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Wilderness Recreation Trends and Impacts: A Case Study of the Sawtooth Wilderness

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WILDERNESS RECREATION TRENDS AND IMPACTS: A CASE STUDY OF THE SAWTOOTH WILDERNESS

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ABSTRACT

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Abstract

As outdoor recreation on public lands continues to increase, land managers are tasked with managing the inevitable detrimental impacts. Wilderness managers must abide by federal legislation requiring them to balance the preservation of wilderness character with the unique recreation opportunity in wilderness for an unconfined experience. To accomplish this, managers need quantitative longitudinal trend data specific to the wilderness(es) they are responsible for. To facilitate this need, this study utilized the unique and robust longitudinal data set, ranging from 1965 to 2015, archived by the Sawtooth Wilderness. Fifty years of visitation data, campsite impact data, and management actions were visualized to reveal solitary trends, and then coupled to reveal relationships. The results from this longitudinal quantitative data exposed unexpected trends in visitation rates, visit characteristics not previously recognized, and successful management actions. By coupling the quantitative data, surprising patterns in detrimental impacts were also exposed, especially at unanticipated destinations throughout the Sawtooth Wilderness. This work will support Sawtooth Wilderness managers in their precipitous goals of endorsing wilderness recreation while simultaneously protecting the wilderness' natural conditions. Advice for management actions and educational messaging may be drawn from these results and recommendations. Future research from wilderness character monitoring in the Sawtooth Wilderness may continue to benefit management direction as it reveals trends in visitors, and detrimental behaviors previously undetected.

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Chapter 1
Introduction

Are public lands being loved to death? Public lands are a national treasure providing recreational opportunities to escape the confines of society and rebuild connections with nature. Popular media reports skyrocketing visitor numbers at National Parks, verified by National Parks, reporting 330 million visits in 2017 (USDI, 2018). Meanwhile, astounding economic values illustrate the thriving U.S. outdoor recreation economy, with a total economic impact of $373 billion in 2016, reflecting 2% of the national Gross Domestic Product (Reimers, 2018). Land managers face an immense challenge in their responsibilities of balancing visitor access to public lands while reducing recreational impacts. To administer access to these spaces, managers require adequate data to guide their decision-making.

Recreational visits on public lands have generally increased over the last century with extended periods of exponential growth, along with some brief declines (USDI, n.d.). Concerns over this growth led Congress to create the Outdoor Recreation Resource Review in 1958 to assess the expansion of outdoor recreation nationwide (PL 85-470). Financial quantifications of outdoor recreation in 2016 recognized the outdoor recreation industry as part of the United States economy with the passage of the Outdoor Recreation Jobs and Economic Impact Act (PL 114-249). These national calculations remind land managers about the importance of access to the public lands they manage but do not provide them with data, such as visitor use or recreational impact data, specific to individual management units. General visitor use data is available for National Park Service areas collecting entry fees and for United States Forest Service (USFS) areas where National Visitor Use Monitoring occurs every five years. However, many public lands, especially wilderness areas, have minimal to no quantitative data on visitation statistics, presenting a problem for public-land managers (USDA, 2018; USDI, 2019b).

Visitor Trends

Public land managers require quantitative visitor use data to adequately manage protected areas, maintain visitor access, and provide satisfying experiences (USDA, n.d.c; USDI, 2019a). Of particular interest is data from federally-designated wilderness areas with statutory legislation requiring information on wilderness use to be gathered and disseminated (PL 88-577). Visitor use and recreational opportunities in wilderness areas are protected to be primitive and unconfined or to provide opportunities for solitude. Simultaneously, these lands must be managed to preserve wilderness character (PL 88-577). Unfortunately, most wilderness managers assume visitor use is increasing but do not adequately capture visitor use data, such as overall visitor use numbers, visitor demographics, or visit characteristics (Cole, 1996b; Dawson & Hendee, 2009). Such information, especially longitudinal data, allows wilderness managers to understand visitor use trends to better balance wilderness access with preservation of wilderness character (Borrie & McCool, 2007; Cole & Wright, 2003; Cordell et al., 2008; Dawson & Hendee, 2009; Hammitt et al., 2015).

Wilderness studies show visitor use has grown dramatically since 1964 and is projected to increase further (Bowker et al., 2012; Dawson & Hendee, 2009). Research from the mid-1960s suggests the demographics of wilderness visitors were primarily male and white with typical visit characteristics of small groups (3 to 5 individuals) backpacking for a few (2 to 3) days in the summer (Lucas, 1980; Lucas & Stankey, 1989). Consistent surveying of visitor demographics does not exist in many wilderness areas. Survey data from general outdoor recreation suggests public land visitor demographics are becoming more diverse in race and gender while visits are becoming shorter, with the proportion of day visits increasing (Bowker et al., 2012; Cordell et al., 2012; Outdoor Foundation, 2020). However, with minimal trend data

available on wilderness visitor demographics or their visit characteristics, managers should be cautious about applying generalized trends to the wilderness areas they manage (Cole,1996b; Hammitt et al., 2015). As a best practice, managers should know who their visitors are so they can appropriately manage for changes in visitors' recreational behaviors (Borrie & McCool, 2007).

Visitor Impact Trends

Wilderness visits occur unevenly throughout a wilderness area, with higher visitor use densities occurring at "popular" trailheads, trails, destinations, and campsites (Dawson & Hendee, 2009; Hammitt et al., 2015; Lucas, 1980). A heavy concentration of visitors can create detrimental impacts that are either biophysical or social. The study of these detrimental impacts, their measurements, changing trends, and effects on wilderness visitor's trip satisfaction is the focus of the academic field of recreation ecology (Hammitt et al., 2015; Marion et al., 2016). Campsites, one of the most apparent detrimental impacts in wilderness, have traditionally only been studied from a single point in time (Cole, 2013; Cole & Monz, 2004; Cole & Wright, 2003; Lucas, 1985). Longitudinal data from studies on visitor use densities and their related impacts, especially at campsites, are necessary to provide statistics to managers on how biophysical attributes respond to influential factors (use density and visitor behavior), especially at destinations with concentrated use (Cole, 1996a, 2013, 2019; D'Antonio et al., 2012; Marion et al., 2016). Understanding the relationship between use densities and impacts will enable managers to preserve wilderness character while continuing to provide access to unconfined wilderness recreation that visitors find satisfying (Dawson & Hendee, 2009; Hammitt et al., 2015).

Management Actions

Wilderness managers are tasked with the seemingly impossible balance of offering access to unique wilderness visits on land protected to preserve its natural, untrammeled, and wild conditions (PL 88-577). Wilderness managers do not manage the wilderness *per se*, but rather its visitors and their detrimental impacts (Dawson & Hendee, 2009; Lucas, 1985; Watson et al., 2016). Managers utilize a range of federal legislation, agency policies, and academic frameworks to create wilderness management plans (Clark & Stankey, 1979; Dawson & Hendee, 2009; PL 88-577). Management plans specific to each wilderness, along with national guidance for wilderness character monitoring and wilderness stewardship performance, compel managers to use monitoring data to assess how visitors are negatively impacting a wilderness (Landres et al., 2015; USDA, 2020). These management plans provide direction for reducing impacts through engineering, enforcement, and education (Dawson & Hendee, 2009; Hammitt et al., 2015; IVUMC, 2016).

Almost all wilderness areas have implemented management actions to reduce detrimental impacts resulting from visitor behaviors, yet there is little research on what management actions are successful (Dawson & Hendee, 2009; Hall, 2001; Lawhon et al., 2013; Marion, 2016; Vagias et al., 2014). Some research reveals unsuccessful measures, such as the enforcement of campsite setbacks from water sources, campfire restrictions, and limiting permit systems (Griffin, 2018; Hall, 2001; Pendergraph, 2019; Reid & Marion, 2005). Research has also found challenges in education programs and trailhead signage (Cole, 1998; Lawhon et al., 2013; Vagias & Powell, 2010). There is a large amount of speculation on the success of engineering practices such as bridges, and of educational messaging like “pack-it in, pack-it out” and Leave No Trace (LNT), but very little measured success (Cole et al., 1997; Dawson & Hendee, 2009; Lucas, 1985;

Marion, 2016). If managers are to choose the most effective action to reduce impacts from detrimental visitor behaviors, they should make these decisions based on data.

The goal of this study is to visualize quantitative data for longitudinal trends in wilderness visitation, associated detrimental impacts, and effective management actions. These three fields have typically been singularly studied through independent, standalone descriptions of baseline data, with little effort to look at the long-term relationships between them (Cole, 1996a; Cole & Monz, 2004; D'Antonio et al., 2013; Loomis, 2000; Lucas, 1989). Managers require a comprehensive understanding of the synergistic effects between changes in visitor trends and their manifestations in visitor behaviors to effectively utilize a diverse array of management strategies that simultaneously preserve access to wilderness recreation and wilderness character (D'Antonio et al., 2013; Dawson & Hendee, 2009; Marion, 2016). This thesis visualized trends of visitation, associated detrimental impacts, and relative management actions, both individually and collectively, to update the recreation ecology literature and inform decision-making.

Problem Statement

This study visualized quantitative longitudinal data from 1965 to 2015 for long-term trends in wilderness visitation, visitor impacts, and relative management actions. Additionally, this research examined the relationship between these three parameters through a case study in the Sawtooth Wilderness. First, this study provides updated trends to the recreation ecology literature on wilderness visitation, associated detrimental impacts, and management actions. Second, this study coupled 50 years of quantitative data sets from the Sawtooth Wilderness to explore relationships between wilderness visitors, associated detrimental impacts, and relative management actions. This work will help wilderness managers plan and implement actions that

preserve wilderness character and access to wilderness recreation for current and future generations.

Research Questions

1. How have visitor trends in the Sawtooth Wilderness changed over the last 50 years?
2. How have detrimental visitor impact trends affected the Sawtooth Wilderness over the last 50 years?
3. How have trends in management actions affected the Sawtooth Wilderness over the last 50 years?
4. What trends are revealed by coupling longitudinal quantitative data for visitation, associated detrimental visitor impacts, and relative management actions in the Sawtooth Wilderness?

Delimitations and Limitations

This study focuses on visits by recreational users who registered at Sawtooth Wilderness trailheads and permit boxes from 1965 to 2015. This data does not include visitation numbers for visitors who chose to visit the Sawtooth Wilderness via an outfitter or commercial guide service, because these types of trips are restricted to specific areas and behaviors under commercial permits. This study did not include data on the following facilities since they are managed by the USFS: outfitter and guide assigned campsites and stock ties, administrative stock ties, and administrative toilets.

Limitations of this study are primarily related to the data that was available for analysis. After decades of storing trailhead registers, wilderness permits, and wilderness recreation reports, it is likely data has disappeared or physically deteriorated. Multiple rounds of campsite monitoring, which consists of measurements from campsites since the 1970s, have been stored in agency buildings and computers, opening up the possibility that records may be missing, incomplete, or incompatible with variations in protocols or measurements. This study

incorporated all available data through 2015. Significant changes in trends concerning visitor use and detrimental impacts began skyrocketing in several wilderness areas in 2015 (USDA,2017a: USDA, 2017b).

Definition of Terms

Impacts: Unless otherwise specified, impacts will focus on detrimental impacts occurring at campsites, which refers to campsite proliferation, total campsite area, and impact index (measures the extent to which a campsite has altered the natural plants and soils) in the Sawtooth Wilderness.

Management Actions: Refers to the actions managers implement on public lands to alter or control visitor behaviors.

Overall Visitor Numbers: The summation of all applicable visitor data for recreational visits to the Sawtooth Wilderness from 1965 to 2015. This is an aggregate from agency reports, documents, trailhead registers, and wilderness permits.

Trend: General direction in which something is changing- increasing, decreasing, consistent, or no change.

Visits, Visitors, Visitation: Refers to recreational visitors who registered at a trailhead register or permit box at a boundary of the Sawtooth Wilderness.

Chapter 2
Literature Review

Introduction

Since the 1930s, public land managers have been interested in managing visitor trends and associated detrimental impacts through appropriate and effective management actions (Freimund & Cole, 2001). Several events in the early 1960s responded to these concerns: statutory wilderness protections via the Wilderness Act of 1964; the emergence of the academic field of recreation ecology; and a Congressional request in 1966 for the USFS to develop a management research unit specific to wilderness (later named the Aldo Leopold Wilderness Research Center) (Cole, 2014, 2019; Hammitt et al., 2015; Lucas, 1985; PL 88-577). This section will review recreation ecology literature on wilderness management actions and trends in wilderness visitors and associated detrimental visitor impacts.

Management Actions

From its early conception, wilderness management was recognized primarily as people management (Dawson & Hendee, 2009; Lucas, 1985). Wilderness managers, responsible for balancing visitor use and their related impacts, utilize a variety of resources, from federal legislation and agency policies to academic frameworks and theories, to create, implement, and monitor a range of management actions (Dawson & Hendee, 2009; PL 88-577). Wilderness managers practice adaptive management as they learn how their on-the-ground management actions affect trends in visitation and associated detrimental impacts over time (Holling, 1978; Stankey et al., 2005).

Recreation Management. Managing recreation on public lands can be categorized into several opportunities across a landscape. The Recreation Opportunity Spectrum helps managers provide specific recreation settings and outcomes across a range of landscapes, including

"urban," "rural," "roaded natural," "semi-primitive motorized," "semi-primitive non-motorized," and "primitive" (Figure 1.1) (Clark & Stankey, 1979; Driver et al., 1987; Lee & Beard, n.d.). This concept of delineating areas with different biophysical naturalness, management prescriptions, and visitor expectations is replicated in the Wilderness Opportunity Spectrum, with the categories of "pristine," "primitive," "semi-primitive," and "transition" (Dawson & Hendee, 2009; Wilderness Connect, n.d.a). Throughout Wilderness Management Plans, these opportunity classes are also referred to as "desired condition classes" or "zones," each with specific management objectives and standards (USDA, 1987, 2012, 2015).

Similarly, wilderness visitors are categorized into groups, which relate to their behaviors (Dawson et al., 2009; Leung & Marion, 2000). "Illegal actions" include breaking wilderness laws, such as using motors or mechanized transportation like ATVs, snowmobiles, bicycles, or chainsaws. "Careless or thoughtless actions" encompass visitors unintentionally violating management restrictions, including administrative closures, group-size limits, or campfire regulations. "Unskilled actions" result due to a lack of skill or knowledge by visitors not utilizing low-impact behaviors, such as Leave No Trace. "Uninformed actions" can result in areas experiencing exceedingly high visitation as visitors don't know of other trailheads. Lastly, "unavoidable impacts" occur accidentally, even by mindful visitors. Knowing what types of wilderness visitor behavior exist enables managers to plan for associated detrimental impacts (Dawson & Hendee, 2009; Manning, 2003; Marion, 2016; Roggenbuck, 1992).

Wilderness Administration. To administer wilderness visitors and their detrimental impacts, wilderness managers reference a series of guiding documents to ensure they are within their legal rights. All wilderness areas are administered under the Wilderness Act of 1964 as a part of the National Wilderness Preservation System (NWPS). The NWPS consists of four

federal land managers: United States Forest Service (USFS), National Park Service (NPS), Bureau of Land Management (BLM), and United States Fish and Wildlife Service (USFWS) (PL 88-577; PL 94-579). All wilderness areas, regardless of managing agency, are to use the minimum requirements, or enforcement actions, in the administration of the land (PL 88-577). Each wilderness area also follows the regulations in its establishing legislation and up to 120 other federal laws, such as the Endangered Species Act, Clean Water Act, and Clean Air Act, among others (Dawson & Hendee, 2009; PL 88-577).

Each federal land managing agency provides additional directives in policies and guidelines; for example, the USFS provides wilderness direction in its agency Manual with specific wilderness direction in Chapter 2320 – Wilderness Management. Each National Forest has a specific Forest Land and Resource Management Plan with an embedded or amended Wilderness Management Plan (Dawson & Hendee, 2009; USDA, 2007). Wilderness management plans outline goals, guidelines, and specific desired conditions for delineated opportunity classes, each with different standards, thresholds, and monitoring requirements (Cole et al., 1987; Dawson & Hendee, 2009; USDA, 2012). NWPS leadership provides requirements for wilderness character monitoring, while the USFS additionally directs all wilderness areas to measure wilderness stewardship performance (Landres et al., 2015; USDA, 2020). Each wilderness area develops its own unique monitoring protocols while abiding by national minimum standards to gather baseline data and assess changing trends (Cole, 2019; Dawson & Hendee, 2009; PL 88-577).

Management Frameworks. The impetus for the design of wilderness management plans originated from theories and frameworks developed by academia. Initial concerns for increasing trends of visitor impacts in the 1960s led managers to apply the theory of carrying

capacity to recreation management. This theory was borrowed from range and wildlife specialists who managed lands for a sustainable number of animals (Dawson & Hendee, 2009; Hammitt et al., 2015; Lucas, 1985; Wager, 1964). Managers realized there was no clear cause-and-effect relationship in recreational carrying capacities since recreation necessitated biological *and* social and managerial carrying capacities – both of which can be confounded by subjective value judgments (Dawson & Hendee, 2009; Lucas 1985; Marion 2016).

***Limits of Acceptable Change*.** The framework of Limits of Acceptable Change (LAC) reformulated recreational carrying capacity to focus attention on desired conditions instead of on the number of visitors (Stankey et al., 1985). The LAC framework walks managers through a planning process to identify acceptable amounts of impacts (biophysical and social) that wilderness opportunity classes can absorb before necessitating appropriate management actions (Figure 1.2) (Hammitt et al., 2015; USDA, n.d.c). LAC is primarily used by the USFS, while other agencies use similar processes to manage wilderness: Visitor Experience and Resource Protection (NPS), Resource Management Plans (BLM), and Comprehensive Conservation Plans (USFWS) (Dawson & Hendee, 2009; Marion, 2016). Today the Interagency Visitor Use Management Council (IVUMC), a collaboration of six federal agencies (USFS, NPS, BLM, USFWS, National Oceanic and Atmospheric Administration, and the US Army Corps of Engineers) working together to provide guidance for comprehensive carrying capacity frameworks for consistent and streamlined visitor use management for all federal lands and waters (Cole, 2019; IVUMC, 2020).

Interagency Visitor Use Management. The IVUMC offers a variety of publications, training, and online resources to inform managers on the "proactive and adaptive process for managing visit characteristics" (IVUMC, 2020). Their six principles echo findings throughout

recreation ecology: all recreation causes impact; change is inevitable; provide diverse opportunities to visitors; be proactive; discuss trade-offs; commitment to implementation is crucial (2020). The IVUMC advises managers who have identified undesired conditions to distinguish probable cause next, and then to develop strategies and actions to address (or ideally prevent) the issue. Management strategies are provided in a "toolbox" of options that help modify visit characteristics such as the type of visit, visitor behaviors, visitor attitudes or expectations, visit timing, visit location, spatial distribution of the visit, resilience of location visited, and as the last resort visitor reductions (Figure 1.3) (Cole et al., 1987; IVUMC, 2020; Marion, 2016). Wilderness management should prioritize modifying visitor behaviors resulting in detrimental impacts instead of being overly concerned with the numbers of wilderness visitors (Cole et al., 1987; D'Antonio & Monz, 2016; IVUMC, 2020; Stankey et al., 1985).

Management Categories. When biophysical or social conditions deteriorate beyond acceptable desired conditions and standards established in wilderness management plans, managers utilize a problem analysis to align visitor behaviors with applicable and appropriate management actions (Cole et al., 1987; Marion, 2003). Managers must assess the probable cause of an impact by linking visit characteristics and detrimental visitor behaviors, with modification strategies, and appropriate management actions and responses (IVUMC, 2016; Marion, 2003). Additionally, managers need to understand and incorporate the priorities of visitors for both the biophysical and social settings when making management decisions (Dawson & Hendee, 2009). Managers can then assess their "toolbox" of strategic modifications and implement their decisions through the fundamental categories of action; engineering, education, and enforcement (Figure 1.3) (Hammitt et al., 2015; IVUMC, 2016; Marion, 2003).

Engineering. Engineering actions reduce visitor impacts by directly modifying the physical environment (Hammitt et al., 2015; Marion, 2016). Such actions are generally undesirable in wilderness as it is managed to be "in contrast with those areas where man and his own works dominate the landscape" (Hammitt et al., 2015; PL 88-577). Engineering actions to alter visitor behaviors should primarily occur outside of wilderness, such as altering the size of parking lots, pulling back trailheads, or erecting informational signs (Dawson & Hendee, 2009). Signage is found to be most effective when only a couple of messages (such as Leave No Trace) are combined with a map and a simple appeal to stop and read (Cole, 1998; Cole et al., 1997a). When engineering does occur in wilderness (trail design, bridges, toilets, site hardening, i.e., constructing tent pads for overnight visitors), the objective is to protect resources, not to increase visitor comfort or convenience (Dawson & Hendee, 2009; Marion, 2016). For example, Marion et al. (2018) recommend allowing managers to design durable or hardened wilderness campsites to avoid the haphazard creation of informal campsites. Managers considering engineering projects need to contemplate the short-term and long-term costs for materials, labor, maintenance, and desired conditions for the area.

Enforcement. Enforcement actions in wilderness have financial and political costs as regulations require employee time and can upset visitors seeking an "unconfined" wilderness opportunity (Cole et al., 1997b; Lucas, 1981; PL 88-577). Enforcement is a "direct" method of control that regulates, restricts, or punishes certain visitor behaviors (Dawson & Hendee, 2009; Marion, 2016). Direct management actions include: limiting group sizes and lengths of stay; restricting campsite locations and activities; reducing stock use; and, as a last resort, limiting access via a permit system (Figure 1.4) (Dawson & Hendee, 2009; Hall, 2001; Marion, 2016). The success and support of various regulations vary widely. Limits on group size and length of

stay are generally well-accepted, while camping setbacks from water sources are rarely enforced and may not protect water quality (Griffin, 2018; Marion et al., 2018; Pendergraph, 2019). Campfire bans have had limited success, as campfires seem to be an integral part of camping, regardless if they are used for cooking (Hammitt et al., 2015; Lucas, 1980; Reid & Marion, 2005).

The extreme action of limiting access to wilderness via a permit system is a last resort, when education, engineering, and all other enforcement actions have been exhausted (USDA, 1987; Stankey et al., 1985). Permit systems limiting access through visitor quotas confine freedoms of choice to visit a wilderness, destination, select a campsite, and require a fee (Dawson & Hendee, 2009; Hall, 2001; Marion, 2016). Increased wilderness visitation in the 1960s and 1970s provoked a surge in permit systems for overnight visitors; by 1980, 36% of NPS wilderness areas and 4% of USFS wilderness areas had such systems in place (Washburne & Cole, 1983). In the 1980s, management priorities shifted to protect visitor freedoms through education and dispersal techniques as permit systems were considered an efficient but inequitable reaction to high visitation numbers (Freimund & Cole, 2001; Hall, 2001; Lucas, 1980).

Recently, two National Forests have undergone extensive processes to create and implement permit systems limiting visitor access to wilderness, with drastically different levels of success (USDA, 2017a, 2017b.). The success of the Maroon Bells and Snowmass Wilderness permit system, to limit overnight visitors, was prefaced with an extensive educational public campaign focused on explaining how detrimental biophysical impacts by overnight visitors are accumulating (USDA, 2017a). The Deschutes National Forest has received immense public pushback in their attempts to limit both day and overnight visitors even though they too are

sharing data from overnight impacts (USDA, 2017b). Visitors more often support limiting their access when detrimental biophysical impacts from overnight visits degrade an area, but do not support limiting day access to reduce social impacts (Allen, 2019; Cole & Hall, 2008; Dawson & Hendee, 2009; Freimund & Cole, 2001; Hall, 2001; Lucas, 1985; Marion, 2016). As wilderness visitor satisfaction has remained high over the last five decades, it is possible that visitors; cope with changing social conditions, prioritize access and freedoms of choice in wilderness, and have different attitudes about wilderness experiences than do wilderness managers (Allen, 2019; Cole, 2011; Hall, 2001; Hall & Cole, 2000).

Education. The preferred "light-handed" or indirect method of control to influence visitor behaviors, and their temporal and spatial distribution, is education (Dawson & Hendee, 2009; Hammitt et al., 2015; Manning, 2003; Marion, 2016). Recognition for the need to prioritize education over enforcement in wilderness visitors harkens back to Bob Marshall in 1933, who believed in allowing visitors to retain the freedom to make well-informed choices for "primitive and unconfined recreation" in wilderness (Lucas, 1985; PL 88-577). Messages on minimum-impact practices for wilderness visitors have evolved, from "pack it in-pack it out" in the 1960s to "soft paths" in the 1980s, and to today's seven principles of Leave No Trace (Figure 1.4) (Cole, 2018; Leave No Trace Center of Ethics, 2020a; Marion & Reid, 2001.).

Leave No Trace. The Leave No Trace Center for Outdoor Ethics (LNT) provides consistent messaging and branding to millions of recreationists each year through their memorandums of understanding with public land managers, partnerships in the outdoor recreation industry, hot-spot traveling trainers, and thousands of educators (Leave No Trace Center of Ethics, 2020b). LNT messaging is primarily persuasive, an effective method to communicate complex concepts to an interested audience to influence their attitudes and

behaviors in wilderness (Marion & Reid, 2007; Roggenbuck, 1992). Persuasive messages consist of a promoted behavior (such as an LNT Principle) with arguments and facts supporting the adoption of the behavior (Ajzen, 1992; Cole, 1989; Roggenbuck, 1992). These messages are provided by LNT educators, agency visitors centers, wilderness rangers, volunteers, and trailhead signs to influence wilderness visitor behaviors that are careless, unskilled, uninformed, unavoidable, or illegal (Dawson & Hendee, 2009; Marion & Reid, 2007). LNT's generalized principles are not always immediately translatable to wilderness visitors as they need more targeted messaging with details on the effectiveness and practical application of desirable behaviors (Lawhon et al., 2013; Vagias & Powell, 2010; Vagias et al., 2014).

Theory of Planned Behavior. This dilemma of translating messages or information is examined in the Theory of Planned Behavior (TPB). One of the three factors of a visitor's behavior in the TPB is their "perceived behavioral control," or the skills, abilities, and understandings needed to achieve a behavioral change (Figure 1.5) (Fishbein & Ajzen, 2010). Understanding the factors contributing to human behaviors helps produce effective and adaptable educational LNT messages in wilderness. Another determining factor of behavior from the TPB is social norms, or pressures from the social environment exerted onto others (Fishbein & Ajzen, 2010). There are two types of social norms: descriptive, when a visitor looks for guidance by observing what others are doing; and injunctive, when a visitor asks themselves what they "ought" to do, or if there will be social rewards or punishments (Cialdini et al., 1990, 1991, 2006). In wilderness areas, these social norms relate to a visitor's ability to accept on-site conditions for impacts (descriptive); and to shared beliefs and observations on how visitors should behave (injunctive), especially for novice visitors (Allen, 2019; Dawson & Hendee, 2009; Hall & Shelby, 1996).

Wilderness Rangers. Wilderness Rangers help clarify both the descriptive and injunctive social norms in wilderness (Dawson & Hendee, 2009; Kidd et al. 2015). They model descriptive norms by providing an excellent example of how to behave, eliminating unnecessary campsites, and cleaning up untidy campsites, thereby setting expectations for clean campsites (Cole, 2013). Wilderness rangers influence the injunctive norm by educating people, via personal contacts, on what they ought to do, and may punish those who do not follow wilderness regulations (Kidd et al., 2015; Manning, 2003). Wilderness rangers receive training on visitor contacts to appropriately and effectively communicate appropriate behaviors, such as LNT, and to enforce wilderness regulations.

Wilderness Rangers are instructed to exercise the Authority of the Resource in visitor contacts. This technique transfers the legal authority of the Ranger to the resource itself; in this case, the wilderness (Wallace, 1990; Wallace & Gaudry, 2002). The majority of these contacts occur in wilderness, while visitors are experiencing their trip. The majority of all educational contacts between land managers and visitors occur during the trip (visitor centers, evening ranger programs, trailheads) (Cole et al., 1997a; Marion & Reid, 2007). These educational contacts do not help a visitor prepare for their trip as it is typically too late for a visitor to change their plans once they are on their trip (Doucette & Cole, 1993; Manning, 2003; Marion & Reid, 2007). The better opportunity to influence a visitor's behavior occurs during the planning phase of their trip (Clawson & Knetsch, 1966; Lucas, 1981; Manning, 2003).

Visitor Trends

Overall Visitor Numbers. The Wilderness Act of 1964 instantly established 54 wilderness areas for visitor "use and enjoyment…in such manner as will leave them unimpaired" (PL 88-577). By 1994 visitation to these 54 wilderness areas had increased by 86%; this trend is

generally assumed to have occurred in all prior established wilderness areas (Cole, 1996a; Dawson & Hendee, 2009; Hammitt et al., 2015; Lucas, 1989; Peterson, 1981). Wilderness visitation projections have continuously projected increases in overall visitor numbers (Bowker et al., 2012; Cole,1996a; Cordell & Bowker, 2012; Dawson & Hendee, 2009; Watson et al., 1999). Research by Bowker et al. suggests that while the number of wilderness visitors will continue to increase, the proportion of the population visiting wilderness areas will actually decrease as population growth continues (2007, 2012). Thus, a smaller percentage of the population will visit wilderness areas.

Visitor Registration. Estimates of wilderness visitation come from several types of registration; most common are trailhead registers and permits, which may be self-issued or agency-regulated (Dawson & Hendee, 2009). The USFS possesses the most complete and longest records of wilderness visitation, with data of varying quality available for virtually every wilderness area (Cole, 1996). Most of these counts are estimates based on observations and best guesses. A 1989 survey found only 13% of USFS wildernesses had overall visitor number estimates based on systematic counts via registers or permits (Cole, 1996). Self-registration rates at trailheads may be as low as 66% compliance, though registration rates are lower at unpopular trailheads, and day users are less likely than overnight users to register (Cole & Hall, 2008)

Visitor Demographics. Wilderness visitor demographics have changed over the last 50 years. Studies from the 1960s to1980s indicate up to 70% of visitors were male until the 1990s when an increase in female visitation began; female visitor numbers today are still below 50% (Bowker et al., 2007; Dawson & Hendee, 2009; Hammitt et al., 2015; Lucas, 1980, 1989; Watson et al., 1999). Research on age groups visiting wilderness in the 1970s was equally represented, but by late 1990s wilderness visitors had aged; for example, the 30 to 40-year-old

visitors had become the 40 to 50-year-old visitors (Borrie & McCool, 2007; Bowker et al., 2007; Dvorak et al., 2012, Lucas,1989; Watson et al., 1999). Today there is disagreement about which age groups constitute the bulk of wilderness visitors: those 55 years and older, or those 16 to 35-years old (Dawson & Hendee, 2009; Hammitt et al., 2015). Early studies on wilderness demographics neglect to mention race or ethnicity (Borrie & McCool, 2007; Cole, 1996b; Lucas, 1989; Roggenbuck & Watson, 1989). By the 1990s, demographic studies on wilderness visitors began to mention the underrepresentation of minorities, while current studies suggest wilderness visitors are becoming more diverse in wilderness areas close to urban centers (Bowker et al., 2007; Dawson & Hendee, 2009). The majority of wilderness visitors have consistently resided in the same state or region as the wilderness they visit (Dawson & Hendee, 2009; Lucas, 1980; Roggenbuck & Watson, 1989).

Visit Characteristics. The characteristics of visits in wilderness have gradually changed over the last 50 years (Dawson & Hendee, 2009; Lucas, 1980; Roggenbuck & Watson, 1989; Watson & Cole, 1999). Visits by large groups have significantly decreased; the average group size of 3 to 6 in the 1970s has dropped to 2 to 4, with solo visits making up to 10% of all visits (Dawson & Hendee, 2009; Dvorak et al., 2012; Hammitt et al., 2015). The proportion of day visits is increasing, while visitors who choose to camp stay only for 1 to 2 nights (Borrie & McCool, 2007; Cole, 1996b, 2001; Dawson & Hendee, 2009; Dvorak et al., 2012; Hammitt et al., 2015; Lucas, 1980, 1989). Most wilderness visits occur in the summer, consistently outnumbering fall hunting visits, though there is an increase of visitation in the “off-season” and winter months (Dawson & Hendee, 2009; Lucas, 1980; Watson et al., 1999). A significant change in wilderness visit characteristics is the dramatic decrease in stock use; today, most

visitors hike or backpack, with some wilderness visits occurring by way of rafts, float planes, and backcountry airstrips (Dawson & Hendee, 2009; Lucas, 1980, 1989).

Visitor Impact Trends

Use Density. Increases in wilderness visits often occur along popular trails and at popular destinations throughout a wilderness (Dawson & Hendee, 2009; Freimund & Cole, 2001; Lucas, 1989). Uneven use densities are typical throughout all wilderness areas, with specific locations receiving a large percentage of the total visitors (Cole & Monz, 2004; Hammitt et al., 2015). These patterns of uneven visitor densities are influenced by water availability, presence of desirable campsites, trailhead access, and trail characteristics like accessibility, length, and steepness (Dawson & Hendee, 2009). This concentration of visitors is desirable, as an even distribution of visitors in wilderness can result in the overuse of all areas, reducing the acreage of pristine wilderness (Cole, 2019; Dawson & Hendee, 2009; Freimund & Cole, 2001; Hammitt et al., 2015).

Visitor Impacts. Wilderness recreation occurs on lands without permanent improvements of human habitation, in a way that leaves the land "unimpaired for future use and enjoyment as wilderness" (PL 88-577). The measure of these impairments, or associated detrimental impacts created by visitors, is the focus of the academic field of recreation ecology (Cole, 2019; Hammitt et al., 2015; IVUMC, 2020; Marion et al., 2016; Monz et al., 2010). Detrimental impacts fall into two categories: *biophysical impacts*, the detrimental effects visitors have on soils, vegetation, wildlife, and water; and *social impacts*, which consists of the negative outcomes of direct or indirect encounters with other visitors (Allen, 2019; Hammitt et al., 2015).

Biophysical Impacts. Detrimental biophysical impacts occur where visitors trample vegetation, erode soils, damage trees, displace wildlife, and pollute water (Dawson & Hendee,

2009; Hammitt et al., 2015; Marion et al., 2016). These types of impacts were the initial focus of recreation ecology, especially campsites, which are arguably the most concentrated and visible areas of impact in wilderness (Cole, 2019; Cole & Wright, 2003; Frissell, 1978; Hammitt et al., 2015; Lucas, 1985; Monz et al., 2010). Measuring campsite impacts began in the 1960s as visual assessments of damage to vegetation, humus, mineral soil, and trees in an aggregated condition-class rating (Frissell, 1978; Frissell & Duncan, 1965). In 1989, David Cole proposed a method to count campsites and measure each campsite with an impact-index condition-class, assigning "weighted values" to select measured campsite impacts based on their permanence (time necessary for impacts to recover). For example, the measured parameter of trash at a campsite receives a low weight, while the measured parameter of exposed tree roots or bare mineral soil receives a heavy weight (Cole, 1989). Wilderness managers select unique combinations of parameters and measurements in their campsite monitoring protocols. Today consistent minimum requirements are established for all wilderness campsite monitoring protocols, though each wilderness may still include parameters unique to the area (Landres et al., 2018; USDA, 2020).

In 2013, Cole published a compilation of existing empirical measurements on wilderness campsite spanning 30 years and incorporating eight case studies, suggesting aggregate campsite area and impacts increased until the early twenty-first century. The proceeding plateau or decline in campsite impacts is credited to successful Leave No Trace camping education, campsite-concentration strategies, and the removal of unnecessary campsites by wilderness rangers (Cole, 2013). Recreation ecologists agree that the relationship between the amount of use and detrimental impacts is *not* linear; thus, an increase in visitor numbers does not necessarily translate into an increase in campsite impacts (Cole 1982, 2019; Cole & Monz, 2004; Frissell &

Duncan, 1965; Leung & Marion, 2000; Marion et al., 2016). Instead, impacts are curvilinear, or asymptotic, meaning as initial uses at a campsite increase during the first year or so of use, both rapid and substantial impacts occur (trampled plants, burnt wood, eroded soils) while continued use over the proceeding decades creates minimal to no additional impacts (Figure 1.6) (Cole, 1982, 1987, 2013; Cole & Monz, 2004; Hammitt et al., 2015; Marion et al., 2016). Thus, moderately and heavily-used campsites appear to be equally heavily impacted, especially in ecosystems where soil and plant recovery rates are extraordinarily slow, sometimes on the order of centuries (Cole, 2004; Cole et al., 2012; Cole & Spildie, 2006).

Impact Perception. The significance of biophysical and social impacts differs between wilderness visitors, managers, and ecologists. A wilderness visitor's sensitivity to impacts is relative to their knowledge of the resource and of appropriate low-impact wilderness behaviors (Cole & Monz, 2004; D'Antonio et al., 2012). Some visitors consider flat areas devoid of plants as improved campsites, while other visitors do not desire solitude on trails but prefer privacy at camp (Dawson & Hendee, 2009; Farrell et al., 2001). Visitors often notice detrimental aesthetic impacts (tree carvings) or reversible impacts (litter); and may categorize inclement weather, insects, and fatigue as negative impacts on their wilderness experience (D'Antonio et al., 2012; Hall & Cole, 2012). In contrast, ecologists focus on visitor impacts that cause long-term effects or hinder ecological functions, such as the alteration of soils, vegetation, wildlife behaviors, and water quality (Dawson & Hendee, 2009; Monz et al., 2009). Wilderness managers fall in between these two (visitors and ecologists) as they must account for aesthetic as well as ecological impacts since they are responsible for balancing access to wilderness recreation and wilderness character protection (IVUM, 2020; Stankey et al., 1985).

Social Impacts. Concern for social impacts relates to the Wilderness Act's enshrinement of "outstanding opportunities for solitude" – a unique social experience in wilderness (PL 88-577). While social impacts, solitude, and privacy are ultimately subjective, determining the number of visitor encounters provides an objective measure of social impacts. Such encounters include the number of direct or indirect contacts a wilderness visitor has with others, including sight, sound, and smell (Allen, 2019; Cole et al., 1997b; Hammitt et al., 2015). Detrimental outcomes of social impacts can lead to a sense of crowding, user conflicts, and spatial or temporal displacement (Allen, 2019; Cole & Hall, 2008; Dawson & Hendee, 2009). Although these issues seem alarming, wilderness visitors are adapting to increasing encounters by coping or adjusting their expectations, norms, standards, and behaviors to be more tolerant, thus maintaining high levels of satisfaction (Allen, 2019; Dawson et al., 2009; Freimund & Cole, 2001; Hall & Cole, 2012).

Satisfaction. Although the overall numbers of wilderness visitors and associated detrimental impacts have continuously increased since 1964, wilderness visitors have maintained they are satisfied with their wilderness experience (Borrie & McCool, 2007; Cole, 1996a; Cole & Hall, 2008; Hall & Cole, 2012; Hammitt et al., 2015; Lucas, 1980). As increasing visitation occurs in wilderness areas, managers need to determine whether increased encounters and detrimental biophysical impacts from other visitors are negatively impacting visitor's wilderness experiences (Dawson & Hendee, 2009; Hall & Cole, 2012). Thus far, surveys suggest that contemporary and past wilderness visitors enjoy similar levels of satisfaction with their experiences (Dawson & Hendee, 2009; Hammitt et al., 2015).

Wilderness Management Opportunities

If wilderness managers, responsible for reducing detrimental impacts from visitor behaviors, intend to protect wilderness access, they will be better equipped to do so with longitudinal quantitative data. It is dangerous to simply assume an increase in overall visitor numbers automatically leads to an increase in visitor associated detrimental impacts; one visitor can leave a bigger impact than hundreds who left the place better than they found it (Cole, 2019; Cole et al., 1989; D'Antonio et al., 2013; Marion, 2016). Wilderness management should utilize monitoring data to be proactive, instead of reactive, as changing established visitor habits is very difficult (IVUMC, 2016; Marion, 2003). To design effective management actions, wilderness managers need to know who their visitors are and their related use-densities to recognize the relationships between their impacts and influential factors (Cole, 1996a; Dawson & Hendee, 2009; Marion et al., 2016). An integration of recreation ecology with social and managerial sciences may produce a diverse array of preventative management actions, focused on effective communication strategies with dialogue around low-impact wilderness behaviors (Allen, 2019; Cole, 2013; D'Antonio et al., 2013; Lucas, 1989; Marion, 2016; Potts, 2007; Watson et al., 2016).

This review of the recreation ecology literature was used to examine the unique longitudinal data set in the Sawtooth Wilderness to discover unique and prevailing trends in wilderness visitors, associated detrimental impacts, and effective management actions. It was also used to interpret both the quantitative and qualitative data to provide management recommendations.

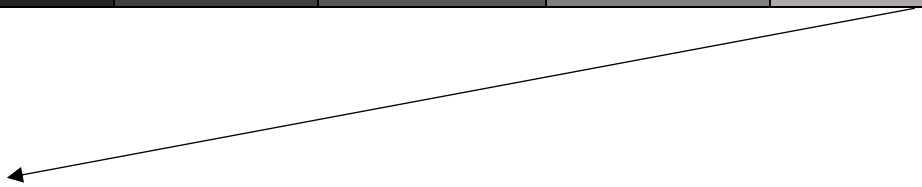
Appendix 1
Literature Review

Figure 1.1

Recreational Opportunity Spectrum & Wilderness Opportunity Spectrum

Recreation Opportunity Spectrum

Urban	Rural	Roaded Natural	Semi-Primitive Motorized	Semi-Primitive Non-Motorized	Primitive



Wilderness Opportunity Spectrum

Transition	Semi-Primitive	Primitive	Pristine

Figure 1.2
Limits of Acceptable Change Planning System Framework

Figure 1.3
Toolbox of Management Actions for Visitor Use in Wilderness

Core strategies	Management actions
1. Manage use levels	Redistribute, discourage, or limit use (e.g., set access point or travel zone quotas).
	Redistribute or reduce use during times of peak use, in high use locations, or when impact potential is high.
2. Modify the location of use	Concentrate use on sustainable expansion-resistant trails and campsites to limit the aggregate area of impact.
	Disperse use on durable substrates at levels that prevent formation of trails and campsites.
	Encourage or require visitors to camp out of sight or a minimum distance from trails and campsites.
	Restrict certain types of use to specific locations (e.g., restrict horses to trails and campsites designed for their use).
3. Increase resource resistance	Construct, reconstruct, or maintain impact-resistant trails and campsites (e.g., construct side-hill trails and campsites, install anchored campfire rings).
4. Modify visitor behavior	Persuasive communication, interpretation, or education: encourage or require Leave No Trace practices when traveling and camping.
	Regulation and enforcement: prohibit or require certain practices and equipment when traveling and camping (e.g., feeding wildlife, safe food/trash storage, woods tools).
5. Close and rehabilitate the resource	Close and rehabilitate unnecessary or less sustainable trail segments and campsites.

Figure 1.4
Leave No Trace 7 Principles

Figure 1.5
Theory of Planned Behavior

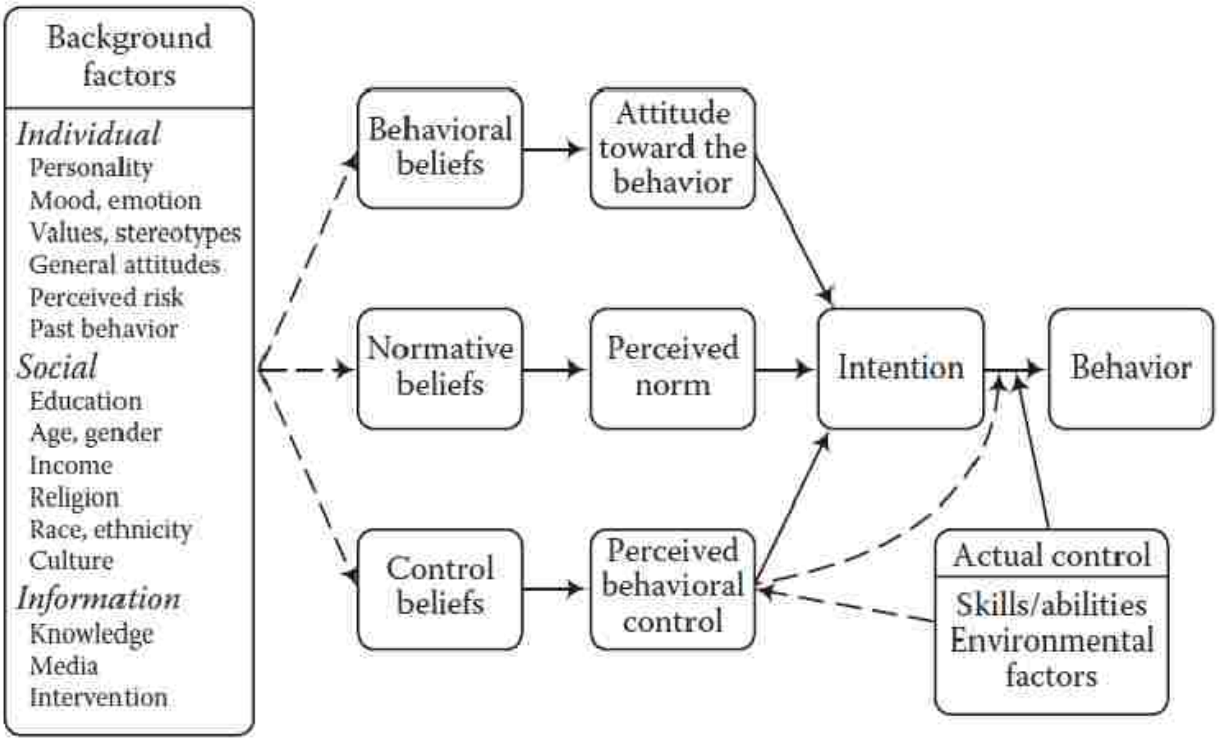
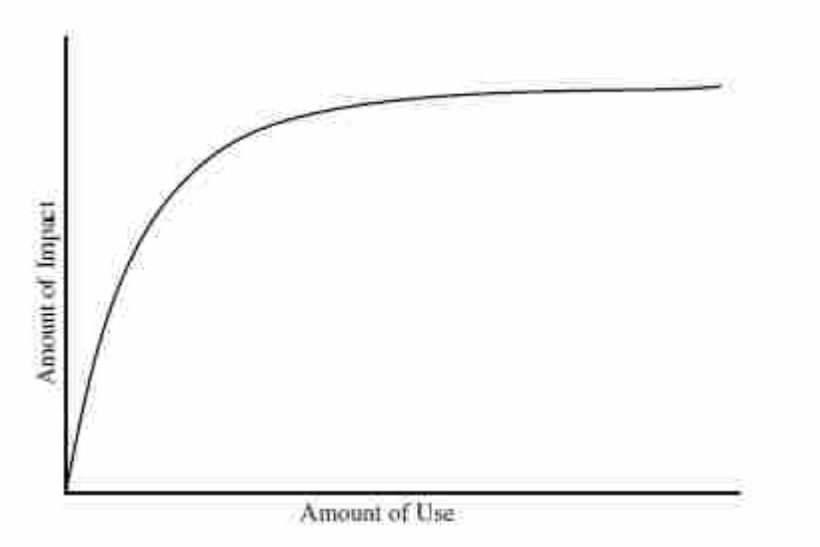


Figure 1.6
Curvilinear, Asymptotic Relationship between Impact & Use



Chapter 3
Methods

Introduction

This chapter describes how archived longitudinal quantitative data was collected, organized, and analyzed to gain an in-depth understanding of the Sawtooth Wilderness's trends in visitation, associated detrimental visitor impacts, and related management actions. The archived longitudinal quantitative data acquired from the Sawtooth National Recreation Area (SNRA) is secondary data ranging from 1964 to 2015. This quantitative data consists of visitation records from archived trailhead registrations and wilderness permits, annual recreation reports and summaries, campsite inventorying and monitoring data, wilderness ranger reports, and Wildland Education Program reports. All quantitative data was utilized as raw data since the United States Forest Service (USFS) assigns significance according to desired conditions, assigned opportunity classes, and prescribed standards detailed in Forest Plans and Wilderness Management Plans (USDA, 1977, 1997c, 2012). Quantitative data for visitor demographics came from the USFS National Visitor Use Monitoring (NVUM) program, which conducts visitor surveys across the National Forest System on a five-year cycle (USDA, n.d.a).

Quantitative Data
Trailhead Registrations
Wilderness Permits
National Visitor Use Monitoring
Campsite Inventories
SWIM Campsite Monitoring
Annual Recreation Reports
° Sawtooth Valley Accomplishment Reports
° Sawtooth Wilderness Management Reports
° Recreation Use Summaries
Wilderness Ranger Reports
Wildlands Education Reports

Study Area: Sawtooth Wilderness

The Sawtooth Wilderness (SW) is part of the Sawtooth National Recreation Area (SNRA), which is managed by the Sawtooth National Forest (SNF) as a Forest in the USFS, under the Department of Agriculture. Lands of the SW were initially protected as a Primitive Area in 1937 and gained federal designation as a Wilderness in 1972 (PL 92-400). The SW is located in central Idaho and can be accessed via a 30-minute drive from Sun Valley Idaho, or a 2-hour drive from Boise, Idaho (Figure 1.1).

The SW is 217,658 acres, with 300 miles of trails providing access to pristine streams, lakes, and meadows full of wildflowers during the short summer season (Wilderness Connect, n.d.b). It's 400 alpine lakes feed into the headwaters of the North and Middle Forks of the Boise River, the South Fork of the Payette River, and the Salmon River. The SW possesses some of the cleanest air in the United States and is registered as a Class I airshed (USDA, n.d.b) Recreational opportunities include sight-seeing, hiking, trail running, backpacking, rock climbing, horseback riding, fishing, and hunting.

Managers responsible for administering the SW for visitor recreation and wilderness preservation have mobilized their concern over increased visitation and impacts in the collection of visitor data, for nearly five decades. Trailhead registration and wilderness permit boxes enabled managers to actually count the number of visitors entering the SW and to collect characteristics on their visits. Concerns over detrimental impacts, especially biophysical impacts created by visitors, spurred SW managers to measure impacts occurring at campsites (USDA, 1997a,c). Over five decades, SW managers have implemented new regulations and management actions to reduce visitor impacts. The record-keeping of all of these factors created a unique

historical, and longitudinal data set archived by the SW, which made for an opportune case study to research trends in visitor use, associated detrimental impacts, and related management actions.

Archived Wilderness Ranger journals parallel the concerns of long-term SW USFS employees, outfitter guides, business owners, and recreationists – the SW has been discovered and consequently is being loved to death. The community's comments and support for new SW regulations over time reflect the growing apprehension over the assumed increase in yearly visitation to the SW, and the anticipated compounding impacts occurring on the ground, especially at campsites (USDA, 1997a,c).

Data Collection

In 1965, the Sawtooth Primitive Area began collecting visitor data at seven trailhead registration boxes (Lee, 1967). By 1979 each of the then 20 trails entering the SW had a trailhead registration box located where the trail crossed into the wilderness (Shrum, 1978, 1979, 1981, 1983, 1984). Visitor registration sheets inside these boxes captured trail accessed, visit date, group size, visitor's name, address, and comments. From 1965 to 1984, visitor totals were summed each year for both trailhead and overall SW visitor numbers. These totals were tracked on a large spreadsheet in the Sawtooth National Forest Service office (Figure 1.2). In 1997, new regulations implemented in the SW required groups, or solo visitors, to fill-out and carry a self-issued wilderness permit acquired from wilderness permit boxes, which replaced trailhead registration boxes on trails at wilderness boundaries (Figure 1.3) (USDA, 1997a, 1997b, 1997c). These SW permits captured permit box location, trip dates, group size, group leader, address, and planned destinations (Figure 1.4). Wilderness rangers frequented permit boxes as necessary to maintain their physical structure, collect permits, and resupply blank permits and pens. At the

end of each season, collected permits were boxed up and archived at the SNRA headquarters, Stanley Visitor Center, or Sawtooth Valley Work Center.

National Visitor Use Monitoring (NVUM) occurs on a five-year rotation at every National Forest. Surveyors interview visitors as they exit a National Forest or wilderness area, requesting data on demographics, recreational activities, and visitor satisfaction (USDA, n.d.a). Since the USFS updated their statistical process used to conduct in 2005, this study will only utilize data collected after this update. SW NVUM data from 2005, 2010, and 2015 was collected at SNRA trailheads (outside of the SW at parking lots) and publicly shared via the NVUM website.

Measurements of detrimental biophysical impacts associated with visitors have primarily accrued in the SW by evaluating campsites. The first campsite inventory in the SW occurred in 1975, which counted campsites and assessed their carrying capacities (Mullins, 1975). Unfortunately, the historic monitoring datasheets from this study are lost, but the archived final report and maps survived (Figure 1.5). That same year a graduate student from Evergreen State College conducted thesis research "Radial Plot Mapping of Campsite Trampling Severity: Sawtooth Wilderness" on eight alpine lakes in the SW (Figure 1.6) (Peterson, 1975). In 1980 the SW conducted a very detailed round of campsite monitoring using the Code-A-Site Method (Figure 1.7). The next round of SW campsite monitoring occurred from 1992 to 1994, utilizing Cole's 1989 widely used campsite monitoring protocol for counting campsites and measuring parameters (Figure 1.8) (Cole, 1989; USDA, 1992). Campsite data collected in the field on paper forms and maps were imported to digitized Excel spreadsheets and saved on USFS databases while paper forms were archived at the Stanley Visitor Center. From 2000 to 2013, campsite monitoring continued via wilderness rangers and a Sawtooth Wilderness Inventory and

Monitoring (SWIM) crew. This SWIM campsite monitoring data was imported into the Environmental Systems Research Institute's (ESRI) Global Information System (GIS) mapping programs (ArcGIS), and digitized Excel spreadsheets were saved on USFS databases.

Additional documents were collected from the SNF archives to verify quantitative data such as Annual Recreation Reports (Sawtooth Valley Ranger District Accomplishment Reports, Sawtooth Wilderness Management Reports, Recreation Use Summaries), Wilderness Ranger Reports, and Wildland Education Reports.

Data Organization

This section will describe the methods used to validate, clean, and organize the longitudinal quantitative data. All data was organized in Excel spreadsheets and will be shared with SW managers and saved on USFS databases.

Trailhead Registrations.

From 1964 to 1985, visitor use in the SW was tracked on a large spreadsheet displaying both trailhead totals per year and overall visitor numbers (Figure 1.2). The following archived Annual Recreation Reports from the SNF were referenced to validate and clean this trailhead registration data: Sawtooth Valley Ranger District Accomplishment Reports (1967 – 1970), Sawtooth Wilderness Management Accomplishment Reports (1978 – 1984) and SNRA Recreation Use Summaries (1990 – 1994) (Britton, 1990, 1991, 1993, 1994; Dean, 1999, 2000, 2001, 2005; Jacobsen, 1966; Lee, 1967, 1968, 1969, 1970; Mullins, 1975; Osmond 1965; Rember, 1972; Shrum, 1978, 1979, 1981, 1983, 1984). Commercial, outfitter, and special use permits were not included in these totals since these visits were confined by their agreements to operate in the SW at specific destinations or with predetermined visit characteristics and behaviors. Visitor numbers in the SW from 1964 to 1985 are an aggregate of actual trailhead

registrations, large group permits obtained at visitor centers, and a non-compliance percentage. Trailhead registration compliance was assessed through surveys conducted in the SW by wilderness rangers. Their calculations found visitor compliance ranged between 80-85% for day users, 87% for overnight visitors, and 30-50% for stock users. SW managers used this compliance data to add a yearly "noncompliance percentage," ranging between 13% and 17. To consistently utilize raw data, these additional compliance percentages, which were noted in each year's annual report, were subtracted from that year's visitor use totals. Archived historical documents also provided percentages for overnight visitors and totals for stock users.

Wilderness Permits.

In 2016, the Aldo Leopold Wilderness Research Institute (ALWRI) cataloged the SW's archived wilderness permits from 1997 to 2015 – totaling over 100,000 permits. Data from each permit was entered into Excel spreadsheets, which were shared with this study after all personal visitor information was removed. Data utilized from permits included: permit box name, trip dates, group size, and intended destinations (Figure 1.4). This data was cleaned through the removal of duplicate records, correcting destinations with "local" names with names from United States Geological Survey maps, and assigning records with no indicated group size number a visitor count of one. ALWRI cataloged permit records provided quality visitor use data for the following years: 1998, 1999, 2000, 2002, 2008, 20010, 2012, 2013, 2014, 2015.

An SNF draft analysis of SW visitor data ranging from 2001 to 2010 provided raw visitor use data for 2001, 2003, 2004, 2005, 2007, 2009 (Dean, 2012). This data set was cleaned for duplicates, mislabeled destinations, and missing group totals- replicating data cleaning procedures from the ALWRI data. After combining these two wilderness permit data sets collected by the ALWRI and the SNF draft analysis, duplicate records were eliminated. This

combined permit data was verified through SW Monitoring Reports (Dean, 1999, 2000, 2001, 2005). Trailhead registration data and wilderness permit registration data, which had all had the same detailed data cleaning, verification, and organization, was then combined into the one Excel database with spreadsheets organized by year.

Data organization included properly combining trailhead and permit data as their locations had experienced changes over five decades- such as relocations or mergers (Figure 1.2, 1.3). To account for these modifications, historic recreation records were utilized to align historic trailhead register locations with the SW permit box names and locations in 2015 (Figure 1.3). Visitor use numbers aggregated for the Grand Jean permit box encompass historic visitor use data from the following trailhead registration boxes: Baron Creek Trail, Baron Creek Road, South Fork Payette Trail, Trail Creek, and Grand Jean Horse permit box. The Bench Lakes permit box numbers include totals from the historic Redfish Highline trailhead registration. The Power Plant permit box totals contain counts from this historic Middle Fork of the Boise River trailhead registration. Tin Cup permit box numbers contain both the Tin Cup hiker and Tin Cup horse permit boxes. Wilderness permits from the Lily Pond permit box were sporadic and incomplete and thus, were not included in this study. Visitor use numbers from the Stanley Creek trailhead register were omitted since the actual wilderness boundary is eight miles up the trail at the Greenback Mine permit box.

These visitor use numbers are likely an under-representation of the actual totals for SW visitors. It is possible errors were made by visitors filling out permits or by those cataloging these 100,000 wilderness permits. Overall visitor numbers were also reduced by cleaning procedures that omitted erroneous permit and trailhead registration data. It is possible permits were lost instead of properly archived at the SNRA. Wilderness permits and trailhead registration

boxes in the field may lose permits when they are damaged or destroyed by inclement weather (avalanches have destroyed the Greenback and Mattingly permit boxes) or rodents (mice will nest in permit boxes).

National Visitor Use Monitoring.

NVUM data was collected, validate, cleaned, and organized by USFS NVUM employees and ultimately shared on the NVUM website. To visualize trends in demographics and satisfaction, secondary statistics from NVUM were separated per demographic category (gender, age, race, and ethnicity) in Excel spreadsheets. Statistics for crowding ratings and various satisfaction ratings (employee helpfulness, interpretive displays, parking availability, parking lot condition, feeling of safety, signage adequacy, trail condition) were also separated into Excel spreadsheets

Campsite monitoring.

The first three rounds of campsite monitoring in the SW in 1975, 1976, and 1980 utilized hand-drawn maps, depicting campsites at destinations (primarily at lakes) where the monitoring occurred (Figure 1.5, 1.6, 1.7). Due to the inaccuracies of hand-drawn maps, these historical sources only provided baseline data for the number of campsites at destinations. Only the 1975 campsite monitoring thesis, focusing on radial campsite measurements, provided campsite area, but only for eight destinations (Peterson, 1975).

The next round of campsite monitoring, from 1992 to 1994, followed the SW's Limit of Acceptable Change Monitoring Campsite Inventory Manual. This protocol recognized all prior efforts to monitor campsites in the SW as insufficient and outlined a new process to systematically monitor campsite impacts (USDA, 1992). This protocol focused on detailed measurements to provide an overall condition-class impact-index calculated from the overall

measurements of nine parameters (Figure 1.8). Each of the nine parameters received a rating (1-3), which was multiplied by an assigned weight (related to the permanence of the impact). All nine totals were summed for an overall condition-class impact-index (Figure 1.9).

From 2000 to 2007, the SWIM crew used a revised version of the 1992 campsite monitoring protocol to monitor "a select few campsites that are chosen subjectively to represent a wide range of impact levels, or roughly 25% of campsites per lake (Collier & Gindling, 2004; SNRA, 2001, p.15, 2007). In 2008, the SWIM crew returned to the 1992 campsite monitoring protocol to obtain "100% of campsite inventories" (Gindling & Serrian, 2008, p. 2; SNRA, 2009). This thesis only utilized campsite monitoring from 2008 on, to stay consistent with the protocol of measuring every campsite per destination, enabling campsite proliferation to be measured.

Campsite monitoring data in this study does not include campsites impacts for administrative outfitter and guide assigned campsites, administrative stock ties, and administrative toilets. All rounds of campsite monitoring data were scrutinized to remove duplicates and erroneous measurements. The compilation of nearly five decades of campsite monitoring was combined and organized in Excel spreadsheets and ArcGIS geodatabases.

Wilderness ranger reports.

Wilderness rangers document work accomplished on each "hitch" or work trips, on Sawtooth Wilderness Trip Report forms (Figure 1.10). These forms were cataloged by year with numerical measurements for various accomplishments: public contacts, trash packed out, and campfire ring maintenance. Individual trip reports and seasonal totals were verified by annual reports written by SW managers (Britton, 1990, 1991, 1993, 1994; Dean, 1999, 2000, 2001, 2005; Jacobsen, 1966; Lee, 1967, 1968, 1969, 970; Mullins, 1975; Osmond 1965; Rember,

1972; Shrum, 1978, 1979, 1981, 1983, 1984; SNRA, 2015.). This data was combined and organized into Excel spreadsheets.

Wildlands education reports.

In 1999 the SW implemented its Wildlands Education Program to teach visitors low impact behaviors. Archived files tallying the number of programs, contacts, and other outreach opportunities were verified by annual reports written by SW managers (Dean, 1999, 2000, 2001, 2005; SNRA, 2017a). Additional quantitative data on the Wildlands Education Program exists in a report on a survey conducted in 2003 to measure the quality of Leave No Trace programs provided by Wildlands Education staff (Focht, 2003). All education data was combined and organized into Excel spreadsheets.

Data Analysis per Research Question

The following section reviews what longitudinal quantitative raw data was graphed per research question, allowing for a visual inspection of trends and a descriptive assessment of changes occurring over time. By utilizing raw data in graphs, instead of statistical analysis, significance can be assigned by SW managers according to their legal management prescriptions (desired conditions, opportunity classes, and standards) outlined in the SNF and SW Management Plans (for an example from the SW see Figure 3.4). This thesis did not utilize the recreational quantification of visitors per day. Instead, it utilized the data according to the day each trip was indicated to have begun on the wilderness permit or trailhead registration.

Research Questions	Quantitative Data
Visitation Trends	
How have visitor trends in the Sawtooth Wilderness changed over the last 50 years?	Annual Recreation Reports
◦ Overall Visitor Numbers	Trailhead Registrations Wilderness Permits
◦ Visitor Demographics	National Visitor Use Monitoring
◦ Visit Characteristics	Wilderness Permits
Impact Trends	
How have detrimental visitor impact trends affected the Sawtooth Wilderness over the last 50 years?	Annual Recreation Reports
◦ Use Density	Trailhead Registrations Wilderness Permits
◦ Campsite Impacts	Campsite Inventories SWIM Campsite Monitoring Data
◦ Satisfaction	National Visitor Use Monitoring
Management Actions	
How have trends in management actions affected the Sawtooth Wilderness over the last 50 years?	
◦ Engineering ◦ Enforcement ◦ Education	Annual Recreation Reports Timeline Wilderness Ranger Reports Wildlands Education Reports
Coupled Data	
What trends are revealed by coupling longitudinal quantitative data for visitation, associated detrimental visitor impacts, and management actions in the Sawtooth Wilderness?	Visitation Trends Impact Trends Management Actions

Research Question 1: How have visitor trends in the Sawtooth Wilderness changed over the last 50 years?

The longitudinal quantitative visitation data, from trailhead registrations and wilderness permits, which were combined and organized into Excel spreadsheets, was divided into three categories of trends: overall visitor numbers, visitor demographics, and visit characteristics. Data for each category was graphed for a visual inspection and a descriptive assessment of trends.

Overall visitor numbers. The data from both trailhead registrations and wilderness permits was used to assess overall visitor numbers. Yearly totals for each trailhead registration and consequent permit box were totaled to calculate yearly visitor numbers, which were graphed per year, to visualize trends in SW visitor numbers. The graph's drastic decreasing trend in visitor numbers in the mid-1990s suggested an error in data collection, organization, cleaning, or visualization. To validate that this decreasing trend truly represented visitor numbers in the SW, it was compared to other visitor use trends on public lands in the Western United States (USDI, n.d.). This decrease in overall visitor use numbers in the mid-1990s seems to be a consistent trend throughout the West and validated the SW data (Figure 1.11).

Visitor demographics. NVUM data was used to assess trends in visitor demographics in the SW, such as gender, age, and ethnicity or race. NVUM statistics from three rounds of surveys (2005, 2010, 2015) were graphed to visualize and descriptively assess trends. Data quantifying trends of residence for SW visitors was obtained from the SNF draft analysis of visitors from 2000-2010 and visualized to display differences in visitor's residences.

Visit Characteristics. Wilderness permit data (1997-2015) was the primary source of quantitative data visualized for trends in visit characteristics. Quantitative data from annual recreation reports (1965-1994) measuring types of visits (day, overnight, and stock) were also used. Permit data sorted by year in Excel spreadsheets was sorted by permit parameter (i.e., "Number of People" per group) and graphed by year to visualize and descriptively assess trends (i.e., average group size per year). By sorting the data by the number of days per trip (end trip date – begin trip date) and multiplying each total by its related permits group size, the amount of day and overnight visitors per year could be graphed per year to display trends. Calculations for the type of visit (day, overnight, stock), occurring before 1997, were sourced from annual reports

(1965-1994) and combined with wilderness permit totals of type of visit to be graphed per year. The count of days, or trip duration, was averaged per year and graphed to visualize trends. To measure the time of visitation, trip dates were sorted by month, counted, and displayed to show visitor totals for each month of the year. Both wilderness permit data and annual reports noted stock use numbers, which were graphed per year to visualize trends.

Research Question 2: How have detrimental visitor impacts trends affected the Sawtooth Wilderness over the last 50 years?

Over the last five decades, the SW has collected and archived quantitative measurements of biophysical impacts at campsites to measure detrimental visitor impacts. In 2016 the SW began drafting a Solitude Monitoring protocol to measure social impacts by counting visitor encounters. No quantitative or qualitative data on social impacts was available for this study by 2020.

Longitudinal quantitative data measuring detrimental trends in visitor impacts was separated into use densities, measuring which destinations visitors are frequenting; and campsite impacts, measuring where visitors are creating detrimental impacts. NVUM data measuring a visitor's satisfaction served as a proxy for impacts affecting a visitor's wilderness experience.

Use density. Trailhead registrations and wilderness permit data were graphed and visualized for trends in use density for both permit boxes and destinations. Each of the 17 trails entering the SW has a wilderness permit box at the wilderness boundary (before 1997, these locations had trailhead registration boxes) (Figure 1.3). Separate graphs for the yearly totals of visitors at each permit box display different trends in use densities at each permit box. Numbers for use density at destinations were obtained from wilderness permits via the required section titled "Planned Destinations (day or overnight) or Camp Locations" (Figure 1.4). Wilderness permit data organized in Excel spreadsheets was sorted for destinations per year, which were

each multiplied by group size noted on the respective permit, and then summed for each destination's total visitors per year. By graphing these totals per year, the individual trends of use density were visualized and descriptively assessed for each destination. It was not possible to differentiate how long visitors stayed at a destination - a quick rest, multiple nights, or a change in plans.

Campsite impacts. To assess nearly five decades of campsite impact trends throughout the SW, campsite numbers (proliferation) at destinations were organized in an Excel spreadsheet to see when (temporally), and where (spatially), campsite numbers increased or decreased. This visualization and descriptive assessment (for campsite proliferation) occurred for all rounds of campsite monitoring spanning the five decades. Visualization and descriptive assessments for trends in additional campsite parameters (aggregate campsite area per destination, and average impact index per destination) occurred for campsite monitoring rounds that occurred both in the 1990s, and during the timespan of 2008 to 2013. Aggregate campsite area per destination was calculated by totaling the area of each campsite measured at a destination (typically lakes). The average impact index per destination was calculated by adding the impact indexes for all campsites at a destination and dividing by the total number of campsites at that destination. This information, along with campsite numbers per destination, was put into Excel spreadsheets to see when, and how, these numbers changed over time at each destination. Campsite data from the 1990s and 2000s was also visualized in ArcGIS maps to see where campsites existed per each round of campsite monitoring, along with each campsite's area and impact index.

Satisfaction. Quantitative measurements from NVUM surveys in 2005, 2010, and 2015 were utilized for visitor satisfaction and a sense of crowding. Various parameters of "satisfaction" from the NVUM analysis in the SW were separated and graphed over time to

visualize if trends varied across parameters (employee helpfulness, interpretive displays, parking availability, parking lot condition, feeling of safety, signage adequacy, trail condition).

Research Question 3: How have trends in management actions affected the Sawtooth Wilderness over the last 50 years?

Management actions are guided by federal legislation, agency regulations, or in specific SNF Land and Resource Management Plans or SW Management Plans. It is the implementation of these management actions that produce quantitative data, which are categorized as the following: engineering, enforcement, and education.

Engineering. Engineering projects implemented in the SW (documented in annual reports) include trail projects (bridges, rehabbed roads), toilets, campsite restorations, and signage. This data was organized chronologically in a timeline to see how often and when engineering management actions occurred in the SW.

Enforcement. Numbers of warnings and fines issued to SW visitors were not available for analysis. A timeline of management actions with enforceable regulations (Code of Federal Regulations) in the SW was created to visualize how often new enforcement actions were created and implemented.

***Education*.** Quantitative data for education comes from reports from both wilderness rangers and the Wildlands Education Program. Accomplishments by wilderness rangers organized in Excel spreadsheets (public contacts, trash removal, campfire rings maintained) were graphed per year to visualize and describe trends. Data from the Wildlands Education program organized in Excel spreadsheets (public contacts, education programs) was also graphed per year to visualize and describe trends.

Research Question 4: What trends are revealed by coupling longitudinal quantitative data for visitation, associated detrimental visitor impacts, and management actions in the Sawtooth Wilderness?

For a different perspective of the SW, the individual trends in visitors, associated detrimental visitor impacts, and related management actions were coupled spatially and temporally. An example of such coupling is visualizing visitation trends at a trailhead, with visitation trends at a destination (accessed via that same trailhead), with campsite impacts at that destination. By visualizing and descriptively assessing trends on the same timeline (high or low visitation), or at the same permit box locations or destinations (high or low visitation), it is possible to see when and where campsite impact trends did or did not occur. By additionally coupling these trends with management actions, such as enforcement (regulations) and education (wilderness rangers and the Wildlands Education Program), trends in visitor impacts and behaviors may be visualized.

Appendix 2
Methods

Figure 1.1 Location of the Sawtooth Wilderness

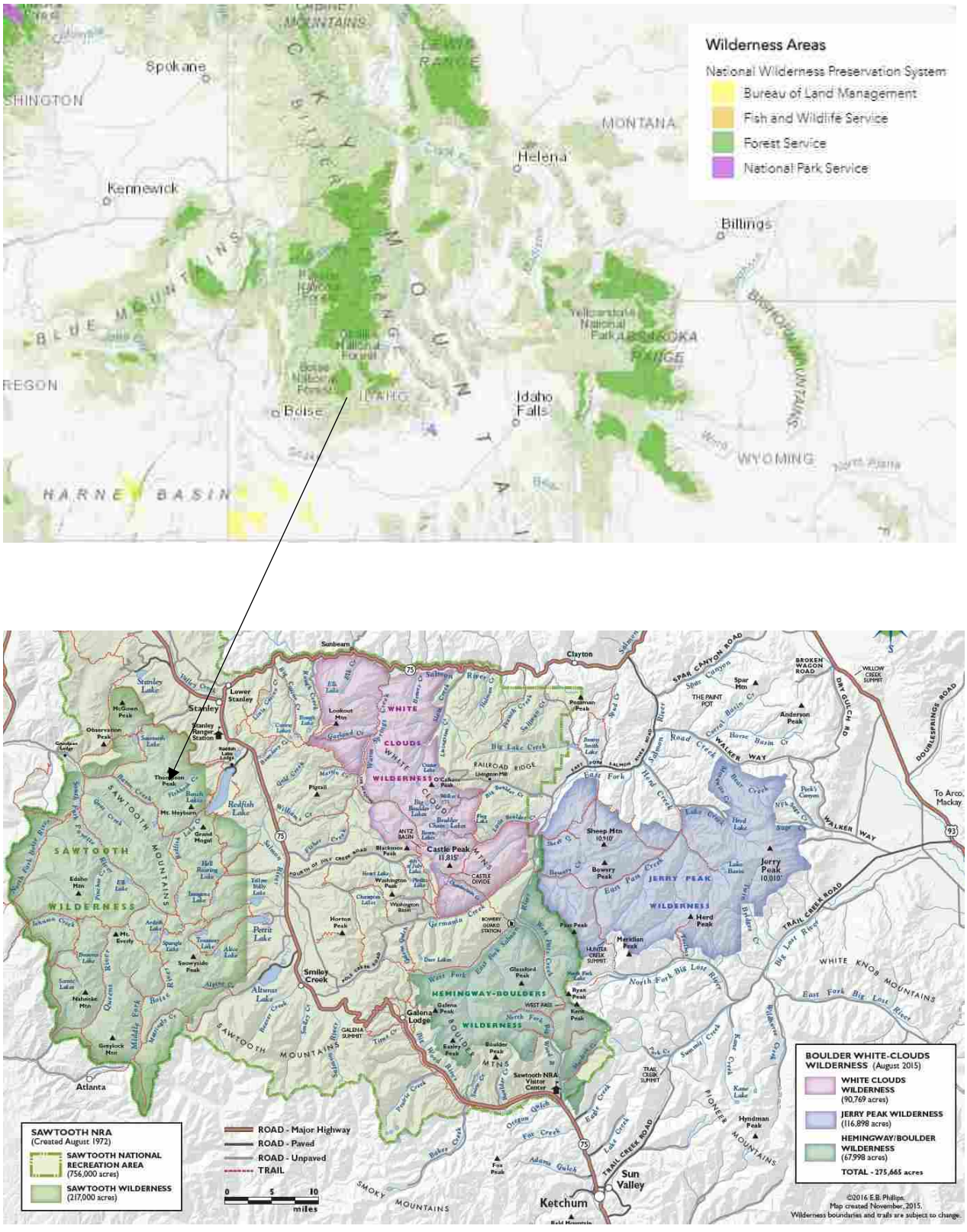


Figure 1.2
Trailhead Registration Record 1964 – 1985

SAWTOOTH WILDERNESS
VISITOR REGISTRATION

REGISTRATION BOX	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Iron Creek									2599	2702	3422	2837	3172	3457	2856		2951	2911	2448	2901	2845	
Tin Cup Backpacker T.C.				480	211	401	615	656		1601	2076	1849	2172	2789	2878		2508	2740	2609	2677	2761	
Tin Cup Horse T.C.												127	84	134	176		238	275	97	127	224	
Bench Lakes				620	824	1102	964	1127		1221	1728	1428	1929	1712	2421		1885	2023	1777	1903	2115	
Hell Roaring				174	260	483	599	642		1029	1026	1280	1657	1894	1594		1881	1609	1693	1658	1606	
Redfish Inlet				370	455	302	455	775		990	1036	705	921	1206	1279		1446	1444	1540	1392	1553	
Baron Creek Trail			335	324	491	443	758	814	1342	1127	1376	768	827	770	940		1147	838	953	973	962	
Baron Creek Road											N/A	390	340	657	453		397	372	274	210	205	
Queens River				166	178	160	302	494		447	708	619	566	726	580		604	510	372	545	541	
Middle Fork Boise River				88	92	139	149	348		258	573	502	452	624	694		536	519	461	442	483	
Trail Creek			34	47	249	221	603	394	501	434	488	457	597	607	560		630	610	575	475	508	
Alpine Creek				307	280	358	269	508		530	388	474	550	697	488		613	511	426	567	642	
Redfish Hiline				33	38	51	66	72		278	362	365	317	495	504		332	276	137	171	325	
Yellow Belly				171	344	422	505	726		523	344	389	510	425	358		171	208	185	144	[illegible]	
Alpine Way										152	334	276	211	493	498		281	363	267	251	241	
Stanley Lake Creek									102	169	313	305	417	921	998		1086	1066	790	822	1148	
Graham			16	36	78	38	129	159	121	163	185	100	114	123	23		45	57	118	58	49	
Alturas Lake Creek														68	103		104	158	145	165	208	
Cabin Creek															109		329	270	304	588	408	
Marshall Lake																	388	421	322	[illegible]	442	
Permits not Registering												116	227	352	228		286	369	321	272	157	
Estimated Use										659	574	1578	1483	2358	2271		2636	2577	2334	2170	2219	
TOTAL	N/A	7340	7309	6878	7164	9106	11264	12581	12812	12431	14933	14565	16546	20508	18971	21100	20364	20127	18141	18012	20[illegible]	
Fishlock																					505	

Figure 1.3
Wilderness Permit Box Locations in 2015

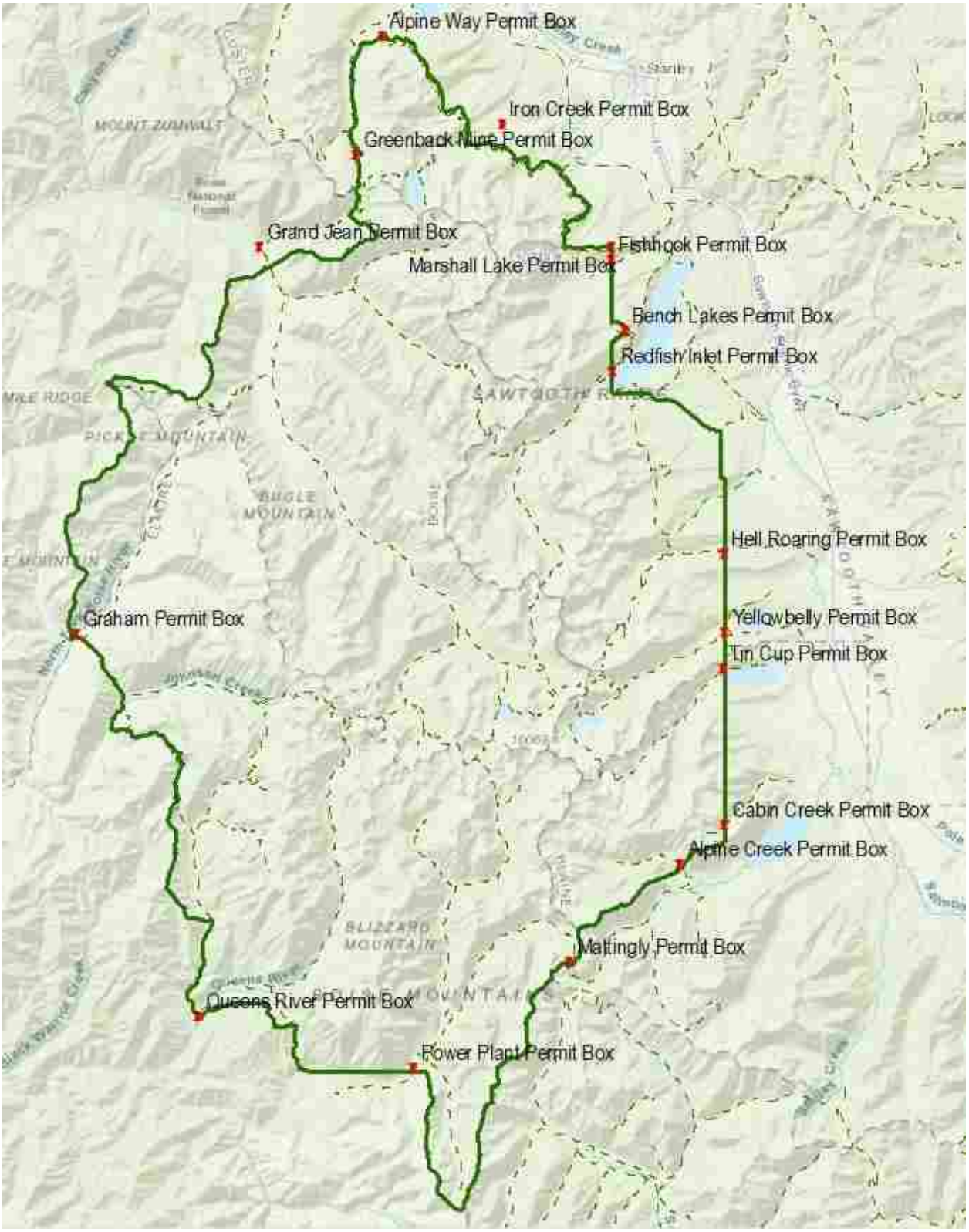


Figure 1.4
Sawtooth Wilderness Permit 1997 – 2015

United States Department of Agriculture

Forest Service Intermountain Region

WILDERNESS USE PERMIT

PLEASE PRINT CLEARLY
DEPOSIT THIS COPY IN BOX

Date Trip Begins	Date Trip Ends
Entry Location	Exit Location

PARTY LEADER

Name		Zip Code
Number of People	Number/Type of Stock	Number of Dogs

Planned Destinations (day or overnight) or Camp Locations	Number of Nights

I agree to abide by all laws, rules and regulations (including those on the reverse of this permit) which apply to this area and will do my best to see that everyone in our group does likewise.

Visitor's Signature Date

VISITOR MUST HAVE THIS PERMIT IN POSSESSION DURING STAY IN THE SAWTOOTH WILDERNESS

(For administrative use) Issuing Office_____

Figure 1.5
Sawtooth Wilderness Campsite Inventory 1975
1975 SNRA Campsite Inventory: Imogene Lake

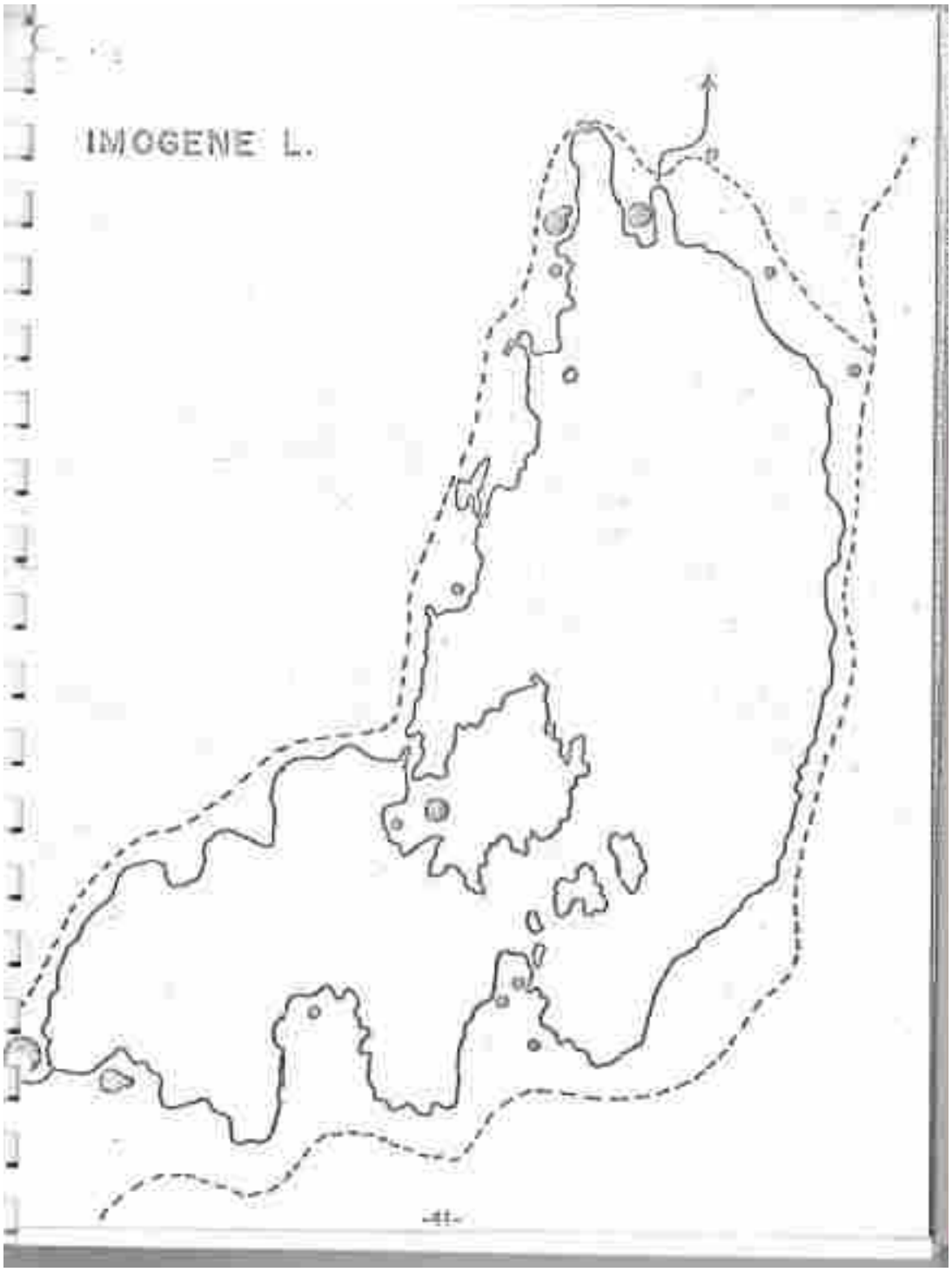


Figure 1.6
Thesis Research on Radial Plot Mapping of Campsites in the Sawtooth Wilderness
1975 Thesis Campsite Research: Imogene Lake

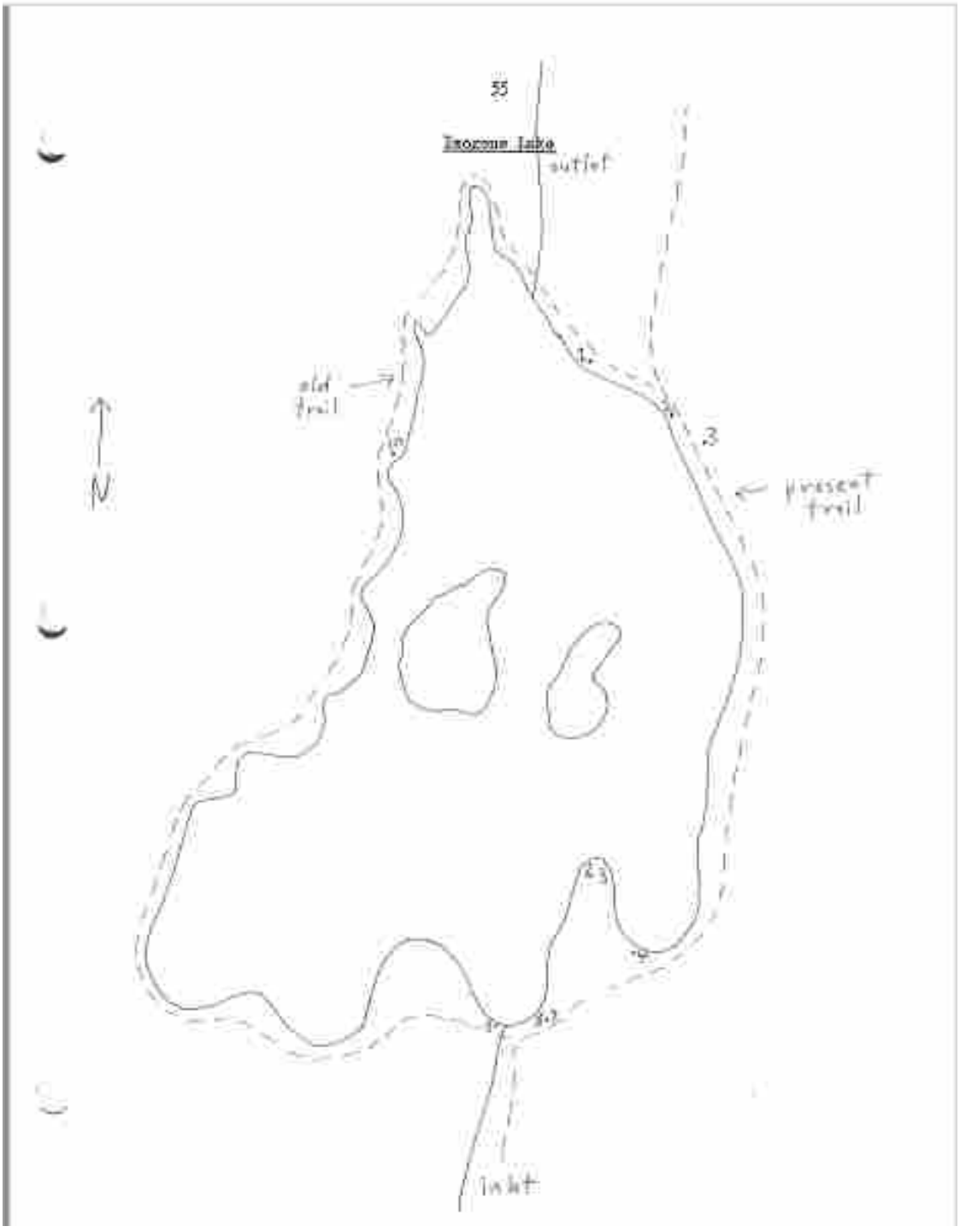


Figure 1.7
Sawtooth Wilderness Campsite Code-A-Site Inventory
1980 SNRA Code-A-Site: Imogene Lake

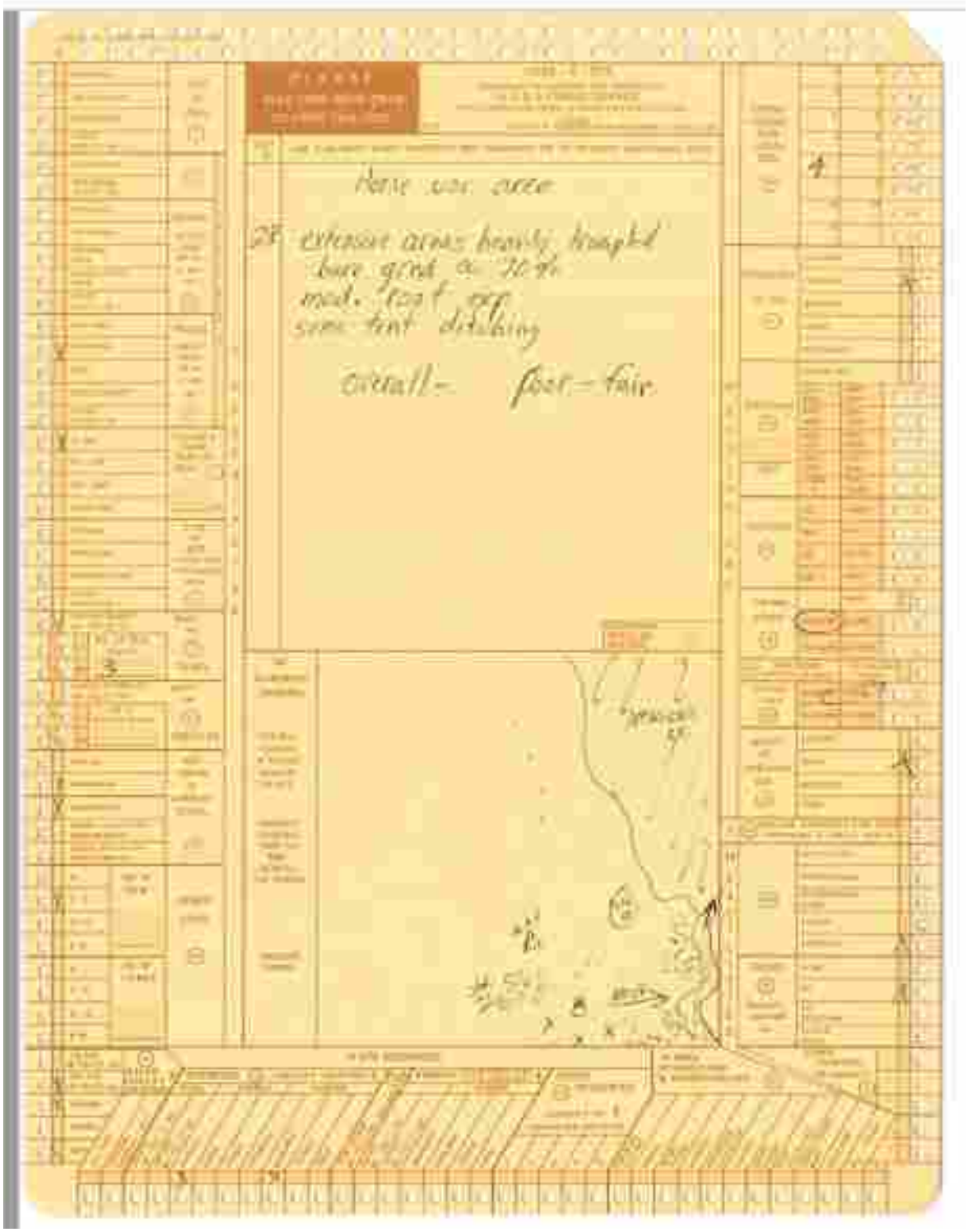


Figure 1.8
Sawtooth Wilderness Limits of Acceptable Change: Campsite Monitoring Data Sheet

Time: start _____ finish _____ Wilderness: _____
Date: _____ Coordinates: Northing _____
Crew: _____ UTMs, NAD83 Zone 11 Easting _____
Weather: Sunny, Partly Cloudy, Overcast, Rain, Snow

Inventory Unit _____
Drainage # _____ Lake # _____
Campsite # _____ Lake Name _____

Campsite Description _____

CIRCLE ONE

Frissel Rating	0 1	2 3	4 5			
Site Locale	Forest Rock	Meadow	Forest & Rock	Forest & Meadow	Rock & Meadow	
CS Distance from Trail	0-100 ft	>100 ft				
Firewood Availability	0-100 ft	>100 ft				
Firewood Natural	Yes	No				
Onsite Veg Cover	0-5%	6-25%	26-50%	51-75%	76-100%	
Offsite Veg Cover	0-5%	6-25%	26-50%	51-75%	76-100%	
Vegetation Class Loss	No Difference	1	2+			
Onsite Mineral Soil Exposure	0-5%	6-25%	26-50%	51-75%	76-100%	
Offsite Mineral Soil Exposure	0-5%	6-25%	26-50%	51-75%	76-100%	
Mineral Soil Class Increase	No Difference	1	2+			
# Trees with Scars	0-25%	26-50%	51%+			
# Trees Fell	0-25%	26-50%	51%+			
Tree Damage	None	Manure/Feed	Manure/Feed/Tree Damage			
Root Exposure	Yes	No	* if Yes, complete Stock Tie Survey Form			
Stock Evidence	None	1-2 Structures	2+ Structures			
Stock Tie Post Developments	None/Fire Evidence	Fire Ring/Litter	Ring/Litter/Human Waste			
Cleanliness	0 1	2 3	4 _____			
# of Fire Rings	Yes	No				
Fire Evidence	0-1	2-3	>3 _____			
Litter	0	1 2	3 4	5 6	7 8	9
# Social Trails	GPS _____					
# Satellite Sites	_____					
	_____					
	_____					
CS Length (ft)	0-500 ft²	501-1500 ft²	>1500 ft²	*includes satellite sites & non FS stock tie		
CS Width (ft)						
CS Area (L x W)						
CS Area Estimate (ft)						

Figure 1.9
Campsite Impact Index Calculations

Parameter	Parameter Ratings	Parameter Weights
Vegetation Loss	1-3	2
Mineral Soil increase	1-3	3
Tree Damage	1-3	3
Root Exposure	1-3	3
Stock Evidence	1-3	2
Development	1-3	1
Cleanliness	1-3	1
Social Trails	1-3	2
Campsite Area	1-3	3

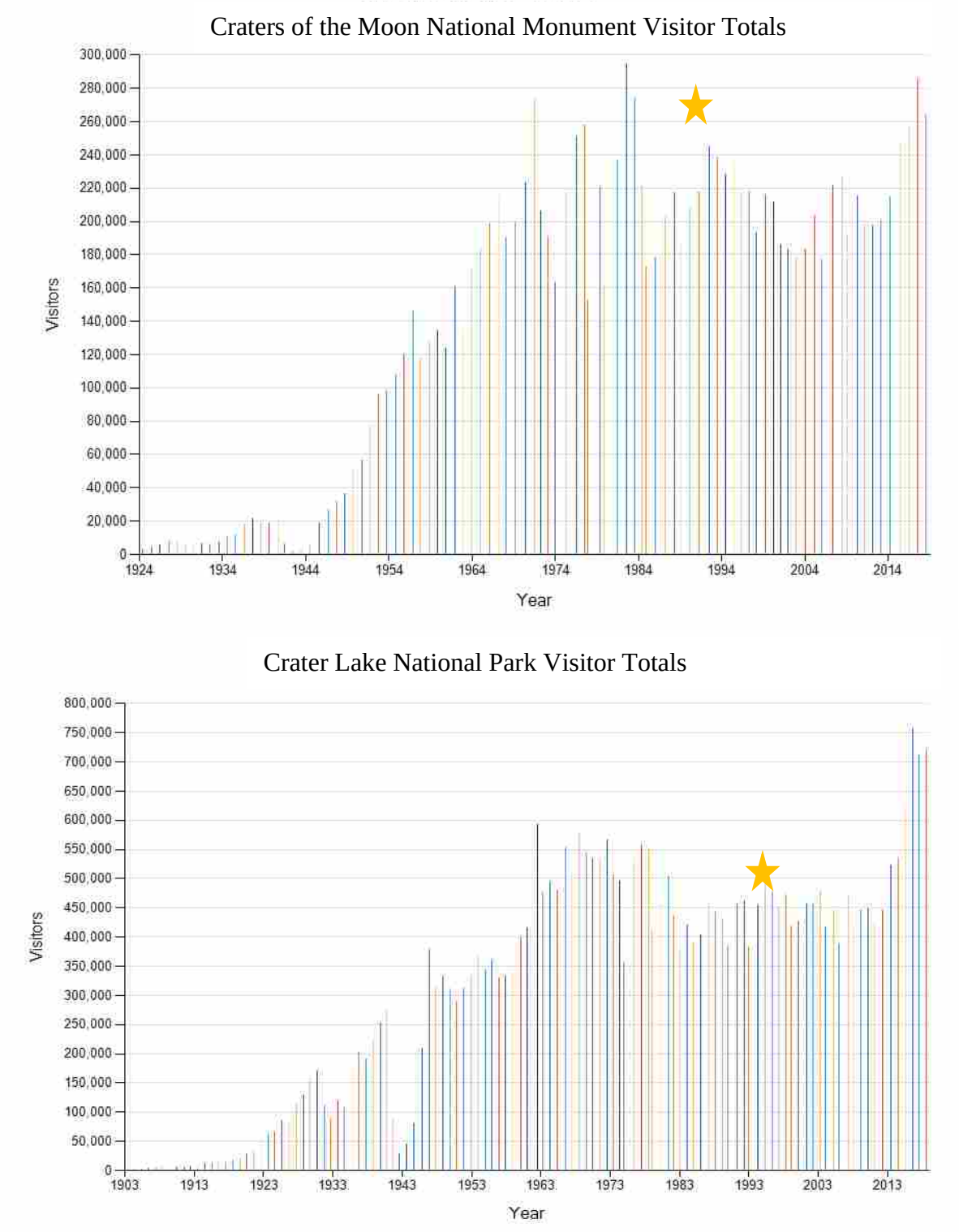
Condition Classes	Impact Index
Light Impact	20-30
Moderate Impact	31-39
Heavy Impact	40-49
Extreme Impact	50-60

Figure 1.10
Sawtooth Wilderness Ranger Trip Report Form

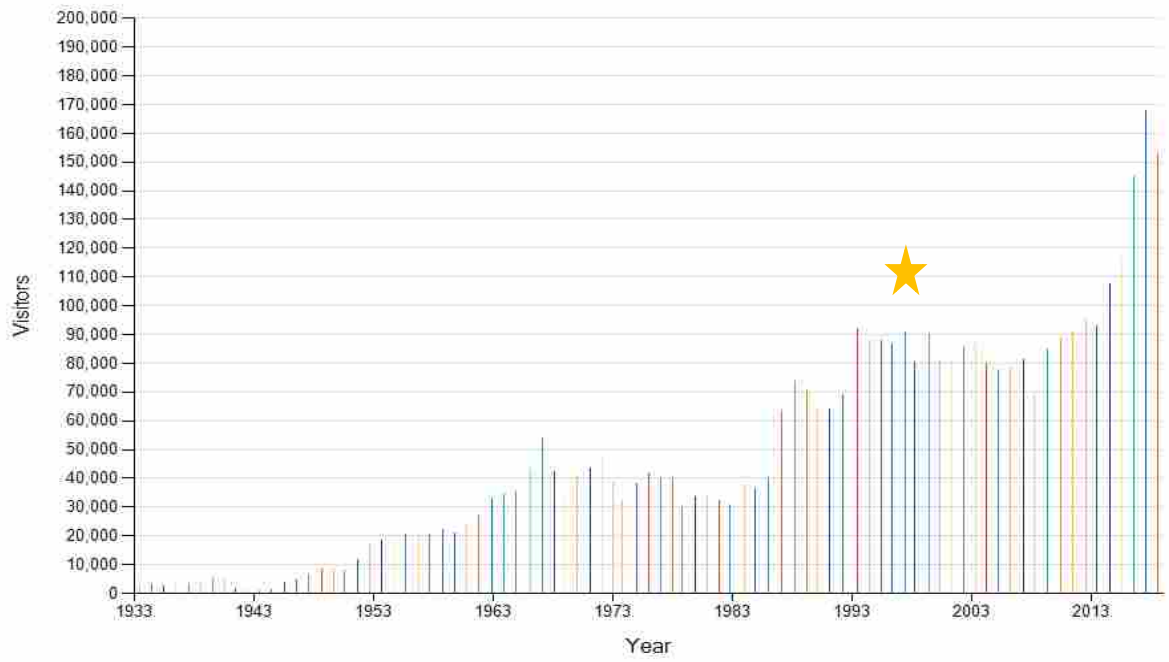
Wilderness Ranger Name:

Day						Total
Date *include year*						
Area						
Day Hikers (group size)						
Backpackers (group size)						
Day Riders (#people/#stock)						
Horsepackers (#people/#stock)						
Llamas (#people/#stock)						
Goats (#people/#stock)						
# Parties This number should add up to the number of parties from the 8 categories above						
# Dogs (#dogs/# on leash)						
Litter Packed Out (# of bags)						
# Fire Pits Cleaned						
Citations Written (# and type) (not IRs/Warnings)						

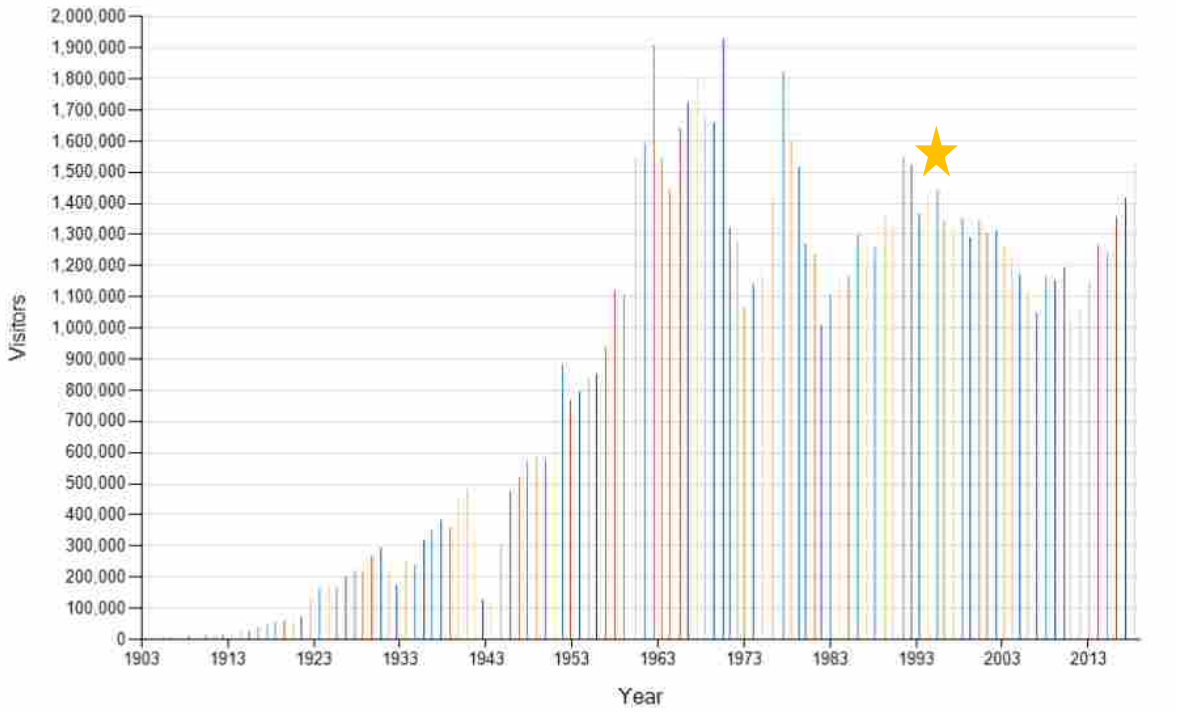
Figure 1.11
Overall Visitor Number Trends from Public Lands
★ Mid-1990s decreasing trend



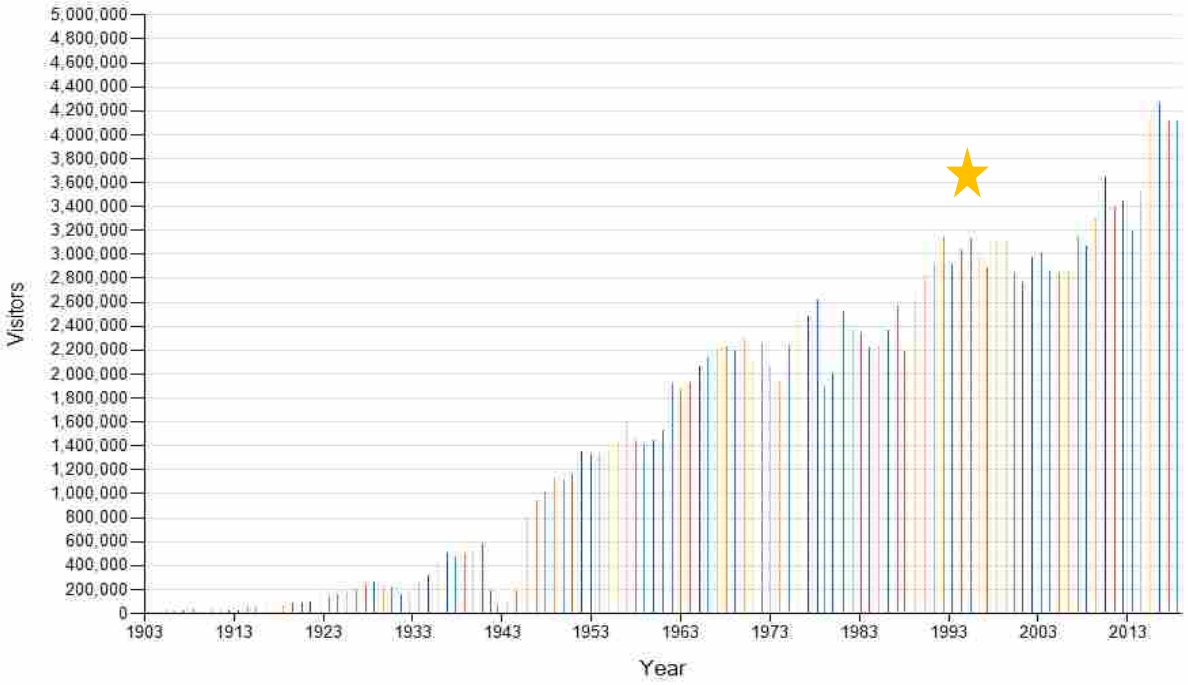
Great Basin National Park Visitor Totals



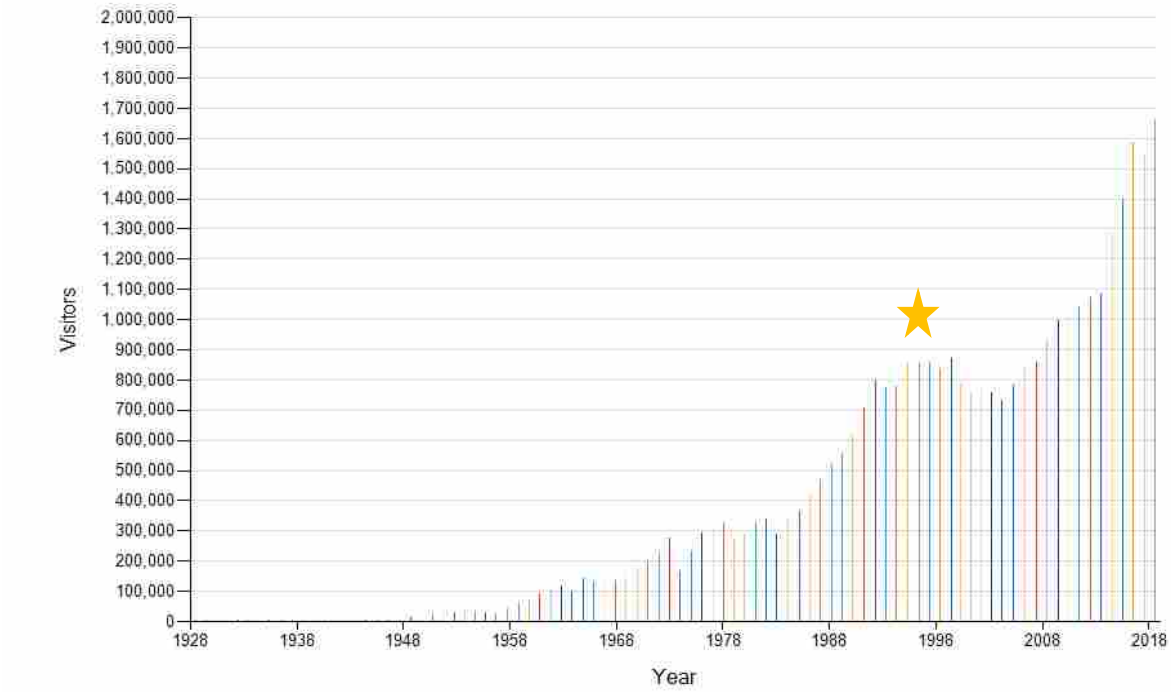
Mount Rainier National Park Visitor Totals



Yellowstone National Park Visitor Totals



Arches National Park Visitor Totals



Chapter 4
Results

This chapter reviews the results of the visualization and descriptive assessment of the subsequent trend data as it applies to each of the research questions. All referenced figures and tables can be found in the subsequent appendix.

Research Question 1: How have visitor trends in the Sawtooth Wilderness changed over the last 50 years?

Overall Visitor Numbers

The general visitation trends in the Sawtooth Wilderness indicate an increase in overall visitor numbers over the last 50 years, from 6,500 visitors in 1965 to over 27,000 visitors in 2015 (Figure 1.1). A spike in visitors occurred from 1992 and 1994, around 30,000 visitors, which was immediately proceeded by a sharp drop in visitation in the mid-1990s. Visitor numbers began increasing again in 1999 and continued to rise until the last year of permit analysis in 2015, which totaled nearly 27,000 visitors.

Visitor Demographics

National Visitor Use Monitoring (NVUM) data from 2005, 2010, and 2015 indicate over half of the SW visitors were male, with the percentage of female visitors increasing from 41% in 2005 to 46% in 2015 (Figure 1.2). This NVUM data shows a large portion of visitors are between the ages of 50-70, with an increase in visitation among younger visitors, especially in the 20 to 40-year-old age group (Figure 1.3). Most visitors to the SW are white, which in 2015 accounted for nearly 100% of surveyed visitors (Figure 1.4). Almost 70% of SW visitors reside in Idaho, with 33% of those living in Boise, Idaho (Figure 1.5, 1.6).

Visit Characteristics

Characteristics of visits in the SW have changed over the last 50 years. Group size has slightly decreased from 3.2 people per group in 1998 to 2.8 in 2015 (Figure 1.7). Both day and overnight visitor numbers have generally increased over the last 50 years in the SW, with overnight visitor proportions rising from 11% of visitors in 1966 to 30% in the late 1990s, and up to 32% in 2015 (Figure 1.8). The duration of an overnight stay has decreased from an average of 3 nights per trip in 1976 to 2.33 nights per trip in 2015 (Figure 1.9). Most overnight and day visits still occur during the summer months (June – September). However, the "off-season" months of April, May, October, and November are seeing increasing numbers of visitors (Figure 1.10). The most significant change in SW visit characteristics is the decrease in stock use (horse, mule, goat, or llama) for day and overnight visits. In the 1960s, roughly 20% of registered visitors in the SW used stock, but by 2015 this type of visitor use had dropped to only 1% of all visitors (Figure 1.11).

Research Question 2: How have detrimental visitor impact trends affected the Sawtooth Wilderness over the last 50 years?

Use Density

Fifty years of trailhead registrations and wilderness permits provided use density data for wilderness access points (via permit boxes) and destinations (as listed on permits). Permit-box registration trends vary dramatically throughout the SW (Figure 2.1-2.17). The overall trend across the SW is decreasing permit-box registration on the western side of the wilderness, and increasing permit-box registration in a few areas on the eastern side of the SW. The Grand Jean permit box is an exception to this trend as it shows consistent visitor numbers over the last five decades. In 2015, the last year included in permit data analysis, use densities reflect this pattern of exceptionally more visits occurring on the eastern side of the SW (Figure 2.18). Six permit

boxes on the eastern side of the SW are experiencing increasing registration trends: Alpine Creek, Iron Creek, Marshall Lake, Redfish Inlet, Tin Cup, and Yellowbelly. Three permit boxes are seeing consistent registration over the last fifty years: Cabin Creek, Grand Jean, and Hell Roaring. Permit boxes with decreasing registration trends include Alpine Way, Bench Lakes, Fishhook, Graham, Greenback Mine, Mattingly, Power Plant, and Queens River. All permit boxes on the western side of the SW have decreasing visitor numbers, except for the Grand Jean permit box.

SW permits require visitors to indicate which destination(s) they plan to travel to. Several trends are apparent by visual inspection of each destination's visitation graph. Destinations deeper in the wilderness have been experiencing higher proportions of overnight visitors, while destinations closer to parking lots and trailheads experience higher frequencies of day visitors (Figure 2.1-2.17). The most recent data, from 2015, suggests the most popular destinations are Sawtooth Lake and Alice Lake, followed by Toxaway Lake, Hell Roaring Lake, Saddleback Lakes, and Alpine Lake via Redfish Inlet (Figure 2.19). Destinations experiencing a majority of day visitors in 2015 include: Alpine Lake via Redfish Inlet, Bench Lakes, Alpine Lake via Iron Creek, Cabin Creek Lakes, Goat Lake, and Sawtooth Lake. Destinations deeper in the SW experiencing increasing rates of overnight visits include Ardeth Lake, Benedict Lake, Browns Lake, Edna Lake, Ingeborg Lake, Packrat Lake, Pats Lake, Vernon Lake, and Virginia Lake.

Destinations located in the center of the SW do not display overall consistent trends for visitation; visits are neither consistently increasing nor decreasing. Spatial and temporal variations in use densities have occurred at destinations deeper in the SW (Figure 2.20-2.52). Destinations less than two trail miles apart display contrasting use density trends. For example, Edna Lake has experienced increasing visitation, while nearby Vernon and Virginia Lakes have

seen decreasing visitation (Figure 2.31, 2.50, 2.51). Upper Redfish Lakes are experiencing fluctuations in its use density, or numbers of visitors per year, while nearby Kathryn Lake has recently seen an increase use density (Figure 2.49, 2.40).

Biophysical Impacts at Campsites

Four decades of campsite monitoring data in the SW indicate where detrimental biophysical impacts have occurred (or not) throughout the SW (Figure 2.53). Due to variations in SW campsite-monitoring protocols, campsite proliferation is the only quantifiable impact that can consistently be compared over the four decades (1975 – 2013). Campsite-area and impact-index analysis can be compared across specific destinations for the two separate rounds of campsite monitoring from the 1990s and 2000s (Figure 2.54).

Campsite impacts vary significantly throughout the SW (Figure 2.53). The overall trend from baseline data (gathered in 1975, 1976, and 1980) is an increase in campsite impacts, reflecting an increase in campsite proliferation and aggregated campsite area. Many destinations have seen an increase in impacts at some point in time, especially at previously unimpacted destinations (with zero campsites) having accrued campsites over the last thirty years, like Goat Lake, Kathryn Lake, and Upper Redfish Lakes (Figure 2.54). A handful of popular destinations (Alice Lake, Farley Lake, Hell Roaring Lake, Imogene Lake, and Virginia Lake) show a reduction of campsite impacts, both in a decrease in total campsite numbers and aggregate campsite area. Nearly a quarter of all destinations have decreasing impact indexes, though the number of campsites or aggregate campsite area may be increasing. Some destinations display trends of decreasing campsite numbers and increasing aggregate campsite area, suggesting that campsites are expanding to merge with nearby campsites.

Satisfaction

NVUM surveys measure several attributes of a wilderness visitor's experience, including a sense of crowding and overall satisfaction. The last three rounds of NVUM surveys (2005, 2010, 2015) in the SW show visitors do not generally feel crowded and are satisfied with their wilderness experience in the SW. NVUM's crowding survey scale ranges from 1 to 10, with 1 signifying a visitor felt there was 'hardly anyone there' and ten signifying they felt 'overcrowded.' In 2005, 93% of respondents provided a rating of 5 or below, in 2010 only 56% of visitors replied with a five or below, and in 2015, 76% of respondents provided a rating of 5 or below (Figure 2.55). The last three rounds of NVUM surveys found SW visitors were satisfied to very satisfied with their trip, providing high satisfaction rates for parking availability, parking lot conditions, feeling safe, and trail conditions (Figure 2.56).

Research Question 3: How have trends in management actions affected the Sawtooth Wilderness over the last 50 years?

Management actions for the SW originate in its establishing legislation and proceeding Wilderness Management Plans (see Figure 3.1 for timeline). These plans provide direction for wilderness character preservation through controlling visitor behaviors via engineering projects, creating and enforcing regulations, and by prioritizing educational opportunities through personal contacts (Figure 3.2, 3.3). The 1997 SW Management Plan applied the Limits of Acceptable Change to manage for impacts rather than focusing on visitor numbers, and utilized the Wilderness Opportunity Spectrum to create four opportunity classes in the SW. Each of these opportunity classes has specific desired conditions and standards, which are to be checked by routine monitoring data and maintained by appropriate management actions (Figure 3.4).

Engineering

The records of engineering projects around and within the SW are minimal (see Figure 3.1 for timeline). In 1965, wilderness rangers began installing wilderness trailhead registration boxes, signage, and wilderness toilets in the SW. Toilet maintenance occurs as necessary up to the present day, though their decommissioning and removal has been underway for nearly a decade. In 1997 another targeted round of registration boxes and signage occurred with the implementation of mandatory self-issued wilderness permits. Several old roads within the SW were rehabilitated in the 2000s.

Enforcement

The timeline of law enforcement on the lands making up the SW began in 1905 when they became the Sawtooth Forest Reserve, administered by the USFS (see Figure 3.1 for timeline). Additional regulations for the area occurred in 1937 under the L-20 Regulations creating the Sawtooth Primitive Area. In 1972, these lands fell under the regulations of the Wilderness Act by receiving federal protections as the Sawtooth Wilderness. In 1977, SW managers implemented new wilderness regulations (Figure 3.2). In 1997, additional regulations transpired with the implementation of the SW's second Wilderness Management Plan (Figure 3.3). Most wilderness rangers in the SW are certified USFS Forest Protection Officers authorized to write citations to visitors breaking the law. Management priorities are to educate visitors on the regulations for the area, resulting in few issued citations. Documentation of law enforcement actions in the SW, such as warnings, citations, and fines, were unavailable for this study.

Education

Both SW Management Plans from 1977 and 1997 call for prioritizing wilderness access and opportunities for satisfactory public use by focusing on indirect methods of control,

primarily education (see Figure 3.1 for timeline). Management plans concentrate on the improvement of visitor behaviors to occur through face-to-face public contacts by wilderness rangers and the Wildlands Education program, who can explain the rules and regulations of the SW.

Wilderness Rangers. Although the Sawtooth Primitive Area was designated in 1937, a wilderness ranger program was not instituted until 1965 (Figure 3.5). The goal of the program then is similar to its goals today: clean up trash and maintain clean campsites, conduct educational visitor contacts, manage necessary signage, and maintain trails. The numbers of wilderness rangers, and eventually volunteers, have varied over the years. Data from wilderness reports suggest increasing the number of rangers in the field increases the number of public contacts (Figure 3.6). Visualizations of graphed trend data from Wilderness Rangers reports suggest the amount of trash wilderness rangers have packed out, and the numbers of campfire rings destroyed in the SW, have both decreased. Yet these actions appear to be still necessary, even though SW regulations have prohibited litter and campfire rings since 1977 and 1997, respectively. (Figure 3.1, 3.2, 3.3, 3.7, 3.8, 3.9).

Wildlands Education Program. The desire for an SW Wildlands Education Program was heard at public scoping meetings for the SW Management Plan of 1997. Though the public supported the new regulations in the Plan, there was a call for the Forest to balance enforcement with education. In 1999, the SW implemented its Wildlands Education Program, which encompassed all three aspects of management: signs at trailhead parking lots and wilderness boundaries, enforcement and education of regulations, and LNT practices by wilderness rangers. Additionally, educational programs were provided by agency employees, volunteers, and interns.

The numbers of Wildland Education Program employees, interns, programs provided, and recipients of Wildlands Education programs have varied throughout the years. (Figure 3.10).

In 2002 and 2003, the Education Coordinator for the Sawtooth Wildlands Education Program conducted a focused LNT survey to evaluate its educational programs. LNT programs occurred before a group's visit to the SW. At each of these programs, evaluation forms were completed before and after the LNT program. The results found that participants were overwhelmingly satisfied and had learned something that would change their wilderness behavior. Findings indicated that 80% of participants planned to change their behaviors in wilderness, 95% of participants were satisfied or very satisfied with the educational LNT program, and 100% reported the program met their expectations.

Research Question 4: What trends are revealed by coupling longitudinal quantitative data for visitation, associated detrimental visitor impacts, and management actions in the Sawtooth Wilderness?

To explore the relationships between SW visitors, associated detrimental impacts, and management actions, the trend data for these three parameters were coupled temporally and spatially. Visual comparisons of graphed trends reveal visitor impacts such as trash and campfire rings have decreased with increased management action (enforcement and education) even as overall visitor numbers have increased, suggesting the combination of actions in enforcement and education have been successful (Figure 1.1, 3.7, 3.8, 3.9). At the wilderness scale, few other relationships are apparent, but by narrowing into specific permit boxes and destinations, more robust relationships are revealed. This thesis completed a detailed analysis of coupling visitor trends and impact trends for all 17 permit boxes and for 40 destinations, revealing significant findings distinct to each destination. A few examples of these findings are described below.

Visitor data indicates the overall number of visitors to the SW is increasing, as is the proportion of overnight visitors (Figure 1.1, 1.8). By breaking down use density by permit box registration, the visualized trends suggest a substantial proportion of visitors enter the SW at the Iron Creek, Redfish Inlet, and Tin Cup wilderness permit boxes (Figure 2.10 2.15, 2.16). The types of visitors (day or overnight visitors) at these locations vary drastically. For example, the majority of Iron Creek visitors are day hikers, while the wilderness permit boxes at Redfish Inlet and Tin Cup see large proportions of overnight visitors.

Trails accessing the SW at these permit boxes offer access to a variety of destinations, each of which experiences unique use density trends and associated trends in campsite impacts. The trail from the Iron Creek permit box accesses the very popular destination of Sawtooth Lake, which has seen an increase of primarily day visitors, and a slight increase in campsite impacts (Figure 2.44, 2.54). Trails out of the Redfish Inlet permit box lead to the popular destinations of Alpine, Baron, and Cramer Lakes (Figure 2.23, 2.25, 2.30). While Alpine Lake has seen an increase in day visitors, both Baron and Cramer Lakes have an increase in overnight visitors. All three destinations are experiencing sizable increases in campsite impacts (2.54). The Tin Cup permit box, along with the Yellowbelly permit box, provides access to a very popular hiking loop. Both permit boxes display high proportions of overnight visitors (Figure 2.16, 2.17). Destinations on this loop include Alice and Toxaway Lakes, which have both experienced an increase of visitors. Just over half of Alice Lake's visitors stay overnight while most Toxaway Lake's visitors stay overnight (2.20, 2.46). Both Alice and Toxaway Lake see the highest number of overnight visitors in the SW, and yet both are experiencing a decreasing trend in campsite impacts (2.54).

Management actions are consistently applied throughout the SW, as directed by the SW Management Plan (Figure 3.4). Each trailhead has signage providing an SW map along with relevant regulations and LNT messages. Trail junctions are appropriately signed, trail maintenance prescribed in management plans are adhered to as possible, and wilderness permit boxes exist at wilderness boundaries. Regulations generally apply to every part of the wilderness, though enforcement varies as the handful of wilderness rangers cannot be everywhere at once. The same can be said for Wildlands Education Staff, who strive to provide as much programming as possible but are limited by staff or intern capacities.

Appendix 1
Results: Visitor Trends

Figure 1.1 Overall Visitor Numbers in the SW

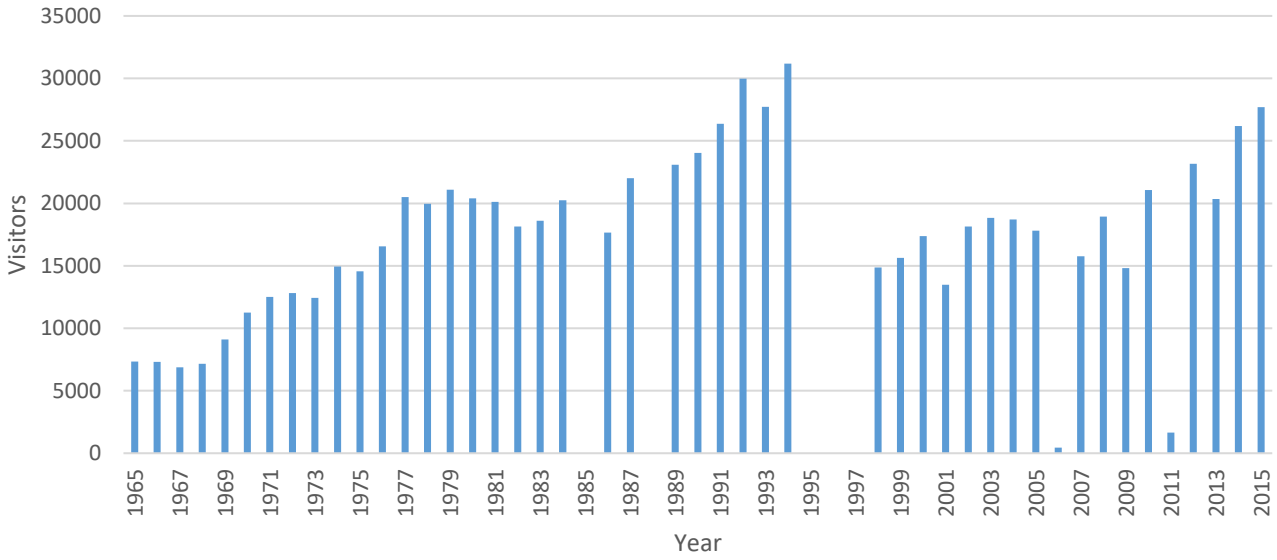


Figure 1.2 Percent of Visitors by Gender

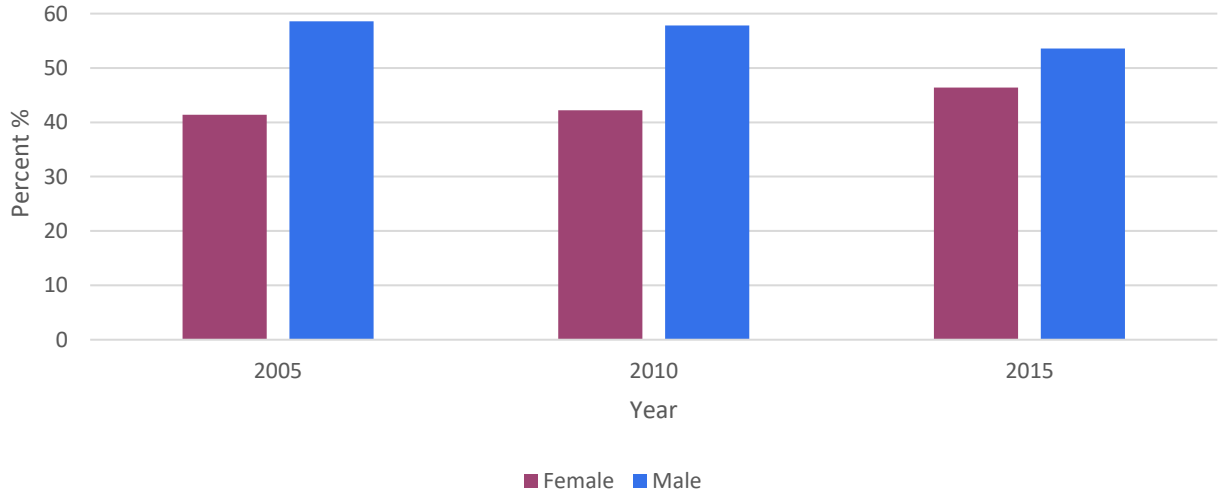


Figure 1.3 Percent of Visitors by Age

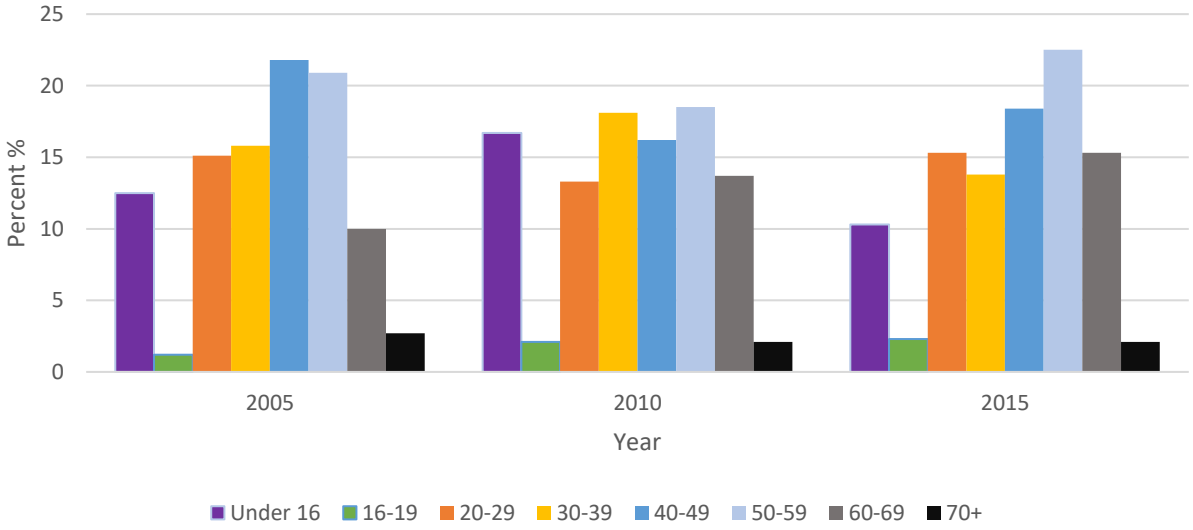


Figure 1.4 Percent of Visitors by Race

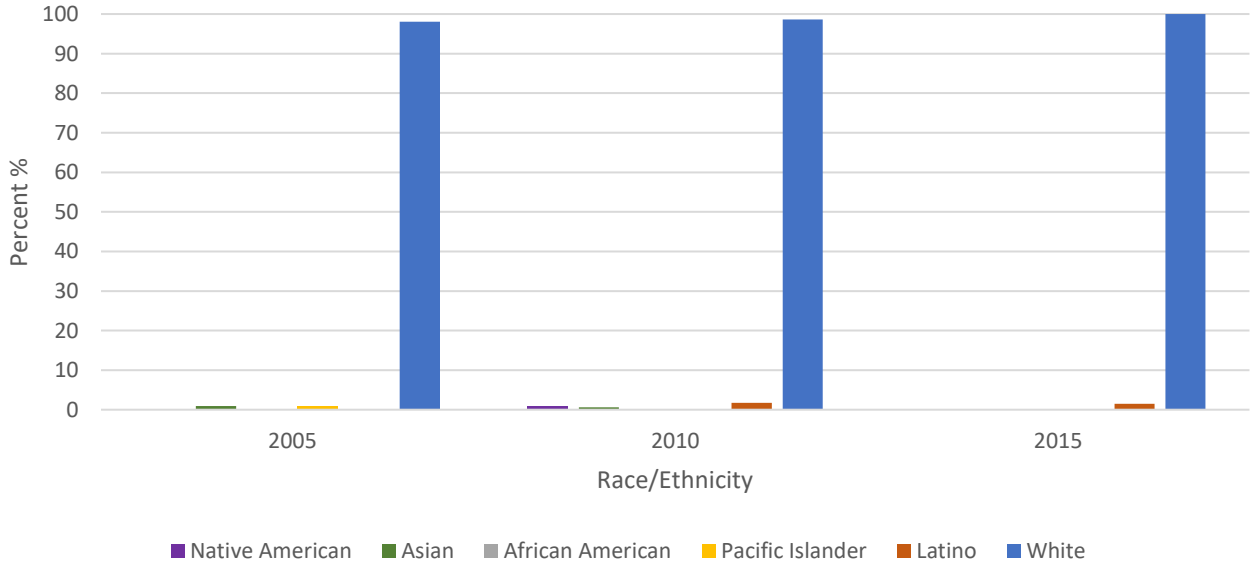


Figure 1.5 Percent of Visitors by Region of USA

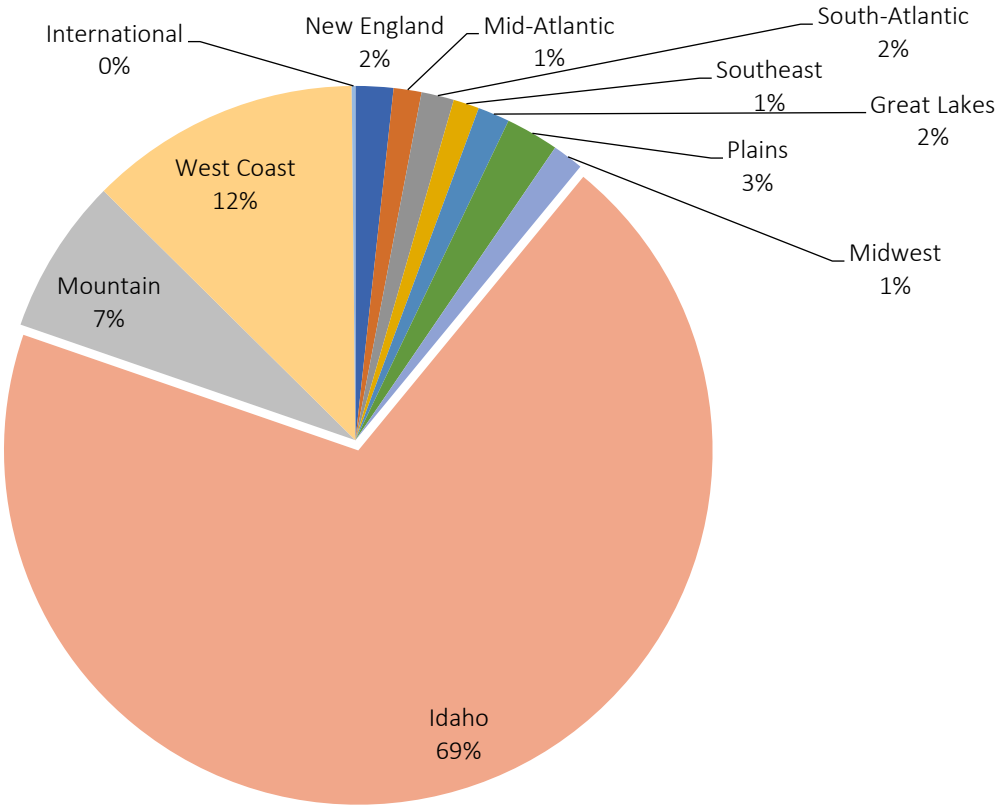


Figure 1.6 Percent of Visitors by Region of Idaho

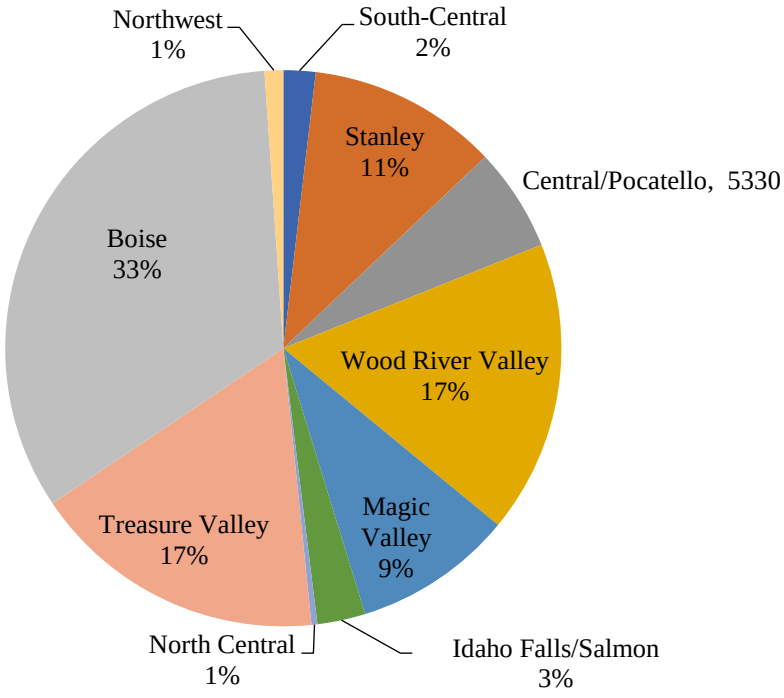


Figure 1.7 Average Group Size

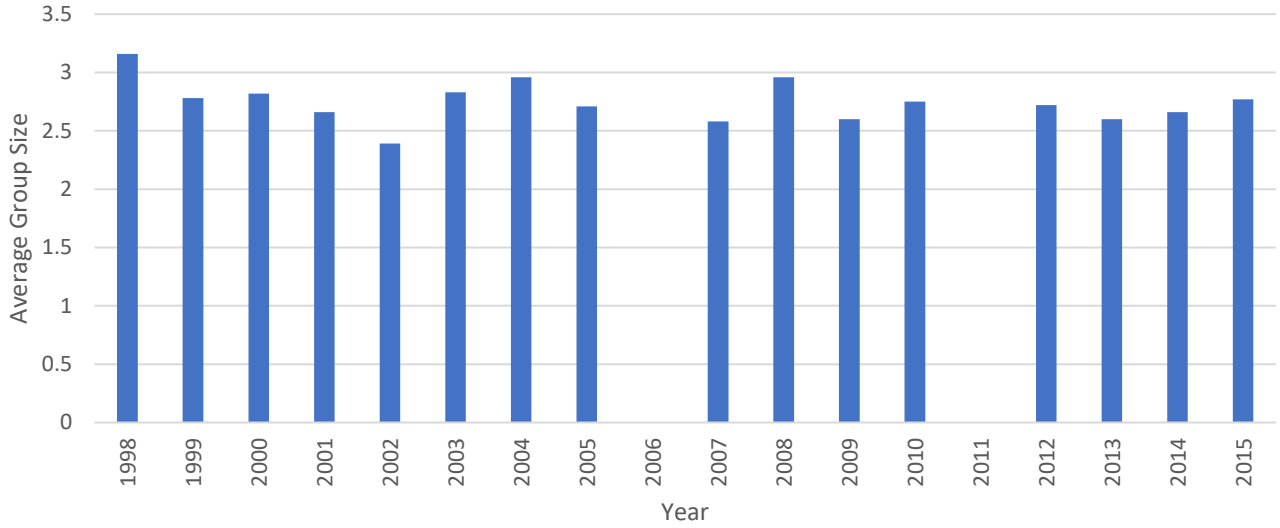


Figure 1.8 Proportion of Day and Overnight Visitors

YEAR	1966	1967	1968	1969	1972	1976	1977	1978	1980	1982	1990	1998	1999	2002	2003	2007	2008	2009	2013	2014	2015
% Day	89	85	87	85	85	78	77	77	79	75	71	71	70	69	69	70	69	73	69	73	68
% ON	11	15	13	15	15	22	23	23	21	25	29	29	30	31	31	30	31	27	31	27	32

Figure 1.9 Average Overnight Duration

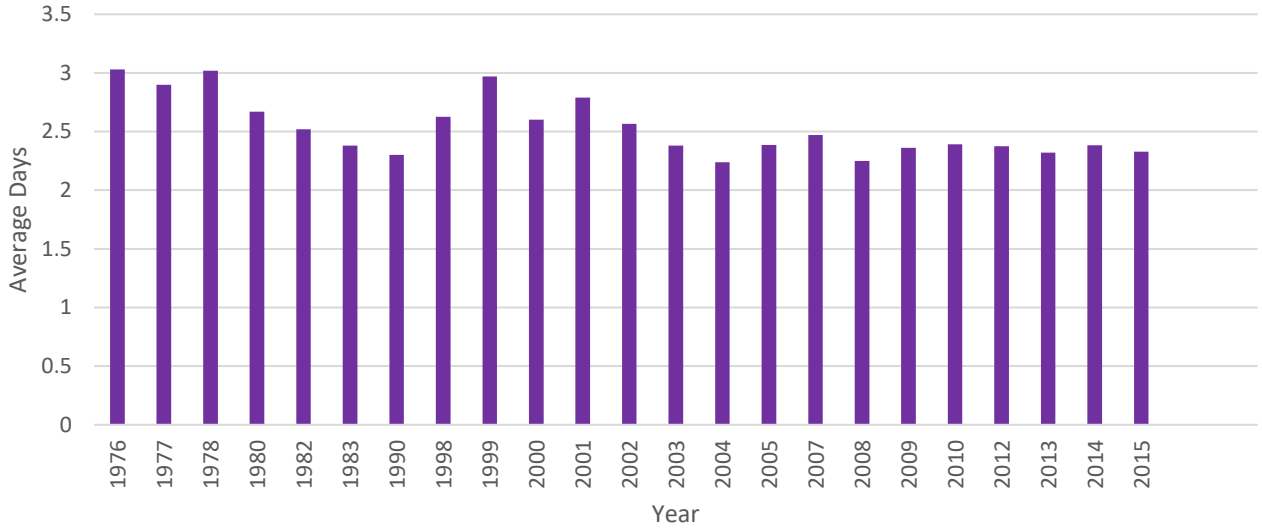


Figure 1.10 Monthly Visitation

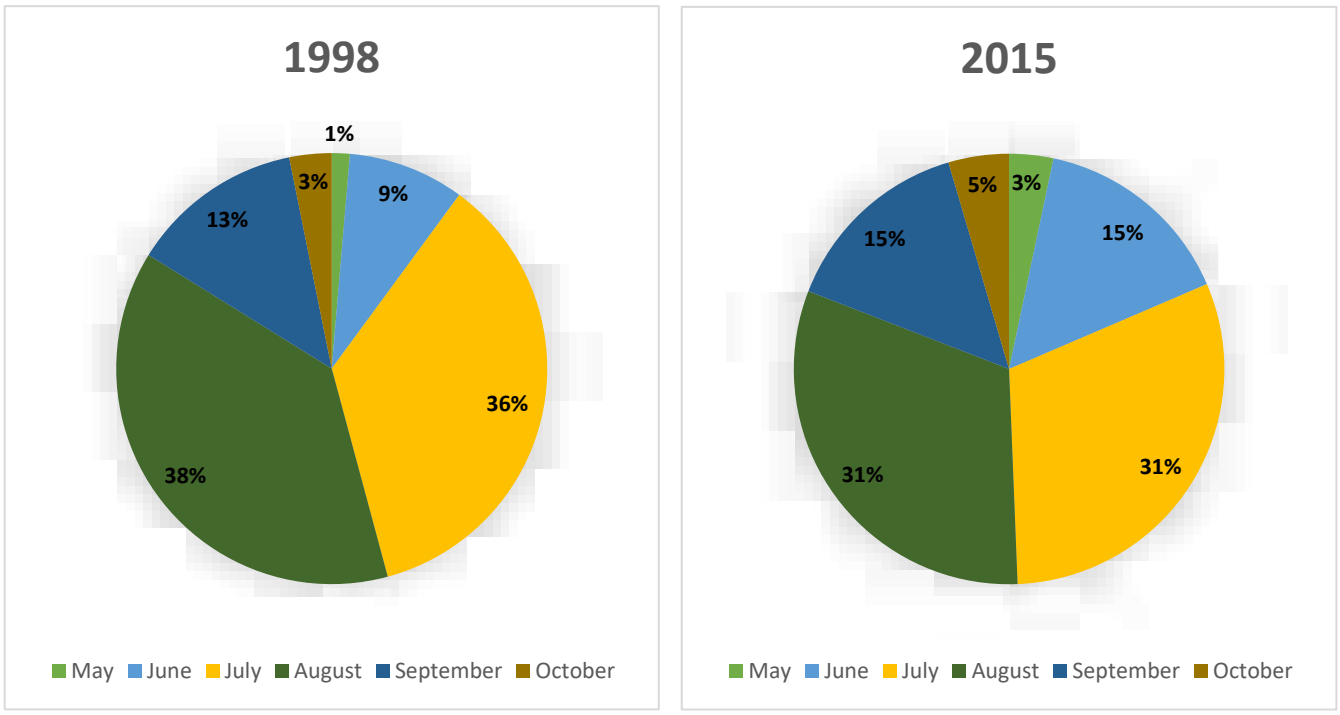
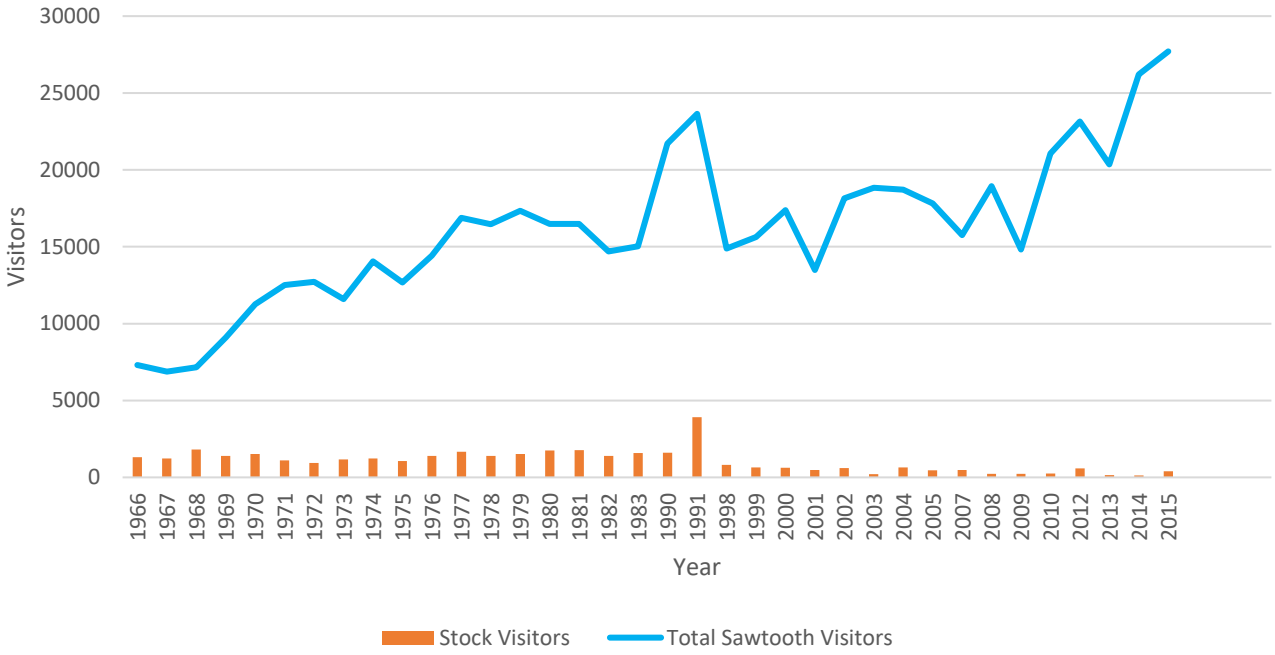


Figure 1.11 Stock Use



Appendix 2
Results: Visitor Impacts Trends

Figures 2.1 – 2.17 Permit Box Registration Trends (Alphabetical Order)
*Vertical Axis are NOT consistent, Horizontal Axis are consistent

Figure 2.1 Alpine Creek Permit Box Registration

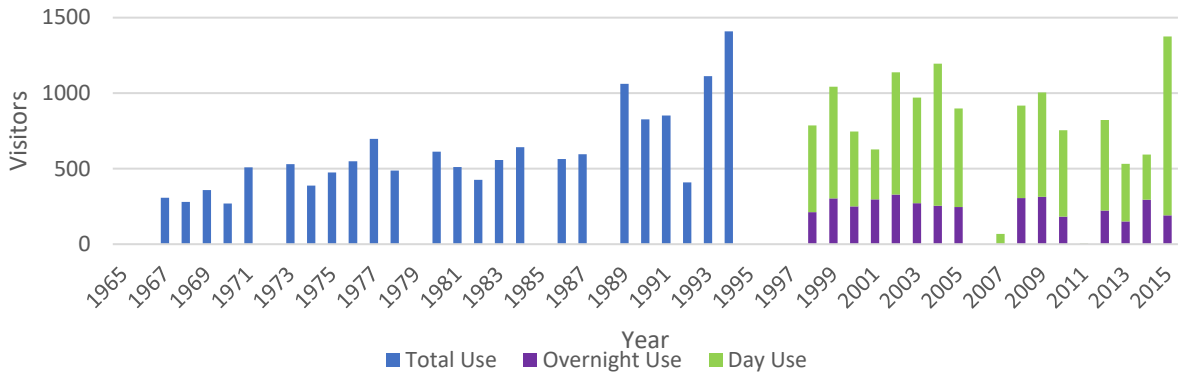


Figure 2.2 Alpine Way Permit Box Registration

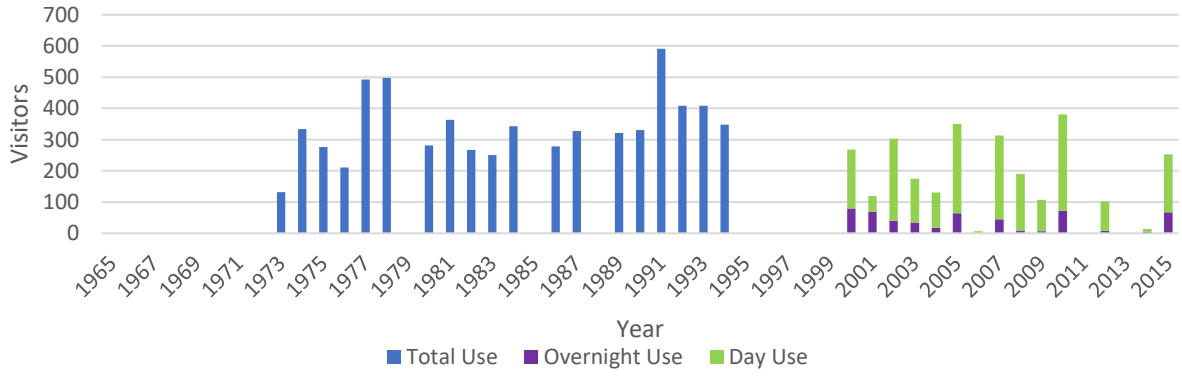


Figure 2.3 Bench Lake Permit Box Registration

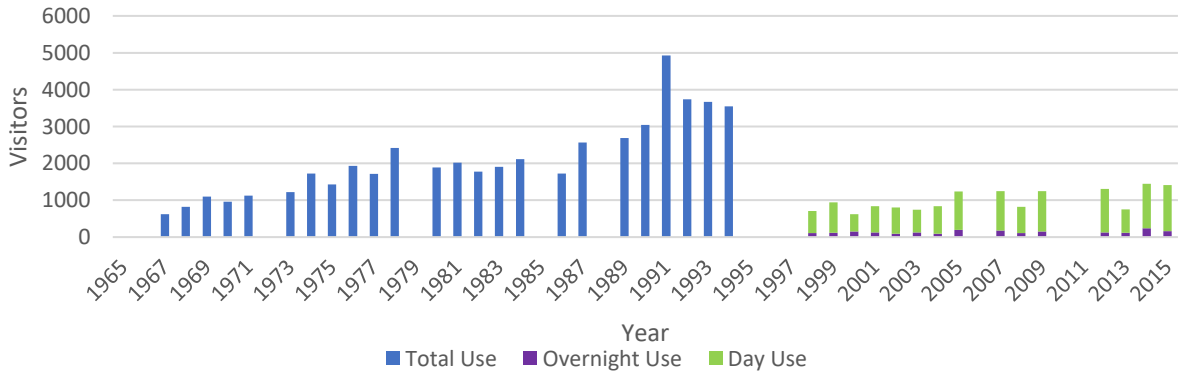


Figure 2.4 Cabin Creek Permit Box Registration

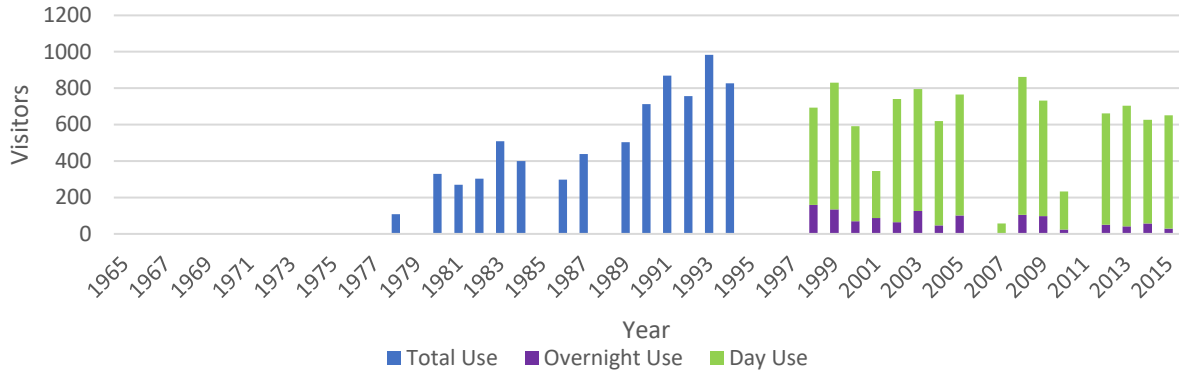


Figure 2.5 Fishhook Permit Box Registration

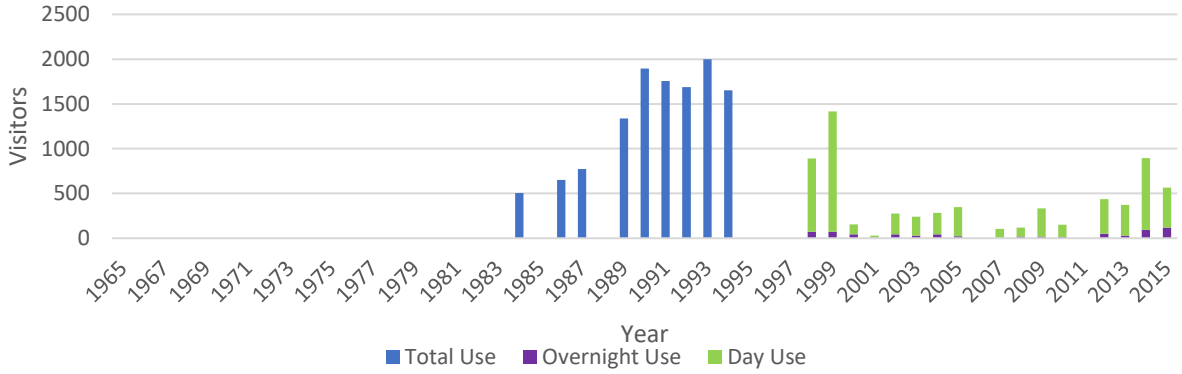


Figure 2.6 Graham Permit Box Registration

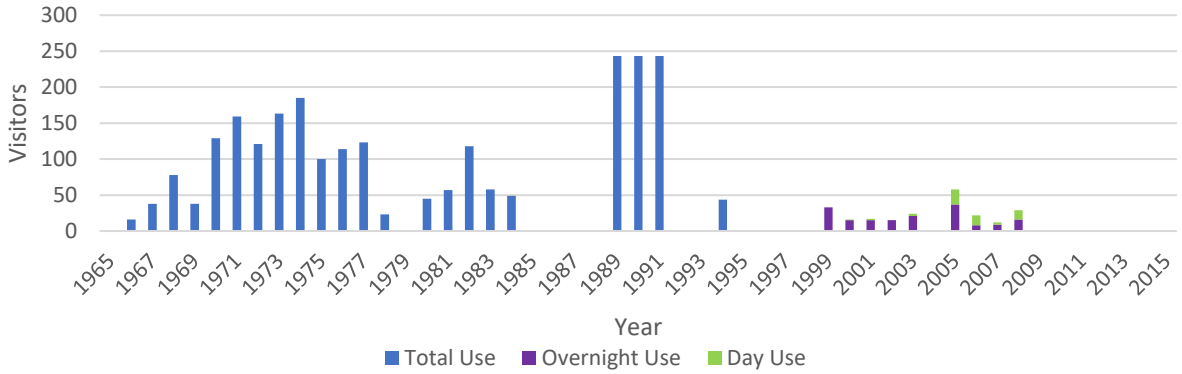


Figure 2.7 Grand Jean Permit Box Registration

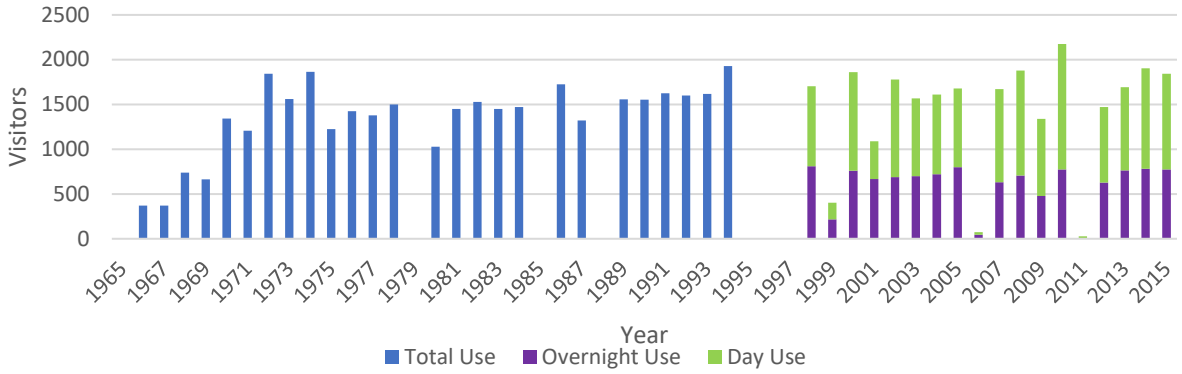


Figure 2.8 Greenback Permit Box Registration

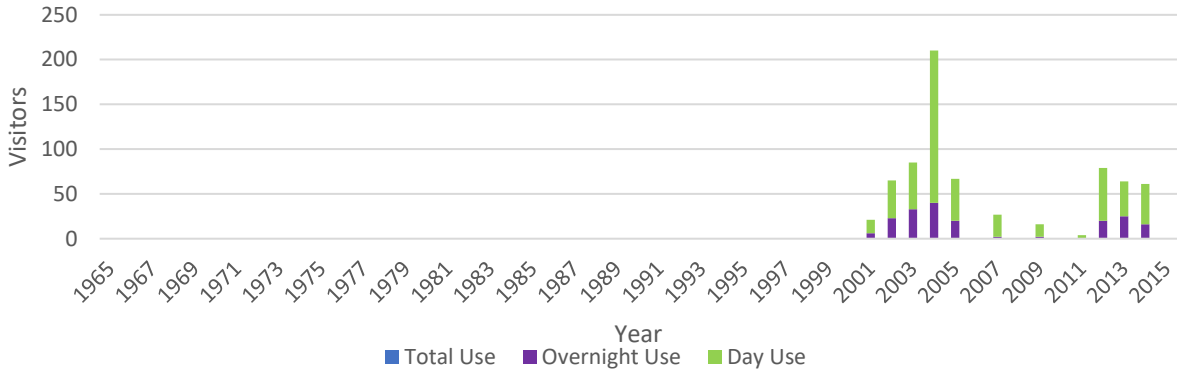


Figure 2.9 Hell Roaring Permit Box Registration

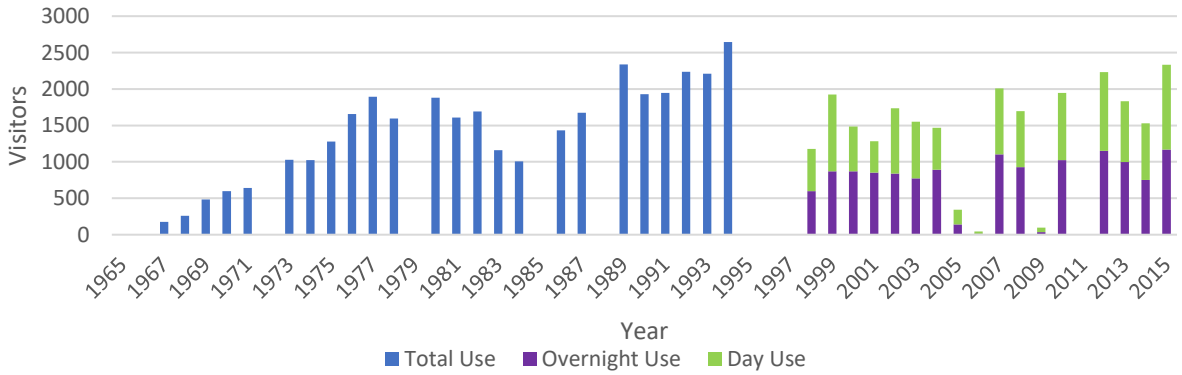


Figure 2.10 Iron Creek Permit Box Registration

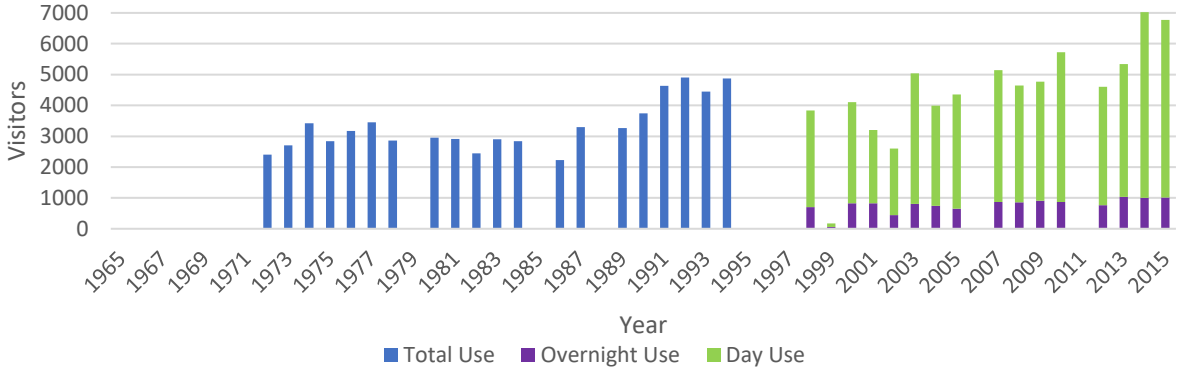


Figure 2.11 Marshall Lake Permit Box Registration

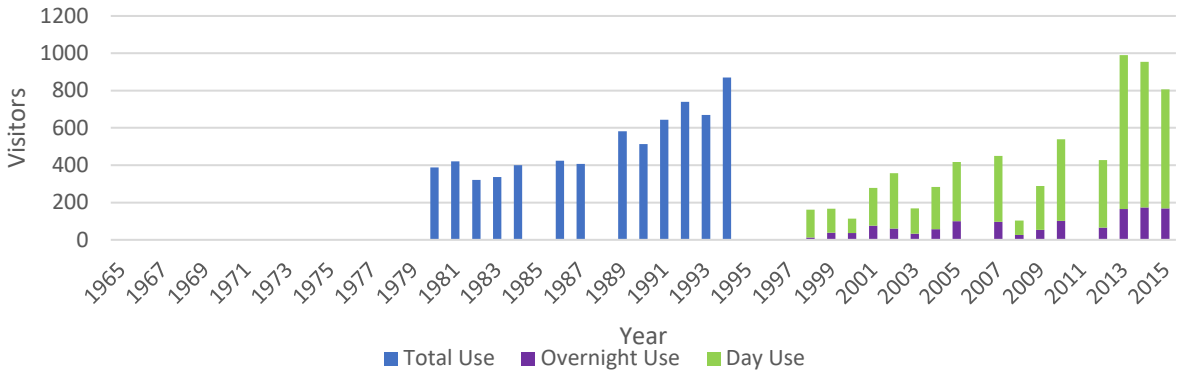


Figure 2.12 Mattingly Permit Box Registration

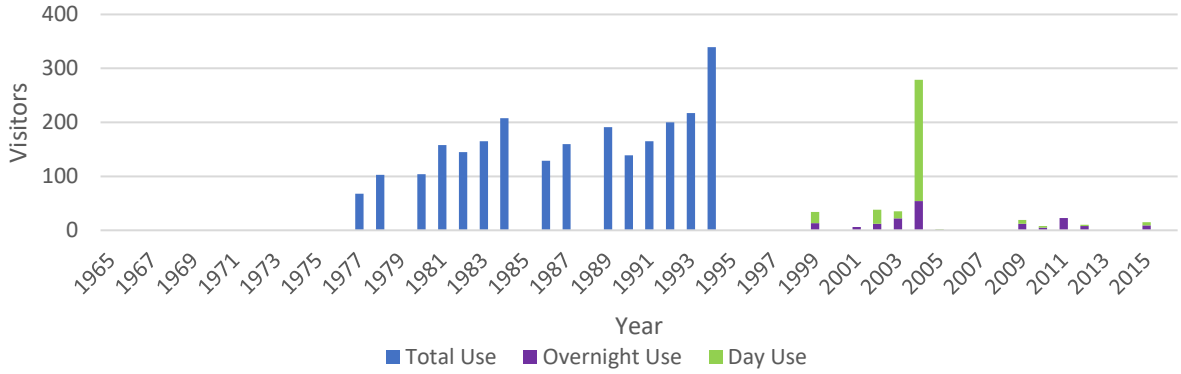


Figure 2.13 Power Plant Permit Box Registration

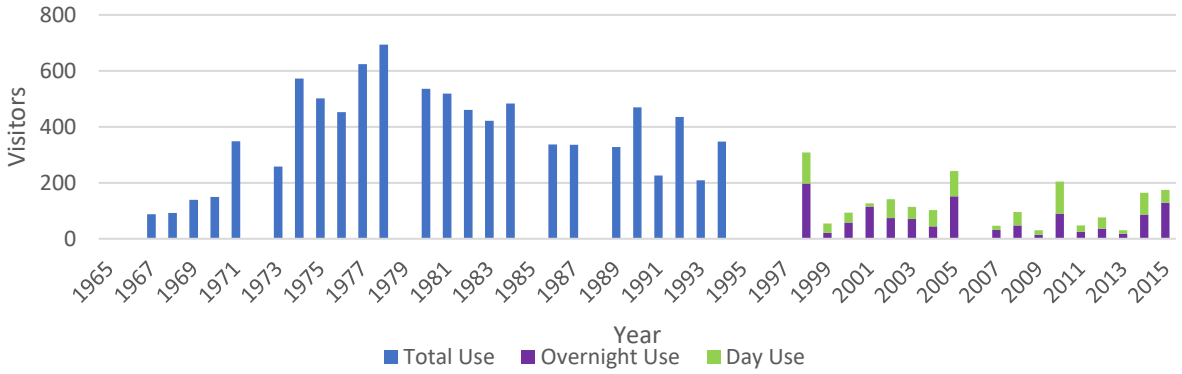


Figure 2.14 Queens Permit Box Registration

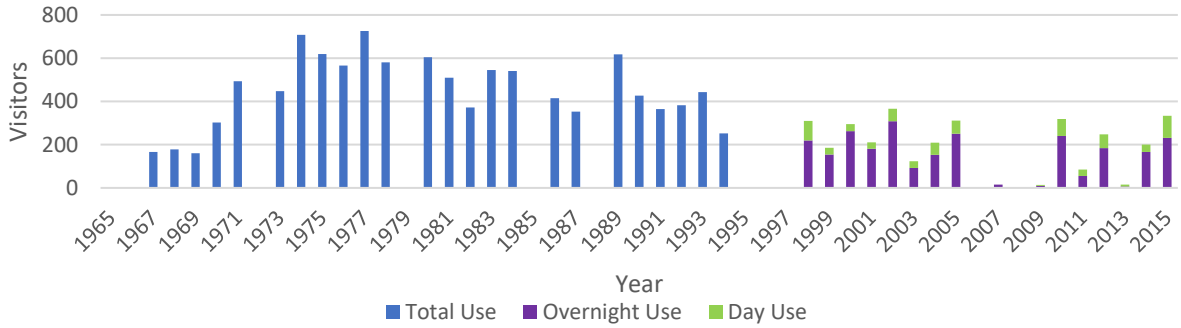


Figure 2.15 Redfish Inlet Permit Box Registration

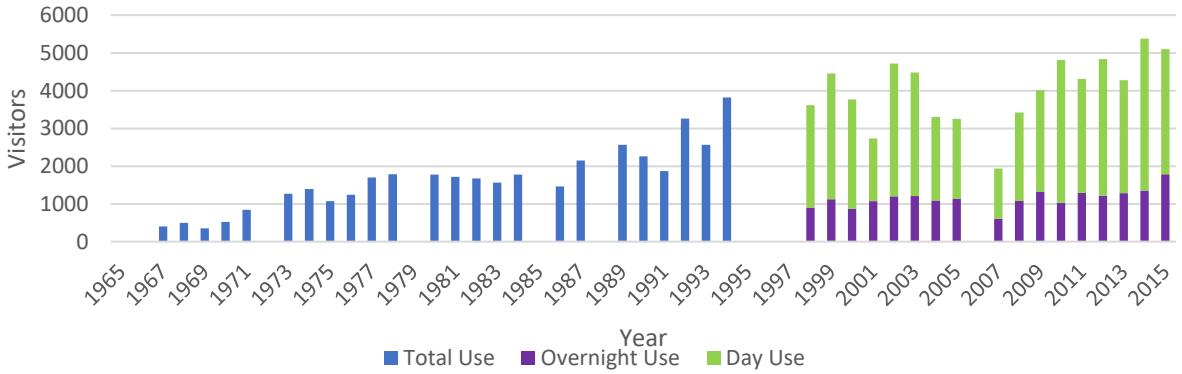


Figure 2.16 Tin Cup Permit Box Registration

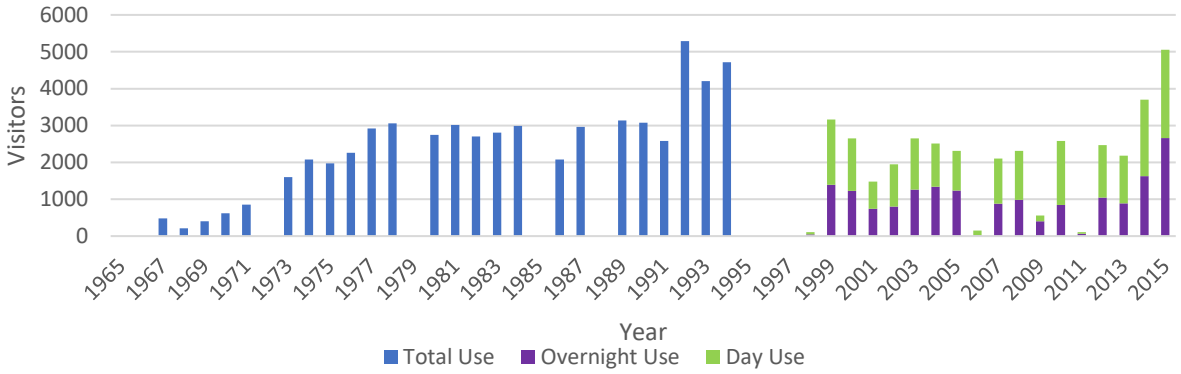


Figure 2.17 Yellowbelly Trailhead Use

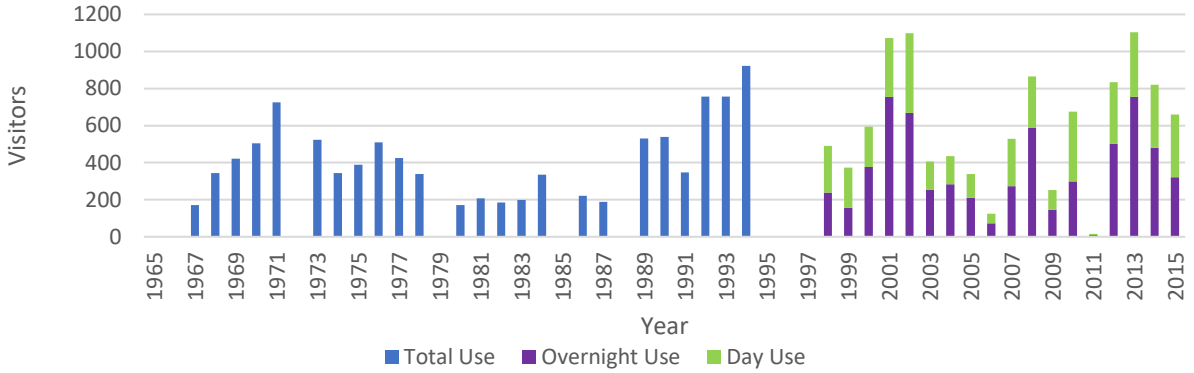


Figure 2.18 2015 Permit Box Registrations

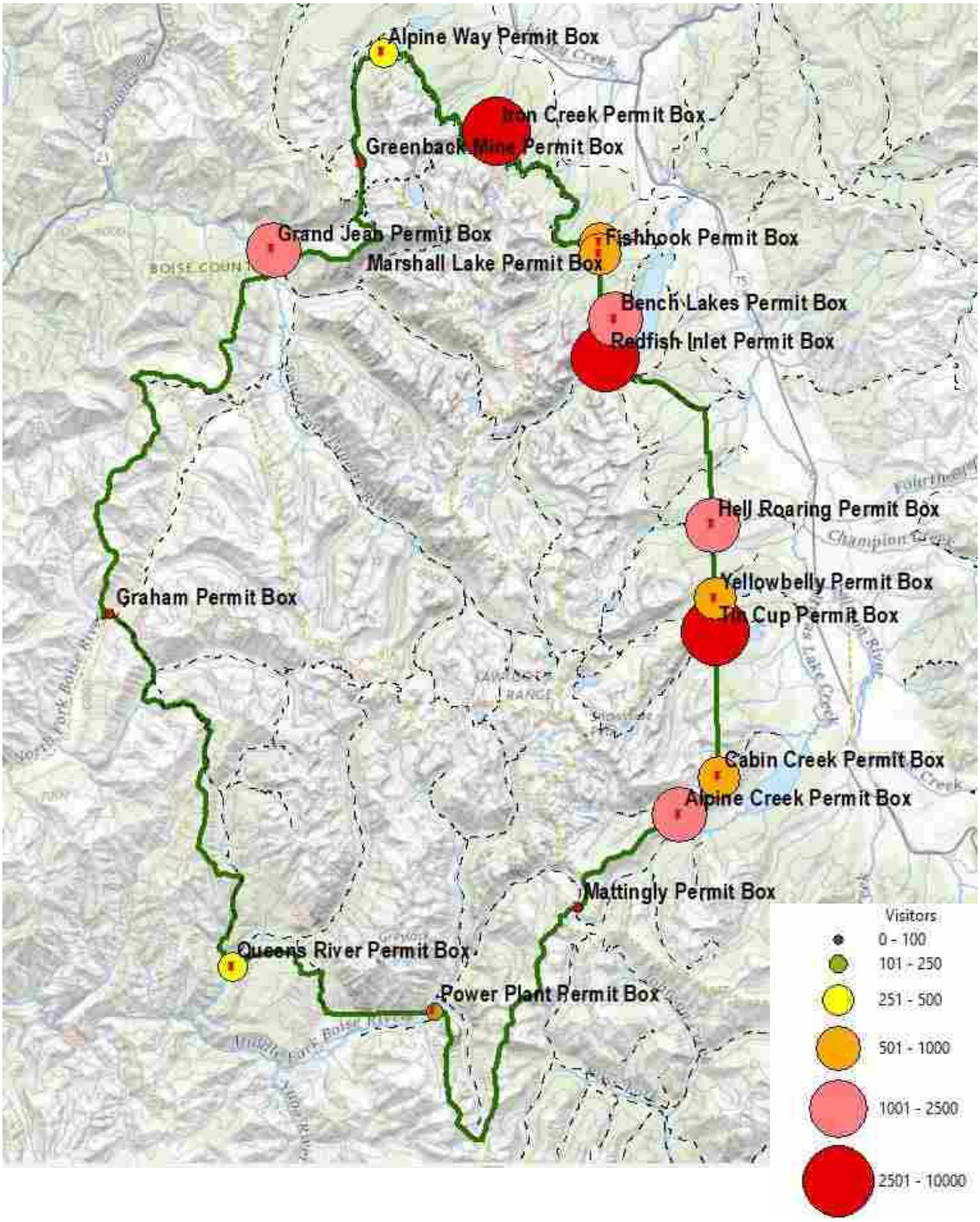
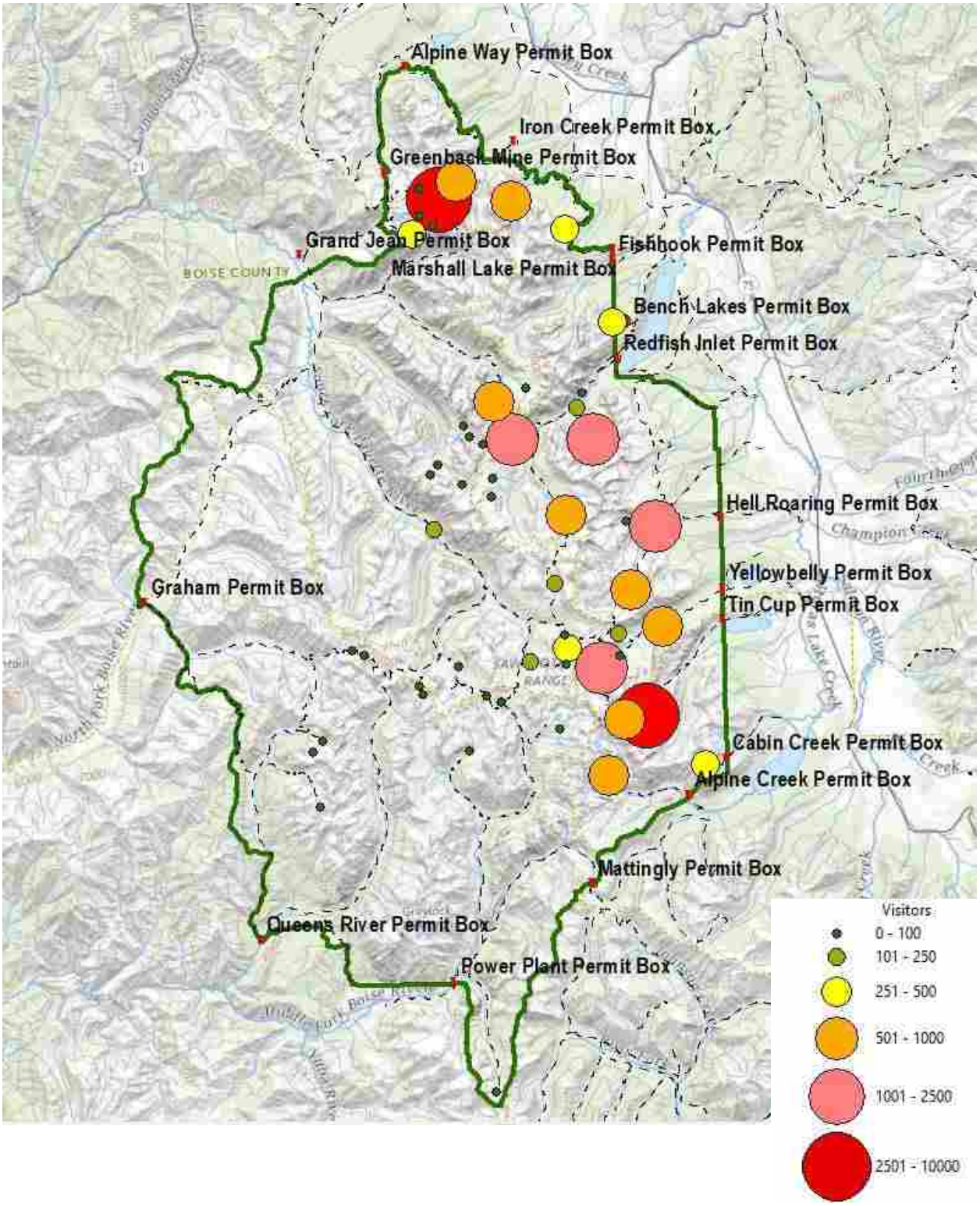
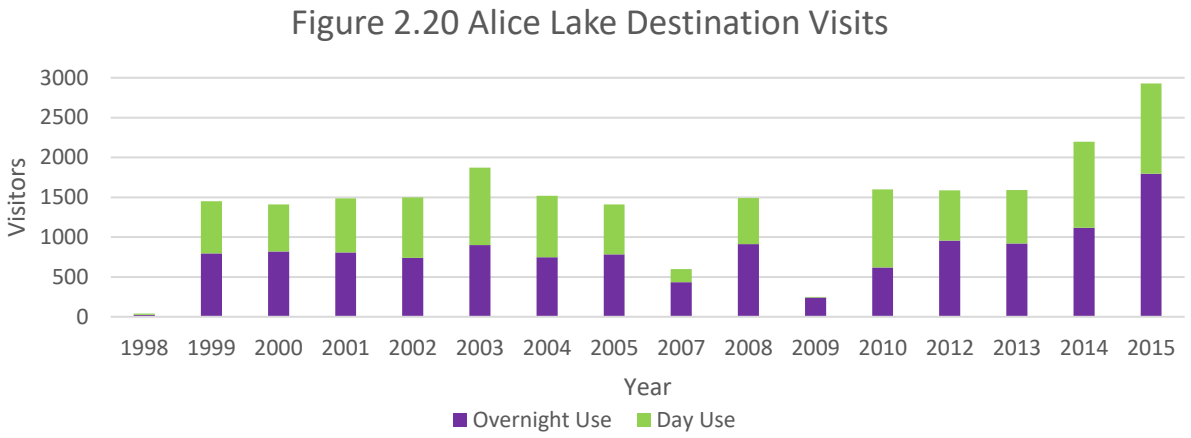
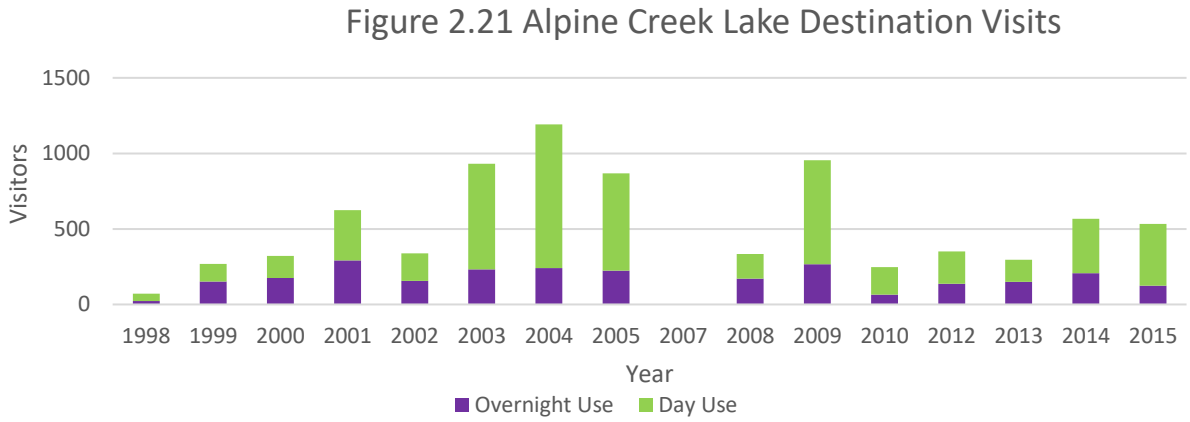


Figure 2.19 2015 Destination Visits



Figures 2.20 – 2.52 Destination Visit Trends (Alphabetical Order)
*Vertical Axis are NOT consistent, Horizontal Axis are consistent
**2006 & 2011 years are omitted due to poor data collection





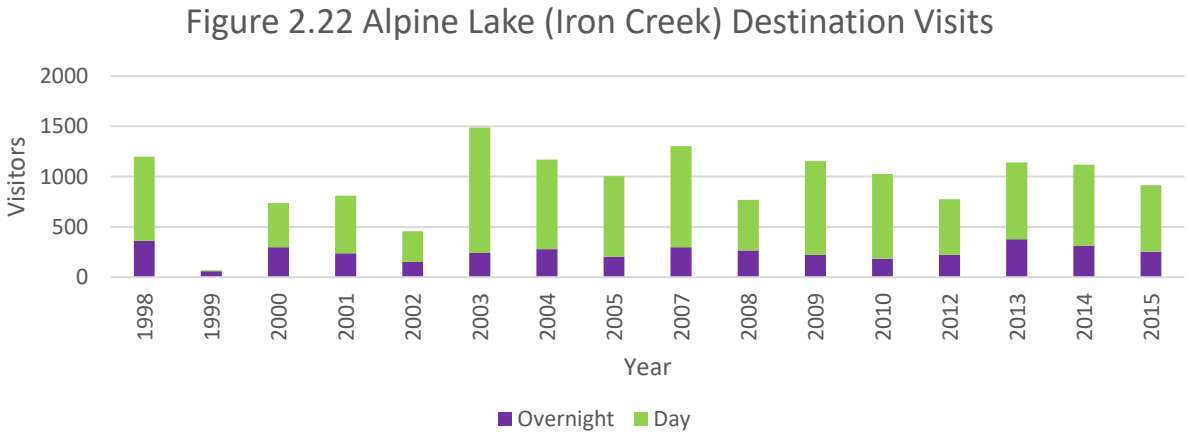


Figure 2.23 Alpine Lake (Redfish Inlet) Destination Visits

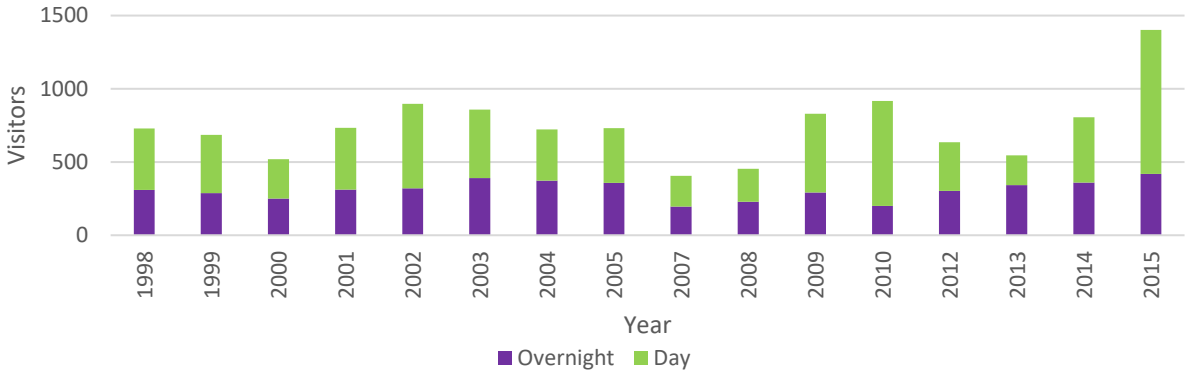


Figure 2.24 Ardeth Lakes Destination Visits

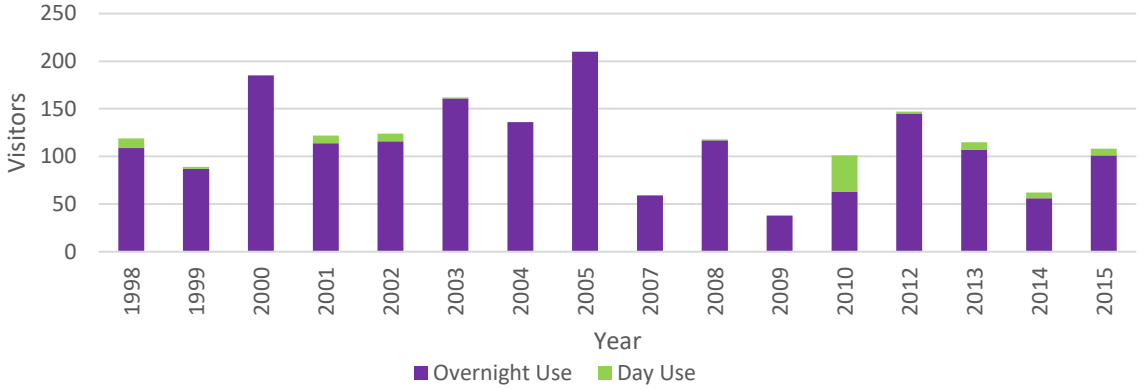


Figure 2.25 Baron Lakes Destination Visits

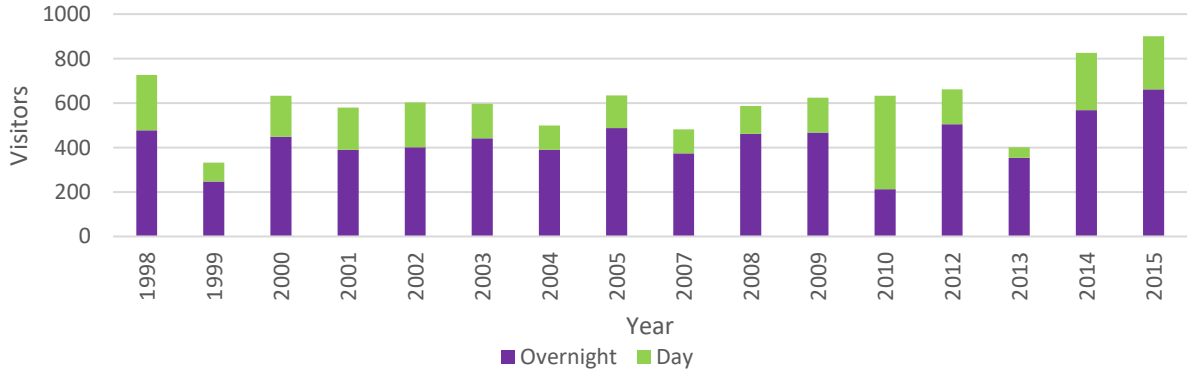


Figure 2.26 Bench Lakes Destination

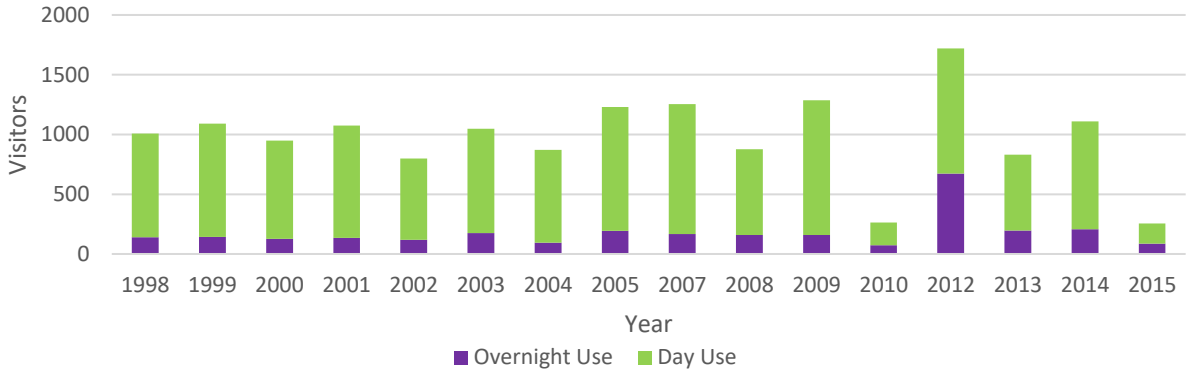


Figure 2.27 Benedict Lake Destination Visits

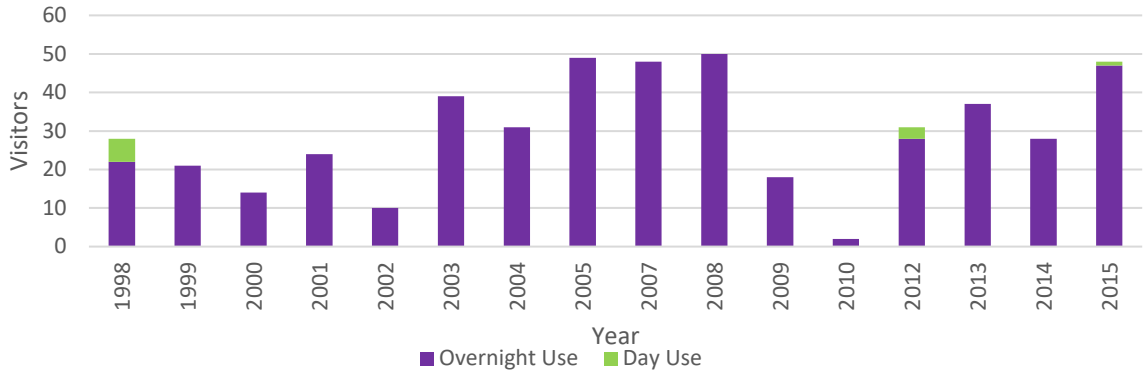


Figure 2.28 Browns Lake Destination Visits

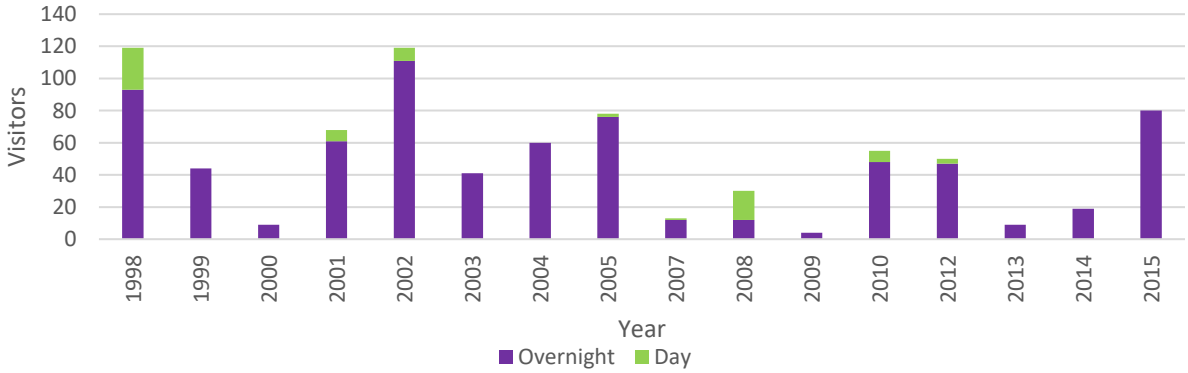


Figure 2.29 Cabin Creek Lakes Destination Visits

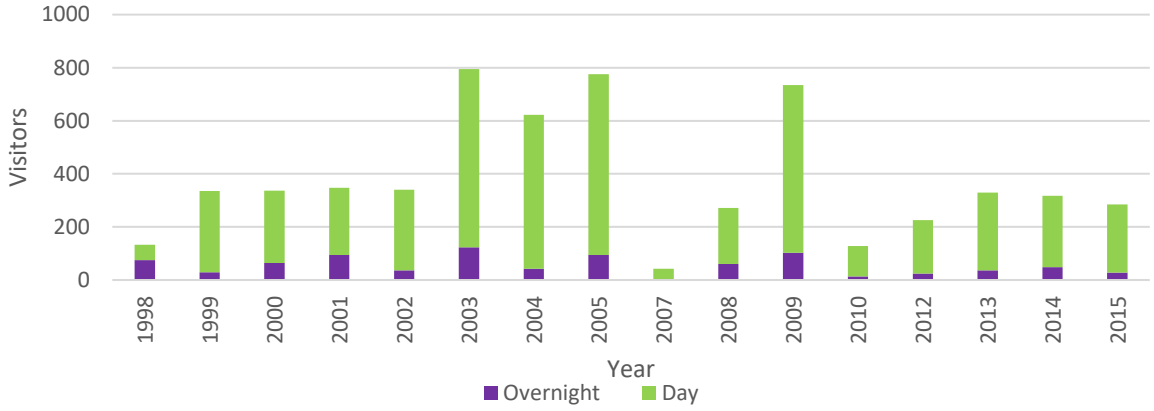


Figure 2.30 Cramer Lakes Destination Visits

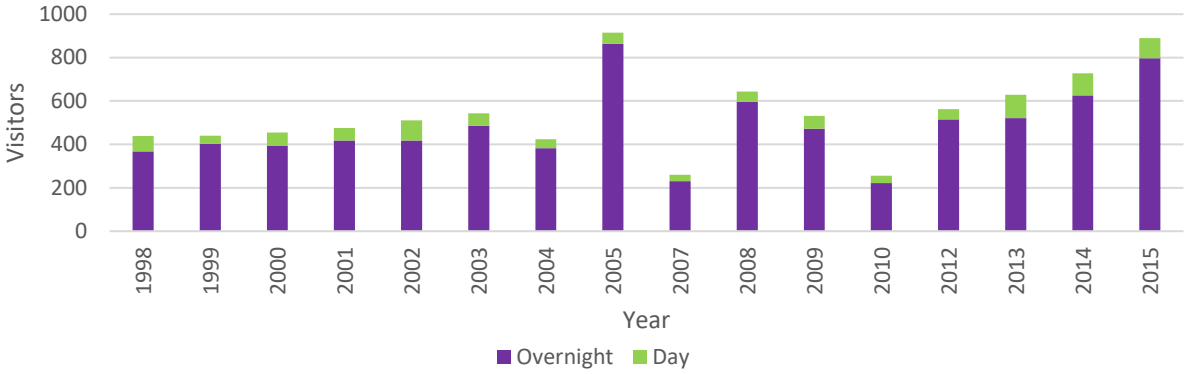


Figure 2.31 Edna Lake Destination Visits

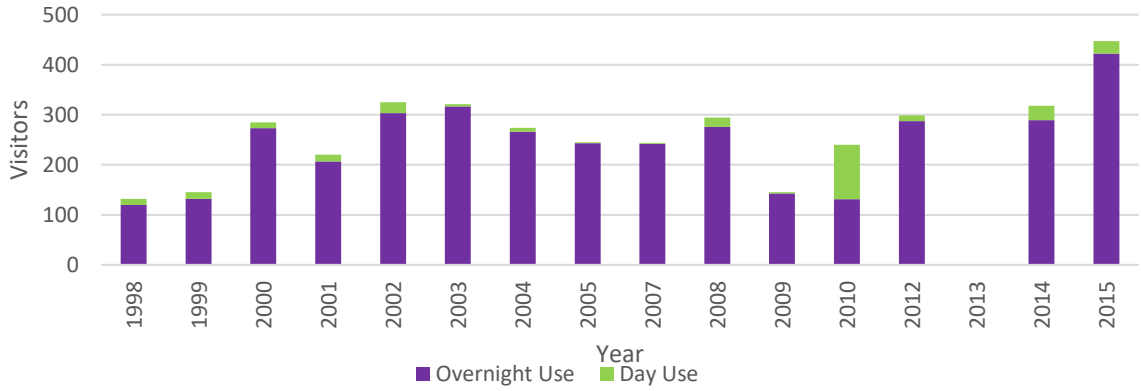


Figure 2.32 Elk Lake Destination Visits

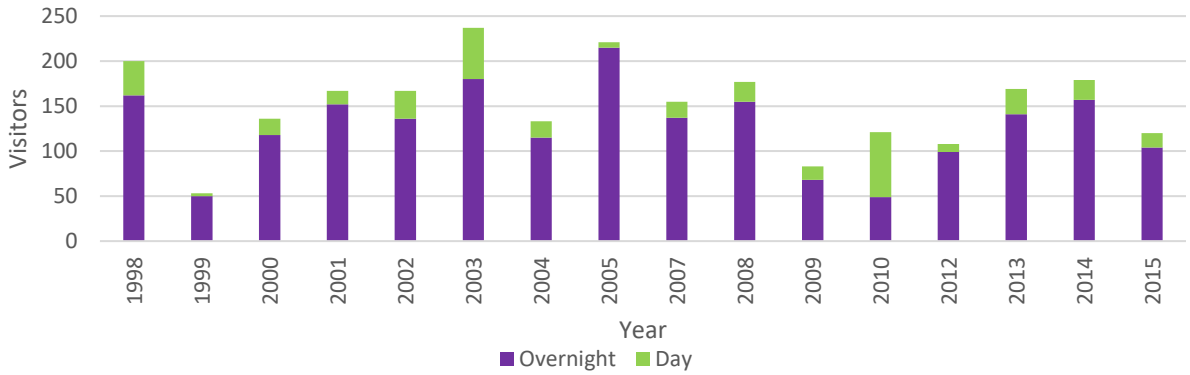


Figure 2.33 Farely Lake Destination Visits

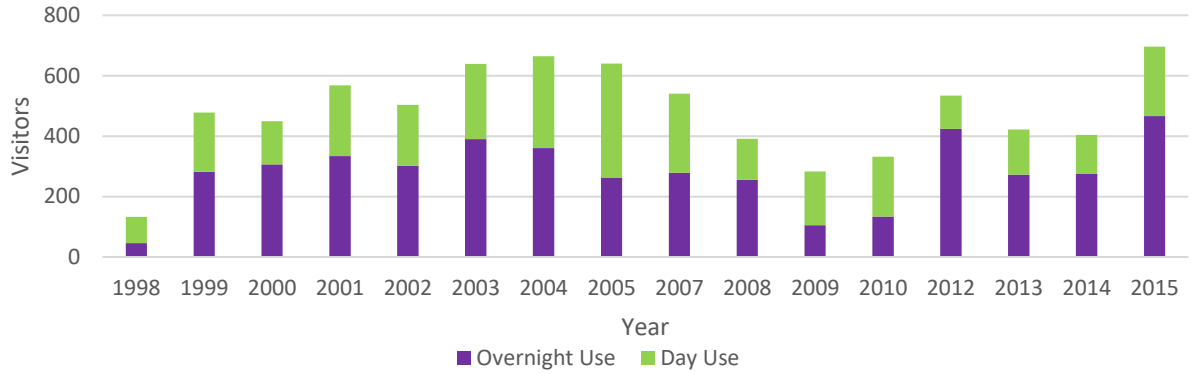


Figure 2.34 Feather Lake Destination Visits

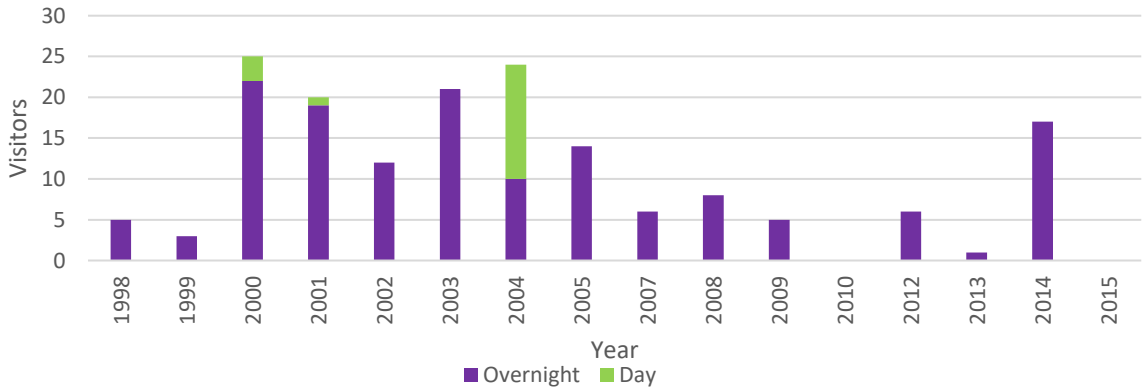


Figure 2.35 Flytrip Lakes Destination Visits

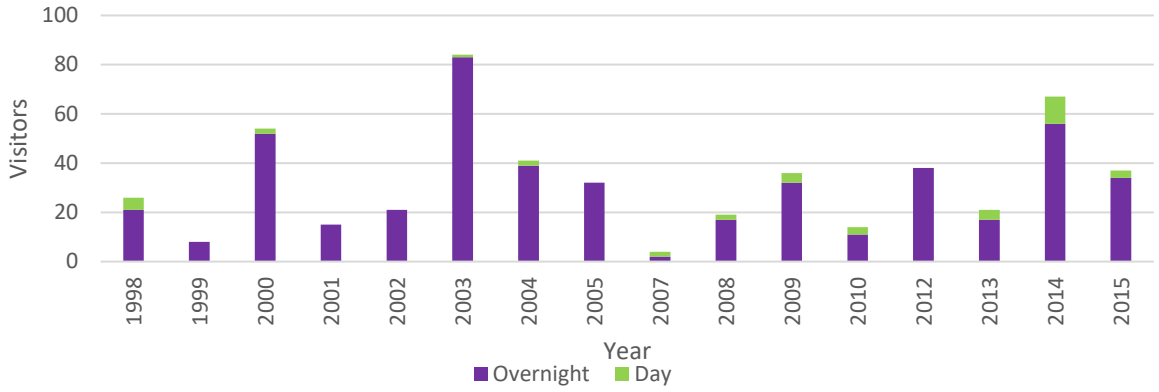


Figure 2.36 Goat Lake Destination Visits

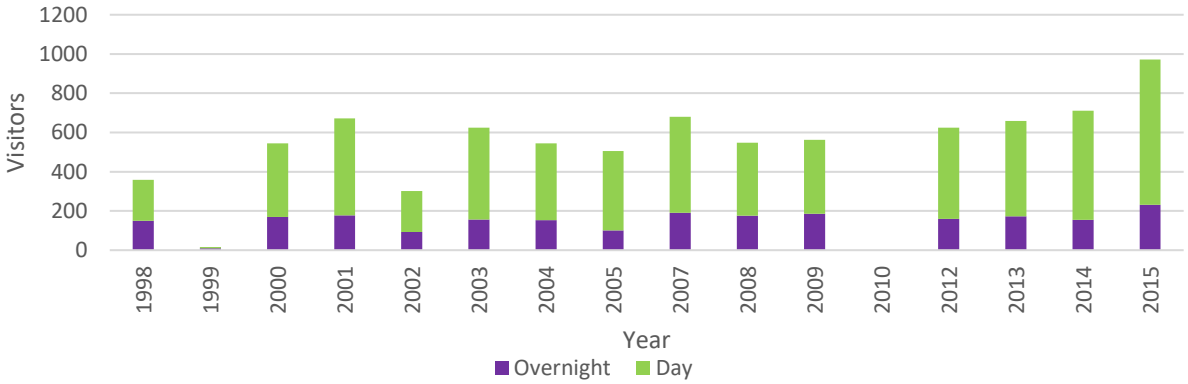


Figure 2.37 Hell Roaring Lake Destination Visits

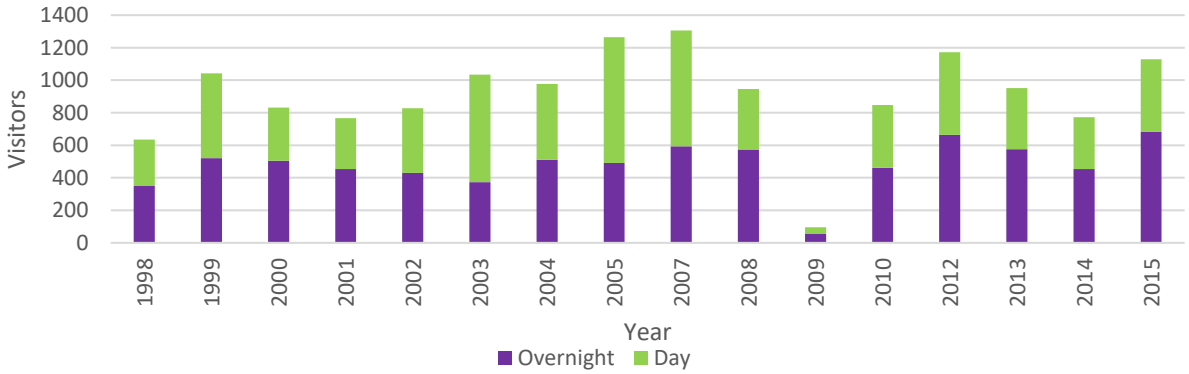


Figure 2.38 Imogene Lake Destination Visits

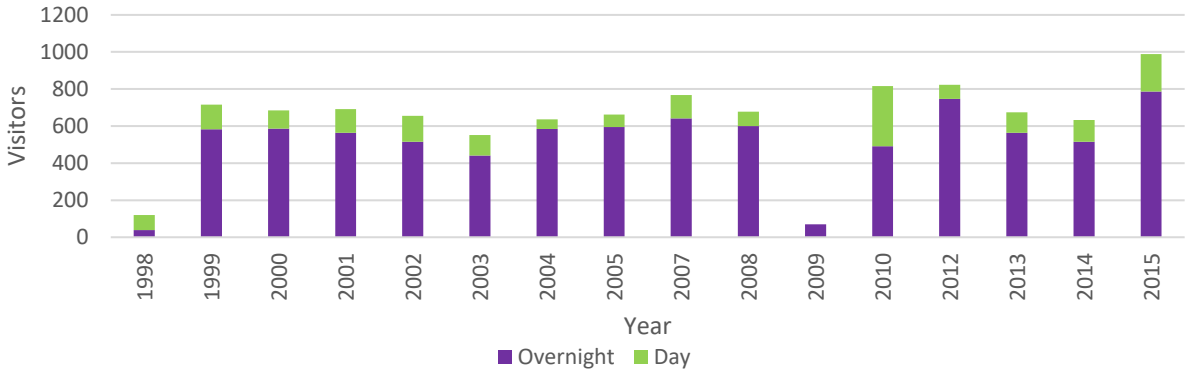


Figure 2.39 Ingeborg Lake Destination Visits

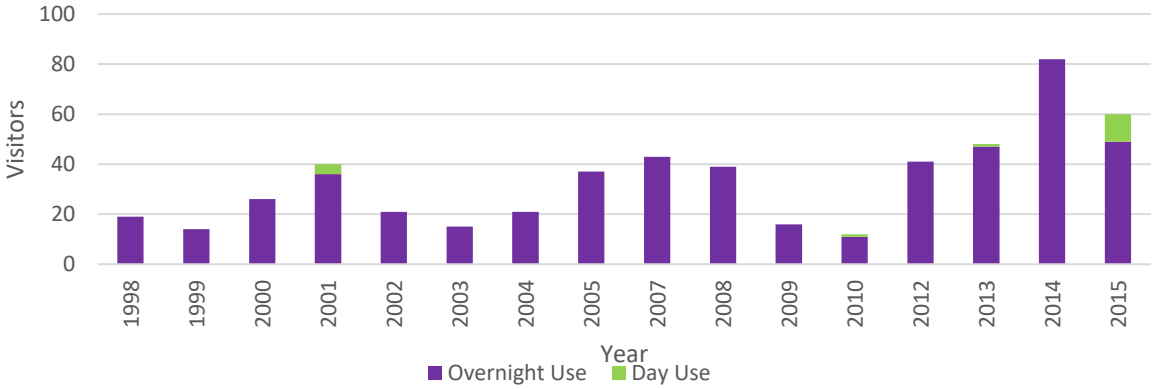


Figure 2.40 Kathryn Lake Destinatin Visits

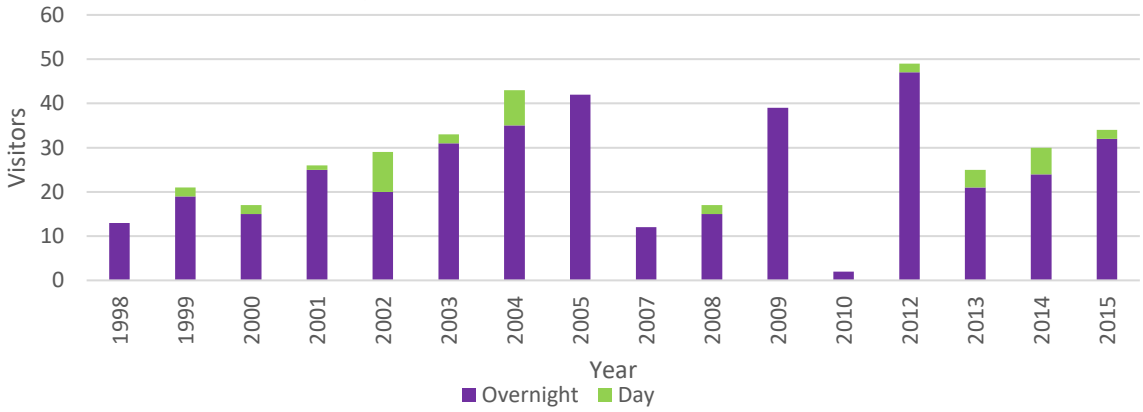


Figure 2.41 Packrat Lake Destination Visitation

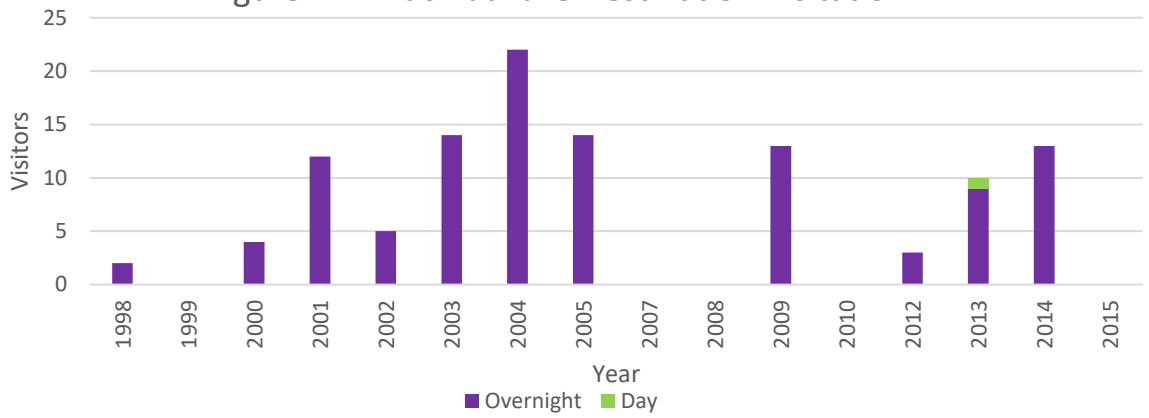


Figure 2.42 Pats Lake Destination Visits

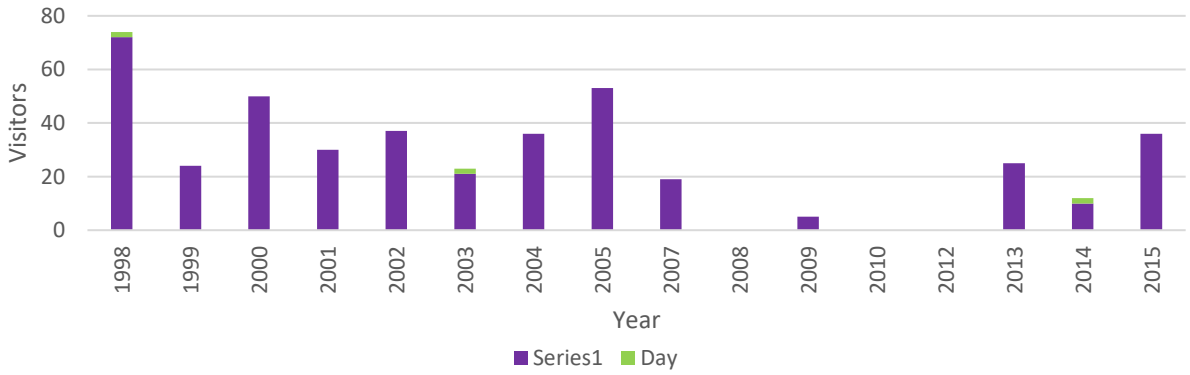


Figure 2.43 Saddleback Lakes Destination Visits

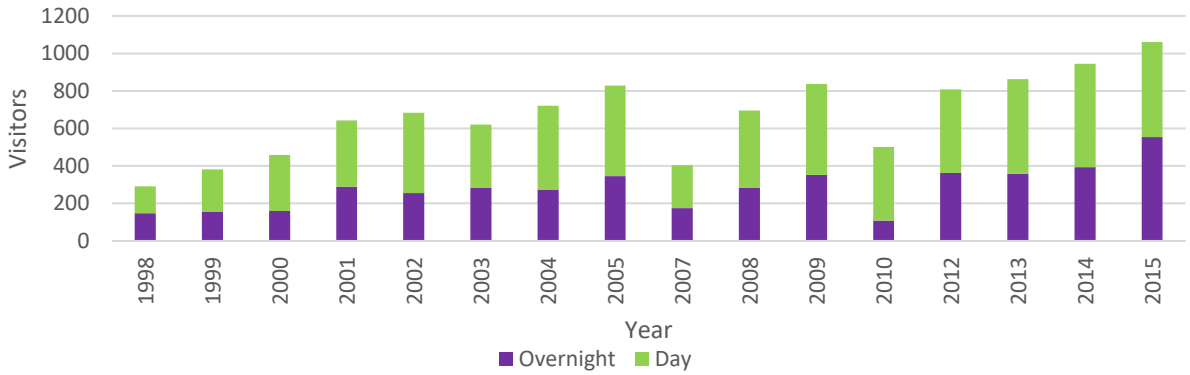


Figure 2.44 Sawtooth Lake Destination Visits

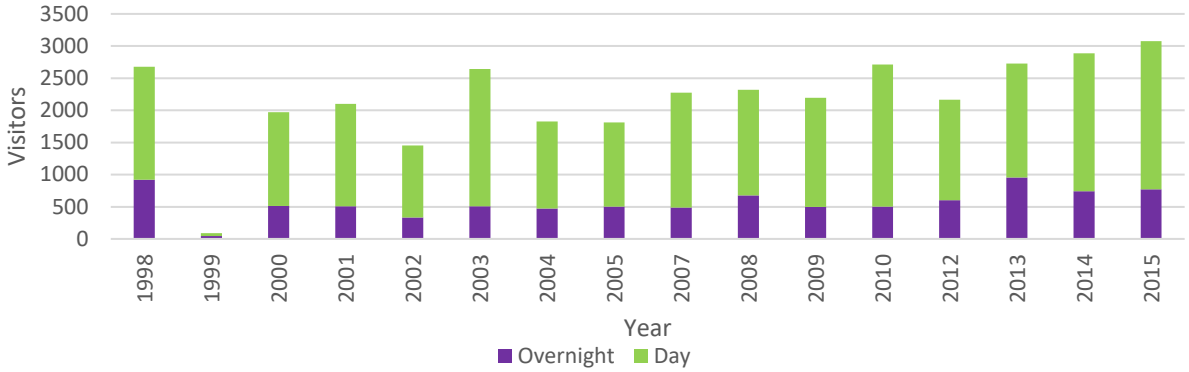


Figure 2.45 Spangle Lakes Destination Visits

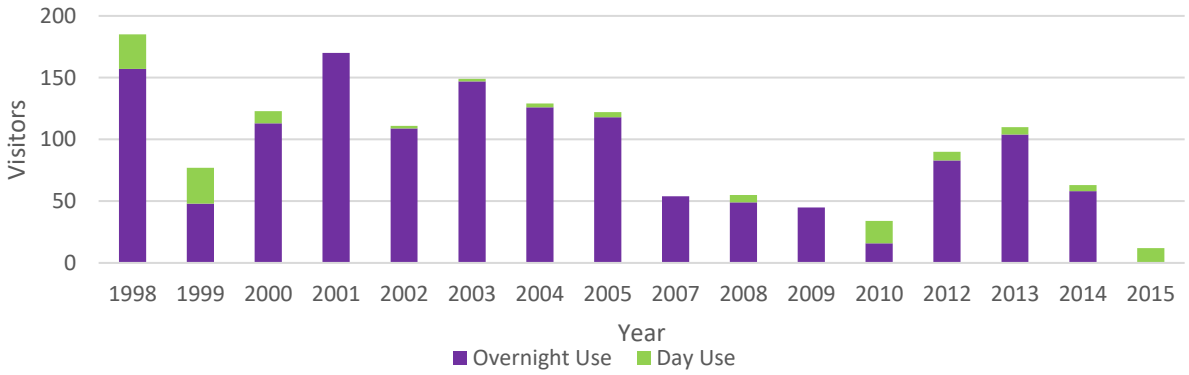


Figure 2.46 Toxaway Lake Destination Visits

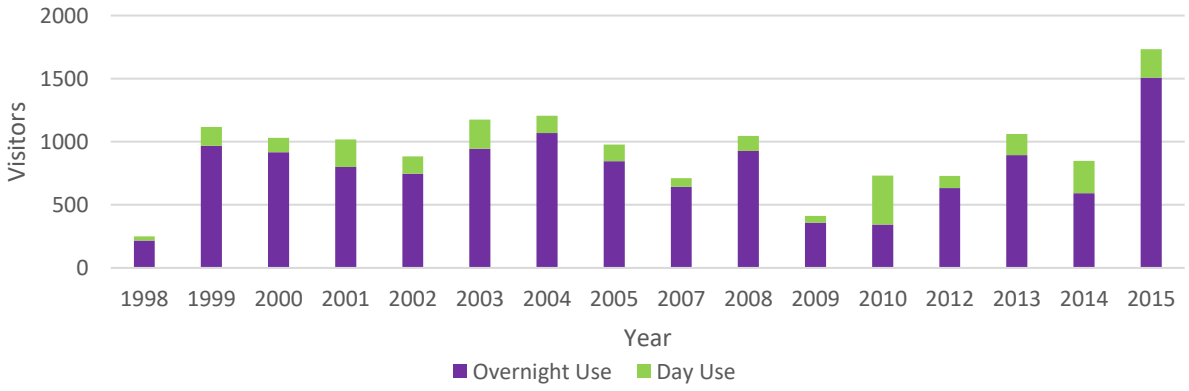


Figure 2.47 Trail Creek Lakes Destination Visits

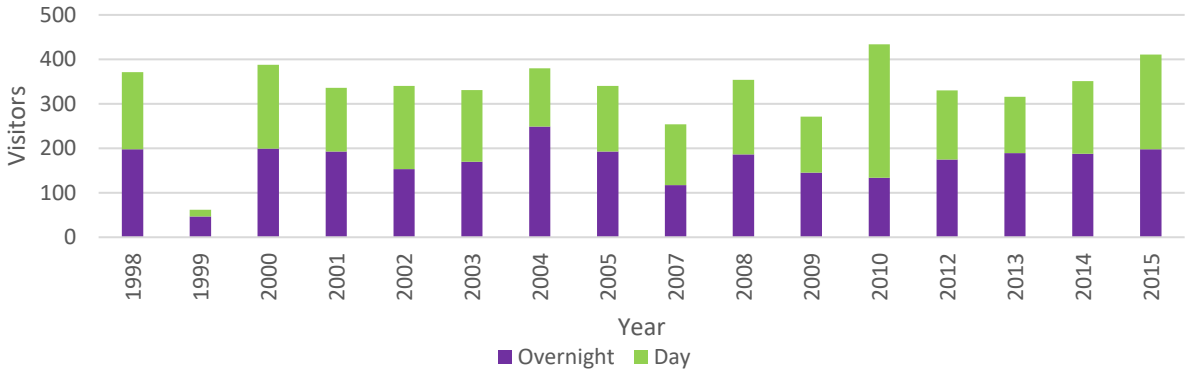


Figure 2.48 Twin Lakes Destination Visits

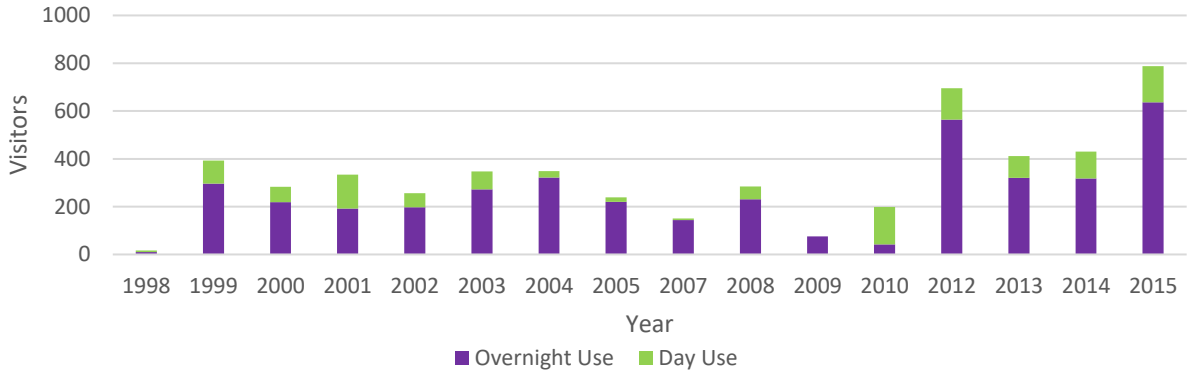


Figure 2.49 Upper Redfish Lakes Destination Visits

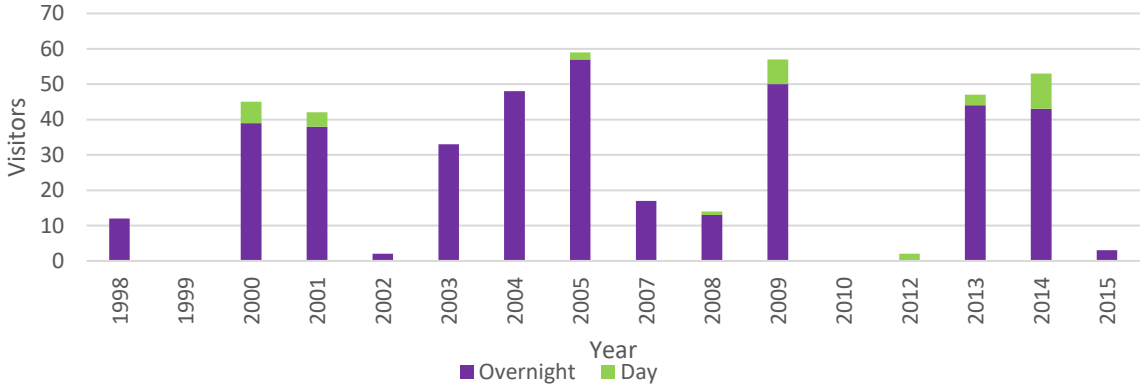


Figure 2.50 Vernon Lake Destination Visits

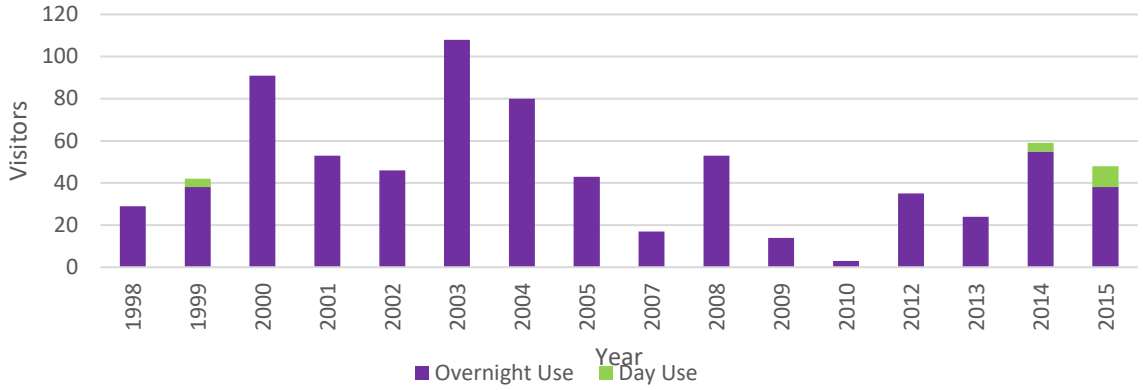


Figure 2.51 Virginia Lake Destination Visits

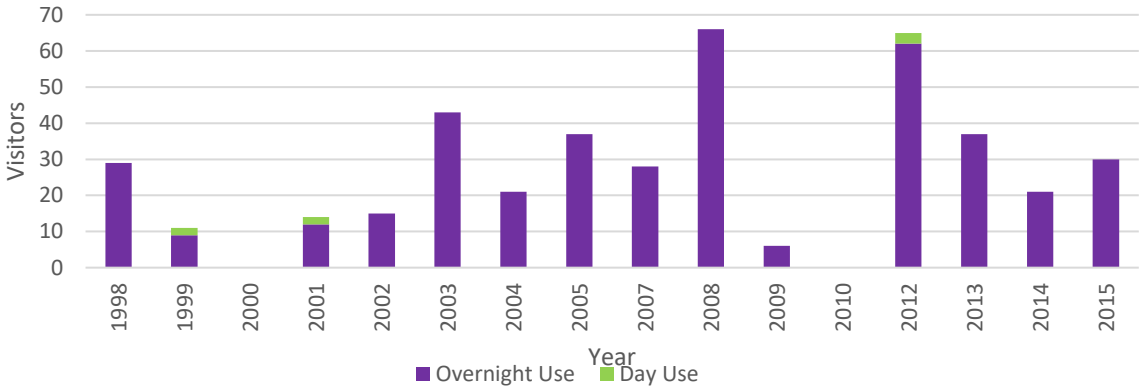


Figure 2.52 Warbonnet Lake Destination Visits

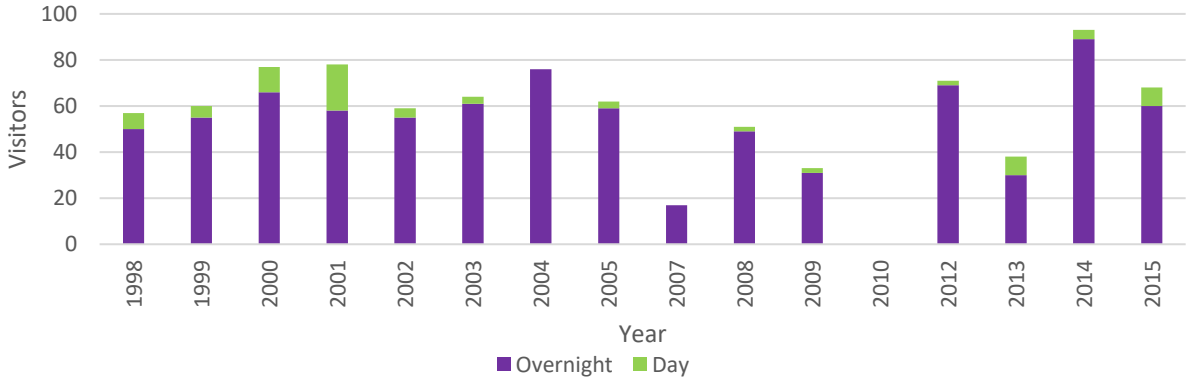


Figure 2.53 Campsite Monitoring Results

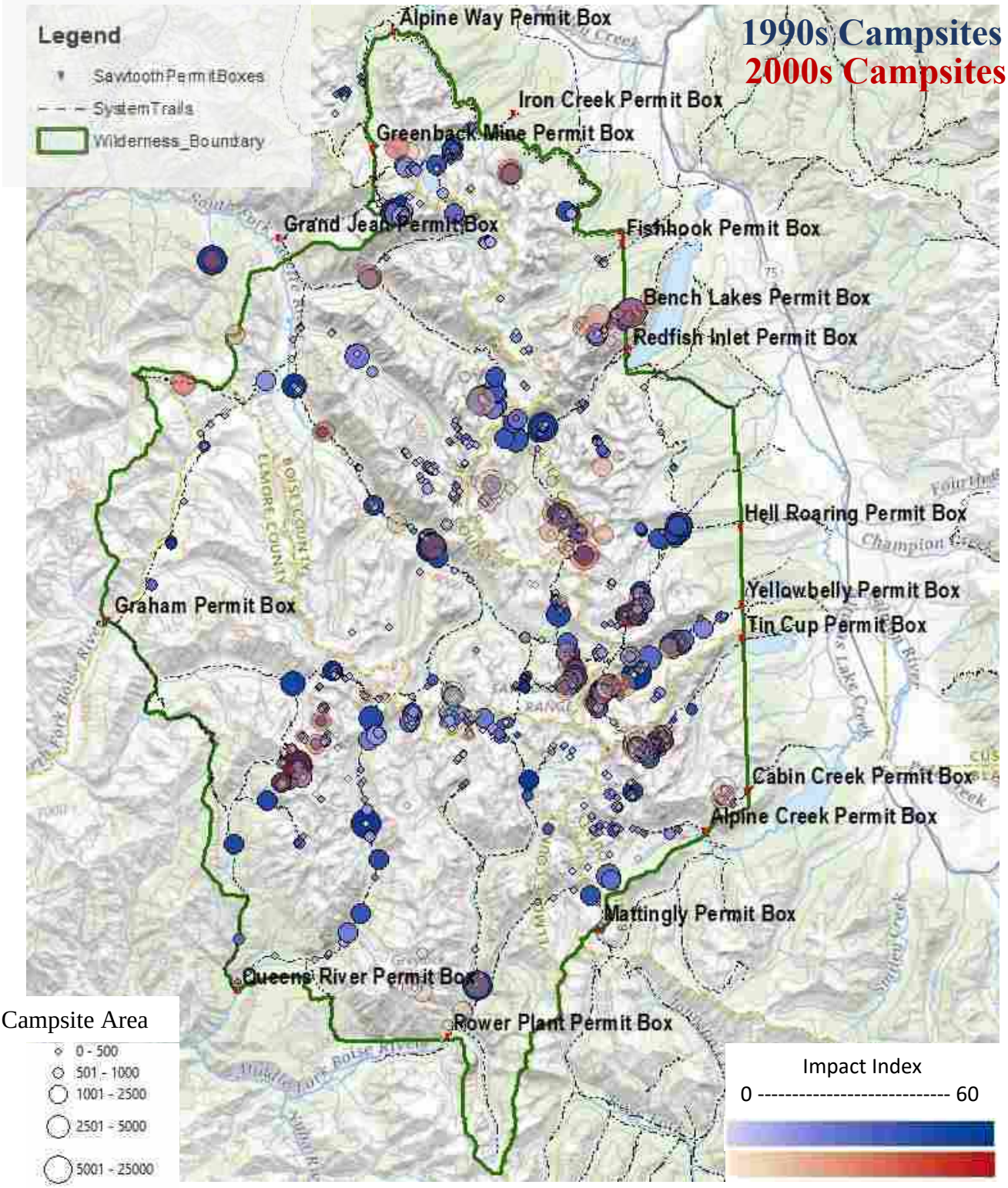


Figure 2.54 Campsite Monitoring Records (1975, 1976, 1980, 1990s, 2000s)

0's indicate there were no findings or no impacts to measure
Blank cells indicate there was no data available

	1975 FS Campsite Inventory	1980 FS Campsite Inventory	1990s Campsite Monitoring	1990s Campsite Monitoring	1990s Campsite Monitoring	2000s Campsite Monitoring	2000s Campsite Monitoring	2000s Campsite Monitoring
Destinations (Lakes)	**#of sites**	**#of sites**	**#of sites**	**Campsite Area (ft2)**	**Impact Index**	**#of sites**	**Campsite Area (ft^2)**	**Impact Index**
Alice	27	30	46	27886	34.59	40	20371	32.86
Alpine Creek		37	31	12080	25.84			
Alpine (Iron Creek)	23	14	15	7920	34.6			
Alpine (Redfish)	7	10	19	21271	37.47			
Ardeth	10		11	4300	44	10	8648	31
Arrowhead	1		2	300	26	4	608	
Baron	11		19	24592	34.91			
Bench	21	28	34	22628	31.83	39	35419	27.68
Benedict	5		6	5330	37.17	9	12422	
Browns	4		8	13775	38	10	22386	35.4
Cabin Creek	1	5	6	1450	29.32	4	7600	27.15
Cramer	11	17	23	16240	40.43	33	56316	32.93
Edith	5	8	5	3229	37	7	6546	33.57
Edna	10		7	10745	41.7	10	11500	32.3
Elk	5		9	13227	43	8	14434	39.63
Farley	9	12	17	14981	35.88	17	13850	39
Feather			6	1660	26.33	10	5681	27
Flytrip	13	14	7	1175	26			
Goat	0	6	4	7390	39.5	6	11025	42.17
Hell Roaring	6	16	26	27286	40.34	10	12710	45
Hidden	10		10	4105	33.6			
Imogene	10	27	23	24964	40.65	22	21763	34.82
Ingeborg	1		7	3525	25.71			
Kathryn	0		5	2675	26	10	3592	24.5
Marshall			5	3155	35.6	5	5174	30.4
Packrat			6	1950	27.33			
Pats	7		10	4965	32.1	12	5819	
Plummer	4		5	3175	27.75	3	5647	32.3
Regan	5		2	575	21	1	680	32
Saddleback	3		12	4181	31.54			
Sawtooth	11	10	15	6655	34.9			

	1975 FS Campsite Inventory	1980 FS Campsite Inventory	1990s Campsite Monitoring	1990s Campsite Monitoring	1990s Campsite Monitoring	2000s Campsite Monitoring	2000s Campsite Monitoring	2000s Campsite Monitoring
Destinations (Lakes)	**#of sites**	**#of sites**	**#of sites**	**Campsite Area (ft2)**	**Impact Index**	**#of sites**	**Campsite Area (ft^2)**	**Impact Index**
Spangle (Little)	15		7	3575	35.57			
Spangle	12		7	3325	33.83			
Toxaway	13	29	34	26864	35.59	25	34950	34.04
Trail Creek	4	11	17	19605	35.9			
Twin	8	12	17	8198	32.24	17	18068	27.29
Upper Redfish	0	7	6	3300	34.8	11	15485	27.67
Vernon	8		9	4590	30.33	9	7550	28.44
Virginia	5		3	4200	42.67	3	4200	36.3
Warbonnet			6	1600	24.8	8	3860	25.63

Figure 2.55 Crowding Ratings

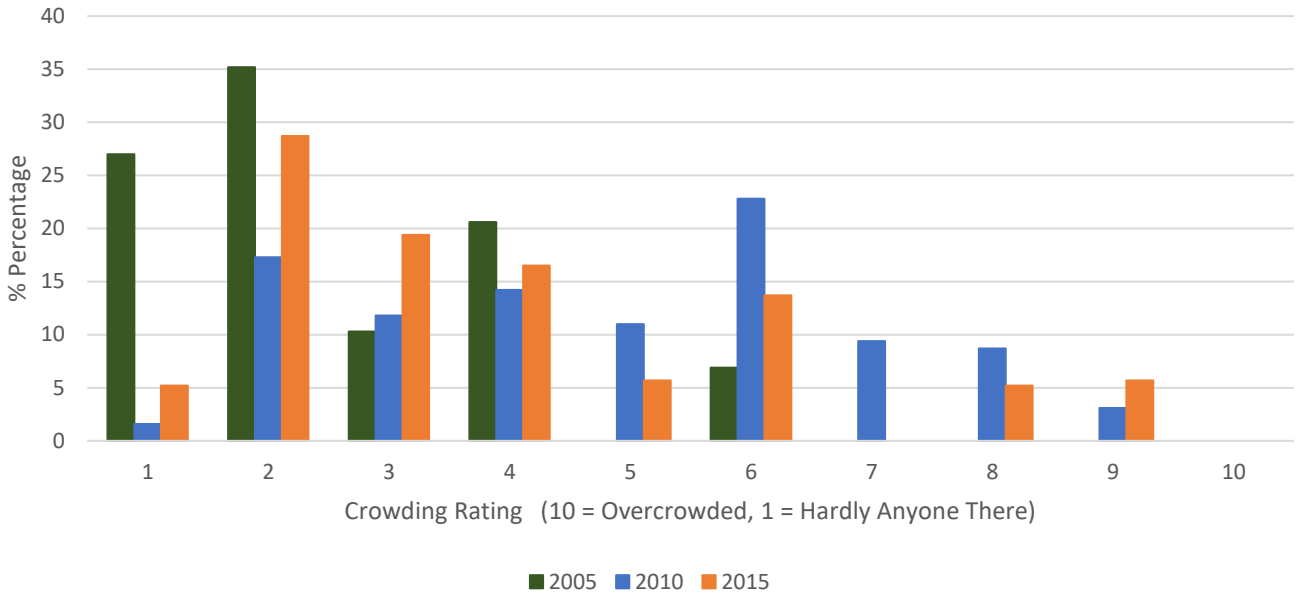
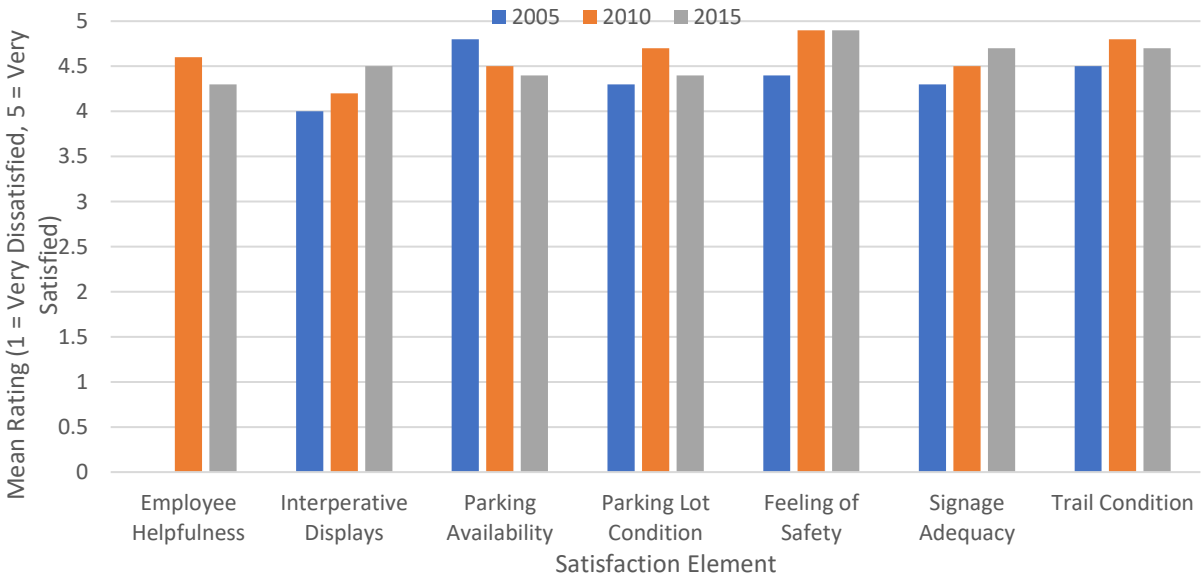


Figure 2.56 Satisfaction with Visit



Appendix 3
Results: Management Actions

Figure 3.1 Timeline of Sawtooth Wilderness Management Actions

Date	Engineering, Enforcement, Education
1905	Sawtooth National Forest protected as the Sawtooth Forest Reserve
1937	Sawtooth Primitive Area created under the L-20 Regulations
1964	Wilderness Act signed
1964	Sawtooth Primitive Area begins Wilderness Ranger Program
1965	Trailhead Registration Box installation begins
1965	Sawtooth Wilderness Ranger begin “Soft Sell” Wilderness Education Approach
1965	Wilderness Toilets Installation begins
1972	Sawtooth Wilderness created under the Sawtooth National Recreation Area Act
1977	Sawtooth Wilderness Management Plan signed
1997	Sawtooth Wilderness Management Plan amended SNRA Trailhead Parking Fee Project begins
1999	Wildlands Education Plan implemented
2000	Knoblock Cabin access road removed from Sawtooth Wilderness
2005	SNRA Trailhead Parking Fee Project ends
2006	Campsite Restoration Project at Hell Roaring Lake
2011	Hell Roaring Road Restoration Project
2012	Sawtooth National Forest Plan Revision completed

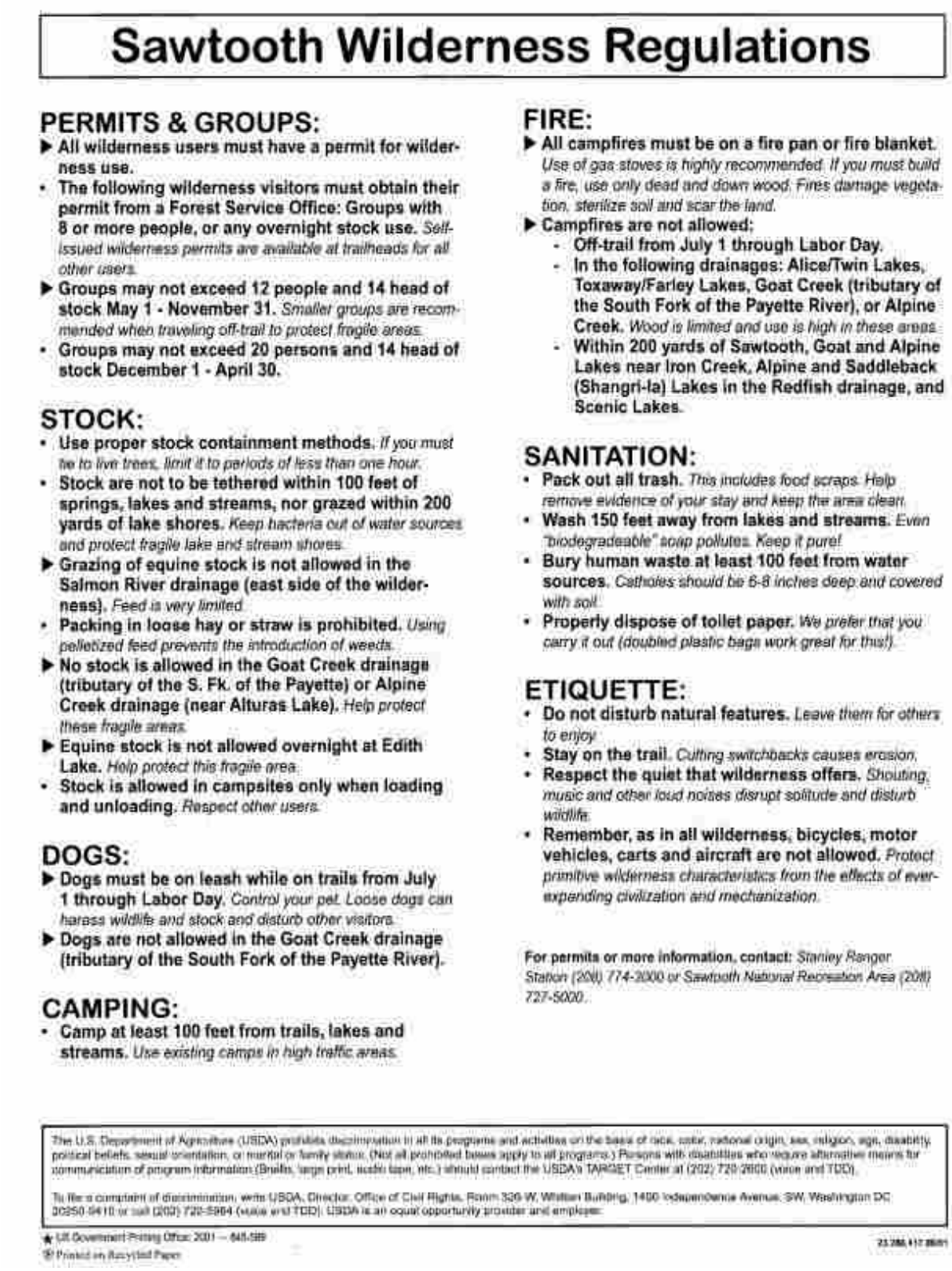
Figure 3.2 Sawtooth Wilderness Management Plan 1977 Regulations

Law Enforcement

The following specified acts are PROHIBITED in the Sawtooth Wilderness

1. Failure to obtain a permit to enter the Wilderness under the following conditions:
    a. When entering the Wilderness with pack or saddle stock.
    b. When group size exceeds 10 persons.
    c. When entering the area between November 15 and May 15.
2. Failure to limit group size to 20 persons.
3. Entering the area with pack and saddle stock exceeding 30 in number.
4. Allowing loose herd of pack and saddle stock within 200 yards of any lake or shoreline.
5. Tethering pack and saddle stock, or digging toilet pits within a 100 foot distance of springs, lakes, or streams, and not covering toilet pits before breaking camp.
6. Taking hay or straw into the Wilderness.
7. Failure to pack all unburnable refuse out of the Wilderness area and deposit at places designated for garbage disposal.
8. Cutting across trail switchbacks on foot or with pack and saddle stock.
9. Discharging firearms in the vicinity of camps and over or into lakes.
10. Camping within 100-feet of main trails, terrain permitting.

Figure 3.3 Sawtooth Wilderness Management Plan 1997 Regulations



Sawtooth Wilderness Regulations

PERMITS & GROUPS:

- ▶ **All wilderness users must have a permit for wilderness use.**
- **The following wilderness visitors must obtain their permit from a Forest Service Office: Groups with 8 or more people, or any overnight stock use.** *Self-issued wilderness permits are available at trailheads for all other users.*
- ▶ **Groups may not exceed 12 people and 14 head of stock May 1 - November 31.** *Smaller groups are recommended when traveling off-trail to protect fragile areas.*
- **Groups may not exceed 20 persons and 14 head of stock December 1 - April 30.**

STOCK:

- **Use proper stock containment methods.** *If you must tie to live trees, limit it to periods of less than one hour.*
- **Stock are not to be tethered within 100 feet of springs, lakes and streams, nor grazed within 200 yards of lake shores.** *Keep bacteria out of water sources and protect fragile lake and stream shores.*
- ▶ **Grazing of equine stock is not allowed in the Salmon River drainage (east side of the wilderness).** *Feed is very limited.*
- **Packing in loose hay or straw is prohibited.** *Using pelletized feed prevents the introduction of weeds.*
- ▶ **No stock is allowed in the Goat Creek drainage (tributary of the S. Fk. of the Payette) or Alpine Creek drainage (near Alturas Lake).** *Help protect these fragile areas.*
- ▶ **Equine stock is not allowed overnight at Edith Lake.** *Help protect this fragile area.*
- **Stock is allowed in campsites only when loading and unloading.** *Respect other users.*

DOGS:

- ▶ **Dogs must be on leash while on trails from July 1 through Labor Day.** *Control your pet. Loose dogs can harass wildlife and stock and disturb other visitors.*
- ▶ **Dogs are not allowed in the Goat Creek drainage (tributary of the South Fork of the Payette River).**

CAMPING:

- **Camp at least 100 feet from trails, lakes and streams.** *Use existing camps in high traffic areas.*

FIRE:

- ▶ **All campfires must be on a fire pan or fire blanket.** *Use of gas stoves is highly recommended. If you must build a fire, use only dead and down wood. Fires damage vegetation, sterilize soil and scar the land.*
- ▶ **Campfires are not allowed:**
  - **Off-trail from July 1 through Labor Day.**
  - **In the following drainages: Alice/Twin Lakes, Toxaway/Farley Lakes, Goat Creek (tributary of the South Fork of the Payette River), or Alpine Creek.** *Wood is limited and use is high in these areas.*
  - **Within 200 yards of Sawtooth, Goat and Alpine Lakes near Iron Creek, Alpine and Saddleback (Shangri-la) Lakes in the Redfish drainage, and Scenic Lakes.**

SANITATION:

- **Pack out all trash.** *This includes food scraps. Help remove evidence of your stay and keep the area clean.*
- **Wash 150 feet away from lakes and streams.** *Even "biodegradeable" soap pollutes. Keep it pure!*
- **Bury human waste at least 100 feet from water sources.** *Catholes should be 6-8 inches deep and covered with soil.*
- **Properly dispose of toilet paper.** *We prefer that you carry it out (doubled plastic bags work great for this!).*

ETIQUETTE:

- **Do not disturb natural features.** *Leave them for others to enjoy.*
- **Stay on the trail.** *Cutting switchbacks causes erosion.*
- **Respect the quiet that wilderness offers.** *Shouting, music and other loud noises disrupt solitude and disturb wildlife.*
- **Remember, as in all wilderness, bicycles, motor vehicles, carts and aircraft are not allowed.** *Protect primitive wilderness characteristics from the effects of ever-expanding civilization and mechanization.*

For permits or more information, contact: *Stanley Ranger Station (208) 774-3000 or Sawtooth National Recreation Area (208) 727-5000.*

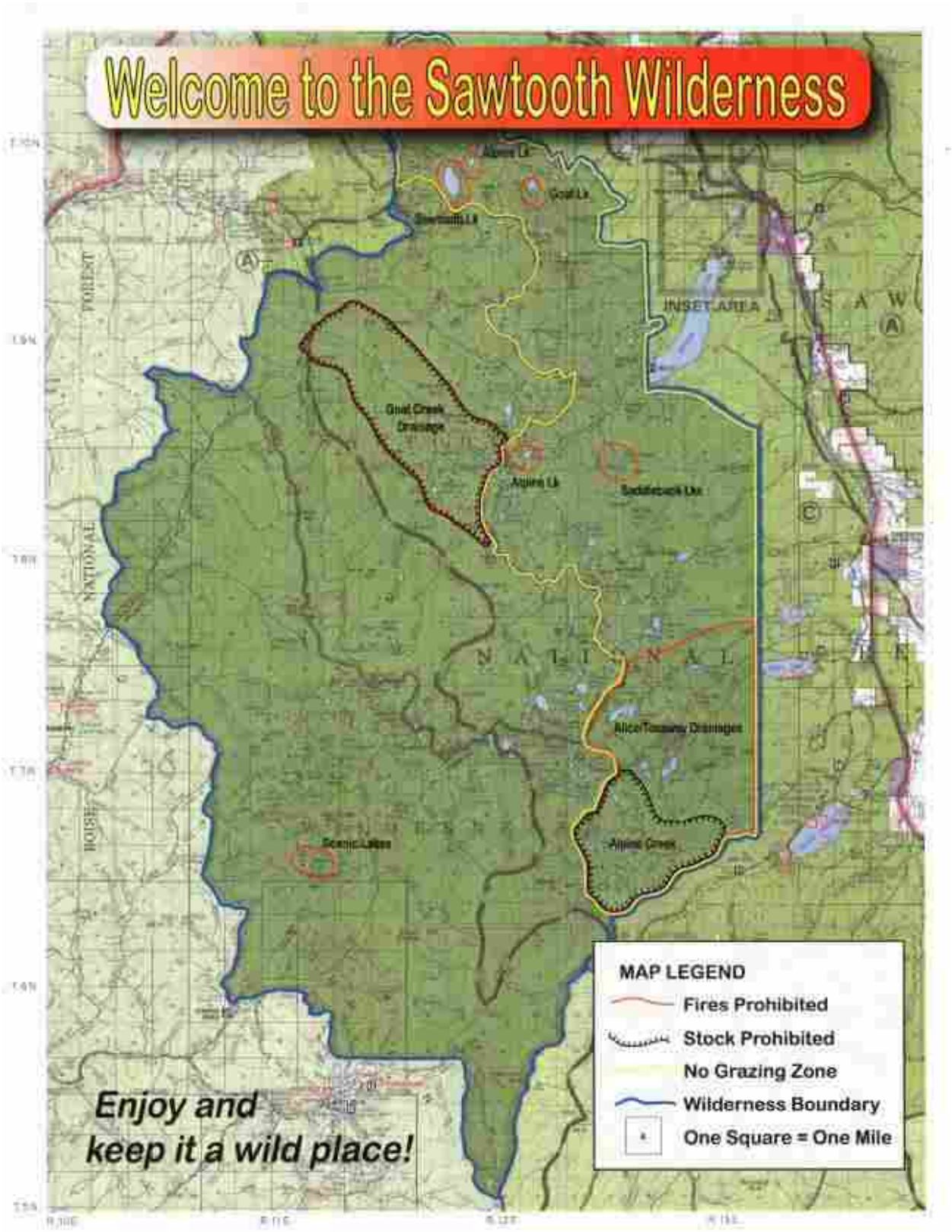
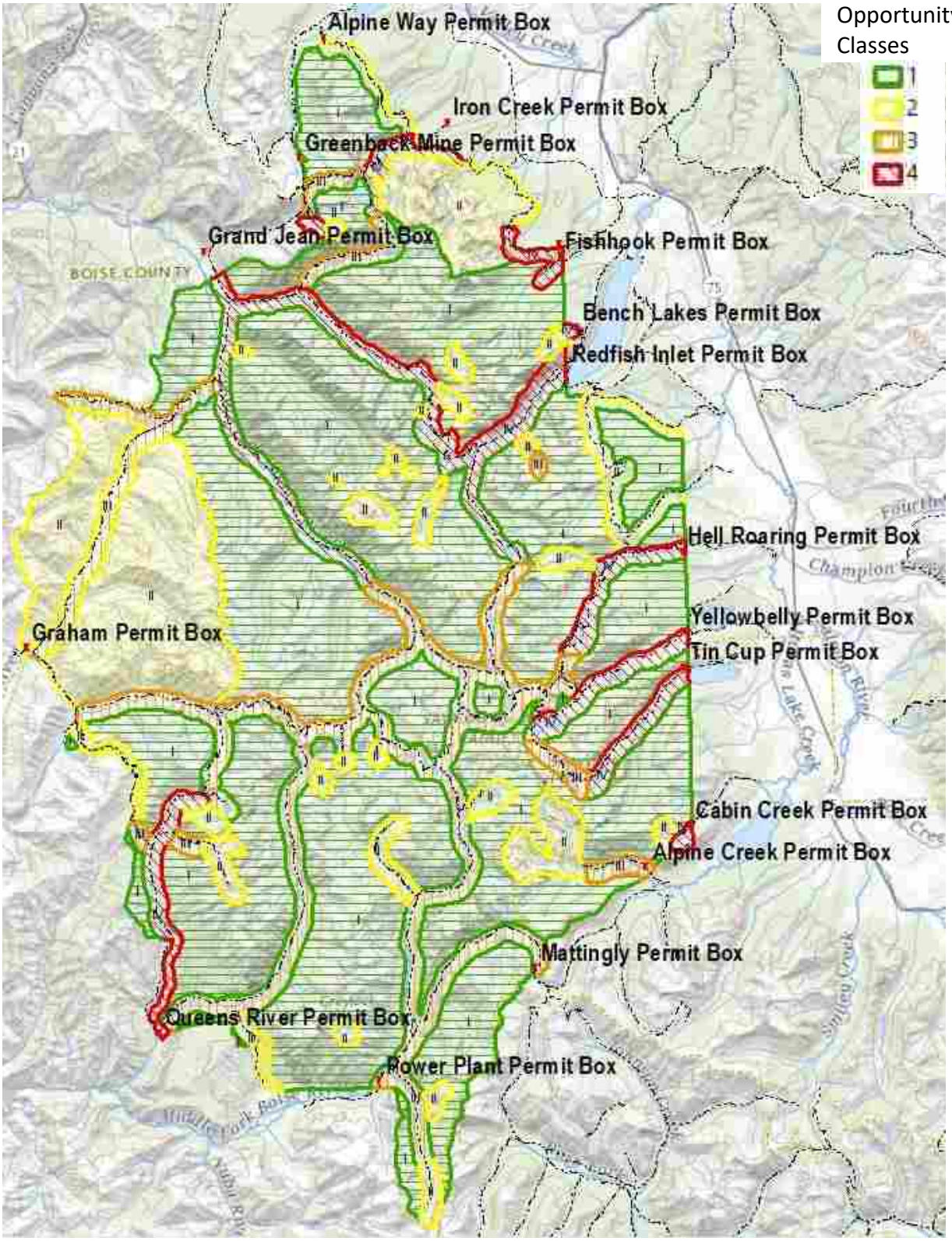

Welcome to the Sawtooth Wilderness
INSET AREA
Goat Creek Drainage
Alice/Toxaway Drainages
Alpine Creek
Scenic Lakes
MAP LEGEND
Fires Prohibited
Stock Prohibited
No Grazing Zone
Wilderness Boundary
One Square = One Mile
Enjoy and keep it a wild place!

Figure 3.4 Opportunity Classes of the Sawtooth Wilderness



Engineering actions, Enforcement actions, Education actions

	Opportunity Class I Pristine	Opportunity Class II	Opportunity Class III	Opportunity Class IV Transition
Desired Conditions				
Trails, Trailheads & Signs *Managerial Setting	No system-trails or structures No signs or route markers	System-trails maintained as Level 1 or 2 of standard Temporary signs for extreme circumstance	System-trails maintained at Level 2 or 3 standard Signs at trail junctions and for resource protection	System-trails maintained to Level 3 or 4 standard Signs at trail junctions and for resource protection
Education & Law Enforcement *Managerial Setting	Communicate LNT regulations outside of wilderness Visitor contacts are seldom for behavior correction	Same as Class I	Communicate LNT and regulations in and outside of wilderness Visitor contacts are routine	Same as Class III
Recreation Experience *Managerial Setting	Emphasis of visitor contact is LNT No permanent or temporary structure	Emphasis of visitor contact is LNT and dispersal Structures permitted in rare case of resource protection	Emphasis of visitor contact is regulations & concentrated use Facilities permitted in few cases of resource protection	Emphasis of visitor contact is regulations & concentrated use Facilities permitted in few cases of resource protection
*Social Setting	Infrequent encounters with others. No user conflicts.	Infrequent encounters with others. Few user conflicts.	Moderate encounters with others. Few user conflicts.	Moderate to high encounters with others. Some user conflicts.
*Resource Setting	Minimal impacts	Few noticeable impacts	Impacts confined to previously disturbed areas (campsite, trail)	Impacts confined to previously disturbed areas (campsite, trail)
Campsite Experience *Social Setting	Unlikely to encounter sights or sounds of other users.	Rarely encounter sights or sounds of other users.	Sounds of other users may occur, but sights are shielded.	Likely to encounter sights and sounds of other users.
*Resource Setting	Minimal evidence of use, no evidence of campsites.	Few noticeable campsites or stock impacts.	Clear evidence of camping. Stock confined to areas.	Clear evidence of camping, expect loss of ground cover.
Standards				
Campsites *number of sites	Extreme 0 Heavy 0 Moderate 1 Minimum 1	Extreme 0 Heavy 0 Moderate 2 Minimum 3	Number of sites may vary with size of lake.	Number of sites may vary with size of lake.

Figure 3.5 Wilderness Ranger Field Presence

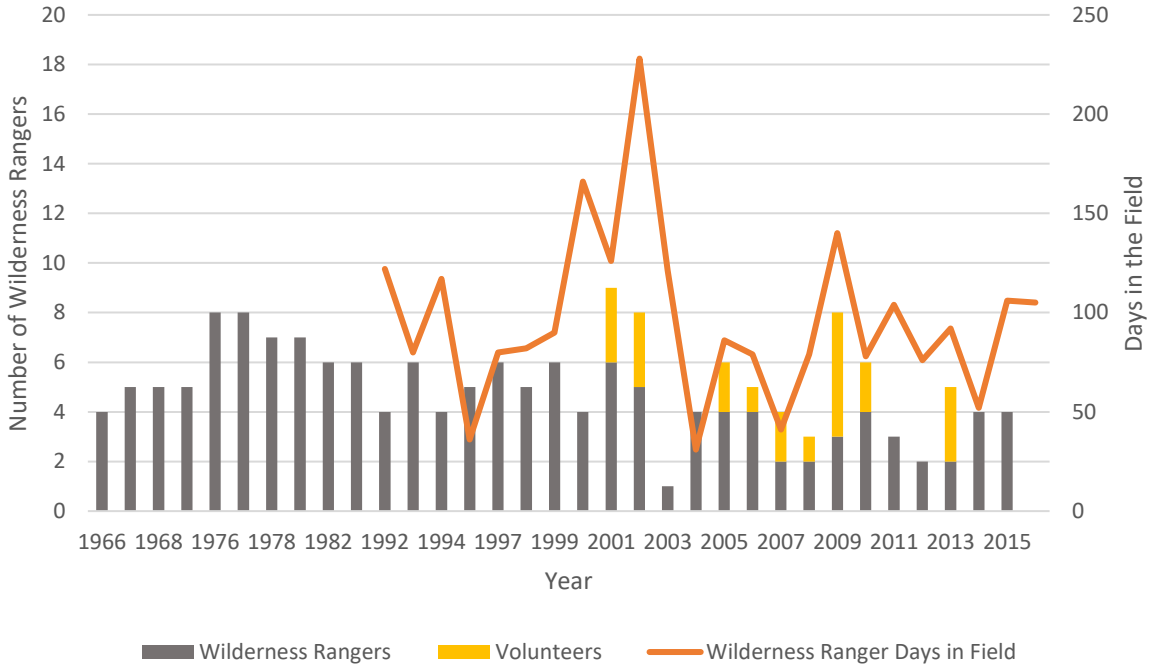


Figure 3.6 Wilderness Ranger Public Contacts

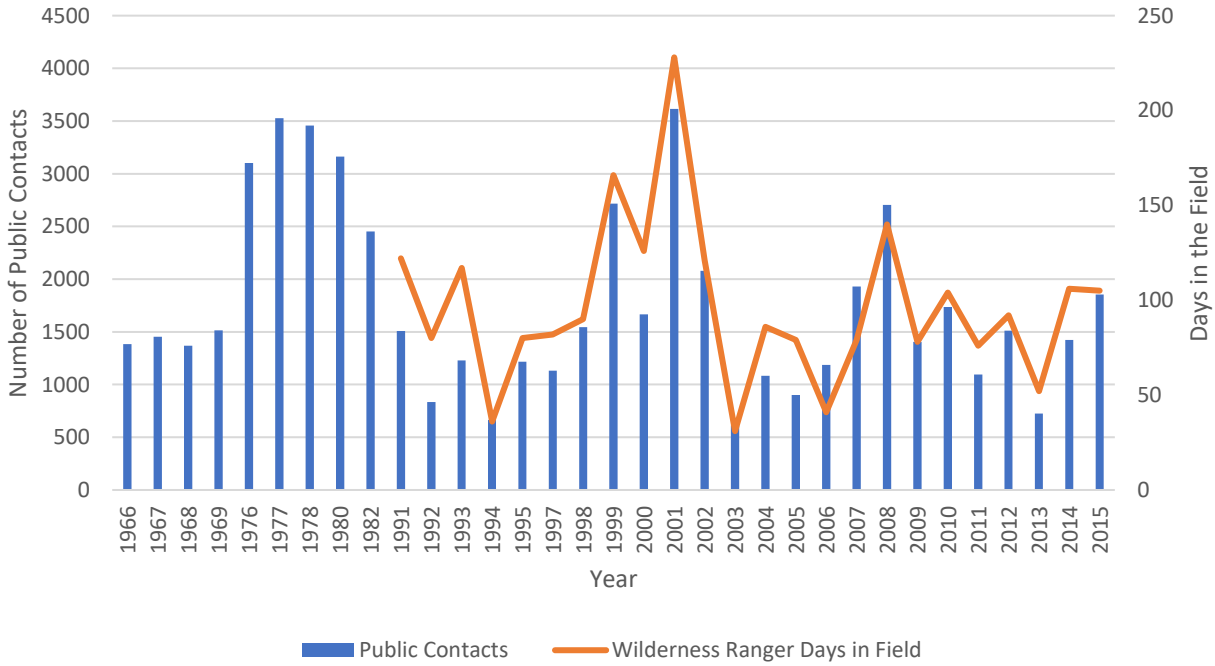


Figure 3.7 Trash Removed by Wilderness Rangers

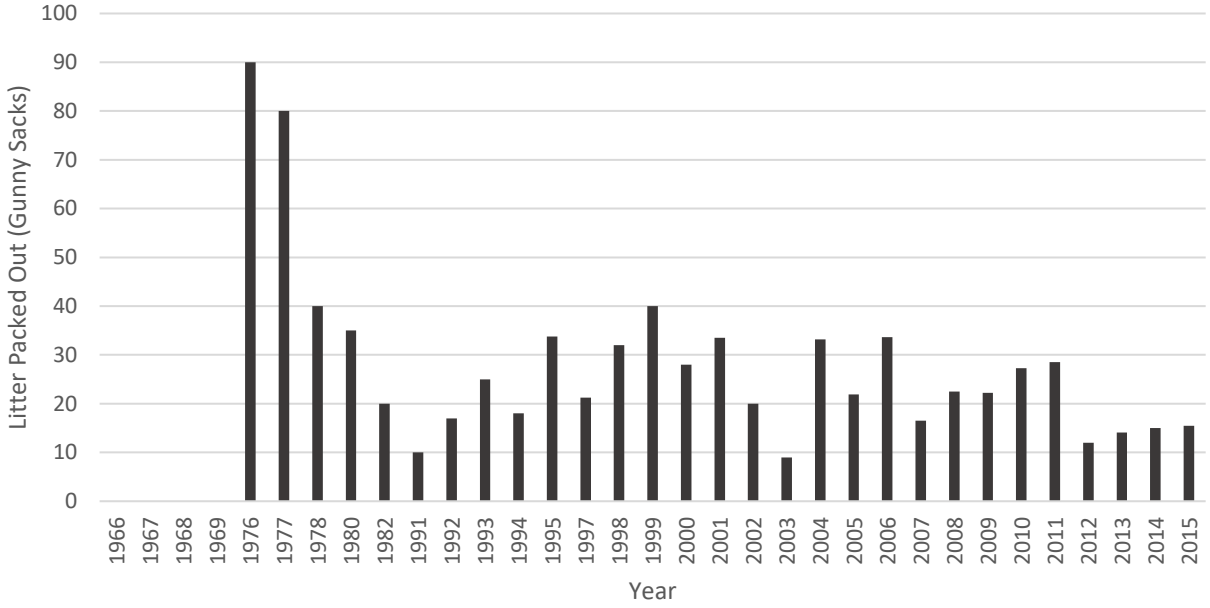


Figure 3.8 Campfire Ring Maintenance by Wilderness Rangers

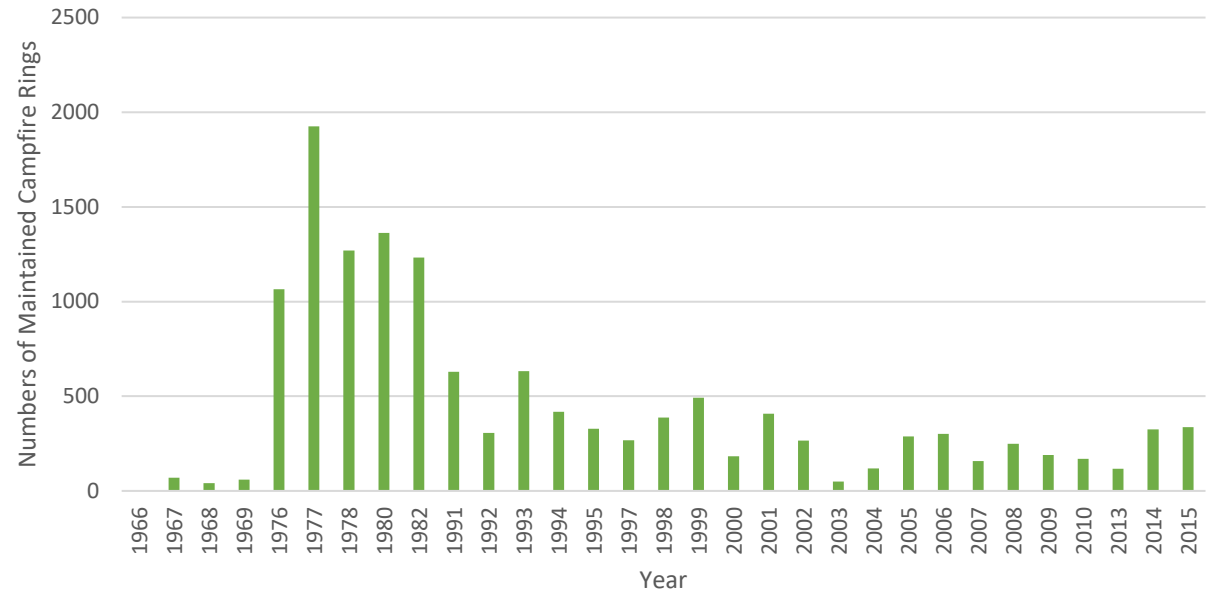


Figure 3.9 Campfire Rings Destroyed by Wilderness Rangers
*no data for 2011, 2012

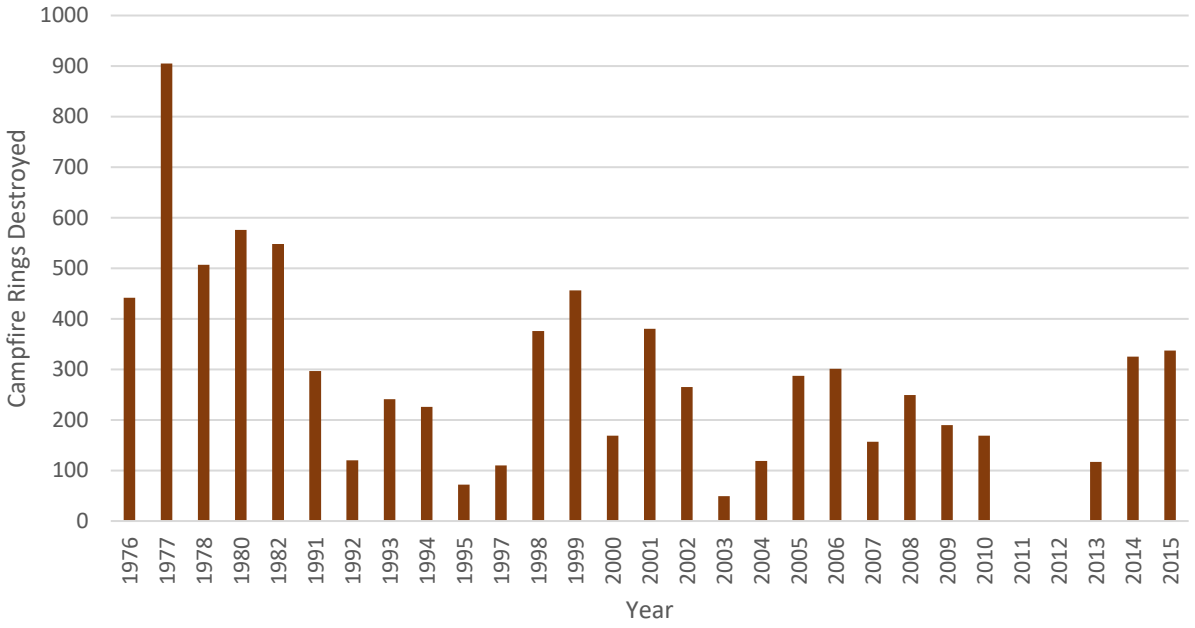
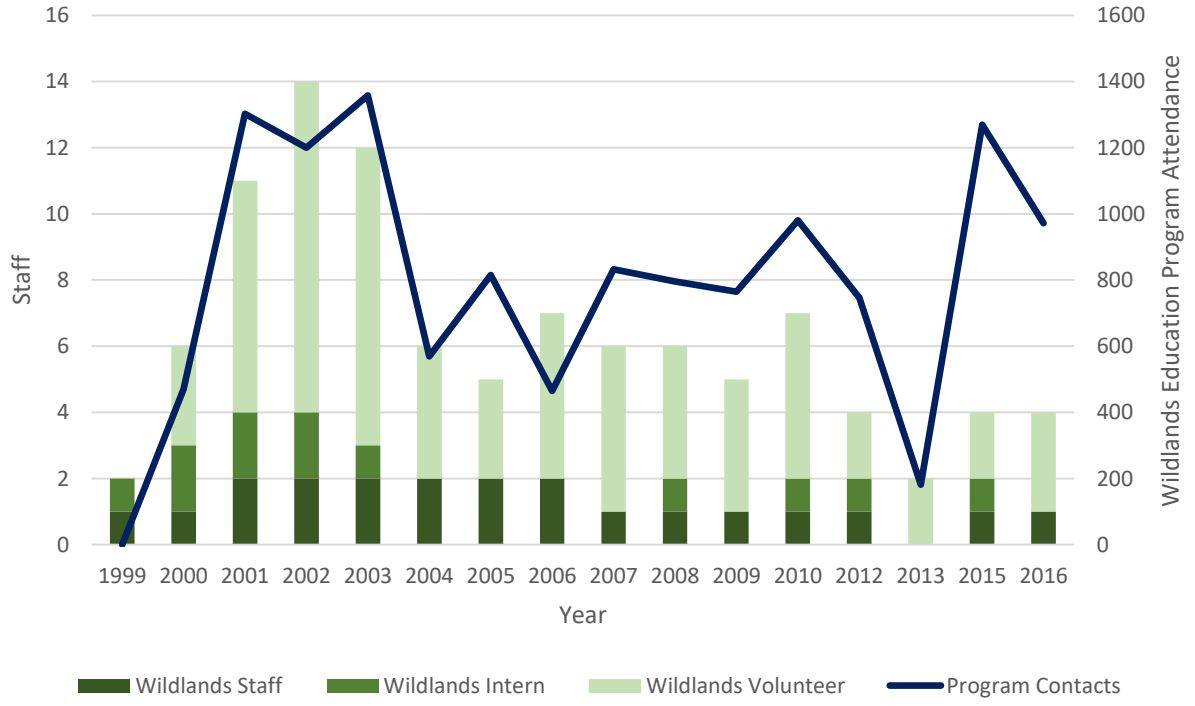


Figure 3.10 Wildlands Educators and Program Attendance



Chapter 5
Manuscript for the International Journal of Wilderness

This chapter is a manuscript prepared for the International Journal of Wilderness. This is an applied journal striving to "present the latest in wilderness research and practice" to its audience of "wilderness professionals, managers, and advocates." Submission requirements include a target length of 3,000 to 3,500 words, an abstract summarizing objectives, methods, and major findings, a factual results section, and an interpretive discussion. More specifically, this manuscript is written for the Science & Research category with a focus on the results and discussion sections.

Abstract

Understanding the relationship between visitor use and detrimental impacts is vital for wilderness managers responsible for protecting wilderness character and unconfined wilderness experiences. This study utilized50 years of quantitative longitudinal data from the Sawtooth Wilderness to understand the relationship between visitor numbers and campsite impacts. This novel approach, to couple long-term stand-alone data, revealed unexpected trends in visitation and campsite impacts. Coupling visit characteristics, use densities, and impacts at various destinations throughout the Sawtooth Wilderness revealed drastically different relationships. An increase in visitor numbers was not a proxy for an increase in detrimental campsite impacts. This work highlights the need to couple longitudinal visitor trends with monitoring data to identify locations and magnitudes of deteriorating conditions. Managers may then determine the types of visit characteristics and visitor behaviors to modify through management actions.

Introduction

Predictions for wilderness recreation have historically and currently call for an increase in visitation numbers (Bowker et al., 2012; Cole, 1996a, Watson et al., 1999). This creates a

seemingly impossible challenge for managers responsible for preserving wilderness character to simultaneously offer opportunities for an unconfined wilderness recreation experience. To help accomplish this, the field of recreation ecology and the Interagency Visitor Use Management Council suggest managers prioritize modifying visit characteristics and visitor behaviors instead of restricting visitor numbers (D'Antonio & Monz, 2016; IVUMC, 2016). Managers have diverse opportunities to reduce detrimental visitor impacts by modifying visit types, amounts, locations, and the spatial and temporal distributions of visits (Cole, 1989; Marion, 2003; Hammitt et al., 2015).

The relationship between visitor numbers and impacts is not linear, but curvilinear, meaning impacts do not necessarily increase as visitation does. Initial impacts at previously undisturbed areas quickly deteriorate, while continued impacts at the same location create less to no additional impacts (Cole 1987, Hammitt et al., 2015; Marion et al., 2016). Managers using campsite monitoring data to identify locations of deteriorating conditions should remember visitor behaviors causing detrimental campsite impacts are not uniform spatially or temporally (D'Antonio & Monz, 2016). Thus, managers need to simultaneously utilize longitudinal visitation data to understand how visit characteristics, use densities, and detrimental impacts are related throughout the wilderness (Cole, 1996; Dawson & Hendee, 2009; Marion et al., 2016).

Recreation ecology literature primarily consists of one-time, stand-alone wilderness studies of visitor trends or associated detrimental impacts, with little work done to utilize longitudinal quantitative trend data, or to couple such data (Cole & Monz, 2004; D'Antonio & Monz, 2016; Lucas, 1989; Loomis, 2000). Though these solitary studies provide essential information on current conditions for managers, the integration of long-term visitation and

impact trends at specific locations throughout a wilderness empowers managers to identify and address detrimental visitor behaviors requiring modification through management actions.

This study visualized and descriptively assessed trends from nearly 50 years of visitor use and campsite data from the Sawtooth Wilderness. These trends were then coupled to reveal relationships between visitation and detrimental impacts. This study helps managers identify areas at risk for deteriorating resource conditions and their causal visit characteristics or visitor behaviors. This allows managers an opportunity to create focused management actions to reduce detrimental impacts by modifying visitation instead of restricting it.

Methods

Study Area

The Sawtooth Wilderness (SW) is 217,658 acres, with 300 miles of trails providing access to pristine streams, lakes, and meadows full of wildflowers during the short summer season. It's 400 alpine lakes feed into the headwaters of the North and Middle Forks of the Boise River, the South Fork of the Payette River, and the Salmon River. The SW possesses some of the cleanest air in the United States and is registered as a Class I airshed (Wilderness Connect, n.d.) Recreational opportunities include sight-seeing, hiking, trail running, backpacking, rock climbing, horseback riding, fishing, and hunting.

The SW hosts a unique, robust dataset of archived longitudinal records from 1965 documenting visitation numbers and campsite impacts. Managers concerned by increasing visitor numbers and deteriorating biophysical campsites instituted trailhead registers and eventually self-issued wilderness permits at all wilderness boundaries (USDA, 1997). Additionally, the SW implemented several rounds of campsite monitoring to assess deteriorating biophysical conditions on the ground. This unprecedented opportunity to visualize nearly five decades of

wilderness recreation in the SW reveals new recreation trends and challenges the recreation ecology literature.

Data Collection & Visualization

Nearly fifty years of trailhead registrations, wilderness permits, campsite monitoring data, and annual reports were collected from Sawtooth National Forest archives. The data was collected from the archives, organized, cleaned, verified, and then visualized for trends. All data was utilized as raw data; no compliance percentages or significance were calculated or included.

Fifty years of trailhead registers and permit data were collected from the field each year by wilderness rangers and stored in the Forest's archives. In 2016, the Aldo Leopold Wilderness Research Institute cataloged over 100,000 wilderness permits, from 1997 to 2015, into Excel spreadsheets. This data was then cleaned for repeat or erroneous records and verified with annual SW recreation reports. This visitation data is an under-representation of the actual numbers as registration compliance rates are not 100%, especially for day hikers and stock users (Cole & Hall, 2008; Dawson & Hendee, 2009). Registrations and permits may not have always been adequately stocked; permit boxes have been destroyed by avalanches and rodents; information may have been lost when archived or cataloged incorrectly.

The implementation of self-issued permits in the SW began in 1997. These permits asked visitors for more detailed visit information previously used trailhead registers, such as trail access, trip dates, planned destinations, group size, and zip codes. This data was organized per category and graphed to view solitary trends over time.

Visitor demographic data came from the United States Forest Service National Visitor Use Monitoring (NVUM) websites. The last three rounds of NVUM in the Sawtooth Wilderness are considered statistically significant under the new process, so only data from the years 2005,

2010, and 2015 were used. Data was organized per category of demographics (gender, age, race, residence) and graphed to view trends.

Nearly four decades of campsite monitoring occurred in the Sawtooth Wilderness from 1975 to 2013. Unfortunately, nearly every round of monitoring utilized a different protocol. Initial campsite inventories of baseline data, from 1975 – 1980, used three different protocols to measure different parameters. From this initial campsite data, this study was only able to utilize campsite locations and numbers to measure proliferation. Proceeding rounds of campsite monitoring in the 1990s and the 2000s followed the same protocol allowing for the additional trend analysis of campsite area and impact index condition class (USDA, 1992). This protocol followed Cole's 1989 widely used campsite monitoring protocol to calculate an overall campsite impact index based on nine parameters (vegetation loss, mineral soil increase, tree damage, root exposure, stock evidence, development, cleanliness, social trails, and campsite area). Each measured parameter received a condition class rating of 1 (low) to 3 (high), which was multiplied by an assigned weight, which was related to the permanence of the impact. These nine figures were summed to create the campsites impact index ranging from 20 to 60 (20-30 light impact, 31-39 moderate impact, 40-49 heavy impact, 50-60 extreme impact) (USDA, 1992). Campsite data was organized in Excel spreadsheets by campsite monitoring round to scrutinize for changes over time at destinations.

Coupling trend data occurred by comparing measured use density, at wilderness access points (permit boxes) and destinations (typically lakes), with visit characteristics (visit type), and measured campsite impacts. This analysis occurred for all 17 trailheads and at 55 destinations throughout the SW (see Phillippe et al. 2020 for more details). The result section presents three

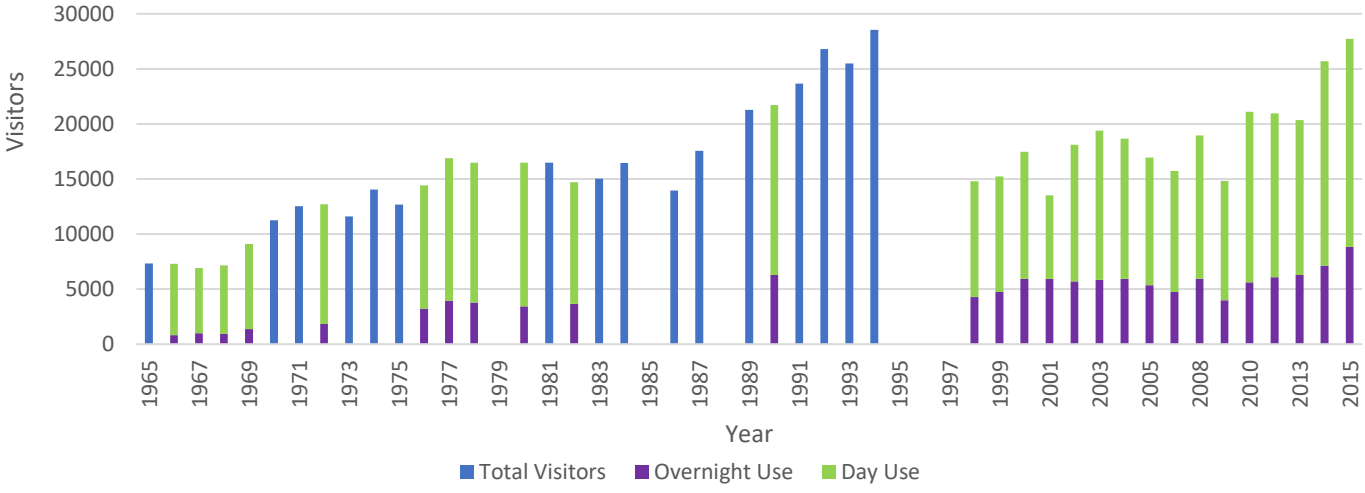
examples of this coupling analysis to highlight the diversity of use density and impacts occurring throughout the SW.

Results

Trends in Visitation

Annual visitation in the SW experienced a drastic decrease in the mid-1990s through the overall trend shows increased visitation over the last 50 years, from 6,500 visitors in 1965 to over 27,000 visitors in 2015 (Figure 1). This downward trend in the mid-1990s is consistent with other public lands managed by the Department of the Interior in the Western United States (USDA, n.d.). This decrease in visitation in the SW coincided with the implementation of a new Sawtooth Wilderness Management Plan in 1997, requiring visitors to obtain a free self-issued wilderness permit. At the same time, a separate fee program was implemented at all trailhead parking lots in Sawtooth National Recreation Areas (PL 104-134).

Figure 1 - Annual Visitation in the Sawtooth Wilderness



The proportion of overnight visitors has steadily increased in the Sawtooth Wilderness, as has totals for both day and overnight visitors (Table 1). The proportion of overnight visitors grew from 11% in 1966, to 23% in 1977, 29% in 1988, 30% in 1999, and up to 32% in 2015.

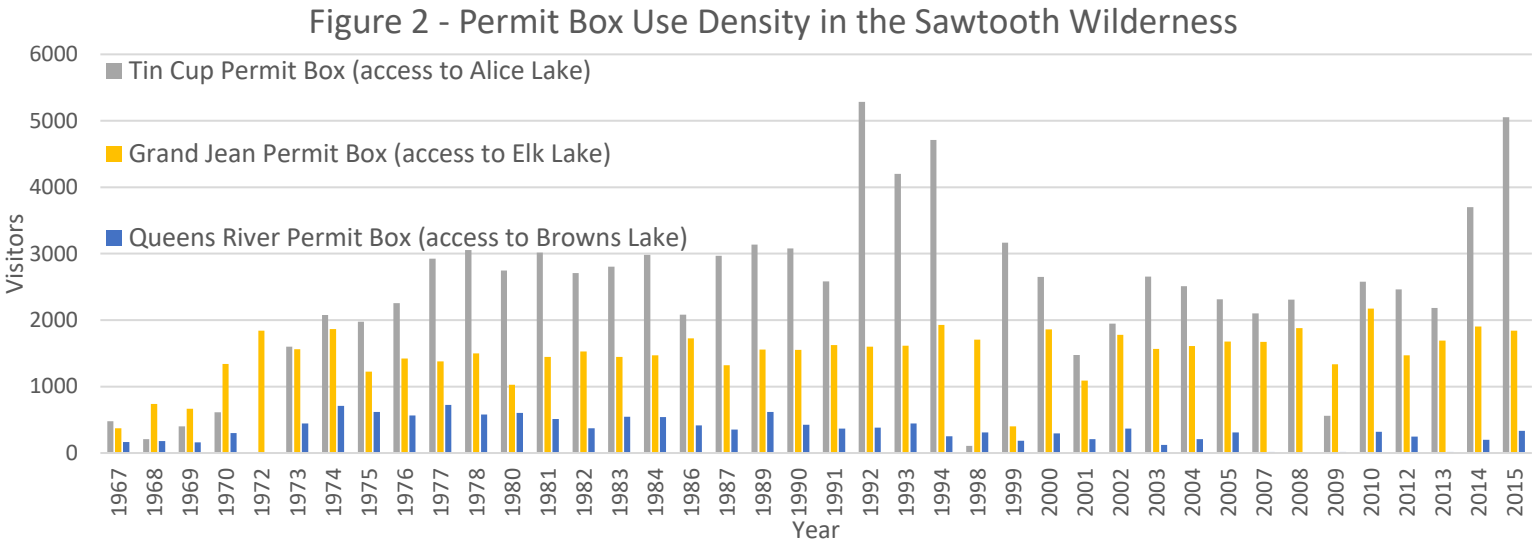
Table 1 – Proportion of Day and Overnight Visitors in the Sawtooth Wilderness

YEAR	1966	1967	1968	1969	1972	1976	1977	1978	1980	1982	1990	1998	1999	2002	2003	2007	2008	2009	2013	2014	2015
% Day	89	85	87	85	85	78	77	77	79	75	71	71	70	69	69	70	69	73	69	73	68
% ON	11	15	13	15	15	22	23	23	21	25	29	29	30	31	31	30	31	27	31	27	32

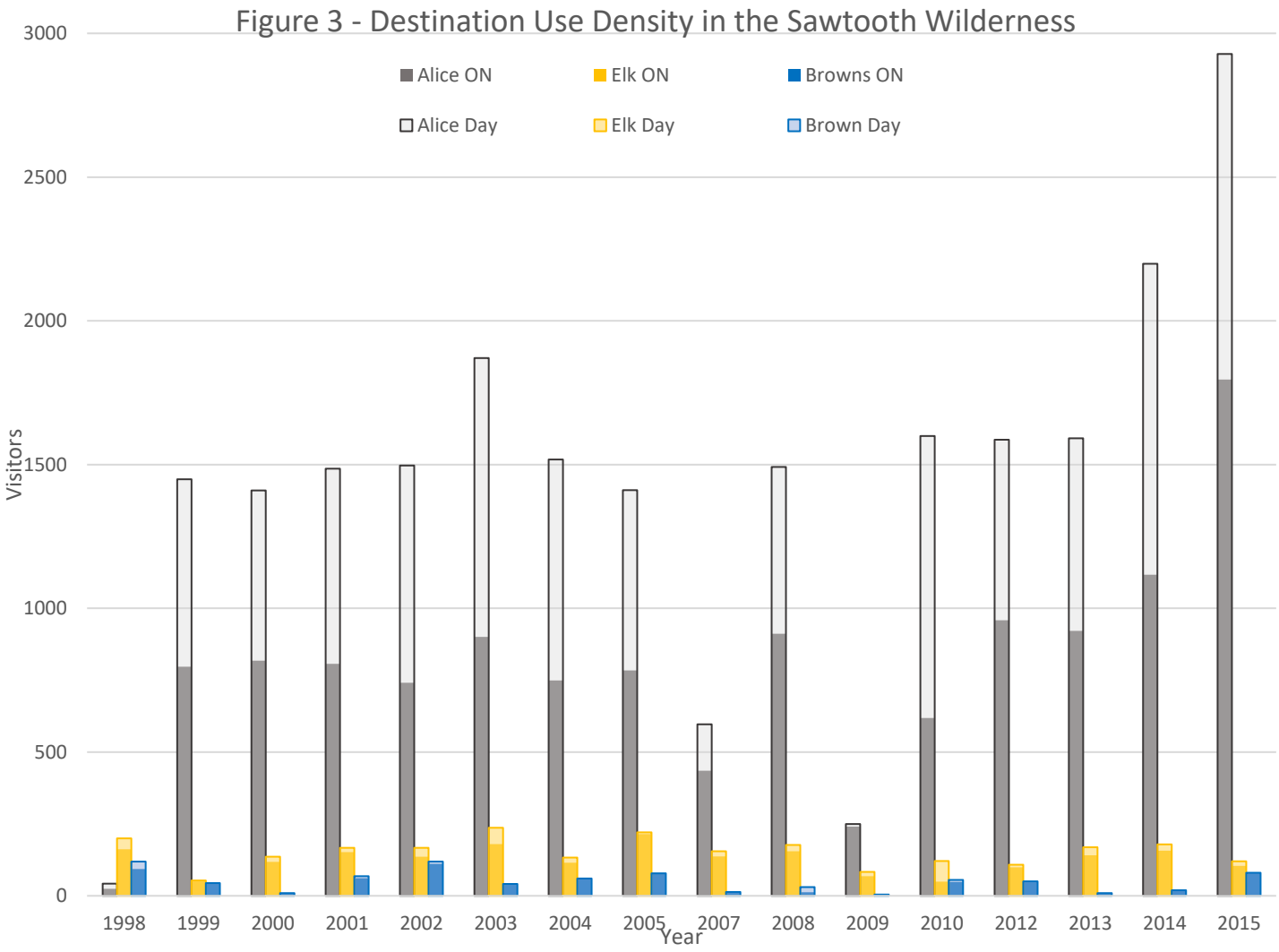
Other trends in visit characteristics for Sawtooth Wilderness include decreasing trends in group size from 3.2 in 1998 to 2.8 in 2015, overnight trip duration from 3 nights in 1976 to 2.33 nights in 2015, and a drop in stock use with 20% of registered visitors using stock in 1960 to 1% in 2015. Trends in demographics in the Sawtooth Wilderness include a rise in female visitors from 41% in 2005 to 46% in 2015, a growing range in ages among visitors, but virtually no diversity in race or ethnicity among users (2015 surveys measured zero non-white visitors).

Trends in Visitor Impacts

The 17 wilderness permit boxes in the Sawtooth Wilderness experience uneven visitation, or drastically different use densities. A sample of three permit boxes (Tin Cup, Grand Jean, and Queens River) to demonstrate the variety of trends occurring (Figure 2). The Tin Cup permit box has experienced considerable variation over the last 50 years, with visitor numbers below 500 in the 1960s, a primary peak of over 5000 visitors in 1992, and a secondary peak of 5000 in 2015. The Grand Jean permit box has seen a relatively steady 1800 visitors per year. Meanwhile, the Queens River permit box experienced relatively low visitation, consistently under 800 visits a year, with a general decrease over the last few decades.



Use density trends also vary significantly at destinations throughout the Sawtooth Wilderness. The sample of three permit boxes and their access to various destinations is continued to exhibit this variation in trends (Figure 3). The very popular destination of Alice Lake, accessed from the Tin Cup permit box, has experienced substantial increases in overall visitation, but especially in the proportion and actual numbers of overnight visitors, from less than 1500 visitors in 1999 to nearly 3000 visitors in 2015. Elk Lake, accessed via the Grand Jean permit box, displays inconsistent trends in both use density and type of visitor (day and overnight). Browns Lake, accessed from the Queens River permit box, has an overall low use density with minor fluctuations and a majority of overnight visitors.



Campsite impacts throughout the Sawtooth Wilderness also vary, both spatially and temporally. The sample of the three permit boxes and destinations is continued to exemplify this trend (Table 2). The destination of Alice Lake has a decreasing trend in campsite impacts, with the number of campsites, aggregate campsite area, and average impact index all dropping. Elk Lake has seen campsite numbers and its average impact index decrease, but the aggregate campsite area increase. In contrast, Browns Lake has an increase in campsite numbers and campsite area, but a decrease in impact index.

Table 2 – Campsite Impacts at Destinations in the Sawtooth Wilderness

	Number of Campsites			Campsite Area (ft2)			Impact Index		
Year	Alice Lake	Elk Lake	Browns Lake	Alice Lake	Elk Lake	Browns Lake	Alice Lake	Elk Lake	Browns Lake
1975	27	5	4		8954				
1990s	46	9	8	27886	13227	13775	34.59	43	38
2000s	40	8	10	20371	14434	22386	32.86	39.63	35.4

Discussion

Trends in Visitation

Though the overall increasing trend of visitor numbers in the Sawtooth Wilderness is consistent with the literature, there was an unexpected significant decline in the mid-1990s (Bowker et al., 2012; Cordell & Bowker 2013). This trend in decreased visitation in the mid-1990s simultaneously occurred in other public lands in the Western United States but is not mentioned in the recreation ecology literature (USDI, n.d.). The increasing proportion of overnight visitors to the SW also diverges from the recreation ecology literature portraying a decrease in overnight visitors (Dawson & Hendee, 2009; Hammitt et al., 2015). These inconsistencies highlight the danger of applying general or national trends to specific wilderness areas instead of utilizing local longitudinal quantitative data for site-specific trends.

Quantitative analysis for most other visitor trends in the Sawtooth Wilderness is consistent with the literature. Most visit characteristics have decreasing trends, group size is smaller, trip durations are shorter, and stock use is down (Cole, 2011; Cordell & Bowker; 2013; Dawson & Hendee, 2009). Most SW visitors hike during the summer months and reside in Idaho, necessitating only a few hours of travel (Dawson & Hendee, 2009; Roggenbuck & Watson, 1989; Lucas, 1989). SW demographics mirror general recreation findings with an

increase in female and younger visitors, but the Sawtooth Wilderness has exceptionally low to no non-white visitors (Dawson & Hendee, 2009; Hammitt et al. 2015; Outdoor Foundation, 2020).

Trends in Use Density

The seventeen permit boxes of the Sawtooth Wilderness have drastically different visitor numbers, which is consistent with recreation ecology findings of uneven use densities throughout a wilderness (Cole & Monz, 2004; Dawson & Hendee 2009; Freimund & Cole, 2001). The overall trend in use density in the Sawtooth Wilderness is an increase in visitors at a few "popular" permit boxes on the eastern side of the Wilderness. In contrast, the western side exhibits a decreasing trend in visitors (other than the Grand Jean permit box, which has maintained consistent use). Generally, the eastern side of the wilderness has more accessible roads, trailheads, and trails than the western side. This pattern of uneven density also occurs spatially throughout the SW, with some destinations being more "popular" than others. This data provides managers valuable quantitative measurements of where visitors prefer to access the wilderness and which destinations they frequent.

Trends in Campsite Impacts

Campsite impact trends throughout the Sawtooth Wilderness are significantly uneven as well, suggesting destinations are experiencing visitors with various visit characteristics and behaviors. Generally, campsite impact trends for the last forty years have deteriorated, with an increase in campsite proliferation and aggregate campsite data. But many SW destinations support Cole's 2013 findings of an increase in campsite impacts up to the 1990s, while many "popular" destinations begin to show a decrease in impacts during the 2000s. This may be an example of the curvilinear relationship between use and impacts, implying that the increase in

visitor numbers is not resulting in increasing impacts at campsites (Cole 1982, 1987, 2019; Frissell & Duncan, 1965; Hammitt et al., 2013; Marion et al., 2016).

Coupled Data Analysis

The coupling of visitor trends and associated detrimental impacts indicates drastically different use densities and campsite impacts occur throughout the Sawtooth Wilderness. Although overall visitor numbers are increasing, different visit characteristics and visitor behaviors cause different detrimental impacts at various destinations. Such variations suggest the need for different management actions. For example, the Tin Cup permit box sees an exceptionally high number of visitors, many of which camp at Alice Lake, which is experiencing a decrease in campsite impacts displaying a curvilinear relationship of use and impacts. A closer investigation or updated round of campsite monitoring may reveal why, or if this trend is still occurring. At less popular permit boxes, such as Grand Jean and Queens River, their destinations (Elk and Brown Lakes) see fewer visitors but have increasing campsite impacts. This suggests visit characteristics and behaviors are not uniform temporally or spatially in the SW wilderness, necessitating managers to focus on reducing detrimental behaviors, not visitor numbers (D'Antonio & Monz 2016; IVUMC, 2020).

Coupling visitor impacts with the management actions of enforcement and education (via wilderness rangers and the Wildlands Education Program) suggested several successes. Enforcement and education to pack out one's trash, and the prohibition of campfire rings seem to have resulted in less clean up required by wilderness rangers. These successful preventative management actions may also be related to national LNT campaigns, whose consistent messaging is repeated on a wilderness level, such as on trailhead signs, in education programs, and in the field by wilderness rangers.

Management Implications

Managers need to collect and utilize longitudinal quantitative data to assess and relate trends in visitation, associated detrimental visitor impacts, and effective management actions – especially those specific to the lands they manage. Using speculation or applying generalized national trends can be erroneous and dangerous, as they may not be accurate for all wilderness areas. The collection of baseline data and routine monitoring data, as specified by the wilderness policies of Wilderness Character Monitoring and Wilderness Stewardship Performance, empower every wilderness to visualize and assess individual and coupled trends (Landres et al., 2018; USDA, 2020). New ESRI GIS technologies, like Collector and Survey123, enable efficient field data collection, analysis, and storage to be conducted by any wilderness ranger, intern, or citizen scientist who know how to operate a smartphone.

Current monitoring data can be used to verify professional 'best guesses' that are used to identify where detrimental impacts are occurring and quantify their magnitude. Comparing quantitative data of current conditions to desired conditions and standards, prescribed in management plans, indicate if, and where, management actions are necessary. If management action is necessary, managers should visit identified destinations with deteriorating campsite conditions to evaluate the probable cause and clarify a link to visit characteristics or detrimental visitor behaviors instead of assuming an increase in visitor numbers is the sole cause.

Once a causal relationship between detrimental impacts and visit characteristics or visitor behaviors are identified, appropriate management actions can be implemented. Mindful managers should realize their perception of detrimental impacts and management priorities may not align with visitors. Some visitors may perceive detrimental impacts, such as trampled vegetation or mineral soil as an opportune campsite (D'Antonio et al. 2012; Farrell et al., 2001).

Such differences should be clearly communicated to visitors, which is most effective when delivered by a uniformed ranger or volunteer (Kidd et al., 2015). Additionally, managers should try to communicate such information to visitors during the planning phase of their trip (Clawson & Knetsch, 1966; Manning, 2003). Extensive opportunities to do so exist online through agency websites and social media, but also website managed by partners and stakeholder groups.

Conclusions

Managing wilderness to protect wilderness character and recreation translates to modifying visitor behaviors or visit characteristics causing detrimental impacts. These relationships are discovered through the coupling of longitudinal trend data from visitor use and monitoring records specific to a wilderness. This allows managers to accurately identify visitor impacts to a specific wilderness and avoid an erroneous application of general wilderness trends. An increase in visitation to a wilderness is not a proxy for an increase in detrimental impacts. Creating management actions to modify an identified detrimental visitor behavior, instead of reducing visitor numbers, not only preserves wilderness character, but protects the unique opportunity in wilderness for unconfined recreation.

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Chapter 5
Discussion, Management Actions, Conclusion

Discussion

The purpose of this study was to utilize the Sawtooth Wilderness's unique longitudinal quantitative data set of 50 years to understand the area's recreation trends. A visual analysis of trend data occurred not only for individual data sets (visitation, detrimental visitor impacts, management actions) but also in a novel coupling of these trends with descriptive assessments. The field of recreation ecology has measured wilderness visitor trends (Cordell, 2012; Lucas, 1989; Marion, 2016) detrimental visitor impacts (Cole, 2013, 2019; Hammitt et al., 2015; Marion et al., 2018), and management actions (Dawson & Hendee, 2009; Hall, 2001; Marion & Reid, 2001). Yet very little literature goes beyond one-time stand-alone studies, or studies that collectively visualize coupled longitudinal quantitative trends (Cole & Wright, 2003; Cole, 2013; D'Antonio & Monz., 2016; Monz et al., 2010). Opportunities for these data sets to progress in the SW are immense, as each year thousands of wilderness permits are collected, and every five years the SW undergoes a full round of campsite monitoring and NVUM surveys (Landres et al., 2018; NVUM, n.d.; USDA, 2020). With the heavy lift of organizing 50 years of data complete, continuing this work may assist SW managers in their precarious balance of simultaneously protecting wilderness recreation and wilderness character.

Visitor Trends

The most significant measure in visitor trends in the SW was the substantial decrease in visitors in the mid-1990s, which is not described in the recreation ecology literature. Reviewing quantitative data from the Department of the Interior suggests this trend occurred on most public lands in the western United States (USDI, n.d.). In the SW, this trend may have been exaggerated by the implementation of a new SW management plan and a non-related policy for a parking fee

at all SNRA trailheads (PL 104-134; USDA, 1997b, 1997c). New management actions could have temporarily impacted overall visitor numbers for several years, but visitor numbers remained low for decades; the 2015 visitor total is lower than the 1994 peak in annual visitation. Also, incongruent with the literature is the increasing trend in overnight visitors in the SW. The recreation literature indicated the national trend to be that day visitors are significantly increasing, which is the opposite in the SW (Dawson & Hendee, 2009; Lucas, 1989). These inconsistencies highlight the need for managers to collect and use local quantitative data, such as visitation and impact data, to design management decisions.

Most other visitor trends in the SW are consistent with the literature. Overall, visitor use numbers generally increased, group size decreased, trip durations shortened, and stock use declined (Cole et al., 2008; Cordell & Bowker, 2013; Lucas, 1989; USDA, 1997c). Most visits occur in the summer (June - September), but "off-season" visits are increasing (Dawson & Hendee, 2009). Demographics in the SW reflect *general* outdoor recreationists with increasing proportions of females and a variety of age groups. However, diversity in race and ethnicity in the SW remains well below national trends (Bowker et al., 2012; Cordell et al., 2008; Outdoor Foundation, 2020). The SW's distance from major population bases and lack of public transportation may affect visitor numbers and demographics. But, as neighboring Boise's population rapidly grows, its sweltering summers may persuade more residents to escape to the Sawtooth's cool mountain temperatures (Blanchard, 2018).

Visitor Impacts

Uneven use densities throughout the SW's permit boxes and destinations support findings in the recreation ecology literature (Dawson & Hendee, 2009; Friedman & Cole, 2001; Lucas, 1980, 1989). Use densities are uneven both spatially and temporally, just like their associated

detrimental visitor impacts, especially at campsites. Fifty years of wilderness permit box data indicate preferences for trails and destinations have wildly varied over time, but provide managers valuable quantitative data on where visitors have preferred as destinations. Consistent and recurring rounds of data collection and monitoring will update managers on current preferences of visitor behaviors (popular destinations and impacts). Generally, the eastern side of the SW sees the majority of visitors as it has more accessible roads, signage, trails, and amenities. Similar to other studies on campsite impacts, the SW experienced an increase in campsite impacts up until the 1990s,but impacts in many "popular" areas began to decrease during the 2000s (Cole, 2013). This supports the recreation ecology literature descriptions of a curvilinear relationship between use and impacts; an increase in visitor numbers may not result in increased impacts at a previously established campsite (Cole, 1982, 1987, 2019; Frissell & Duncan, 1965; Hammitt et al., 2015; Marion et al., 2016). Since campsite impacts are quick to form but slow to be restored, routine campsite monitoring can alert managers to campsite proliferation locations, and provide quantitative measurements of degrading campsite impacts - especially those surpassing management's prescribed standards (Cole, 1982, 2013; Marion et al., 2016).

Even though SW visitor numbers are increasing, especially at popular destinations (some with increasing campsite impacts), visitors consistently report they are satisfied and do not feel crowded. Recreation ecology literature suggests visitors "cope" with deteriorating biophysical and social impacts (Allen, 2019; Cole & Hall, 2008; Dawson & Hendee, 2009; Freimund & Cole, 2001). Differences in impact perceptions and prioritizations in the SW appear to be consistent with findings in the literature, implying impact perceptions vary between visitors, managers, and ecologists (D'Antonio et al., 2012; Dawson & Hendee, 2009; Monz et al., 2010).

These significant differences between visitor and manager perspectives need to be recognized and addressed when designing management actions. Educational messages need to explain what impacts are detrimental and why, and then provide instruction on what visitor behaviors are appropriate and how they protect wilderness character.

Management Actions

Management actions in the SW have generally intensified over time, though mindful management direction has intentionally protected visitor's access to an unconfined wilderness experience (USDA 1977, 1997b, 1997c). Successful management actions in the SW mirror other wilderness areas, especially those that combine enforcement and education actions (Watson et al. 1999). In the SW, such measured successes include the reduction of trash and the construction and use of prohibited campfire rings. By enforcing SW regulations and providing focused educational messages to pack out trash and restrict (not eliminate) campfires to firepans, wilderness rangers data measured less trash packed out and campfire ring destruction.

Similar to other wilderness areas, SW regulations on prohibiting campsites within 100 feet of water have had minimal success (Griffin, 2018; Marion et al., 2018). Engineering actions such as signs, bridges, and toilets were constructed for resource protection. Yet, their success may be limited as bridges require continuous maintenance, and SW toilets are being decommissioned and removed.

The overall preferred method to modify detrimental visitor behaviors in wilderness is through education (Dawson & Hendee, 2009; Hammitt et al., 2015; Manning 2003, Marion, 2003; USDA, 1997c). At the opposite end of the behavior modification spectrum is a permit system limiting access to wilderness. Permit systems typically receive minimal public support, especially if implemented to reduce social impacts (Dawson & Hendee, 2009; Freimund & Cole,

2001; Hall, 2001; Marion, 2016; Stankey et al., 1985). The SW recognizes this public preference for education over regulation through its *non-limiting* permit system, informative trailhead signs, Wildlands Education Program, visitor centers, and wilderness ranger program.

Thousands of educational contacts occur in the SW every year, mostly with visitors already on their trip. This provides minimal to no opportunities for a visitor to actually alter their planned behaviors (careless, unskilled, uninformed, unavoidable, illegal) (Dawson & Hendee, 2009; Manning, 2003; Reid & Marion, 2007). Historically, wilderness managers have gone to great extent to train wilderness rangers to make meaningful contacts *in* wilderness, but this might not be enough (Wallace, 1990; Wallace & Gaudry, 2005; Vagias & Powell, 2010). The best opportunity for a visitor to plan ahead and prepare to follow wilderness regulations occurs during the "planning phase" of the trip (Clawson & Knetsh, 1966; Manning, 2003; Marion & Reid, 2007). Today, a primary method of pre-trip planning occurs via the internet. A Google search for the words "Sawtooth Wilderness" brings up 400,000 websites, and although the Sawtooth National Forest site is first, it takes a minimum of four clicks to find the SW's regulations.

Wilderness Management Opportunities

A coupling of the temporal and spatial trends in SW's visitors, detrimental visitor impacts, and related management actions provides essential insights for wilderness managers and recreation ecologists. Unexpected success stories from the coupled data include the decrease in wilderness ranger removal of trash, and the necessary destruction of prohibited campfire rings-even though overall visitor numbers increased. Visualization of coupled trend data also showed that several "popular" destinations, with increasing numbers of visitors, experienced a decrease in campsite impacts. These trends, measured with local, site-specific longitudinal quantitative data, may tell a different story than human perceptions or national trends. Though detrimental

impacts may deteriorate at some destinations, this type of analysis of coupling longitudinal quantitative data sets provides managers with details for such destinations and the degree to which those detrimental impacts are occurring. A longitudinal understanding of the trends in SW visitors, detrimental visitor impacts, and effective management actions empowers managers to continue to preserve wilderness character and access to wilderness recreation both today and tomorrow.

Management Recommendations

The Interagency Visitor Use Management Council (IVUMC) and recreation ecology literature recommend wilderness managers focus on managing visitor behaviors to reduce detrimental impacts, instead of prioritizing the reduction of overall visitor numbers. Research has revealed increasing visitor numbers do not necessarily translate to increasing detrimental impacts, even at places with high use densities. Guidance on designing management actions focusing on visitor's detrimental behaviors exist in a variety of frameworks and theories, many of which the IVUMC integrates into a consistent national management framework.

Once managers are aware of problematic visitor impacts, longitudinal quantitative data needs to be assessed. Qualitative data, such as a manager's memory, perspectives, or impact perceptions, may not interpret or prioritize impacts the same as Forest's management plans do. These plans define desired conditions and quantify standards to alert managers of what deteriorating, and unacceptable conditions are. It is likely an updated round of monitoring will be necessary, which should follow pre-existing protocols, if they exist, to enable consistent data comparisons. Current conditions can then be compared to longitudinal data to reveal trends; and to desired conditions and standards detailed in a Forest's management plans.

Wilderness managers challenged by capacity have technological opportunities to increase monitoring efficiency through ESRI GIS programs (Collector and Survey123). These programs condense an immense amount of monitoring requirements into one program utilizing offline surveys on a mapping platform. These programs are quickly learned by wilderness rangers, interns, and citizen science volunteers with smartphones. Field data is promptly uploaded upon returning to the office, which is then organized and analyzed online by the programs.

Managers should visit problem areas to assess the probable cause of detrimental impacts to clarify links to visitor behaviors. Managers should identify visit characteristics that may be related to the impact, such as: timing or location of visit, spatial distribution or amount of use, visitor activity or behavior, and inadequate site durability or visitor expectations (IVUMC 2020). Identifying the impactful visit characteristic, and associated behaviors, empowers managers to select a management strategy to modify visit characteristics, such as timing, location, spatial distribution, amount of visitors, type of visitor, site durability, and visitor expectations.

Coupling monitoring data with use density data informs managers if impacts are occurring at specific “popular” destinations, places with little visitation, or throughout the whole wilderness. Options for action strategies should begin with education, and move onto engineering and enforcement if the issue continues or escalates. Since wilderness is managed for the preservation of both unconfined recreation and wilderness character, management directives propose using the “minimum tool.” Though there is no perfect formula, all management actions should focus on correcting specific impactful behaviors, for example, deteriorating campsite impacts, which can not be corrected by a limiting-permit system that does not address where or how visitors camp.

Successful plans for implementing new management actions need a communication strategy for internal and external use. All employees need to be aware of new management actions, as should agency partners, commercial outfitters, local and national recreation groups, and local businesses. Messages need to be clear, consistent, and targeted to the area's visitors, which may be accomplished through an evaluation of the area's visitor demographics. Messages should provide direction on expectations and details on "how to" behave appropriately. These messages need to go beyond trailhead signs, visitor centers, and agency online communication channels to meet visitors where they are – especially on non-agency recreation focused websites and smartphone apps. Messages should utilize theories from social science; for example, understanding the Theory of Planned Behavior may remind the manager to utilize the power of social norms in messaging to more effectively change detrimental behaviors.

Management action success (or failure) can be measured through routine monitoring programs. Regular analysis of quantitative monitoring data allows managers to measure if trends are improving or deteriorating at specific areas or overall in the wilderness. Managers learning what is or isn't work can make appropriate changes, or manage adaptively and ideally, proactively.

Conclusion

Managing wilderness translates to managing visitor behaviors. A firm understanding of which visitor behaviors need to be eliminated, due to their detrimental impacts, can be derived from a coupled analysis of longitudinal quantitative data. Collecting and utilizing such data provides a wilderness manager insight into past and current trends for a specific wilderness, which enables the creation and implementation of effective management actions tailored to protect wilderness recreation and wilderness character. To achieve this precarious balance of

recreation and protection, managers may implement actions on a spectrum of light-handed education to limiting access through restrictive permit systems. By utilizing longitudinal qualitative data to measure a detrimental impact and associated visitor behavior, a manager does not need to rely on their perspective or educated guess.

Future studies, especially incorporating requirements related to Wilderness Character Monitoring and Wilderness Stewardship Performance, have the potential to update these quantitative data sets consistently. Other research might investigate the relationship between impacts and the drop in stock users, or wildland fires, and visitation rates. Possibilities for research also exist in the social sciences, such as how education is obtained, understood, or alters behaviors of visitors. Managers responsible for balancing wilderness recreation and protection need data to help ensure wild places remain loved, just not to death.

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