THESIS

# COMPARING SPATIAL MODELING TECHNIQUES FOR EXPLORATORY MAPPING: APPLICATIONS IN WILDERENSS CAMPSITE SEARCHES


Submitted by

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ABSTRACT OF THESIS

# COMPARING SPATIAL MODELING TECHNIQUES FOR EXPLORATORY MAPPING: APPLICATIONS IN WILDERNESS CAMPSITE SEARCHES


Camping impacts are known to damage vegetation, impede ecological processes, and negatively affect visitor experiences in wilderness areas. In response to national mandates from the Chief of the Forest Service in 2004, wilderness managers are pursuing an effort to find and inventory 95% of the campsites in designated wilderness. In 2009 the Rocky Mountain Region (Region 2) Wilderness Program of the United States Forest Service focused its resources on carrying out the mandate. This thesis uses spatial models to predict areas likely to have camping impacts. The resulting maps can be utilized by wilderness managers in Region 2 find and inventory camping impacts in wilderness areas.

Understanding the spatial distribution of campsites is an important step in the inventory, monitoring and analysis of damage related to camping activities. Recreation Habitat Suitability Indices and Maxent are two tested methods for predicting where an object can be found based on the objects relationship to environmental variables. This research employs these methods for determining the suitability of an area for camping. For this study, A Recreation Habitat Suitability Index was developed using *a priori* knowledge, without the use of data. A Maxent approach was also implemented using n= 1658 points for model development. Both models were tested with n=1446 points, using Area Under the Curve (AUC) and maximized Cohen's Kappa methods for validating the models. Using these test procedures, the research

found that both methods performed outstanding when tested with independent data. Models were then compared, and it was found that the models predict camping impact location with remarkable similarity. The research determined that both methods work well for predicting the most important areas to prioritize campsite inventories.

This thesis is divided into four chapters and a technical appendix. It begins with an introductory chapter which overviews the project and explains the goals and objectives. The second chapter is a literature review of past efforts which used similar methods. The third chapter presents the modeling research as a journal article which compares two methods for using predictive modeling to understand the spatial distribution of wilderness camping sites.

Following the research chapter, a fourth, conclusions chapter, speaks to the limitations of the model, and indicates what future research efforts may focus on. Following the conclusions chapter is a technical appendix (Appendix A) which contains a technical report in the form of a desktop guide which is intended to help wilderness managers understand camping impacts and analysis techniques. The technical appendix is a summary of knowledge gained by working in the field with camping impacts. The technical report is designed to help managers understand and train wilderness staff to complete campsite inventories, start to finish.

The research portion of this thesis provides wilderness managers with two tested methods for determining areas most likely to contain camping impacts in wilderness. This research offers managers an option for determining which areas of a wilderness are important to search in order to find 95% of the campsites. When combined with the technical appendix this thesis as a whole provides wilderness managers with tools for understanding, finding and inventorying camping impacts in the wilderness areas of Region 2.

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# DEDICATION

This thesis is dedicated to the many wilderness managers of the United States. This project could not have come to fruition without the help of the United States Forest Service partners who made it possible.

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# CHAPTER 1

# INTRODUCTION

Recognition of the ecological and social consequences of camping has resulted in monitoring efforts throughout the designated wilderness areas of the United States (Cole, 1989). Due to limited funding and staffing, these efforts have focused primarily in popular corridors (Cole, 2004). A national mandate by the Chief of the United States Forest Service (USFS) in 2004 has pushed wilderness managers to begin inventorying and monitoring campsites throughout the entire wilderness, and not just popular basins (Emerich, 2008). Recently, wilderness managers, staff and volunteers began campsite searches with the intention of finding and inventorying 95% of the camping impacts in the wilderness units of the United States. This thesis is a compilation of a project geared towards assisting managers in the Rocky Mountain Region (Region 2), of the United States Forest Service in this effort.

This thesis is a manuscript meant to be published in two documents. A research report in the form of a journal article (Chapter 3), tests and compares two methods for defining areas likely to have camping impacts in wilderness. The modeling techniques proposed in this document can be used to spatially define areas likely to contain camping impacts, and help managers to strategically plan campsite searches in areas where prior searches have not been implemented. The second part (Appendix A) is a manuscript for a technical manual which explains campsite inventory techniques and guides managers in completing campsite inventory and analysis.

## 1.1 PURPOSE

In 2004, USFS Chief Dale Bosworth implemented the 10-Year Wilderness Stewardship Challenge (10YWSC). The Chief's goal was to bring the level of wilderness management to "new millennium ideals" through the implementation of modern technologies, inventory and management techniques (Emrich, 2008). Advised by the Chief's Wilderness Advisory Group (WAG), Bosworth issued 10 elements to the challenge in order to address growing pressure on wilderness resources and a decreasing budget for staff. The 10 'elements' to the 10YWSC involve the implementation of; (1) fire management plans, (2) invasive species mitigation plans, (3) air quality monitoring programs, (4) wilderness education programs, (5) primitive recreation plans, (6) recreation site monitoring programs, (7) outfitter training and support plans, (8) wilderness resource plans, (9) updated data collection, storage and analysis capacities, and (10) plans which assess that staffing levels are appropriate for the management of wilderness areas. The 10YWSC is to be met by each wilderness unit, and consequentially each region, requiring the collaboration of specialists in the fields of airs quality management, watershed management, botany, fire management, wildlife sciences and recreation management (Emerich, 2008).

At the regional level, wilderness directors are working to help forest level managers create and implement plans that work towards the goals of the 10YWSC. The Rocky Mountain Region, Region 2, of the Forest Service has developed a technique of focusing on one element of the 10YWSC per year. In 2009, the focus of Region 2 was Element 6: recreation site monitoring. Region 2 is comprised of Colorado, South Dakota, Nebraska, Kansas and Parts of Wyoming.

## 1.2 GOALS

The graduate work for this thesis focuses on assisting managers in Region 2 who are working on Element 6 of the 10YWSC. The Standards for Element 6 are: (1) sites must be censused; (2) all likely locations in the entire wilderness must be visited; (3) data cannot be older than 10 years old; (4) data for each site must include; (a) location, (b) campsite condition, and (c) presence/absence of administrative structures.

Element 6 census surveys are new to the USFS and new methods are necessary to inventory wilderness campsites effectively. The goals of this project are to (1) develop maps which assist managers by showing which areas of the wilderness should be prioritized for conducting campsite searches and (2) assist managers by explaining the technique for completing Element 6 of the 10YWSC, prescribed by the Region 2 Wilderness program. This thesis contains manuscripts for two publishable documents geared towards completing these goals. The next sections of this introduction overview these two key parts of this document.

### 1.2.1 THE RESEARCH ARTICLE

Standards for Element 6 require that all likely locations for campsites in a wilderness are inventoried. Chapter 3 presents, in the form of a journal article, research which can help wilderness managers strategize campsite searches by indicating which areas are likely to contain camping impacts. Past campsite inventories of popular basins are common throughout the wilderness units of the USFS (Cole, 2004). However, Element 6 requires managers to search all likely areas of the wilderness. Unregulated camping common in most wilderness areas allows visitors to decide where to camp, making Element 6 a difficult task. The research in Chapter 3 is meant to help wilderness managers plan efficient searches for campsites throughout the entire wilderness. Spatial modeling techniques utilizing Geographic Information Systems (GIS) are commonly used to address similar concerns (Newman, Monz, Leung & Theobald, 2006). Chapter 3 introduces tests and compares two methods of modeling the areas of a wilderness most likely to contain camping impacts.

Several research questions directed this study:

- What spatial attributes define a “likely area” for camping?
- What are the spatial relationships between the attributes related to camping and how should they be weighted?

These questions were addressed in two ways. One method for addressing the research questions was to take a qualitative approach using *a priori* knowledge to model areas likely to contain camping impacts. A Recreation Habitat Suitability Index (RHSI) was developed following methods similar to Hamilton (1996). A thorough literature review revealed several spatial attributes related to camping. These attributes were used in conjunction with local knowledge from the USFS to develop an index which indicates areas likely to have camping impacts. Although RHSI methods may be useful for informing search protocols, statistical models provide higher accuracy, precision and reliability (Brooks, 1997) so a second, statistical, method was employed for comparison purposes.

The second method for addressing the research questions was to construct a statistical model in an effort to quantitatively understand how landscape attributes affect campsite location in wilderness. Campsite presence locations from 13 wilderness areas (n=1658) were input into the predictive modeling software Maxent (Phillips, Anderson & Shapire, 2006) to statistically model likely campsite areas. Both the RHSI and the Maxent models were tested using independent campsite data, and then compared. Both models were found to perform well when tested (Section 3.4).

The use of a qualitative (Maxent) and quantitative (RHSI) method for modeling campsites was intentional. Some wilderness areas in the USFS Wilderness Preservation System do not have campsite location data. The use of an RHSI approach allows managers to develop a model of areas likely to contain camping impacts in the wilderness without data. When good campsite data is available, Maxent is an easy to use tool for statistically modeling areas likely to be impacted by camping.

Using the modeling techniques developed during this study, likely areas to find camping have been mapped in the 46 wilderness areas of Region 2. These maps provide wilderness managers in Region 2 with a statistically supported tool for planning and implementing efficient campsite inventory searches which meet the standards of Element 6. The resulting maps can help focus resources in the most important areas to search for campsites in the wilderness, and provide managers with a statistically supported protocol for conducting searches.

### 1.2.2 THE WILDERNESS MANAGERS GUIDEBOOK (APPENDIX A)

This thesis contains the manuscript of a technical report (Appendix A) developed for Region 2 of the USFS. In order to better understand Element 6, a regionally funded team led by the author was sent to multiple wilderness areas with the goal of gaining on the ground experience with Element 6. The expertise for writing the technical appendix of this document was the result of many months working in the field.

For the month of September 2008, the author led a team which was sent to several wilderness areas in Region 2 to field test techniques for completing Element 6 inventories. The

2008 effort served as a pilot study for the Minimum Protocol for Campsite Assessment method which was developed by Dr. David Cole of the Aldo Leopold Research Institute specifically for the evaluation of campsites to meet the Element 6 challenge. The 2008 pilot effort was important to understand the new protocol for campsite inventories and gain knowledge of what challenges would be encountered by surveyors in the field. The result of the effort was the completion of several surveys along with the development of training material presented to managers during the Region 2 Wilderness Winter meeting of 2008.

During the summer season of 2009, another regionally funded team was led by the author to help managers throughout the region. The team had three goals. The first goal was to travel to districts and directly assist managers with inventory work in the field. The team visited 17 wilderness areas and hiked more than 386 miles completing inventories in 8 areas and partially completing inventories in 9 areas.

The second goal of the 2009 team was to train managers and volunteers in Region 2. The primary goal of trainings was to adopt a “Train the Trainer” approach. At each district the team met with a line officer (District Ranger). Wilderness rangers and managers were given a presentation on the key aspects of Element 6. The Likely Campsite Maps (Chapter 3) were examined and local experts verified the maps. Logistics were planned based on local knowledge and the Likely Camping Maps. In the field, rangers were paired with a team member and then instructed in inventory methods in the field. The goal of this “Train the Trainer” approach was to teach wilderness rangers inventory techniques, so rangers would be capable of training volunteers and other seasonal staff.

The third goal of the team was to work as a regional liaison to friends and volunteer groups. Throughout the season, multiple trainings for volunteers were held. During one effort, the team assisted in an inventory effort by the Saguache Ranger District which involved over 100 volunteers from Colorado College.

Appendix A captures the experience gained through working in the field with campsite inventories. The technical appendix is written as a guide for managers completing Element 6 and provides a tool for training purposes. A major portion of the technical appendix is dedicated to explaining the Minimum Protocol for Campsite Assessments; a campsite inventory technique was developed specifically for completing Element 6 of the 10YWSC.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 AN INTRODUCTION TO THE LITERATURE

Wilderness managers are faced with many challenges. Protected area planning and management is facing increasing budget deficits, government downsizing and privatization of some functions. Often, as is the case with Element 6, managers are asked to implement programs with little or no funding. McCool and Cole (1999) identified that the lack of funding commitment leads to a lack of support for research, training and continuing education opportunities, fatigue among faculty and a lack of accountability in planning decisions. This study seeks to create a scientifically-informed search protocol which will balance the needs of a thorough census inventory with the limited amount of staff hours to dedicate to this process. This literature review evaluates the importance of wilderness research, the impacts that campsites have on the wilderness and the various research strategies that scientists employ when monitoring and studying recreation impacts.

Whenever wilderness managers create programs to assess and manage a wilderness they must consider the social, biophysical and economic components underlying decisions. The Wilderness Act of 1964 implicates the importance of this balance. The Wilderness Act defines wilderness areas as protected lands in their natural condition which are administered for the use and enjoyment of the American people in such a way which leaves them unimpaired for future use (1964, §2a). Delineated within the Wilderness Act, areas of wilderness are devoted to the public purposes of recreational, scenic, scientific, education, conservation and historical uses (1964, § 4b). Beyond the use of humans, wilderness is to be managed in a such a way that it is untrammeled by man (sic), where man (sic) is a visitor that does not remain (Wilderness Act of 1964, § 2c).Throughout the past four decades scientists and managers have worked together to create management plans that balance these often competing ideals, however the ability to sustain current use and accommodate future growth in visitation while balancing social and physical impacts is a considerable challenge for wilderness managers (Leung & Marion, 2000).

Three fields; recreation ecology, recreation geography and the human dimensions of natural resources comprise the bulk of wilderness research. The next section overviews the role of research in wilderness and then reviews work done in the three most influential fields.

## 2.2 BACKGROUND

### 2.2.1 THE ROLE OF RESEARCH IN WILDERNESS

Watson (1990) identified that wilderness regulations specifically require periodic estimates of the maximum level of use that will allow natural processes to operate freely and not impair the values for which wilderness areas were created. Although the National Forest Management Act (1976) does not mandate wilderness management, wilderness regulations necessitate accurate measurements of use. Often, inventory, monitoring and analysis of recreation impacts in a wilderness are required by a forest plan. Even with the current national prescriptions for wilderness research following the 10YWSC, scientists have recognized that many wilderness areas have insufficient information regarding the current conditions of the resource (McCool & Cole, 1999). The lack of quality research may be due to large areas of difficult to access land which has led to the belief that collecting new information would be too costly and time consuming (Landres, Spildie & Queen, 2001).

Planning frameworks have been developed by the USFS in an effort to use the research that does exist to create management plans which reflect the goals of the Wilderness Act of 1964. The planning framework implemented by the Forest Service specifically delineates the importance of monitoring (McCool & Cole, 1999). When inventory and monitoring are part of the management discussion, adaptive management is made possible. McCool & Cole define monitoring as a periodic and systematic measurement of indicator variables (1999). Indicators are specific, measurable variables which indicate the condition of a site, such as common campsite assessment techniques like Modified Cole or Frisell (Explained in detail later). Monitoring, using indicators, allows managers to track the changes in social and biophysical conditions and evaluate emerging characteristics (Stankey *et al.,* 1985). Monitoring is important to adapt to changes and address new impacts and concerns to a wilderness area (Stankey *et al.,* 1985).

A monitoring and researching recreation impact is a critical step toward informing the management efforts which seek to maintain wilderness character. Understanding recreation impacts helps managers make decisions which limit biophysical impacts and maintain people's satisfaction in the most economically efficient way possible. The intensity and magnitude of campsite impacts are important to study because of the negative social and ecological effects of camping are cumulative in nature (Cole, 2004). Scientists in the field of recreation ecology have presented managers with the tools necessary to conduct inventory, analysis and monitoring of recreation sites (McCool & Cole, 1999). The following section reviews efforts in the field of recreation ecology.

### 2.2.2 A BRIEF HISTORY OF RECREATION ECOLOGY

The field of recreation ecology has contributed greatly to what is known about the condition of our wilderness areas. Recreation Ecology is defined by Leung and Marion (2000) as a field that examines, assesses and monitors use effects in natural areas and compares the effects to influential factors such as amount of use. Recreation ecology research provides managers with the ability to identify and evaluate resource impacts and generate an understanding of the causal relationships between use and impact. Recreation ecology can provide insights into the prevention, mitigation and management of natural resources within the context of recreation and tourism (Leung and Marion, 2000).

Recreation ecology began in the 1920's when Meinecke (1928) studied the effects of tourist travel in the redwood parks of California (from Cole, 2004). Increasing trends and impacts from tourism in the 1960's brought about a new era of studies in what is now considered recreation ecology (Cole, 2004). A review of the literature by Cole (2004) identifies that the 1970's brought about the first long-term research programs, with the addition of the Aldo Leopold Wilderness Research Institute in 1993. Since the 1970's, research and development programs have made considerable progress in impact monitoring protocols (Cole, 1987), management strategies (McCool & Cole, 1999), and low impact education programs such as "leave no trace" (Hampton & Cole, 1995).

The need for wilderness campsite monitoring has led to a plethora of analysis techniques beginning with the "code-A-Site system" by Hendee et al. (1976). The most common current protocols in USFS wilderness management are the Frissell (1978), Cole, and Modified Cole techniques (1989), although other inventory techniques do exist (Cole, 2004).

### 2.2.3 HOW CAMPING IMPACTS THE WILDERNESS

Camping impacts are a matter of ecological concern, and can detract from visitor experiences (Cole, 2004). A summary of camping impact shows that camping activities are known to heavily impact soils and vegetation by user trampling (Cole, 1987). Camping activities damage and eliminate plants, compact mineral soils and displace organic soil horizons. The effect of soil compaction and vegetation loss often cascades down ecosystems and can alter the structure, composition and function of ecosystems. Trampling effects models show these cascading influences (Cole, 2004). The scale and magnitude of this impact depends on the amount of use. Cole (2004) uses the following example of feedback loops in trampling studies;

> *"...trampling eliminates vegetation cover, which reduces inputs of organic matter and root exudates into the soil. Along with the physical effects of soil compaction, this alters the microorganisms that live in the soil. Since soil microorganisms are critically important both to the alleviation of soil compaction and the establishment and growth of vegetation, soil and vegetation are further altered by these changes to the soil biota. Consequently, sites can remain compacted and barren, even in the absence of further trampling." (Cole 2004: pp. 108)*

The amount of use at a campsite in relationship to the amount of impact has been studied extensively (Cole, 1992; 1993b; 1987). Cole (2004) found that there is a common relationship with the life cycle of a campsite. Typically, the first few days that vegetation is camped on creates little impact. As the vegetation is camped on for longer, the impact accelerates rapidly. Eventually, vegetation will be disturbed and the site will remain relatively stable, with little further impact. This relationship shows that the amount of impact a camper creates depends on, and changes with, the amount of nights spent at a site (Marion, 1998). This asymptotic relationship is observed generally across vegetation trampling studies (Cole 1992;

1993b; 1987), resulting in a curvilinear relationship between nights stayed at a site and impact (Figure 1).

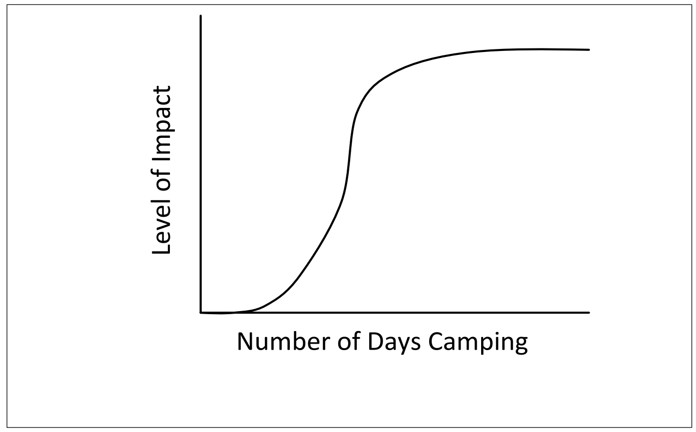


**Figure 1** The curvilinear relationship between days of camping and impact

Although the site impact and time relationship remains curvilinear, the resilience and resistance of vegetation is a factor in determining how quickly and for how long camping will have an impact on a given ecosystem (Leung & Marion, 2000). Cole (1993b) defines resistance as an ecosystem's ability to defend and recover from a disturbance. Resilience is defined as an ecosystems tolerance to impact before the ecosystem passes its threshold and changes to a new composition, in which the old composition will never return.

The resistance of the system that is being camped on is different depending on the type of vegetation that is impacted. For example, an impact study revealed that Grouseberry (*Vaccinium scoparium)* is resistant to 500 passes of trampling before 80% is depleted (Cole, 1993b). This is compared to the less resistant Canada Mayflower (*Maianthemum Canadensis)* which is resistant to only 80 passes before 80% is depleted.

Studies which measured resilience demonstrate that camping impacts vary by region. Cole (2004) sites two studies, one on the banks of the Delaware River, the other in the alpine meadows of Glacier National Park. While residual camping effects on the Delaware River were largely unnoticeable on the banks, effects on the alpine meadows in Glacier National Park lasted 30 years, indicating that the Delaware River site was more resilient to impacts. The study indicates the importance of searching for campsites outside of popular areas. Although alpine ecosystems are camped in less frequently, the disproportionate impacts that occur in sensitive ecosystems create a need for census inventories.

Campsite proliferation and expansion is one of the most serious concerns of camping impacts. Proliferation can occur rapidly even when use levels remain the same. For example, a study conducted by Cole (1993a) in the Eagle Cap Wilderness in Oregon found extensive campsite proliferation in the area. The amount of campsites in the wilderness more than doubled from 1975 to 1990 even though use levels have not drastically increased. Proliferation has a tendency to occur in wilderness areas with unregulated camping policy. Often, established campsites in an area will have a trend of slight deterioration while new sites appear (Cole, 1993a). Cole (1993a) defines the activity of users finding new pristine areas to camp as site pioneering. Site pioneering can lead to the proliferation of camping impacts, which results in a cumulative nature of camping impacts and leads to the need for management actions.

Other subsidiary impacts from human activities relating to camping are common in wilderness areas. People will use soap that is not biodegradable for cooking and cleaning; human waste is often not properly disposed (Leung & Marion, 2000). People will leave trash and food at campsites, and camping may adversely affect wildlife. These common negative effects from camping may cause a deterioration of the environment, but can be mitigated through low impact camping techniques such as Leave No Trace (Hampton & Cole, 1995).

### 2.2.4 HOW RECREATION CREATES SOCIAL IMPACTS

In 1990, Watson reviewed the importance of monitoring wilderness for social conditions as well as biophysical condition. Watson observed that much research has been conducted which focuses on the social implications of wilderness management (1990). Many studies in the field of the Human Dimensions of Natural Resources have shown the social importance of wilderness areas and the impacts that resource degradation can have on a visitor satisfaction (Shelby, Vaske & Harris, 1988; Cole, 2004; Leung & Marion, 2000; Manning & Lime, 2000).

Generally, people will create a perception of "what" a wilderness is. This perception can create an expectation when a wilderness is visited. The social perception of what a wilderness "is" was, in part, developed during the creation of the Wilderness Act of 1964. The Wilderness Act of 1964 describes wilderness areas as pristine tracks of land untrammeled by man (sic). The wilderness is to be managed in such a way as to provide solitude, and to appear "to have been affected primarily by the forces of nature, with the imprint of mans (sic.) work substantially unnoticed" (Wilderness Act of 1964, § 2c). The Wilderness Act also describes the wilderness as a place of "unconfined recreation." These descriptions set the foundation for what a wilderness is expected to be, and can lead to a satisfied or unsatisfied wilderness visitor.

Studies indicate that campsites impacts can give the wilderness a "soiled" or "used" appearance (Leung & Marion, 2000). Even the mere presence of campsite impacts can detract from a wilderness experience if the user is in an area that they consider to be pristine (Shelby, Vaske & Harris, 1988). With an increase in recent visitor use, crowding and conflict resulting in decreased satisfaction are known to occur (Manning & Lime, 2000). Farrell, Hall and White (2001) indicate that certain impacts such as campfires and tree damage can evoke symbolic meanings, and while the impact may not be significant ecologically it can have profound impacts on a visitor's experience. These social and biological impacts to a wilderness create a direct necessity for inventorying, monitoring and managing the wilderness.

### 2.2.5 RECREATION GEOGRAPHY

The field of recreation geography has its roots in studies conducted during the 1920's. An investigation conducted by Mitchell and Smith (1985) found that several unanimously written articles appeared in the Geographic Review in the 20's. It was not until the 1960's, following the leisure boom, that recreation geography became a popular subject (Hall & Page, 1999). Since the 1990's, access to software and advanced computer programs have greatly expanded the ability of recreation geographers to understand and analyze spatial relationships.

Recreation geography is a field of science which uses geographic tools to understand the spatial and temporal relationships between recreation activities and the world. Recreation geography methods can be descriptive, explanatory and predictive. The goal of recreation geography is to understand the spatial distribution of recreation impacts in order to inform management. The Spatial distribution of impacts is important to understand because of the variability of impacts at the international, regional and local scales (Hall & Page, 1999). Geographic tools can be used to understand relationships between destinations, travel routes, transportation corridors as well as social and environmental relationships (Hall & Page, 1999). Recreation Geography has seen applications in transportation cost assessments, social equality studies, behavior and use patterns, spatial planning and gender and recreation studies (Hall & Page, 1999; Talen & Anselin, 1998).

Leung and Marion (1999) identified four themes in recreation geographic literature: (1) spatial variability of recreation and tourism demand, (2) distribution of spatial patterns and processes of recreation, (3) explanatory studies of land use decisions, and (4) recreation planning and management solutions to resource and social problems at large areal extents. The current study deals with the distribution and spatial pattern of campsites in several wilderness areas. In order to form a solid understanding of where campsites are located in the wilderness, this study combines recreation ecology and geography to inform and test a search protocol. The conceptual models used to create similar indices have been most thoroughly explored by wildlife biologists. The next section reviews some past studies that used methods similar to the current study.

## 2.3 PAST STUDIES APPLYING MODELING TO CAMPSITES

Element 6 will provide information that is imperative to understanding, at a large landscape scale, the impacts that an unregulated camping policy has had in the wilderness areas of the USFS. Although geospatial methodologies are fairly new to resource monitoring they can result in efficient monitoring methods that assist managers in times of budget constraints (Newman *et al.* 2006). This section reviews some past research modeling camping impacts.

### 2.3.1 CAMPSITE TYPOLOGY STUDY

Several studies have focused on the spatial distribution of campsites in wilderness areas using GIS and Spatial Analysis techniques. A study conducted by Leung and Marion (1999) in the Great Smokey Mountain National Park used campsite assessments to understand the spatial distribution of sites and create site typologies. Leung and Marion used data collected in the field to profile clusters of campsites (1999). The researchers collected location and environmental attributes in combination with condition ratings of campsites and performed cluster analysis to determine campsite types. The typology of campsites was a function of intensity and areal extent of impact. Four campsite clusters (types) resulted from the study. The study mapped the spatial distribution of sites as well.

Leung and Marion (1999) identified the importance of typology from a management perspective. Sites with certain character will have a more likely chance to proliferate, while other sites types will not. The research conducted by Leung and Marion (1999) concludes that an improved understanding of impact patterns is indispensible. The Great Smokey Mountain study illustrates an application of geospatial tools for understanding campsite management impacts. Geospatial applications of campsite inventories can be a pragmatic and important tool for managers. Leung and Marion (1999) identified that campsite typologies vary by region; the current study will provide data that could be used to better understand campsite types in the Rocky Mountains in the future.

### 2.3.2 GIS AS A MONITORING TOOL

Research conducted in Yosemite Valley utilized GIS to generate a model of "camping probability." The study used five variables; (1) distance from trailheads, (2) Distance from water, (3) Distance visitors tend to travel off trail, (4) Presence of designated no-camping zones, and (5) landscape slope (Newman *et al.* 2006). Newman *et al*. (2006) were able to generate an unequal inclusion probability within the 'campable' area and test the model in the field. From the field work, the researchers estimated the total portion of the river corridor that was camped on. The study identified that the monitoring approach has potential to estimate total impacts and proliferation.

The goals of Element 6 are to conduct a census of areas likely to have camping impacts. The difference between the sample survey technique and the development of search protocols for a census survey are a key distinction between this study and the Newman *et al.* ( 2006) study. In order to create a smaller margin of error for search protocols, the variables of distance from trailhead has been removed from the current model. It has also been determined by

Region 2 management that it is important to search no-camping zones for sites in order to determine and check compliance. The model that the current study, and Newman *et al.* (2006), used is similar to the idea of Campsite Habitat Suitability Models explained below.

### 2.3.3 CAMPSITE HABITAT SUITABILITY MODELS

Several studies have used the concept of a Habitat Suitability Index in formulating recreation management plans. The US Army Corps of Engineers has designed what it refers to a Recreation Habitat Analysis Method (RHAM) which it utilizes to understand the best facility locations on popular recreation waterways (Hamilton, 1996). RHAM essentially creates a list of attributes for recreation "habitat" and weights the attributes according to importance. Some example attributes for camping are: distance from a lake, convenience of visibility of a lake, shadiness of the site, convenience to access a lake and presence or absence of picnic table. The RHAM model is used in conjunction with field data in order to appropriately position campsites around newly developed lake recreation sites. The RHAM model can be used to help mitigate conflict, and to appropriately place facilities.

More complex models have been utilized in the management of specific areas of tourism and recreation. Provencher and Bishop (1997) piloted an effort to create a "catch" model to analyze fishing recreation behavior. The model was applied to salmon and trout fishermen on Lake Michigan in effort to inform management for the local fisheries. Similarly, Roberts, Stallman and Bieri (2002) created models using agent based modeling, artificial intelligence and GIS to inform managers of appropriate river quotas. The study used an algorithm informed by use data to determine the suitability of individual campsites.

One major difference between this study and past studies in the topic area is the descriptive design of the current study. Most of the past studies have focused on a prescriptive approach to finding suitable habitat based on values and features. This study will focus on the actual distribution of camping throughout the wilderness. Most of the previous studies which used the concept of recreation habitat have focused on micro-topographical attributes. This study will use the meso-topographical (landscape level) attributes of camping habitat in order to inform a model which will show "likely campsite areas" over a broad landscape in an attempt to focus search team resources to likely campsite areas.

## 2.4 LITERATURE REVIEW CONCLUSIONS

Several key authors in the field of recreation ecology have identified the importance of geospatial applications to wilderness campsite monitoring programs. Cole (1989) identified that the field of recreation ecology has a large body of research that describes the impact of campsites on vegetation in wilderness areas. Cole (1989) states that the use of what is already known about camping can be combined with geographic analysis methods in order to better understand the impacts occurring in our wilderness. Cole (1989) concludes that geographers can contribute in three primary ways by: (1) showing the spatial variability and susceptibility of site impacts, (2) identifying the spatial distribution of impacts, and (3) mapping the social and ecological concerns during the development of natural resource programs. This study will directly address the second area by predicting the spatial distribution of campsite impacts in a wilderness area. This study will also contribute to the other two areas by assisting manager with the generation of campsite data which can be used to understand the susceptibility and variability of site impacts. The data generated will also assist managers to map, in combination with vegetation and social layers, the potential social and ecological concerns surrounding a given area.

Leung (1998) determined through research that there is a need to explore potential indicators and indices that may be available to characterize the spatial dimension of recreation impacts. Utilizing indices will be important for gaining an understanding of the overall magnitude of camping impacts. This study will contribute to this area by building an understanding of where impacts are across the land. With the assistance of a search protocol, the field work done throughout the region will aid the USFS in gathering the data necessary to understand the magnitude of camping impacts in the wilderness areas of the central Rocky Mountains.

The current study will contribute to the fields of recreation ecology and geography through piloting the creation of a scientifically informed search protocol that can potentially standardized the way that Element 6 is conducted throughout Region 2. The study will also benefit the Region by providing information on the distribution of campsites in the wilderness areas of the Rocky Mountains. Campsite monitoring via a census provides the most precise and accurate picture of campsite distribution (Newman *et al*., 2006). If future studies are warranted, researchers will have the ability to generate temporal models with the new and old information which show site proliferation and change in the area. This study will also be useful as a framework for future researchers interested in modeling site distributions in other areas.

The model that is generated and field tested through this study will be useful to managers as they deal with budget deficits and minimal staff levels. The model will help managers key in on the areas of the wilderness that are most important to search, which will save time and money. Although the model will remain a hypothesis, it is a first attempt at standardizing Element 6 searches.  The standardization of searches throughout the region is important to future work identifying new campsites from old sites resulting  in a better understand proliferation and site distribution with a temporal aspect.

# CHAPTER 3

# RESEARCH COMPARING SPATIAL MODELING TECHNIQUES FOR EXPLORATORY MAPPING

## 3.1 INTRODUCTION TO THE MODELING APPROCHES

Spatial modeling can provide a tool for developing exploratory search methods by predicting and spatially mapping areas likely to have the occurrence of a dependent variable, such as campsite location (Phillips, 2008). Spatial models are commonly applied across different fields of natural resources for predicting floral and faunal occurrence and distribution (Steiner *et al.* 2008; Martinez-Freiria, Sillero, Lizana & Brito, 2008; Evangelista *et al,.* 2008; Lauver, Busby & Whistler,. 2008; and others). These predictive models use a variety of methods ranging from *a priori* knowledge in the development of Habitat Suitability Indices (HSI) to statistical algorithms that rely on occurrence and/or absence data.

Spatial models generally use ecosystem characteristics important to a species life cycle to predict distribution or habitat suitability across a given landscape. Models have also been applied in the field of recreation for the purpose of mitigating conflict, mapping recreation impacts and defining areas most suitable to locate facilities (Roberts *et al,* 2002; Provencher & Bishop, 1997; Hamilton, 1996). This study uses two common modeling approaches to predict suitability of a dependent variable (such as a campsite): a Habitat Suitability Index and Maxent.

The term habitat refers to the range of environments or communities in which a species occurs (Whittaker, Levin & Root, 1973). Habitat Suitability Indices are spatial models used by ecologists and wildlife biologists to spatially represent areas that organisms could potentially inhabit. Also referred to as Habitat Evaluation Procedures (HEP), HSI models were originally created to assist biologists with environmental impact assessments and to make daily decisions about managing wildlife and their habitats. Brooks (1997) identifies that HEP and HSI models were originally developed using *a priori* knowledge to provide a rapid assessment method to assist wildlife practitioners in understanding what landscape attributes are important to a species and how the species is distributed across a given landscape.

The concept of HEP and HSI models has been used in the field of recreation management to model areas desirable for certain activities. Clark (1987) presented several wildlife habitat concepts that are analogous to recreation 'habitat' concepts. For example, wildlife travel corridors are analogous to recreational trails. 'Critical habitat features' for recreationists would include flat ground for campers or boat landings for rafters (Clark, 1987). Greer (1990) defined recreation habitats as the areas that people go to that are chosen based on the values that will enhance or support their recreation activity. Within the bounds of the common definition of habitat, humans can exist in almost any terrestrial location in the wilderness for a limited period of time. However, suitability for recreational camping can be identified along a gradient, and people have a tendency to camp in particular areas (Brunson & Shelby, 1990). Habitat suitability can be characterized by variables such as elevation, slope exposure, proximity to trail corridors and proximity to water (Brunson & Shelby, 1990). This study uses HSI methods to develop a Recreation Habitat Suitability Index (RHSI) to determine areas of Colorado wilderness likely to have campsite occurrence.

Although HSI models that have not been validated are commonly used for determining habitat suitability, Brooks (1997) recommends using a statistical approach to determining suitability. Statistical models attempt to predict the behavior of a process by using stochastic model and statistics functions (Berger, Della-Pietra, & Della Pietra*,* 1996). The ultimate goal of statistical modeling is to take what is known about an object and extrapolate the possible distribution of that object across the landscape. Statistical modeling is synchronous with this study, and managers who have adequate campsite data should consider utilizing statistical approaches. Along with the use of a Recreation Habitat Suitability Index (RHSI), this study implements the predictive modeling program Maxent v.3.2 (www.cs.princeton.edu/~schapire/maxent/) to statistically determine areas likely to have campsites (Phillips *et al.,* 2006). Maxent software is based on the concept of Maximum Entropy principles (Jaynes 1957a; 1957b). The goal of the Maxent project was to create a statistical package that models what is known about a species while avoiding the prediction of what is not known (Berger *et al*., 1996). Maxent uses presence-only data to predict a species' distribution by identifying known conditions of occurrences relative to the parameters of the independent variables (Evangelista, Stohlgren, Morisetta & Kumar, 2009). Maxent has proven its utility in many ecological modeling studies (Hernandez, Graham, Master & Alber, 2006; Ficetola, Thuiller, & Miaud, 2007; Pearson, Raxworthy, Nakamura & Peterson, 2007; Evangelista *et al.* 2008; and others) and was chosen for this study because of its ability to use presence-only data.

### 3.1.1 PURPOSE AND GOALS

The purpose of this study is to develop, test and compare two spatial modeling methods that predict campsite suitability in wilderness areas. The goal of this study is to provide managers with two tools for determining which areas of a wilderness are most likely to have camping-related impacts. Data is not always available to managers, so a qualitative Recreation Habitat Suitability Index was developed using *a priori* knowledge gained during focus groups with specialists, without of the use of data.  When data is available, statistical methods are recommended.  A quantitative statistical approach using Maxent software (Phillips, 2006) with presence data collected by the United States Forest Service (USFS) is also employed.  These two methods are tested, and the resulting models are compared.

## 3.2 METHODS

### 3.2.1 STUDY AREA

The USFS manages 36 wilderness units in Colorado totaling 3,216,956 acres of land as part of the National Wilderness Preservation System (Figure 2).  Most of the wilderness units in Colorado are located in the mountain ranges of central and western Colorado.  The USFS wilderness areas of Colorado range in size from the 8,800-acre Byers Peak Wilderness to the 497,228-acre Wiminuche Wilderness.  The climate and ecosystems of Colorado vary dramatically, from the arid pinyon–juniper woodlands in the southwest to the high alpine in the central Rockies.  While the wilderness areas of Colorado are diverse in size and climate, recreation within the wilderness boundaries is limited to primitive activities.  Mechanized vehicles are not allowed in wilderness units, and activities generally include backpacking, climbing, hunting, fishing, horse-packing and other primitive forms of recreation (Loomis, 2000). These activities result in intensive use of areas with high recreational value (e.g., close proximity to trails and water, flat terrain for campsites).  Although recreation activities in a wilderness are diverse, camping activities generally share a common set of meso-scale variables between wilderness areas (Brunson & Shelby, 1990).

### 3.2.2 DATA SOURCES

#### *3.2.2.1 Sample Data*

Campsite data has been collected by the USFS in many wilderness areas throughout Colorado but has not been entered into digital databases. Data for this study was collected from multiple districts of the USFS in Colorado using Global Positioning Systems (GPS). Each district had collected Universal Transverse Mercator (UTM) points at campsites. Data from the districts incorporated entire sections of a wilderness and not just popular areas and trail corridors. Two data sets were gathered for this analysis: Data Set A was obtained from districts that attempted to complete a census inventory of the district's portion of a wilderness unit (Table 1); Data Set B was collected from districts that completed portions of the wilderness but not the entire wilderness (Table 2). The districts where campsite data was obtained were in charge of collecting the data. Data was collected by each district using purposive sampling techniques with the goal of collecting as many presence points as possible. These two data sets are used for different purposes throughout the modeling process. (Brunson & Shelby, 1990).

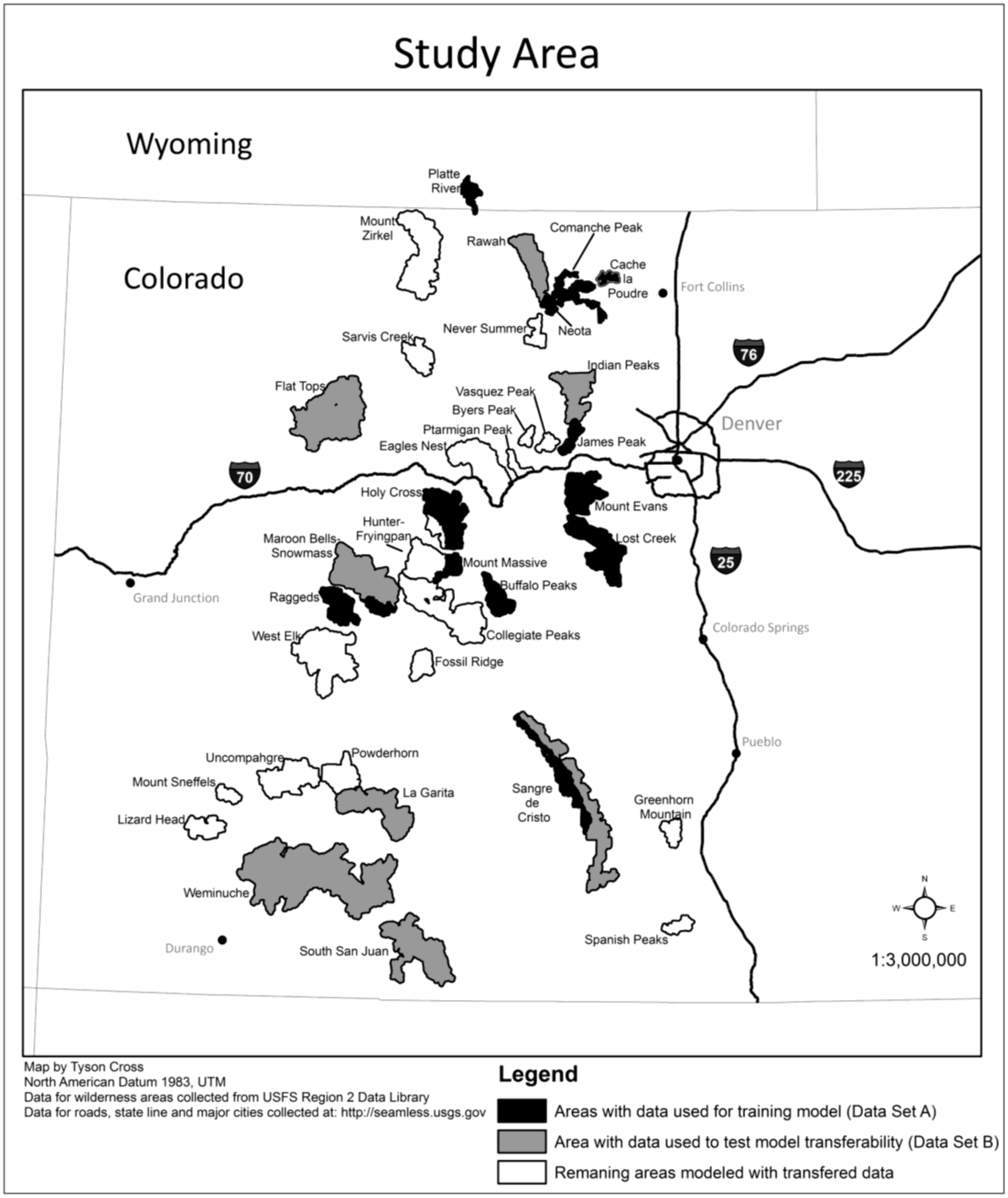


**Figure 2** Study Area Map

**Table 1** Data Set A

| Wilderness | District | Number of Sites |
|---|---|---|
| Buffalo Peaks | Leadville and SouthPark | 72 |
| Cache la Poudre | Canyon lakes | 26 |
| Comanche Peaks | Canyon lakes | 44 |
| Holy Cross | Eagle and Sopris | 98 |
| James Peak | Clear Creek and Boulder | 325 |
| Lost Creek | South Platte and South Park | 196 |
| Maroon Bells | Gunnison | 53 |
| Mount Evans | Clear Creek and South Platte | 215 |
| Mount Massive | Leadville | 161 |
| Neota | Canyon lakes | 31 |
| Platte River | Larimer | 54 |
| Raggeds | Paonia | 141 |
| Sangre de Cristo | Saguache | 314 |
| | **Total N** | **1658** |

**Table 2** Data Set B

| Wilderness | District | Number of Sites |
|---|---|---|
| Flat Tops Wilderness | Yampa | 48 |
| Maroon Bells | Aspen and Sopris | 248 |
| Indian Peaks | Boulder | 90 |
| La Garita | Saguache | 47 |
| Rawah | Canyon Lakes | 31 |
| South San Juan | Rio Grande | 68 |
| Wiminuch | Rio Grande, Pagosa and Conejos | 465 |
| | **Total N** | **949** |

#### *3.2.2.2 Environmental Variables*

A thorough review of the literature revealed habitat concepts and attributes that have a relationship with campsite location (Table 3). These attributes relate to macro-, meso- and micro-landscape features that create camping 'habitat.' This study focuses on using meso-scale, or topographic-scale, landscape features that allow for a model useful at the regional scale (Phillips, 2006). The variables included in the model are: (1) distance from trails, (2) distance from roads, (3) distance from streams, (4) landscape slope, and (5) access to lake. Even though wilderness areas are roadless, areas where roads border the wilderness area are accounted for in the model. Streams and lakes are treated as separate variables due to the importance of lakes as a destination for campers (Hamilton 1996, Greer 1990). All environmental variables were modeled with 30 meter resolution.

**Table 3** Environmental variables used in past RHSI studies (adapted from Bresson, 1996).

| Author/Year | Habitat Concept | Wilderness Camping Habitat Attributes |
|---|---|---|
| Clark, 1987 | Travel Corridors | Trails, roads, limited by slope* |
| | Home Range | Most recreation is local, home range can be large |
| | Territory | Sense of place |
| | Hiding Cover | Cover in between sites |
| | Edges | People prefer eco-tones |
| | Critical Features | Water source* |
| Greer, 1990 | Over lapping conflict | Back packers and stock users |
| | Habitat Interface | Higher density of use at interface |
| Bresson, 1996 | Attraction places | Places of scenic vistas, points of interest |
| | Biological diversity | Color, wildflowers, insect abundance |
| | Lack of human influence | Natural quiet, vehicle restrictions |
| | Microclimate | Temperature, dampness |
| | Topography | Steepness, availability of flat-ground* |
| Hamilton, 1996 | Aesthetics | Lake Visibility, Access to lakes* |

## 3.3 ANALYSIS

### *3.3.1 Recreation Habitat Suitability Index*

The utility of HSI theory in understanding which environmental attributes are important drivers for recreation has been shown through multiple studies (Clark, 1987; Hamilton, 1996; Brunson, 1996; Greer, 1990). In 1996, Brunson used a method similar to a wildlife HSI when he created a Recreation Habitat Suitability Index (RHSI) for scenic viewing, hiking and camping. Basing his work on previous research conducted by Greer (1990) and Clark (1987), Brunson (1996) used social-value surveys to understand what attributes of recreation activities are important to visitors. Social-value surveys by Brunson (1996) concluded that the attributes most important to scenic viewing, hiking and camping were: attraction to places, biological diversity, canopy closure, lack of human influence, microclimate, topography, and forest health. Brunson (1996) weighted attributes related to camping by the relative importance of each attribute and then expressed the model using GIS data of the attributes across the landscape. RHSI methods similar to Brunson's (1996) are a useful tool in understanding what landscapes are most suitable to camping.

This study uses the meso-topographic attributes of camping habitat in order to inform a Recreation Habitat Suitability model that shows "likely campsite areas" over a broad landscape using a RHSI approach (Hamilton, 1996). The development of a RHSI for camping locations in Colorado wilderness areas utilized available geospatial information for the independent variables identified in Table 3. Through multiple meetings and focus groups with wilderness managers, values were determined for rating and weighting the variables used to create the RHSI model for campsites in Colorado wilderness areas. The highest rating is given to areas directly adjacent to trails, lakes, streams and roads, indicating a high suitability. The lowest rating is given to areas located more than a half mile away from a lake, stream, trail or road. It was determined that, although the exact distribution of sites and the relationship of sites to the independent variables is unknown, campsites would not be found outside of 800 meters from a variable. Using the 800-meter parameter, Suitability Index (SI) curves (Figure 3) were created for each of the variables. SI curves are used to value distance in relationship to each environmental variable. The variables were then equally weighted and mapped using the following algorithm:

$$RHSI = [.2V_1 + .2V_2 + .35V_3 + .05V_4] + .2V_s$$

Where $V_x$ is the pixel value of the distance variable (distance from water, lakes) times the equation of the line for each SI curve, and $V_s$ is the pixel value for slope times the equation of the line for the SI curve for slope. The RHSI was then expressed for 36 wilderness areas in Colorado using GIS and the environmental layers.

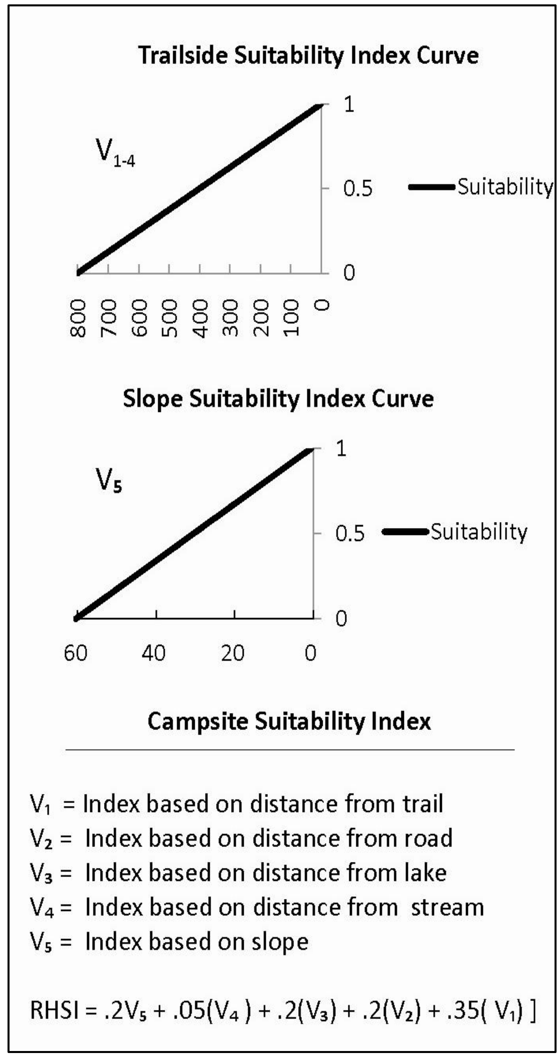


**Figure 3** Habitat Suitability Index Curves

### *3.3.2 Maxent*

Campsite data collected in wilderness by the USFS in Region 2 does not include the collection of campsite absence points. For management reasons, the USFS has opted out of sampling techniques which involve random sampling and the collection of absence points in favor of search techniques that result in finding the most campsites (Emerich, 2008). Furthermore, collecting an absence point for a campsite is difficult because objective indications of camping activities (such as a fire ring) are often absent even though an area has been impacted by camping (Hampton & Cole, 1995).

Although absence points are used in common spatial modeling approaches such as kriging and linear regression analysis (Arab, Hooten & Wikle, 2007), the problem of creating absence points and the difficulty of generating a random sampling scheme is not new to predictive modeling (Williams, Margules & Hilbert, 2002). The development and wide spread use of modeling tools that use presence-only techniques to predict habitat (Evangelista *et al.,* 2008; Martienez-Freiria *et al.,* 2008; Phillips *et al.,* 2006; and others) is testimony to this fact. Although there are many techniques used to overcome this problem, such as generating psuedo-absence points using logistic regression models (Wisz & Guisan, 2009), Maxent has proven to be a useful tool for modeling presence only data. Maxent has been shown to produce similar or better results than other presence-only predictive models such as GARP (Berger *et al.,* 1996; Phillips *et al.,* 2006; Hernandez *et al.,* 2006; Evangelista *et al.,* 2009), and was chosen for this study based on its utility and ease of use.

The Maxent model analysis was developed in multiple stages using Data Set A. A flowchart of these operations can be found below the analysis section (Figure 4). First, a random selection of 30% of the data from Data Set A was withheld. The remaining 70% of Data Set A was used to create a training model with Maxent. This training model was tested with the residual 30% of Data Set A to make sure the model was valid prior to transferring the data to the rest of the areas. After testing the model, the full data set (A) was then used to create a final training model, and that model was transferred to the remaining wilderness areas. Creating a training model in areas where the data was collected is important for avoiding transferability bias (Phillips, 2008).

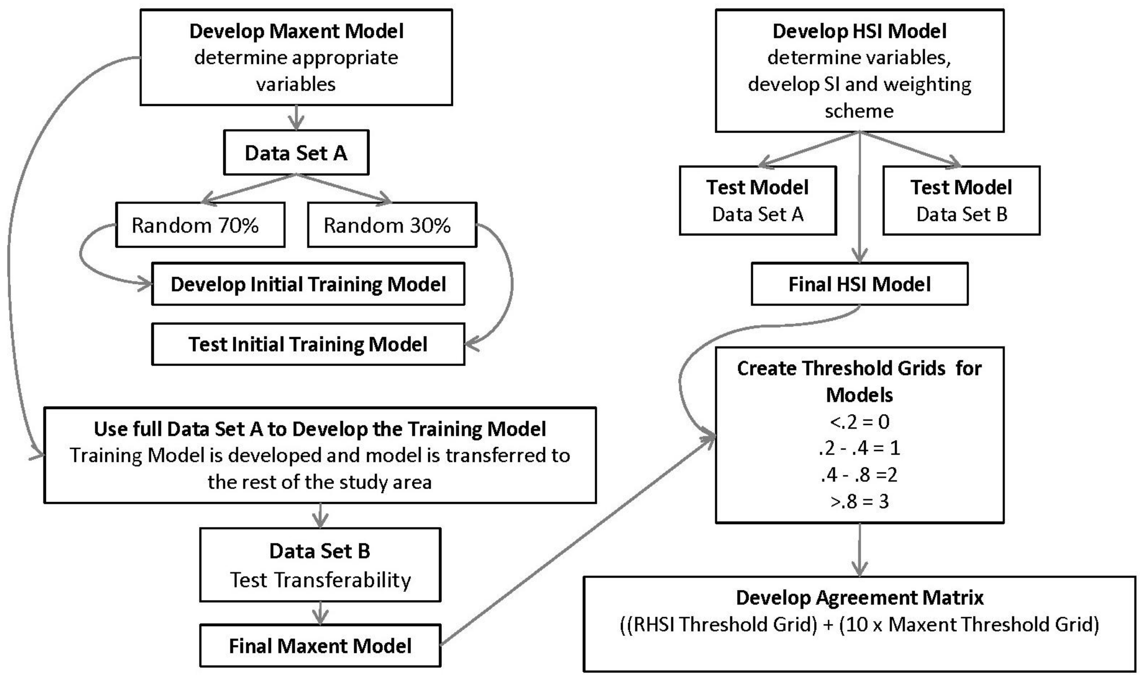


**Figure 4** Flow Chart

### *3.3.3 Model Analysis*

The RHSI and Maxent Models were used in conjunction with the environmental layers to model campsite suitability in 36 Colorado wilderness areas. The resulting RHSI and Maxent layers were analyzed. The Maxent model was tested using the 30% of data from Data Set A that was withheld during the initial development of the Maxent model. Data Set B was used to test the transferability of the Maxent model. The RHSI model was tested with the same data for purposes of comparison.

Model results were tested using both threshold-dependent and threshold-independent measures with Schroder's ROC/AUC software (http://brandenburg.geoecology.uni-potsdam.de/users/schroeder/download.html) using methods similar to Evangelista *et al*. (2009).

Schroder's ROC/AUC software was developed to assess modeling validity. This method of analysis requires presence and absence data. Absence data is not available for this study, so absence points were randomly generated. In order to use AUC as a method for analysis, random or psuedo-absence points must be generated (Phillips, 2006). These points are generated within the boundary of the area where the data originated using Hawths tools for ArcGIS 9.x. When using this method, the AUC is tested as chance of occurrence vs. random occurrence (Phillips, 2006). Although AUC scores may be inflated using this technique, Phillips *et al.* (2006) show that this method of analysis is a useful, non-prejudiced measure of presence-only model validity.

The ROC curve is developed by plotting sensitivity on the y axis and 1-specificity on the x axis for all thresholds (Pearce & Ferrier*,* 2000; Phillips *et al.,* 2006). The Area Under the Curve (AUC) is calculated by connecting the resulting points with a straight line and measuring the area underneath the line. AUC measures the probability that a random positive point would fall outside the predictive range and the probability that a random negative would fall inside the predictive range. This measurement will vary between .5 and 1. An AUC score of .5 indicates no better than random, while 1 is perfect discrimination. Hosmer and Lameshow (2000) define AUC model performance of <.5 as no discrimination, .7 to .8 as acceptable, .8 to .9 as excellent, and >.9 as outstanding.

Kappa values are also reported for each model. Kappa values are based on a threshold-dependent measurement. A threshold-dependent test for measuring the validity of these two models is useful in this study. This study proposes to define the Kappa threshold by using the area of each model that contains 95% of the sites from the census data. In this case, the threshold for the Maxent model is >.24 and the RHSI model is >.28. Using these thresholds, a binary map is developed with 0 indicating not to search and 1 indicating search areas. The corresponding thresholds were used to measure the Kappa (K) statistic for both models. The Kappa statistic accounts for the probability of chance agreement and ranges from -1 to +1. The closer the Kappa statistic is to +1 the greater the agreement of the models. Any scores less than 0 indicate that the model did not perform better than random (Allouch, Tsoar & Kadmon., 2006; Tsoar, Allouche, Steintz, Rotem & Kadmon, 2007). Landis and Koch (1977) defined Kappa values of < .4 as poor, .4 to .75 as good, and >.75 as excellent.

### *3.3.4 Model Comparison*

Models were compared by developing an Agreement Matrix. To develop an Agreement Matrix, four thresholds were assigned to each model (Table 4). The threshold maps were created by assigning pixel values relating each threshold to each value from the models resulting in a grid of thresholds. The grids were then multiplied using the following equation:

Agreement Matrix = (RHSI Threshold Grid) + (10 x Maxent Threshold Grid)

This matrix can be used to compare and determine the level of agreement between the two models. The ArcGIS function 'Extract by Points' was used with Data Set A to determine where sample data falls in the agreement matrix. This allows us to understand the different ways that the models predict camping locations.

**Table 4** Thresholds assigned to each model during the development of the agreement matrix

| Threshold Value | Habitat Quality | RHSI Grid Value | Maxent Grid Value |
|---|---|---|---|
| | Hi | 3 | 3 |
| | Medium | 2 | 2 |
| | Low | 1 | 1 |
| , No Data | No | 0 | 0 |

The effectiveness of the models as a search protocol can be determined by extracting the area necessary to complete the goal of searching 95% of the areas likely to contain camping impacts. The more effective model is defined here as the model that incorporates 95% of campsites in the least amount of area. In order to determine the most effective model, another threshold was determined for each model. This threshold is the area that 95% of Data Set A and B fall into. This threshold creates a binary grid, search or not search. A comparison of the area that is required to be searched in each model determines the efficiency of each approach as a searching tool.

## 3.4 RESULTS

Both models performed outstanding and produced predictions that were better than random, following definitions for AUC model performance defined by Hosmer and Lemeshow (2000). Threshold-dependent and threshold-independent measures were statistically significant (Table 5). Testing with the random 30% withheld from Data Set A, the AUC indicates that the RHSI model performed outstanding (.92). The Kappa value indicated that the RHSI model performed good (.66). The AUC and Kappa values for the Maxent model were greater than that for the RHSI, with an AUC of .93 and a Kappa of .72, indicating similar results.

**Table 5** Performance of the two models for Area Under the Curve (AUC) and Cohen's maximized kappa

| | **Data Set A** | | **Data Set B** | |
|---|---|---|---|---|
| | **Training Data** | | **Transferability data** | |
| **Model** | **AUC** | **Kappa** | **AUC** | **Kappa** |
| RHSI | 0.92 | 0.66 | 0.93 | 0.71 |
| Maxent | 0.93 | 0.72 | 0.93 | 0.74 |

All values are significant at the $p < .001$

The transferability test data indicates that the area where the Maxent model was transferred to is outstanding (Data Set B). The AUC for the transferred area for Maxent was .93 and the Kappa was .74. The RHSI also performed outstanding when tested with Data Set B, with an AUC of .93 and a Kappa value of .71.

The Maxent model indicated that the best predictors for determining campsite location are trails and streams, combining to contribute 74.9% of the contribution to the model (Table 6). Slope was the next best predictor followed by lakes and then roads. Jackknife reports for the regularized training gain for campsites indicate that all variables were important contributors to the Maxent model.

**Table 6** This table shows the percent contribution of each independent variable by the analysis of the Maxent model

| **Variable** | **Percent Contribution** |
|---|---|
| Trails | 41.2 |
| Streams | 33.7 |
| Lakes | 10.6 |
| Slope | 14 |
| Roads | 0.4 |

The agreement matrix was developed and then analyzed (Figure 5). The agreement matrix analysis showed that the majority of the Maxent and RHSI grids fell into agreement across the various thresholds (Table 7). The majority of the pixels for the agreement matrix (56.3%) fell into areas of agreement: Hi-Hi, Medium-Medium, Low-Low, No-No (Table 9). Only 5.42% of the total pixels are in disagreement, for example, where one model is predicting high and the other is predicting low or no or where one model is predicting medium and the other is predicting no suitability. This indicates that the two models agree on which areas are suitable for camping.

When agreement matrix values from Data Set A are extracted, most of the points fall into areas of agreement (Table 8). Only five sites from the data fell into places of disagreement, and zero sites fell into areas where one model was predicting high and the other predicting no probability. The majority of the sites (74.43%) fell into areas of agreement (Table 10).

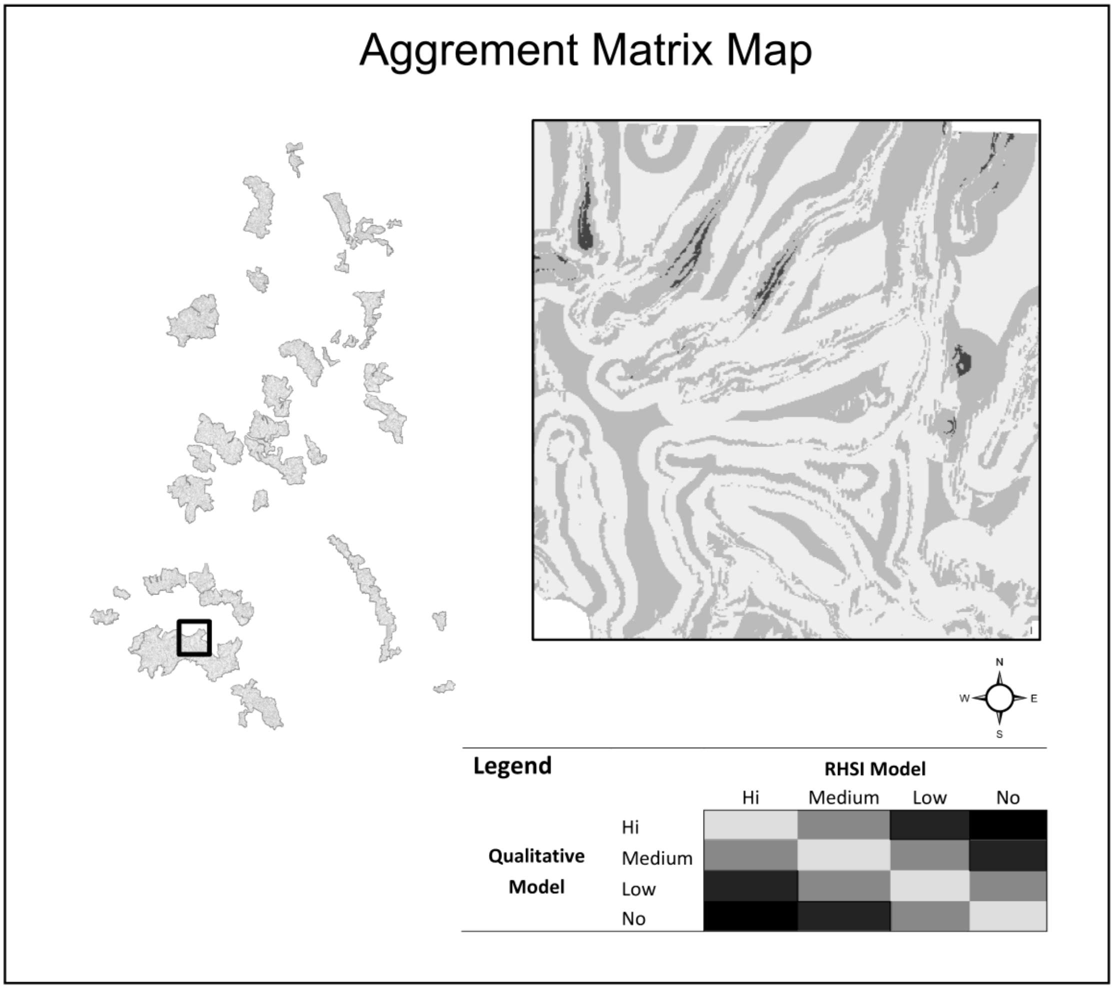


**Figure 5** Agreement Matrix Map

**Table 7** Agreement Matrix Pixels

| | | Qualitative Model | | | |
|---|---|---|---|---|---|
| | | Hi | Medium | Low | No |
| **Quantitative Model** | Hi | 30308 (1.54%) | 64799 (3.30%) | 11527 (0.59%) | 122 (0.01%) |
| | Medium | 11847 (0.60%) | 152115 (7.75%) | 103970 (5.30%) | 11719 (0.60%) |
| | Low | 15 (0.00%) | 196341 (10.00%) | 231153 (11.77%) | 147826 (7.53%) |
| | No | 2 (0.00%) | 82881 (4.22%) | 222146 (11.32%) | 696357 (35.47%) |

Thresholds were determined for each model, and the models were then added together. The individual pixels were counted to determine the level of agreement for each threshold level between the models. The percentage of the total pixels are in parentheses. White cells indicate agreement between the models, and black cells indicate disagreement.

**Table 8** Agreement Matrix Presence Points

| | | Qualitative Model | | | |
|---|---|---|---|---|---|
| | | HI | Medium | Low | No |
| **Quantitative Model** | Hi | 173 (11.05%) | 142 (9.07%) | 4 (0.26%) | 0 (0.00%) |
| | Medium | 30 (1.92%) | 885 (56.55%) | 173 (11.05%) | 0 (0.00%) |
| | Low | 0 (0.00%) | 21 (1.34%) | 88 (5.62%) | 0 (0.00%) |
| | No | 0 (0.00%) | 1 (0.06%) | 26 (1.66%) | 19 (1.21%) |

ArcGIS 9.2 function Extract by Points was used to determine the Agreement Matrix Value of Data Set A. This is used to indicate the differences in how the models predict campsite locations. White cells indicate agreement between the models, and Black cells indicate disagreement.

The total amount of pixels for the binary grid that incorporated 95% of the presence points for each model was calculated. The total search area predicted by the Maxent model was 982,196 acres, compared to the RHSI which predicted an area of 979,661 acres. This indicates that the Maxent and the RHSI performed remarkably similar in search efficiency.

## 3.5 DISCUSSION

Though un-calibrated HSI models are often used, it is commonly recommended that HSI's be validated with data using statistical analysis (Brooks, 1997). Statistical analysis can be applied to create more precise and accurate models for predicting campsite suitability (Brooks, 1997). Logistic regression analysis is often used to calibrate HSI models in the field of wildlife management (Brooks, 1997; Roloff & Kernohan, 1999; Lauver, Busby & Whistler, 2002). Methods common to HSI calibration require the use of absence points or the generation of psuedo-absence points for analysis, however these methods are inappropriate for the current study due to the relative difficulty of developing absence points for camping impacts.

In order to determine a camping presence point, an objective sign of camping, such as a fire-ring, trash, or tent stakes must be present. Leave No Trace practices encourage campers to practice camping techniques that minimize the objective indications of camping (Hampton & Cole, 1995). Repetitive visits to an area will leave an impact from camping, but the signs of camping will be removed by visitors. This results in the presence of a camping impact without any indication of use by a human, and the inability to legitimately create absence points. This dataset, therefore, lends itself to a Maximum Entropy approach of using what is known without inferring what is not known.

Models can be biased by the quality of the data used for both the independent and dependent variables used. Error associated with generating presence location must be accounted for. Often, modeling efforts that take place at the regional scale rely on data collected from exterior sources. Missing data from the independent variable data sets can be common. The maps that result from this study may reflect this inaccuracy. Local knowledge is critical when utilizing maps resulting from this applied research. The utility of the maps is only as good as the data that went into making the maps.

For this study, the introduction and testing of an un-calibrated model was intentional, as data to calibrate a model is not always available. Some of the conclusions from the Maxent analysis indicated that the contribution of the variables used is not consistent with the RHSI model, and that some variables are more important in modeling site locations than others.

Contribution is related to the weighting scheme used in the RHSI and is determined by methods similar to logistic regression. Managers interested in implementing a RHSI similar to the one presented in this article should modify the RHSI accordingly. The variables streams and trails are shown to be the best predictors and should be weighted heavier. Lakes, roads and slope should be weighted less. This may explain some of the differences in the models that were found in the agreement matrix. Perhaps calibrating the RHSI would produce a grid that agreed more closely with the quantitative approach.

Wilderness managers may be surprised by the limited contribution of lakes to the Maxent model. This limited contribution may be related to the fact that magnitude of impact was not accounted for in this effort, and only the presence of a site was used for modeling. A model that relates magnitude of impact to the independent variables related to camping may result in a higher contribution from lakes in the modeling effort. Also, although Maxent is not sensitive to multicollinearity (Phillips, 2006), the variables streams and lakes are heavily correlated. Determining the difference in contribution between streams and lakes may be difficult because of this potential multicollinearity.

The variable distance from roads was a small contributor to the model. This may change depending on the nature of the wilderness areas. Some wilderness units directly border popular dispersed camping roads, which may result in additional impacts in wilderness. Understanding the relationship between the type of road and camping impacts resulting (i.e., well-traveled), may be useful to take into account in future analysis.

The total search area predicted by each of the models is expansive, nearly one third of the total wilderness area. This may seem like a large area, but the maps developed by these models are only an indication of suitability. Campsite proliferation research by Cole (1993a) indicates that campers will start in the most desirable location for camping. Once the most suitable areas are impacted, campers may move to new sites. This is important for managers interested in using this approach to develop a search protocol. When using the models, the most likely areas should be visited first. If camping impacts are found at the most likely spots, further searches should be conducted into the less likely areas. If sites are not found in the most suitable places, it is unlikely that sites will be in less suitable areas.

### 3.6 RESEARCH CONCLUSIONS

This study has presented wilderness managers with several methods useful in creating search protocols for finding most of the camping impacts in a wilderness. This study has also shown the utility of using Maxent in the field of recreation. Future modeling efforts may seek to understand the magnitude of impacts from camping in relationship to environmental layers. As new data sets become available, models that predict areas of high human impact may be possible. Nested scale models that begin to understand the micro- and meso-scale environmental factors associated with camping may be possible. Abundance data on the amount of visitors to certain areas would useful in understanding the magnitude and amount of impacts in certain areas.

The goal of this study was to introduce two methods for defining areas likely to contain camping impacts in Colorado wilderness areas. The RHSI is a simple method that can be utilized by managers who do not have campsite data for the wilderness area they are managing. When good data sets are available, Maxent may create more precise and accurate search plans. The results of this study indicate that both RHSI and Maxent methods can be an effective tool for creating and standardizing search protocols.

The results of this study can be used by wilderness managers to implement efficient campsite searches.  Recent national mandates are requiring wilderness manager to complete surveys with the goal of finding most of the camping impacts in the wilderness.  Although the results of the current study cannot be used to determine the total level of camping impacts in a wilderness, the product of the current study can be used as a guide for planning these searches.

# CHAPTER 4

# CONCLUSIONS

## 4.1 STUDY LIMITATIONS

This study is limited in several ways. Certain environmental variables known to have a relationship to camping have not been used. For example, variables such as distance to an ecotone, and cover between sites require a higher resolution to be useful to modeling, and were left out. Additionally, distance from trailheads was not used in the current study because of the difficulty incorporating the layer into a qualitative model. The variables used for modeling needed to be standardized between the two models to be comparable. This also limited the ability of this study to test additional variables that may be related to camping.

Another major limitation of this study was the resolution of the data used. Slope was found to have a relatively weak relationship (14%) with campsite location. This is most likely due to the low spatial resolution of the data. The Digital Elevation Model used for this study had a spatial resolution of 30 meters. This resolution is an average between several known elevations in a 30 meter grid. Campsites can be very small at times, and a suitable place for a campsite may be just 5 meters squared. Smaller resolution Digital Elevation Models may result in a higher predictive value for slope.

The quality of the data used to obtain campsite location points can bias the model. For this study, UTM points were taken with common, hand held GPS units. The error for these GPS points can vary from three to 30 meters depending on signal strength and time spent at any given location. In an effort to use higher resolution data in the future, researchers will also need to use higher grade GPS units with smaller error. More accurate GPS points will create better models.

All modeling efforts are limited by the quality of the sampling scheme used to collect data. Proper sampling schemes are critical for developing unbiased models that predict dependent variable occurrence well. The lack of sampling strategies and the inconsistency of the sampling strategies of some USFS data collection efforts has resulted in a set of data that has a purposive, heterogenic sampling scheme. Although these sampling methods are appropriate for developing efficient search protocols, they lack the statistical strength to create unbiased models that may be used to determine population parameters (Theobald *et al.*, 2007). A systematic sampling scheme would be imperative for the development of models that can be used to more accurately and precisely predict campsite locations, as purposive sampling schemes can result in model bias.

For this model, use levels were not accounted for. Accurate use data at the regional level does not currently exist. The lack of use data limits the utility of this model. The model that resulted from this study indicates campsite suitability, but lacks the ability to accurately predict the magnitude of impact at a site. This is because a suitable site may not be used by campers and there will not be impacts from camping. This model was specifically designed as a search tool, with the intention of assisting managers to implement more efficient campsite searches. Once site searches have been completed, the resulting data may be used to create models which predict the magnitude impact at certain sites relative to use.

## 4.2 GENERAL CONCLUSIONS

The inventory, monitoring and analysis of camping impacts are important aspects of a wilderness program. Many years of scientific research has resulted in a plethora of campsite impact literature, and evaluation systems (Cole, 2004). As our understanding of camping impacts evolves, new questions arise. The data collected during the census inventories of Element 6 will gain indispensible information about the distribution and magnitude of camping impacts in wilderness. This information can be used by managers in making many management decisions and also by researchers interested in analysis and answering new research questions. It is my hope that the information contained in this thesis will assist managers in their pursuit of Element 6.

At the end of 2014, the 10YWSC will come to a close. Although the 10YWSC will end, the information gathered during the challenge will be useful into the future. The Minimum Protocol for Campsite Assessment technique developed by Dr. David Cole for Element 6 provides managers with a quick, yet precise and accurate scientific tool for measuring campsite impacts. Less time spent at each site results in more time finding additional impacts. The Minimum Protocol for Campsite Assessment is an invaluable tool for future managers interested in gaining a thorough understanding of camping impacts in the wilderness units.

Using this predictive modeling research, likely areas to find camping impacts in the 46 wilderness units in Region 2 of the USFS have been mapped. These maps will be distributed to the various managers and rangers who manage wilderness areas of Region 2. The modeling process used to develop these maps used purposive sampling techniques. This is because the development of a consistent sample across the large geographic area of the study site is difficult and costly to implement. In this instance, Maxent is an ideal tool for developing a search protocol, using the best available data.

Future modeling efforts may involve randomized sampling schemes. Randomized sampling schemes allow managers to statistically calculate error and population parameters. Future modeling work may also benefit from exploring relationships between camping and other environmental variables such as size of lakes and use, as well as distance from trailhead. Potential studies may also be interested in teasing out the relationships between abundance of use and camping impacts in various wilderness corridors. Linking accessibility to trailhead, visitation and impact may provide insight into what decisions are related to campsite location, and how campsite location decisions impacts wilderness. It is my hope that this research will provide a base for these future efforts.

The statistical determination of the area necessary to search to find 95% of camping impacts, and the error associated with it, cannot be reliably determined with purposive sampling techniques (Tsoar *et al.*, 2007). An effort to determine the exact amount of land necessary to survey to insure that 95% of sites have been found would be a costly task. Although this research effort does not determine population parameters, it is a pragmatic, applied method for increasing search efficiency using the data currently available.

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# APPENDICES

## APPENDIX A: A WILDERNESS MANAGERS DESKTOP GUIDE TO RECREATION SITE INVENTORIES: FOCUS ON ELEMENT SIX OF THE TEN YEAR WILDERNESS STEWARDSHIP CHALLENGE

The goal of this guidebook is to provide wilderness managers with a tool for completing Element 6 of the 10-Year Wilderness Stewardship Challenge (10YWSC): recreation site inventories. This guidebook provides an overview of the 10YWSC and the Element 6 Challenge. Element 6 has a possible 10 points associated with its completion. The various chapters of this guidebook provide managers with information necessary to acquire 10 points for Element 6. The objective of this guidebook is to make the information easily accessible and usable to anyone interested in inventorying recreation sites. While the 10YWSC will be completed by the year 2014, the information collected during the challenge will be useful for future applications in research and management.

Campsite inventory and analysis is an important aspect of wilderness management. With the introduction of the 10YWSC, new mandates in the wilderness management curriculum have been established. Element 6 of the 10YWSC requires managers to complete a census of campsites throughout the wilderness areas of the United States Forest Service (USFS) (Emrich, 2008). The completion of this effort will result in a comprehensive data set of camping impacts in the wilderness areas of the USFS National Wilderness Preservation System (NWPS).

Although the requirement of a census survey is a new aspect of wilderness management for the USFS, campsites have been inventoried and monitored in many wilderness areas for many years (Cole, 2004). Recreation site inventories have been a part of wilderness management since before the Wilderness Act of 1964 (Cole, 1989). Recording and monitoring impacts caused by recreational activities is an important step toward understanding camping related impacts to the resource, and mitigating these impacts while allowing people the freedom to explore and interact with land in the NWPS.

This manual was formatted in a way that will benefit the potential audiences that will use this guidebook. Not all of the parts of this manual will be useful to everyone, and it is organized around this principle. This guidebook starts with an overview of the 10YWSC, and Element 6. The second chapter of this guidebook discuses and compares common campsite inventory methods in an effort to help managers choose the appropriate inventory system to complete campsite surveys. The third chapter of this guidebook focuses on planning and preparation for Element 6 surveys. The entire fourth chapter is dedicated to the Minimum Protocol for Campsite Assessment, a national campsite assessment system developed by the Wilderness Advisory Group (WAG) and the Aldo Leopold Wilderness Research Institute (ALWRI) for inventorying campsites (Emrich, 2008). The fifth chapter is titled 'Back in the Office', and focuses on inputting campsite data into usable formats. Chapter five also exemplifies ways to display data and provides examples of how the data collected from Element 6 surveys may be used to make management decisions.

## THE TEN YEAR WILDERNESS STEWARDSHIP CHALLENGE AND ELEMENT 6

In 2004, USFS Chief Dale Bosworth implemented the 10YWSC. The goal of the 10YWSC is to bring USFS wilderness areas to a minimum level of stewardship by the 50th anniversary of the Wilderness Act of 1964. The 10YWSC encourages wilderness managers to bring the level of wilderness management to "new millennium ideals" through the implementation of modern technologies, inventory and management techniques (Emrich, 2008).

Advised by the Chief's WAG team, Bosworth challenged wilderness mangers across the nation to meet 10 elements in order to address growing pressure on wilderness resources and a decreasing staff budget. The 10YWSC is to be met by each wilderness unit and consequentially each region, requiring the collaboration of specialists in the fields of air quality, aquatics, botany, fire, wildlife, and recreation management (Emerich, 2008).

To develop standards for the 10YWSC, the national Wilderness Information Management Steering Team (WIMST) began a process of deliberation. Two hundred individual tasks were originally identified as important factors in campsite management, but the number and nature of the tasks made a measurement process difficult. Using the original 200 tasks, the WIMST team distilled 10 elements considered to be the most critical for wilderness stewardship. These 10 elements became the framework for the 10YWSC. In 2002, a national assessment by the WAG, using the 10 elements of the 10YWSC as a guide, revealed that wilderness areas were not managed to desired standards (Emrich, 2008). Following the 2002 national assessment, the WAG advised Chief Bosworth to implement the 10YWSC, which he did in 2004. In 2008, a letter to the Regional Foresters from USFS Chief Abigail R. Kimbell reaffirmed the importance of the 10YWSC to the USFS (Appendix B). The 10 elements to the 10YWSC are:

1. Fire management plans which relate specifically to wilderness
2. Invasive species mitigation efforts
3. Air quality monitoring
4. Implementation of priority actions from a wilderness education plan

5. Monitoring and management actions which protect opportunities for solitude or primitive and unconfined recreation
6. Recreation site inventories
7. Outfitter and guide training and support plans and needs assessment
8. Assuring that the Wilderness has adequate direction in the forest plan to prevent degradation to the Wilderness resource
9. Assuring that the priority information needs for the wilderness have been addressed through data collection, storage and analysis
10. Assuring that the wilderness has a baseline workforce in place

At the regional level, wilderness program managers are working to help forest recreation staff officers and wilderness mangers create and implement plans that work towards the goals of the 10YWSC. Element 6 is a distinct challenge which requires managers to find and inventory camping impacts within each wilderness unit. Element 6 also requires managers to inventory and monitor administrative sites in wilderness. Other areas, such as scenic vistas, climbing areas, and popular peaks should be monitored as well. Most wilderness areas have recreation sites other than campsites, but the type of site and intensity of use may vary. The Element 6 challenge, and this manual, focuses primarily on the most common recreation sites found in wilderness areas: campsites. The specific standards for Element 6, and the points earned at each stage, are listed below (Table 1).

**Table 1** This table shows the accomplishment level for element 6. Points are earned for element 6 by completing certain tasks.

| Score | Accomplishment Level |
|---|---|
| 2 | A recreation site inventory plan is in place along with a recreation site monitoring protocol as a minimum |
| 4 | A recreation site inventory has been conducted in a portion of the wilderness. The inventory uses a protocol which conforms to the national site monitoring protocol as a minimum – with the exception that all likely sites have not yet been assessed |
| 6 | A recreation site inventory has been completed for this wilderness using the recreation site monitoring protocol which conforms to the national site monitoring protocol as a minimum |
| 8 | Data collected from the recreation site inventory are entered into Infra-WILD or are in another type of format, such as a database or spreadsheet, which supports subsequent analysis |
| 10 | Information generated from the analysis of recreation site inventory data are used routinely to support the local decision making process |

## CHOOSING A CAMPSITE ASSESSMENT SYSTEM

### COMMON CAMPSITE ASSESSMENT SYSTEMS

This section briefly describes the three most common inventory methods used to monitor campsites in USFS wilderness areas across the NWPS: Frissell, Cole and Modified Cole. The purpose of introducing these methods is to compare and contrast them to the Minimum Protocol for Campsite Assessment. This guidebook provides a brief overview of campsite monitoring techniques, and is a supplement to Cole's 1989 sourcebook which provides detailed information and assessment forms for each approach introduced in this chapter.

Accuracy, precision and sensitivity are three concepts used in this chapter. Accuracy relates to how close an estimated value is to its true value. Precision refers to the clustering or spread of estimated values; estimates that are grouped closely together are considered precise.

Sensitivity refers to how significant changes in the condition of a site need to be before a conclusion can be made that an actual change has occurred. For example, tree root exposure can be measured in different ways. A sensitive system will measure the surface area of a tree root exactly, by using a measuring tape to determine the area of exposure. With this, sensitive, measuring system, if two measurements are taken over time the detectible change may be from two square inches to four square inches; a difference of two. This is compared to a less sensitive system which takes measurements and groups the results into categories. In this example, a less sensitive system categorizes root exposure into groups of less than five square inches (category one), from five to 10 square inches (category two) and from 10 to 15 inches square (category three). In this, less sensitive system, the change over time from two to four square inches of exposure is not detectable because both measurements are valued as category one, resulting in an unobservable change.

*Condition Class Estimates, Frisell 1978*

The Frissell survey method (1978) is a 'Condition Class' estimate of impacts. When completing a Condition Class estimate, the surveyor assigns levels of impact to various factors affected by camping, such as damage to trees or vegetation. Using the Frissell survey, the rater will determine the impact to an area and classify that impact on a scale from one to five. The main advantage of using this approach is that the Frissell method is cost efficient. Although the Frissell method is both precise and accurate, the sensitivity is generally lower than other techniques. The major deficiency to this approach is that only one piece of information is provided for each site. It is impossible to determine what the site looks like, in terms of specific impact. Frequently, sites may have severe damage to trees, but relatively little ground disturbance. The Frissell method may not fit sites with similar levels of impact to certain factors, such as ground disturbance, into a similar category. For example, if one site has a lot of impact to trees, and little impact to ground cover it may be valued as three. Another site may not have damage to trees but a lot of impact to ground cover, and also be valued as three. Using the Frissell method, the two example sites share a rating, even though the damage is different.

*Measurements on Permanent Sampling Units (Cole, 1989)*

Another approach to measuring camping impacts in USFS wilderness management is the use of permanent plots to take detailed measurements of camping impacts in one location. The most common permanent plot system is the Cole method. Measurements involve creating a plot center, such as a large nail buried in the center of the site, along with a metal tag with the name and number of the site, usually attached to a tree. Permanent plot sampling methods collect a wide range of exact measurements. Sensitivity is higher with the use of these methods, as specific changes to the site can be easily detected and analyzed. Using a Cole Permanent Plot approach is time consuming, taking over an hour to complete at each site.

*Index Based Assessments, Modified Cole*

There are many types of Modified Cole assessments for measuring camping impacts. The 'Modified Cole' assessment system was originally called The Bob Marshall Rapid Estimation Procedure (Cole, 1989). The measurements are similar to Condition Class estimates (i.e. Frissell, 1978), and a condition class is ultimately assigned to each campsite. The key difference between the Frissell and Modified Cole is that, using Modified Cole, a class is assigned to each of the factors that are affected by camping. Factors include changes in the density of vegetation, changes in the composition of vegetation, the total area of the campsite, damage done to trees, etc. Each of these impacts is given a class value, and then the values of each impact are added creating an index of the site. Modified Cole has a moderate to high level of precision and accuracy and a moderate to low level of sensitivity (Cole, 1989).

*Minimum Protocol For Campsite Assessment*

In 2005, the Minimum Protocol for Campsite Assessment, referred to as the Minimum Protocol, was developed by Dr. David Cole and the WAG as a survey which meets the minimum requirements of Element 6. The Minimum Protocol was developed specifically as a quick inventory tool which gathers the most basic information necessary to understand the condition of a campsite. The primary advantage of the Minimum Protocol is that the assessment at each site takes less time, making a census inventory of campsites realistic for small wilderness inventory teams. The Minimum Protocol is an accurate and precise, scientific tool for measuring camping impacts. The minimum protocol is not sensitive, and lacks some utility for understanding changes that are occurring at the site. Although the Minimum Protocol does not have as much utility for analyzing small changes at individual sites, it is a useful tool for understanding the changes occurring at a larger, landscape level in the wilderness. Table 2 compares the Minimum Protocol to the other assessment systems reviewed in this document.

**Table 2** This table compares common monitoring systems to the Minimum Protocol

| Monitoring System | Accuracy | Precision | Sensitivity | Amount of Information | Cost |
|---|---|---|---|---|---|
| **Frissell** | Mod. | High | Mod. Low | Low | Low |
| **Cole** | High | High | High | High | High |
| **Modified Cole** | Mod. High | Mod | Mod | High | Mod. Low |
| **Minimum Protocol** | Mod. High | High | Mod. Low | Mod | Low |

## DECIDING WHICH SURVEY TECHNIQUE TO USE

The Element 6 challenge does not mandate the use of any particular survey system, just that the wilderness is census surveyed and that certain data, such as a location and description of the sites condition, is gathered and recorded in a database. Given all the choices of systems for assessing campsite condition, the choice of an appropriate monitoring scheme can be difficult. Regardless of which technique is used, the survey should conform to the following standards (Emerich, 2008):

1. The survey must be a census of all likely sites, including trace sites. It is not sufficient to monitor only a sample of campsites in an area
2. All likely locations in the entire wilderness must be visited (95%)
3. Partial credit can be obtained for a census of a portion of the wilderness.
4. Data no older than 5 years is recommended, and it is recommended to re-inventory sites every 5 years
5. Data for each site must include:
    - A. Location (GPS coordinates, UTM NAD83)
    - B. Photo(s)
    - C. Campsite condition
    - D. Presence / absence of administrative structures. (These are structures installed by the USFS)

The protocol for recreation site inventories may not require managers to implement any particular field inventory method, however it does require managers to census all campsites. Completing a census inventory earns six points for Element 6. The census survey of a wilderness can be an exhausting task, requiring teams to visit a large portion of the wilderness. Although the data collection process is extensive, census inventories of recreation sites are an important part of wilderness inventory, monitoring and management. The information gathered during census inventories is useful to managers for several reasons. First, managers can gain an understanding of the location and magnitude of recreation impacts in wilderness. This information will allow management to create plans which protect wilderness character. The data collected during the survey may allow management to better create and understand the true Wilderness Recreation Opportunity Spectrum (WROS) in a given unit. Using this information, managers can protect opportunities for solitude. The data will also empower managers to develop efficient restoration plans and assess the need for designating sites or implementing permit and quota systems.

There are several primary considerations when determining which survey technique will provide the results that management is interested in. Different surveys gather different kinds of information (Cole, 1989). It is important to think about how the information gathered will be used. Several questions should be asked before committing to a protocol: (1) is it the goal of the inventory to understand trends in individual sites, or trends across the landscape? (2) Is management interested in knowing the location and magnitude of impacts in the wilderness, or understanding what is causing the impact? There is a temptation to gather additional information because it may be used for some purpose in the future. Though gathering additional information while you are at a site might be tempting, it also takes time to record. Additional time spent at each site means less time searching the area for further impacts. In any case, the kind of data gathered and how it will be used is an important consideration for deciding which survey format to use. The cost and time allotted for surveys will change between districts. This guidebook recommends employing a 'Pyramid' approach to conducting campsite searches, using available resources at the ranger district level to complete the most comprehensive survey possible (Figure 1).

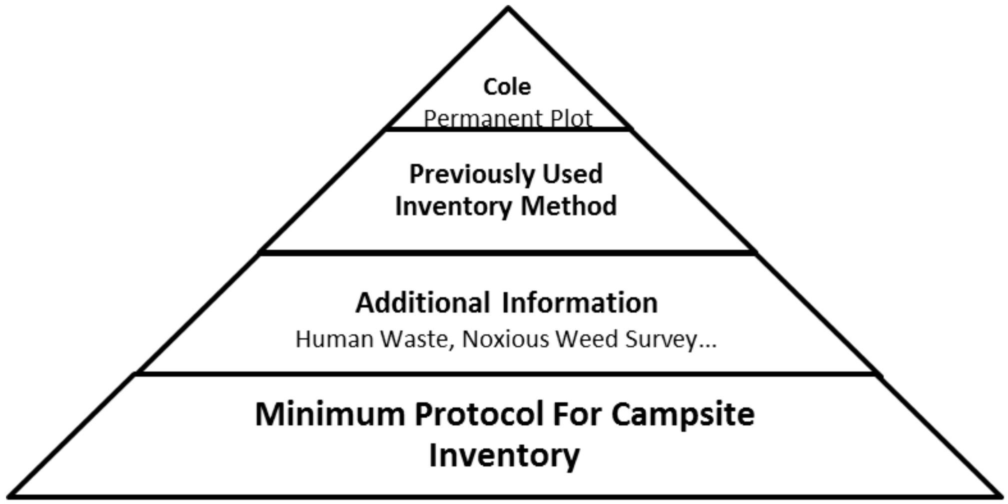



**Figure 1** This figure represents the pyramid sampling scheme. Managers should, as a baseline minimum, inventory sites using the Minimum Protocol during a census survey. As time allows, additional information may be collected.

Using the Minimum Protocol alone will satisfy the requirements of Element 6. A major advantage of using the Minimum Protocol is the ability to quickly assess sites and complete census surveys. Completing a census survey of the wilderness may better reflect the impact and use in all management zones. Any previous monitoring surveys completed only in high use zones do not provide the information needed to protect solitude and pristine conditions in less used areas. If management chooses to continue using past survey techniques, **it is recommended to complete a Minimum Protocol survey in addition to other surveys**. The Minimum Protocol can provide beneficial information depending on the survey being used. If the wilderness unit is inventoried with the Frissell survey, the Minimum Protocol will add additional information because it is an index survey, which separately measures factors. If the Cole or Modified Cole is used, filling out the Minimum Protocol sheet will only take 2-3 additional minutes at each site. Completing the Minimum Protocol in addition to other surveys will help to create a region wide data set of camping impacts. Standardized inventories allow for regional level analysis of factors related to camping impacts, as well as the ability to prioritize management at larger scales. Consistency of campsite assessment methods may also assist in single unit wilderness management efforts. Most wilderness areas cross district boundaries, and it is important that management teams for each unit are using the same inventory techniques throughout the wilderness. Completing the Minimum Protocol will benefiting the regional database while simultaneously collecting the information needed at the district. The Minimum Protocol is the foundation of the pyramid, and should be completed prior to other surveys.

In addition to the Minimum Protocol for Campsite Assessments, the WAG and ALWRI recommend collecting additional information at the campsite. The amount of additional information will vary depending on the time allotted at each site, the unique needs of the wilderness, and requirements from the Forest Plan. Recommended additional information can be found in section 4.13 of this guidebook. Additional information is the second layer of the pyramid, and should be collected following the Minimum Protocol.

The Minimum Protocol for site inventories is a new analysis technique, so most wilderness units have likely been inventoried using Frissell, Modified Cole or other older monitoring system. If staffing and budget allows, it may be desirable continue to use the inventory method used in past, particularly if management plans on using past data to analyze changes in wilderness condition over time. Additionally, it may be important to continue using existing inventory methods to collect information needed to meet existing Forest Plan or Wilderness Plan indicators and standards. Using inventory methods such as Frissell and Modified Cole would be the third layer of the pyramid, collected after the minimum protocol inventory and other useful information has been collected.

If management is interested in understanding what changes are occurring to an individual site, a Cole survey, or similar 'permanent plot' method is recommended. Cole surveys garner precise, accurate information that is sensitive to site level changes, and generally take around one to two hours to complete at each site. This approach for sampling sites is not recommended for census surveys. If Cole surveys are to be used to determine population parameters, randomized sampling schemes may be necessary. Appropriate sampling schemes take some thought to implement, particularly if management is interested in using statistics to predict the total number of sites or how impacted a wilderness is based on a sample of sites. A Cole survey is most useful for tracking changes at designated sites, or in popular basins. It is recommended that managers implement this technique in addition to an index or condition class estimate. This would be the top layer of the pyramid; and collected after all other information is collected at the site.

Although this guidebook recommends collecting information in the order identified above, this may not fit the needs of all wilderness curriculum. Surveys which collect necessary information for the management of the wilderness, following guidelines from the Forest and Wilderness Plan, can take many forms. Regardless of the system which is chosen, it is important that efforts are made to implement survey systems that are standardized across district, forest and regional boundaries as best as possible. Tools such as the Minimum Protocol may be useful in this effort, and communication across management boundaries is critical for determining the appropriate survey method to use.

## PREPARATION AND PLANNING FOR THE FIELD

Budgeting for survey crews is an important aspect of planning. Also, proper preparation and planning for the field is critical to completing surveys in the most efficient and safest manner possible. This section provides an overview of considerations for budgeting searches as well as tools that can be used to determine which areas to focus campsite searches. This section also includes some tips for effectively planning surveys and conducting tailgate safety sessions.

## BUDGETING ELEMENT SIX SURVEYS

The budget for census campsite surveys will vary depending on several factors. Along with the size of the wilderness area, the total area necessary to survey must be taken into consideration. Open, park like areas with available water sources will have many potential camping areas that need to be searched. Rocky, steep areas will have less area likely for camping. Aside from terrain and campsite likeliness, the popularity of an area will need to be accounted for. Popular basins frequently have many campsites that require a survey. More campsites will necessitate more time spent in each area. In a typical day, surveyors will hike four to 15 miles, depending on the terrain and amount of campsites encountered. Although fit crews can put in up to 20 miles of hiking in a day, it is recommended that survey teams try to hike 10 miles or less in a 10 hour day due to the effects of fatigue over multiple days in the field. Time for breaks and site surveys, as well as difficult hiking conditions must be accounted for.

The amount of area that needs to be searched can vary from wilderness to wilderness. In the case of the Greenhorn Mountain Wilderness, in south-central Colorado, it was determined that 3,017 acres of the wilderness needed to be surveyed to complete a census. Greenhorn Mountain Wilderness is a steep rocky wilderness with low use levels. To complete surveys, a team of two wilderness rangers hiked 51 miles over four days, averaging 12.75 miles a day. The team completed a census survey of most of the 23,087 acre wilderness in a four day period.

In another case, three teams of two surveyors completed 95% of the Platte River and Savage Run Wildernesses, located in north-central Wyoming, in four 10 hour days. Analysis prior to the surveys concluded that 2,815 acres of the wilderness needed to be surveyed. In this case teams hiked an average of 13 miles a day and completed a census survey of 95% of the 23,290 acre Platte River Wilderness and the entire 15,264 acre Savage Run Wilderness. Surveyors in these wilderness areas were able to hike more miles and survey more acres per day than average do to the relative low use of the areas.

In the case of the high use Conundrum Valley in the Maroon Bells-Snowmass Wilderness, in central Colorado, surveyors were impeded by the need to survey a high density of sites and search more area relative to the total size of the valley. In this case, surveyors needed to search 1,100 acres of the 2,500 acre valley. In the Conundrum Valley, a team of two surveyors were able to hike 28 miles over four 10 hour days, averaging just 7 miles per day. On one day, the team was only able to hike 4 miles, and surveyed 45 sites. Further slowing the process, campsite proliferation in the popular valley has resulted in campsite occurrence in areas considered less likely to have campsite impacts.

On average, teams can search 200 to 700 acres of wilderness in a day. The area of wilderness that needs to be surveyed must be accounted for prior to surveys in order to better budget survey teams. The amount of area needed to survey in a given wilderness can vary from five to 30%. Section 3.2 overviews some methods for determining areas to search. Remember that survey time can vary due to weather and hiking conditions as well as experience and fitness of the surveyor.

The cost of a surveyor per day varies with the pay grade of the surveyor. Often times, volunteers and interns can be used which will save money. A consideration when developing a survey team is that surveyors will become faster as they gain experience in inventory methods and techniques.

## DETERMINING AREAS TO SURVEY

Understanding the landscape attributes that influence the distribution of campsites is important to effectively planning field surveys. Management needs to determine which areas to inventory in order to fulfill the 95% criteria. As written, the 95% rule appears to suggest that teams need to search in 95% of the wilderness. This is incorrect. The goal is to find most of the camping impacts in a wilderness, perhaps 95%. Ninety five percent of campsites are likely to be found in less than 10% of the wilderness. The goal of management is to survey most, but not necessarily all, of the places where campsites are likely to be found. This section reviews the factors that affect campsite location, and overviews an example of a tool which can help managers strategically plan searches.

### *Factors that Affect Camping Location*

The potential area where people are capable of camping in a wilderness is expansive. Recreation activities such as rafting and kayaking, hunting, and climbing often result in people camping in remote areas that may be difficult to find. Local knowledge of the wilderness is an indispensible tool for finding these sites. Also, understanding the landscape attributes which influence the spatial distribution of camping impacts is critical to effectively planning field surveys.

Although finding all of the impacts in the wilderness may be difficult or impossible, determining a search area that incorporates 95% of the likely areas is feasible. This is because most people camping in the wilderness are seeking certain areas to camp. The locations that people choose to camp involve a number of factors. Some of the factors that affect campsite choice relate to biological needs. People are generally limited by the amount of weight they carry and will often search out water sources to spend the night near. Off-trail hiking requires a greater amount of energy. People will often camp near trails (Clark, 1987). Also, people will have a tendency to camp in areas that are comfortable, generally avoiding exposed ridges and seeking out cover near trees.

Aside from selecting sites based on biophysical needs, people will often choose sites based on tastes and preferences. Several studies have identified that people enjoy camping near large bodies of water (Hamilton, 1996). People also gravitate toward attractive places such as scenic vistas or points of interest (Bresson, 1996). Research has found that people will generally find areas with cover in-between sites, and have a tendency to prefer eco-tones such as the edge of the forest (Clark, 1987). Other selection criterions are influenced by the principles of “Leave No Trace”, and laws and regulations from the Forest Service, such as not camping within 100 ft. of a stream, lake or trail.

*Likely Camping Maps for Planning Logistics*

Maps defining areas likely to contain camping impacts have been developed for Region 2 of the USFS. These maps have been created by comparing two methods using ArcGIS to model and map likely camping areas. First, Ralph Bradt and the author used an approach common in the field of wildlife biology to develop and index of “Camping Habitat.” A thorough review of the literature revealed that many habitat concepts and attributes can be used to create a “Campsite Suitability Index” for wilderness camping (Chapter 3). For the R2 mapping effort, the Campsite Suitability Index focused on landscape, or topographic, scale features that allow for the development of a generalized search protocol useful at the regional or national level. Based on a literature review, the attributes chosen to develop the Likely Sites Index were: (1) Trails, (2) Roads, (3) Streams, (4) Slope, and (5) access to lake. These attributes were chosen to model campsites at the landscape, or topographic level. Even though wilderness areas do not have roads, areas where roads border the wilderness are accounted for in the model. Streams and lakes are treated as separate variables due to the importance of lakes as a destination for backpackers in the wilderness. Other environmental factors, such as cover and distance from ecotones, are known to influence camping behavior. These factors were discounted from the topographic scale model due to a lack of accurate data, but may be used in future modeling efforts to better understand campsite location related to small scale landscape features.

Based on local knowledge from regional and district level Forest Service staff, values were determined for rating and weighting the variables used for the Campsite Suitability Index. The highest rating was given to the areas directly adjacent to trails, streams, lakes, and roads. Low values for campsite likelihood was assigned to areas located more than a half mile away from a lake, stream, trail or road. The variables were then equally weighted and an algorithm was developed based on the attribute indices (Section 3.3). Using ArcGIS software, a model was created which outputs a mapping layer representing the Likely Campsites Index (Figure 2)

The Likely Sites Index was compared to an approach which utilized modeling software called Maxent in an effort to better understand the relationship between camping impacts and spatial attributes such as streams, lakes, roads, and trail systems. Both models were validated with camping data, and both models performed well. A comparative analysis of the two methods determined that the Maxent and Likely Sites Index performed similarly in terms of minimizing search area while maintaining the area necessary to incorporate 95% of the campsites from an independent data set. Although the modeling software produced a slightly more efficient map, the Likely Sites Index did perform well compared with test data (Section 3.4). This approach can be implemented by GIS professionals in other Forest Service Regions. More technical information can be found on using these approaches by contacting the author.

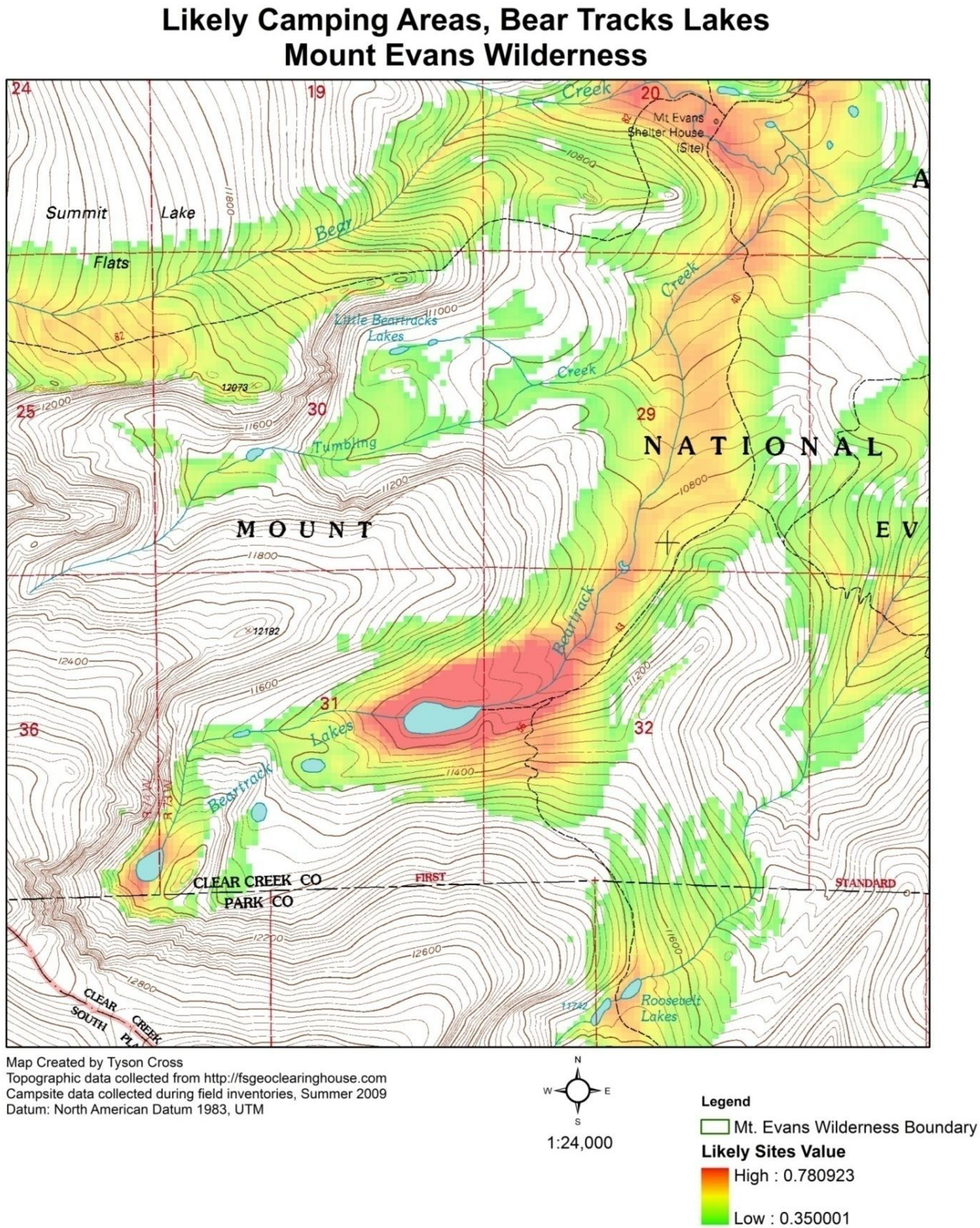



**Figure 2** This figure shows the Likely Campsites Index. Areas in red are highly likely to have camping impacts, while areas in green are unlikely. A study with independent data showed that 95% of camping impacts are located in the colored areas (Section 3.4).

## STRATEGIZING SEARCHES

### *Using Likely Campsite Maps to Plan Searches*

Completing logistics and planning surveys is an important step in any successful inventory. Prior to implementing searches, plan the logistics and routes surveyors will take. Map out areas that need to be surveyed, and try to determine the amount of time that each area will take to survey, accounting for difficulty of travel and amount of sites that may be encountered. Plan ahead and anticipate shuttles and food drops. If surveyors will be in remote areas, consider using stock to create a base camp.

Keep in mind that plans do not always work out in the field and have to be adjusted according to weather and other hazards. Organizing multiple search teams can be difficult logistically. The more preparation and planning work that is done, the smoother and safer surveys will be.

## INVENTORY SAFETY AND JOB HAZARD ANALYSIS

Census surveys require strenuous hiking which is frequently in remote, off trail wilderness settings. Planning and preparation are important for completing surveys safely. Fitness and wilderness knowledge are critical to any ranger or volunteer in the field. Make sure that surveyors are fully prepared to stay the night if they get injured or lost. Also, when working in groups, make sure to have a place to meet if surveyors get separated. Several sample Job Hazard Analysis (JHA) forms have been attached to this document (Appendix C). A JHA needs to be completed and signed during tailgate safety sessions prior to the implementation of field surveys. The attached JHA's should provide a starting point for creating a JHA for recreation site inventory work.

## NECESSARY SURVEY GEAR

A checklist of necessary field gear is included (Figure 3). The checklist includes survey work essentials, general day pack items and camping items. Some of the essential items to remember are a GPS unit, digital camera with an extra flash card, a metal clipboard, and writing tools. **Bring a copy of the Guide to Minimum Protocol, by Dr. David Cole, into the field (Appendix D)**. If inventories are being completed using other assessment methods, bring a guide for those methods as well. Also, **bring extra batteries into the field.** Running out of batteries for the GPS unit or camera will result in the inability to finish surveying. Most digital cameras require special batteries. If extra batteries for a digital camera are too expensive or unavailable, bringing a disposable camera is a good backup strategy.

In addition to these items, it is recommended that surveyors consider bringing a small Dry Erase Board and erasable pen into the field. While this extra gear may seem cumbersome, it provides a good way to imprint photos with the campsite number. It would be unfortunate to get back to the office and not know what photos are tied to which campsite.

## Rapid Assessment Gear List

| | RA Work Essentials | | General Day Pack Items | | Camping Items |
|---|---|---|---|---|---|
| ☐ | GPS unit | ☐ | Day Pack | ☐ | Sleeping Bag |
| ☐ | Digital Camera with extra flash card | ☐ | First Aid Kit | ☐ | Sleeping Pad |
| ☐ | Extra Batteries for GPS & Camera | ☐ | Rain Gear | ☐ | Tent, Bivy or Shelter, Ground Cloth |
| ☐ | Metal Clipboard (rain protection) | ☐ | Hat, Ball Cap | ☐ | Camp Stove & Fuel |
| ☐ | Pens, Pencils and Magic Markers | ☐ | Map & Compass | ☐ | Layers of Waterproof & Windblock Garments |
| ☐ | White Board, Field book (optional) | ☐ | Radio, Cell Phone, SPOT | ☐ | Waterproof & Windblock Gloves and Liners |
| ☐ | Rapid Assessment Evaluation Forms | ☐ | Water Bottle & Water | ☐ | Extra Dry Socks |
| ☐ | "Likely Campsite" map | ☐ | Water Filter/Purifying Tabs | ☐ | Gaiters |
| ☐ | Cord – to measure 250 sq. ft. | ☐ | Emerg. Blanket/Duct Tape | ☐ | Headlamp & Flashlight |
| ☐ | Work Gloves | ☐ | Sunblock & Sunglasses | ☐ | |
| ☐ | Small Litter Bag | ☐ | Whistle/Lip Balm | ☐ | |
| ☐ | FS Uniform (if protocol) | ☐ | T.P. & Towel | ☐ | |
| ☐ | Binoculars | ☐ | Insect Repellant | ☐ | |

**Figure 3** This is a list of recommended gear to bring into the field during surveys

## USING THE MINIMUM PROTOCOL FOR CAMPSITE ASSESSMENT

### INTRODUCTION TO THE PROTOCOL

This section includes a detailed explanation of the Minimum Protocol for Campsite Inventories. This information is a supplement to the original guidebook written by Dr. David Cole, Researcher at the Aldo Leopold National Wilderness Research Institute. This is not a replacement of the guidebook; however the incorporation of pictures will help managers interested in training rangers and volunteers. In order to better illustrate the Minimum Protocol for Campsite Assessment, the inventory form is presented below (Figure 4). The steps below review each part of the inventory form. Addition inventory forms can be found in Appendix F, and as well as a cheat sheet which can be take into the field (Appendix G).

**WILDERNESS CAMPSITE INVENTORY FORM**

**Campsite Number:**______________________________

**Recorder(s):**_________________________ **Date:** ______________

**GPS Coordinates: UTM:** __ __ __ . __ __ __ **E** __ __ __ __ . __ __ __ **N** **Legal Site (Y/N):**____

**Location Description:**______________________________________________

**Photo Azimuth**_____________ **Photo Description:**_________________________

***Optional Information***

| **Litter:** None, Some, Abundant | **Human Waste:** None, Some, Abundant | **Noxious Weeds:** Y/N | **User Developed Trails:** Y/N | **User Created Structures** (list type and number) |
|---|---|---|---|---|
| | | | | |

***Rapid Assessment Required Data***

| **Ground Disturbance Rating** (0-4) *0 = Trace | **Tree Damage Rating** (0-2) | **Disturbed Area Rating** (0-2) | **Overall Impact Rating** (0-8) | **Administrative Structures** (list type and number or n/a if none are provided) |
|---|---|---|---|---|
| | | | | |

**WORK COMPLETED/REMARKS:**

**Figure 4** This is an example of the form used for completing Minimum Protocol for Campsite Assessment surveys.

## CAMPSITE NUMBER

There are two approaches to numbering a campsite. These approaches have been developed to work with the Infra-WILD database. **To number a campsite:**

1. The first number is the three digit Infra-WILD number of your wilderness.
2. There are two options for the second digit. Either:
   a. Use the four digit trail number from Infra-WILD

   or

   b. Use the name of the drainage
3. The third digit is the campsite number

**Example**: 124-4560-001 (Lost Creek Wilderness, Hells Hole Trail, campsite #001). The site number is somewhat arbitrary, but is important for consistent photo points (explained below). Number the sites in the order you find them.

***Other approaches to naming sites may be used; however the first part of the campsite number must be the Infra-WILD Wilderness ID number.**

## SITE LOCATION; GPS COORDINATES

There are two key aspects to recording campsite location. The location should be in a **UTM** projection, and must be in **NAD83** datum. An appendix on GPS basic (appendix E) has additional information explaining projections and datum's. **The settings UTM and NAD83 are generally not the default for GPS units**.

***If the wrong datum is used in the field, do not throw out the data. Simply write the datum that was used next to the space on the inventory form for the coordinates. Datum's can be transformed by a specialist using ArcGIS software. However, if the wrong datum is used and not kept track of, the UTM points could be hundreds of feet off.**

In some cases, et may be difficult to obtain a GPS coordinate for a site due to a poor GPS signal. If this is because of weather, wait to continue surveys. If the GPS is unable to generate a location because of steep canyon walls or dense canopy, there are two options:

1. The first, and preferred method, is to find a spot near the campsite where the unit works. From here record the point, and then take an azimuth to the center of the site. Pace to the center of the site. Record this information in the Work Completed/Remarks section.
2. The second option is to estimate and mark the location on a topographic map.

LEGAL SITE (Y/N)

Many wilderness areas have special orders which specify where camping can occur. These special orders do not exist in all wilderness areas and are not standardized. However, it is generally illegal in wilderness to camp within 100 ft. of a body of water or a trail. In some cases, campers must stay in designated sites, or have a permit for camping. It is important that the surveyors know the regulations of the wilderness area. This information is important, and illegal sites can later be queried and identified in a GIS database for management purposes.

LOCATION DESCRIPTION

The location description is generally a physical description of the site. The location description is a key aspect for relocating the sites in the future and supplements the GPS point. The goal is to write something unique about the site. For example:

*On the north east shore of Deadmans Lake near a large boulder.*

*or*

*In-between the Conundrum trail and Conundrum creek, in a clump of trees south of a meadow*

PHOTOGRAPHS

Photographs are important for several reasons, and are a good supplement to the rating of a camp site. Photographs will not only help with relocating the site in the future, but can also be used in the office to gain an understanding of the condition of the site. A good photo point will include some aspect of the site that is unique and semi-permanent, for example; large boulders, scarred or prominent trees, stumps and background features. Here are some suggestions:

- Take a Dry Erase Board and erasable pen into the field. Write the name of the site on the board and include it in the picture. This is a method of permanently imprinting the site number into the photo.
- If using a dry erase board is not an option, take a photo of the inventory form before the picture of the site, or vice versa. The key is to be consistent with the approach.

- When taking more than one picture, make field notes to indicate the number of photos and distances.
- Another good rule-of-thumb is to always shoot photos back to the trail and camera lens to the campsite. This improves the chances of finding the photo-point in five years.

## ASSESSING THE CAMPSITE

The Minimum Protocol uses an index to independently evaluate three criteria related to camping impacts; (1) groundcover disturbance of the main campsite, (2) impact to standing trees and roots, and (3) the size of the disturbed area (including satellite tent pads and stock-holding areas). These impacts often vary independently, and set a baseline for understanding the impact at a site.

### *Ground Cover Disturbance*

The ground cover disturbance rating focuses on the size and disturbance of the bare area at the center of the site. Mid points may be used when the condition of a site is close to the boundary of two classes. If midpoints are used, make sure to use only a midpoint, and not other decimals (i.e. 2.5, not 2.3). As an option, management may want to rate campsites which have fully recovered. Sites which do not show signs of camping, but are known to exist can be rated as 0. There are two reasons for the 0 rating. First, the site may have recovered since the previous inventory, which is important information to record. Without tracking the site, management will not know if the site was missed during the inventory, or if it has recovered. The second reason that a 0 rating is a useful option is because a site may be impacted in the future by camping, and managers can track the site as it changes. The ratings for ground cover disturbance are:

1- Ground vegetation flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace.
2- Ground vegetation worn away around fireplace or center of activity.
3- Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas.
4- Bare mineral soil widespread over most of the campsite.

There are several rules of thumb for assessing the bare area:

1- If there is very little bare area (area void of natural vegetation) then assign a rating of 1 (Figure 5, Figure 6).
2- If the bare area extends out somewhat from the fire ring, but a single 2 person tent would not fit on the bare area, assign the site with a 2 (Figure 7).
3- If the bare area extending out from the center of activity is large enough to accommodate more than one 2 person tent, assign it a 3 (Figure 8).
4- If the bare area extending out from the center of activity is large enough to accommodate more than one 2 person tent, AND the area is void of humus/litter, assign it a 4. Humus and litter are associated with the 1$^{st}$ layer of organic material. This layer is generally darker, and fluffier than the hard packed, light color of mineral soil (Figure 9).

**Figure 5** This is an example of a level 1 site. There is minimal damage to this site, other than a rock fireplace.

**Figure 6** This is another example of a level 1 site. There is very little ground cover disturbed here accept for a rock fire place

**Figure 7** This is an example of a level 2 site. The bare area of this site extends out beyond the rock fire ring, but there is not an area large enough to put a tent. This site may also be rated as a 2.5, but is not a level 3 site.

**Figure 8** This is an example of a level 3 site. Ground cover is disturbed, and vegetation throughout the site has been removed. This is not a level four site because organic material covers the site.

**Figure 9** This is an example of a level 4 site. The ground cover is completely removed from the center of the site, and compacted bare mineral soil is spread throughout the site.

*Special Situations Involving Ground Cover Disturbance*

Three situations may be encountered in Region 2 that require adaptation of the ground cover disturbance rating. This section reviews how to rate ground cover when special situations are encountered. One situation that may be common to R2 is an area with little perennial vegetation but organic horizons remain. This category is common in densely forested ecosystems, where little light reaches the forest floor to support perennial groundcover vegetation (Figure 10). In this situation, rate as follows:

1- Evidence of camping but minimal physical change except for possibly a simple rock fireplace.

2- Soil litter/duff removed with soil compaction extending out from center of activity, but not enough to accommodate a two person tent.

3- Soil litter/duff removed with soil compaction extending out from the center of activity, but exposed bare mineral soil only in a few spots.

4- Soil litter/duff removed with bare mineral soil spread throughout the site.

**Figure 10** This is an example of a special situation involving ground cover disturbance. In this situation, there is very little natural perennial vegetation. In this case, a close examination of the center of the site will provide the information needed to rate the site. The area of this site encircled in black, with the arrow pointing to it, is highly compacted. The natural litter is worn away at the center of the site, as well. In this situation, the groundcover disturbance does not extend out much past the center of the site, and is given a rating of one.

The second situation lacks both perennial vegetation and organic horizons, such as a desert ecosystem. These systems may still have cryptobiotic soils (living soils) present. In this situation, rate as follows:

1- Evidence of camping but minimal physical change except for a simple rock fire place.

2- Soil surface flattened (for the long-term), around center of activity.

3- Soil surface flattened (for the long-term) on most of the site, but exposed mineral soil not highly compacted except in a few areas.

4- Mineral soil exposed and highly compacted (to a cement-like state) over most of the campsite.

***In any situation where the site has no vegetation or consolidated soil, such as beaches, dry washes or rocky ledges, the site will always get a rating of 0 or 1.**

TREE DAMAGE

Trees are only counted if they are considered severely damaged. In order to count, the damage must have been caused by a camping activity. If it is not certain whether or not the damage is camping related, err on the side of not counting the impact. Trees on site and trees that were damaged in association with the site will be counted.

***It is critical to use the definition of a 'severely damaged tree' described below. There is a tendency to incorporate trees that have ugly scars, pruning and nails in them, even though they do not fit the above definition. The validity of the survey depends on avoiding this tendency.**

A tree that is severely damaged is a tree that:

A- Has been felled and is larger than 4 inches Diameter at Breast Height (DBH). If a tree has multiple stems, then count any stem that has been felled and is greater than 4 inches DBH. Pruning (cutting branches) does not count.

B- Has scarring that exceeds 1 square foot (Figure 12).

C- Has more than three feet of root exposure. The roots must stick out of the ground at least 1 inch (Figure 11).

D- Any size Krumholtz tree or stem that has been cut down. Krumholtz are trees in the high alpine that are dwarfed do to harsh alpine growing conditions, rarely growing over 8ft. tall. Krumholtz can be any species of tree found in the high alpine (Englemenn Spruce, Subalpine Fir, Limber Pine etc.). These trees are often found in matted clumps, and frequently have flagged stems (Figure 13)

*__Region 2 only__

Assign tree damage to one of the following classes:

0- Less than 4 severely damaged trees.

1- 4 to 10 severely damaged trees.

2- More than 10 severely damaged trees.

**Figure 11** This is an example of root exposure caused by camping activities. Black arrows point to the areas where roots have been exposed. Roots must rise one inch out of the ground, and have three feet of exposure to count as a severely damaged tree. Although two roots count in this scenario, only one tree is counted as severely damaged because the roots are part of the same tree.

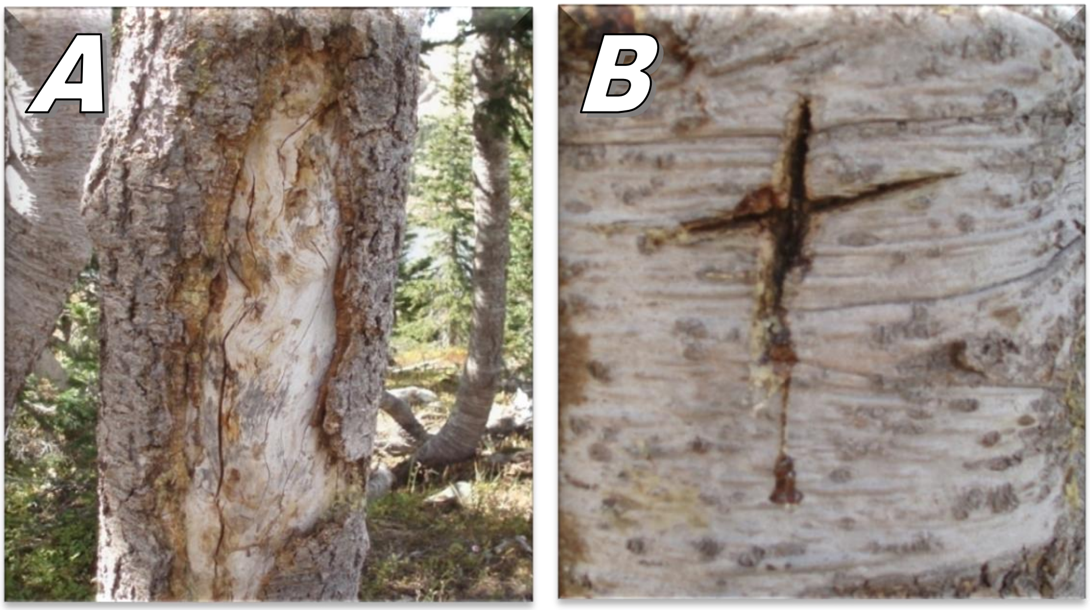



**Figure 12 A;** The scars on this tree are larger than one square foot, however there are not any objective indications that the cause of damage was camping activity, so this tree is not counted. **B;** The scar on this tree is not pleasant to look at, however there is not one square foot of scaring, so this tree is not counted.

**Figure 13** The black arrow in this photo points to krumholtz trees. These ancient trees, although small, can be very old. In Region 2, krumholtz are counted if they have been cut down, regardless of the size.

## DISTURBED AREA RATING

The disturbed area is a measurement of the total area disturbed by camping activities. This includes the main campsite, satellite tent pads, areas where horses are confined, and boat landings. This area is defined by obvious vegetative loss (either partial or complete, Figure 14). When assessing the disturbed areas, **do not include areas where the vegetation has been affected but is likely to recover in the short term.** For the disturbed area rating, measure the area of each part of the campsite separately, and then add up the total area. **Do not include the social trails, or areas in-between disturbed parts of the campsite in the total.** The classes for disturbed area are:

0- Less than 250 $ft^2$

1- 251 - 1000 $ft^2$

2- more than 1000 $ft^2$

***When determining ground cover disturbance and disturbed area, the surveyor should examine what is 'normal' for the ecosystem. The surveyor should pay close attention to the areas that are not disturbed by camping. Keeping track of what kind of vegetation is naturally present will allow the surveyor to determine if an area has been disturbed by camping, or is in a natural state.**

### *Special Situations Involving Disturbed Area*

Special situations exist for the disturbed area rating (Figure 15). The following two situations require an adaptation of the protocol for disturbed area:

- In an area with little perennial vegetation, but with organic horizons, such as the lodgepole pine forest, or a dense forest understory, the definition of disturbed area must be related to the natural state. In these situations, look for where the forest litter has been disturbed, and soils have been impacted

- In areas where there is a lack of perennial vegetation and a lack of organic horizons, look for areas where the soil has been compacted in the long term.

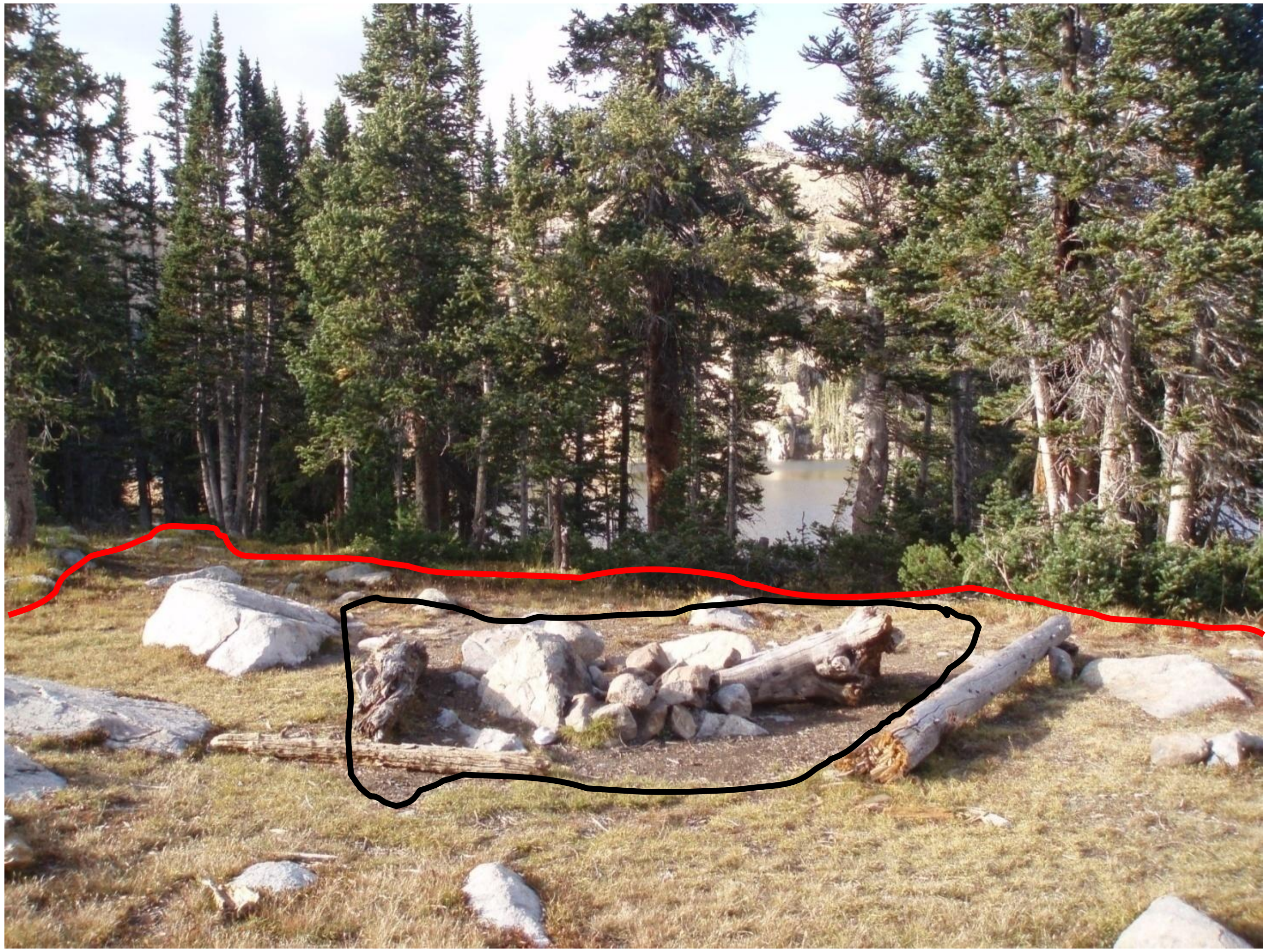


**Figure 14** This photo is meant to show the difference between ground cover disturbance and total disturbed area ratings. Only the area within the black circle is counted for ground cover disturbance, while all of the area within the red boundary counts as disturbed area.

**Figure 15** This photo illustrates how determine disturbed area when there is litter present, but in the absence of perennial vegetation. The red line indicates the area that is counted for the disturbed area rating. It is important to look at what is natural for the area in order to tell what part is disturbed.

## OVERALL IMPACT RATING

The overall impact rating is calculated by adding up the ground cover, tree damage, and disturbed area ratings. This sum is the overall impact rating and ranges from 0 to 8.

## ADMINISTRATIVE STRUCTURES

Administrative Structures are structures placed and maintained by the USFS. This does not include user built structures. Administrative Structures are rare in Region 2 wilderness areas. If a structure exists, include the number and type of structure. Common administrative structures are corrals, tables, toilets, fireplaces and the like. If administrative structures are common in the wilderness, it may be necessary to complete a more involved assessment of the condition of the structures.

## RECOMMENDED ADDITIONAL INFORMATION

The form created specifically for surveys in R2 includes several, but not all, of the additional procedures recommended by the USFS. This information is not required to meet the minimum of the 10YWSC, but is quick to gather and is helpful to management efforts. Some additional information recommended to collect is:

- Presence and relative amount of litter
- Presence and relative amount of human waste
- Presence of invasive weeds
- Presence of user developed trails
- Presence and type of user created structures

***Training staff to complete more detailed invasive species and trails surveys is recommended. The census survey nature of the Element 6 challenge requires surveyors to visit remote areas of the wilderness. If properly trained, a plethora of additional information can be gathered during these surveys.**

## MINIMUM PROTOCOL TIPS

Here are some suggestions for completing Minimum Protocol inventories:

- Keep the backpack on. The main advantage of the Minimum Protocol is that it can be used to gather the critical information about a site in 2-3 minutes. The rapid assessment approach to inventorying campsites allows for more time searching, finding and inventorying new sites.

- Leave the GPS unit on. While leaving the GPS unit on all day can use up battery power, it has several advantages. Every time a GPS unit is restarted, it needs to locate satellites and calculate its position. Determining an accurate position for the GPS unit can take more time than assessing the site. The speed and accuracy of the unit will depend on the model. Another advantage to leaving the GPS unit on is that the surveyor can save the route they took, which can later be analyzed to determine, more accurately, the areas that was searched.

- During inclement weather, use a field notebook. Do not let inclement weather stop a survey...unless it a matter of safety. Use a waterproof field notebook and a pencil/waterproof pen. Make a column for each piece of information in the survey. Take a photo of the notebook, followed by a picture of the site to keep track of photos.

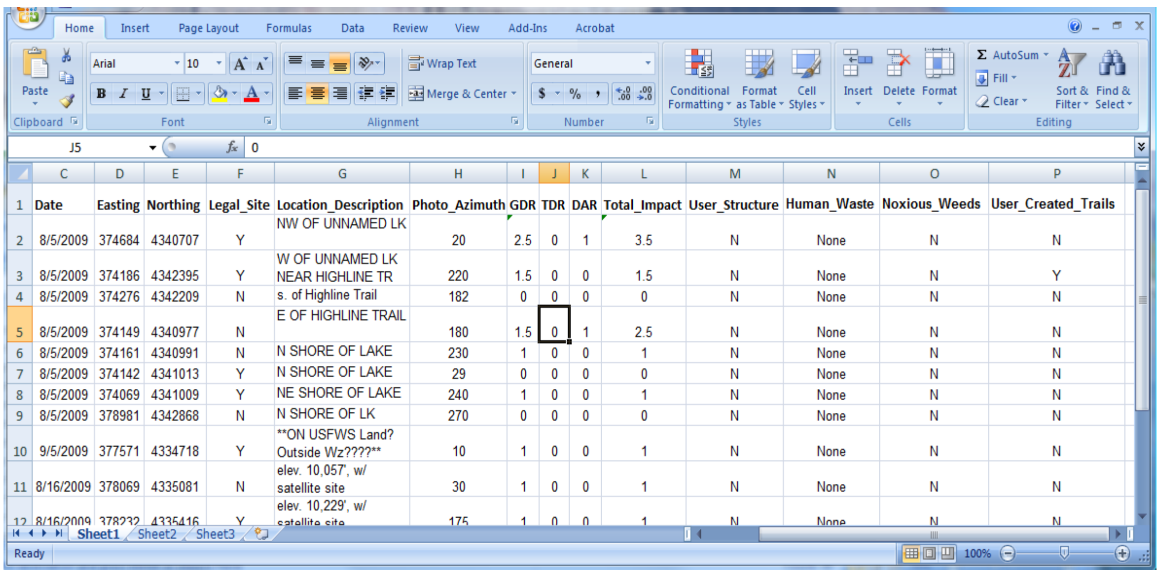
## BACK IN THE OFFICE

### INPUTTING DATA AND KEEPING TRACKS

Displaying the data and creating tracks of campsite searches is an important step in the process of utilizing data that has been collected. This section provides a brief overview of ways that data can be input into a usable format. This step is an important part of Element 6, as inputting data into one of these file formats earns eight points.

*Inputting Data into a Spreadsheet*

It recommended that data collected in the field be input into an Excel spread sheet (Figure 16). This simple step is important for many reasons, and is the first step in making the data useful and accessible. Inputting data into excel will provide a copy of the data, and also allow data to be input into ArcGIS and represented spatially. The key to entering data into a spreadsheet is to keep it simple. Comma-Separated Value (CSV's) files can be made from a simple spreadsheet with a header text row and values in the columns. CSV files interface with ArcGIS as well as many statistical analysis software packages.



| Date | Easting | Northing | Legal_Site | Location_Description | Photo_Azimuth | GDR | TDR | DAR | Total_Impact | User_Structure | Human_Waste | Noxious_Weeds | User_Created_Trails |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/5/2009 | 374684 | 4340707 | Y | NW OF UNNAMED LK | 20 | 2.5 | 0 | 1 | 3.5 | N | None | N | N |
| 8/5/2009 | 374186 | 4342395 | Y | W OF UNNAMED LK NEAR HIGHLINE TR | 220 | 1.5 | 0 | 0 | 1.5 | N | None | N | Y |
| 8/5/2009 | 374276 | 4342209 | N | s. of Highline Trail | 182 | 0 | 0 | 0 | 0 | N | None | N | N |
| 8/5/2009 | 374149 | 4340977 | N | E OF HIGHLINE TRAIL | 180 | 1.5 | 0 | 1 | 2.5 | N | None | N | N |
| 8/5/2009 | 374161 | 4340991 | N | N SHORE OF LAKE | 230 | 1 | 0 | 0 | 1 | N | None | N | N |
| 8/5/2009 | 374142 | 4341013 | Y | N SHORE OF LAKE | 29 | 0 | 0 | 0 | 0 | N | None | N | N |
| 8/5/2009 | 374069 | 4341009 | Y | NE SHORE OF LAKE | 240 | 1 | 0 | 0 | 1 | N | None | N | N |
| 8/5/2009 | 378981 | 4342868 | N | N SHORE OF LK | 270 | 0 | 0 | 0 | 0 | N | None | N | N |
| 9/5/2009 | 377571 | 4334718 | Y | **ON USFWS Land? Outside Wz????** | 10 | 1 | 0 | 0 | 1 | N | None | N | N |
| 8/16/2009 | 378069 | 4335081 | N | elev. 10,057', w/ satellite site | 30 | 1 | 0 | 0 | 1 | N | None | N | N |
| 8/16/2009 | 378232 | 4335416 | Y | elev. 10,229', w/ satellite site | 175 | 1 | 0 | 0 | 1 | N | None | N | N |

**Figure 16** This figure shows a simple spreadsheet acceptable for campsite data entry. Simple spreadsheets should be used for initial data entry, as they interface easier with programs line ArcGIS.

*Entering Data into Infra-WILD*

Inputting the data into the corporate database is important to understanding wilderness impacts at larger scales. Only Data Stewards have access to the database. Inputting data into Infra-WILD can be a time consuming process. The WIMST is currently working on ways to interface Infra-WILD with Excel spreadsheets using the Microsoft Access database. Check the

USFS Intra-net for updates on the data migration project. For now, enter data into Infra-WILD as time allows.

### *Inputting Data into ArcGIS*

Data can be directly uploaded from a GPS unit into an ArcGIS compatible shape file using free software called DNR Garmin, available for download online. DNR Garmin was developed by the Minnesota Department of Natural Resources to provide the ability to directly transfer data between ArcGIS and a Garmin handheld GPS unit. The downfall of using DNR Garmin is that the transferred data is only a location point, and does not contain information about the impact to the site. DNR Garmin only interfaces with Garmin GPS units.

Excel spreadsheets can be uploaded directly into ArcGIS, without the use of additional software. Inputting data into ArcGIS is a key step to using the data for mapping sites and planning management actions. District or Forest GIS staff will be able to help with this process. DNR Garmin is available for free download at:

**http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmine.html**

## DISPLAYING AND USING RECREATION SITE INVENTORY FOR MANAGEMENT

This section provides some examples of how campsite data can be utilized to make management decisions. It also demonstrates a way to track campsite searches using ArcGIS. Some example graphics are provided. Working with a local GIS expert is a valuable step toward using the data to make management decisions, and earn 10 points for Element 6. Below are only a few examples of how data can be used for managment.

*Creating 'Hashmaps' Using ArcGIS*

Keeping track of the areas that have already been inventoried is a significant step in the campsite inventory process. 'Hash' or Track maps can be used by current managers as a way of tracking areas of the wilderness where inventories have been completed. Hash maps may also be used by future managers interested in re-inventorying every 5 years. Tracking areas visited during inventories is important to future research efforts, where knowledge of which areas were inventoried is critical. The knowledge of where camping impacts are present and absent is important to research. Without a hash map, future wilderness managers would be unsure whether an area was inventoried and did not have campsites, or if it simply wasn't inventoried.

There are several ways to creating hash maps. It is possible to keep track on a master topographic map by simply taking a pen and hashing the areas that have been inventoried. Another method is to use ArcGIS to create simple polygons which estimate the areas that have been inventoried (Figure 17).

*Displaying and Using Data: Some Examples*

Once data has been input into ArcGIS, data can be used for management in many ways. Campsite data can be displayed by using ArcGIS so that managers can visualize camping impacts in the wilderness. This section provides a few examples of how data can be displayed (Figure 18), as well as some examples of how the data may be utilized by management.

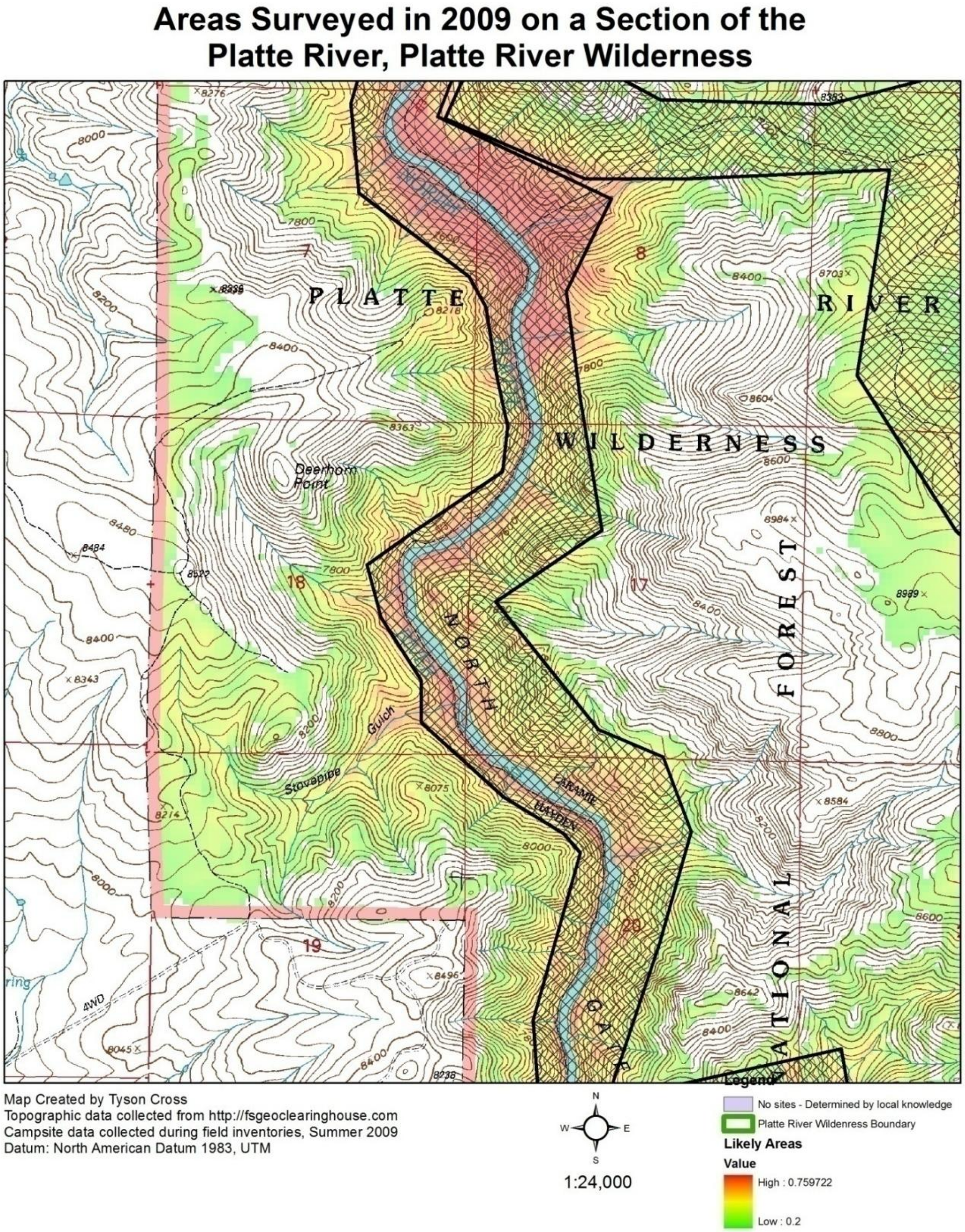



**Figure 17** This figure shows an example of a hash map developed to keep track of areas that have been searched. This can be done by simply making hashes with a pen on a printed topographic map, or using ArcGIS to create polygons.

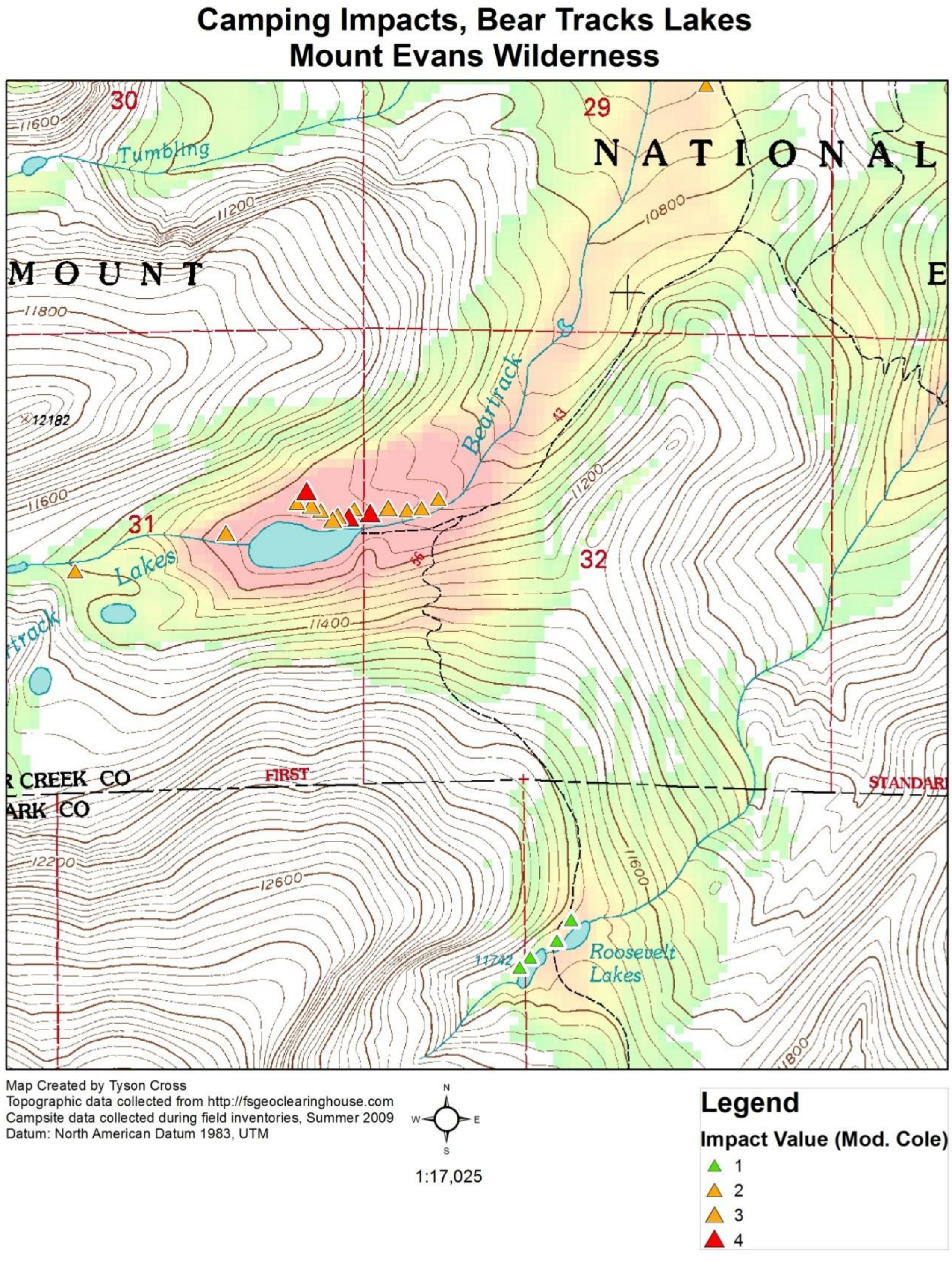



**Figure 18** This map is an example of using ArcGIS to display the campsite information collected in the field. Using ArcGIS to create impact maps earns the full 10 points for Element 6, if the maps are used to make management decisions.

### Re-vegetation Efforts

ArcGIS can also be used to create a list of illegal sites, using the query tool. A map showing the locations of all illegal sites in the wilderness can be created, and waypoints to the sites can be transferred to GPS units. If these steps are taken, large scale re-vegetation efforts can be planned and efficiently implemented. A trail or wilderness crew can be handed a map, pictures and waypoints to all of the known illegal sites in the wilderness.

### Designating Sites

After the information has been displayed visually, management actions to designate sites may be desirable. Designating sites can be a controversial action, and will require more intense monitoring and management efforts. If designating sites is a desired action, the data collected during field surveys will be critical to determining which sites to keep and which sites to re-vegetate. Keep in mind the curvilinear impact relationship between camping and impacts (Appendix G). Sites that are already heavily impacted may be resilient to further impact. If these heavily impacted sites are in an acceptable position and are relatively stable, they may become designated sites. Using the information from inventories, it is possible to determine the best spacing and amount of sites necessary. Creating designated sites without a permit and quota can lead to crowding and proliferation problems. Busy times of the year may bring more campers than sites are available for, requiring regulation and/or the creation of 'back up' sites.

### Permit and Quota Implementation

Although uncommon to R2 wilderness areas, permit and quota systems have been implemented in some NWPS units. Permit and Quota systems can be very contentious and may require public stakeholder meetings, complex management plans and possibly NEPA actions. A full census inventory of the Wilderness unit will be absolutely critical to justifying permit quota systems. If a permit and quota system is determined necessary for protecting the character of a wilderness, the management plans that follow will use the data from the census inventory for determining which sites to designate and which sites to re-vegetate.

## ADDITIONAL WORKS CITED

Cole, D.N. (1983). Monitoring the condition of wilderness campsites. (Research Paper. INT-302). Ogden, UT: U.S. Department of Agriculture-Forest Service, Intermountain Research Station.

All other references can be found on pp. 51-55

APPENDIX B, CHIEFS LETTER

**File Code:** 2320 **Date:** April 4, 2008
**Subject:** 10-Year Wilderness Stewardship Challenge

Congressionally designated wilderness areas represent some of the most natural, undisturbed, and ecologically significant places in America and, indeed, the world. The Forest Service has been entrusted with stewardship of more than 400 units in the National Wilderness Preservation System totaling some 35.3 million acres. I want you to know that I am firmly committed to honoring that public trust through achievement of the 10-Year Wilderness Stewardship Challenge.

It is my expectation that by the 50th anniversary of the Wilderness Act in 2014, 100 percent of the wilderness areas entrusted to us will be managed to the minimum standard outlined in the 10-Year Wilderness Stewardship Challenge. Over the last three years, 16.5% percent of the wilderness areas we manage were brought up to the minimum standard (67 of 407 wildernesses). At this rate, our goal will not be met. I am counting on you to explore ways to ensure that over the next six years your wilderness areas are brought up to the minimum management standard.

Several resources are available to help you. The Chief's Wilderness Advisory Group (WAG) has developed a guidebook to clarify the required tasks. The WAG members are available to Forests to provide coaching for element completion. Informational Toolboxes have been developed for each of the 10 Elements of the Challenge and are available on www.wilderness.net. The National Forest Foundation continues to make grants available to citizen groups who are helping us meet the Challenge.

The example you set as a leader is vital and, if you haven't already, I encourage you to consider attending the National Wilderness Stewardship Training course offered by the Carhart Center each year. I ask that you encourage your Line Officers to take advantage of one of these courses. There are additional Wilderness Stewardship courses offered through Carhart, many available "on-line," that will also benefit your staff.

I am tremendously proud of our rich tradition and role as world leaders in wilderness stewardship stemming from the pioneering efforts of Forest Service employees Aldo Leopold, Arthur Carhart, and Bob Marshall. With your continued help, the record will show that, like these conservation giants, we rose to the challenge and made significant contributions to preserve our nation's wilderness legacy for future generations.

Thank you for all you do to keep wilderness wild.

*/s/ Abigail R. Kimbell*
ABIGAIL R. KIMBELL
Chief

APPENDIX C, SAMPLE JOB HAZARD ANALYSIS (JHA)

FS-6700-7 (2/98)

| | | | |
|---|---|---|---|
| U.S. Department of Agriculture<br>Forest Service<br><br>**JOB HAZARD ANALYSIS *(JHA)***<br>References-FSH 6709.11 and -12<br>*(Instructions on Reverse)* | 1. WORK PROJECT/ACTIVITY<br>**Wilderness Rapid Assesement Prg** | 2. LOCATION<br>**White River National Forest** | 3. UNIT<br>**Aspen R.D.** |
| | 4. NAME OF ANALYST<br>**Martha Moran** | 5. JOB TITLE<br>**Recreation Staff** | 6. DATE PREPARED<br>**9/02/08** |

| 7. TASKS/PROCEDURES | 8. HAZARDS | 9. ABATEMENT ACTIONS<br>Engineering Controls * Substitution * Administrative Controls * PPE |
|---|---|---|
| **Vehicle Travel** | **Vehicle Accident** | **A) Follow the Health and Safety Code -Guidelines: Chapter 10 Sec 12.<br>B) Everyone in vehicle must wear safety belts at all times.<br>C) Drive defensively: look far down the road to get the "big picture" and avoid accident situations caused by the mistakes of others.<br>D) Never exceed posted speed limits.<br>E) Compensate for road and weather conditions.<br>F) All drivers must have a current drivers license and attend a defensive driving course-once every three years<br>G) Trailers will be towed only by those who pass the district towing test<br>H) Passengers will never ride in the bed of a pickup truck. Tools and materials will always be secured before a vehicle is moved<br>I) Crew members will be familiar with vehicle radio and radio check daily<br>J) Flammable liquids shall not be transported in passenger compartment, approved containers shall be used** |
| | **Vehicle Mainttanence** | **A) Crew members will be familiar with changing tireschaining tires, basic vehicle mechanisms, maintanence and operation safety.<br>B) Driver shall not proceed if all passengers are asleep The driver should always have a "co-pilot"<br>C) PM checks will be completed fully and monthly<br>D) Drive no more than 2 hours without a rest stop<br>E) drive with lights on<br>F) Spotters shall be used when backing** |
| **Public Contacts** | **Aggressive visitors** | **A) Warning signs: words or posture. Visitors stressed due to: a) Not wanting to be contacted by F.S. personel, b)not agreeing with management, c)problems with other visitors, d)physical exhaustion. Concern should be increased with use or presence of alcohol or drugs. Do not make contact if drugs/alcohol are present. End contact and leave if necessary.<br><br>B) Don't exceed your comfort zone. Proceed with caution or back off. Use radio to request assistance or radio and let someone know your location, the problem, and personal descriptions. Proceed and arrange follow-up check in within 1/2 hour.<br><br>C) If drugs are involved back off and notify LEO.** |

| | | |
|---|---|---|
| | | D) If alcohol is involved back off until alcohol is no longer a limiting factor in the contact. |
| Backcountry travel<br><br>Note call Martha after each day at 970.580.9367 | Lost/Injury | A) Follow the Health and Safety Code-Guidelines: Chapter 10 Sec 11.2<br>B) Never work or travel without a radio and detailed emergency plan. Always carry an extra set of batteries. Basic orientation skills required<br>C) Radio contact with district oiffice required during work, daily radio check required, on overnight trips check in required at 9:00 am and 3:00 pm., or as close as possible. If returning late, contact district office by 4:30 pm or have a check in plan established.<br>D) Have required equipment on all trips including survival equipment for up to 48 hours. Carry the "ten essentials"<br>E) Be aware of elemental hazardsand take appropriate actions (i.e. weather, avalanche, lightning, stream crossings, snags)<br>F) Leave detailed itenerary with supervisorand/or district personnel. Include route, destinations, dates, and estimated time of departure and arrival<br>G) When camping: set up camp well before dark, use proper bear etiquitte, do not place tent or any cam[p area beow snags and/or debris flow areas. Always use Leave No Trace principles. Camp out of site of others.<br>H) Check in and out according to the district check in/check out policy, know contact numbers for satellite phone use.<br>I) Overnight patrols will be done in pairs if possible.<br>J) Map radio "dead spots" whenever possible for future reference.<br>K) Rangers will take the satellite phone on overnight trips whenever it is available.<br>L) Avoid lightning storms! Watch the sky, and be aware! |
| Wildlife encounters | Injury | Proper reactions to close wildlife encounters vary depening on type of wildlife and the exact situation at hand. This topic will be discussed in tailgate safety meetings. All rangers will be familiar with how to minimize the chances of unexpected wildlife encounters. Attend 8 hour pepper spray training when it is offered, and carry pepper spray. |
| Dogs | Injury/conflict with owners | Call out to camps where dogs are present, have owner leash dogs before approaching. Always carry a tool; shovel, pulaski, combi. If approached, keep the tool between you and the dog. Be assertive, but not aggressive. If owner is nearby, ask that the dog be leashed. Attend the 8 hour pepper spray training when it is offered and carry pepper spray. |
| Livestock | Injury | A) Follow the Health and Safety Code - Guidelines: Chapter 10 Sec. 16<br>B) District authorization required before handling, contact or usage of livestock<br>C) When stock approaches on trailstand on down hill side of trail with no sudden motions and speak calmly to stock users |
| Foot Travel | Injury | A) Follow the Health and Safety Code - Guidelines: Chapter 10, Se. 18.<br>B) All rangers will wear leather hiking boots in good condition. |

| | | |
|---|---|---|
| | | C) Treat "hot spots" and blisters promptly, break in boots before beginning of field season<br>D) If traveling above timberline attempt to do so in morning hours, to avoid lightning storms. |
| Trail Work | | A) Follow Health and Safety Code - Guidelines: Chapter 20 Sec. 22.34<br>B) Users of non-mechanized hand tools suchb as shovels, pulaskis, etc. shall be trained in proper use and care of tools. Gloves shall be worn at all times.<br>C) Crew shall identify, communicate, and avoid hazards, both project and environment related<br>D) Any boulder/stone that needs to be moved by two persons shall me moved by persons trained in proper boulder moving techniques<br>E) Hard hats must be worn during heavy construiction and maintanence<br>F) Always maintain 10 feet of distance between crew members when working. Call ot "swinging" if tool is raised above shoulder height.<br>G) Skidding and/or moving timber more than 6 inches in diameter shall only be moved by trained personnel using skidding and carrying techniques<br>H) All crew members shall be notified and aware of procedure whenever felling is to be done or when objects over 150 lbs are being moved<br>I) Always cache tools safely off trail in one designated spot when not in use<br>J) Before startingb work, be sure to have stable footing.<br>K) Always use "call out" leader when working in group lifting situations<br>L) Be aware and use proper body mechanics<br>M) Wear eye protection when working with rock |
| Environmental Hazards | | A) Follow the Health and Safety Code - Guidelines: Chapter 50 Sec. 54<br>B) Drink treated water only<br><br>A) Scope each work site, camp site, and travel corridors for snags and remove/alter location as necessary<br><br>A) During storms stay out of dry creek beds, off ridge ntops, off rock outb croopings, avoid loneb trees, and wide open spaces. Take shelter in vehicles or buildings or seek protection in ditches, sepressions, depressions or head high clumps of treesin forest glades, squat on feet, do not lay or sit on ground. cache all metal tools and materials away from you. Turn radios off<br><br>A) Always anticipate bad weather and dress accordingly, carry clothing that keeps you warm even when wet. Know the signs of hopothermia and act accordingly<br><br>A) Wear sunscreen and sunglasses<br><br>A) Set a moderate work pace and gradually slow as temperatures increase. Schedule the hardest work during the cooler morning or evening hours.<br><br>A) Keep water available and hydrate often |
| Safety Awareness | | A) Participate in bi-weekly tailgate safety meetings. |

**JHA Instructions** ***(References-FSH 6709.11 and .12)***

The JHA shall identify the location of the work project or activity, the name of employee(s) writing the JHA, the date(s) of development, and the name of the appropriate line officer approving it. The supervisor acknowledges that employees have read and understand the contents, have received the required training, and are qualified to perform the work project or activity.

**Blocks 1, 2, 3, 4, 5, and 6:** Self-explanatory.

**Block 7:** Identify all tasks and procedures associated with the work project or activity that have potential to cause injury or illness to personnel and damage to property or material. Include emergency evacuation procedures (EEP).

**Block 8:** Identify all known or suspect hazards associated with each respective task/procedure listed in Block 7. For example:

a. Research past accidents/incidents
b. Research the Health and Safety Code, FSH 6709.11 or other appropriate literature.
c. Discuss the work project/activity with participants
d. Observe the work project/activity
e. A combination of the above

**Block 9:** Identify appropriate actions to reduce or eliminate the hazards identified in Block 8. Abatement measures listed below are in the order of the preferred abatement method:

a. Engineering Controls (the most desirable method of abatement). For example, ergonomically designed tools, equipment, and furniture.
b. Substitution. For example, switching to high flash point, non-toxic solvents.
c. Administrative Controls. For example, limiting exposure by reducing the work schedule; establishing appropriate procedures and practices.
d. PPE (least desirable method of abatement). For example, using hearing protection when working with or close to portable machines (chain saws, rock drills portable water pumps)
e. A combination of the above.

**Block 10:** The JHA must be reviewed and approved by a line officer. Attach a copy of the JHA as justification for purchase orders when procuring PPE.

**Blocks 11 and 12:** Self-explanatory.

**Emergency Evacuation Instructions** ***(Reference FSH 6709.11)***

Work supervisors and crew members are responsible for developing and discussing field emergency evacuation procedures *(EEP)* and alternatives in the event a person(s) becomes seriously ill or injured at the worksite.

Be prepared to provide the following information:

a. Nature of the accident or injury *(avoid using victim's name)*.
b. Type of assistance needed, if any *(ground, air, or water evacuation)*
c. Location of accident or injury, best access route into the worksite *(road name/number)*, identifiable ground/air landmarks.
d. Radio frequency(s).
e. Contact person.
f. Local hazards to ground vehicles or aviation.
g. Weather conditions *(wind speed & direction, visibility, temp)*.
h. Topography.
i. Number of person(s) to be transported
j. Estimated weight of passengers for air/water evacuation.

The items listed above serve only as guidelines for the development of emergency evacuation procedures.

**JHA and Emergency Evacuation Procedures Acknowledgment**

We, the undersigned work leader and crew members, acknowledge participation in the development of this JHA *(as applicable)* and accompanying emergency evacuation procedures. We have thoroughly discussed and understand the provisions of each of these documents:

| SIGNATURE | DATE | SIGNATURE | DATE |
|---|---|---|---|
| Work Leader | | | |
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# Minimum Recreation Site Monitoring Protocol

Recreation Site Monitoring Procedures for Element 6
of the
Chief's 10 Year Wilderness Stewardship Challenge
7/27/2009

## Introduction

The objective for developing this R2 Minimum Recreation Site Monitoring Protocol (known as Rapid Assessment) is to provide a consistent process for monitoring recreation sites in the 46 R2 Wilderness areas. Due to differences in ecosystems and other parameters, not all sites will have all indicators (i.e. trees on site). Additionally, managers may choose to continue with existing monitoring protocol (such as Modified-Cole). However, it is recommended that all units conduct Rapid Assessment census surveys as a core inventory and then gather additional data as directed by Forest Plan standards.

## R2 Protocol Standards

1. Census survey of likely sites, including trace sites. It is not sufficient to monitor only a sample of campsites.
2. Likely locations in the entire wilderness must be visited (95%)
3. Partial credit can be obtained for a census of a portion of the wilderness.
4. Data no older than 5 years is recommended.
5. Data for each site must include:
   (a) Location (GPS coordinates, UTM NAD83)
   (b) Photo(s)
   (c) Campsite condition
   (d) Presence / absence of administrative structures. (These are structures installed by the USFS)

## Pre-Work for inventorying campsites

1. Review past inventory data and location of existing campsites.
2. Prepare a monitoring plan or strategy to achieve survey of likely sites.
3. If possible, prepare a "most likely" campsite map.

## Protocol for inventorying campsites

1. Naming campsites: use the 3-digit INFRA wilderness number, 4-digit INFRA trail number or drainage name/number followed by a 3-digit campsite number (number sites in the order they are found). Other formats may be used as long as they start with the 3-digit wilderness number.
2. Collect GPS information on the site in **UTM using NAD83**. If you are not sure what this means, find someone to help you. Ideally, set a waypoint in case the coordinates you write on the form are wrong (switched numbers are not uncommon). Name the waypoint the same as the campsite.

3. Take a digital picture of site. Be sure you are including as many identifiable features (rocks, scarred or prominent trees, stumps, background features, etc.) as possible to aid in relocation. Record the azimuth of the photo and the distance to the center of the site. Be sure you have a way to positively tie the image on the camera to the campsite it belongs to. Write tracking notes.
4. Evaluate site, 0-8. 0= trace site with sign of some past use.
5. If necessary, use midpoints (½ point rating), example groundcover damage 2.5.

## Procedures for assessing campsite condition

Independently assess: (1) groundcover disturbance of the main campsite, (2) impact to standing trees and roots, and (3) size of disturbed area (including satellite tent pads and stock-holding areas). Each of these three parameters should be separately assessed. They are combined in a single impact index but the individual ratings will be kept separate as well. In addition, any administratively provided structures are recorded.

**Record disturbance to the groundcover of the central portion of the campsite** (disregarding satellite disturbed areas) as one of the following classes. Select a midpoint when the condition is close to the boundary between classes.

1 – Ground vegetation flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace.
2 – Ground vegetation worn away around fireplace or center of activity.
3 – Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas.
4 – Bare mineral soil widespread over most of the campsite.

As a general rule of thumb, if bare area (without vegetation) is virtually absent, assign a rating of 1. If bare area is obvious at the center of the site, extending out somewhat from a fire ring, but a single 2-person tent would extend onto portions of the site that are still vegetated (i.e. the bare area cannot accommodate both a fire ring and a single tent), assign the site a rating of 2. If the central bare area is large enough to accommodate a fire ring, as well as two 2-person tents, assign a rating of 3 (if most of the bare area still retains a humus/litter cover) or a rating of 4 (if the humus/litter cover is gone from most of the site). A site with enough bare area to accommodate a fire ring and one adjacent 2-person tent would be given a rating of 2.5.

**Record tree damage** as one of the following classes, depending on the number of trees that have been severely damaged. Assess damage off-site as well as on-site, particularly in stock-holding areas associated with the campsite. Include any trees judged to have been damaged as a result of camping activities at the site being monitored. Severely damaged trees are those that (1) have been felled and are at least 10 cm (4 inches) in diameter where felled (if trees have multiple stems, consider the tree felled if any stem at least 10 cm (4 inches) in diameter has been cut off); (2) have scarring that exceeds 1000 $cm^2$ (1 $ft^2$) in total area or (3) have highly exposed roots (more than 1 m (3 feet) of root sticks out at least 2.5 cm (1 inch) above the ground surface). Select a midpoint when the condition is close to the boundary between classes.

0 – No more than 3 severely damaged trees.
1 – 4 to 10 severely damaged trees.
2 – More than 10 severely damaged trees.

**Record disturbed area** as one of the following classes, depending on the size of the area disturbed by camping activities, including the main campsite, satellite tent pads and areas where horses are confined. Where there is a landing area for boats, include this. In most situations, disturbed places are distinguished by obvious vegetation loss (either complete lack of vegetation or sparse vegetation resulting from trampling). Places where vegetation has been flattened but is likely to recover in the short-term should **not** be included in the disturbed area. Where vegetation is naturally absent, it may be necessary to identify disturbed places on the basis of flattening of soil or litter on the forest floor (see special situation 1 below). When there are multiple separate disturbed parts of the campsite, do NOT include undisturbed areas in between. For example, if there is a main campsite, two tent pads and a stock-holding area, assess the size of each of the four areas separately and then sum them. Social trails between separate disturbed areas can be ignored. Select a midpoint when the condition is close to the boundary between classes.

0 – No more than 25 $m^2$ (0-250 $ft^2$).
1 – 26 to 100 $m^2$ (251 - 1000 $ft^2$).
2 – More than 100 $m^2$ (more than 1000 $ft^2$).

Using this protocol, assign the campsite an overall impact rating between 0 and 8 (0 if trace site). The overall rating is the sum of the groundcover disturbance rating (0-4), the tree damage rating (0-2) and the disturbed area rating (0-2). **Once you are comfortable with the protocol it should take no more than three to five minutes to assign a rating.**

**Record the presence/absence of various administrative structures**. If structures are present, note their type (e.g. corral, table, toilet, fireplace, etc.) and the number of each. This should **not** include user-built structures, although information about the prevalence of user-built structures is one of many types of recommended information that go beyond the minimum protocol.

## Special Situations

1**. Procedures for campsites without much perennial understory vegetation and/or without organic soil horizons.**

On sites without organic soil horizons and/or much perennial vegetation (for example, desert sites, beaches, sites on rock, sites dominated by annual vegetation or sites in the dense shade where understory vegetation is absent), the **groundcover** class definitions must be adapted. It would be good to note whether standard or adapted groundcover classes were used.

In ecosystem types with a poorly developed organic soil horizon, use the level of soil compaction to differentiate between class 3 and class 4 campsites. Where there is sparse but regularly-distributed perennial vegetation, use the size of the central area from which all perennial vegetation has been eliminated (regardless of the annual vegetation) to differentiate between class 2 and class 3. Where there is little perennial vegetation, use the size of the central area that has experienced long-term flattening of the soil surface to differentiate between class 2 and class 3. This might involve flattening of microbiotic crusts and a hummocky or rocky surface in deserts or flattening/abrasion of forest litter in dense shade. Conversely, a campsite entirely confined to a vegetation-less beach or a rocky ledge would always get a rating of 1 because there is no long-term flattening of the soil.

Ratings for sites in ecosystem types that have perennial vegetation but lack organic horizons would be as follows:

- 1 – Evidence of camping but minimal physical change except for possibly a simple rock fireplace.
- 2 – Perennial vegetation gone and soil surface flattened (for the long-term) around fireplace or center of activity.
- 3 – Perennial vegetation gone and soil surface flattened (for the long-term) on most of the site, but exposed mineral soil not highly compacted except in a few areas.
- 4 – Mineral soil exposed and highly compacted (to a cement-like state) over most of the campsite.

Ratings for sites in ecosystem types that lack both perennial vegetation and organic horizons would be as follows:

- 1 – Evidence of camping but minimal physical change except for possibly a simple rock fireplace.
- 2 – Soil surface flattened (for the long-term) around fireplace or center of activity.
- 3 – Soil surface flattened (for the long-term) on most of the site, but exposed mineral soil not highly compacted except in a few areas.
- 4 – Mineral soil exposed and highly compacted (to a cement-like state) over most of the campsite.

**2. Procedures for campsites with no trees**

These campsites would be given a rating of 0 (no tree damage).

**3. Damage to krumholtz**

Damage to krumholtz trees are rated, no matter the height or DBH or amount of damage.

## Procedures for assessing campsite condition-Summarized

1. Assess groundcover disturbance of main campsite.
2. Assess impact to standing tree and roots.

3. Size of disturbed area (including satellite tent pads and stock-holding areas.
4. Document administrative structures.
5. Sites with no trees get a 0.

Using this protocol, assign the campsite an overall impact rating between 1 and 8. This is the sum of the groundcover disturbance rating (1-4), the tree damage rating (0-2) and the disturbed area rating (0-2). **It should take no more than a minute or two to assign a rating.**

## Procedures for wildernesses with established campsite monitoring protocols

Some wildernesses already have impact assessment procedures that are as effective as our proposed procedures but that are simply different. These procedures are adequate for getting credit for Element 6 if they record (a) location; (b) campsite condition; and (c) presence/absence of administrative structures and meet the other standards described above.

## Recommended Additional Procedures

We strongly recommend that this minimum protocol be supplemented with additional data that is both more comprehensive and more precise. This minimum protocol does not provide information sufficient to be used to assess change over time on individual sites, unless the amount of change is huge. Nor does it document all the significant types of impact occurring on campsites. We are in the process of developing further information for monitoring protocols that go beyond the minimally acceptable procedures described above.

**For additional information go to**:
Recreation Site Monitoring Toolbox on www.wilderness.net.
Scroll to the following URL:
http://www.wilderness.net/index.cfm?fuse=toolboxes&sec=recsitemonitor.
All toolboxes are products of the Arthur Carhart National Wilderness Training Center.

## APPENDIX E, GPS UNITS

### *Using GPS Units*

There are many different brands and models of GPS units. Common models are; Garmin, Magellan, TomTom, Delorme and others. Each of these brands has different models. Less expensive models are often slower, less accurate, and hold less information (Tracks, Waypoints, Topographic maps...). Although more accurate units are preferred, most GPS units in the lower price ranges are acceptable for Recreation Site Inventories. There are several critical pieces to using a GPS unit for Recreation Site Inventories. This section will demonstrate the most important steps to take when using GPS units for these surveys.

### *GPS Basics*

Common, hand held, GPS units use a satellite signal to calculate their position on the surface of the earth. To complete these calculations, a GPS unit must have a signal from at least 3 satellites in order to triangulate its position. If a GPS unit has a barometer, it can determine its altitude but it must be calibrated (See owner's manual for instructions on calibrations). For GPS units without a barometer, at least 4 satellites are needed for the unit to correctly calculate its altitude. Most frequently, the first "page" of the GPS unit will show how many satellite signals are currently received by the GPS unit, and how strong the signals are.

### *Accuracy*

The accuracy of a GPS unit will change depending on the model you are using. Accuracy can vary from 3 centimeters to 10 meters depending on the GPS unit. Where you are in relation to terrain and canopy, as well as weather can change the accuracy of your unit. In addition to terrain, the kind of satellite signal that your GPS unit is receiving can affect the accuracy of the device.  WAAS (Wide Arial Augmentation System) send a signal from a satellite which is stationary over the surface of the earth.    The WAAS satellites use a system of ground based reference stations to measure and correct for the variation of satellite signals sent from GPS satellites.  Some units are WAAS enabled, which will enhance the accuracy of the GPS unit.  It is a good idea to check the accuracy of your GPS in the field during surveys.  You may have to set the unit down in the center of the site for a few minutes before you can obtain an accurate reading from the device.

Every time you turn on a GPS unit, it will need to track satellites and calculate a position. The amount of time that it takes to calculate a position depends on the type of unit you are using.  It is recommended that you leave your unit on in-between sites so that you can improve the speed and accuracy of the coordinates you collect.

### *Units and Datum's*

#### Datum's

The goal of any mapping exercise is to represent a place in space in a two dimensional form, such as a computer screen or sheet of paper.  The earths shape is an oblate ellipsoid, meaning that it bulges in the center.   Representing the surface of an oblate ellipsoid on a two dimensional plane has been approached in many ways.   A modern approach is to use models which account for many of the irregularities in the earth actual shape.  The collection of these models called a datum.  A datum uses the information from the GPS unit to determine its location on earth.  There are many kinds of datum's, and your GPS unit will have many options. Pay attention to the datum used during inventories, past and present.  For Minimum Protocol, use the datum NAD 83 (North American Datum 1983).  This is most likely **not** the default Datum for your GPS unit and must be changed.

Units

Different projects will recommend using different coordinate systems to track locations. The two common coordinate systems used are Longitude and Latitude or Universal Transverse Mercator (UTM). The Longitudinal system is a continuous coordinate system, while UTM's break the world into grids. It is important to know which grid you are in when using the UTM system. For Colorado, we are in zone 13 North. The zone will change depending on where you are in the world.

APPENDIX F, ADDITIONAL SAMPLE INVENTORY FORM

**WILDERNESS CAMPSITE INVENTORY FORM**

**Campsite Number:**______________________________________

**Recorder(s):**______________________________ **Date:** ________________

**GPS Coordinates: UTM:** __ __ __ . __ __ __ **E** __ __ __ __ . __ __ __ **N** **Legal Site (Y/N):**____

**Location Description:**____________________________________________________________

**Photo Azimuth**________________ **Photo Description:**______________________________

***Optional Information***

| **Litter:** None, Some, Abundant | **Human Waste:** None, Some, Abundant | **Noxious Weeds:** Y/N | **User Developed Trails:** Y/N | **User Created Structures** (list type and number) |
|---|---|---|---|---|
| | | | | |

***Rapid Assessment Required Data***

| **Ground Disturbance Rating** (1-4) | **Tree Damage Rating** (0-2) | **Disturbed Area Rating** (0-2) | **Overall Impact Rating** (0-8) | **Administrative Structures** (list type and number or n/a if none are provided) |
|---|---|---|---|---|
| | | | | |

**WORK COMPLETED/REMARKS:**

______________________________________________________________

# Region 2 Minimum Protocol Cheat Sheet

**Part A** **Disturbance to Groundcover Rating**

Note – Ground disturbance focuses on the center of the site. See the SPECIAL SITUATIONS section in the Campsite Monitoring Procedures for alternate criteria if needed. If an alternative is used, check the box in the site info form

1 - Groundcover vegetation flattened, not permanently damaged, minimal change except for rock fireplace.

2 - Ground vegetation worn away around fireplace or center of activity. Not enough to put a two person tent

3 - Ground vegetation lost on most of site, most humus and litter still present. Enough vegetation is worn away to fit a two person tent.

4 - Bare mineral spoil widespread over most of site.

**Part B** **Tree Damage Rating**

Note – Count only trees that (1) have been felled and are at least 4 inches in diameter where felled; (2) have scarring that exceeds 1 $ft^2$ or (3) have more than 1 meter of exposed roots. *Areas with sensitive trees such as krumholtz may qualify as a severely damaged tree even if they are smaller than 4 inches in diameter

0 - 0-3 severely damaged trees or no trees on site

1 - 4-10 severely damaged trees

2 - 11 or more severely damaged trees

**Part C** **Disturbed Area Rating**

Note – Examine vegetation in the area for what is "natural." Disturbed area is a measure of the area that has been disturbed by the camping activities. Make sure to include satellite tent pads, stock holding area and areas where people have landed boats along the river or lake.

0 - 0-250 $ft^2$

1 - 251-1000 $ft^2$

2 - More than 1000 $ft^2$

**Part D** **Overall Impact Rating**

____ Sum of index ratings for Part A + Part B + Part C