MONITORING PUBLIC ACCESS IMPACTS ON CONSERVATION FORESTS: A MANAGEMENT FRAMEWORK

By

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Abstract

The Conservation Fund (TCF), a national nonprofit working in land and water conservation, established its North Coast Forest Conservation Program in Mendocino County, CA in 2004. In 2007 TCF acquired two coastal redwood forest properties, Salmon Creek & Big River, through a funding partnership with three state agencies and additional private funding. Its sustainable forest management program includes endangered species protection, water quality improvements, stakeholder involvement and public recreational use. Recreation impacts, defined in this report as any undesirable visitor-related change to the natural resources, trails, or recreational experience of other users, can have detrimental results including erosion, vegetation trampling, and degraded water quality. This project was developed to meet TCF's needs for responsible management of visitors to the properties, to both protect the natural resources and allow active forest management. A review of recreation ecology literature was conducted to identify key trends and results in the field, as well as locate experts. A survey of eight recreation experts, including both scientific researchers and recreation managers, was conducted to gain additional insight and various perspectives on recreation impact issues. Their responses and the literature review were analyzed and discussed to inform recreation monitoring recommendations for Salmon Creek and Big River. These were summarized in a final monitoring plan to aid TCF in its management of public access on these conservation forest properties.

Acknowledgements

This project would never have been possible without the guidance of my advisor, Dr. Norman L. Christensen. He has been an inspirational mentor whose support and advice have given me the skills to develop this monitoring plan. Special thanks to the staff at The Conservation Fund, especially Jenny Griffin & Evan Smith, who gave me a fantastic experience through my summer internship working with the organization on the management plan for the properties. Their support and wonderful insight continued as I developed and conducted this project and produced my final recreation impact monitoring plan recommendations to aid in sustainable management of Big River and Salmon Creek. Thank you to Holly Newberger for her friendship and help getting to know the North Coast, and Lynsey Kelly for the use of her maps and the GIS data to create my own. Thank you also to the Maahs & Carpenter family, who hosted me during my internship and made me feel welcome and a part of the family from the very beginning. To my friends at the Nicholas School, you've been an unwavering source of encouragement and inspiration for me to push the limits of my academic ability, and have helped me become a more well-rounded and thoughtful environmentalist. Finally to my family, I couldn't have made it through the challenges of this program without your love and confidence in me, I can never thank you enough for all that you do.

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Introduction

The Conservation Fund (TCF), a national nonprofit working in land and water conservation, has established the North Coast Forest Conservation Program to permanently protect areas of coastal redwood and Douglas fir forests from development, fragmentation and unsustainable timber harvesting. The program currently includes 40,000 acres of forested land in three separate properties in Mendocino County, CA. This report focuses on two of the properties, Salmon Creek and Big River, which encompass approximately 4,000 and 12,000 acres respectively. TCF's management plan for both properties will involve sustainable timber management which will lengthen harvest cycles, serve to restore more natural species composition and structure, and establish the areas as healthy working conservation forests.

TCF desires to offer opportunities for public access and participation in recreation and education activities, research, and restoration projects for Salmon Creek and Big River. TCF must be able to reasonably manage the activities by the surrounding community to maintain protection of the natural resources as well as active forest management practices. Uncertainty exists however on how much, what types, and where recreation should be permitted and how to monitor its impacts to both the trail system and natural features. Here I review the literature on recreation ecology, particularly focusing on recreation impacts to trails and natural resource communities. I use this research as a basis to develop and administer a recreation expert survey exploring opinions on recreation monitoring methods and community involvement. Recreation ecologists and professional recreation managers were participants in this survey. The responses to direct questions and the additional insights of these professionals along with the literature review then shape my recommendations and associated plan for TCF to monitor the potential recreational impacts on Salmon Creek and Big River. The monitoring plan will guide TCF in

managing public access to minimize impacts to the natural environment, inform the public of trail conditions, justify closures and other management actions during timber harvesting, fire or other events, and assess the effectiveness of their recreation management measures.

Project Objectives

My overarching goal is to provide a feasible recreation impact monitoring plan in the context of active forest management and protection of the natural resources. Establishing an impact monitoring framework within sustainable forestry practices will help TCF more effectively manage Salmon Creek & Big River in both the immediate and distant future. Monitoring that actively engages property managers to make decisions relevant to current, and in light of, future environmental needs is necessary for the successful ecological management of the forests. The monitoring plan will address the organization's commitment to funders to provide public access only to the point to where the ecological integrity of the natural resources isn't jeopardized. Practical monitoring techniques are essential for TCF to assess and mitigate potential recreational impacts on these properties. Relevant literature review, recreation expert (scientific and managerial) survey results and TCF's goals for these forests will be the basis for the monitoring plan. This framework will serve to better manage and conserve the ecological integrity of these working conservation forests for future generations.

Background – Big River & Salmon Creek Properties

Big River and Salmon Creek properties are both located in Mendocino County, in close proximity to the Pacific Ocean along the northern California coast (Figure 1). The properties were owned by various logging companies which were managed as private industrial timberlands

starting in the 1850s. Historic construction of dams and logging roads mainly along waterways to provide easy transportation of lumber severely impaired the ecological health of the properties. Past destructive logging practices, including clear cutting, dramatically changed the historical forestry composition of Coastal Redwood (*Sequoia sempervirens)* and Douglas Fir (*Pseudotsuga menziesii*) communities on the properties. These past practices led to detrimental impacts to the natural environment including erosion and associated stream sedimentation, loss of wildlife habitat, and many others. Despite this history, many portions of the properties are considered healthy and all areas are on their way to a better ecological future through sustainable and ecologically conscious management.

Figure 1: TCF North Coast Property Locations (courtesy Lynsey Kelly)

Currently the properties have a combination of graveled logging roads, dirt roads and dirt seasonal trails throughout their boundaries, resulting from past logging operation, fire and general forestry management needs (Appendix A: Property Maps). There are also various bridges, stream crossings, and areas of difficult terrain in higher elevations at each location that add challenges to management. TCF has locked gates at all main road entrances to each property, though there are no boundary fences and each is accessible from many points. Big River is bordered by Big River State Park to the west, to the north by Jackson State Demonstration Forest, and to the east by Mendocino Redwood Company (Figure 2). This makes it vulnerable to unauthorized property access by recreationists on those properties. Salmon Creek is located in the town of Albion, primarily surrounded by individual property owners which often have direct and relatively easy access to this TCF property (Figure 2).

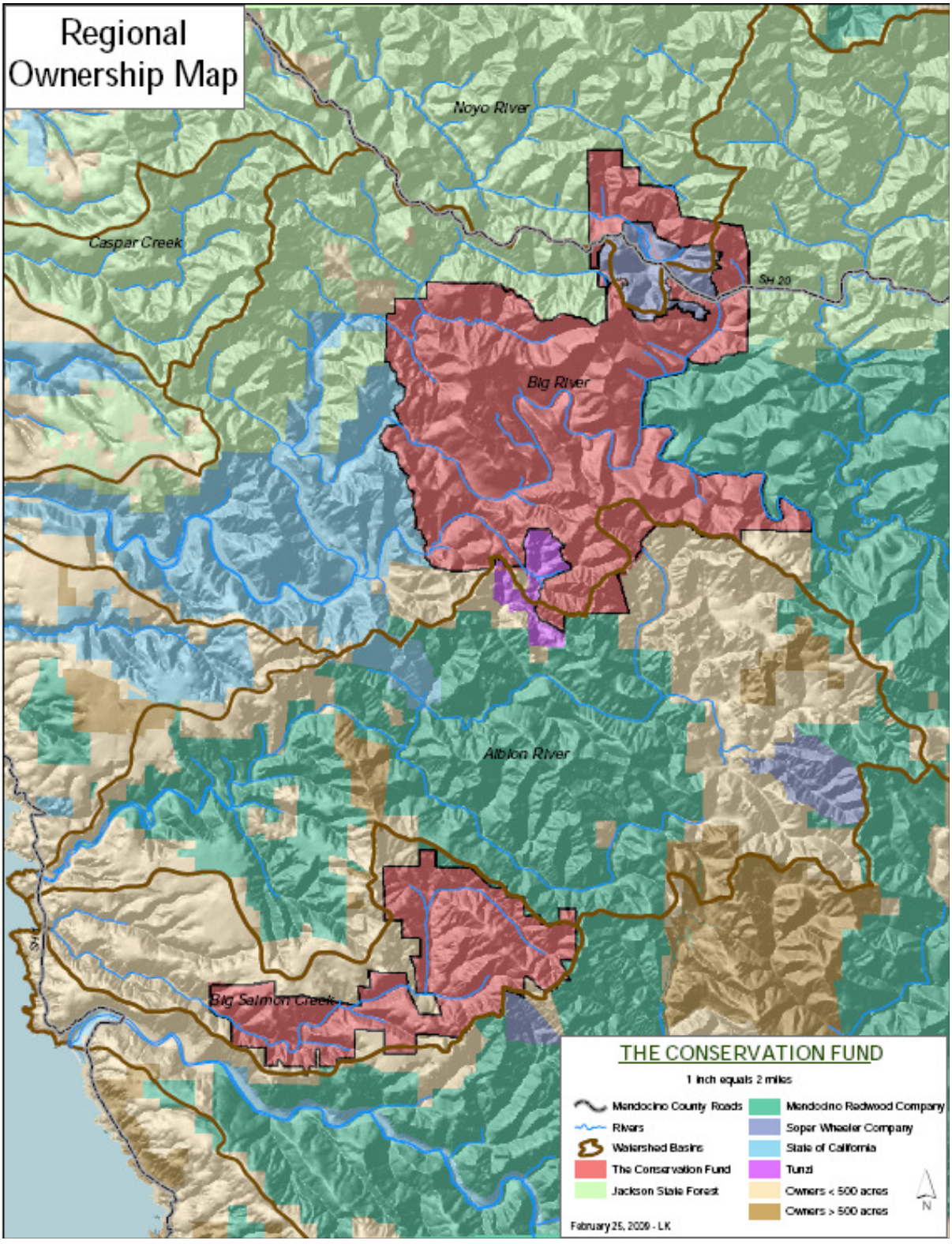

Figure 2: North Coast Regional Property Ownership Map (courtesy Lynsey Kelly)

During the private timber industry ownerships, a range of unauthorized recreational access activities occurred on both properties. The logging companies all officially had "no trespassing" policies, including warnings on property boundaries and security patrols, but trespass was difficult to prevent. Recreation types included hiking, hunting, fishing, mountain biking, camping, equestrian and OHV (off-highway vehicles includes all-terrain vehicles and off-road motorcycles) use. These all continue to be community favored recreational activities.

TCF persistently faces issues associated with unauthorized recreational and other activities on both properties, including marijuana cultivation. This practice causes pollution, growers vandalize security gates and locks to gain access, and potential safety concerns exist for employees and guests on the properties. Trash dumping is a concern specific to Salmon Creek, most likely because more individual properties have direct border access to the property. This is unsightly, causes pollution and is costly from the standpoint of both human and economic resources.

The community of Albion, however, has been supportive of TCF's management of the properties and wishes to see continued joint efforts to allow access to the property for pedestrian and equestrian use. Activities already initiated by the community include an annual tree planting and invasive plant removal event which fosters a working relationship with TCF to aid in the management of the properties.

The overall management goals of Salmon Creek and Big River are to restore and enhance the natural and ecological values of the properties with sustainable forestry practices while establishing viable working conservation forests. Goals incorporate prioritizing the protection of important conservation components of the properties, including the coastal redwood & Douglas fir forest, anadromous fish-bearing streams, grasslands, and the threatened Northern Spotted Owl

(*Strix occidentalis caurina*). These conservation components are all imperative to maintaining the health of the forests at the landscape level. Monitoring public access and recreation impacts in light of these forest management goals will serve to ensure human use on the properties is not causing or contributing to degradation of the natural resources.

Recreation Ecology Literature Review

Introduction - Recreation Ecology & the Significance of Recreation Impacts

Recreation ecology is the field of ecology that examines, assesses and monitors visitor impacts, and their relationship to influential factors (Marion 1998). The research aims to assess and help alleviate recreational impacts as they relate to sustainable tourism, protected areas, parks and other recreational areas. Recreation ecology research has helped formulate many management and monitoring methods appropriate for various managing organizations (whether public or private), ecosystems, and areas impacted (trails, campsites, or natural areas). This knowledge serves to prevent, mitigate, and manage issues associated with recreational impacts. The term *impact* is used in the context of this report to denote any undesirable visitor-related change to the natural resources, trails or the recreational experience of other users. Recreational activities can cause a diverse array of impacts, of which Leung & Marion (2000), provide a detailed table of the common forms of recreation impacts, focusing on wilderness (Table 1). Social impacts of degraded aesthetic value, safety, indications of human disturbance, crowding, and noise all are additional challenges associated with managing public recreational use.

Table 1: Common forms of recreation impacts in wilderness (Leung & Marion 2000)

	Ecological component			
	Soil	**Vegetation**	**Wildlife**	**Water**
Direct effects	Soil compaction Loss of organic litter Loss of mineral soil	Reduced height and vigor Loss of ground vegetation cover Loss of fragile species Loss of trees and shrubs Tree trunk damage Introduction of exotic species	Habitat alteration Loss of habitats Introduction of exotic species Wildlife harassment Modification of wildlife behavior Displacement from food, water and shelter	Introduction of exotic species Increased turbidity Increased nutrient inputs Increased levels of pathogenic bacteria Altered water quality
Indirect/ derivative effects	Reduced soil moisture Reduced soil pore space Accelerated soil erosion Altered soil microbial activities	Composition change Altered microclimate Accelerated soil erosion	Reduced health and fitness Reduced reproduction rates Increased mortality Composition change	Reduced health of aquatic ecosystems Composition change Excessive algal growth

Recreational impacts can often cause serious negative changes in trail, campsite and natural areas that are both detrimental and difficult to mitigate or repair. Establishing the causal relationships between impacts and visitor use gives researchers and recreation managers the scientific basis to develop appropriate monitoring and management strategies.

Various types of uses, from day hiking to mountain biking to horseback riding to OHVs, including the extent and frequency of their trail use, all impact and degrade the natural conditions to various extents. Vegetation, soil, wildlife and water are all potential impacted natural resources, from trampling, compaction, disturbance and other impacts (Leung & Marion 2000).

The extensive network of impacts, including frequency, type, season, topography, environmental conditions and spatial distribution of use, are the primary factors into the total biophysical impact from recreation use (Cole 2004). The amount of use and amount of impact have been shown through numerous studies to consistently exhibit a curvilinear and asymptotic relationship (Figure 3), where there is a sharp increase in impact with relatively low use and a consistency of that impact level through much increase in use (Cole 2004). Considerable impacts can occur at low use frequencies, indicating that substantial use reductions must occur on highly frequented trails to achieve a significant impact reduction (Marion & Leung 2001).

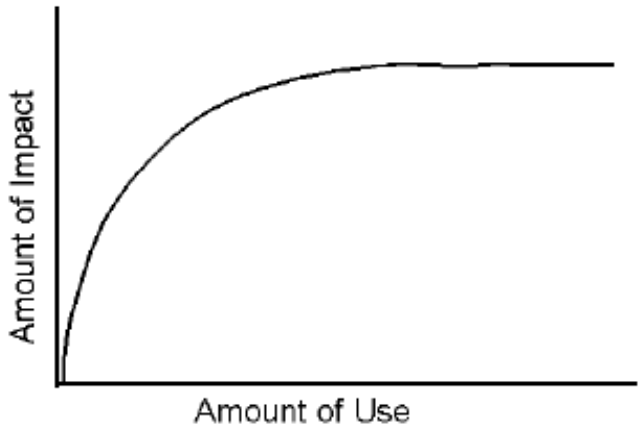

Figure 3: Curvilinear relationship of amount of impact to amount of use (Cole 2004)

Soils can be significantly impacted by recreational use, resulting in soil compaction, exacerbating muddiness issues, and accelerating soil erosion (Leung & Marion 2000). These factors impact trails, and also the natural areas and natural processes surrounding them. If recreation use is significantly increasing the amount of erosion, higher levels of sedimentation may occur in nearby streams from the eroding soil. Degradation of trail structure through

erosion, muddiness, displacement or compaction all can lead to visitor dissatisfaction with their recreational experience and the creation of new informal trails to circumvent the impacted trails.

Vegetation impacts of trampling and invasive species introductions are a primary concern. Creation of new informal trails by pedestrians and other users increases the risk of trampling vegetation, which has significant biophysical feedbacks including changing soil biota, reduction in plant vigor and reproduction, change in species composition and reduction in vegetative cover (Cole 2004). Invasive species can also be brought in by visitors on clothing or vehicles, which can cause significant impacts on the natural vegetation composition and species' distributions.

Trail use can affect water quality by increasing sedimentation, turbidity, nutrient uptake, pathogens and the introduction of exotic species. If suitable water drainage and control features such as grade reversals on trails and rolling dips on roads are installed, many of these detrimental impacts can be mitigated or prevented altogether. Trails in close proximity to water do require special consideration in their design and management to prevent introduction of suspended sediments into the water. Poorly designed and placed trails can also interfere with natural hydrologic functions such as water flow from seeps or springs (Marion & Wimpey 2007). Pathogens and exotic species can also be introduced, but their potential negative effects can be limited if there are very few opportunities for people to physically disturb the water.

Wildlife can be affected by trails and general public use by possible habitat alteration, fragmentation or loss, introduction of exotic species, harm to rare or endangered species, wildlife harassment and modification of wildlife behavior (Leung & Marion 2000). The influence on wildlife habitat and behavior may range from insubstantial to significant, depending on the species and its use of publicly accessed areas. Wildlife may become adapted to non-threatening

recreational activities, for example on a frequently-used trail, limiting human-caused impact. Some wildlife however will avoid such areas altogether, causing them to expend extra energy and to leave their preferred habitat for a short or permanent amount of time (Marion & Wimpey 2007).

Different user groups inflict varying impacts on trails and the natural resources, in part dependent on trail and environmental conditions, which pose challenges for both management and monitoring of recreation. Hiking may appear firsthand to be the least impactful recreation activity, but erosion, soil compaction, off-trail travel, vegetation trampling and wildlife disturbance are all potential negative outcomes. Horseback riding can cause significant impacts to trails and natural resources, from damage to soils (compaction, erosion, displacement, deepening) and vegetation (trampling, loss of cover, browsing), to nutrient enrichment from manure and disturbance to wildlife (Newsome et al. 2004). Wilson and Seney (1994) found in a comparison study of different soil treatments that horses and hikers (hooves and feet) make more sediment available (high erosion potential) than wheels (motorcycles and off-road bicycles) on pre-wetted trails and that horses also make more sediment available on dry plots.

Cessford (1995) found the key physical impact distinction between mountain biking and other non-motorized trail activities lies in the unique effects of wheels on surfaces, relative to those from foot trampling. Skidding and braking on downhill slopes causes ruts which can promote erosive water-flows to a greater extent than by foot-step puddling. Similar sediment and trail tread gouging is also found on uphill slopes, particularly by motor-powered wheels associated with OHVs. OHVs can cause varying impacts dependent on the trail tread conditions and slope. OHV influence on off-trail natural areas can be significant considering the ability of the motor-powered vehicle to tread on and over more varying slopes, vegetative cover and soil

types than other users. Seasonal closures and zoning recreation use according to trail tread type and width are applicable management actions to reduce the negative ramifications of public access and recreation. Appropriate trail location and design, regulation, and education on codes of behavior and potential impacts can all help minimize negative recreation results.

Monitoring Methods for Recreation Impacts

Compiling and accruing useful and relevant information on trail conditions can be difficult due to lack of funding, personnel or logistics. "In order to make judicious trail and visitor management decisions, protected area managers need objective and timely information on trail resource conditions" (Leung & Marion 1999a). Managers cannot make appropriate decisions for the environmental conditions on the property and their needs to manage the area for a sustainable future without appropriate and applicable monitoring data.

Monitoring the impacts from these factors on the conditions of trails or other allowed access areas is imperative in order to mitigate their effects on the ecosystem. "Visitor impact monitoring programs can assist managers in making objective evaluations of impact acceptability and impairment and in selecting effective impact management practices by providing quantitative documentation of the types and extent of recreation related impacts on natural resources" (Marion et al. 2006). Sound research design will inform management actions that land managers can develop through scientifically-based policies. This will help track and manage recreational impacts to ensure the natural resources are protected and the public is informed as to how the decisions and management protocols were decided.

Various methods of recreation impact monitoring have been developed in the fields of recreation ecology and recreation management to assess and better manage the results. Investigating the relationship between the amount of use and intensity of impact, as well as

environmental attributes and quality of recreation impacts (Leung & Marion 2000), are the driving force behind the development of various types of analyses. Methods are distinguished by their implementation, unit of observation, typical data results, major utility and their limiting factors in a summary of approaches in Table 2 (Leung & Marion 2000). Reconnaissance, sampling-based, and census-based approaches are compared to demonstrate their potential use, applications and requirements for scientific studies and recreation managers.

Table 2: Summary of trail impact assessment and monitoring approaches and designs (Leung & Marion 2000)

	Reconnaissance approach		Sampling-based approach		Census-based approach	
Item	**Condition class**	**Photo appraisal**	**Point sampling**	**Point-quadrat sampling**	**Sectional evaluation**	**Problem assessment**
Implementation	Descriptive classes are defined and assigned to trails/segments	Trails are identified and evaluated from aerial photos	Measurements are performed at a series of points along a trail that is determined by a sampling scheme	Measurements are performed within quadrats at a series of points that is determined by a sampling scheme	Trail is divided into sections; evaluation is made for each section	Impact problems are defined, followed by complete census of these problems
Unit of observation	Segment/trail	Trail/regional	Site (point)	Site (quadrat)	Segment	Dimension of impact problem
Typical data type(s)	Nominal/ordinal	Interval/ratio	Interval/ratio	Interval/ratio	Ordinal/ percentage	Interval/ratio
Major utility	Prompt assessment of trail conditions	Detect proliferation of trail networks; detect new trails	Quantitative data for statistical analysis; adaptable to management frameworks	Quantitative data for statistical analysis; adaptable to management frameworks	Prompt assessment of trail conditions and their spatial variations	Data on the frequency, extent, and distribution of impacts; adaptable to management frameworks
Limiting factor(s)	Singular qualitative measure; conflicting criteria within a condition class	Availability; resolution of aerial photos; photo interpretation skills	Relocation of sampling points; measurement error; field time	Relocation of sampling points; measurement error; field time	Definition of section; scale dependence of results	Quantitative definition of impact problems; interrater variability
Examples	Cole and others (1997)	Coleman (1977); Price (1983)	Cole (1991)	Hall and Kuss (1989)	Bratton and others (1979)	Marion (1994a); Leung and Marion (1999a)

There are two main general approaches and designs in trail impact assessment and monitoring (IA&M), which are sampling-based and census-based (Leung & Marion 1999b). In the sampling-based approach, a systematic point sampling method is most commonly used to make observations or measurements at fixed distances along a trail (Leung & Marion 1999b). This method is used by both researchers and protected area managers to measure impact indicators and environmental characteristics in more detail at specific sampling points. It is most effective when the impacts being investigated have no regular pattern or distribution, so the systematic point sampling is able to capture a representative sample of the trail system. In the census-based approach, the method of problem assessment is most frequently used to survey the entire length of trail through predefined impact issues and a complete census of those issues (Leung & Marion 1999b). This method is most effective when investigating dimensions of problem segments and counts, but can have issues associated with the quality of quantitative data through variability in the evaluators and their implementation of assessments.

Conclusions

The literature of recreation ecology demonstrates the multidimensionality of the types of recreation and public use and their associated potential recreation impacts. The environmental conditions as well as the frequency and type of use are all contributing factors to the overall resulting impacts on the users as well as the natural and built environments such as trails. Questions surrounding how to manage the various user groups on each property to align with overall forest management goals needs to be a primary focus of TCF in managing public access. Deciding on which type(s) of recreation impact monitoring strategies are best for the management goals, budget, organization configuration, existing road/trail infrastructure and natural resources is the challenge and purpose of this project. To aid in the development of the

monitoring plan, I developed a recreation impact expert survey to gain more detailed and personal insight from experienced managers and researchers with recreation monitoring.

Recreation Impact Expert Survey

Introduction

The recreation impact expert survey was developed based on the background insight gained and methods used in recreation ecology from the literature review. This elicited questions relevant to monitoring public access impacts, and both recreation ecologists and recreation managers were interviewed. The goal of the survey is to identify and evaluate monitoring methods employed in assessing public recreational impacts to both the trail and natural environment. The survey also seeks to investigate the challenges and controversies in the various monitoring methods as well as with community involvement in monitoring recreational impacts or other activities. Additional insight was also requested in follow-up questions from the survey participants on managing and monitoring public access recreational impacts.

Methods

The expert survey includes an initial section of informed consent for the participants as well as a project purpose section to familiarize them with their rights as well as the intent of the project. The survey was split into three sections, Professional Background, Monitoring of Impacts, and Organization Management and Community Involvement in Monitoring Public Access (Appendix B). The first section, Professional Background, served to gather information on the participants' level of recreational research or management experience through multiple choice and fill in the blank questions. It inquired about the length of experience with recreation research and/or management, positions held, employing organizations, and what type(s) of

ecosystems have they worked with and/or managed recreational activities. The second section, Monitoring of Impacts, used Likert scale questions to elicit the degree of agreement or disagreement the participants had with statements relating to a numerical carrying capacity management method and two monitoring methods commonly used with studying recreation impacts. The Likert scale method seeks to determine how the participant feels about a topic by indicating how closely their attitudes match the statement on a rating scale ranging from strongly disagree to strongly agree (Waddington 2000). Short answer questions that served as a follow up to each of the three Likert scale questions were included to give the participants the opportunity to elaborate on the reasons for their selected answer. The third section, Organization Management and Community Involvement in Monitoring Public Access, aimed to discover what techniques the participants had possibly used to involve the community in recreation impact monitoring or other activities. Additionally, their feelings on community involvement in monitoring or other activities are examined further through a combination of multiple choice, Likert scale and short answer questions.

Researchers and recreation managers were contacted through email, given background on the purpose of the study, and asked if they would volunteer to participate in a phone survey. Each participant was selected for their contribution to the recreation ecology literature or their experience as a manager of recreation. Four established recreation ecologists, two candidates for PhD's in natural resources focusing on recreation management, and two national park service managers experienced in recreation were surveyed for a total of eight participants. The phone survey interviews were recorded to encourage full explanations to each question and get additional information that wasn't directly requested in the survey. The interviews were transcribed and the short answer questions were analyzed for further insight and information as

related to the direct questions or additional topics. Multiple choice questions were analyzed in terms of the frequency of each selected answer by the participants, and all these questions had the choice of circling all applicable answers. Likert scale questions were analyzed to compare the amount of consensus or divergence in opinion among the participants with each question.

Results

Please refer to Appendix B for the actual recreation expert impact survey. All the multiple choice questions are set up for the participants to select all applicable answers, so results may have more than a total of eight responses. The additional insight provided by the participants in the short answer questions is presented in the discussion and not the results section because of its context and the length of applicable information.

Professional Background

The participants all had significant experience in recreation ecology or management, with only one participant having less than five years experience and the rest having either 5-15 or over 25 years experience (Question 1). The majority of participants, the six recreation ecologists, had acted as principal investigators of research projects, with only one not also having acted as a project assistant (Question 2). Three participants, including the management professionals, had acted as recreation program managers. The majority of participants have worked for government or universities, as well as nonprofits but not private companies (Question 3). Question 4, which requested the participants to list their current employing organization, was not included in the analysis. All eight respondents have worked in forest ecosystems, with no experience in prairies but many have worked in other ecosystems including alpine, urban and suburban, subarctic, volcanic and tundra (Question 5).

Table 3: Recreation Impact Expert Survey Professional Background

	Answer					
Question	**A**	**B**	**C**	**D**	**E**	**F**
1	1	3	0	4	n/a	n/a
2	6	5	3	1	3	n/a
3	4	6	0	6	0	n/a
5	8	0	2	3	3	4

Monitoring of Impacts

The first question, which addressed the issue of using carrying capacity (in the strict numerical sense) as an effective method to manage recreation, had a range of opinions (Figure 4). Three participants strongly disagreed that the use of this method was effective. Two participants disagreed and two were neutral, indicating disapproval and inconclusive opinions on this management method. Only one participant strongly agreed, indicating that this management method may not address the underlying origins of the issues the survey participants believe are important to manage and ultimately prevent recreation impacts.

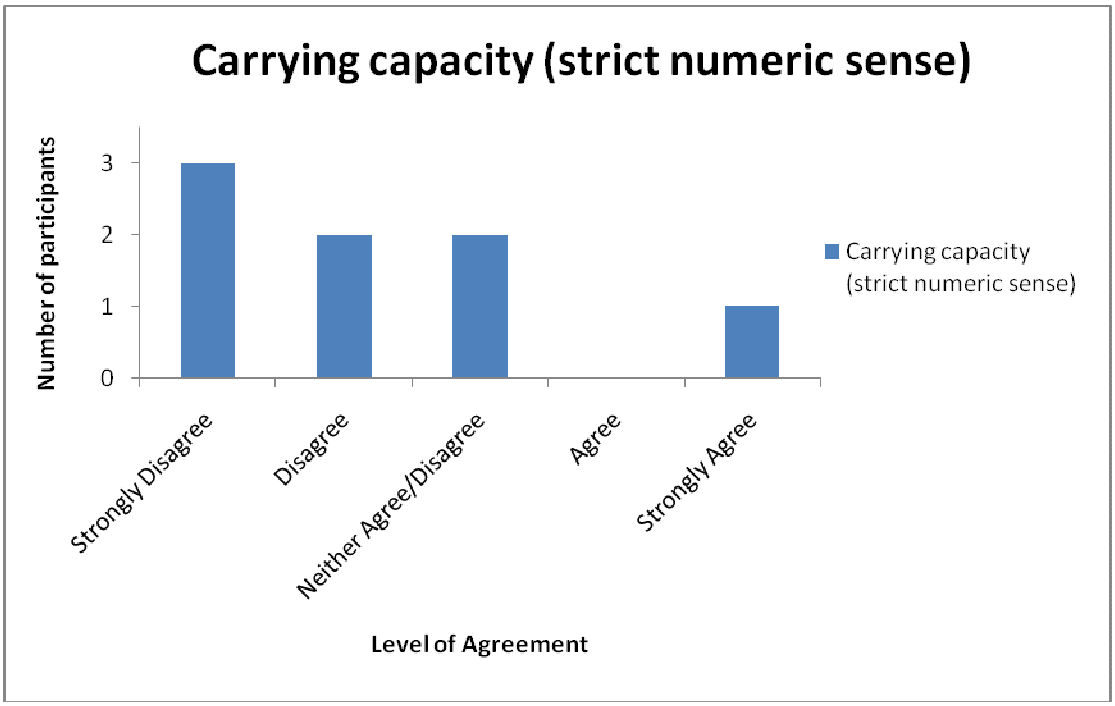

Figure 4: Carrying capacity (strict numeric sense) as an effective management strategy

The third and fifth questions addressed the respondents' opinions on whether point sampling is the most effective method to monitor recreation impacts (Question 3) or if problem assessment is the most effective (Question 5). One researcher and one manager disagreed with point assessment being most effective, and one student and one researcher strongly or simply disagreed with problem assessment as most effective (Figure 5). Two researchers and one student were neutral on the questions, while two participants believed the point sampling method (Question 3) and three agreed the problem assessment method (Question 5) was the most effective (Figure 5). One researcher felt that point sampling was distinctively more effective at monitoring recreational impacts while no participant had the same belief with the problem assessment method.

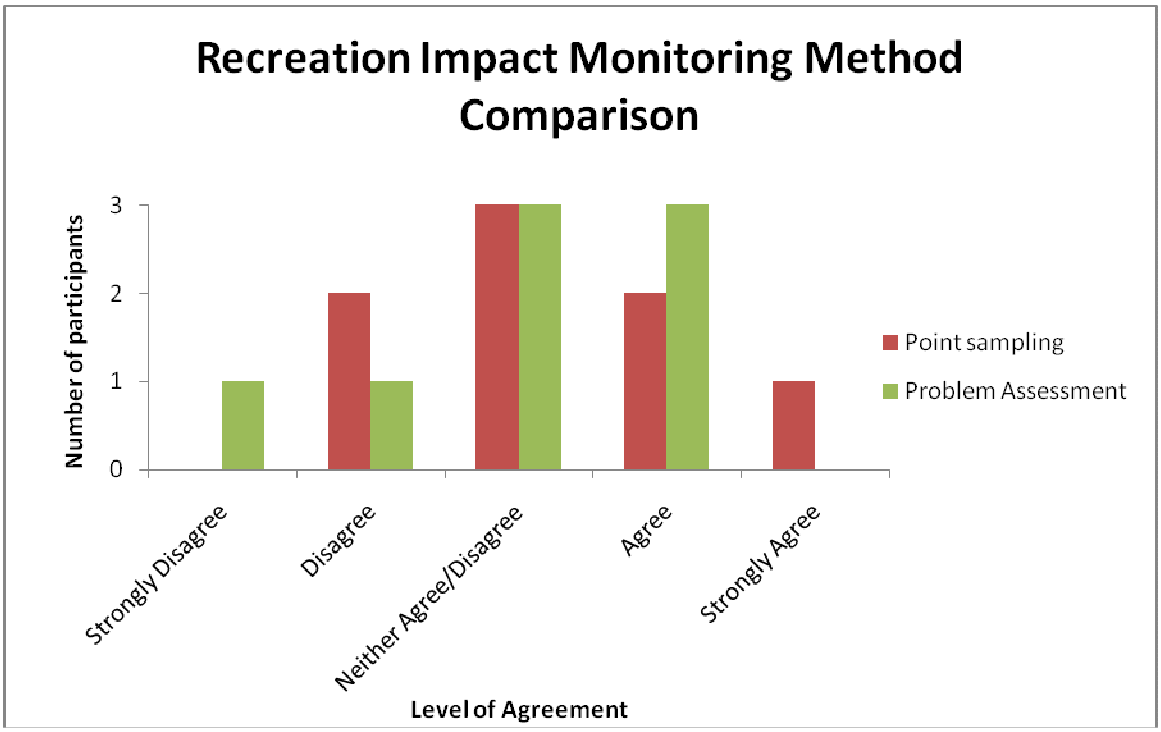

Figure 5: Point sampling vs. problem assessment as the most effective monitoring method

Organization Management and Community Involvement in Monitoring Public Access

The majority of the respondents felt that all the listed optional measures to ensure a safe recreating environment were effective through their experience except for signed release forms (option f), which most had not personally utilized at all (Table 4, Question 1). Five of the participants had personally designed, managed or helped implement a recreation impact monitoring program involving the community (Question 2). Of those five, four had involved them in direct monitoring and as property stewards, while only three had the community involved in restoration projects (Question 3).

Table 4: Expert Survey Organization Management & Community Involvement in Monitoring

	Answer						
Question	**A**	**B**	**C**	**D**	**E**	**F**	**G**
1	6	8	7	6	7	1	1
2	5	3	n/a	n/a	n/a	n/a	n/a
3	4	3	4	2	n/a	n/a	n/a

The fourth question investigates the feelings of the participants on involving the community in monitoring to foster a better working relationship between the property owner and the community. There was a general positive consensus for participation, with four participants strongly agreeing, three agreeing, and one disagreeing with this statement (Figure 6).

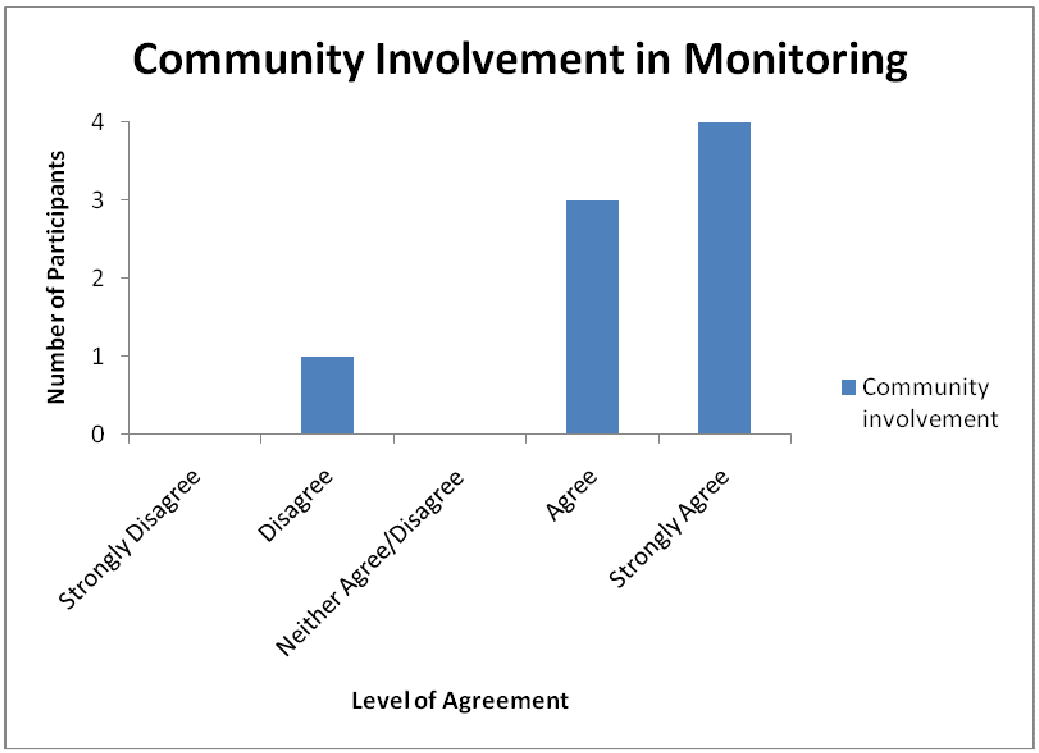

Figure 6: Community involvement in recreation impact monitoring

Recreation Ecology Literature & Recreation Impact Expert Survey Discussion

An integral part of this project and the resulting development of the monitoring plan were the questions that investigated the reasoning behind the participants' Likert scale answers as well as the request for additional insight on monitoring techniques. These questions aimed to elicit more in depth expertise and knowledge from the vast experience of the professionals and students that participated. This discussion serves to investigate those responses in an exploration of selected statements that summarize the opinions of the participants to further solidify the recommendations in the recreation impact monitoring plan framework.

Monitoring of Impacts: Questions 4 & 6 (Point Sampling vs. Problem Assessment)

The comparison of these main two types of monitoring methods pointed out both strong differences and converging opinions between the researchers and the managers as well as those participants less and more experienced with recreation impacts. Dr. Jeff Marion (USGS researcher) was the only participant that strongly agreed that point sampling is the better method for monitoring:

> The point sampling is going to give you better data to characterize what's going on out there on the trail system. It's a sampling-based approach, it gives you representative data, it will be able to characterize what's going on this trail for comparison to that trail, so it's basically the best approach. *18 January 2009*

However, he did not dismiss problem assessment as an important and useful monitoring technique, but rather that a combination of the methods with a focused scope on only a couple of the main impact issues is preferred:

> Well what we've discovered is that these techniques are fairly rapid assessment and they're pretty efficient and you can do both, it's not like you necessarily have to make a decision. In most of my surveys we do the point sampling and then do problem assessment for 1 or 2, generally 2 indicators. I will interview the area

> managers to see which kinds of impacts are the biggest concern, is it erosion, muddiness, trail widening, generally it's one of those three. And I ask what if we were only to monitor 1 or 2 of those concerns, what if we monitored every occurrence of running water on your trail so you could send some crew out there to put a culvert in, or a tread drainage feature in and they'll often say yeah. So then I'll say we can do a census on that one, and it's more to direct their management than it is to provide us for data… *18 January 2009 Marion*

This statement points out the differences in the type of monitoring method used is partially dependent upon if it is intended for scientific study, land management, or both. This is particularly clear in Logan Park's (PhD candidate) explanation of the origin of these two distinct methods and their strengths and weaknesses:

> Regarding point sampling versus problem assessment I think it's important to know where each grew out of. Problem assessment basically grew out of a management need to pinpoint specific problem areas, the little hotspots, where is trail muddiness, what do we need to fix this year with our limited person power and budgetary resources. It's very good at pinpointing spots on the map where we need to get a work crew out and it's rehabilitation. Point sampling is built out of a geospatial statistics approach, so you take a representative sample of the entire trail system and it helps to give an efficient and wonderful picture of the whole system. It's very poor at being able to pinpoint problem spots like those muddy areas. So if you say point sampling happens to fall on the muddy spots, great. But managers express reservations, well what if it falls 10-20 feet on the other side of the puddle, and we've spent all this money and we've missed the problem. *26 January 2009*

From a management perspective, George Minnigh (National Park Service backcountry manager) emphasized the obvious practicality of problem assessment to the management staff, and how point sampling can miss those areas truly in immediate need of attention and restoration:

> I think that the point sampling system and having sort of a systematic way of looking at, for example a trail system, has some value and merit to it to establish a baseline and determine changes over time. I think the problem with that, and the reason that problem assessment is more effective is because land managers generally know where somewhat significant problems are developing and can measure those problems specifically and seek the funding required to mitigate the

> problem. Whereas the point method, you might not be measuring the right point, if it was established it was every mile you were going to monitor, if your mile marker didn't fall on the areas that were the steeper grade, then you might miss the area that's receiving erosion. *23 January 2009*

Jeremy Wimpey (PhD candidate), emphasized that in his opinion problem assessment had a different purpose than monitoring in recreation management and that there isn't an ideal monitoring method at this time:

> I don't think that problem assessment is an effective monitoring tool, I do think it's an effective tool for building new maintenance logs, developing visitor program plans and it could probably be adapted a bit to be more monitoring oriented. But I think for the time implemented you still have to walk the entire trail or trail networks, probably better off using a point sampling technique and keeping abreast of what else might be being developed. I don't think that point sampling is the be all, end all, I think something can be developed that would be more useful but I just don't know what that is yet. *22 January 2009*

This quote demonstrates the complications associated with distinguishing management maintenance versus monitoring, and where these methods are most applicable. Another area of confusion arises if the impact problems and/or standards haven't yet been clarified in the study or management area, as there may be additional challenges to monitoring as Dr. David Cole explains:

> The other extreme is if you don't really know very well and haven't articulated very clearly what you think is really a problem out there and you don't really know how the problems are distributed, a sort of point sampling approach is going to be much more conducive to learning a lot about your system, what's going on with it and sort of transit it. One of the drawbacks of the problem assessment approach is that you have to find your priority of what you're going to consider a problem or not, so at some point in the future if your notion of what is or is not a problem changes, your data is of no value anymore. So that's why something like the clarity of the standards is important. *23 January 2009*

There doesn't necessarily have to be a distinct direction to one or the other types of methods, as Dr. Marion mentioned above. Most of the participants agreed that in an ideal world, a combination of both methods is best, as soundly stated by Dr. Dave White:

> As someone who is also aware of management issues the problem assessment technique appeals to me as well because there is a lot of professional judgment, intuitive, native knowledge that the managers have of which areas are of concern, and the problem assessment method tends to be very efficient in the field. And so I think the combination of the two would yield the most comprehensive picture, so if you're trying to figure out the problems along the trail using a point sampling approach and combining it with a problem assessment method is probably the best of both worlds. *2 February 2009*

This combination gives scientifically rigorous statistics as well as identifying the key problem areas for managers to tackle and get to work on solving.

Organization Management and Community Involvement in Monitoring Public Access: Question 4 (Community Involvement in Monitoring)

This question was asked to investigate how the managers and researchers felt about involving the community in the monitoring of recreation impacts to possibly both help TCF with its limited staff situation and create more of a partnership between the organization and the community. Seven of the eight participants either agreed or strongly agreed that community involvement in monitoring was a positive, though Dr. Marion believed the public had a better place as stewards:

> If you have large numbers of people involved in collecting monitoring data, the data you get can be extremely poor quality and maybe even worthless. The reason is there's a certain amount of judgment involved with implementing any form of resource monitoring. So if you have large numbers of people who aren't trained in the natural resource sciences you're going to have people making different judgments on conditions in different ways that the real conditions will be masked by measurement error…My recommendation would be not to involve them so much in the monitoring as much as we involve them in activities of maintaining trails and campsites and picking up trash and stuff like that. …I've

> had people argue with me that 'citizen science' is still nonetheless good even if they're not collecting decent data. Now I'm too much of a scientist to agree with that, but I know where they're coming from. They're coming from basically saying we need people who are going to be vocal advocates of this protected area. And my response would be fine, make them vocal advocates in terms of their stewardship work, not monitoring kinds of work. *18 January 2009*

It is important to address these considerations when potentially involving the public in monitoring, issues such as contributor bias, lack of education, and simply the large numbers of participants can lead to degradation in the quality of data. Involving the community also requires a significant time commitment; to organize training and tasks can possibly take more effort and time than it's worth. However, many of the participants felt strongly that involving the community in monitoring is applicable, important and possible, including Dr. Yu-Fai Leung:

> It is important to engage the community, force them to think of the results of their actions, whatever they do they will hopefully feel a sense of responsibility in their recreation behavior. I think forming a partnership between the organization and the community, monitoring is good and also in management is good too. I think it should be in all communities, I think we can do more. *3 February 2009*

Steve Bair (National Park Service backcountry, wilderness and trails manager), feels confident in his park's use of volunteers for monitoring:

> These volunteers are very well trained, we educate them, we train them exactly what we're looking for, what our management strategies are, they understand the national park service mission, so we're very confident in the data that's being collected by these folks and frankly it's something we can't do with our staff, it requires the involvement of the community. *30 January 2009*

His park staff takes the time to educate the volunteers on the specific needs of the management policies and data, and with that in-depth training the park can collect more data than ever possible with its limited staff. Dr. David Cole and other researchers agree that public involvement is important both to make management policies possible and get the public personally invested in the future of the property:

> From several aspects, one that I commonly deal with is that there are no resources available to do monitoring and so getting the public involved can be a way to bring resources to it. I guess the other issue that I shall put forth is, maybe a bit more challenging in some ways is just through the ownership aspect of getting people involved and therefore personally invested. There raises some data quality issues and stuff like that but I believe that those can be dealt with. *23 January 2009*

In the same line of thinking, Dr. Dave White explains his view of visitor "buy-in" when it comes to encouraging visitors to regulate themselves and each other to minimize recreational impacts:

> …One of the things I learned, especially with voluntary compliance, if you're going to have limited staff/resources to be able to impact monitoring and to implement your monitoring program, and to manage impacts, one of the things you really need to rely on the visitors to police themselves, to engage in appropriate behaviors and make appropriate choices about their recreation behavior. If you're going to do that, then you really need "buy-in." They need to understand the rationale behind the types of regulations or management actions you have in place, they need to believe it's justified, believe it's based on either sound science or public involvement, they need to basically buy into it and then they will police themselves. *2 February 2009*

I believe this concept gets at the core of public involvement, having the people feel as passionate about the protection of the property as the managers do while still being able to enjoy the properties recreationally. The involvement may end up being anything from property stewards to guiding native plant walks to monitoring, but the important thing is gaining public trust and involvement in the conservation of the properties' resources.

Big River & Salmon Creek Public Access Monitoring Plan

Monitoring Plan Development

The literature review and results of the recreation impact expert survey are the basis of the monitoring framework developed for TCF's working conservation forests properties of Big River and Salmon Creek. The recommended guidelines take into account the scientific and managerial recommendations and insights found through the literature review and expert survey results. The monitoring plan is designed to align and work towards TCF's forestry management goals and vision for the properties. This information "can be used to inform the public of trail resources, justify staffing and funding, evaluate the acceptability of existing resource conditions, analyze relationships between trail impacts and contributing factors, identify and select appropriate management actions, and evaluate change in trail conditions and the effectiveness of implemented actions" (Marion & Leung 2001). This framework was specifically designed for TCF's Big River and Salmon Creek properties, but may have applicable methods and recommendations to other sustainably managed forests. Hopefully, it will bring new insights and direction into recreation monitoring for conservation forests that are useful to other audiences.

The plan was developed with two distinct implementation stages, within which there are immediate recommendations as well as more involved methods to be used in the future dependent upon staff and funding capabilities. The first stage, Initial Phase Monitoring, outlines the recommended first phase of monitoring that is expected to be both needed and plausible (through staffing and funding) in the monitoring of recreational impacts. This phase focuses on the identification of problem areas and directing management staff to address these issues. The second stage, Secondary Phase Monitoring, includes more involved and detailed methods to monitor public access impacts that may not be initially possible. This phase entails point

sampling with a limited problem assessment component to create a more in depth landscape-scale picture of the recreational impacts with the possible contribution of the community. This monitoring framework seeks to create a long-term focused strategy for preventing, limiting, tracking, and managing impacts associated with public access on Big River and Salmon Creek.

The Conservation Fund's Big River & Salmon Creek Public Access Monitoring Plan

The Conservation Fund seeks to provide public access on its Big River & Salmon Creek working conservation forest properties as part of the overall forest management regime. The goal of this plan is to outline key methods and considerations in monitoring potential public access and recreational impacts associated with permitted use on the properties. Monitoring these impacts is imperative to effective, timely management and conservation of the forest resources as well as safe and enjoyable public access experiences. Protecting sensitive areas such as those containing steep slopes, habitats for threatened and endangered species, corridors for animal movement, water resources, critical nesting, breeding or mating areas, and historical sites are key concerns for the monitoring and management of public access. Monitoring visitor-related recreation impacts provides the information needed for managers to formulate realistic standards for the management area and evaluate the resource conditions in relation to these set standards (Marion 1991).

A. Goals

1. *Overall*: To prevent additional harm or degradation to the natural resources by allowing public access participation in guided and unguided recreational, educational, experimental and/or restoration activities.

2. *Water*: The water quality of the streams will not be further degraded by public use, including no additional sediment or nutrient loading, pathogenic bacteria, exotic species introductions, or any other indicator of reduced aquatic ecosystem health.

3. *Soils*: Impacts on soils including erosion, compaction, and muddiness will be minimized by monitoring and managing to acceptable standards. A certain level of soil compaction will be expected in designated trail areas, but water management techniques will be employed to ensure this does not lead to additional runoff, erosion and possible negative water quality impacts.

4. *Vegetation*: Loss of ground cover, root exposure, introduction of exotic species and overall compositional changes will be prevented to the furthest extent in both the proximate trail areas and areas removed from trail use.

5. *Wildlife*: To incur minimal negative responses to wildlife, including modification of wildlife behavior, habitat alteration, wildlife harassment, introduction of exotic species, increased mortality or compositional change.

B. Initial Phase Monitoring Structure

1. *Graveled Roads*

A. Introduction

Monitoring on graveled, permanent logging roads on the properties will be conducted using the problem assessment method and photo points. These roads will be maintained, including graded and re-graveled periodically dependent upon the general sustainable forestry management needs and not in particular reference to recreational needs. The periodic re-leveling of graveled roads and their inherent tread characteristics eliminates the need for impact assessments of such indicators as soil compaction, and focuses the monitoring on possible areas of water runoff because of the hardened tread surface. By conducting a census of the issues on

the roads, managers can be aware of and manage possible problem areas that may affect vehicles and recreation users in different ways. This will serve to monitor conditions and create a prescriptive work log for graveled trails used by both the public and forestry management. The focus of the monitoring on this trail type will also focus upon informal trail creation, proximal vegetation and soils impacts, and any observed wildlife impacts.

B. Problem Assessment & Photo Point Monitoring Methods

A census of all graveled roads that are approved for recreational use by management staff will need periodic monitoring to track indications of recreation impact and adjacent trail impacts. The problem assessment approach involves an assessment of any observed resource condition indicators of impacts to trail structure or within proximate vicinity of the trail on the natural resources. Global positioning system (GPS) units will be used to track the problem locations, and photographs taken at the problem points will be used to visually track road issues over time. Notation of the user type(s) on the roads will serve to track indicators of potential user-specific impacts to the road system and adjacent natural areas. This approach should effectively track running water on the graveled tread. If the tread is properly designed there should be minimal issues associated with erosion or muddiness.

A staff member will be responsible for walking or driving the entire subset of graveled roads that have been approved for recreational use. A census of informal secondary trails (>3m in length) to assess the predefined impact problems of trampled vegetation, root exposure, soil compaction, erosion and muddiness will be conducted. The staff member will note the location of the informal trail(s) in the GPS unit, and then record its resource condition indicators including the length and width of the secondary segment. Pre-defined tread problems including percent of vegetation cover on the informal trail and evidence of muddiness, erosion and soil

compaction will be noted. The staff member will then take a photo of the informal trail condition issue to track its progress in development and to justify management action if necessary to fix the issue through signs or barriers to allow restoration of the area. This census will serve to alert management staff to possible problem areas where the public is going off trail against the rules and causing degradation of the natural resources. Running water or muddiness on the graveled roads will be photographed, noted for location, and measured for width and length of problem area. The census of graveled roads will indicate to management the particular portion(s) of roads that may need management action to fix the issue(s) and reduce the risk of degrading the natural resources.

2. *Seasonal Dirt Roads & Trails*

Seasonal dirt roads have dirt treads with no other substrate additions (including gravel), that are used for forestry management and security patrols and are wide enough to accommodate vehicles. Seasonal dirt trails are those that have dirt treads and are not wide enough to accommodate vehicles, approximately less than 6ft (183cm) wide (Leung & Marion 1999a). These seasonal roads and trails will be the secondary and tertiary areas open to public access (after graveled roads) since they are more difficult to manage and monitor, and are more likely to be impacted by recreational activities. Evaluation of the dirt roads and trails for potential recreational use will be conducted by management staff based on management capabilities, timber harvesting locations and schedules, and type(s) of recreation use. This section provides a general framework for assessing the potential impacts of public use on the dirt roads and trails.

The dirt roads and trails will be monitored using a modified version of the trail problem-assessment method (TPAM), developed by Yu-Fai Leung and Jeffrey Marion to address managerial needs with a problem-oriented approach (Leung & Marion 1999a). This approach

uses three categories of indicators, including 1) inventory indicators to characterize trail type and use, 2) resource condition indicators to characterize the location, number and extent of pre-defined tread problems, and 3) design and maintenance indicators to document design problems and maintenance features (such as water bars and drainage dips). The individual indicators for this monitoring plan are modified from Leung & Marion's list used in Great Smoky Mountain National Park to best fit the needs and capabilities of TCF for public access management (Table 5).

Table 5: Trail problem-assessment method indicators (adapted from Leung & Marion 1999a)

Indicator		Indicator Description
Inventory indicators		
User Type:	Pedestrian	Segment open to pedestrian use.
	Equestrian	Segment open to equestrian use.
	Equestrian/Pedestrian	Segment open to equestrian & pedestrian use.
	Pedestrian & Vehicle	Segment open to pedestrian use & used by TCF vehicles.
	Equestrian & Vehicle	Segment open to equestrian use & used by TCF vehicles.
	Equestrian/Pedestrian & Vehicle	Segment open to pedestrian/equestrian use & used by TCF vehicles.
	Other	Individual or combination of uses not described above.
Tread Width:	Trail ~ 61-183cm	Segment width
	Trail on road ~61-183cm	Segment width on a road narrowed to <183cm
	Road >183cm	Segment width
Resource condition indicators		
Soil Erosion		Segment has eroded below the constructed tread surface by the amount specified (Recommended: >30cm).
Excessive root exposure		Segment has severe tree root exposure: tops/sides of roots are exposed.
Excessive width:	Trail ~61-183cm	Segment has expanded ~61-183cm past adjacent/typical sections of trail.
	>183cm	Segment has expanded >183cm past adjacent/typical sections of trail.
Running water on trail		Segment has running water on tread.
Wet soil		Segment has muddy soil, including puddles, over half the tread width.
Multiple tread		Segment has more than one definable tread path.
Design/maintenance indicators		
Drainage Dip:	Very effective Partially effective Ineffective	Human-constructed dip and berm to divert water from the trail tread, evaluated for effectiveness.
Water Bar:	Very effective Partially effective Ineffective	Human-constructed rock or dirt structure to divert water from the trail tread, evaluated for effectiveness.

These indicators should be used to monitor impacts on dirt roads and trails as recreation use is being allowed on them. It is assumed that a baseline survey of any roads or trails open for public access will be conducted before that use is allowed, both to ensure protection of the natural resources and to provide safe areas for recreational use. Two staff members are presumed adequate for this analysis as road and trail segments approved will expand over time and not be opened all at once or for all potential uses. Monitoring the roads and trails during peak seasonal recreational use would be the most appropriate in order to assess the extent of potential impacts from recreation and public access. This method would be repeated at intervals designated by management staff based on monitoring results and management capabilities. The indicators above should be relatively rapid-assessment so that the monitoring staff can efficiently investigate potential developing or developed recreational use impacts.

Two field staff working as a pair is assumed adequate to conduct this monitoring, both to lower the likelihood of assessor variability and to ensure consistent evaluations that will be able to be comparable across different roads and trails. The staff will record the use type of the road or trail and its tread width category at the beginning of the road or trail segment survey. The staff will stop at any resource condition indicators, noting the occurrence of soil erosion >30cm, exposed roots, excessive road or trail width, wet soil, running water on road or trail or evidence of multiple treads. The degraded location will be recorded in the GPS unit, and measured as appropriate for lineal extent. Any informal trail >3m in length observed along the surveyed segment will also be assessed as per methods described in section 1B of this plan (Graveled road monitoring). For each drainage feature (drainage dip or water bar), its estimated effectiveness in diverting water off the tread will be rated as very effective, partially effective, or ineffective (Leung & Marion 1999a). The standards of these resource indicators must be discussed and

clarified in management meetings and staff training to ensure reproducible, accurate and precise monitoring data. The trail problem-assessment method will be used to identify counts and dimensions of problem areas, which management will use to prioritize preventative action and possible restoration efforts.

Wildlife impacts are not the primary focus of this problem-assessment method, but are a consideration in overall public access impacts. Monitors will note any disturbance related to altered habitat with secondary tread indications (vegetation trampling, tree trunk damage, etc.), but will not be completing wildlife animal-specific monitoring. The trail segments opened to public access will be with the approval of the staff biologist(s), so that the health of the threatened species and any other species they foresee could be negatively impacted are prioritized above permitting recreation use. Management may request monitors to note damaged nests or other indications of human-induced degradation to the wildlife for further management actions, but these indicators are not a direct part of the overall monitoring framework at this time.

3. *Non-trail areas*

Indications of public access off of primary trails will be assessed by the informal trail measurements described above. There will be monitoring and management actions (such as signs) that will aim to prevent informal trail creation that would allow the public access to non-trail areas not approved for public use on the properties. Monitoring staff will record their observations of informal trail occurrences and characteristics, and note any additional natural resource impacts observed. Monitoring staff will inform management of areas of concern, at which time management actions to regulate and maintain visitor use only on approved roads and trails will be enacted. Guided tours by TCF staff or other approved individuals will be responsible for minimizing the potential public access impacts of the activity, including

trampling of vegetation. Visitors who are participating in native plant walks, timber harvesting plan tours, and other activities will need to be educated by the guides on their potential negative impacts to the natural resources and ways to minimize this potential.

C. Secondary Phase Monitoring Structure

1. *Introduction*

The purpose of this secondary phase is to build upon the problem assessment method from the initial monitoring phase, to capture more potential issues with recreational use across the whole system instead of problem areas trail segment by trail segment. This phase may not be possible to implement for logistical, financial or managerial reasons for a few years, but once the public access program is well established it may be the most useful and effective in assessing recreation impacts. The systematic point sampling will bring a more in-depth and statistically-rigorous data collection of recreation impacts to coincide with previous and continuing problem assessment monitoring.

2. *Systematic Point sampling*

The systematic point sampling method will conduct tread assessments at a fixed interval along a trail to investigate its characteristics. This is recommended to be conducted on the dirt roads and trails, as this assessment along with the selected indicators are not appropriate for the graveled roads. The proximate proposed indicators for this point sampling survey are outlined in Table 6, as adapted from Marion & Leung (2001). The number of sampling points will depend on the road or trail length, as recommended lengths of segments between samples will be determined by the management staff at the time (lengths in recreation ecology literature range from 50-500m). Use of a trail measuring wheel will track where the designated sample points

are as well as note the problem assessment areas. The use of a GPS unit in this method will aid in future tracking, mapping and ability to easily return to sample points.

Table 6: Point sampling indicators (adapted from Marion & Leung 2001)

Indicator	Indicator Description
Tread width	Tread width of road or trail boundaries.
Max Incision, Current Tread	Maximum distance between tread surface and a line connecting tread boundaries.
Max Incision, Post-Construction Tread	Maximum distance between tread surface and a line to depict ground level after trail construction.
Informal Trails (#)	Count of informal trails since last sample point.
Secondary Treads (#)	Count number of separate or multiple treads parallel main tread at sample point.
Tread Condition Characteristics	
a) Exposed Soil (%)	Exposed soil excluding rock & litter.
b) Rock (%)	Naturally occurring rock surfaces.
c) Organic Litter (%)	Organic litter covering tread surface.
d) Exposed Roots (%)	Exposed tree or shrub roots.
e) Muddy Soil (%)	Existence of muddy soils and puddles.
f) Vegetation Cover (%)	Vegetative cover rooted within tread boundaries.

I recommend a pair of staff members to conduct this sampling to ensure accuracy and consistency in evaluations and measurements. Tread width as well as maximum current incision and post-construction incision will be recorded help to characterize trail soil erosion. Tread characteristics are recommended to be evaluated in 10% increments, as measured at the sample point for proportion of linear extent perpendicular to the trail (Marion & Leung 2001). These indicators will provide a more systematic view of the potential impact issues as well as the stability of the overall trail infrastructure.

Problem assessment methods (as described in Section C - the initial monitoring phase) will be used in conjunction with the point sampling technique to develop a comprehensive picture of the recreation impacts. However, so as to avoid repetition or consume too much time, only one or two types of indicators should be selected from the most prominent problematic issues of trail widening, muddiness or erosion found during the initial phase. Selecting only one or two of these indicators to assess at problem areas not at designated sampling points will still locate and capture the issue while focusing the monitoring on the most prominent concerns affecting the trails and roads. Existence of informal trails will be noted, including length and again selection of one or two indicators to minimize field time. Ideally by implementation of this phase there would already be problem assessment data established to clarify which are the more pressing recreation impact issues for management on these properties.

D. Community Involvement

Community involvement in monitoring recreational impacts is recommended to bring the public recreating on the properties together in lessening their negative influence on the trails or natural resources. I recommend involving the public in identifying and locating secondary trail treads (informal trails) created by users as well as any use by a recreation user type that is not allowed on a particular trail segment. The equestrian and pedestrian users (the initial proposed property user groups) both are required to have stewardship public access permits through TCF in order to use the approved areas on Salmon Creek (both groups) and Big River (pedestrians only). Asking the permit holders to notify management staff of problem areas with the creation of informal trails or noting the trail segment where a particular user type is not allowed will help management better track trail issues in between monitoring surveys. Engaging the permitted community users to report recreation impacts is the best way they can provide feedback and

insight into problem areas unbeknownst to the management staff. I do not recommend using the community to conduct the detailed problem assessment or point sampling monitoring, as that data will be most consistent and reliable if left to a limited number of trained staff. Involving the community through educational tours or restoration projects could be the best way to make them aware of TCF's goals for the properties and how they can contribute to their sustainable future.

Literary Citations

Cessford, G.R. 1995. Off-road impacts of mountain bikes: a review and discussion. Off-road Impacts of Mountain Bikes: A Review and Discussion Science & Research Series No. 92. Wellington, NZ, Department of Conservation. 42-70.

Cole, David N. 2004. Monitoring and Management of Recreation in Protected Areas: the Contributions and Limitations of Science. Working Papers of the Finnish Forest Research Institute 2.

Leung, Yu-Fai and Jeffrey L. Marion. 1999a. Assessing trail conditions in protected areas: application of a problem-assessment method in Great Smoky Mountains National Park, USA. Environmental Conservation **26** (4): 270-279.

Leung, Yu-Fai and Jeffrey L. Marion. 1999b. The influence of sampling interval on the accuracy of trail impact assessment. Landscape and Urban Planning **43**: 167-179.

Leung, Yu-Fai and Jeffrey L. Marion. 2000. Recreation Impacts and Management in Wilderness: A State-of-Knowledge Review. USDA Forest Service Proceedings RMRS-P-15-VOL-5.

Marion, Jeffrey L. 1991. Developing a Natural Resource Inventory and Monitoring Program for Visitor Impacts on Recreation Sites: A Procedural Manual. Natural Resources Report NPS/NRVT/NRR-91/06. U.S. Department of the Interior, National Park Service, Denver, Colorado.

Marion, Jeffrey L. 1998. Recreation ecology research findings: Implications for wilderness and park managers. In: Kirchner, H., ed. Proceedings of the National Outdoor Ethics Conference; St. Louis, MO. Gaithersburg, MD: Izaak Walton League of America: 188-196.

Marion, Jeffrey L. & Jeremy Wimpey. 2007. Environmental Impacts of Mountain Biking: Science Review and Best Practices. In: Managing Mountain Biking: IMBA's Guide to Providing Great Riding. International Mountain Bike Association. Retrieved February 2, 2009.
http://www.imba.com/resources/science/marion_wimpey_2007.html

Marion, Jeffrey L and Yu-Fai Leung. 2001. Trail Resource Impacts and An Examination of Alternative Assessment Techniques. Journal of Park and Recreation Administration **19** (3): 17-37.

Marion, Jeffrey L. and Yu-Fai Leung. 2004. Environmentally sustainable trail management. In: Buckley, Ralf (ed.), Environmental Impact of Tourism, Cambridge, MA: CABI Publishing. pp. 229-244.

Marion, Jeffrey L., Yu-Fai Leung and Sanjay K. Nepal. 2006. Monitoring Trail Conditions: New Methodological Considerations. The George Wright Forum **23** (2): 36-49.

Newsome, David E., David N. Cole and Jeffrey L. Marion. 2004. Environmental impacts associated with recreational horse riding. In: Buckley, Ralf (ed.), Environmental Impact of Tourism, Cambridge, MA: CABI Publishing. pp. 61-82.

Wilson, J.P. and J.P. Seney. 1994. Erosional impact of hikers, horses, motorcycles, and off-road bicycles on mountain trails in Montana. Mountain Research and Development **14** (1): 77-88.

Waddington, H. 2000. Types of survey questions. In B. Hoffman (Ed.), *Encyclopedia of Educational Technology.* Retrieved February 22, 2009. http://coe.sdsu.edu/eet/Articles/surveyquest/start.htm

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Appendix A

Big River & Salmon Creek Property Maps
Created by: Laura Wittman, Master of Environmental Management Program, Nicholas School of the Environment, Duke University, March 2009

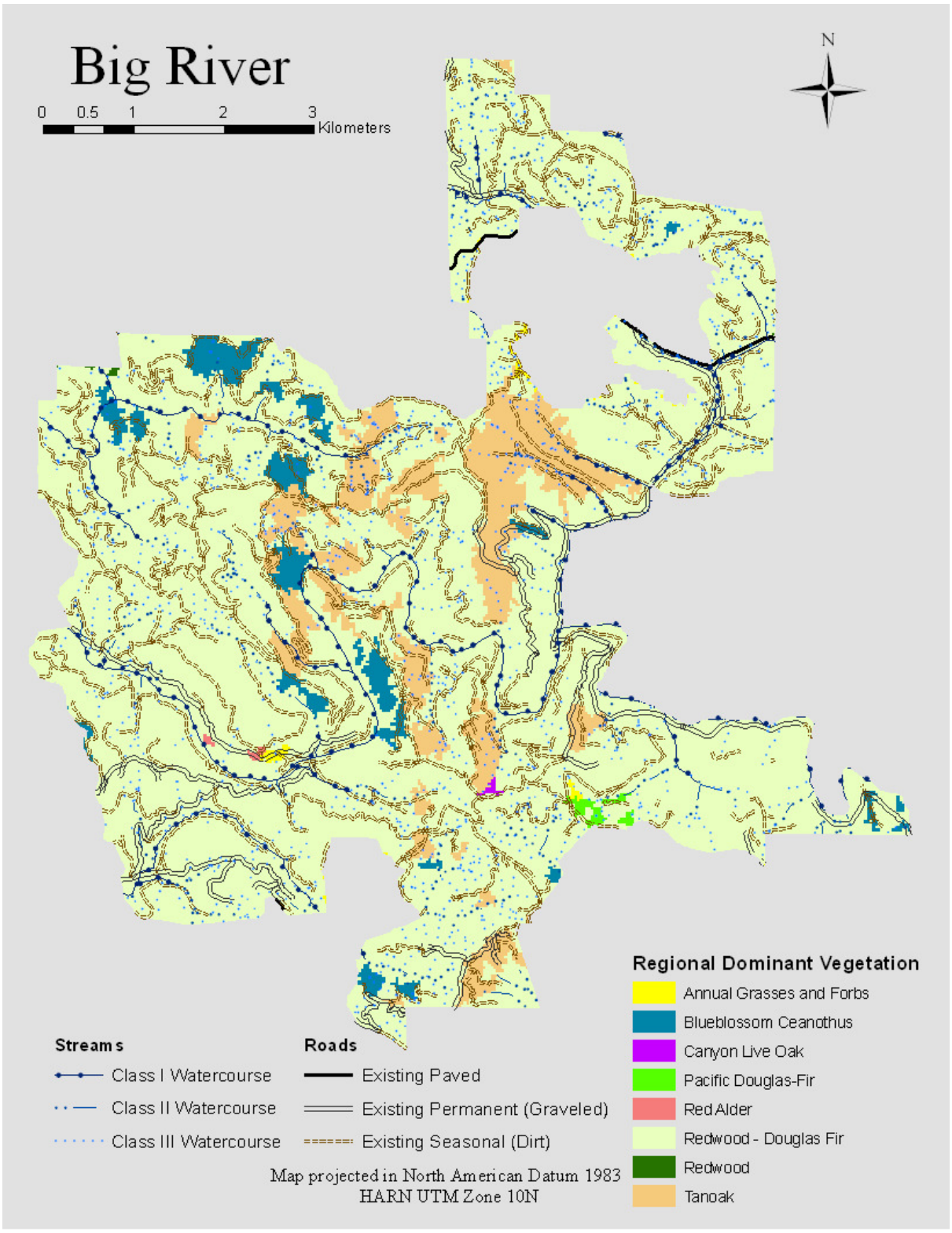

Figure 1: Big River Vegetation & Property Characteristics

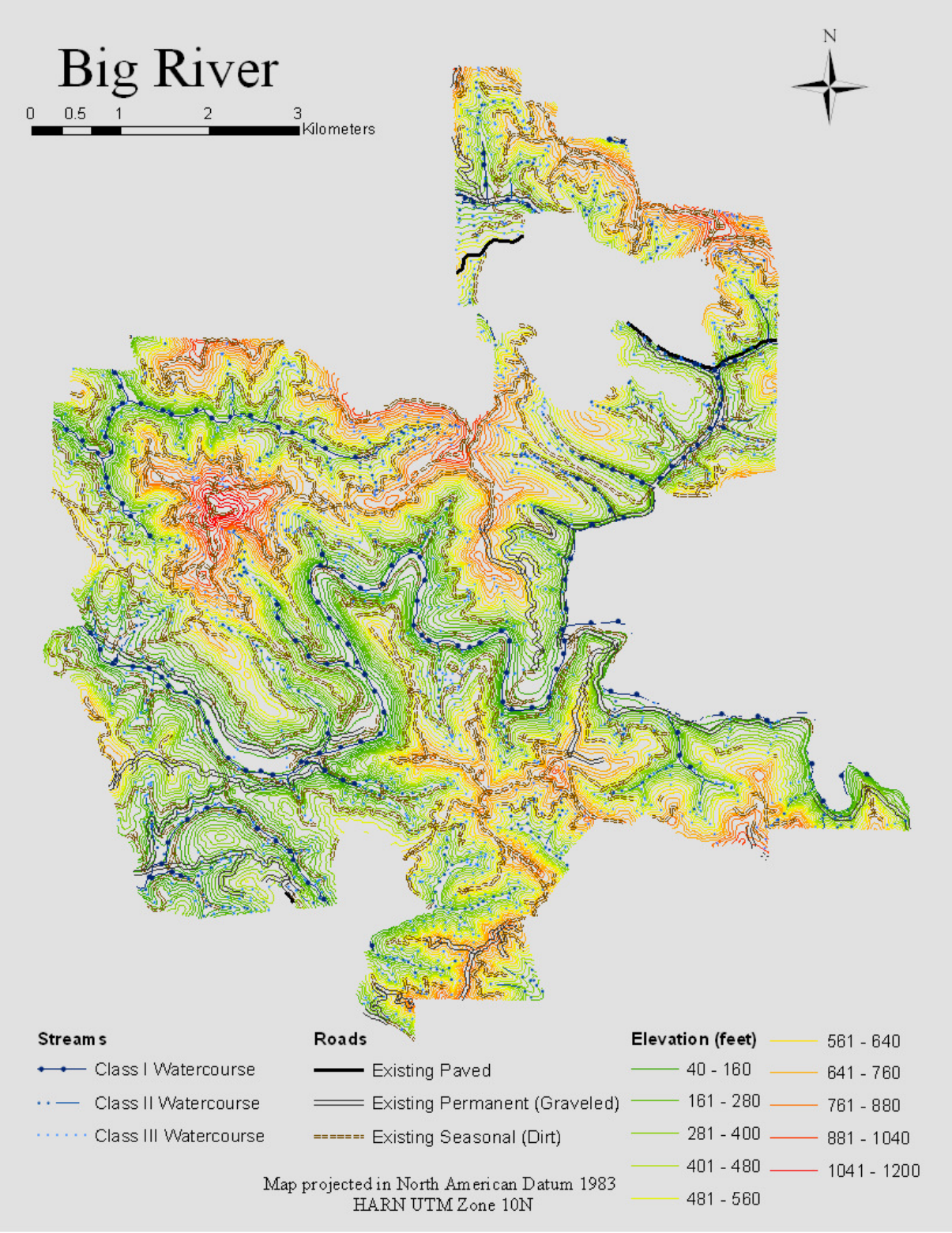

Figure 2: Big River Elevation & Property Characteristics

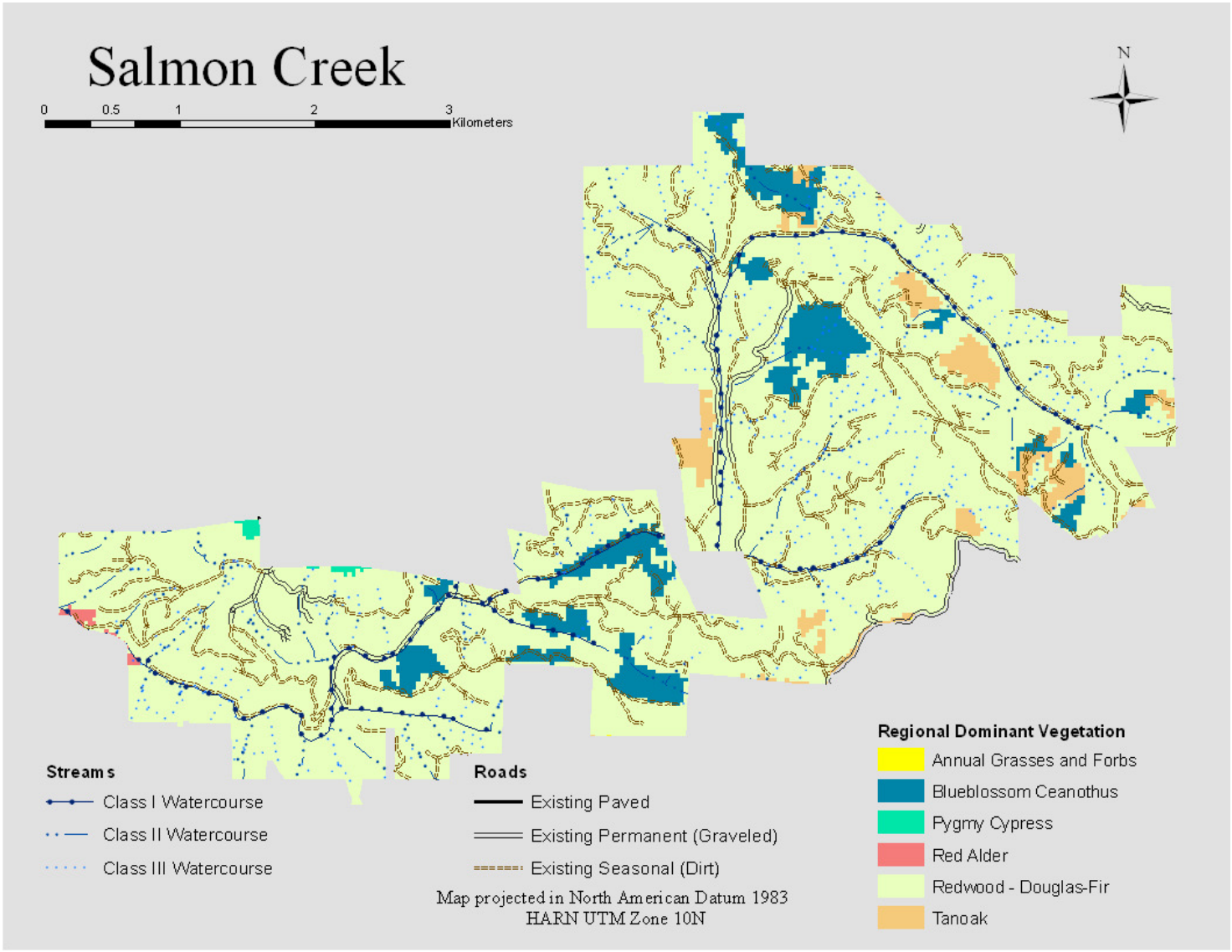

Figure 3: Salmon Creek Vegetation & Property Characteristics

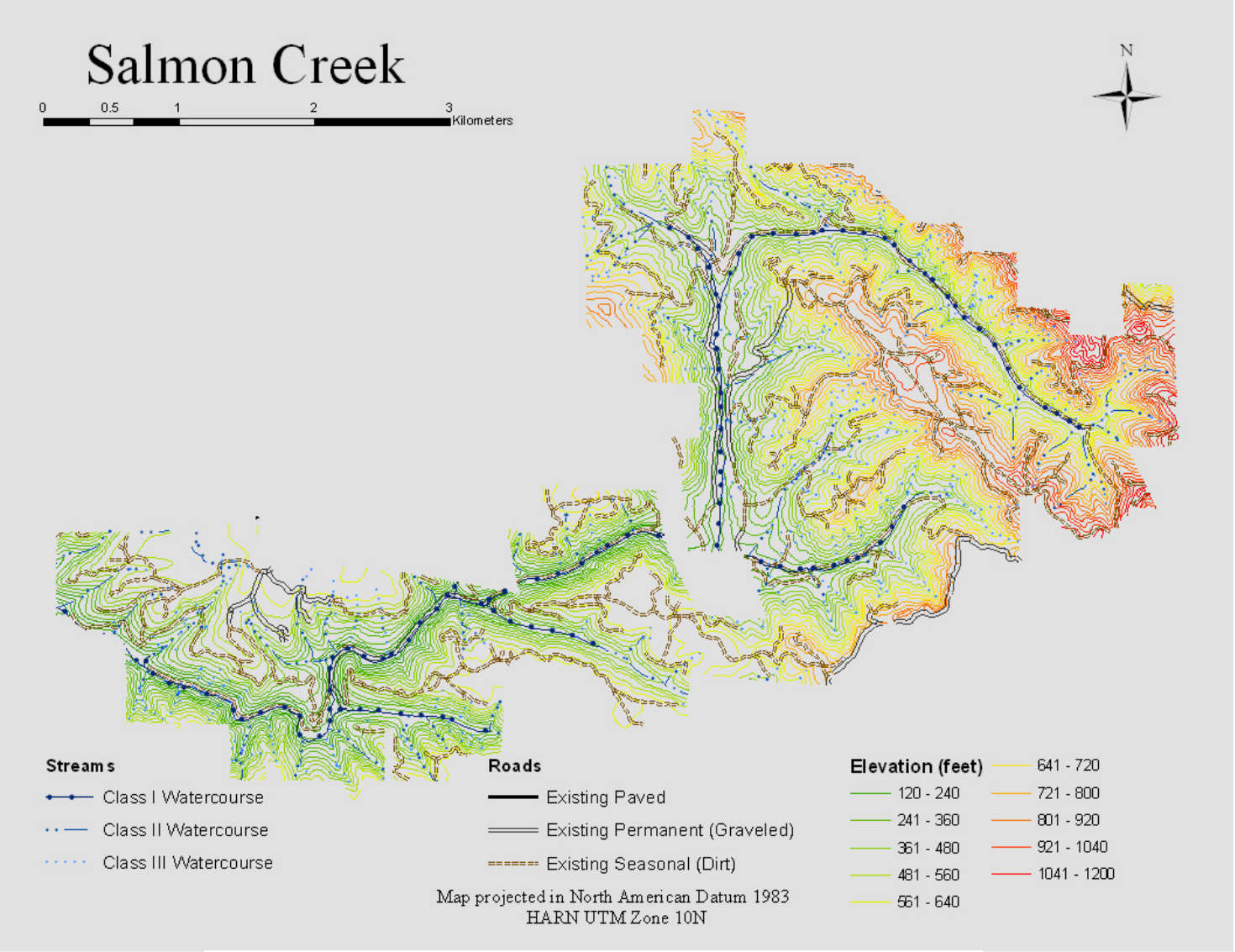

Figure 4: Salmon Creek Elevation & Property Characteristics

Appendix B

Recreation Impact Expert Survey
Master's Project for Laura Wittman
Nicholas School of the Environment at Duke University, MEM 2009

Informed Consent

My name is Laura Wittman and I am a second year Master of Environmental Management student at the Nicholas School of the Environment at Duke University in Durham, NC. I am developing a framework to monitor potential public access impacts on working conservation forest properties for The Conservation Fund (TCF) as my master's project required for graduation. TCF is a non-advocacy, nonprofit organization working in land and water conservation, and is looking to develop a monitoring plan for recreational impacts on their forest properties. I would like to ask you questions about your experience and/or research in relation to the topic of monitoring recreational impacts, which will take approximately a half-hour to complete. Participation in this project is completely voluntary and at any time you may choose not to answer a specific question, give additional details or withdraw altogether. This project will become a working management framework for TCF, and will also be accessible online through Duke University's website. There will be no compensation for your time, but you will be cited and provided credit for your contribution to this project. For further information or future contact, please contact the researcher:

Laura Wittman
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Purpose

The purpose of this study is to attain relevant background information from scientists and other relevant professionals for my master's project. This will provide the basis to create a management plan for monitoring impacts of public recreational access on working conservation forests. This plan seeks to create a management framework with inputs from professionals to gather their insight into feasible methods for monitoring these impacts. This framework will specifically be designed to help TCF in managing two of their working conservation forest properties in northern California. TCF is bound to provide public access to their properties by the state agencies that funded their acquisition as long as it does not degrade the natural resources. There will always be some types of recreational impacts, but minimizing them and protecting the endangered species and other conservation values of the properties is the priority of TCF. Interviewing scientists and professionals experienced with research and/or management of recreational impacts such as yourself will help me gain further insight on the aspects I must consider in making this management framework work effectively for the organization and its goals for these coastal redwood forest properties.

Professional Background

1. What is your level of experience with recreational ecology research or management?

   a. < 5 years
   b. 5-15 years
   c. 16-25 years
   d. > 25 years

2. What type(s) of position(s) have you held? Please circle all applicable answers.

   a. Research project principal investigator
   b. Research project assistant
   c. Recreation program manager
   d. Recreation program assistant
   e. Other _____

3. What types of organization(s) have you worked for? Please circle all applicable answers.

   a. Nonprofit
   b. Government
   c. Private company
   d. University/College
   e. Other _____

4. Please list the name of your current employing organization _____,
   position type _____,
   and length of time employed _____.

5. In what types of ecosystem(s) have you studied and/or managed recreational activities? Please circle all applicable answers.

   a. Forests
   b. Prairie
   c. Marine
   d. Freshwater
   e. Desert
   f. Other _____

6. Please provide specific examples of the systems you have worked in (e.g., Sonoran desert, New England Salt Marsh)
   _____
   _____

Monitoring of Impacts

1. Establishing a carrying capacity (in the strict numerical sense) for the property is an effective method to manage the recreational, ecological and social impacts of public use.

    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

2. Please list the reason(s) you believe carrying capacity is an effective or ineffective tool to manage the recreational, ecological and social impacts of public use.

_____
_____
_____
_____

3. Point sampling is the most effective method to monitor recreational impacts to the natural environment and trail system. Please consider question 5 when answering.

    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

4. Please list the reason(s) you believe point sampling is the most effective method (if applicable) to monitor recreational impacts to the natural environment and trail system.

_____
_____
_____
_____

5. Problem assessment is the most effective method to monitor recreational impacts to the natural environment and trail system. Please consider question 3 when answering.

    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

6. Please list the reason(s) you believe problem assessment is the most effective method (if applicable) to monitor recreational impacts to the natural environment and trail system.
   _____
   _____
   _____
   _____

Organization management and community involvement in monitoring public access

1. Which specific techniques listed below have in your experience been effective in providing a safe environment for public use? Please circle all applicable answers.

   a. Gates
   b. Signs
   c. Maps
   d. Pamphlets (citing property use rules and additional information)
   e. Security staff
   f. Signed release forms
   g. Other _____

2. Have you personally designed, managed or helped implement recreational impact monitoring program(s) involving the community?

   a. Yes
   b. No

3. What types of activities was the community involved in (if applicable)?

   a. Direct monitoring (sampling, etc.)
   b. Restoration projects
   c. Property stewards
   d. Other_____
      _____
      _____

4. Involving the public in monitoring is an important step in achieving a successful public access program creating a partnership between the organization (property owner) and the community.

   a. Strongly disagree
   b. Disagree
   c. Neither agree nor disagree
   d. Agree
   e. Strongly agree

5. Please list any other techniques involving the public in monitoring or other activities that you have found benefits the organization, property and/or community that could be potentially applied to the working conservation forests in this project.

_____
_____
_____
_____

Additional Information

If there any further insights, past examples of successes or failures of techniques or projects, additional methods/techniques of monitoring, or recommendations of professionals to contact or resources to investigate that you could provide please list them below. Thank you for your time and effort in aiding my research and development of a monitoring management plan for TCF's working conservation coastal redwood forests in Northern California.