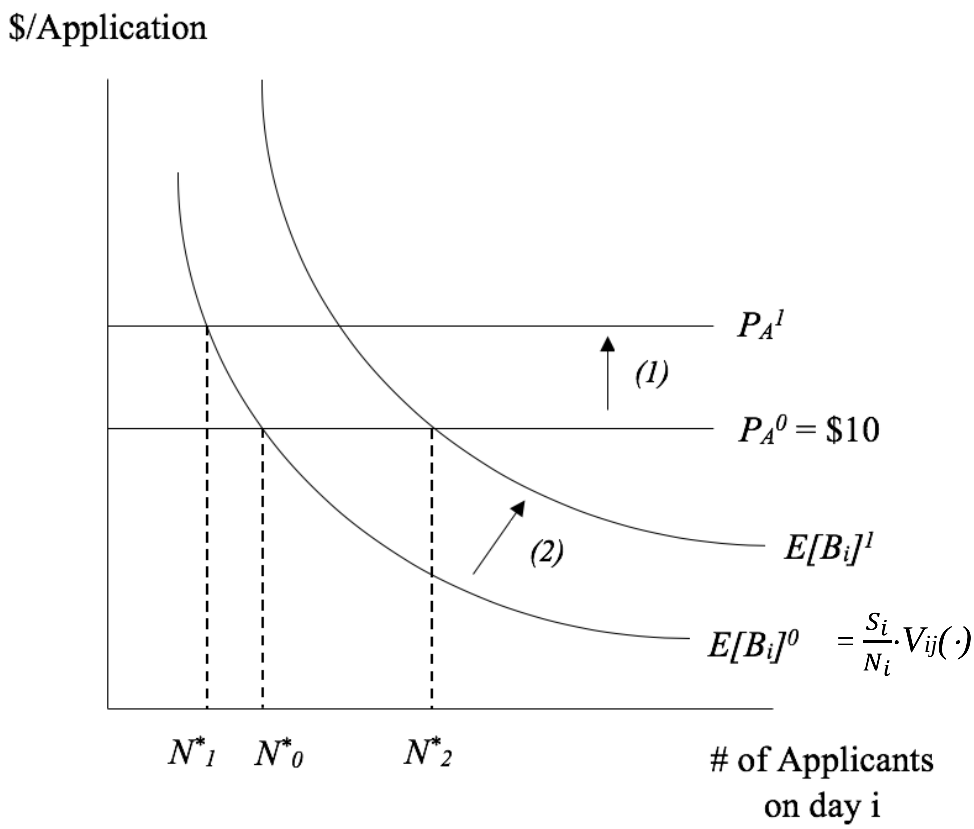
Before comparative statics results are shown, a graphical analysis of the lottery equilibrium will help to visualize the mathematical results. Equation (1) from above is graphed below in Figure (5). The price of applications, P_A, is constant and is represented by the horizontal line at \$10 graphically. The shape of the curve for the expected benefit on day *i* for individual *j* can be found by taking the first and second partial derivatives with respect to N_i.

$$\frac{\partial E\left[B_{ij}\right]}{\partial N_i} = -\frac{S_i}{N_i^2} \cdot V_{ij}(F_i, T_i, O_i) < 0 \quad (4)$$

$$\frac{\partial E\left[B_{ij}\right]^2}{\partial^2 N_i} = 2 \cdot \frac{S_i}{N_i^3} \cdot V_{ij}(F_i, T_i, O_i) > 0 \quad (5)$$

Thus, the $E\left[B_{ij}\right]$ curve for given parameter values is downward sloping and convex, as displayed graphically below. The equilibrium number of applicants is found where $E\left[B_{ij}\right] = P_A$, and is represented graphically by N*.

Figure 5. Lottery Equilibrium



Initially, equilibrium is found at N_0^*, where the expected benefits of applying on day i, $E[B_i]^0$, are equal to the application price of $10 at P_A^0. An increase in price to P_A^1 is represented by (1) graphically. Ceteris paribus, an increase in the application price will decrease the equilibrium number of applicants from N_0^* to N_1^*. An increase in water flow, air temperature or supply, or a decrease in the number of outfitter launches will lead to the outward shift of expected benefits from $E[B_i]^0$ to $E[B_i]^1$, represented by (2) graphically. If the expected benefits increase as a result of the change in one of the specified parameters, the number of applicants will increase from N_0^* to N_2^*, holding application price constant at $10. Alternatively, decreases in water flow, air temperature or supply, or an increase in the number of outfitter launches will decrease the expected benefit on day *i*, and will thus decrease the number of applicants on that day.

Differentiating the identity in equation (3) with respect to P_A yields the comparative statics prediction associated with a change in the price of an application:

$$\frac{\partial N_i^*(\cdot)}{\partial P_A} \equiv -\frac{S_i}{P_A^2} \cdot V_{ij}(\cdot) < 0 \quad (6)$$

This result clearly displays that $\frac{\partial N_i^*(\cdot)}{\partial P_A} < 0$. If the price of applying for the lottery increases, then the number of applicants will decrease. It is important to note that this price change will not affect an applicant's decision of which day to choose in the lottery, but rather whether the applicant chooses to enter the lottery at all. The application fee is the cost of entering the lottery and the applicant can choose whichever day she wants to apply for in the lottery once she has paid the fee.

Differentiating the identity in equation (3) with respect to F_i provides the comparative statics predictions for a change in water flow to be found. First, the partial derivative of $N_i^*(\cdot)$ with respect to $V_{ij}(\cdot)$ is found:

$$\frac{\partial N_i^*(\cdot)}{\partial V_{ij}(\cdot)} \equiv \frac{S_i}{P_A} > 0 \quad (7)$$

Given that the supply of permits and application price are both positive, $\frac{\partial N_i^*(\cdot)}{\partial V_{ij}(\cdot)} > 0$.

Therefore, differentiating the identity in equation (3) with respect to F_i gives:

$$\frac{\partial N_i^*(\cdot)}{\partial F_i} \equiv \frac{\partial N_i^*(\cdot)}{\partial V_{ij}(\cdot)} \cdot \frac{\partial V_{ij}}{\partial F_i} = \frac{S_i}{P_A} \cdot \frac{\partial V_{ij}}{\partial F_i} > 0 \quad (8)$$

Because the partial derivative of $N_i^*(\cdot)$ with respect to the value function is greater than zero and $\frac{\partial V_{ij}}{\partial F_i} > 0$, then $\frac{\partial N_i^*(\cdot)}{\partial F_i} > 0$. This finding indicates that an increase in water flow will lead to an increase in the number of applicants on that lottery day. Comparative statics predictions with respect to air temperature T_i will yield the same results as the predictions with respect to F_i.[8]

Differentiating the identity with respect to S_i allows me to obtain the comparative statics results associated with a change in the supply of permits available on a lottery day:

$$\frac{\partial N_i^*(\cdot)}{\partial S_i} \equiv \frac{V_{ij}(\cdot)}{P_A} > 0 \quad (9)$$

Given that both $V_{ij}(\cdot)$ and P_A are assumed to be positive values, $\frac{\partial N_i^*(\cdot)}{\partial S_i} > 0$. Based on this, an increase in supply would cause the number of applicants to also increase on that day, and a decrease in supply would lead to a decline in the number of applicants. This finding makes sense because a higher supply of permits available would increase the probability of winning a permit on that day, which would intuitively cause an increase in applications. In theory, with a supply increase, the number of applicants would increase until the probability of winning became the same as it was before the supply change. Any increase in the number of applicants greater than this would decrease the probability of winning and thus decrease expected benefits on that day *i*.

[8] For simplicity, increases in flows and temperature are assumed to generally increase application rates. In reality, it is likely that some high level of flow and temperature actually begins to decrease application rates. To account for this, a quadratic functional form is used in the empirical model.

Differentiating the identity in equation (3) with respect to O_i yields the comparative statics prediction with respect to outfitter use:

$$\frac{\partial N_i^*(\cdot)}{\partial O_i} \equiv \frac{\partial N_i^*(\cdot)}{\partial V_{ij}(\cdot)} \cdot \frac{\partial V_{ij}(\cdot)}{\partial O_i} \equiv \frac{S_i}{P_A} \cdot \frac{\partial V_{ij}(\cdot)}{\partial O_i} < 0 \quad (11)$$

Given that $\frac{\partial N_i^*(\cdot)}{\partial V_{ij}(\cdot)} > 0$, and under the assumption of homogeneous preferences and $\frac{\partial V_{ij}}{\partial O_i} < 0$, then $\frac{\partial N_i^*(\cdot)}{\partial O_i} < 0$. This indicates that if the number of outfitters that can launch on a day increases, that the number of applicants on that day will decrease. This finding makes sense, because I assume that floating the river with a high number of outfitter groups takes away from the float experience. Commercial outfitters know the river well and are likely to outcompete river users who acquired a permit in the lottery for fishing spots and prime campsites. Additionally, my data reveal that the average group size of outfitted trips on the Smith River is larger than the average group size of private trips by almost five individuals, so applicants could reasonably expect to be seeing more people and boats on their trip if they launch on the same day as multiple outfitters.

Discussion of Supply vs. Outfitter Effects

The Smith River Lottery is structured to allow a maximum of nine float groups to launch on each day of the float season, including both private trips and outfitted trips. Outfitters are allotted a set number of these nine daily launches reserved separately from the lottery system from May through September. This means that during those months of the season there are only seven or eight permits (instead of nine) available to private floaters who apply for a launch date through the lottery system. The implication of that fact for this analysis is that an increase in the number of outfitters is always accompanied by an equal decrease in the supply of private launch slots, which makes it unclear whether application rates respond to the decrease in supply on days in which two outfitters can launch, the supply effect, or if application rates respond because of the potential of having more undesirable interaction with outfitters for days when two can launch, the outfitter effect, or a combination of both.

Comparative statics predictions from the mathematical model above are consistent with the preceding discussion. The predictions derived above for S_i and O_i assume that supply adjusts independently of the presence of outfitters, however, this is not true in the lottery. Therefore, supply is a direct function of outfitter presence, $S_i = S_i(O_i)\ and\ \frac{\partial S_i}{\partial O_i} = -1$, and the comparative statics prediction for outfitter presence can be rewritten with this relationship taken into account.

The comparative statics prediction with respect to a change in outfitter presence is now:

$$\frac{\partial N_i^*(\cdot)}{\partial O_i} \equiv \frac{S_i}{P_A} \cdot \frac{\partial V_{ij}(\cdot)}{\partial O_i} + \frac{\partial S_i}{\partial O_i} \cdot \frac{V_{ij}(\cdot)}{P_A} < 0 \qquad (12)$$

Additionally, given the structure of the model, more specific predictions can be made for how application rates will change in response to changes in outfitter presence and supply. To begin, start by multiplying both sides of (12) by $\frac{1}{N_i^*(\cdot)}$, which yields:

$$\frac{\frac{\partial N_i^*(\cdot)}{N_i^*(\cdot)}}{\partial O_i} \equiv \frac{S_i}{P_A \cdot N_i^*(\cdot)} \cdot \frac{\partial V_{ij}(\cdot)}{\partial O_i} + \frac{\partial S_i}{\partial O_i} \cdot \frac{V_{ij}(\cdot)}{P_A \cdot N_i^*(\cdot)} \qquad (13)$$

Next, subbing in $N_i^*(\cdot)$ from identity (3) above and canceling terms yields (14):

$$\frac{\frac{\partial N_i^*(\cdot)}{N_i^*(\cdot)}}{\partial O_i} \equiv \frac{S_i}{P_A} \cdot \frac{P_A}{S_i} \cdot \frac{1}{V_{ij}(\cdot)} \cdot \frac{\partial V_{ij}(\cdot)}{\partial O_i} + \frac{\partial S_i}{\partial O_i} \cdot \frac{V_{ij}(\cdot)}{P_A} \cdot \frac{P_A}{S_i} \cdot \frac{1}{V_{ij}(\cdot)}$$

$$\equiv \frac{\frac{\partial V_{ij}(\cdot)}{V_i}}{\partial O_i} + \frac{1}{S_i} \cdot \frac{\partial S_i}{\partial O_i} \quad (14)$$

Identity (14) allows for the outfitter effects and supply effects from the change in outfitter allocations to be separated, where the first term in the identity shows the outfitter effects, and the second term shows the supply effect. The exact expected effects on application numbers from the supply effect can be found by subbing in the supply of permits available from when there are changes in outfitter allocations from one to two outfitter slots and from two to one outfitter slots. A change from one outfitter slots to two outfitter slots means that $S_i = 8$ and that the supply effect will be negative because $\frac{\partial S_i}{\partial O_i} < 0$.

Subbing $S_i = 8$ into (14) yields:

$$\frac{\frac{\partial V_{ij}(\cdot)}{V_i}}{\partial O_i} + \frac{1}{8} \cdot \frac{\partial S_i}{\partial O_i} = \frac{\frac{\partial V_{ij}(\cdot)}{V_i}}{\partial O_i} - 0.125$$

A change from two outfitter slots to one outfitter slot means that $S_i = 7$ and that the supply effect will be positive because O_i is decreasing now, which means that $\frac{\partial S_i}{\partial O_i} > 0$.

Subbing $S_i = 7$ into (14) yields:

$$\frac{\frac{\partial V_{ij}(\cdot)}{V_i}}{\partial O_i} + \frac{1}{7} \cdot \frac{\partial S_i}{\partial O_i} = \frac{\frac{\partial V_{ij}(\cdot)}{V_i}}{\partial O_i} + 0.143$$

Multiplying (14) by 100 puts the identity in terms of percentages. Therefore, the effects of going from one outfitter launch to two outfitter launches on Wednesday and Sunday, should theoretically lead to a 12.5 percent decrease in application numbers due to the supply effect, in addition to the first term that captures the effect of the increased presence of outfitters, which is negative under the assumption that $\frac{\partial V_{ij}(\cdot)}{\partial O_i} < 0$. The effects of going from two outfitter launches to one outfitter launch on all other days of the week except Wednesday and Sunday, on the other hand, should theoretically lead to a 14.3 percent increase in application numbers due to the supply effect, in addition to the first term that captures the effect of the decreased presence of outfitters, which is now positive.

It is also possible, however, that applicants may not be sufficiently sophisticated to respond to a change in supply within the lottery, given that the supply change is only a change of one permit available. On days in which there are over 100 applications, which is frequently the case in the peak season, one less permit becoming available does not substantially decrease the probability of winning, so it is possible that the supply effect could be less than 12.5 percent.[9]

To be able to empirically estimate the supply effect in identify (14), there would need to be a supply change that occurs without the number of outfitters changing. It turns out that these conditions exist in the early and late parts of the float season (during the first half of May and second half of July), which allows the estimation of (14) above, where the effects of both outfitter use and supply can be accounted for separately. Late

[9] If there are 100 applications on day *i*, and eight permits available, the probability of winning is 8 percent. If the number of permits available on day *i* decreases to seven, the probability of winning is now 7 percent, only a 1 percent decrease. It is possible that this change may not be substantial enough for applicants to respond to a change in supply.

May and early July are still considered the peak float season, and consequently there is high usage by outfitters during these times, so applicants can expect to be sharing the river with an outfitter group if they float in late May or early July. In early May and late July, however, usage by outfitters is sufficiently low that the outfitter launch allocations are essentially only causing a change in the supply of permits available.[10] Therefore, a comparison of early May outfitter days to late May outfitter days and early July outfitter days to late July outfitter days could provide some clarity from an empirical standpoint on whether applications respond to what are essentially only supply changes from outfitter launch allocations in early May and late July, and thus only a measurement of the supply effect. Results and model specification for these comparison tests will be discussed further in the empirical analysis section.[11]

[10] Because outfitters generally do not use their launch spots in the shoulder seasons, there is also the possibility that there is an added benefit to these days to private users due to there being one or two less groups on the river on those days overall. It is possible, however, that a private user could acquire an outfitter launch through the reservation line, but the outfitter launches do not become available to private users until fairly short notice before the launch date. Actual usage rates of permits are frequently below one during the shoulder seasons as well, so permit holders who acquired permits through the reservation hotline should not have any substantial effect on permit holders who acquired permits through the lottery.

[11] Another possibility that should be mentioned is that applicants may not be sufficiently sophisticated to respond to supply changes, which would suggest that the supply effect may not be 12.5 percent, as stated in the theory above. The supply effect could be smaller than that, which would therefore leave any extra effect on applications to be attributed to outfitter effects. Additionally, there is the possibility that there is no supply effect, which means any effects from outfitter allocations could be attributed fully to outfitter presence. As mentioned, applicants may only be concerned with win probability, which is not greatly affected by supply changes and therefore may not lead to any substantial supply effects being found.

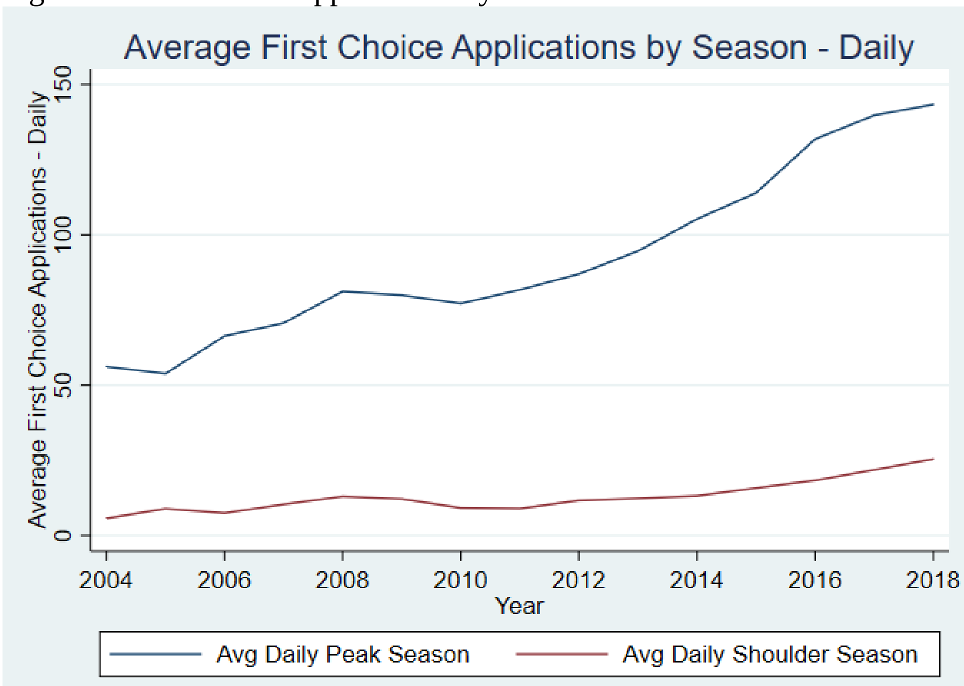
CHAPTER FOUR

DATA

Annual statistical reports are published each year for the Smith River, summarizing highlights, regulations, use statistics, and qualitative information from floater logs and surveys over the season. These reports contain usable data that help define characteristics of the river and that applicants are assumed to use to learn information about the lottery and make application decisions. These data include daily flows (measured in cubic feet per second), number of groups on the river each day, number of people on the river each day, and average group size. Additionally, launch choice reports are also published on the Smith River website each year. These reports show number of first, second, and third choice applications received and won for each day of the float season. Montana FWP began tracking detailed statistical information in 1993, the year that the lottery system was first implemented. For this thesis, reports have been provided from 2004-2018.[12] Figure 6 below displays the daily average first choice applications received over this time period for the peak season and shoulder seasons.

[12] Smith River Annual Reports and Launch Choice Reports were provided by Colin Maas, the State Park Manager for Smith River State Park. The Launch Choice Reports older than 2004 were unavailable.

Figure 6. First Choice Applications by Float Season



Data on other river characteristics include daily air temperatures and daily river flows. Daily air temperatures are retrieved from a National Oceanic and Atmospheric Administration (NOAA) database, and include daily maximum, minimum and average temperatures for White Sulphur Springs, Montana. White Sulphur Springs is used because it is the town nearest to the Smith River launch point at Camp Baker, and is also the weather station with the most complete dataset in the area. It is assumed that most people looking at the weather for the Smith will look up the weather for this town, given its close proximity to the river. In the empirical model, the daily maximum temperature is used as the measure for air temperature.[13] Daily flow measures are also gathered from

[13] Minimum air temperature and a variable that represents a running probability that the temperature would drop below freezing were also tested. These did not explain as much of the variation in the model as maximum temperatures, and yielded similar inferences to maximum temperature on applicant preferences.

USGS, which has a gauge installed on the river near Fort Logan. This gauge measures average daily water temperature and flows (flow data from this gauge match the flow data from the statistical reports). Optimal flows for floating the river lie approximately between 350 and 800 cfs. Flows below 350 cfs generally begin to limit the types of boats that can make it down the river, and flows above 800 cfs are likely to begin to limit fishing opportunity due to muddy water and fast current.

Because applicants do not know the flows and temperatures for the float days in the upcoming season for which they are applying, these variables will represent expectations that need to be predicted based on data available to applicants from past float seasons. There are three methods applied for creating these expected values, which include creating one year lagged variables, five year moving average variables, and predicted values from first stage regressions.

The generation of the one-year lag variables was fairly straightforward - they simply take on the value of the flow/temperature of the same float day from the previous float season. This variable is created under the assumption that applicant's expectations for flow and temperature are fairly simple, and that lottery applicants only account for conditions from the previous float season. The five year moving average variable was created by taking the average of flows/temperature of the same float day from the past five float seasons. To create the predicted values for flow and temperature, a first stage regression was estimated. Both the five-year moving average and predicted variables are created under the assumption that applicant's expectations are more complex and take into account more than one year of previous data.

The specification for the first stage regression is fairly simple and is estimated using OLS. The left-hand side variable is either daily maximum air temperature or the natural log of daily flows. Flow data date back to 1997, so I gather data from 1997-2018 on daily flows. Temperature data were obtained from 1984-2018. Right hand side variables include a dummy variable that takes on a different value for each day of the float season, and a year dummy variable that accounts for differences across each float season. I run a separate regression using this specification for each year in my dataset from 2004 to 2018, using the previous seven years of flow data and previous 20 years of temperature data to generate predicted values for each year. The values for flow and temperature that are used in the final regressions are then simply generated from predicting the y-values from first stage regressions.[14] The first stage regression specification allows for a unique predicted value for each observation in the dataset that is based upon the flows and temperatures from each of the previous 7 and 20 years, respectively.

Descriptions of the variables used in the main analysis are displayed in table 1 below. Summary statistics for the total season are shown in table 2, and summary statistics for peak season are in table 3. The total shoulder season summary statistics are displayed in table 4, and the summary statistics for the early and late shoulder seasons are in tables 5 and 6. A correlation matrix for the variables is provided in table 7. The dataset for the total season has 1,830 observations and the dataset for the peak season has 930

[14] The predicted flow value was in log form when it was predicted, following a similar specification by Yoder et. Al (2014). The predicted values were exponentiated to display the flow values in cubic feet per second, which are used in the final model. More detailed information on the first stage regression and how predicted values were generated can be found in Appendix C.

observations. The total shoulder season has 900 observations, with 660 observations in the early shoulder season and 240 observations in the late shoulder season. The number of observations used in the analysis will be limited to competitive lottery days, which will be discussed further in Chapter 5.

Figure 7 below shows the average number of daily first choice applications received from 2004 through 2018 through the total float season from April through October. Figures 8-11 show the average number of daily first choice applications received each month from April-July over the 2004-2018 data period. Figures 12-15 show the average daily water flow for each month from April-July from 2004 to 2018. Figures 16-19 show the average daily maximum air temperature for each month from April-July from 2004 to 2018.

Table 1. Variable Descriptions.

Variable	*Observation Level*	*Description*	*Source*
Applications	Daily	Total number of first choice permit applications.	Smith River Launch Choice Reports
Outfitter Day	Daily	Indicator variable for days when two commercially outfitted groups can launch (Wed. and Sun.)	Smith River State Park
Air Temperature	Daily	Daily maximum air temperature, White Sulphur Springs Weather Station	National Oceanic and Atmospheric Administration (NOAA)
Flows	Daily	Daily average river flows, cubic feet per second. Smith River below Eagle Creek near Fort Logan, MT gauge.	United States Geological Survey (USGS)

Table 2. Summary Statistics - Total Season Data (April-July)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Applications - Daily	1,830	53.23	61.68	0	345
Outfitter Day	1,830	0.29	0.45	0	1
Lagged Air Temp	1,830	66.41	15.42	19	100
Average Air Temp	1,830	66.37	12.83	37.6	91.8
Predicted Air Temp	1,830	66.85	11.28	41.02	91.7
Lagged Flows	1,830	476.55	444.22	50	3820
Average Flows	1,830	463.29	312.89	77	1545.4
Predicted Flows	1,830	440.27	338.66	46.75	2014.06

Notes: Lagged Air Temp and Flows represent a one-year lag. Average Air Temp and Average Flows represent a five-year moving average. Predicted Air Temp and Flows are calculated from first stage regressions.

Table 3. Summary Statistics - Peak Season Data (May 15th-July 15th)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Applications - Daily	930	92.18	64.74	0	345
Outfitter Day	930	0.29	0.45	0	1
Lagged Air Temp	930	70.81	12.11	36	98
Average Air Temp	930	70.94	8.79	51.4	91.8
Predicted Air Temp	930	71.20	6.81	57.62	90.49
Lagged Flows	930	646.46	546.67	76	3820
Average Flows	930	633.79	342.88	107.4	1545.4
Predicted Flows	930	578.83	375.07	71.93	2014.06

Notes: Lagged Air Temp and Flows represent a one-year lag. Average Air Temp and Average Flows represent a five-year moving average. Predicted Air Temp and Flows are calculated from first stage regressions.

Table 4. Summary Statistics - Total Shoulder Season (April - May & July)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Applications	900	12.99	14.82	0	99
Outfitter Day	900	0.29	0.45	0	1
Lagged Air Temp	900	61.86	17.08	19	100
Average Air Temp	900	61.65	14.54	37.6	90.4
Predicted Air Temp	900	62.35	13.07	41.02	91.70
Lagged Flows	900	300.64	178.92	50	1360
Average Flows	900	287.11	128.58	77	712.2
Predicted Flows	900	297.10	218.14	46.75	1384.36

Notes: Lagged Air Temp and Flows represent a one-year lag. Average Air Temp and Average Flows represent a five-year moving average. Predicted Air Temp and Flows are calculated from first stage regressions.

Table 5. Summary Statistics - Early Shoulder Season (April 1st-May 14th)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Applications	660	14.90	15.53	0	87
Outfitter Day	660	0.29	0.45	0	1
Lagged Air Temp	660	53.65	11.22	19	82
Average Air Temp	660	53.46	5.79	37.6	69.8
Predicted Air Temp	660	55.00	5.17	41.02	70.39
Lagged Flows	660	353.01	171.99	93	1360
Average Flows	660	334.49	113.33	139.2	712.2
Predicted Flows	660	346.55	229.41	91.41	1384.36

Notes: Lagged Air Temp and Flows represent a one-year lag. Average Air Temp and Average Flows represent a five-year moving average. Predicted Air Temp and Flows are calculated from first stage regressions.

Table 6. Summary Statistics - Late Shoulder Season (July 16th-July 31st)

Variable	N	Mean	Std. Dev	Minimum	Maximum
Applications	240	7.71	11.07	0	99
Outfitter Day	240	0.29	0.45	0	1
Lagged Air Temp	240	84.46	7.15	55	100
Average Air Temp	240	84.19	2.72	75.8	90.4
Predicted Air Temp	240	82.57	3.10	75.32	91.70
Lagged Flows	240	156.64	102.26	50	650
Average Flows	240	156.83	59.42	77	352.6
Predicted Flows	240	161.10	92.53	46.75	443.92

Notes: Lagged Air Temp and Flows represent a one-year lag. Average Air Temp and Average Flows represent a five-year moving average. Predicted Air Temp and Flows are calculated from first stage regressions.

Figure 7. Average number of First Choice Applications, Daily

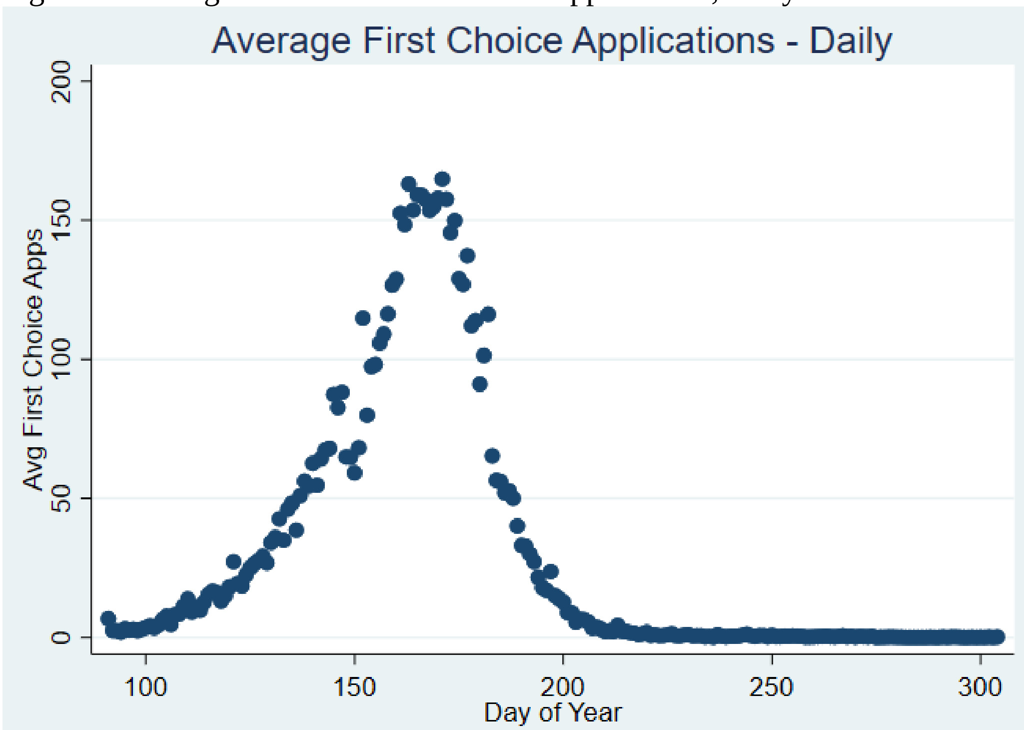


Table 7. Correlation Matrix of Variables

	Apps	Lag Flow	Avg Flow	Predict Flow	Lag Temp	Avg Temp	Predict Temp	Outfit Day
Apps.	1.00	-	-	-	-	-	-	-
Lag Flow	0.31	1.00	-	-	-	-	-	-
Avg Flow	0.61	0.64	1.00	-	-	-	-	-
Predict Flow	0.53	0.34	0.46	1.00	-	-	-	-
Lag Temp	0.17	-0.14	-0.08	-0.07	1.00	-	-	-
Avg Temp	0.17	-0.11	-0.13	-0.08	0.83	1.00	-	-
Predict Temp	0.17	-0.06	-0.07	-0.18	0.76	0.92	1.00	-
Outfit Day	-0.04	0.00	0.00	-0.00	-0.01	-0.00	-0.00	1.00

Figure 8. Average Number of April Applications, Yearly

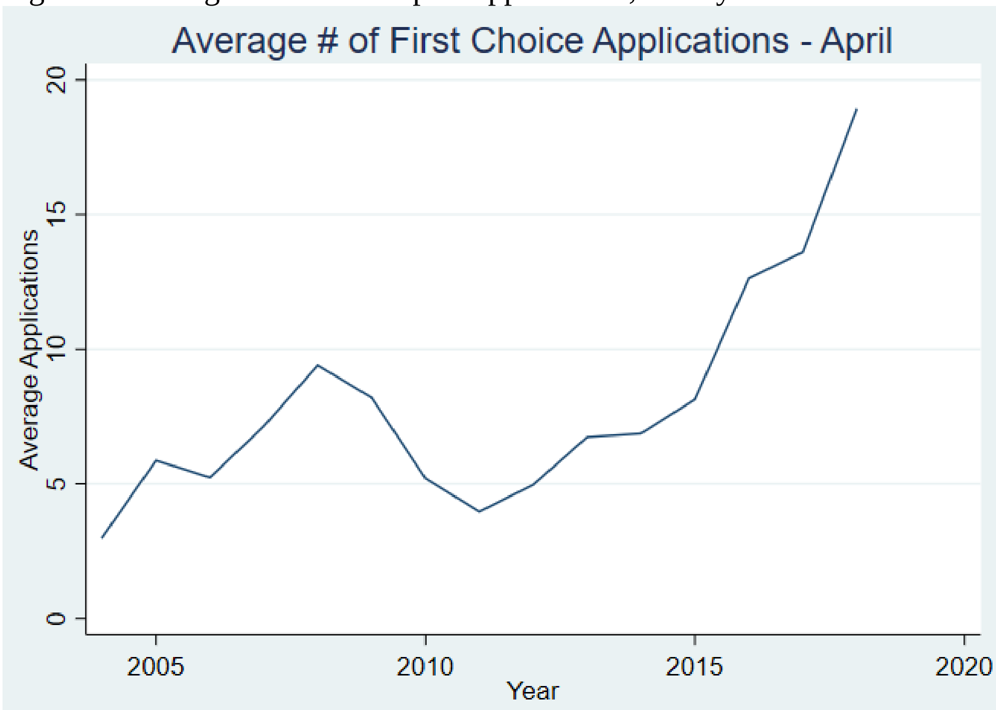


Figure 9. Average Number of May Applications, Yearly

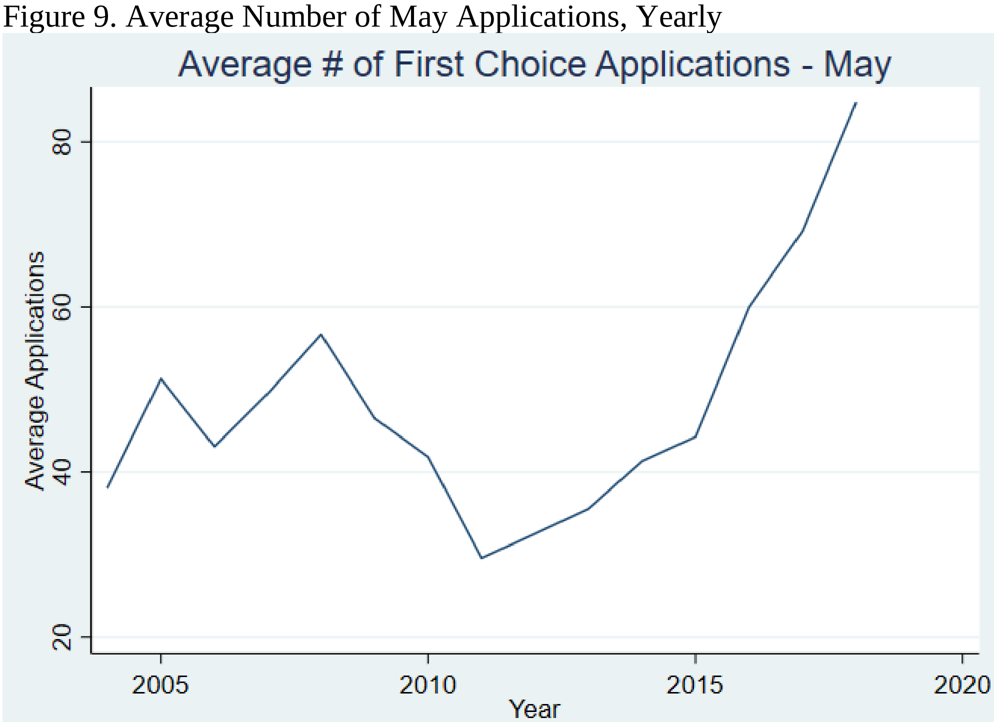


Figure 10. Average Number of June Applications, Yearly

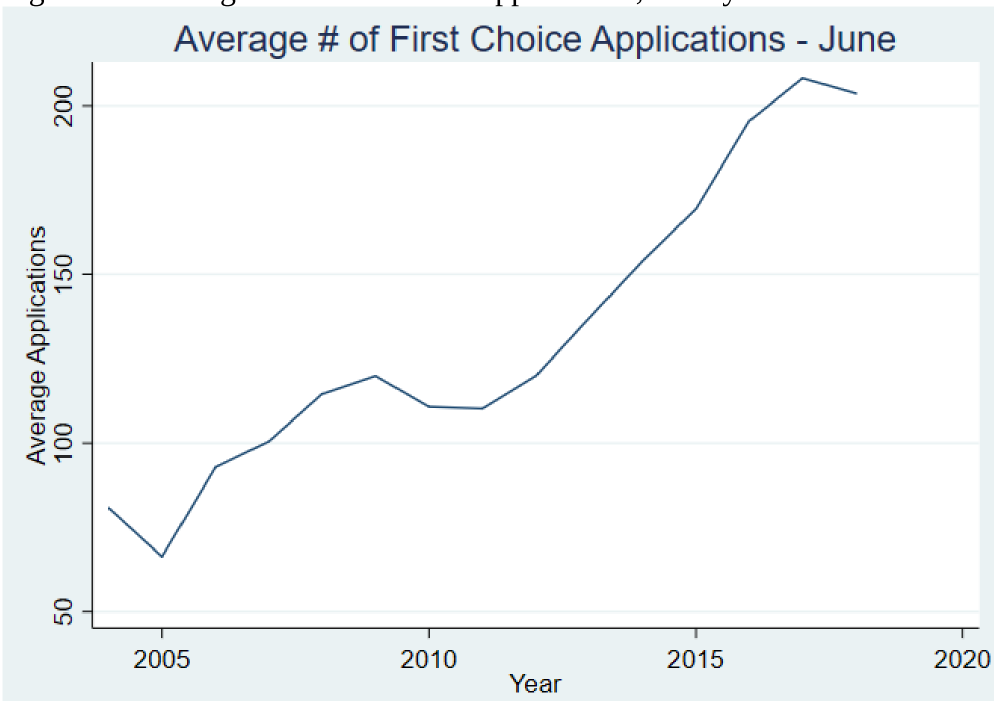


Figure 11. Average Number of July Applications, Yearly

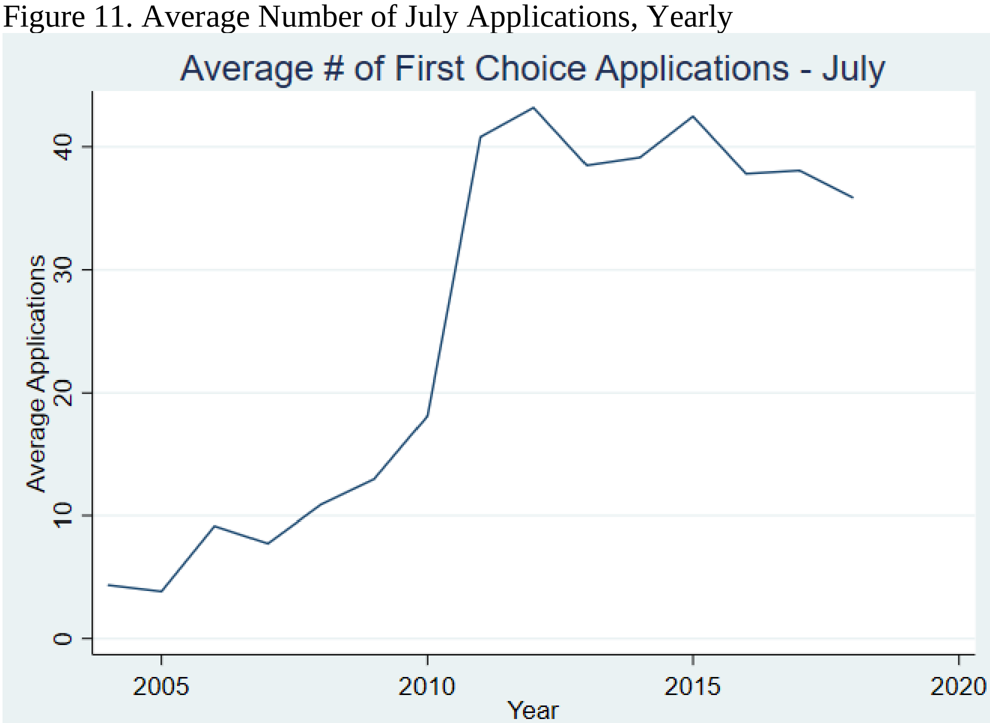


Figure 12. Average April Flows (cfs), Yearly

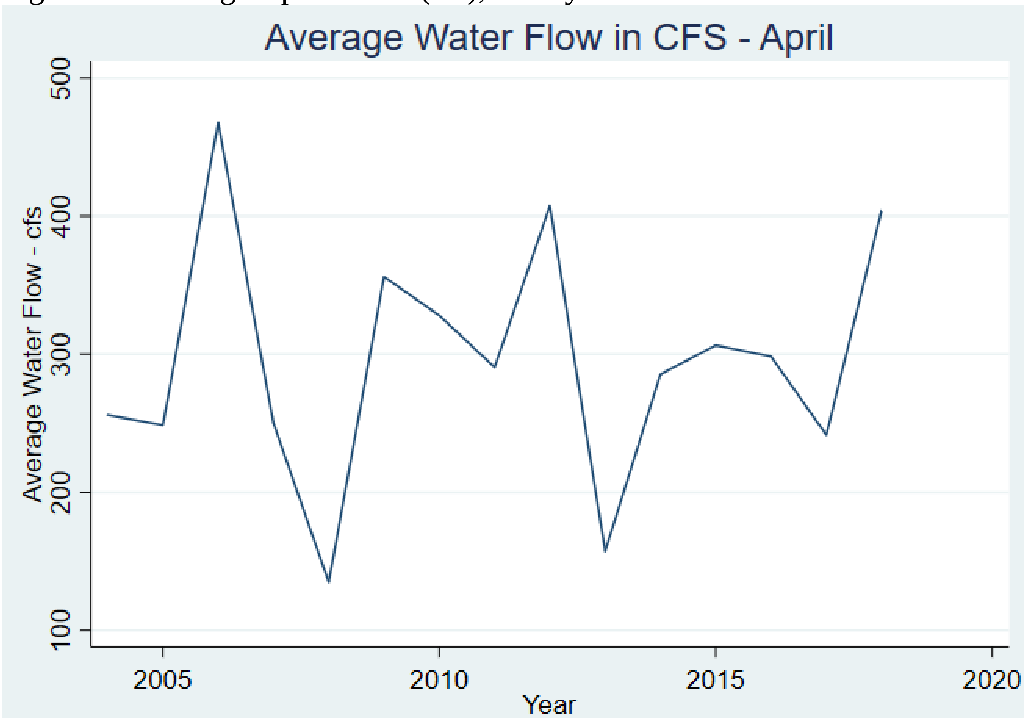


Figure 13. Average May Flows (cfs), Yearly

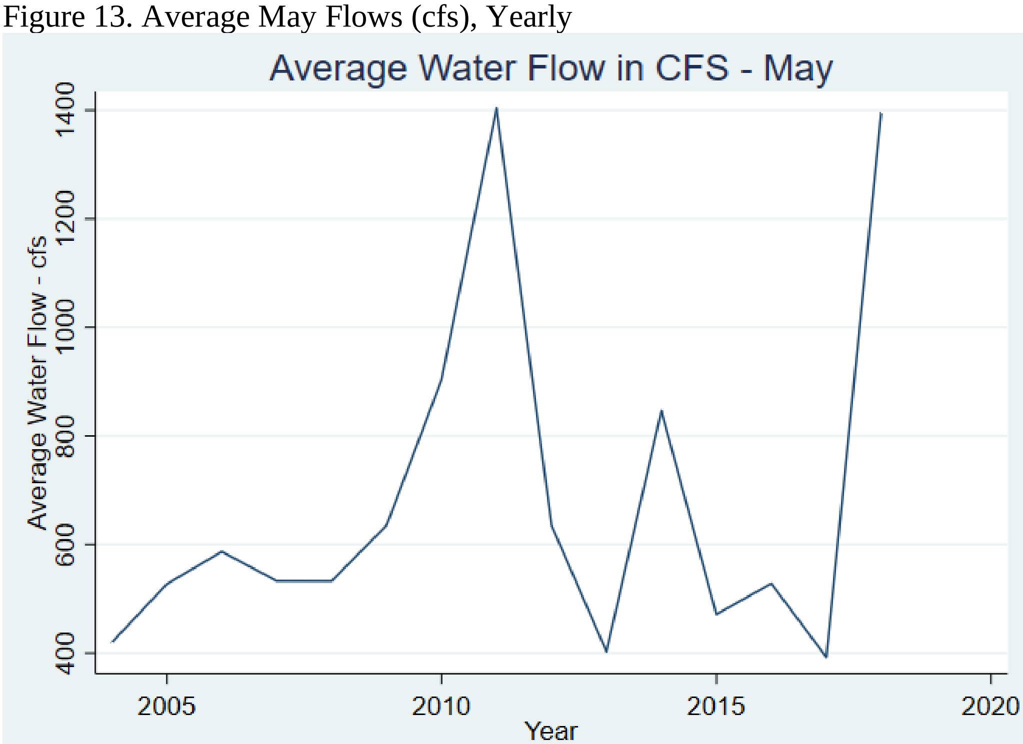


Figure 14. Average June Flows (cfs), Yearly

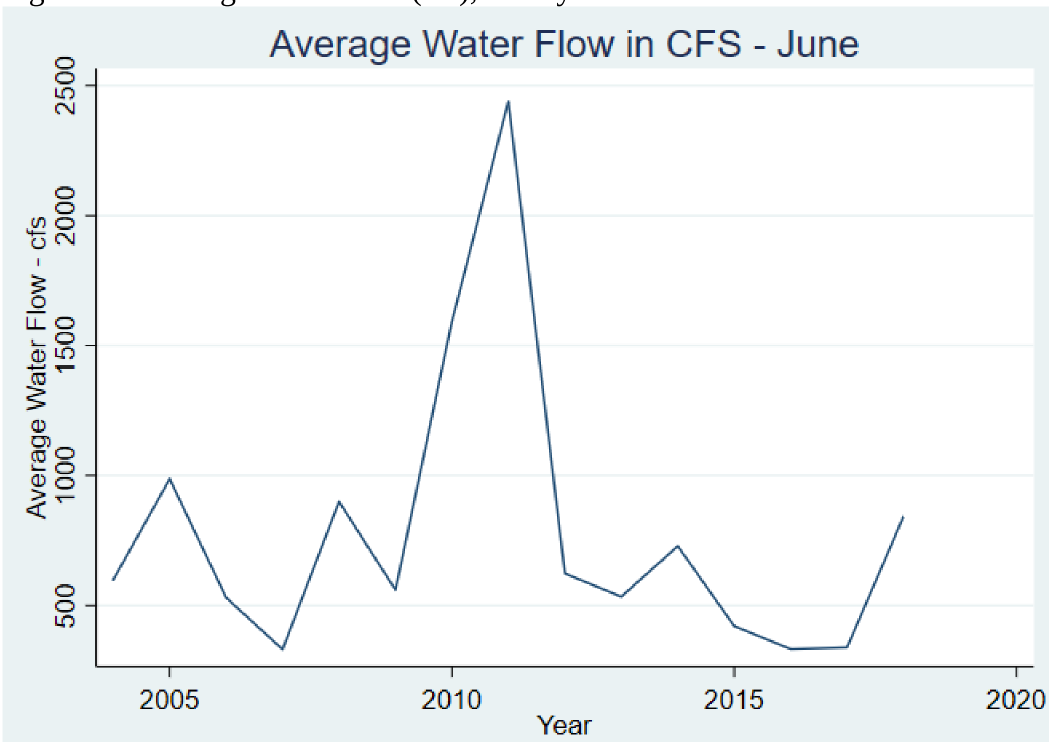


Figure 15. Average July Flows (cfs), Yearly

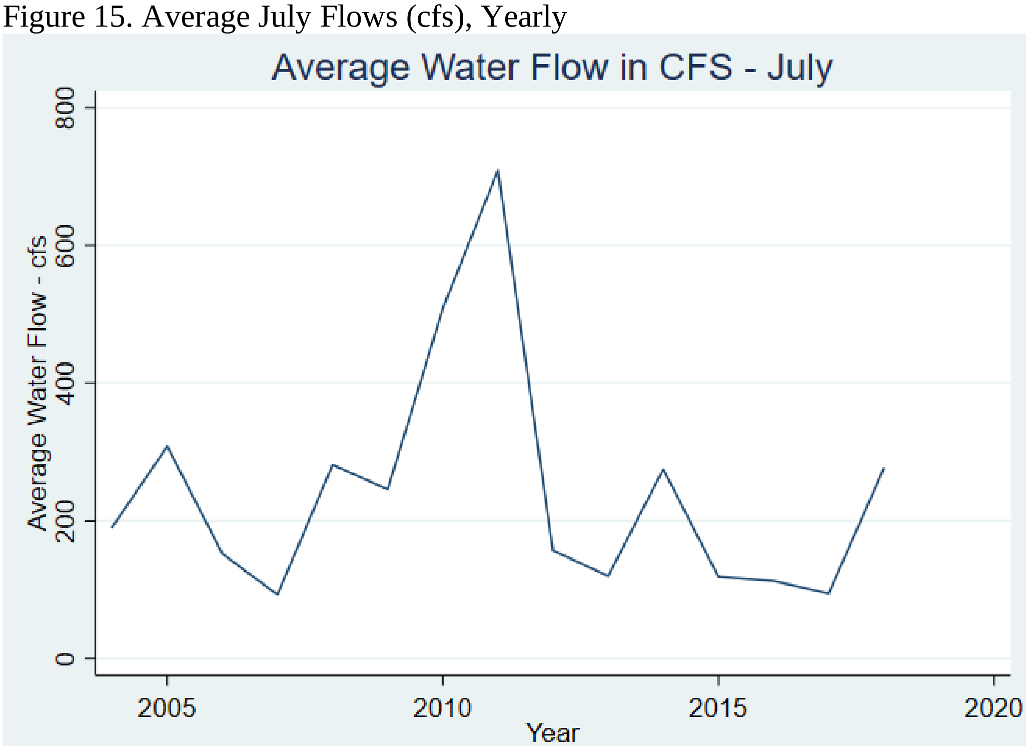


Figure 16. Average April Temperature (Fahrenheit), Yearly

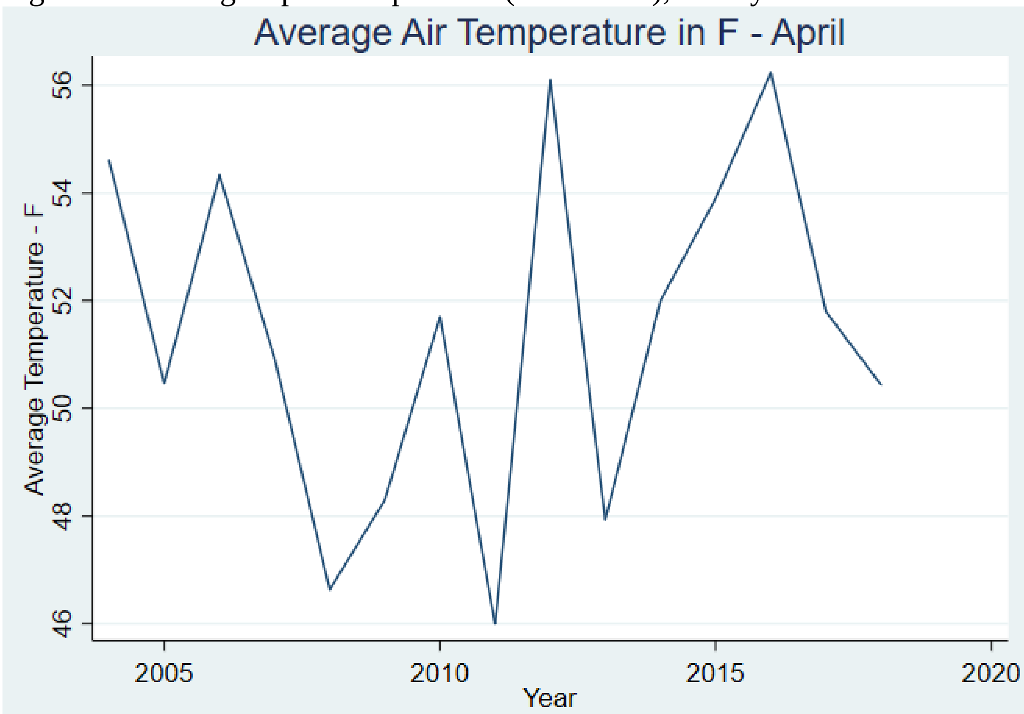


Figure 17. Average May Temperature (Fahrenheit), Yearly

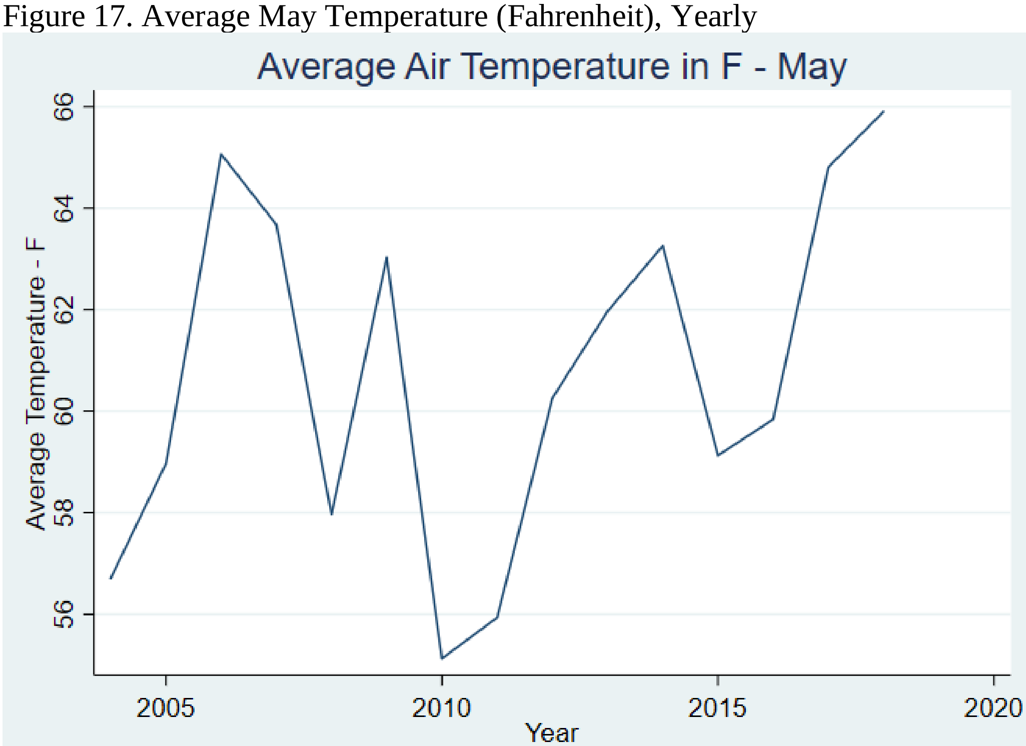


Figure 18. Average June Temperature (Fahrenheit), Yearly

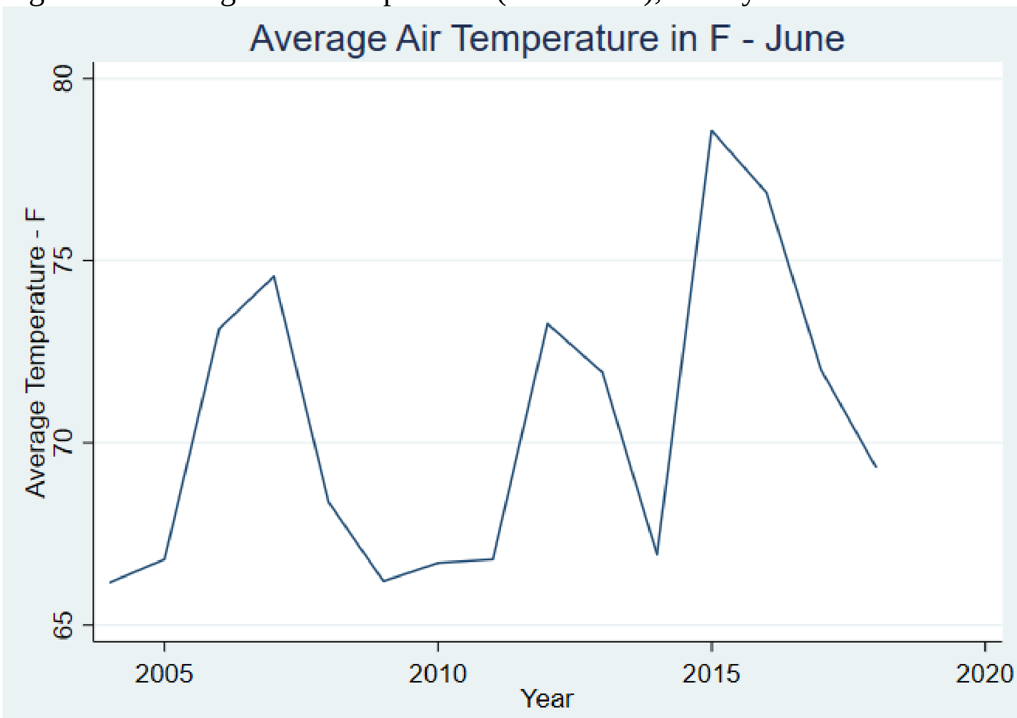
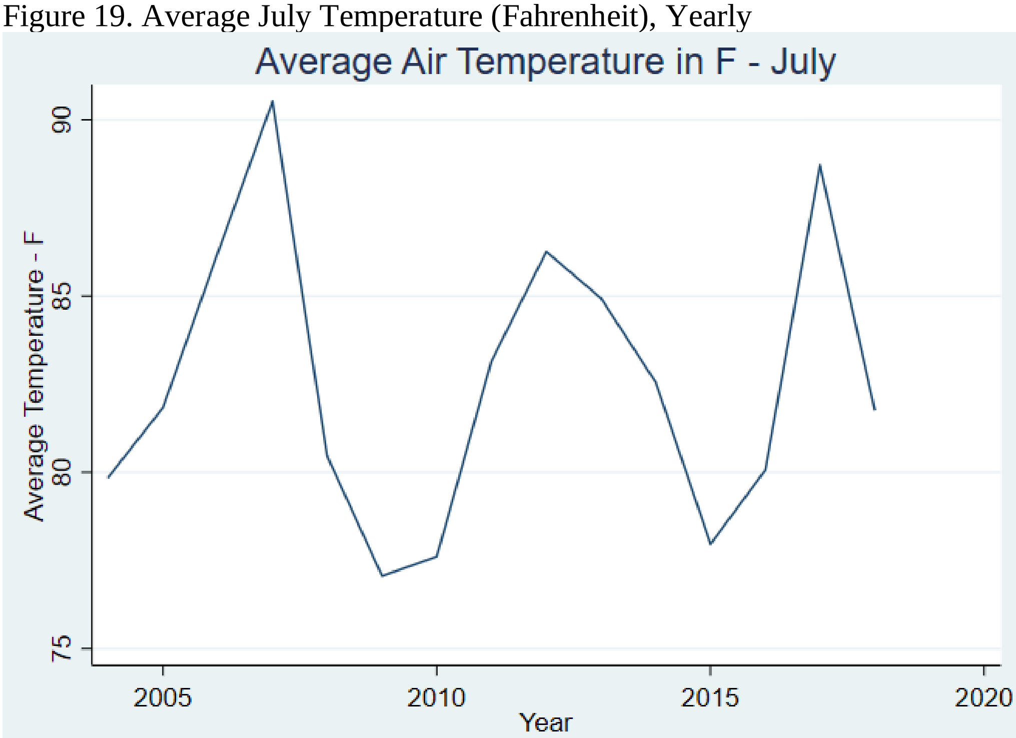


Figure 19. Average July Temperature (Fahrenheit), Yearly



CHAPTER FIVE

EMPIRICAL STRATEGY

The empirical analysis for Smith River lottery applications is presented by separating the analyses between total, peak and shoulder float seasons as a result of application rates differing greatly across the float season and the Smith River management having a defined "peak" float season. Results will be presented for the total season, peak season (May 15th-July 15th), total shoulder season, early shoulder season (April 1st-May 14th) and late shoulder season (July 16th-July 31st). The data for these analyses are for the float seasons from 2004-2018. The primary variable of interest is the outfitter day variable, which indicates a day where two commercially outfitted groups may launch, as opposed to one outfitted group on other days for the months of May-July. The month of April does not have any outfitter launch allocations, so the value of the outfitter variable is always zero during April.

Although the official float season for the lottery system is from April 1st-October 31st, the analysis is limited to the months of April through July because application rates from August through October are generally so low that the lottery becomes non-competitive, meaning that applicants are almost always guaranteed to win if they apply during this time.[15] The purpose of this analysis is to identify the variation in application

[15] The flows from August-October are usually too low for floating, which is why application rates are always low in this period. On years with higher than average flows, people will acquire permits for these late season days through the Smith River Permit hotline, which is unobserved in the data for this thesis.

rates on competitive float days where the number of applications exceeds the supply of permits available, which all lie in the months of April through July.

Even within the main part of the float season, there are often times where the number of applications in the shoulder seasons (generally in April and late July) are lower than the supply of permits available, which indicates a non-competitive day. These non-competitive days do not provide insight into how applications respond to changes in supply because the application numbers are lower than the supply, and therefore would not respond to a change.[16] Because my interest is in highly competitive days where application rates could respond to supply changes or outfitter use, I limit my analysis to days where the number of applications is greater than the supply of permits available. To avoid bias, I drop all days previous to the last non-competitive day for each float season.[17]

Given that the application data are in the form of counts, represented as the number of people who apply for a given float day, a count model is preferred over a classic OLS model because count models account for the fact that the response variable in the regression is a non-negative integer that is generally skewed to the left. OLS models with a log transformation of the dependent variable may be used, but this method is usually an inferior approach to other count data models, however initial OLS results

[16] For this to be true, applicants would need to know that these days have fewer applicants than permits available, which is not the case. My method, however, simply cuts off the ends of the dataset to include only continuously competitive days, which does not rely on the applicants understanding specifically which days will be competitive.

[17] For example, if April 15th received 6 applications, April 16th received 20 applications, April 17th received 6 applications and April 18th and each day after received more applications than supply of permits was available, then each day previous to April 18th would be dropped, even though April 16th had received a competitive number of applications.

are shown in Appendix D. The starting point in analyzing count data is the Poisson distribution and Poisson model (Cameron and Trivedi, 2009).

Although the Poisson is the starting point for count data, it is often too restrictive, necessitating the use of an alternative model. A primary assumption of the Poisson model is equidispersion, or equality of the variance and mean. Count data, however, frequently break this assumption and feature overdispersion, or the variance exceeding the mean. If overdispersion is present, a Negative Binomial model is preferred to the Poisson.

Overdispersion tests for the Smith River application data are statistically significant, leading to the use of a Negative Binomial model for this analysis.[18] Interestingly, overdispersion in count data is often due to the failure of the assumption of independence of events, which is another assumption of the basic Poisson model (Cameron and Trivedi, 1999). Dependence in count data is introduced when the occurrence of one event makes subsequent events more likely, which is frequently the case in lottery applications for floating the Smith. Applicants frequently coordinate with potential group members on which days to apply for to increase the probability that their group acquires the desired float day. In other words, one person applying for a float day leads other potential group members to also apply for that day, which models dependence and provides an additional reason for using the negative binomial over the Poisson.

[18] The Negative Binomial model contains a dispersion parameter, alpha, which indicates overdispersion is present if it is statistically significantly different from zero.

The regression equation for the main analysis is specified in equation (15), and is estimated using a Negative Binomial model:

(15) $Applications_{it} = \beta_0 + \beta_1 \cdot flowcfs_{it} + \beta_2 \cdot flowcfs2_{it} + \beta_3 \cdot airtemp_{it} + \beta_4 \cdot airtemp2_{it} + \beta_5 \cdot outfitday_{it} + Z_t + \varepsilon_{it}$

where $Applications_{it}$ is first choice lottery applications on day *i* of year *t*, $flowcfs_{it}$ is the predicted average flows, five year moving average flows, or one year lagged flows in cubic feet per second (cfs) on day *i* of year *t*, $airtemp_{it}$ is the predicted maximum air temperature, five year moving average maximum air temperature, or one year lagged maximum air temperature in degrees Fahrenheit on day *i* of year *t*, and $outfitday_{it}$ is an indicator variable that takes on the value of one on Sundays and Wednesdays when two commercially outfitted trips can launch on a float day and zero otherwise. Commercial outfitters are not allocated launches in April, so $outfitday_{it}$ is always zero during that month. Year dummies are represented by Z_t and the error term for day *i* in year *t* is ε_{it}. The year dummies account for unobserved characteristics of each float season.

Application numbers are likely heavily influenced by expected flows and temperature, and in general, should increase as flows and temperatures rise. A linear model would not be a good representation of the relationship between flows/temperature and application rates, however, because there are points at which additional flows and higher temperature may begin to reduce the enjoyment of floating. To capture the diminishing marginal effects of flow and temperature on application rates, a quadratic functional form is used, which allows the calculation of maximum or minimum flow and temperature levels where the marginal effects of increased flow and temperature actually begin to decrease application rates. The maximum/minimum is found at the point:

(16) $$x_{max} = \beta_1/(-2*\beta_2)$$

where x_{max} represents either flow or temperature. This point is found by taking the partial derivative of the regression equation with respect to flow or temperature, and it provides a useful coefficient interpretation of the preferred flows and temperatures for potential river users.

Outfitter vs. Supply Testing Model

As discussed in the theoretical chapter, beginning in May (relative to April), launch spots are allocated to outfitters on each day, which decreases the supply of permits available to lottery applicants by two on Wednesday and Sunday, and one on all other days of the week for the rest of the season. Similarly, in late July there are also outfitter launch allocations that decrease the supply of permits available to lottery applicants. Because of this, as discussed previously, it is difficult to distinguish between outfitter effects and supply effects. The usage of outfitter launches by outfitters in early May and late July before and after the peak season is extremely low, however, with an average of a total of only 2.9 outfitted groups launching in the whole two-week period in early May, according to data from the float seasons from 2007 to 2018. In late July, outfitter use is even lower, with only 2% of all outfitter days between 2007 to 2018 being used by outfitters. Alternatively, outfitter use of the late May and early July peak season outfitter launch allocations is quite high.

To test if there is a response to what are essentially only supply changes, and thus supply effects, in early May and late July, separate analyses testing the months of May and July individually are conducted. Based on the discussion of outfitter use above, I use the peak season cutoffs in these months to run regressions testing if there is a response in application rates between early and late May and early July and late July. This model will also be estimated using the Negative Binomial because the dependent variable is the daily number of applications, which are counts. The regression equation for May is displayed below in equation (17):

$$Applications_{it} = \beta_0 + \delta \cdot LateMayDummy_{mt} + \lambda \cdot OutfitDay_{it} + \beta_1 \cdot LateMayDummy_{mt} x OutfitDay_{it} + Z_t + \Theta_{it} + \varepsilon_{it} \tag{17}$$

Where $Applications_{it}$ is the number of applications on day i of year t, $LateMayDummy_{mt}$ is a dummy variable that takes on a value of one in late May (May 15th-31st) when there is high outfitter use and zero in early May (May 1st-14th), $OutfitDay_{it}$ is a dummy variable equal to one on days in which two outfitters can launch and zero otherwise, and it tests the early May supply effects. $LateMayDummy_{mt} x OutfitDay_{it}$ is an interaction between the late May dummy and outfitter dummy variables that is equal to one if two outfitters can launch in late May, and zero otherwise. This variable is testing the effects of actual outfitter use in late May relative to the response to the outfitter allocations in early May, which are representative of supply effects measured by $OutfitDay_{it}$. If the outfitter effects are greater than the supply effects, the estimated coefficient for the interaction should be negative. The total effects of supply and outfitters is found by adding the coefficients λ and β_1. Z_t are year dummies that account for differences between float seasons, Θ_{it} is a control for daily weather and river characteristics such as flow and temperature that may also influence application rates, and ε_{it} is the error term. The flow and temperature variables use the quadratic functional form and predicted values used in equation (15).

The regression equation for July is displayed below in equation (4):

(18) $$Applications_{it} = \beta_0 + \delta \cdot EarlyJulyDummy_{mt} + \lambda \cdot OutfitDay_{it} + \beta_1 \cdot EarlyJulyDummy_{mt} x OutfitDay_{it} + Z_t + \Theta_{it} + \varepsilon_{it}$$

Where $Applications_{it}$ is the number of applications on day i of year t, $EarlyJulyDummy_{mt}$ is a dummy variable that takes on a value of one in early July (July 1st-15th) when there is high outfitter use and zero in late July (July 16th-31st), $OutfitDay_{it}$ is a dummy variable equal to one on days in which two outfitters can launch and zero otherwise, and it tests the late July supply effects. $EarlyJulyDummy_{mt}xOutfitDay_{it}$ is an interaction between the early July dummy and outfitter dummy variables that is equal to one if two outfitters can launch in early July, and zero otherwise. This variable is testing the response to actual outfitter use in early July relative to the response to the outfitter allocations in late July, which are representative of supply effects measured by $OutfitDay_{it}$. If the outfitter effects are greater than the supply effects, the estimated coefficient for the interaction should be negative. The total effects of supply and outfitters is found by adding the coefficients λ and β_1. Z_t are year dummies that account for differences between float seasons, Θ_{it} is a control for daily weather and river characteristics such as flow and temperature that may also influence application rates, and ε_{it} is the error term. Once again, the flow and temperature variables use the quadratic functional form and predicted values used in equation (15).

CHAPTER SIX

RESULTS

The empirical results for my analyses will be presented by separating float seasons as follows. First, results from the total season regression will be presented. Next, peak season regressions will be discussed, followed by shoulder season regressions. The shoulder season regressions will be broken down into three parts, beginning with the total shoulder season, followed by early shoulder season results, and finally, late shoulder season results. Of primary interest are the results for the peak season regressions. Peak season is when a majority of the outfitter use occurs and when private float parties are most likely to encounter commercial parties as a result of launching on the same day as a commercial group and consequently interacting with them throughout their float trip. Therefore, the estimated coefficient on outfitter day is of particular interest because it will show whether there is significant avoidance of days where two outfitted parties can launch rather than only one, which could be attributed to the outfitter effect or supply effect, discussed further below.

As mentioned in the theoretical discussion, it is unclear whether a reduction in applications on days when two outfitter launches are allowed could be attributed to outfitter avoidance or to the change in supply of permits available to lottery applicants on those outfitter days. Because outfitter use in the shoulder seasons is low, the main shoulder season regression results do not provide as much insight into the outfitter day variable from an outfitter and private group conflict standpoint. As a result of the low outfitter use, however, the outfitter day variable is representative of a supply change from unused outfitter launch allocations and may provide an indication of whether applicants respond to supply effects.

Each table below contains four columns, which represent separate regressions with alternative forms of the flow and temperature variables, and year dummies. Columns (1) and (3) are regressions that use the five year moving averages, and columns (2) and (4) are regressions that use the predicted values from first stage regressions. Columns (3) and (4) are the regressions that include year dummies, which are shown to explain more of the variation in the model according to likelihood ratio tests. Results using the lagged values of flow and temperature are not presented because initial testing indicated that they explained a substantially smaller amount of variation in application rates and are likely not representative of how applicants generate expectations. Alpha is the dispersion parameter from the Negative Binomial regression, and statistical significance greater than zero of this parameter indicates the presence of overdispersion. In the negative binomial regression model, the coefficients are interpreted as a semi-elasticity, so a unit change in the independent variable will lead to a $\beta \cdot 100$ percent change in applications.

I include results for the regressions with both the five-year moving averages and predicted values for flow and temperature because I assume that applicants' decision process takes into account multiple years of previous information about river conditions. It is plausible that many applicants conduct a substantial amount of research on characteristics to try and determine the best day to float, which would imply that the predicted values are most representative of applicant behavior. Other applicants may do considerably less research. A five-year average is plausible, because five years of previous data are fairly easy to obtain and would allow applicants to get a good general picture of what to expect for a float trip on the Smith River.

Total Season Results

The results for the total season analysis are presented in table 8. These results are presented first to provide a baseline for the analysis, and represent a view of how application rates are determined throughout the entire float season, although they are of less interest than the results for the peak season and shoulder season individually because of the significant differences between the peak and shoulder seasons. A Chow test for the difference between the peak season and shoulder season indicate that there are statistically significant structural differences between the two seasons, which provides justification for focusing primarily on the separate analyses that follow.

In the two regressions of primary interest, represented by columns (3) and (4), the variable for outfitter day is negative and statistically significant at the one and five percent levels, indicating that on the two days where two outfitter parties may launch, application rates are about 10 percent lower than on the other five days of the week. The estimated coefficients for water flow in column (4) suggest that application rates increase at a diminishing rate as flows increase up to a peak of 1,559 cubic feet per second (cfs) and will then start to decrease as expected flows rise higher than these. Also, the estimated coefficients for air temperature in column (4) imply that as temperatures increase, application rates will increase at decreasing rate up to 80 degrees Fahrenheit, and then will decrease after applicants' expectations for temperature increase above that level.

Table 8. Total Season Results (April-July)

VARIABLE: Applications	(1)	(2)	(3)	(4)
Water Flow (cfs)	0.00306***	0.00201***	0.00496***	0.00421***
	(0.000238)	(0.000180)	(0.000241)	(0.000241)
Water Flow^2	-1.31e-06***	-6.47e-07***	-1.86e-06***	-1.35e-06***
	(1.39e-07)	(9.09e-08)	(1.37e-07)	(1.06e-07)
Temperature (°F)	0.336***	0.600***	0.0982***	0.366***
	(0.0382)	(0.0381)	(0.0332)	(0.0455)
Temperature^2	-0.00223***	-0.00406***	-0.000426*	-0.00227***
	(0.000275)	(0.000278)	(0.000243)	(0.000336)
Outfitter Day	-0.104**	-0.0998***	-0.0997***	-0.102***
	(0.0418)	(0.0378)	(0.0324)	(0.0331)
Constant	-9.260***	-18.31***	-1.989*	-13.05***
	(1.289)	(1.276)	(1.106)	(1.452)
Observations	1,135	1,135	1,135	1,135
Year Dummies	N	N	Y	Y
Alpha	0.324***	0.311***	0.227***	0.239***
Pseudo R^2	0.0488	0.0529	0.0828	0.0778

Notes: Estimates are reported with standard errors in parentheses. Water flow represents the predicted daily mean flow. Temperature represents the predicted daily maximum air temperature. (1) and (3) use five year moving averages for flow and temperature. (2) and (4) use predicted values for flow and temperature generated from first stage regressions. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days analyzed. * $p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Peak Season Results

The peak season results are presented in table 9 and are the results of primary interest because of the high outfitter use during this time. Once again, regressions (3) and (4) are the most important results because likelihood ratio tests show that year dummies are important, and that the five-year moving averages and predicted values for flow and temperature yield similar results.

The estimated coefficient for outfitter day is statistically significant at the 1 percent level and negative across all regression specifications, with outfitter days receiving 11.7 percent fewer applications according to (3) and 10.3 percent fewer applications according to (4). Insofar as outfitter effects are important, this is expected for the peak season because this is when a majority of commercially outfitted trips float, so private float parties can reasonably expect to see at least one commercial group on their trip. The average group size for an outfitted trip is around 13 group members, compared to only about eight members for a private party. Therefore, on days when two outfitters can launch, private launch members can expect to be on the river with two parties of over 13 people, in addition to the other private parties that also launched on that day. It is likely that most of the group members on a guided trip will be fishing because all of the commercial outfitters are fishing outfitters. Additionally, guides generally know the river and campsites better, so private members who are fishing will be competing for prime fishing water with guides, and are more likely to lose out on the most desirable campsite reservations to commercial parties as well. It is also possible that these negative coefficients could be attributed to there being a smaller supply of permits on outfitter days, but this will be discussed in further detail later.

The variable for water flow is statistically significant at the 1 percent level, which is consistent with our prior that this factor is extremely relevant in determining float day choice. Using the quadratic coefficient of the regression, lottery applications will increase at a decreasing rate up until flows reach 1,692 cfs according to regression (4).[19] The flow peak is somewhat high, and some may argue that these flows are too high to realistically be able to fish. Many river users, however, do not fish (or are not serious about fishing), and float for the scenic beauty of the landscape. Flows at these peak levels allow for a fairly quick and easy float because there will not be many gravel bars exposed and any type of boat is able to make it down the river without issue. High flows do, however, present other dangers such as strong and unpredictable currents, potential for floating debris, and larger rapids. Additionally, fishing conditions can be highly variable. Rainstorms can muddy the river overnight, and weather conditions and water temperatures are also highly influential on fishing conditions, so it would be unreasonable to assume that flows are the only factor that affect fishermen. Unfortunately, these other variables are unobserved in the data, and simply represent some of the risk of applying for a Smith River permit as a fisherman desiring perfect conditions.

The temperature variables for both the regressions of interest are also highly significant, indicating that applicants attempt to apply for the days in which they perceive

[19] Quadratic coefficient peaks for regressions can be found in Appendix C.

the most desirable weather conditions. Temperature quadratic coefficients indicate that applications will increase at a decreasing rate up to 76 degrees Fahrenheit for regression (4), and then decrease as temperatures rise above this peak.

Finally, it should be reiterated that the temperature values come from the nearest weather station with available data, in White Sulphur Springs, which lies in an open valley approximately 30 miles from the Smith River launch point at Camp Baker where temperatures could be somewhat different. The shade from the canyon walls and microclimates within the region are likely to lead to slightly different temperatures on the river than in a wide-open valley, so the quadratic coefficients may not be perfectly representative of the temperatures in the Smith River canyon.

Table 9. Peak Season Results (May 15th – July 15th)

VARIABLE: Applications	(1)	(2)	(3)	(4)
Water Flow (cfs)	0.00243***	0.00142***	0.00404***	0.00369***
	(0.000260)	(0.000208)	(0.000288)	(0.000319)
Water Flow^2	-1.05e-06***	-3.63e-07***	-1.42e-06***	-1.09e-06***
	(1.47e-07)	(9.94e-08)	(1.52e-07)	(1.23e-07)
Temperature (°F)	0.299***	0.749***	0.192***	0.746***
	(0.0394)	(0.0598)	(0.0368)	(0.0607)
Temperature^2	-0.00200***	-0.00511***	-0.00111***	-0.00488***
	(0.000282)	(0.000418)	(0.000266)	(0.000426)
Outfitter Day	-0.116***	-0.109***	-0.117***	-0.103***
	(0.0441)	(0.0402)	(0.0348)	(0.0353)
Constant	-7.445***	-23.29***	-4.872***	-26.55***
	(1.361)	(2.136)	(1.259)	(2.168)
Observations	876	876	876	876
Year Dummies	N	N	Y	Y
Alpha	0.310***	0.299***	0.222***	0.227***
Pseudo R^2	0.0231	0.0266	0.0546	0.0522

Notes: Estimates are reported with standard errors in parentheses. Water flow represents the predicted daily mean flow. Temperature represents the predicted daily maximum air temperature. (1) and (3) use five year moving averages for flow and temperature. (2) and (4) use predicted values for flow and temperature generated from first stage regressions. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days are included in this analysis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Shoulder Season Results

Shoulder season results are presented below in tables 10-12. Table 10 provides insight into the shoulder season as a whole and is a useful starting analysis. A Chow test for structural differences between the early and late shoulder seasons was significant, therefore justifying separate analyses for each of the seasons. Table 11 shows results from the early shoulder season, and table 12 shows late shoulder season results. Early shoulder season float days are frequently cold, and can have highly fluctuating flows and variable weather conditions. Late shoulder season days are generally hot with lower water flows, typical of mid to late July. As mentioned previously, the regression results of interest are in columns (3) and (4). It will be useful to focus on the separate analyses for early and late season because of the significant differences between them.

The total shoulder season results for regressions (3) and (4) in table 10 show that the variable for outfitter days is insignificant. These results are likely not attributed to the outfitter effect because of the fact that outfitters generally do not launch during the shoulder season, so there is no reason to avoid the higher outfitter use days during this time for that reason. Trip data from the Camp Baker Journal confirm that outfitters use of the shoulder season is extremely low, with only occasional trips taken in early May, and an even smaller number of outfitter trips taken in July.[20] Additionally, applicants have access to the outfitter launch calendar for the upcoming season during the application

[20] The Camp Baker Journal data were provided by Colin Maas (Smith River State Park Manager). The Journal has data on number of groups and people launching each day of the float season. The average number of trips taken by outfitters in early May is 2.9 (out of 18 possible trips), a considerably low number compared to the high use in the peak season.

period via the Smith River website, so they can check this to see which days outfitters are scheduled to launch before they apply. These results therefore suggest that the response to supply effects is insignificant, which will be discussed in further detail in the early and late shoulder season results discussion.

The variables for water flow and air temperature are statistically significant at the 1 percent level for both regressions (3) and (4), confirming that expectations for flows and weather are important to applicants in the shoulder seasons, as they are in the peak season. Applications increase at a decreasing rate up to 1,252 cfs according to (4). Flows are typically lower in the shoulder season than in peak season because the shoulder seasons occur in pre and post runoff periods, although if there are warm temperatures or rain early in the spring, runoff can happen early, which would increase flows in the early shoulder season.

Quadratic coefficient values for temperature are not statistically significant for (4) and represent a minimum value rather than a maximum. The minimum in (4) is found at 38 degrees, which implies that application rates will always increase for temperatures higher than that level.

Early Shoulder Season Results

The early shoulder season stretches from the opening of the permitted float season on April 1st and "ends" on May 14th, when the official peak season for the Smith River starts. Because the analysis is focused on competitive lottery days, and many days in April do not receive a sufficiently high number of applications to be considered competitive, many days in April are dropped from the analysis, as discussed in Chapter 5.

Additionally, as mentioned previously, the outfitter variable for the April days that remain in the analysis always takes on a value of zero because no outfitter trips are allocated until May.

The variable for outfitter day in regression (4) in table 11 is not statistically significant and is fairly low in magnitude compared to the peak season, indicating that application numbers decrease by 3.3% on days in which there are two outfitter launches allocated, relative to days in which only one launch is allocated. The coefficients for outfitter day in the other early shoulder regressions are all negative but lack statistical significance and are low in magnitude as well. These findings indicate that there is no statistical response to outfitter allocations in the early shoulder season, which, given the fact that outfitter use is extremely low, suggest that there is not a significant response to the supply effect at this time. Additionally, a Wald test indicates that the estimated coefficient for outfitter day from regression (4) in the peak season is statistically significantly different from the estimated coefficient for outfitter day in (4) during the early shoulder season, providing evidence that there is some response to outfitter launch allocations in the peak season that could be attributed to the outfitter effect.[21] These findings will be discussed in further detail in the discussion section below.

The coefficients for water flows for the early shoulder season are statistically significant at the one percent level and indicate that applications will increase at a decreasing rate up to 1,276 cfs according to (4) in table 11. This value is very similar to

[21] The Wald test was conducted using the Stata test command after the peak season regression, specifically testing if outfitter day from the peak season was equal to the estimated coefficient for outfitter day from the early shoulder season. I rejected the null hypothesis that they were equal, thus confirming a statistical difference.

the findings from the total shoulder season results. In the early part of the float season, flows can vary greatly depending on a variety of weather and snowpack factors. If the spring is warm, snowpack may melt early, leading to high flows. On the other hand, springtime weather may be cold, which will lead to the snowpack in the mountains melting off later and lower winter-like flows.

The temperature coefficient in the early shoulder season regression (4) has the same interpretation as a minimum rather than a maximum, as in total shoulder season regression (4), but is statistically significant at the 10% level. In regression (4), the minimum lies at 55 °F and implies that applications will increase as temperatures rise above this point. Temperatures during the early shoulder season tend to be quite a bit colder than during other parts of the float season, so it makes sense that the temperature quadratic coefficient is low, and that application numbers generally rise as temperatures increase.

Late Shoulder Season Results

The late shoulder season for this analysis is defined from July 16th, when the peak season ends, until July 31st. After July 31st, application rates are low, with there often being zero or one application, and acquiring a permit through the lottery is not difficult. In fact, the late shoulder season days did not start to become competitive until the 2011 float season, so only competitive days in late July since 2011 are analyzed. After 2011, late shoulder season days have become more popular, leading to many of the late July days being competitive since then. As a result of only including the competitive days in the analysis, the late shoulder season analysis has a lower number of observations compared to other parts of the season.

As can be seen in table 12, the outfitter day variable is negative and is not statistically significant in any of the regressions, although the magnitude of the coefficient is more substantial than in the early shoulder season. In regression (4), the outfitter day coefficient indicates that application numbers decrease by 6.4 percent on days where there are two outfitter allocations relative to only one. Outfitters almost never plan trips late into July because of the risk of low flows and poor fishing conditions, so it is unlikely that this finding is attributed to outfitter effects. According to the most recent outfitter launch calendar, there are no outfitters that have dates reserved after July 12th.[22] Therefore applicants who try for a permit during this time are unlikely to be too concerned about outfitter competition and crowding during the application period, and are more likely responding to supply effects. Finally, a Wald test for the statistical difference between the outfitter day coefficient in the peak season and the outfitter day coefficient in the late shoulder season indicates that they are not statistically different, which suggests that the supply effect in the late shoulder season is not statistically different from the outfitter effect in the peak season. The Wald test was conducted using the same method as the Wald test between the peak and early shoulder season outfitter coefficients.

[22] The outfitter launch calendar is available on the Smith River State Park website, and shows which outfitters are scheduled to launch on specific days throughout the season. Outfitter dates are set prior to the closing of the lottery. An example of the launch calendar can be found in Appendix B.

Response to water flow remains highly statistically significant at the 1 percent level for the late shoulder season and indicates that applications increase until flows reach 506 cfs for regression (4). This result also suggests that applications would decrease if flows were to increase beyond this point, which could raise some speculation about its validity. It would be reasonable to assume that application rates would continue to increase if flows were higher than the value above, but during the late shoulder season, flows rarely rise above this value, so applicant expectations are that flows will be lower, which is reflected in lower application rates during this time. Because a reservation hotline is available, any available dates during this time on a high-water year are likely to be taken up through the hotline after more information on the real time flows is available. Finally, the data simply do not have any observations with high flow predictions in the late shoulder season, so the values from the quadratic formula are lower as a result of this fact. The results simply reflect applicant expectations during the application period.

In the regressions of interest, the temperature coefficients are insignificant, indicating that temperature may not be a deciding factor in late shoulder season application decisions. This is unsurprising because of the generally consistent temperatures in July in central Montana. Daily maximum temperatures tend to be in the 70s and 80s, favorable temperatures for floating, and are unlikely to deviate much from that during this time. Therefore applicants do not have to predict which days they perceive to have the most ideal temperatures because of the general lack of variation in daily maximums during this time.

Table 10. Total Shoulder Season Results (April 1st – May 14th & July 16th – July 31st)

VARIABLE: Applications	(1)	(2)	(3)	(4)
Water Flow (cfs)	0.00342**	0.00112**	0.00845***	0.00649***
	(0.00147)	(0.000459)	(0.00152)	(0.000949)
Water Flow^2	-2.39e-06	-2.05e-07	-5.17e-06***	-2.59e-06***
	(1.59e-06)	(3.03e-07)	(1.54e-06)	(4.87e-07)
Temperature (°F)	0.113**	0.192***	-0.112**	-0.0468
	(0.0545)	(0.0475)	(0.0532)	(0.0653)
Temperature^2	-0.000764*	-0.00136***	0.00105***	0.000614
	(0.000400)	(0.000344)	(0.000406)	(0.000500)
Outfitter Day	-0.0323	-0.0132	-0.0169	-0.0462
	(0.0647)	(0.0617)	(0.0501)	(0.0513)
Constant	-1.563	-3.606**	4.257***	0.197
	(1.802)	(1.633)	(1.618)	(1.986)
Observations	260	260	260	260
Year Dummies	N	N	Y	Y
Alpha	0.168***	0.151***	0.100***	0.109***
Pseudo R^2	0.0221	0.0332	0.0737	0.0655

Notes: Estimates are reported with standard errors in parentheses. Water flow represents the predicted daily mean flow. Temperature represents the predicted daily maximum air temperature. (1) and (3) use five year moving averages for flow and temperature. (2) and (4) use predicted values for flow and temperature generated from first stage regressions. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days analyzed. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 11. Early Shoulder Season Results (April 1st – May 14th)

VARIABLE: Applications	(1)	(2)	(3)	(4)
Water Flow (cfs)	0.000884	0.00125**	0.00910**	0.00743***
	(0.00244)	(0.000513)	(0.00356)	(0.00131)
Water Flow^2	-4.76e-08	-2.62e-07	-5.92e-06*	-2.91e-06***
	(2.48e-06)	(3.33e-07)	(3.49e-06)	(6.59e-07)
Temperature (°F)	-0.263	-0.271*	-0.259*	-0.323*
	(0.182)	(0.148)	(0.144)	(0.183)
Temperature^2	0.00254*	0.00258**	0.00233*	0.00291*
	(0.00154)	(0.00124)	(0.00123)	(0.00154)
Outfitter Day	-0.00720	-0.00690	-0.0116	-0.0331
	(0.0716)	(0.0623)	(0.0551)	(0.0531)
Constant	9.695*	9.867**	8.303**	7.896
	(5.293)	(4.417)	(4.134)	(5.288)
Observations	209	209	209	209
Year Dummies	N	N	Y	Y
Alpha	0.160***	0.138***	0.0967***	0.0889***
Pseudo R^2	0.0232	0.0383	0.0730	0.0791

Notes: Estimates are reported with standard errors in parentheses. Water flow represents the predicted daily mean flow. Temperature represents the predicted daily maximum air temperature. (1) and (3) use five year moving averages for flow and temperature. (2) and (4) use predicted values for flow and temperature generated from first stage regressions. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days analyzed. *$p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Table 12. Late Shoulder Season Results (July 16th – July 31st)

VARIABLE: Applications	(1)	(2)	(3)	(4)
Water Flow (cfs)	-0.0137**	0.0126**	0.0110	0.0251***
	(0.00560)	(0.00599)	(0.0108)	(0.00483)
Water Flow^2	3.76e-05***	-2.13e-05*	4.11e-07	-2.48e-05***
	(1.32e-05)	(1.14e-05)	(2.08e-05)	(7.42e-06)
Temperature (°F)	-3.257**	-1.262	-0.248	1.260
	(1.374)	(2.538)	(0.917)	(2.248)
Temperature^2	0.0194**	0.00791	0.00151	-0.00767
	(0.00829)	(0.0154)	(0.00546)	(0.0136)
Outfitter Day	-0.0692	-0.0924	-0.0562	-0.0604
	(0.115)	(0.130)	(0.0803)	(0.0774)
Constant	140.7**	51.80	10.96	-51.99
	(56.95)	(104.6)	(39.35)	(93.07)
Observations	51	51	51	51
Year Dummies	N	N	Y	Y
Alpha	0.0920	0.149	0.0348	0.0447
Pseudo R^2	0.0738	0.0264	0.151	0.136

Notes: Estimates are reported with standard errors in parentheses. Water flow represents the predicted daily mean flow. Temperature represents the predicted daily maximum air temperature. (1) and (3) use five year moving averages for flow and temperature. (2) and (4) use predicted values for flow and temperature generated from first stage regressions. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days analyzed. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Test of Supply vs. Outfitter Effects

As discussed, it is difficult to distinguish whether the outfitter day coefficient is picking up the effects of outfitter conflict or supply changes on application numbers. In the peak season analysis, the coefficient for the outfitter variable is negative and statistically significant, which is consistent with the theoretical comparative statics results that show that an increase in outfitters decreases application rates, and also that a decrease in supply decreases application rates. I cannot definitively say, however, whether the finding in the main analysis that application rates are statistically significantly lower can be attributed to the outfitter effect, or to the supply effect, or a combination of both.

In the early and late shoulder season results, Wald tests for the difference between the outfitter coefficients in the peak and shoulder seasons indicate that the early shoulder season outfitter coefficient is statistically different from the peak season coefficient but that the late shoulder season coefficient is not statistically different from the peak season. Additionally, the late shoulder season outfitter coefficient is larger in magnitude than the early shoulder season, indicating that there may be some level of supply response in the late season. This analysis will provide further clarity into what may be driving those results by testing the months of May and July individually using regression specifications (17) and (18) from Chapter 5. Results are presented in Table 13 below, where column (1) shows results from the May regression and column (2) shows results from the July regression.

Table 13: May and July Tests

VARIABLE: Applications	(1)	(2)
Late May Dummy	0.355***	-
	(0.0786)	
Early July Dummy	-	-0.052
		(0.106)
Outfitter Day	-0.076	-0.075
	(0.0594)	(0.101)
Late May x Outfitter	-0.193**	-
	(0.079)	
Early July x Outfitter	-	0.110
		(0.116)
Constant	12.180***	4.430*
	(3.502)	(2.428)
Observations	432	221
Year Dummies	Y	Y
River Characteristics	Y	Y
Alpha	0.131***	0.196***
Pseudo-R^2	0.0902	0.147

Notes: Robust standard errors in parentheses. The July test uses data from 2011-2018. Previous to 2011, late July days were not competitive. River characteristics added in (2) are the quadratic functions of the predicted values for flow and air temperature. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. *$p < 0.10$, ** $p < 0.05$, ***$p < 0.01$.

Recall that outfitter use is very low in early May and late July despite there being outfitter launch allocations. Results from the May regression indicate that application rates on days in which two outfitters can launch in late May are a statistically significant 19.3 percent lower than days in which two outfitters can launch in early May, which is the outfitter effect. This suggests that applicants are significantly responding to the outfitter effect in late May relative to early May when outfitter allocations are measuring the supply effect. The outfitter day coefficient, which represents the supply effect, in column (1) is an estimate of the effects of days in which two outfitters can launch in early May in this regression. The coefficient for this variable shows that application rates are 7.6 percent lower on days in which two outfitters can launch in early May due to the supply effect, and it is not statistically significant using a two-tailed test but is significant using a one-tailed test at the 10 percent level, which is appropriate given the prior expectation that this coefficient should be negative.

The outfitter effect on application numbers of 19.3 percent suggests that there is significant avoidance of outfitter days during the late May peak season due to outfitter use, relative to the early May shoulder season dates that show supply effects. This finding is consistent with the peak season results in the main analysis and is also consistent with the Wald test that shows the outfitter day coefficient in the early shoulder season is statistically different from the outfitter day coefficient in the peak season. This analysis shows that there is some small level of response to supply effects in early May, but that the outfitter effect is larger and more significant. The late May dummy is also positive and statistically significant, indicating that application rates increase in late May relative to early May, which is expected given the increased popularity of the peak season.

The primary results from the July regression are not statistically significant, but indicate that application rates are 11 percent higher on days in which two outfitters can launch in early July relative to late July. Although this finding is not consistent with the expectation that the coefficient for the early July-outfitter day interaction term would be negative, it is consistent with the Wald test from the main analysis that shows that the outfitter coefficient in the peak season in column (4) of table 9 is not statistically different from the outfitter coefficient in column (4) of table 12 in the late shoulder season main analysis. Additionally, it is important to note that application numbers are lower in July relative to application numbers in May. In late July, the average number of applications is about 23, so an 11 percent difference is only about 2.5 applications, which is not substantial. In July, application numbers also steadily decrease throughout the month, so it is possible that this finding is partly picking up the fact that there are more applications in early July due to other reasons than outfitter presence or supply effects.

The coefficients for the early July dummy variable and outfitter day variable are also not significant. Although there are no statistically significant responses to the supply effect in late July that are found, there is also no statistical difference between the early July peak season and late July shoulder season according to this test and the Wald test from the main analysis. Therefore, it is possible that there may be some level of response to the outfitter allocations in late July and during the peak season that could be attributed to a small supply effect. The implications of these findings will be examined in the discussion section further below.

Robustness Checks

To test the robustness of the findings in the main analysis with respect to the outfitter variable, I re-specify the model using two separate methods. First, instead of using weather and river characteristics as control variables, I add week and month dummies into the model to replace the weather controls.[23] The week and month dummies being used as a robustness check should theoretically account for much of the same variation in the model as the weather and river characteristics, and thus should yield similar coefficient estimates for the outfitter variable as in the primary model. The second method I use is to replace the outfitter variable with day of the week dummies. Because the coefficient of the outfitter variable indicates that application rates are lower on average on Wednesday and Sunday, I should also find that the coefficients on the day of week dummies for Wednesday and Sunday are generally lower on average relative to other days of the week as well. The day of week dummies may also provide other interesting information on application rates for other days of the week.

Results for the first robustness check are presented in table 14, with each column representing a regression for a different part of the float season. As in the main analysis, the outfitter day variable remains negative and displays statistical significance at the 1 percent level during the peak season. Additionally, the coefficient is of very similar magnitude as the main analysis results. The coefficient for the peak season shows that application rates are about 12.9 percent lower, on average, on days in which two outfitters can launch, compared to about 11 percent lower based on main analysis results. The shoulder season outfitter coefficients are similar in magnitude to the coefficients in the main analysis results, and similarly are not statistically significant.

[23] I also tested this robustness check without month dummies, under the assumption that the same variation explained by month dummies would simply be explained by week dummies alone. I found, however, that month dummies explain some of the variation in the model and are therefore included.

The results for the second robustness check using day of week dummies are shown in table 15, with each column once again representing a separate part of the float season. Of primary interest once again are the results for the peak season because of the highest outfitter use occurring during those times. In the regressions, the omitted dummy variable is Sunday, so I would expect that in general, that the coefficients for all other days of the week be statistically significantly positive under the assumption that applicants are avoiding outfitter days.[24] I would also expect that Wednesday's coefficient would display a smaller coefficient on average than the other days of the week.

According to columns (1) and (2) in table 15, the coefficient for Wednesday is smaller than all the other days of the week except for Tuesday and Saturday, with values of 0.187 and 0.174 for the total season and peak season, respectively. In a calculation of the average difference of the Wednesday and Sunday coefficients to all other days of the week, I find that the coefficients for Wednesday and Sunday are about 9.7 percent lower on average from all other days, which is consistent with the findings from the main analysis. The coefficients for Tuesday and Saturday are smaller than all other coefficients, with Saturday's being shown to receive less applications relative to Sunday, although these findings are not statistically significant.

The fact that application rates are lower on weekends, as well as on Tuesdays, is interesting. Because the supply of permits on each day is known and is relatively similar across all days of the week (other than days in which two outfitters may launch), theoretically application rates on the weekend should be somewhat similar to weekdays.

[24] The exception to this is Wednesday, which is the other outfitter day. The coefficient for Wednesday may be positive or negative depending on if the avoidance of outfitter days is higher on Wednesday or Sunday.

A plausible explanation for lower weekend application rates could be that applicants are attempting to minimize the number of workdays missed from taking a Smith River trip. A majority of river users are Montana residents, so it is not unreasonable to assume that resident permit holders would be able to minimize the number of workdays missed because of the relative ease at which they can get to and from the Smith River. As a result of the river being located directly in Central Montana, it is only a few hours from most of the major population centers in the state, meaning that it is possible for resident permit holders to get off work in the afternoon, drive to the river, and be able to launch the next day. Because of that ability, launching on a weekend day would not make sense, because two to four days of the next work week would be missed if a trip began on Saturday or Sunday, which may be one reason application rates are lower then. In relation to that fact, application rates are the highest on Thursday. If a resident permit holder can leave Wednesday after work, launch Thursday, and complete their float in 4 days (which is possible and frequently done by river users), then they can be back to work by Monday and have only missed two workdays at the end of the week.

This is one plausible explanation for the findings from table 15, and these are based on the strategy used by a past resident permit holder who I have had discussions with. Without more detailed level individual level data, it is difficult to say exactly why application rates are found to be lower on weekends and Tuesdays. For the applicant attempting to apply on days with the highest probability of winning during the peak season, however, this information may be valuable given that it reveals which days receive the lowest number of applications.

Table 14. Robustness Check 1

VARIABLE: Applications	(1) Total	(2) Peak	(3) Shoulder	(4) Early Shoulder	(5) Late Shoulder
Outfitter Day	-0.119***	-0.129***	-0.0725	-0.0459	-0.107
	(0.0264)	(0.0294)	(0.0547)	(0.0551)	(0.0936)
Constant	2.467***	3.547***	2.660***	2.544***	3.207***
	(0.187)	(0.0896)	(0.176)	(0.168)	(0.145)
Observations	1,135	876	260	209	51
Year Dummies	Y	Y	Y	Y	Y
Month Dummies	Y	Y	Y	Y	Y
Week Dummies	Y	Y	Y	Y	Y
Alpha	0.155***	0.161***	0.110***	0.0837***	0.0944***
Pseudo-R^2	0.117	0.0826	0.0653	0.0849	0.0738

Notes: Robust standard errors in parentheses. Testing the robustness of the outfitter day variable by replacing weather variables with week, month and year dummy variables. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days analyzed. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 15. Robustness Check 2

VARIABLE: Applications	(1) Total	(2) Peak	(3) Shoulder	(4) Early Shoulder	(5) Late Shoulder
Monday	0.296***	0.285***	0.320***	0.284***	0.413***
	(0.0536)	(0.0574)	(0.0888)	(0.0919)	(0.116)
Tuesday	0.0478	0.0623	-0.0354	-0.0322	-0.0867
	(0.0520)	(0.0551)	(0.0973)	(0.112)	(0.151)
Wednesday	0.187***	0.174***	0.182**	0.238***	-0.0526
	(0.0522)	(0.0565)	(0.0828)	(0.0909)	(0.134)
Thursday	0.482***	0.485***	0.381***	0.462***	0.0210
	(0.0533)	(0.0564)	(0.0886)	(0.0939)	(0.136)
Friday	0.189***	0.205***	0.107	0.189**	-0.306**
	(0.0531)	(0.0580)	(0.0821)	(0.0913)	(0.147)
Saturday	-0.0775	-0.0832	-0.0718	-0.0317	-0.209*
	(0.0543)	(0.0590)	(0.0868)	(0.101)	(0.122)
Constant	-2.384**	-4.850***	3.309**	7.766**	93.56***
	(0.985)	(1.172)	(1.423)	(3.024)	(32.64)
Observations	1,135	876	260	209	51
Year Dummies	Y	Y	Y	Y	Y
Alpha	0.199***	0.193***	0.0776***	0.0693***	2.81e-08***
Pseudo-R^2	0.0950	0.0668	0.0961	0.101	0.230

Notes: Robust standard errors in parentheses. Testing the robustness of the outfitter day variable by replacing it with day of week dummies. Alpha is the dispersion parameter, statistical significance indicates overdispersion is present. Only competitive lottery days are analyzed. *p < 0.10, ** p < 0.05, ***p < 0.01.

Discussion of Results

The results for the main analysis indicate that there is a statistically significant decrease in application rates by 10.3 percent on days in which two outfitters can launch compared to days where only one outfitted trip may launch in the peak season according to regression (4). These results are further confirmed by similar findings in robustness checks. Additionally, the results with respect to the river characteristics of flow and temperature are consistent with theoretical comparative statics predictions and display quadratic coefficients that make intuitive sense.

The measurement of the impact of outfitter days, as discussed, could be attributed to either a supply change or expected conflict with outfitters, and the coefficient for this variable in the peak season analysis was consistent with comparative statics predictions for both of these variables. In the early and late shoulder seasons, the impact on application rates on outfitter days remained negative but was lower in magnitude and was not statistically significant. The coefficient for regression (4) in the early shoulder season indicates that application rates decrease by only 3.3 percent on days in which two outfitters can launch, and the coefficient from (4) in the late shoulder season indicates a 6.4 percent decrease in application rates. Wald tests indicate that the impact of the outfitter day variable in the peak season is significantly different from the impact of the outfitter day variable in the early shoulder season, but not significantly different from the outfitter day variable in the late shoulder season. These main analysis results provide some evidence that there may be a small but insignificant response in application rates to what are supply effects in the shoulder season, and that there is some level of response to outfitter effects in the peak season. To attempt to gain more clarity on if application rates are responding to supply, further tests were conducted using the shoulder season data where outfitter use is close to zero.

The months of May and July provide data where a comparison can be made between the shoulder season when outfitter use is essentially non-existent, to the peak season where outfitter use is high. Each of these months have the peak season cutoff directly in the middle of the month, with all days after May 15th being considered peak season and all days before July 15th also considered peak season. Therefore, the tests comparing early May to late May and early July to late July provide the best comparisons of what can be considered a supply effect (when outfitter use is very low) to an outfitter effect (when outfitter use is very high).

I find that the supply effect in early May decreases application numbers on days in which two outfitter launches are allowed by 7.6 percent, and that this finding is marginally significant using a one-tailed test. In late May, application numbers on days in which two outfitters can launch statistically significantly decrease by 19.3 percent relative to early May, which is the outfitter effect. This shows that the outfitter effect is more substantial than the supply effect in May, and between the early shoulder and peak seasons.

In July, there is no statistically significant finding that indicates that there is a response to the outfitter effect in early July that is different from the response to the outfitter allocations that represent the supply effect in late July. The coefficient from column (2) of table 13 that shows that application rates are 11 percent greater on days in which two outfitters can launch in early July could be attributed to other factors than outfitter use or supply effects, such as the general decrease in application numbers over the month of July, or lower application numbers in July compared to other months such as May and June.

Overall, when the Wald tests from the main analysis between the peak season and the shoulder seasons are considered with the individual tests of May and July, there is a general consistency in overall findings. The peak season outfitter variable is statistically different from the early shoulder season outfitter variable, and the outfitter effect according to the May regression indicates that application rates decrease by 19.3 percent in the late May peak season time compared to the early May shoulder season time when the supply effect is being measured. On the other hand, the peak season outfitter variable is not statistically different from the late shoulder season outfitter variable, and, according to the July regression, there is no statistically significant outfitter effect in early July compared to the late July supply effect. Altogether, the outfitter effect is larger, and more statistically significant, than the supply effect according to these analyses.

These findings provide some early evidence that commercial use possibly negatively impacts outdoor recreation quality, and that there appears to be some attempted outfitter avoidance by Smith River applicants. I find that the effects of outfitters are larger and more significant than the impacts of supply, which is consistent with the media coverage and proposed management plans that highlight the negative impacts of commercial use and crowding on public resources elsewhere. These results are interesting and are the first to test the effects of commercial use on outdoor recreation, and they suggest that further research to gain more conclusive evidence regarding this question would be valuable.

CHAPTER SEVEN

POST APPLICATION ANALYSIS

Applicants make decisions to apply for a permit based on their expectations regarding river characteristics and floating conditions on the day for which they are applying. Previous literature on public lotteries has mostly focused on analyzing lottery choices based on applicant expectations, given that most data available are based on statistical reports and characteristics from previous lottery years. As far as I know, there are no studies that analyze permit holder decisions post lottery using real time data on characteristics, most likely because of data limitations and lottery structures.[25] The Smith River management keeps a detailed journal, called the Camp Baker Journal, which tracks the number of groups and people that launched on each day of the float season on the Smith River. Access to data from this journal allows the estimation of a post lottery analysis of permit use, which gives insight into how permit use is actually affected by river characteristics and if the results from the main analysis of application rates using expectations for flow and temperature align closely with actual usage and known flows and temperature. This analysis adds to both the revealed preference and recreation demand literature.

[25] The literature on lotteries is primarily made up of hunting lottery analyses. It is unlikely that real time characteristics on hunting lotteries vary as drastically as characteristics do on river lotteries.

Data

The data for the post application analysis are quite similar to the data used in the main analysis. Daily average flow data come from the USGS gauge on the Smith River at Fort Logan. Daily air temperature data are retrieved from a NOAA database that includes the daily maximum, minimum, and average temperatures for White Sulphur Springs, Montana. For this analysis, the daily maximum temperature is used, similarly to the main analysis. The data sources for the flow and weather characteristics are the same sources as were used in the main analysis, however, the real time data are used in this analysis as opposed to the predicted or average values that were used in the main analysis.

The Montana unemployment rate variable is gathered at the monthly level from the Bureau of Labor Statistics and provides insight into how economic conditions during the float season affect usage rates and river recreation. One possibility is that an increase in the unemployment rate could lead to individuals having more leisure time to recreate and float the river, in which case the coefficient would have a positive sign. The other possibility is that an increase in unemployment decreases income and eliminates the possibility for a recreational float trip because the costs make it unaffordable, in which case the coefficient would be negative.

The dependent variable is the usage rate of float days by private floats groups and is created using data from the Camp Baker Journal, and information on the maximum number of private groups that are allowed to launch on each float day. The variable is calculated by dividing the number of private groups that launched, over the maximum number of private group permits allotted in the lottery. To expand, the denominator for this variable is allowed to take on three different values. On every single float day, a maximum of nine groups can launch, which includes both outfitted and private groups, where private groups are defined as groups that applied through the lottery and are floating independently. On Wednesday and Sunday, outfitters are allotted two out of the nine launch slots, and one out of the nine slots on every other day, so the denominator for the usage rate variable is seven on Wednesday and Sunday, and eight on all other days. Additionally, in the month of April, outfitters are not allotted any of the nine launches, so the denominator during April for the usage rate is always nine.

Theoretically, the usage rate variable should range in value between zero and a maximum of one, however, the usage rate occasionally is found to be greater than one. Values above one are not errors, however, but rather indication of private users acquiring float days through the Smith River reservation hotline after the lottery has closed.

Outfitters are given designated launch dates that are not available in the lottery and must follow certain rules if they do not have trips reserved on their designated dates after the public lottery closes. During the months of May, June and July, according to the Smith River Outfitter Calendar and Commercial Launch Rules (2020):

> All commercial float trip launches not reserved by an outfitter will be designated “On Hold” and will not be included in the public lottery. After the lottery, commercial outfitters may utilize available “On Hold” launches 29 or more days in advance of an available date. Commercial outfitters seeking to reschedule a launch to an available date 28 days or fewer from a desired launch date must use the reservation system to request an open launch. All commercial launches not utilized by an outfitter will be available to the public via the reservation system 28 days prior to the launch date.

Therefore, when the usage rate variable takes on a value of greater than one, it is an indication that an individual used the reservation system within 28 days of the launch date to claim an unused outfitter launch. In the analysis, I limit usage rate observations that are greater than one to simply take on a value equal to one so as to simply indicate full usage on that day. Usage is considerably higher during the peak season than in the shoulder season, which is not surprising given that shoulder season dates more frequently exhibit undesirable floating conditions that would lead to trip cancellations. The usage rate in the peak season averages around 77 percent, whereas in the shoulder seasons it averages around 39 percent.

Descriptions for the variables in the post application analysis are in table 1 below. Summary statistics for the total season are in table 2, and summary statistics for the peak season are in table 3. The total shoulder season summary statistics are shown in table 4, early shoulder season summary statistics are in table 5, and late shoulder season summary statistics are in table 6. The dataset for the total season has 1,464 observations and the dataset for the peak season has 744 observations. The total shoulder season dataset has 720 observations, with 528 observations in the early shoulder season and 122 observations in the late shoulder season. Figure 21 below shows the daily average usage rate over the time period of my dataset. The dataset spans the years 2007-2018.

Table 16. Post Application Variable Descriptions.

Variable	*Observation Level*	*Description*	*Source*
Usage Rate	Daily	Rate at which public lottery permits are used	Smith River State Park
Outfitter Day	Daily	Indicator variable for days when two commercially outfitted groups can launch (Wed. and Sun.)	Smith River State Park
Air Temperature	Daily	Daily maximum air temperature, White Sulphur Springs Weather Station	National Oceanic and Atmospheric Administration (NOAA)
Flows	Daily	Daily average river flows, cubic feet per second. Smith River below Eagle Creek near Fort Logan, MT gauge.	United States Geological Survey (USGS)
MT Unemployment Rate	Monthly	Unemployment Rate for the state of Montana	Bureau of Labor Statistics (BLS)

Table 17. Summary Statistics: Total Season

VARIABLES	N	Mean	SD	Min	Max
Water Flow	1,464	515.65	495.3	57	3,820
Air Temp	1,464	66.45	15.49	19	100
Outfitter Day	1,464	0.286	0.452	0	1
Unemployment	1,464	5.140	1.328	3.10	7.40
Usage Rate	1,464	0.584	0.366	0	1.286
Total Groups	1,464	4.949	3.086	0	10

Table 18. Summary Statistics: Peak Season

VARIABLES	N	Mean	SD	Min	Max
Water Flow	744	707.2	592.5	87	3,820
Air Temp	744	71.11	12.08	39	98
Outfitter Day	744	0.286	0.452	0	1
Unemployment	744	5.143	1.305	3.300	7.300
Usage Rate	744	0.770	0.308	0	1.286
Total Groups	744	6.578	2.604	0	10

Table 19. Summary Statistics: Total Shoulder Season

VARIABLES	N	Mean	SD	Min	Max
Water Flow	720	317.8	243.5	57	2,350
Air Temp	720	61.63	17.07	19	100
Outfitter Day	720	0.286	0.452	0	1
Unemployment	720	5.136	1.352	3.100	7.400
Usage Rate	720	0.392	0.320	0	1.143
Total Groups	720	3.267	2.606	0	10

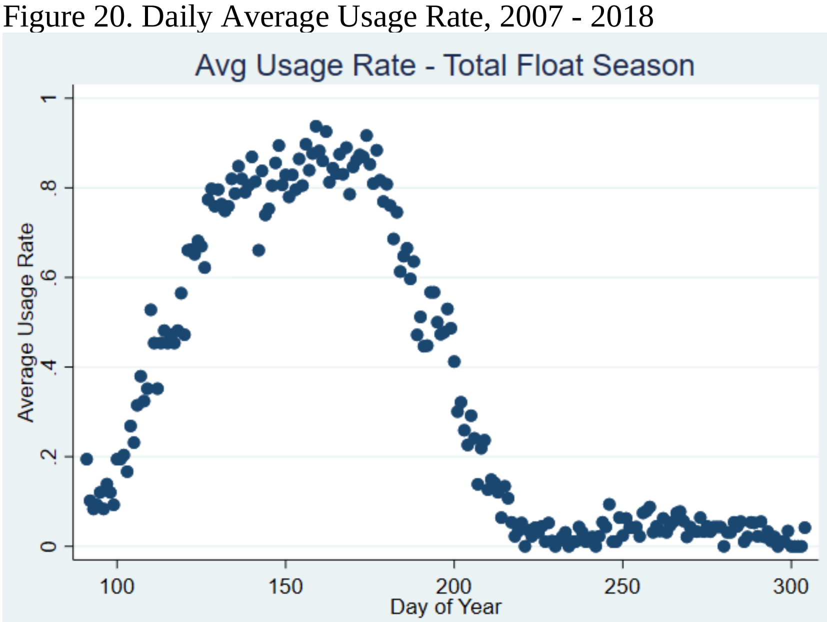
Table 20. Summary Statistics: Early Shoulder Season

VARIABLES	N	Mean	SD	Min	Max
Water Flow	528	373.1	255.3	93	2,350
Air Temp	528	53.56	11.65	19	82
Outfitter Day	528	0.288	0.453	0	1
Unemployment	528	5.131	1.385	3.100	7.400
Usage Rate	528	0.432	0.311	0	1.143
Total Groups	528	3.652	2.547	0	9

Table 21. Summary Statistics: Late Shoulder Season

VARIABLES	N	mean	sd	min	max
Water Flow	192	165.7	108.2	57	650
Air Temp	192	83.85	6.810	55	100
Outfitter Day	192	0.281	0.451	0	1
Unemployment	192	5.150	1.261	3.700	7.200
Usage Rate	192	0.285	0.318	0	1.143
Total Groups	192	2.208	2.475	0	10

Figure 20. Daily Average Usage Rate, 2007 - 2018



Empirical Model and Results

The empirical model for the post application analysis is quite similar to the analysis of applications in the primary model. The primary differences between the two models are that the dependent variable is now permit usage rate rather than number of applications, the flow and temperature variables now represent actual flow and temperature values rather than predicted values, and a measure for the unemployment rate is included. Additionally, because the permit usage rates are not counts, OLS is used to estimate this model, rather than a Negative Binomial that was used for the application data.

The regression equation is displayed in equation (19):

$$(19) \quad UsageRate_{it} = \beta_0 + \beta_1 \cdot flowcfs_{it} + \beta_2 \cdot flowcfs2_{it} + \beta_3 \cdot airtemp_{it} + \beta_4 \cdot airtemp2_{it} + \beta_5 \cdot outfitday_{it} + \beta_6 \cdot MTUnemployment_{mt} + Z_t + \varepsilon_{it}$$

where $UsageRate_{it}$ is the permit usage rate by the public on day i of year t, $flowcfs_{it}$ is the water flow in cubic feet per second (cfs) on day i of year t, $airtemp_{it}$ is the maximum air temperature on day i of year t, $outfitday_{it}$ is an indicator variable that takes on the value of one if two commercially outfitted trips can launch on a float day and zero otherwise, and $MTUnemployment_{mt}$ is the Montana unemployment rate for month m of year t. Year fixed effects are represented by Z_t and the error term for day i in year t is ε_{it}. The year fixed effects account for unobserved characteristics of each float season.

Results for the model are displayed below in table 22, where each column represents results for each sub season within the overall float season. Column (1) shows results for the total season analysis (April-July), column (2) shows peak season results, and columns (3)-(5) display the shoulder season results in order from total shoulder season in column (3), early shoulder season in column (4) and late shoulder season in column (5). As in the main analysis on applications, Chow tests indicate that there are significant differences between the peak season and shoulder seasons, as well as between the early and late shoulder seasons. Therefore, the focus will be on the peak, and early and late shoulder season regressions.

The regression of primary interest is for the peak season because, as discussed previously, that is when river use is the highest for both the public and outfitters. In the main analysis the primary variable of interest was the outfitter day variable because it shows whether application rates decrease from the potential to be competing with two outfitted trips rather than one. The interpretation of this variable for this analysis is slightly different and does not provide as much insight as the main analysis because this analysis is looking at the permit usage rate by permit holders, rather than total number of applications. In each regression specification, the outfitter day variable is not statistically significant, indicating that outfitter days do not significantly affect usage rates.

The fact that outfitter use does not affect usage rates is unsurprising for the post application analysis. It is important to remember that application rates during the peak season generally reach up to several hundred for each day. This means that for each day, every permit available is awarded in the lottery system. It is highly unlikely that an applicant who wins a permit on a day in which two outfitters can launch will cancel their trip solely because of the potential for increased outfitter competition. In theory, the applicants who are extremely worried about outfitter competition would not apply on higher outfitter use days anyway, and this theory is reflected in the statistically significant lower application rates on outfitter days found in the main analysis.

During the peak season, usage rates are shown to increase at a decreasing rate as water flows approach about 1,372 cfs and as maximum daily air temperatures approach 69 degrees. This flow quadratic coefficient is about 250 cfs lower than the quadratic coefficient from the main analysis that uses predicted values for flows. As mentioned in the discussion of the main analysis results, the flow prediction may seem quite high to some, however it is not unrealistic. Flows at this peak level are very high for safely floating the Smith River, and fishing is unlikely to be good at this level. But because obtaining a lottery permit to float the river is so difficult, most people are still likely to use their permit even if flows are too high for good fishing. Additionally, many people do not fish seriously or at all, and the scenic beauty is also one of the main draws to the river. I assume permit holders are unlikely to cancel their permit for reasons related to river characteristics unless conditions are dangerous or if high flows combine with extremely undesirable weather events such as substantial rain or cold.

The temperature quadratic coefficient peak of 69 degrees falls within the range of what many would consider good fishing temperatures. It could also be argued that this temperature is fairly low during the peak season. The low value is likely at this level partly because of the nature of the data. For the time period of my data, the average of air temperature does not reach above 70 degrees until about midway through June, which is slightly more than halfway through the peak float season. Therefore, the lower average temperatures in early May and June are the probable cause of the maximum lying only at 69 degrees. A quick look at the quadratic coefficients for other parts of the float season provides confirmation that usage rates will increase for higher temperatures.[26]

In the primary regression of interest for the peak season, the unemployment rate variable is negative and statistically significant indicating that the income effect is dominating the leisure effect. As unemployment increases, usage rates of permits will decrease according to these regressions.

Interestingly, the early and late shoulder season results have positive coefficient signs for the unemployment rate variable, with the late shoulder season coefficient being statistically significant, which is the opposite finding of the negative results in the peak season. The peak season finding makes sense, because it is likely that at times of high unemployment, incomes are lower, and people may not be able to afford to take a trip. Based on this, it may be reasonable to assume that the unemployment rate would negatively impact usage in the early and late shoulder seasons as well, however, this is not the case according to these results because an increase in the unemployment rate is shown to increase usage rates in those analyses.

A possible explanation for this finding is that the unemployed, who have more leisure time, are being opportunistic and claiming available launch permits in the early and late shoulder seasons through the Smith River reservation hotline. During the peak season, application numbers and usage rates are considerably higher than in the shoulder seasons, so it is unlikely there are many permits available through the reservation hotline

[26] Quadratic coefficient estimates can be found in Appendix C.

in the peak season. The peak season coefficient is likely negative because it is possible that if unemployment were to increase, the ability to use a float permit may decrease because of the costs of taking a trip. These costs may be due to income loss, or time spent searching for a new job. During the early and late shoulder seasons, there are often times many days where not all of the permits are allocated in the lottery. If, for example, someone was unemployed during the lottery or became unemployed after the lottery had closed, they could use the reservation hotline to claim a permit on relatively short notice, which would explain the positive coefficient for unemployment during the early and late shoulder season.

Table 22. Post Application OLS Analysis

Dependent Var: Usage Rate	(1) Total Season	(2) Peak	(3) Total Shoulder	(4) Early Shoulder	(5) Late Shoulder
Water Flow (cfs)	0.000953***	0.00045***	0.00178***	0.00154***	0.00627***
	(6.4e-05)	(6.42e-05)	(9.21e-05)	(9.57e-05)	(0.00083)
Water Flow^2	-3.18e-07***	-1.64e-07***	-7.49e-07***	-6.08e-07***	-6.55e-06***
	(3.21e-08)	(2.29e-08)	(6.15e-08)	(4.72e-08)	(1.08e-06)
Temperature (°F)	0.0393***	0.0411***	0.0193***	0.0141***	0.0439**
	(0.0038)	(0.0076)	(0.00357)	(0.00545)	(0.0229)
Temperature^2	-0.00027***	-0.00030***	-0.000118***	-6.87e-05	-0.00024*
	(3.0e-05)	(5.62e-05)	(2.85e-05)	(5.14e-05)	(0.000139)
Outfitter Day	0.00107	0.0130	-0.0150	-0.0321	0.0365
	(0.0159)	(0.0196)	(0.0191)	(0.0217)	(0.0273)
Unemployment	-0.265***	-0.645***	-0.231***	0.343	0.268***
	(0.069)	(0.146)	(0.068)	(0.243)	(0.099)
Intercept	-0.187	1.446**	0.0041	-1.595**	-3.435***
	(0.257)	(0.556)	(0.254)	(0.772)	(0.922)
Observations	1,464	744	720	528	192
R-squared	0.420	0.322	0.492	0.507	0.728
Year Dummies	Y	Y	Y	Y	Y

Notes: Estimates are reported with robust standard errors in parentheses. Usage rate is calculated by dividing the number of users by the number of permits available on each lottery day. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

CHAPTER EIGHT

CONCLUSION

Outdoor recreation, particularly on rivers across the West, has steadily increased over the past decade to a point where some of the negative recreation effects are being highlighted in the media. Overcrowding, harmful ecological impacts, and increasing commercial use are some of the issues that have been at the forefront of news stories and proposed regulation changes. Despite the negative media coverage and proposed regulations to limit use, there is little empirical evidence to test if some of these issues are truly problematic. The main objective of this thesis is to fill a portion of that empirical gap and identify specifically whether commercial outfitting actually impacts the recreational experience for the general public.

Results from the main empirical model for the peak season indicate that application rates are, on average, about 11 percent lower during the peak season for float days on which two outfitters can launch compared to all other days on which only one outfitter launch is allowed. Additionally, robustness checks of the outfitter variable yield similar results, providing confirmation of the findings in the main empirical analysis. I also find that application rates statistically significantly correspond to river characteristics such as water flow and air temperature in ways that are consistent with prior expectations regarding applicant preferences.

A post-application model that looks at actual river usage using real time water flow and air temperature generates similar results that are consistent with the main empirical analysis, indicating that lottery winners have consistent preferences for river characteristics when compared to the main analysis, which uses expectations for river characteristics. Finally, the post-application model also includes a measure of unemployment to test whether economic conditions impact permit usage. The results indicate that an increase in unemployment decreases usage in the peak season, but actually increases usage in the early and late shoulder seasons. It is possible that permits not allocated in the lottery during the shoulder seasons are claimed through the reservation hotline by unemployed individuals who have more leisure time.

As discussed, the primary goal of this thesis is to identify the impacts of commercial outfitter use on application rates, which presented one of the biggest research challenges as a result of the lottery structure. Specifically, on Wednesday and Sunday there is one extra outfitter allowed to launch compared to all other days of the week, which is the variation I use to identify changes in application rates. The challenge with this strategy is that when there is one extra outfitter allocation, there is also one less permit available in the lottery because of the rule that a maximum of nine total launches are allowed each float day. As a result, it is unclear whether the decrease in application rates on outfitter days is because of the presence of outfitters, the outfitter effect, or is the result of the decrease in the supply of launch permits on those days, the supply effect.

To attempt to identify the outfitter effect more conclusively, two levels of tests were conducted. First, I used Wald tests to test if the peak season outfitter variable was statistically different from the early and late shoulder season outfitter variables in the main analysis. I find that the peak season outfitter variable is statistically different from the early shoulder season, but not from the late shoulder season. Secondly, I ran two separate analyses using the months of May and July individually. Because half of each of these months contain shoulder season dates where outfitter use is close to zero (so outfitter launch allocations are representative of a supply effect), and the other half of the months contain peak season dates where outfitter use is high (so outfitter launch allocations represent both a supply and an outfitter effect), I tested the difference between the first and second half of these months to attempt to better separately identify the supply and outfitter effects. I find that there are both statistically significant supply effects and outfitter effects in May, but that the outfitter effect in the late May peak season days is greater and more significant than the supply effect. In July, I find no statistical evidence that there are differences between the outfitter effect and supply effect. These tests are both consistent with the Wald tests from the main analysis.

Overall, I find some evidence that the presence of outfitters may decrease application rates on the Smith River on competitive lottery days, which could imply that commercial use on public resources negatively impacts the outdoor recreation experience for other users. Despite the fact that supply is also found to be partially effecting application rates, I find that the impacts of outfitter use are larger than the effects of supply, which is interesting and significant given the media coverage and proposed management changes on other resources (such as the Madison River) to limit commercial use and overcrowding on public resources.

This paper is the first to attempt to estimate the effects of outfitter use on outdoor recreation by private recreators, and the first to develop a theoretical equilibrium analysis for an outdoor recreation lottery of this type. To gain more clarity on the full impacts of outfitter use, more research would need to be conducted, and these findings provide justification for exploring this issue further. The potential for using this analysis to measure the impacts of outfitters on other regulated rivers is high and could also be extended to other recreational resources that experience substantial levels of commercial use such as backcountry/wilderness areas, and national or state parks. Future research would ideally include data on outfitter use where outfitter allocations do not impact the supply of permits available to private resource users. Additionally, detailed individual level applicant or user data could provide more information regarding applicants' behavioral changes and preferences over time, as well as the possibility of measuring travel costs.

REFERENCES CITED

Akabua, Kojo M; Adamowicz, Wiktor L; Phillips, William E; Trelawny, Peter. 1999. "Implications of Realization Uncertainty on Random Utility Models: The Case of Lottery Rationed Hunting". *Canadian Journal of Agricultural Economics.* 47 (1999), 165-179.

American Whitewater. 2019. List of rivers requiring permits. Retrieved September 23rd, 2019. Retrieved from: https://www.americanwhitewater.org/content/River/list-permits/?

Boxall, Peter C. 1995. "The Economic Value of Lottery-rationed Recreational Hunting". *Canadian Journal of Agricultural Economics.* 43 (1995), 119-131.

Bureau of Labor Statistics. Montana Unemployment Rate – Monthly.

Bureau of Land Management. 2020. Lotteries and Permit Systems. Retrieved from: https://www.blm.gov/programs/recreation/permits-and-passes/lotteries-and-permit-systems

Buschena, David E; Anderson, Terry L; Leonard, Jerry L. 2001. "Valuing Non-Marketed Goods: The Case of Elk Permit Lotteries". *Journal of Environmental Economics and Management.* 41 (2001), 33-43.

Byron, Eve. 2019. "More restrictions possible on Flathead River floats". *The Missoulian.* August 15, 2019.

Cameron, A. C., & Trivedi, P. K. 1999. "Essentials of Count Data Regression." *A Companion to Theoretical Econometrics. Malden, MA: Blackwell Publishing Ltd*.

Cameron, Colin A.; Trivedi, Pravin K. 2009. "Microeconometrics Using Stata". *Stata Press.*

Loomis, John B. 1980. "Monetizing the Benefits under Alternative River Recreation Use Allocation Systems." *Water Resources Research.* 16, 28-32.

Loomis, John B. 1982a. "Use of Travel Cost Models for Evaluating Lottery Rationed Recreation: Application to Big Game Hunting". *Journal of Leisure Research.* 14, 117-124.

Loomis, John B. 1982b. "Effect of Non-price Rationing on Benefit Estimates From Publicly Provided Recreation". *Journal of Environmental Management.* 14, 283-289.

Montana FWP, 2019. “Appendix D – Annual Angling Pressure by Region and Drainage 2017.” *2017 Angler Pressure Surveys.* May 23rd, 2019.

Montana FWP, 2020. “River Recreation Permits.” *Licenses and Permits.* Retrieved from: http://fwp.mt.gov/recreation/permits/floating/

Nickerson, Peter H. 1990. “Demand for the Regulation of Recreation: The Case of Elk and Deer Hunting in Washington State”. *Land Economics.* 66 (4) Nov 1990, 437-447.

National Oceanic and Atmospheric Administration. Daily Air Temperature – White Sulphur Springs, MT Station. 1984 – 2018.

National Park Service. 2020. Grand Canyon River Trips and Permits. Retrieved from: https://www.nps.gov/grca/planyourvisit/whitewater-rafting.htm

Petersen, Shannon. 1995. “Environmental history of Montana’s Smith River”. *Graduate Student Theses, Dissertations, & Professional Papers – University of Montana.* 8516.

Scrogin, David; Berrens, Robert P; Bohara, Alok K. 2000. “Policy Changes and the Demand for Lottery-Rationed Big Game Hunting Licenses.” *Journal of Agricultural and Resource Economics.* 25 (2) Dec 2000, 501-519.

Scrogin, David O; Berrens, Robert P. 2003. “Rationed Access and Welfare: The Case of Public Resource Lotteries”. *Land Economics.* 79 (2) May 2003, 137-148.

Scrogin, David. 2005. “Lottery-rationed Public Access Under Alternative Tariff Arrangements: Changes in Quality, Quantity, and Expected Utility.” *Journal of Environmental Economics and Management.* 50 (2005), 189-211.

Scrogin, David. 2018. “Risk Preferences Over Simple and Compound Public Lotteries”. *Economics Letters.* 170 (2018) 85-87.

Simmonds, Charlotte. 2018. “Crisis in our national parks: how tourists are loving nature to death”. *The Guardian.* November 20, 2018.

Smith River Annual Reports. 2004 – 2018.

Smith River Camp Baker Journal. 2007 – 2018.

Smith River Launch Choice Reports. 2004 – 2018.

Smith River Management Plan. 1996, 1988.

Stata Manual. 2020. “predict command”. Retrieved from: https://www.stata.com/manuals13/rpredict.pdf

Taylor, John D. 2018. “Changes could be coming to Madison River”. *The Madisonian.* December 27, 2018.

United States Geological Survey. Smith River below Eagle Creek near Fort Logan, MT – flow gauge. 1997-2018.

Wright, Michael. 2018. “Fish and Wildlife Commission rejects proposed Madison River outfitting regulations.” *Bozeman Daily Chronicle*. April 19, 2018.

Wright, Michael. 2019a. “Madison River committee fails to reach consensus, disbands”. *Bozeman Daily Chronicle.* May 3, 2019.

Wright, Michael. 2019b. “Commenting begins on potential regulations for Madison River.” *Bozeman Daily Chronicle.* November 27, 2019.

Yoder, Jonathan K; Ohler, Adrienne M; Chouinard, Hayley H. 2014. “What Floats Your Boat? Preference Revelation From Lotteries Over Complex Goods”. *Journal of Environmental Economics and Management.* 67 (2014), 412-430.

APPENDICES

APPENDIX A

SMITH RIVER LOTTERY APPLICATION

MONTANA STATE PARKS

MONTANA **FWP**

2020 SMITH RIVER STATE PARK & RIVER CORRIDOR PRIVATE FLOAT TRIP PERMIT APPLICATION

ONLINE SUBMISSIONS OPEN JANUARY 2, 2020 AND CLOSE AT 11:45 PM (MST) ON FEBRUARY 13, 2020

DATE OF BIRTH	MM	DD	YYYY		ALS	**YOUR DATE OF BIRTH AND ALS NUMBER WILL BE NECESSARY TO LOG INTO THE APPLICATION SYSTEM.** Your ALS number is the 1 to 3 digit number that follows your date of birth. If you do not have an ALS number, the first time you apply for a license through ALS, you will be assigned a lifetime "ALS number" randomly issued by the system.

NAME	FIRST	MI	LAST	❑ **RESIDENT** ❑ **NON RESIDENT**	❑ USA ❑ OTHER (SPECIFY)	LAST 4 OF SSN
IF YOU HAVE A PO BOX PHYSICAL ADDRESS				CITY	STATE	ZIP CODE

EMAIL ADDRESS – You must provide a valid email address to receive your float information. You will not be contacted in any other format.

( ) HOME PHONE ( ) WORK PHONE

FWP receives requests for mailing lists. Do you want your name included on lists provided to requestors? ❑ YES ❑ NO

NOTE: Even if you choose NO, under state law FWP is required to allow those who wish to compile their own mailing list access to department records, including name, address, gender, residency, and whether you were successful.

X ______________________________

I am the applicant, or the immediate family member, & I have their permission to submit this on their behalf (ARM 42.2.304). All statements on this form are true & correct. I understand that if I subscribe to any false statement in this application, I am in violation of MCA 87-6-302.

LAUNCH DATE CHOICES **NOTE**: The typical float season extends from mid April through mid July

1ST CHOICE — — 2020 MONTH - DAY - YEAR **2ND CHOICE** — — 2020 MONTH - DAY - YEAR **3RD CHOICE** — — 2020 MONTH - DAY - YEAR

All valid applications postmarked on or before **THURSDAY, FEBRUARY 13, 2020** will be entered in the random drawing. Applications postmarked after **February 13, 2020** will be returned to the applicants.

REMINDERS FOR 2020:

* A $10.00 non-refundable application fee must accompany each application.
* Applicants must be a minimum of **12 years old** at the time of submitting the application.
* Each successful permit can have a maximum group size of **15 people,** including children.
* Successful permits are non-transferable and non-refundable. If you drew a permit successfully last year (2019) and did not float, and did not properly cancel your reservation, you are not eligible to apply in 2020.
* Successful applicants who receive a permit during the time period of **May 15 through July 15 (peak season)** will **not** be eligible to apply for a permit for this time period the following year. This applies even if the permit is cancelled. Applicants may still apply for launch dates outside this time period, accompany other permitted trips during this time period, or acquire a cancelled permit for any launch date.
* A Super Permit drawing will also be conducted. Go online to stateparks.mt.gov for details and to purchase unlimited chances.
* Food, garbage, and other attractants must be properly stored. Go to stateparks.mt.gov/smith-river/ for additional information and requirements.

PAYMENT INSTRUCTIONS

MONTANA RESIDENTS - $10.00 Personal checks are accepted.

NON-RESIDENTS - $10.00 **NO PERSONAL OR COMPANY CHECKS.** **Pay by money order or cashiers checks.**

MAKE PAYMENT TO: Montana Fish, Wildlife & Parks

CHECK NUMBER ______________________ **CHECK AMOUNT $**______________________

DRAWING CONDUCTED IN EARLY MARCH - RESULTS WILL BE MADE AVAILABLE ON THE FWP WEBSITE AT: stateparks.mt.gov

SUCCESSFUL APPLICANTS WILL BE EMAILED A PERMIT ALONG WITH ADDITIONAL INFORMATION REGARDING THE FLOAT.

Take another shot at the dream. Enter Smith River Super Permit Lottery. Go to stateparks.mt.gov and click on Super Permit

REV 12/19

2020 SMITH RIVER STATE PARK & RIVER CORRIDOR PERMIT APPLICATION INSTRUCTIONS

READ THIS INFORMATION COMPLETELY BEFORE SUBMITTING YOUR APPLICATION
RETURN ONLY THE APPLICATION WITH $10 NON-REFUNDABLE APPLICATION FEE

Please call the Smith River State Park office in Great Falls, Montana for any additional questions: (406) 454-5840

- To apply for a private float permit for Smith River State Park & River Corridor, fill out the attached application and return to:
  Montana Fish, Wildlife and Parks
  Licensing Bureau- Smith River
  1420 East 6th Ave.
  PO Box 200701
  Helena MT 59620-0701

- All applications must be **POSTMARKED** or submitted on or before **Thursday, February 13, 2020.**

- A $10 non-refundable application fee applies for all applicants regardless of whether you're a Montana resident or non-resident. You must be a minimum of **12 years old** at the time of submitting the application. This application fee must accompany each application. Successful applicants will be required to pay the applicable float fees at Camp Baker during registration on launch day. Unsuccessful applicants will not receive a refund.

- The actual float fees, to be paid during registration at Camp Baker on the launch day are as follows.

Under 6 years (resident/non-resident)	FREE
6-12 years (resident/non-resident)	$15.00
13 and older (resident)	$25.00
13 and older (non-resident)	$60.00

- You may submit only **one application per person**. Submittal of more than one application per person will disqualify those applications from the drawing. You may submit up to three different launch dates on your application in the priority of first, second and third choices. Only one date will be chosen via the drawing process and it is based on your order of choice and the availability of a launch for that specific date.

- The drawing will be conducted in early March 2020. Successful applicants will receive a permit with a floater information packet. Results of the drawing will be made available in early March on the FWP web site at: stateparks.mt.gov

- Beginning on Monday, **March 9, 2020,** you may call the Smith River Reservation Line at (406) 454-5861 Monday through Friday between 8:00 a.m. and 12:00 noon MST to:
  1. Request any remaining launch dates that may be available
  2. Pick up a cancelled launch date
  3. Cancel a launch date

- Permits are non-transferable and non-refundable. Permit holders must bring photo ID to the put-in. Permit holders must cancel their permit if they are not going to use their launch regardless of weather or water flows above 100 cfs. **Failure to cancel a permit at least 2 days prior to your launch date, at flows above 100 cfs, will result in losing next years' privileges for the Smith River permit drawing.**

- Successful applicants who receive a permit during the time period of **May 15 through July 15 (peak season)** will not be eligible to apply for a permit for this time period the following year. This applies even if the permit is cancelled. They may still apply for launch dates outside this time period, accompany other permitted trips during this time period or acquire a cancelled permit for any launch date.

- **FOOD STORAGE REGULATION**: Food, garbage and other attractants must be properly stored. Go to stateparks.mt.gov/smith-river/ for additional information and requirements.

NOTE: Please submit ONLY the following application fee with your completed application:

Montana Residents (12 years +)	**$10.00 non-refundable application fee (Personal checks accepted)**
Non-Residents (12 years +)	**$10.00 non-refundable application fee (Personal and business checks not accepted. Money Order or Cashier's Check only)**

PLEASE MAKE CHECKS PAYABLE TO: Montana Fish, Wildlife & Parks

APPENDIX B

SMITH RIVER OUTFITTER LAUNCH CALENDAR

June 2020 **OUTFITTERS MASTER CALENDAR** **2020-21-22** Updated: 1/09/20

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1 B&C	**2** MAFF	**3** PRO ~~OPEN~~ BRO FROM 5/12	**4** PRO	**5** MAFF	**6** L&C
7 MFFC L&C	**8** MFFC	**9** PRO	**10** MAFF L&C	**11** PRO	**12** B&C	**13** L&C
14 MFFC MAFF	**15** L&C	**16** L&C	**17** PRO GG (Rotating)	**18** PRO	**19** B&C	**20** L&C
21 MAFF L&C	**22** L&C	**23** MFFC	**24** L&C MFFC	**25** PRO	**26** PRO	**27** L&C
28 MAFF L&C	**29** MFFC	**30** MFFC				

Outfitter Key

MAFF – Montana Angler Fly Fishing

PRO – Pro Outfitters

BRO – Blackfoot River Outfitters

B&C – Blast and Cast Outfitters

GG – Glacier Guides

L&C – Lewis and Clark Expeditions

MFFC – Montana Fly Fishing Connection

APPENDIX C

PREDICTED FLOW AND TEMPERATURE VALUE DISCUSSION

The regression specification for generating the predicted values for flow and temperature is:

$$Water\ Flow/Air\ Temperature_{it} = \beta_0 + \beta_1 * Dayofseason_i + \beta_2 * Year_t + \varepsilon_{it}$$

Where $Water\ Flow/Air\ Temperature_{it}$ is the natural log of water flow in cfs or the maximum air temperature on day i of year t, $Dayofseason_i$ is a dummy variable for the day of the float season, and $Year_t$ is a dummy variable for the year to account for differences across seasons.

To generate predicted values for water flow and air temperature for each year, the Stata predict command was used. This command in Stata generates a linear prediction based on the regression for the dependent variable for each observation in the dataset, both within sample and out of sample (Stata Manual, 2020). As discussed, I run a separate regression for each year in my dataset, from 2004-2018, using the previous 7 years of flow data and previous 20 years of temperature data for each year to generate a predicted value. For example, to generate temperature predictions for the year 2004, I run a regression using temperature data from 1984-2003, and then predict yhat for the year 2004 within Stata. The output for the year 2004 is generated by plugging in values for each observation in 2004 to the regression equation. Because the year 2004 was not in the sample used in the regression, the predicted values are simply the constant term plus the coefficient for each day of the season dummy. Then to generate predicted values for 2005, I would do the same process, except using the temperature data from 1985-2004. I do this for each year in my dataset, which generates unique linear predicted values for each observation based only on 20 years of previous data.

APPENDIX D

ADDITIONAL RESULTS AND TABLES

Table 23. Post Application Quadratic Coefficients

Dependent Var: Usage Rate	(1) Total Season	(2) Peak	(3) Total Shoulder	(4) Early Shoulder	(5) Late Shoulder
Flow (cfs)	1498 (max)	1372 (max)	1188 (max)	1266 (max)	479 (max)
Temperature (F)	73 (max)	69 (max)	82 (max)	103 (max)	91 (max)

Table 24. Main Analysis Quadratic Coefficients

Dependent Var: Usage Rate	(1) Total Season	(2) Peak	(3) Total Shoulder	(4) Early Shoulder	(5) Late Shoulder
Flow (cfs)	1559 (max)	1692 (max)	1252 (max)	1276 (max)	506 (max)
Temperature (F)	80 (max)	76 (max)	38 (min)	55 (min)	82 (max)

Table 25. OLS Results

VARIABLE: Applications	(1) Total	(2) Peak	(3) Shoulder	(4) Early Shoulder	(5) Late Shoulder
Water Flow (cfs)	0.00425***	0.00387***	0.00626***	0.00744***	0.0240***
	(0.000251)	(0.000327)	(0.000960)	(0.00142)	(0.00532)
Water Flow2	-1.38e-06***	-1.16e-06***	-2.47e-06***	-2.83e-06***	-2.38e-05***
	(1.14e-07)	(1.30e-07)	(4.97e-07)	(7.12e-07)	(8.47e-06)
Air Temperature	0.370***	0.773***	-0.0111	-0.326	0.430
	(0.0467)	(0.0646)	(0.0678)	(0.211)	(2.751)
Air Temperature2	-0.00231***	-0.00505***	0.000344	0.00295*	-0.00245
	(0.000343)	(0.000452)	(0.000516)	(0.00177)	(0.0167)
Outfitter Day	-0.0963***	-0.0930**	-0.0442	-0.0439	-0.0510
	(0.0361)	(0.0390)	(0.0576)	(0.0626)	(0.0902)
Constant	-13.25***	-27.80***	-0.873	7.835	-18.93
	(1.494)	(2.312)	(2.071)	(6.101)	(113.8)
Observations	1,135	876	260	209	51
R-squared	0.540	0.409	0.377	0.432	0.620
Year Dummies	Y	Y	Y	Y	Y

Robust Standard errors in parentheses. Dependent variable is the natural log of first choice applications. *** p<0.01, ** p<0.05, * p<0.1