2009 Annual Report

Visitor Use and Impact Monitoring Program

Division of Resources Management and Science
Yosemite National Park

2009 Annual Report

User Capacity Management Monitoring Program

United States Department of the Interior
National Park Service
Yosemite National Park

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1.0 INTRODUCTION AND BACKGROUND

The Organic Act established the National Park Service to, “conserve the scenery and the natural and historic objects and the wild life therein” while at the same time providing for “the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (NPS Organic Act 1916 - 16 USC 1). Thus, park planners and managers are charged to protect resources while providing for their enjoyment. How do we strike this balance?

The Visitor Use and Impact Monitoring Program has been developed to serve as a report for the park on how we are managing the natural, cultural and social resources (visitor experience). The indicators that have been developed for this program have been identified as impacts by visitor use and are measurable, non-destructive to collect, and sensitive to change (Hof et al. 1994, NPS 1995, NPS 1997). The monitoring program and process is dynamic and constantly being updated with the advent of technological advances, changes in visitor behavior and the successes that management action yields. Figure 1.0.1 displays the process that a multitude of protected areas, including Yosemite National Park, go thru to manage and provide meaningful data from their long-term visitor use management programs.

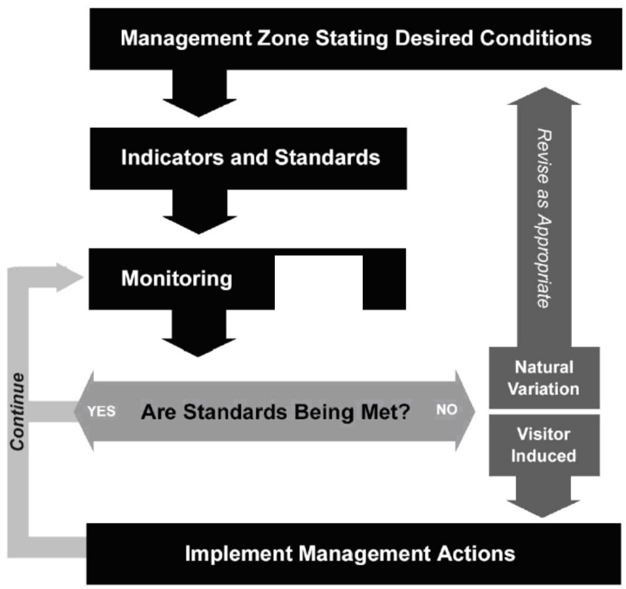

Figure 1.0.1 demonstrates an example of an adaptive management monitoring framework.

Indicators are measurable, manageable variables that reflect the condition of park resources and visitor experiences, while standards represent the desired condition of indicator variables (Manning 1999, Manning 2007). Monitoring indicator variables provides important information to park planners and managers on the condition of park resources and human experiences (Hof and Lime 1997). Collectively, defining indicator variables, setting standards, and monitoring serve as an early warning system informing park managers of potentially unacceptable changes in resource and social conditions. This program utilizes the National Park Service’s Visitor Experience Resource Protection (VERP) framework and the United States Forest Service’s Limits of Acceptable Change

(LAC) protocol as a model for the continued implementation of a long-term monitoring program to understand visitor caused impacts.

1.1 INDICATORS AND STANDARDS

In an adaptive management process and subsequently in Yosemite's Visitor Use and Impact Monitoring Program, *indicators* are measurable, manageable variables that reflect the condition of park resources and the quality of visitors' experiences. *Standards* reflect the desired condition of these variables (Manning 2007). The Visitor Use and Impact Monitoring Program for the Merced Wild and Scenic River originally defined a suite of eight selected indicators. (YOSE 2004). Many of these indicators were first monitored in 2004. With the ongoing development of the Tuolumne River Plan, additional indicators have been selected along with measureable standards. Some of these indicators overlap with current efforts in the Merced River Corridor, however, some represent monitoring opportunities unique to the Tuolumne River corridor. In this document, we will present a total of nine indicators and their corresponding draft standards, when applicable. In some cases standards are still in the development phase, and will not be presented until an adequate amount of data is available for standard development. Currently, none of our standards presented here are included in any decision documents. Draft standards for the Tuolumne River Corridor are included in the upcoming draft version of the Tuolumne River Plan.

INDICATOR 1: Water Quality

Visitor impacts including pollutants into the rivers are known to create resource degradation. Such constituents are monitored to identify potential changes over time. The following water quality parameters are measured: Nutrients (total dissolved nitrogen, nitrate + nitrite, total phosphorous and total dissolved phosphorous), E. coli, and total petroleum hydrocarbons. Associated field data collected with each water quality sample included water temperature, specific conductivity, dissolved oxygen, and pH.

Draft Standard: The standards developed from 2005-2009 baseline data are intended to be anti-degradation for each segment for E. coli, nutrients (total dissolved nitrogen, nitrate + nitrite, total dissolved phosphorous, and total phosphorus), and total petroleum hydrocarbons per sampling period. Additionally, the park must comply with the proposed state standard for E. coli for recreational contact at all times

INDICATOR 2: Riverbank Erosion

This indicator examines the degree of riverbank erosion along the Merced River. This will be assessed through a combination of vegetative cover condition and substrate erosion condition characteristics.

Standard in Development:

A proposed standard would address the following elements:

1). Channel Morphology: No greater than 10 percent increase in cross-sectional area due to bank scour in 80 percent of sites.

2). Vegetation Condition (Trend): No greater than 10 percent cover of bare ground in 80 percent of sites. This trend will be determined using the 2009 data to reflect current condition as compared to future assessments. This will help determine our desired condition and to detect change.

3). Vegetation Condition (Status): No greater than 20 percent of (strata-based) sites will have less than X percent green understory cover.

INDICATOR 3: Wildlife Exposure to Human Food

Wildlife impacts are heavily caused by access to food. Understanding visitors' abilities to comply with food storage regulation has been developed as a proxy for these wildlife impacts.
Draft Standard: 95% or greater compliance with food storage regulations in selected campgrounds and parking areas.

INDICATOR 4: Extent and Condition of Informal Trails

This indicator monitors the proliferation and condition of informal trails in meadows and the resulting fragmentation of meadow habitat. Informal trail monitoring has been applied to both river corridors to identify trampling related impacts to Yosemite's unique meadow habitat.
Draft Standard: Two draft standards have been developed for the Tuolumne River Corridor. Standard development for the Merced River Corridor is ongoing.
Fragmentation Standard: Meadows with informal trailing in the Tuolumne River Corridor will display fragmentation represented through a specific landscape index: the Largest Patches Index Five (LPI5) of no more than 92.84%. Decreasing percentages will indicate an increased degree of fragmentation
Meadow Condition Standard: Trend data will demonstrate improvement of condition for recorded informal trails in meadows.

INDICATOR 5: Wilderness Encounters

This indicator monitors encounters with other parties gauge the density levels and opportunities for solitude that visitors experience in designated Wilderness areas.
Draft Standard: No more than two encounters with another party per hour, 80 percent of the time. This standard will be evaluated based on study sites that reflect the range of use levels with varying distances from roads and trailheads within the Tuolumne River Corridor.

INDICATOR 6: Extent of Visitor Use

Visitor use monitoring serves as a gauge of park visitor use activity along the river. This indicator reflects visitor use levels and behaviors that potentially cause negative impacts such as crowding, user conflict, noise and other visitor caused disturbances on both natural resources and the visitor experience. Visitor count measures overall recreation use in the river corridor and helps to protect the Merced River's Outstandingly Remarkable Values.
Standards in Development: This indicator is still in development stages and encompasses a variety of visitor use studies throughout Yosemite.

INDICATOR 7: Archeological Resource Integrity

This indicator examines the condition, stability, and integrity of archeological sites within the Merced and Tuolumne Wild and Scenic River corridors. This work explored the applicability of the National Park Service's Archeological Site Monitoring Information System (ASMIS) to monitor visitor use impacts to archeological resources.
Draft Standard: Assuming archeological sites are assessed per the established ASMIS inspection schedule, no more than 10% of current, unmitigated impacts from visitor use on archeological sites visited within each season display a *Disturbance Effect to the Resource* category higher than *Negligible* or *Partial Loss-Repairable* on individual sites assessed with a low estimated data potential. Additionally, no current, unmitigated impacts from visitor use on archeological sites visited within each season display a

Disturbance Effect to the Resource category higher than *Negligible* or *Partial Loss-Repairable* on individual sites with an estimated moderate or high data potential.

INDICATOR 8: Parking Availability

This indicator is used to evaluate the conditions of the transportation system in Tuolumne Meadows and Yosemite Valley. In Tuolumne Meadows, the visitor center and the wilderness parking lots will be monitored to document the amount of time that they are at full capacity, forcing them to be shut down to incoming visitors. In Yosemite Valley, the Camp 6, Wilderness, and Camp Four parking lots will also be monitored for the same values.

Standard in Development: Standards are being developed utilizing past data, and other ongoing traffic related research in Tuolumne Meadows. Standards should reflect maximum capacity from the document of decision for 2 to 3 centralized parking areas in the Tuolumne Meadows area. Standards for Yosemite Valley parking lots are currently being developed.

INDICATOR 9: Natural Soundscapes

This indicator evaluates soundscapes as measured by (1) the change in sound levels from natural ambient in areas more than 100 feet from roads, and (2) the amount of time above speech interference thresholds in areas more than 100 feet from roads.

Draft Standard: The proposed standard will look at hourly change in sound levels exceeding 3 dB(A) and 6dB(A) to assess cumulative noise impacts, and at noise events exceeding 60 dB(A) to assess speech interference. Different standards will be proposed for frontcountry vs. backcountry areas, and for day-time vs. night-time hours.

The following maps present the various sampling sites for each indicator monitored in 2009.

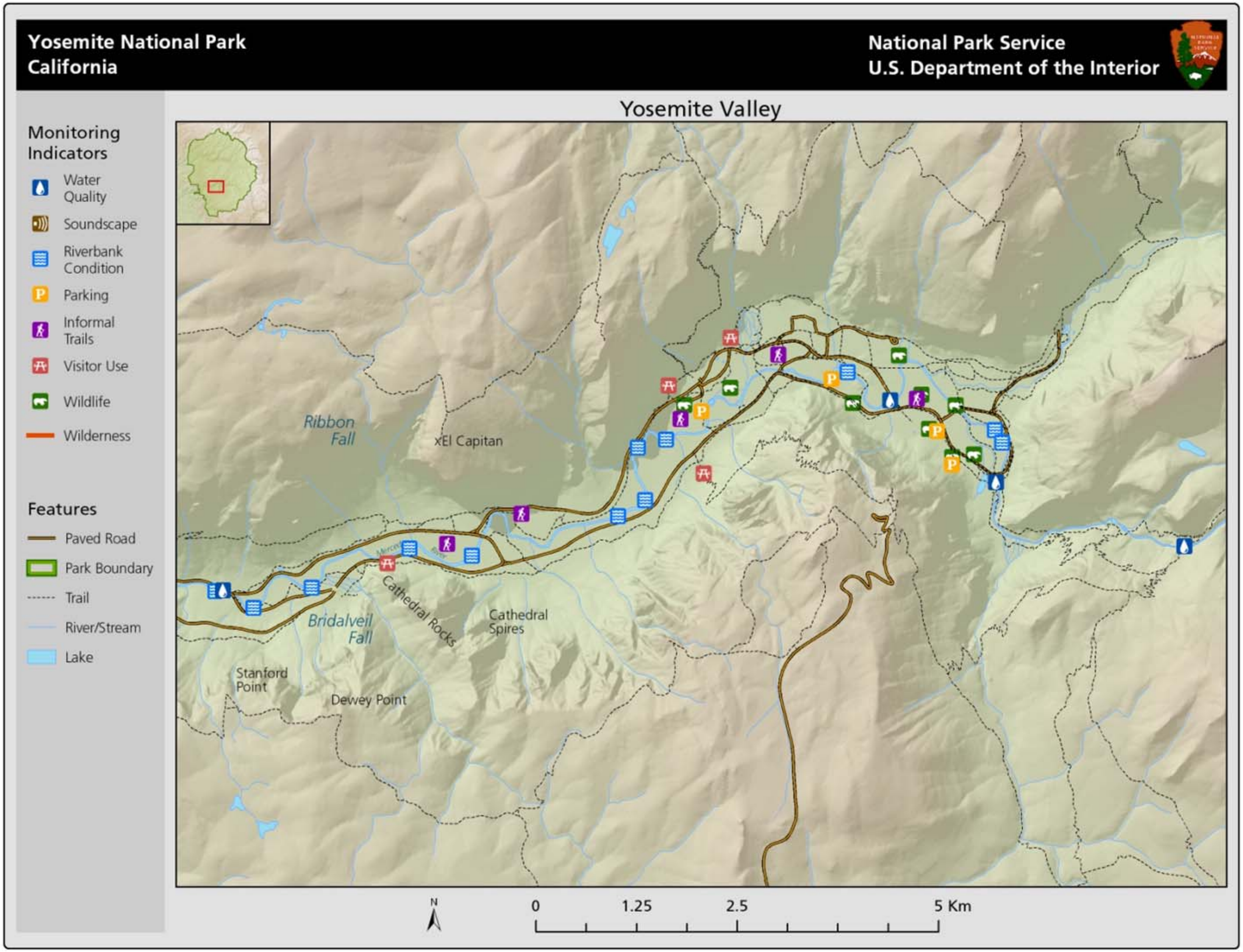

Figure 1.1.1 shows monitoring sites in Yosemite Valley.

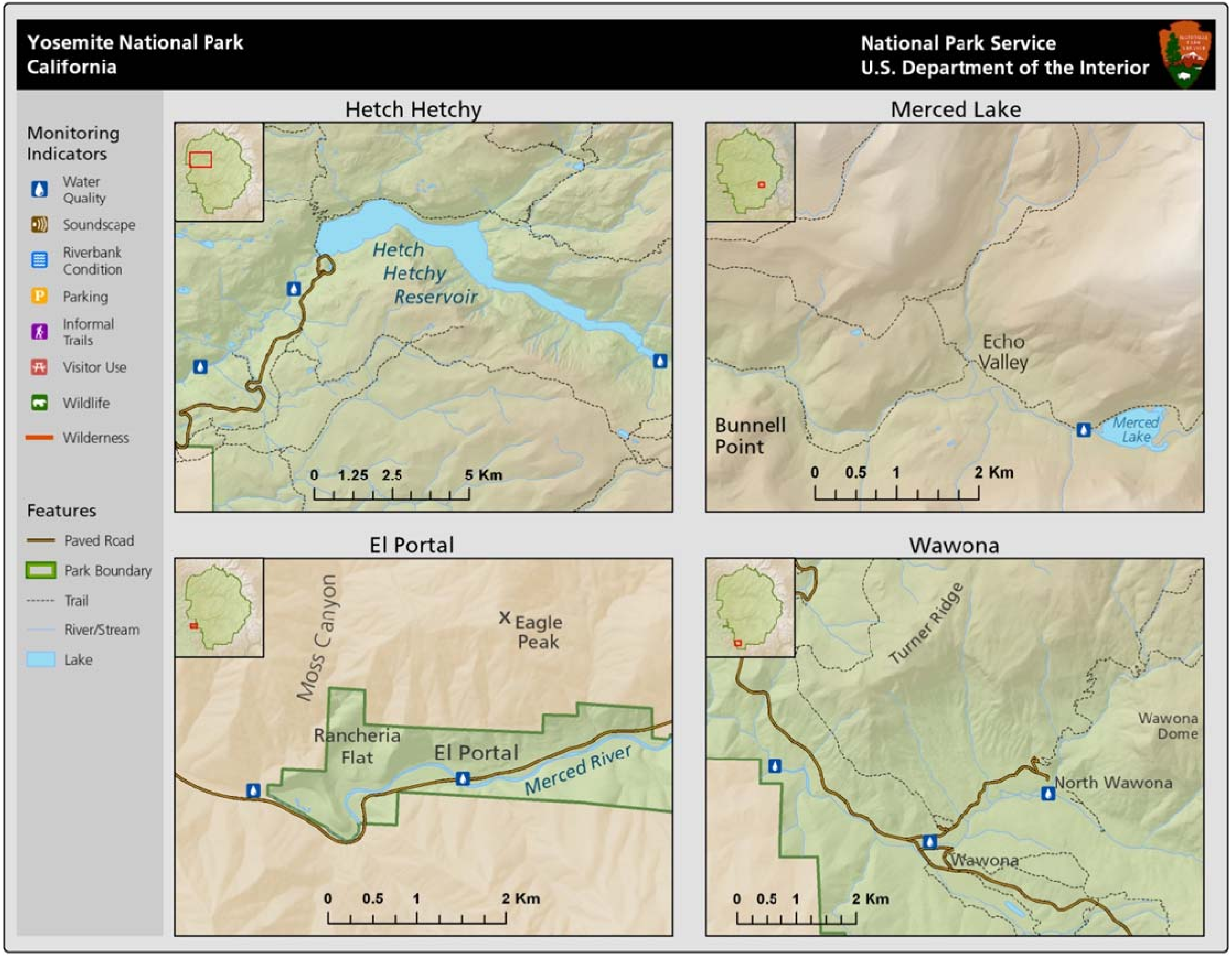

Figure 1.1.2 displays monitoring Sites in Wawona, El Portal, Hetch Hetchy, and Merced Lake.

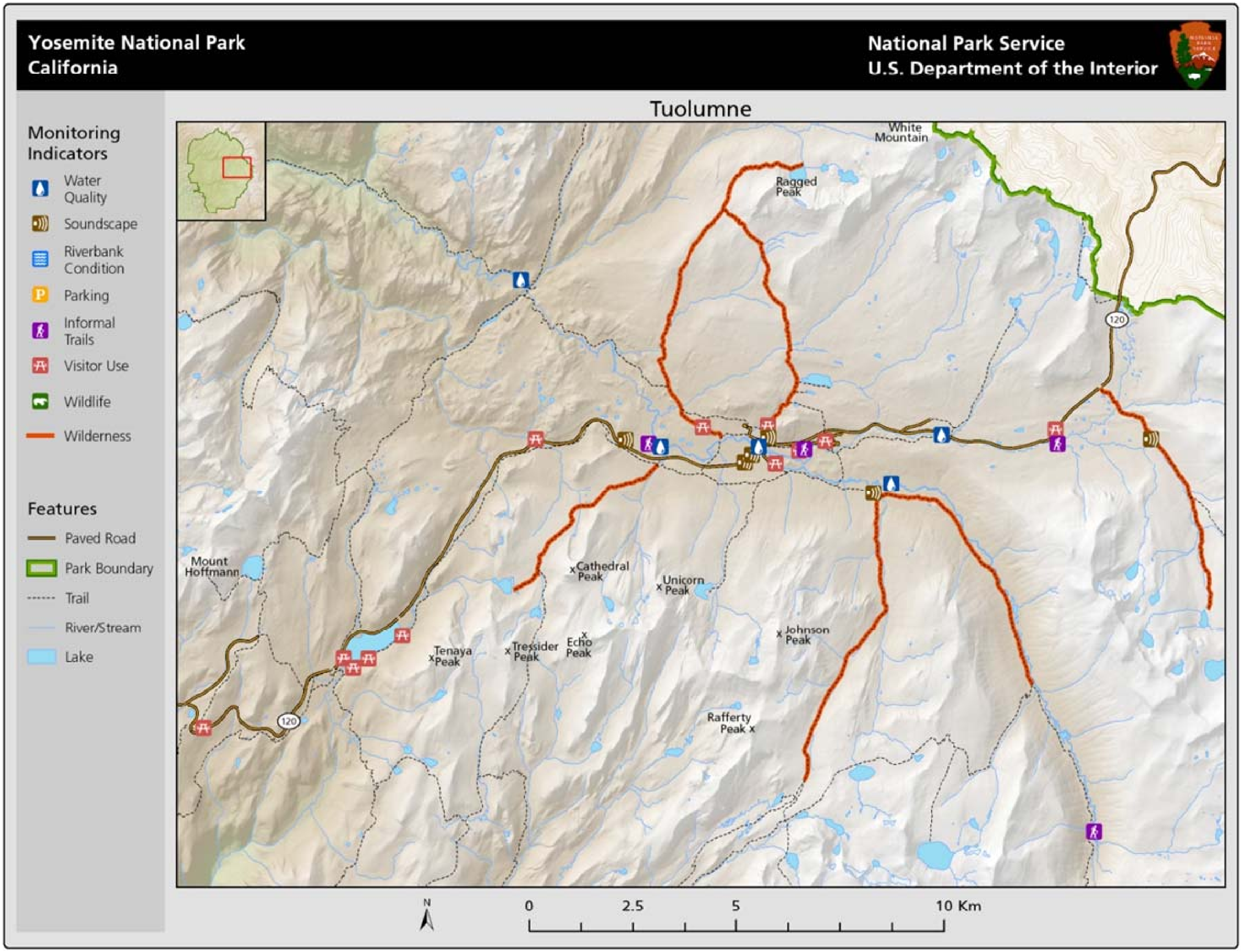

Figure 1.1.3 displays sites in the Tuolumne Meadows area

Similar to previous years, the Visitor Use and Impact Monitoring Program followed a timeline as represented in Figure 1.1.4 below. Generally, the late winter and early spring months were spent refining and improving monitoring protocols. In the spring, preparations were made for data collection including hiring field staff, recruiting and organizing volunteers, preparing data sheets and finalizing protocols, checking and obtaining equipment, etc. The majority of data collection efforts took place during the summer and early fall. In the fall, data were coded, analyzed and incorporated into a draft report. The annual report is, generally, finalized during the winter and spring months concluding the program year. A results symposium has been organized for April 7, 2010 in order to present updates and findings from our 2009 season, and present on related work occurring at other parks and protected areas.

<table>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>June</th><th>July</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="4">Complete Annual Report from previous year</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Refine monitoring protocols, prepare for new field season</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="6">Finalize Field Monitoring Guide, conduct field monitoring and collect data</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Visitor Use and Impact Monitoring Symposium</td><td></td><td></td><td></td><td></td><td colspan="4">Compile and analyze data, report writing, Fall workshop</td></tr>
<tr><td colspan="3">Progress report</td><td colspan="3">Progress report</td><td colspan="3">Progress report</td><td colspan="3">Progress report</td></tr>
<tr><td colspan="12">Implement management actions throughout as stipulated in action plan</td></tr>
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Figure 1.1.4 shows the Visitor Use and Impact Monitoring program timeline.

1.2 2009 VISITOR USE SUMMARY

In order to understand some of the underlying factors which influence the park's intention to monitor the levels and impacts of visitor use, it is important to include a characterization of visitor use for 2009, as this may assist in understanding the results.

In 2009, Yosemite National Park received 3,737,472 recreation visits. Compared to 2008, recreation visits fell by 234,044 visits. Table 1.2.1 presents visitor use statistics by month throughout 2009. It is important to note that Tioga Road opened on May 19th and closed on November 12th. Glacier Point Road opened on May 5th and closed November 12th.

Table 1.2.1 shows the number of recreation visits to Yosemite National Park in 2009.

Month	Recreation Visits
January	101,984
February	78,795
March	132,711
April	230,828
May	399,683
June	483,382
July	586,591
August	643,300
September	471,530
October	346,826
November	151,297
December	110,545
Total	

For more information on Yosemite NP's visitor use statistics please visit http://www.nature.nps.gov/stats/.

1.3 Collaboration and Consultation

Yosemite National Park's Visitor Use and Impact monitoring program relies on the efforts of a diversity of park staff, park partners, cooperating institutions, interns, volunteers and other members of the public.

The National Park Service collaborated with Colorado State University and the University of Idaho under cooperative agreements for technical expertise and academic support on monitoring protocol development, data collection and analysis, and reporting. Applying monitoring methods that have undergone academic rigor, Yosemite's program was able to make substantial progress in its iterative capacity.

The monitoring program also benefited in 2009 from the efforts of several Student Conservation Corps (SCA) volunteers. Each year, SCA volunteers provide a vital component to the field team of the monitoring program. The SCAs provided crucial field and technical support for data collection and monitoring. Additionally, the program relies heavily on intern and volunteer support to provide data collections and input while providing a key educational component on the park's visitor use management issues.

Additional information will be found in the final reports provided by our cooperators. In the spring of 2010, researchers from the University of Idaho will produce a final document which will include much important reporting on the development of the Wilderness Encounters Indicator.

1.4 REPORT OVERVIEW

This Annual Report presents Visitor Use and Impact monitoring activities and data collection results for the 2009 calendar year. The reader will note that a section outlining the various methods used to collect and analyze data is absent from this report. This information is compiled in the 2009 Visitor Use and Impact Monitoring Field Monitoring Guide. This guide and other documents pertaining to the long-term monitoring of visitor impacts in Yosemite National Park may be found on the park's website at: www.nps.gov/yose/. Data collected from the 2009 field season is available on request from the Visitor Use and Impact Monitoring Program Manager, Todd Newburger at (209)379-1434 or todd_newburger@nps.gov. In the coming years, data will be posted on the park's website with brief descriptions on how to interpret the indicator datasets. Additional analysis of datasets from research institutions and other interested organizations is encouraged.

2.0 MONITORING RESULTS

This section presents the findings from indicator monitoring in 2009. Results are organized by indicator variable including the following information: indicator and standard description; indicator performance summary; monitoring activities; results; discussion; and management implications.

2.1 WATER QUALITY

Introduction

Excellent water quality was identified by the Merced River Plan as part of the hydrologic processes Outstandingly Remarkable Value in three segments of the river corridor: in the wilderness reaches of the main stem and South Fork, as well as in the impoundment segment of the South Fork (above Wawona). Water quality will also be a significant indicator along the Tuolumne Wild and Scenic River.

This report summarizes water quality data collected during Water Year (WY) 2009 (October 1st, 2008 to September 30th, 2009) and compares these results to draft water quality standards developed from 2004-2007 data (Clow et al., in prep.). The water quality constituents sampled in WY 2009 are listed in Table 2.1.1.

Table 2.1.1 shows water quality constituents sampled in WY 2009.

Constituent	Analytical Method	Analytical Reporting Limit	California Standard	Source Document
Total Dissolved Nitrogen (TDN)	USGS/NWQL[1] 2754	0.03 mg/l	None	
Nitrate + Nitrite (NO3+NO2)	USGS/NWQL[1] 1979	0.016 mg/l	10 mg/l (Drinking water)	State of California Regulations, Title 22 – Drinking water standards, Maximum Contaminant Levels - Inorganic Chemicals
Total Phosphorous (TP)	USGS/NWQL[1] 2333	0.004 mg/l	None	
Total Dissolved Phosphorous (TDP)	USGS/NWQL[1] 2331	0.004 mg/l	None	
E. coli	SM 9221F[2]	2 MPN/100ml (MPN = Mean Probable Number of bacterial colonies)	Geometric Mean of 5 samples taken over a 30-day period shall not exceed 126 MPN/100 ml. No single sample shall exceed 235 MPN/100 ml.	Proposed standard currently under review by the California Regional Water Quality Control Board.
Total Petroleum Hydrocarbons (TPH)	EPA 306M[3]	13-17 µg/l	Waters shall not contain oils, greases, waxes, or other materials in concentrations that cause nuisance, result in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect beneficial uses.	State of California, 1998. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region. Fourth Edition—1998. California Regional Water Quality Control Board.

[1] U.S. Geological Survey National Water Quality Laboratory
[2] Standard Methods for the Examination of Water and Wastewater
[3] Environmental Protection Agency Standard Method

Standards

The standards developed from 2004-2007 baseline data (Table 2.1.2) are intended to be anti-degradation for each segment for *E. coli*, nutrients (total dissolved nitrogen, nitrate + nitrite, total dissolved phosphorous, and total phosphorus), and total petroleum hydrocarbons per sampling period. Additionally, the park must comply with the proposed state standard for *E. coli* for recreational contact at all times (Table 2.1.1). Standards are worded as follows:

Nutrients: The 75th percentile concentration of constituent X over one water year shall not exceed the standard for a site (at the 95th confidence interval) more than 1 in 5 years.

E. coli: The 50th percentile concentration of E. coli colonies over one water year shall not exceed the standard for a site (at the 95th confidence interval) more than 1 in 5 years.

Total Petroleum Hydrocarbons: The concentration at a site over one water year shall not exceed 14 µg/l 80% of the time in more than 1 in 5 years.

Table 2.1.2 represents Yosemite's water quality standards.

Site	NO3+NO2 (mg/l)	TDN (mg/l)	TDP (mg/l)	TP (mg/l)	*E. coli* (MPN/100ml)
Merced River (main stem)					
Below Merced Lake	0.044	0.109	0.0032	0.004	n/a
Above Nevada Falls	0.034	0.088	<0.003	<0.004	n/a
Above Happy Isles Bridge	0.032	0.128	0.0032	0.0074	6.0
Above Pohono Bridge	0.020	0.130	0.0061	0.0114	7.0
Below Foresta Bridge	0.043	0.238	0.0049	0.0123	5.0
South Fork Merced River					
Above Swinging Bridge	0.037	0.172	<0.003	0.0047	2.0
Below Wawona Campground	0.017	0.143	0.0064	0.0089	4.1
Tuolumne River					
Dana Fork Below Gaylor Creek	0.013	0.079	<0.003	<0.004	4.1
Lyell Fork Above Twin Bridges	0.048	0.097	<0.003	0.0052	5.0
Tuolumne River Above Tioga Road Bridge	0.064	0.096	<0.003	0.0042	5.2
Tuolumne River Above Budd Creek	0.049	0.131	0.0031	0.0181	4.1
Tuolumne River Below Conness Creek	0.019	0.074	<0.003	<0.004	*

* Insufficient data for standard determination as of October 2008.

Measurement

The following water quality parameters were measured: Nutrients (total dissolved nitrogen, nitrate + nitrite, total phosphorous and total dissolved phosphorous), *E. coli*, and total petroleum hydrocarbons. Associated field data collected with each water quality sample included water temperature, specific conductivity, dissolved oxygen, and pH.

Sampling

For WY 2009, the sampling frequency was increased at the Merced River sites from quarterly to monthly; however, due to funding constraints, it was necessary to reduce the number of total sampling locations. As a result, two sites, Sentinel Bridge and Highway 140, are no longer being sampled.

Field staff sampled at seven locations monthly (except December and February) on the Merced River and South Fork Merced (Figure 2.1.1) and monthly during the summer at five locations on the Tuolumne River (Figure 2.1.2). In addition, two storm events were sampled and bimonthly winter samples were obtained from two sites in Tuolumne Meadows (Lyell Fork above Twin Bridges and Tuolumne River above Budd Creek). At all other wilderness locations, winter samples were not obtained due to access constraints. Nutrients (total dissolved nitrogen, nitrate, total phosphorous and total dissolved phosphorous) were sampled at all sites. *E. coli* was sampled only at frontcountry sites due to the maximum six-hour hold time for these samples. Total petroleum hydrocarbons were sampled at four locations downstream of developed areas. In addition to collecting samples, field staff measured water temperature, specific conductivity, pH, and dissolved oxygen as well as river stage where possible.

Quality control procedures included the collection and analysis of field blanks and replicates for nutrients. Beginning in July of 2009, replicate *E.coli* samples were collected.

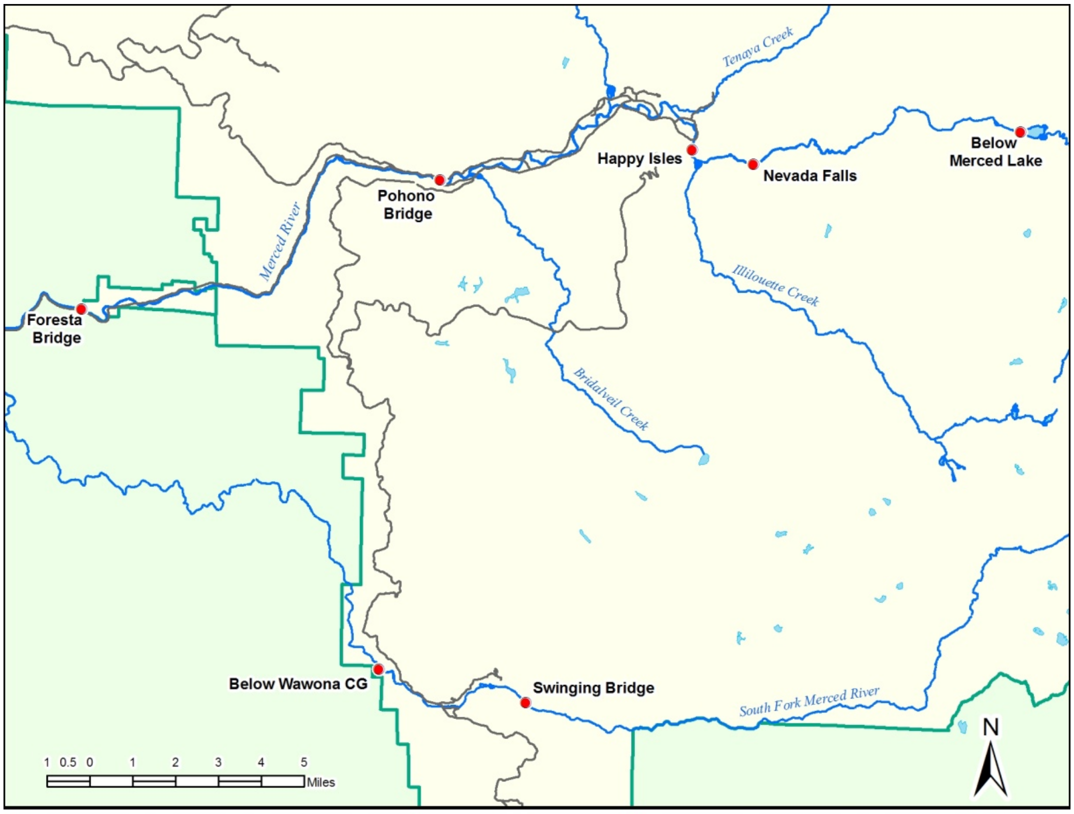

Figure 2.1.1 shows water quality sampling locations on the Merced River.

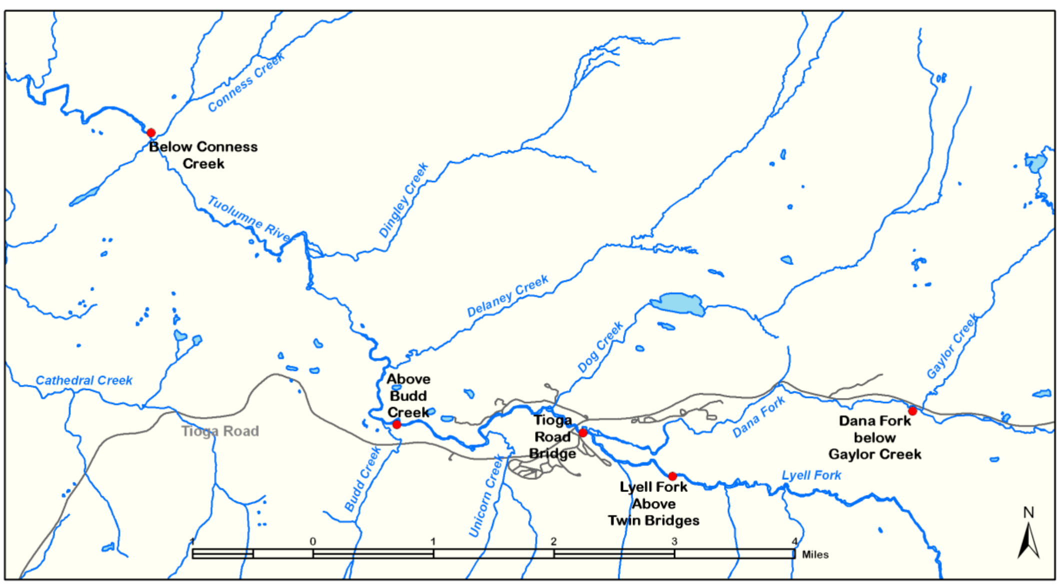

Figure 2.1.2 shows water quality sampling locations on the Tuolumne River.

Results

Table 2.1.3 summarizes 2009 data indices by site. Nutrient values represent the 75th percentile of data, *E.coli* values represent the 50th percentile, and TPH values are numbers of exceedances of the detection limit. No indices exceeded the draft standard at the 95% confidence level.

Summary statistics for blanks and replicates analyzed for nutrients and *E. coli* are listed in Table 2.1.4. A signed rank test was used to test for contamination. The test indicated that there were no significant differences between the replicates and regular samples.

Sampling for petroleum hydrocarbons revealed no reportable amounts in all sampling for the reporting period.

Table 2.1.3 represents a summary of water quality indices by site for WY 2009. The top number is the value of the index and the bottom number (in italics) is the number of samples.

Site	NO3+NO2 (mg/l)	TDN (mg/l)	TDP (mg/l)	TP (mg/l)	*E. coli* (MPN/100 ml)	TPH (exceedance of detection limit)
Merced River (main stem)						
Below Merced Lake	0.0564 *3*	0.248 *3*	* *2*	* *2*	–	–
Above Nevada Falls	0.090 *6*	0.135 *6*	0.003 *6*	0.004 *6*	–	–
Above Happy Isles Bridge	0.037 *12*	0.098 *12*	0.002 *12*	0.005 *12*	2.6 *12*	–
Above Pohono Bridge	0.034 *12*	0.099 *12*	0.003 *12*	0.011 *12*	3.1 *12*	0 *11*
Below Foresta Bridge	0.135 *12*	0.153 *12*	0.004 *12*	0.009 *12*	6.3 *12*	0 *11*
South Fork Merced River						
Above Swinging Bridge	0.066 *12*	0.108 *12*	0.002 *12*	0.004 *12*	5.2 *12*	–
Below Wawona Campground	0.024 *12*	0.093 *12*	0.003 *12*	0.006 *12*	4.2 *12*	0 *12*
Tuolumne River						
Dana Fork Below Gaylor Creek	0.016 *5*	0.045 *5*	0.002 *5*	0.001 *5*	1.0 *5*	–
Lyell Fork Above Twin Bridges	0.057 *7*	0.073 *7*	0.002 *7*	0.002 *7*	1.0 *5*	–
Tuolumne River Above Tioga Road Bridge	0.018 *5*	0.052 *5*	0.002 *5*	0.003 *5*	1.0 *5*	–
Tuolumne River Above Budd Creek	0.043 *8*	0.072 *8*	0.003 *8*	0.003 *8*	1.0 *5*	0 *5*
Tuolumne River Below Conness Creek	0.015 *4*	0.043 *4*	0.002 *4*	0.003 *4*	1.0 *3*	–

* Insufficient data for index determination
– Indicates data not collected for a particular site

Table 2.1.4 displays summary statistics for blanks and replicates analyzed for nutrients and *E. coli*.

Constituent	Percent of blanks below Analytical Reporting Limit	Mean difference between replicates	Median difference between replicates
NO3+ NO2	94	0.0003	0.0002
Total Dissolved Nitrogen	100	0.0015	0.0030
Total Dissolved Phosphorus	100	-0.0002	-0.0001
Total Phosphorous	100	-0.0014	0.0000
E. coli	-	-1.4	0.0

Discussion

Water quality in the Merced and Tuolumne River Basins continue to remain excellent for WY 2009. That is, nutrient and *E. coli* concentrations are not significantly (at the 95% confidence level) different from conditions in 2004-2007, when the baseline data were collected.

2.2 RIVERBANK CONDITION

Introduction

Riverbank condition has been selected as an indicator because the soils and vegetation that stabilize them are essential to the integrity of riparian ecosystems. Although soil erosion occurs along the river as a result of natural river processes, such erosion can be accelerated and exacerbated by human activities (Kondolf et al 1996). Increasing visitor use on susceptible substrates, often results in increased soil erosion. Therefore, this indicator is valuable for assessing a site's ability to sustain varying types and levels of visitor use.

Riverside soils and vegetation affect water quality by regulating the entry of groundwater, surface runoff, nutrients, sediments and other particulates, and fine and coarse organic matter to rivers and streams. Accelerated erosion associated with trampling and visitor access can alter these processes, leading to changes in hydrology and water quality.

In addition to indicating loss of soil, erosion may affect cultural values. The amount of riverbank erosion associated with visitor use will be used as an indicator of changes that may be occurring to any cultural resources—namely to archeological sites—that may exist along the river corridor. Riverbank soil erosion that occurs at archeological sites would suggest a potential loss of site's stability and a loss of intact archeological artifacts and features, critical components of archeological site integrity. Once artifacts and features are displaced from their original context or lost, the information inherent to those deposits is also lost.

Measurement

At each 200 meter long sample reach, we measure channel dimensions, bank vegetation cover, substrate size, and the amount of large wood in the channel. We also collected photographic-qualitative data.

Channel cross-sectional transects are measured between permanent markers on opposite sides of the river at three locations: 1) the downstream end of the reach, 2) the center of the reach, and 3) the upstream end of the reach. We also obtain high-resolution topographic scans of the entire reach using a tripod-mountain LiDAR (Light Detection and Ranging) scanner. Two 100-meter vegetation plots are located in the center of the reach, one on each bank.

Vegetation cover, substrate size and the amount of large wood in the channel are measured using point-intercept methodology within a 100-meter vegetation plot and along transect lines. The vegetation plot consists of one baseline and several transect lines, resulting in approximately 200 points per plot. The baseline is located 4 meters beyond the top of the river terrace with the midpoint perpendicular to the reach mid-point. The transects are located from the baseline to the water's edge at 10-meter increments with point data being collected at 1, 2, or 4-meter increments along the transects.

Within the vegetation plots, percent cover of bank stabilizing functional groups (bare ground, canopy cover, herbaceous cover, shrub cover, trees, and large wood) is determined using a presence or absence indicator. Substrate is classified by size. (For more detailed information on the vegetation plots see the Riverbank Condition section of the 2008 User Capacity Monitoring Field Guide).

Photographs of the riverbank are collected using a high-resolution digital camera and taking photos approximately every 50 meters along each bank or at such spacing as to allow stitching photos together without edge distortion. Permanent monuments are installed for exact relocation and replication.

Indicator Language

Degree of riverbank erosion along the Merced River. This will be assessed through a combination of vegetative cover condition and substrate erosion condition characteristics.

Potential Standards

Standards for this indicator will consider both the aspect of vegetation monitoring and river morphology. Vegetation trends will be assessed on sites after sites are repeatedly measured on a 3-5 year rotation.

Channel Morphology
X percent increase in cross-sectional area due to bank scour will lead to management action.

Vegetation Condition (Trend)
No greater than 10 (or 20) percent decrease in green understory as compared to an established baseline per stratum.

Vegetation Condition (Status)
No greater than 20 percent of sites will have less than X percent green understory cover per stratum.

Sampling

In order to be able to characterize conditions along the Merced River in Yosemite Valley, we randomly selected 24 sites using the Generalized Random Tessellation Stratified (GRTS) model (Stevens and Olsen 2004) in two river strata. Sites were grouped in stretches of river with gradients greater than 0.005 (Strata 1) or less than 0.005(Strata 0). Figure 2.2.1 shows all sites sampled in 2009. More detail is available in the 2009 Field Monitoring Guide. Sites are visited in order and are discarded only if the site contains major infrastructure such as bridges or extensive rip-rap (>50% of site length) or if surveying the site presents serious safety concerns.

In addition to the randomly selected sites, deliberately chosen sites were selected at four locations in Yosemite Valley and were sampled during the field season of 2008. This aspect of the sampling program is vital to ensuring that we are able to examine the types of visitor-related impacts that exist in comparison with the randomly selected sites. Four sites were chosen with consideration given to site access, proximity to destination sites or infrastructure, evidence of erosion, and vegetation quality. Two sites were chosen with these parameters to represent areas of seemingly high-use. Two low-use sites were additionally chosen to represent less impacted conditions, stable banks, and healthy vegetation communities. In 2009, a visitor use study was initiated to link actual visitation numbers of the deliberately chosen sites with the findings of our vegetation and cross-section monitoring (see Figure 2.2.2). The visitor use component of this study will be more specifically detailed in section 2.6 of this document.

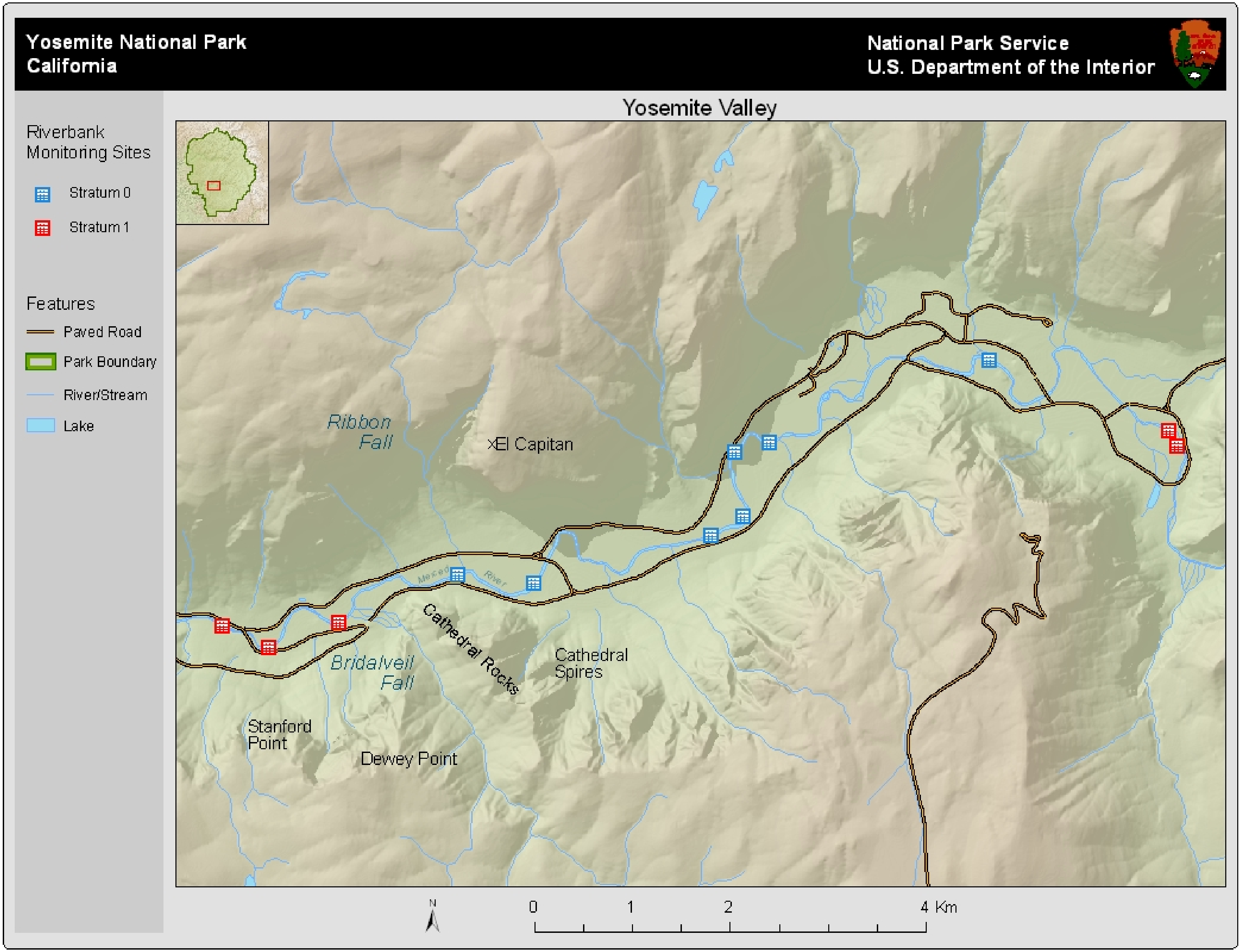

Figure 2.2.1 shows the riverbank condition 2009 monitoring locations by stratum.

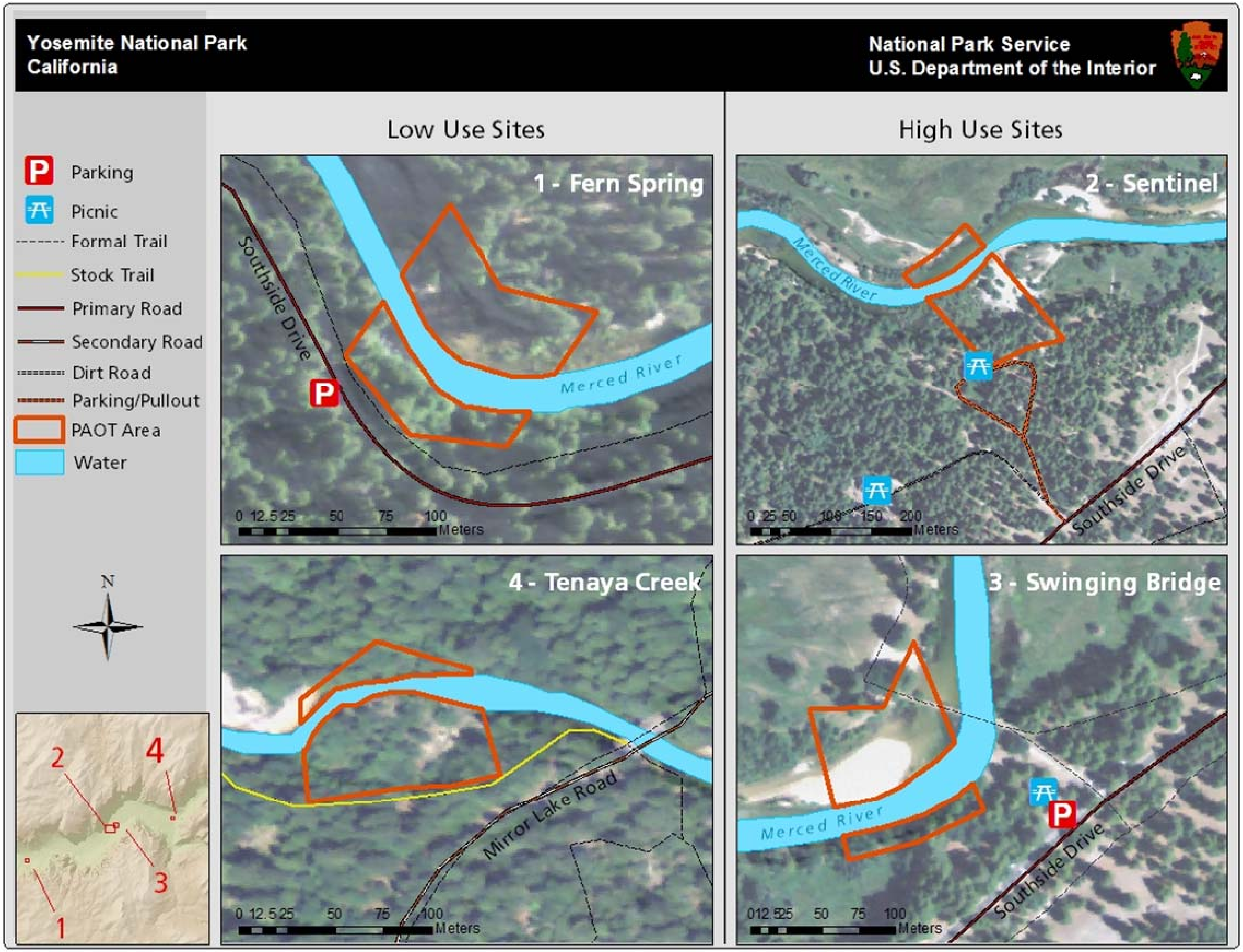

Figure 2.2.2 shows visitor use estimation sites in detail.

Results

Channel Morphology

Given that this was the first season of data collection under this protocol, there is nothing with which to compare cross-section and scanned topographic data. We can, however, demonstrate how this analysis will take place. Figure 2.2.3 is cross-section data from the three cross-sections at Site 009.

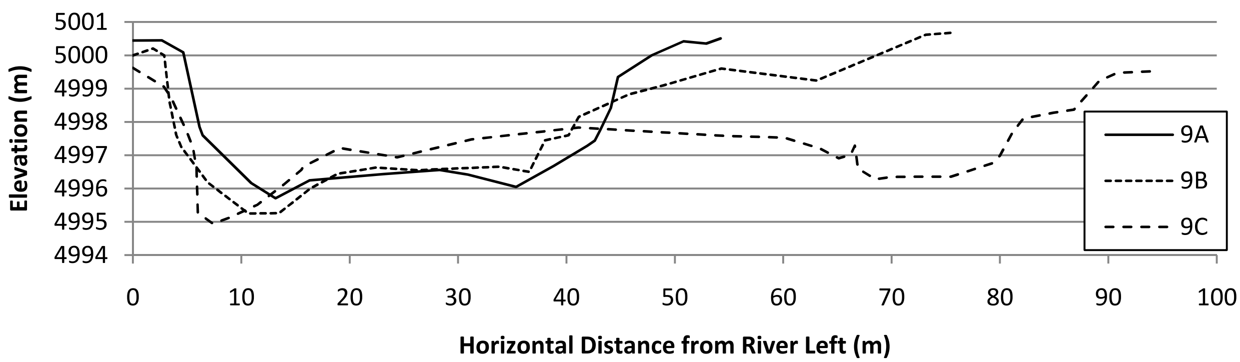

Figure 2.2.3 gives detail of cross-sections at Site 009. The view is looking downstream with cross-section 9A furthest upstream to 9C at the downstream end of the reach.

Each cross-section would be compared to the previously surveyed cross-section at that location via the permanent benchmarks at the endpoints, and a rate of bank retreat would be calculated. Figure 2.2.4 shows a schematic illustration showing how this would be done. Bank retreat rate for each cross-section would be summed and averaged for each reach.

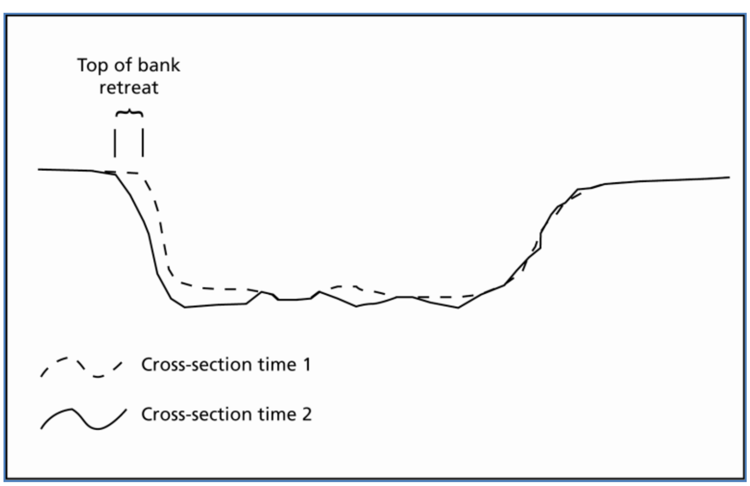

Figure 2.2.4 represents a schematic cross-section comparison and calculation of bank retreat.

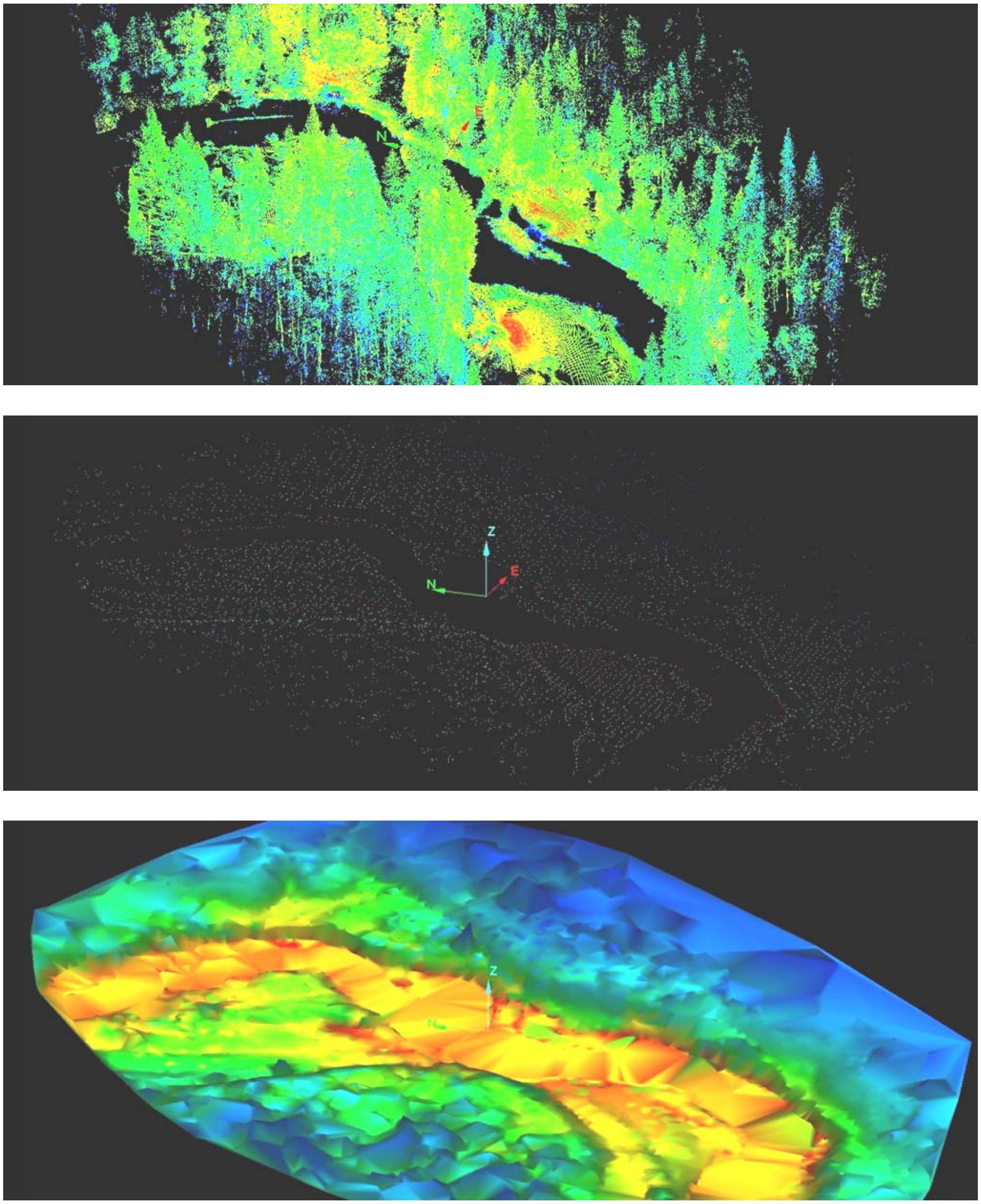

Figure 2.2.5 depicts LiDAR data from Site 010 first as unfiltered point data, then point data with most vegetation filtered out, and finally a surface generated from the ground points. The latter is the most useful for this indicator as we will be able to compare future scans of the same reach and detect changes in riverbank morphology and determine the net amount of change to bank volume, loss or gain.

Vegetation Status

For 2008 and 2009 data, summary statistics are provided to give a course overview of our preliminary findings. Tables 2.2.1 and 2.2.2 depict the status of the riverbank condition as presented in the mean percent cover of functional groups for strata 0-1 and the deliberately chosen sites.

Table 2.2.1 shows mean percent cover of functional groups for strata 0.

Percent Cover of Functional Groups: Strata 0													
Plot	**Bare Ground**	**Litter**	**LWD**	**Expos-ed Roots**	**Non-Vascular**	**Ann / Bien**	**Fibrous Rooted Peren-nial**	**Tap-Rooted Peren-nial**	**Shrub**	**Woody Seedling**	**Ever-green Tree**	**Decid-uous Tree**	**Snag**
009L	40.20	59.80	0.00	4.90	0.00	0.00	48.04	0.00	0.00	0.00	13.73	12.75	0.98
009R	11.99	88.01	0.00	0.00	0.00	11.40	80.12	10.23	0.00	0.29	3.22	18.71	0.00
010L	29.92	67.72	3.15	0.79	0.39	1.57	46.06	0.00	0.79	0.00	40.16	26.38	0.00
010R	20.37	76.39	0.46	4.63	0.46	6.94	33.33	0.00	0.46	0.46	65.28	15.28	0.46
011L	35.75	61.45	2.79	0.28	1.68	8.38	59.78	7.82	0.00	0.84	15.36	41.34	0.00
011R	52.55	47.45	0.73	0.00	0.00	4.38	40.15	0.00	0.00	0.36	0.00	30.29	0.36
013L	7.61	71.20	0.54	0.54	0.00	3.26	8.15	45.11	0.54	1.63	65.22	6.52	0.00
013R	33.19	65.50	1.31	0.87	0.44	0.87	43.23	3.49	0.00	0.44	47.16	23.58	0.00
014L	24.26	71.91	0.85	9.79	0.43	1.70	40.00	0.43	0.00	0.43	62.55	15.74	0.00
014R	37.36	59.62	3.02	3.02	0.00	0.00	48.68	0.00	0.38	0.38	18.49	19.25	0.38
015L	46.31	52.68	0.00	1.68	0.34	3.02	40.60	0.00	0.00	1.34	1.34	55.37	0.67
015R	20.30	79.70	1.98	2.48	1.49	13.86	64.85	1.49	0.00	0.99	40.10	29.70	0.50
016L	42.31	55.77	0.64	0.64	1.28	0.00	9.62	0.00	2.56	0.64	12.82	56.41	0.00
016R	16.67	81.41	0.00	3.21	3.85	3.21	26.92	0.00	0.00	2.56	33.33	51.92	0.00

Table 2.2.2 shows mean percent cover of functional groups for strata 1.

Percent Cover of Functional Groups: Strata 1													
Plot	Bare Ground	Litter	LWD	Expos -ed Roots	Non-Vascular	Ann / Bien	Fibrous Rooted Peren-nial	Tap-Rooted Peren-nial	Shrub	Woody Seedling	Ever-green Tree	Decid-uous Tree	Snag
209L	12.24	80.00	11.43	0.82	1.63	0.00	18.37	0.00	4.90	3.27	30.20	53.06	0.82
209R	40.63	55.00	5.00	5.63	7.50	0.63	7.50	0.00	6.25	0.00	61.25	8.75	1.88
210L	19.62	73.42	3.80	4.43	2.53	0.00	4.43	0.00	1.90	1.90	69.62	19.62	2.53
210R	44.73	53.74	0.46	0.61	0.00	0.00	13.89	1.68	4.12	0.15	42.75	5.04	3.66
211L	19.90	76.62	8.96	6.47	24.38	2.99	27.36	5.97	9.45	1.99	30.35	63.68	1.00
211R	24.29	74.29	3.33	0.00	0.95	0.48	18.57	0.48	14.76	0.95	41.90	23.81	0.48
212L	48.72	46.79	1.28	5.77	16.03	0.00	8.33	0.00	4.49	0.64	37.82	47.44	1.28
212R	38.24	59.31	1.47	1.47	0.49	0.49	11.27	4.41	0.98	1.96	43.63	32.35	0.49
213L	39.78	56.99	0.00	4.84	4.30	0.00	2.69	0.00	4.30	0.54	55.38	24.73	3.23
213R	43.75	54.86	1.39	5.56	11.11	0.69	4.86	0.69	0.69	0.69	49.31	30.56	0.00

List of Abbreviations	
Ann / Bien	Annual/Biennial Plant
VL	Vegetation Plot Left Bank
VR	Vegetation Plot Right Bank

Figure 2.2.6 shows the list of abbreviations used in Tables 2.2.1 and 2.2.2.

Brief Definition of Terms	
Litter	Less than 25 centimeters in diameter
Large Woody Debris	Less than 25 centimeters in diameter
Shrub	Woody, multi-branched at base, life form and adult stage typically a shrub
Woody Seedling	Tree or shrub less than 0.5 meters tall and less than 0.5 meters wide
Snag	Dead standing tree

Figure 2.2.7 shows a brief definition of terms used in Tables 2.2.1 and 2.2.2.

Functional Groups:

The following graphs (Figures 2.2.8 through 2.2.20) show the means for each functional group measured throughout sites. The sites are grouped by strata in the random sample. When a complete sample of random sites is completed at the end of the 2010 field season, further analysis will be used to determine significance of individual functional groups. At this point we will better understand the relationships between the presence or absence of these groups to the overall bank stability and channel morphology. The improved visitor use monitoring will further our understanding of the relationship between vegetation status and degree of impact.

Figures 2.2.8 through 2.2.20 represent box and whisker plot of the one-way analysis of large woody debris. The x axis represents the average percent cover for all of strata 0 and strata 1 sites as observed in 2009. The width of the boxes shown corresponds to the overall number of points sampled in that group. These plots demonstrate how findings vary with functional groups based on strata chosen for sampling design. Although the findings demonstrate a noticeable degree of variability, they will help set the direction through which we analyze our results once a complete data set is achieved.

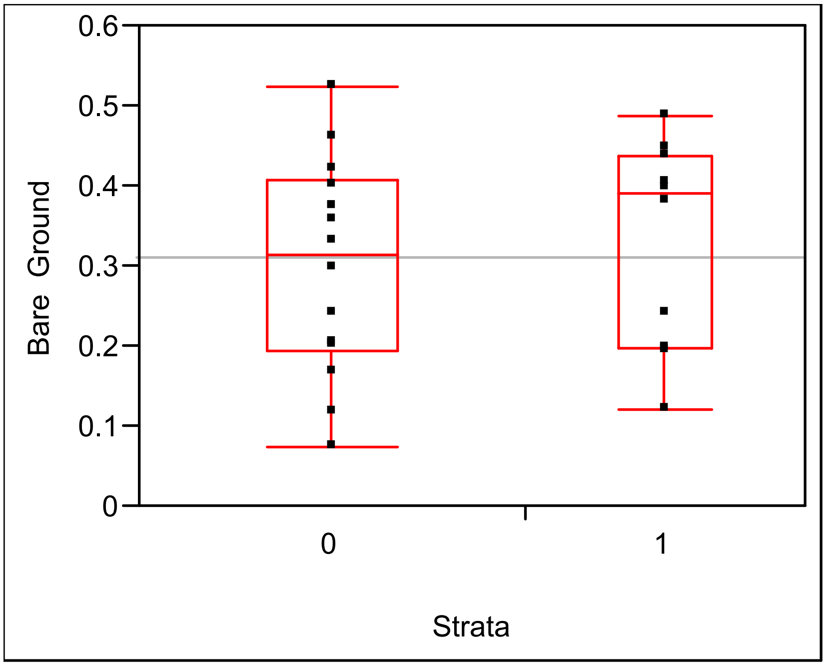

Figure 2.2.8 shows a one-way analysis of percent cover for bare ground.

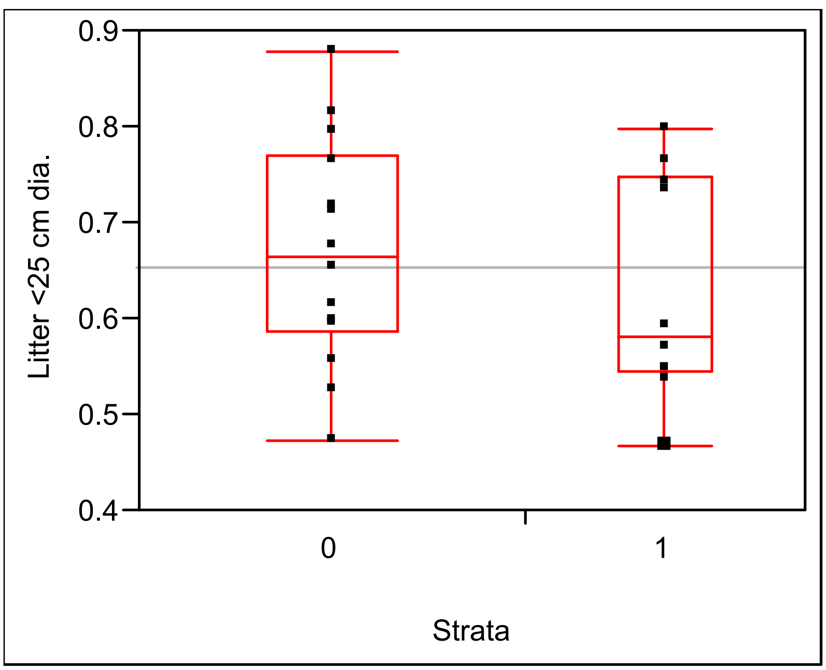

Figure 2.2.9 shows a one-way analysis of percent cover for litter <25cm.

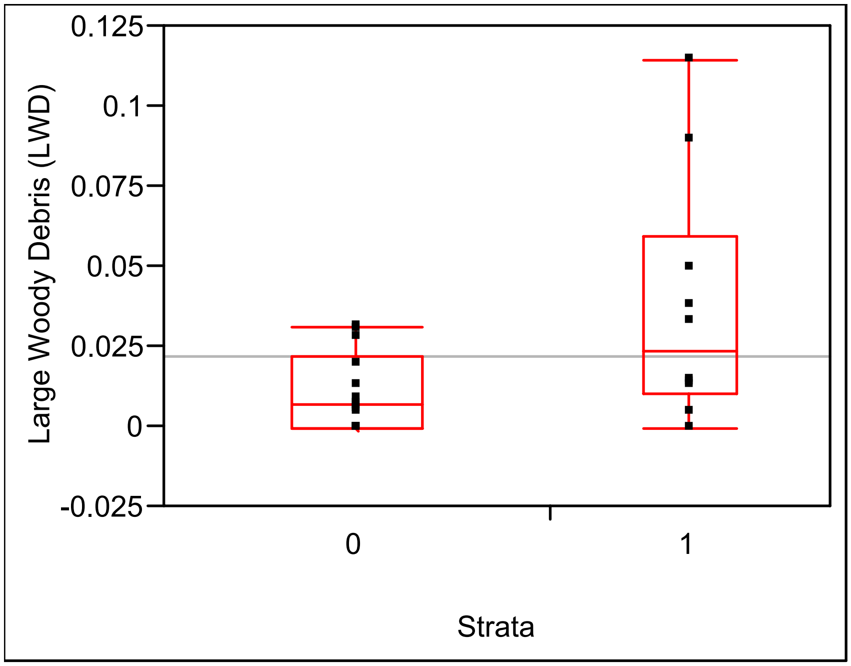

Figure 2.2.10 shows a one-way analysis of percent cover for large woody debris.

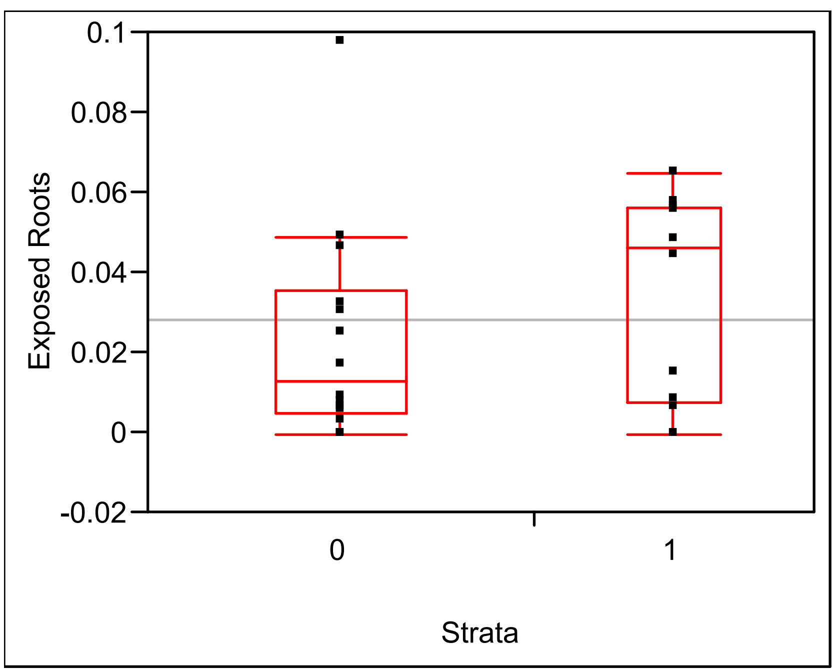

Figure 2.2.11 shows a one-way analysis of percent cover for exposed roots.

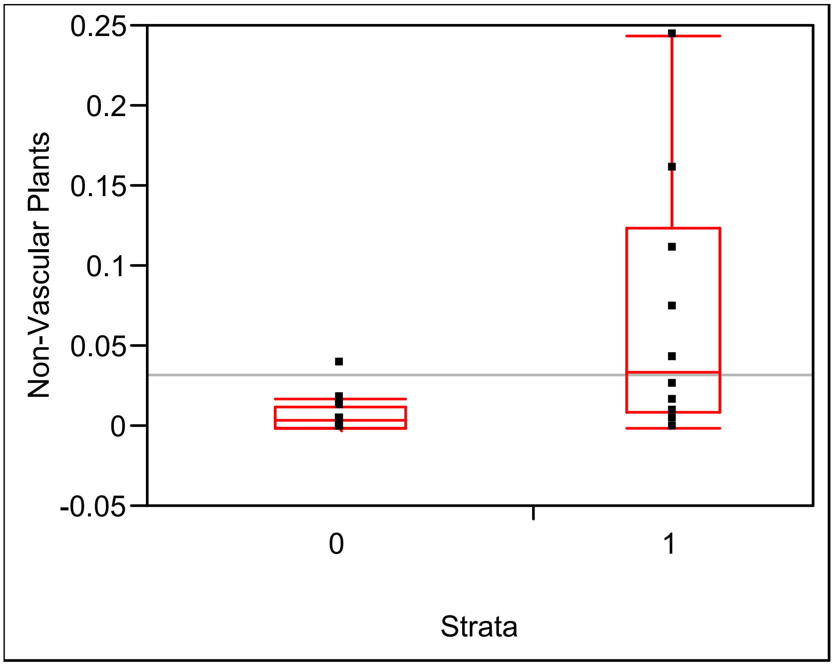

Figure 2.2.12 shows a one-way analysis of percent cover for non-vascular plants.

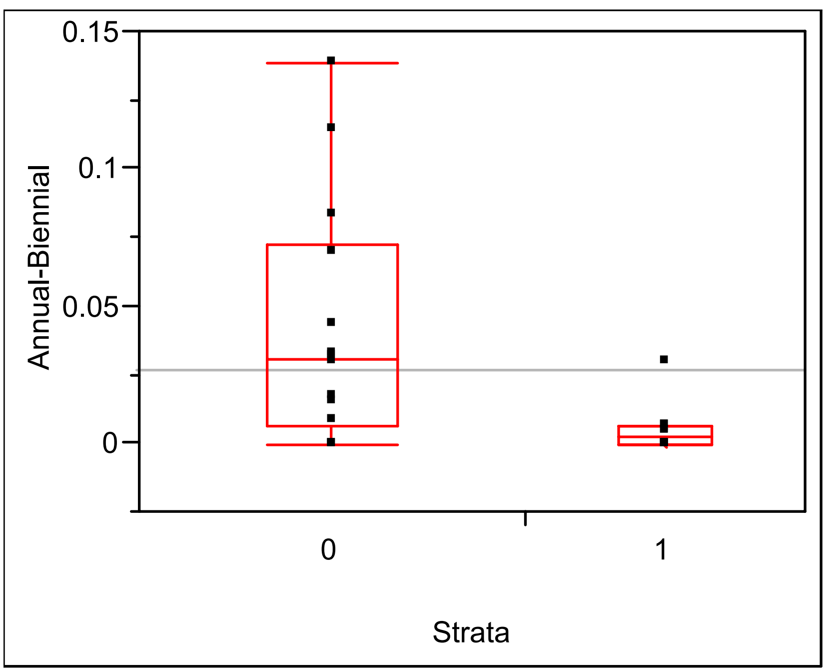

Figure 2.2.13 shows a one-way analysis of percent cover for annual/biennials.

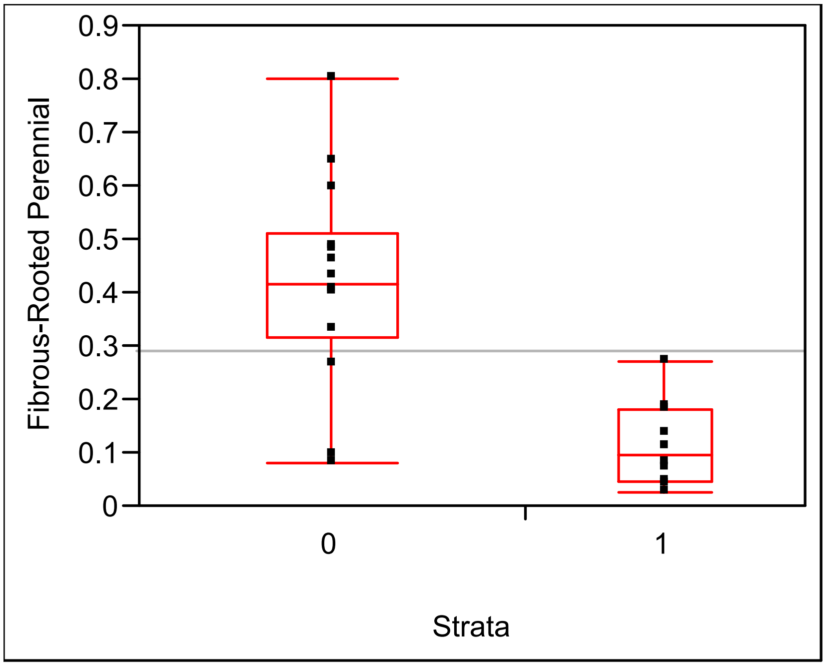

Figure 2.2.14 shows a one-way analysis of percent cover for fibrous-rooted perennials.

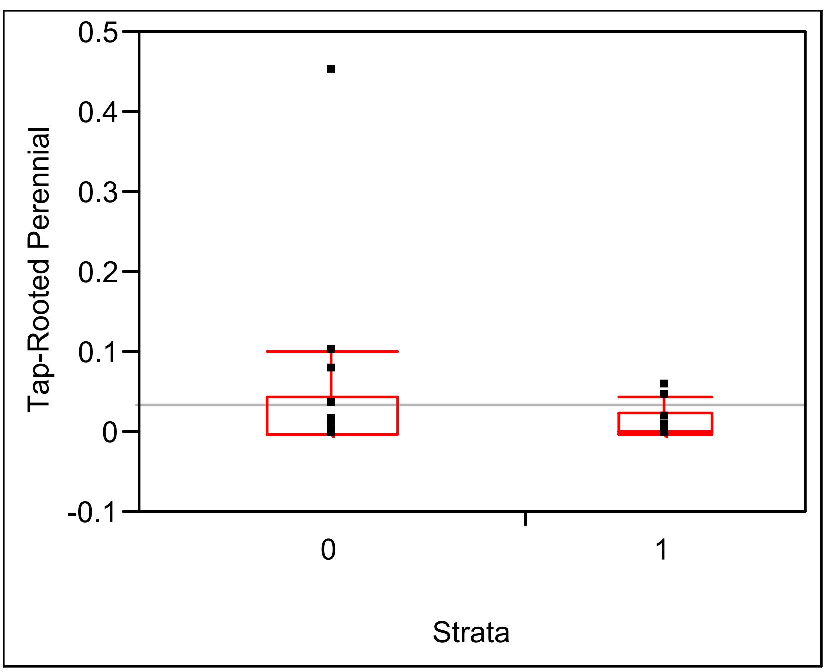

Figure 2.2.15 shows a one-way analysis of percent cover for tap-rooted perennials.

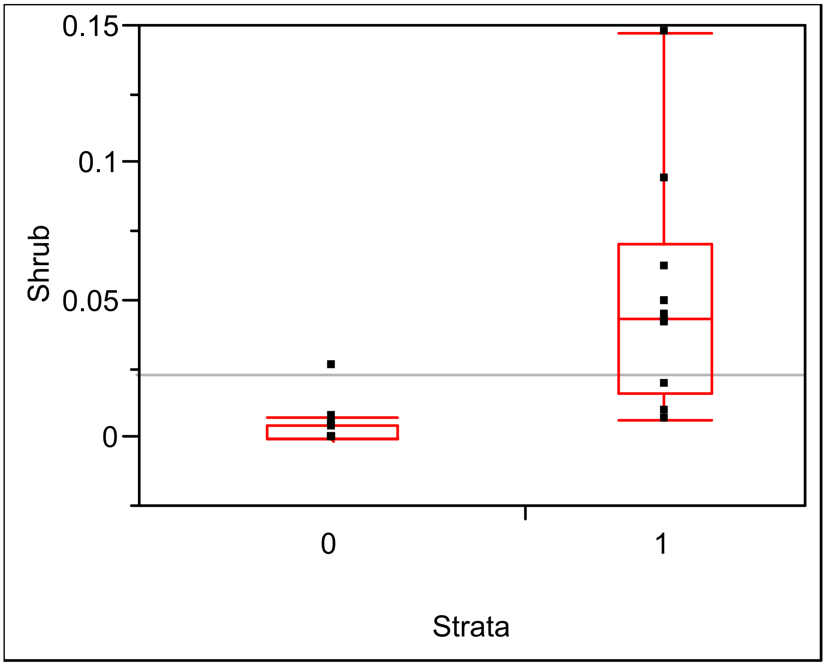

Figure 2.2.16 shows a one-way analysis of percent cover for shrubs.

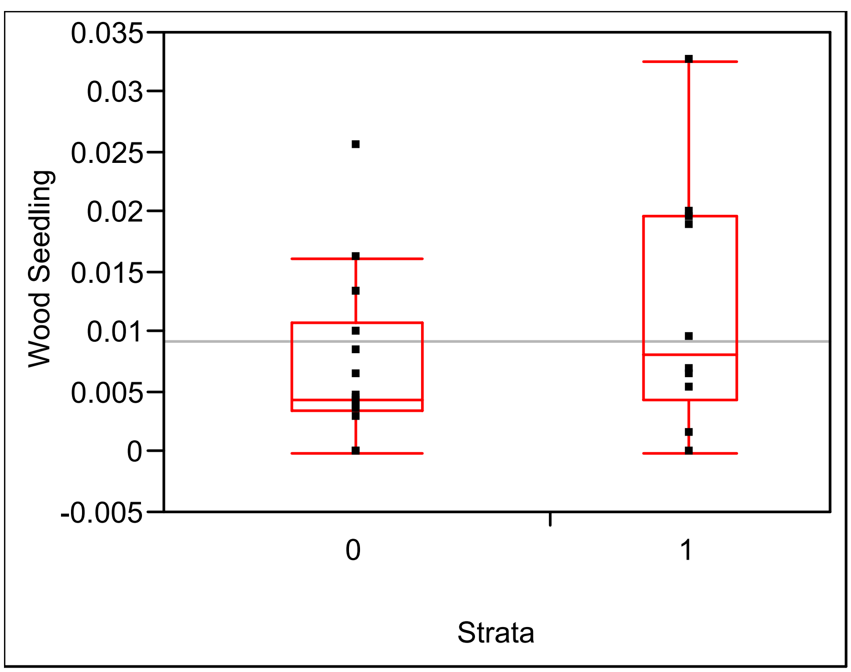

Figure 2.2.17 shows a one-way analysis of percent cover for woody seedlings.

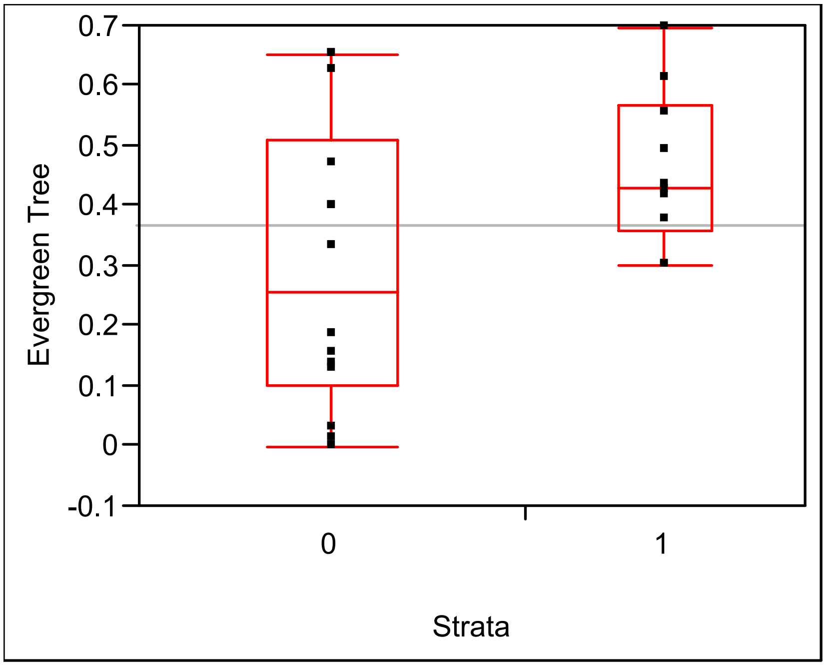

Figure 2.2.18 shows a one-way analysis of percent cover for evergreen trees.

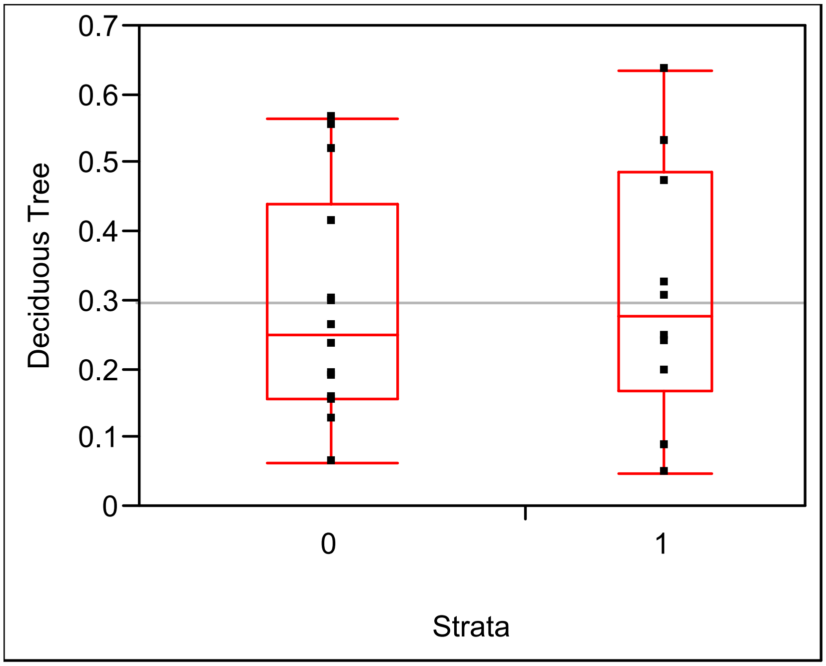

Figure 2.2.19 shows a one-way analysis of percent cover for deciduous trees.

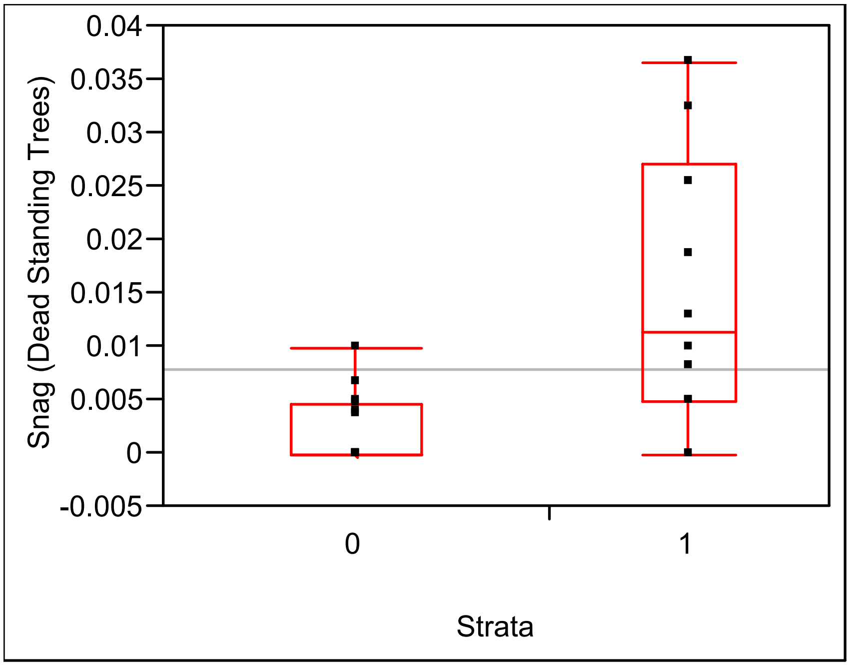

Figure 2.2.20 shows a one-way analysis of percent cover for snags.

The following graphs demonstrate groupings of functional groups and their percent cover for all sites recorded in 2009. Sites that begin with 0 represent those located in Strata 0, while those that begin with 2 are located in Strata 2. With the addition of a visitor use layer to these randomly selected sites, we will begin to evaluate the relationship between visitor use levels and individual findings at each site.

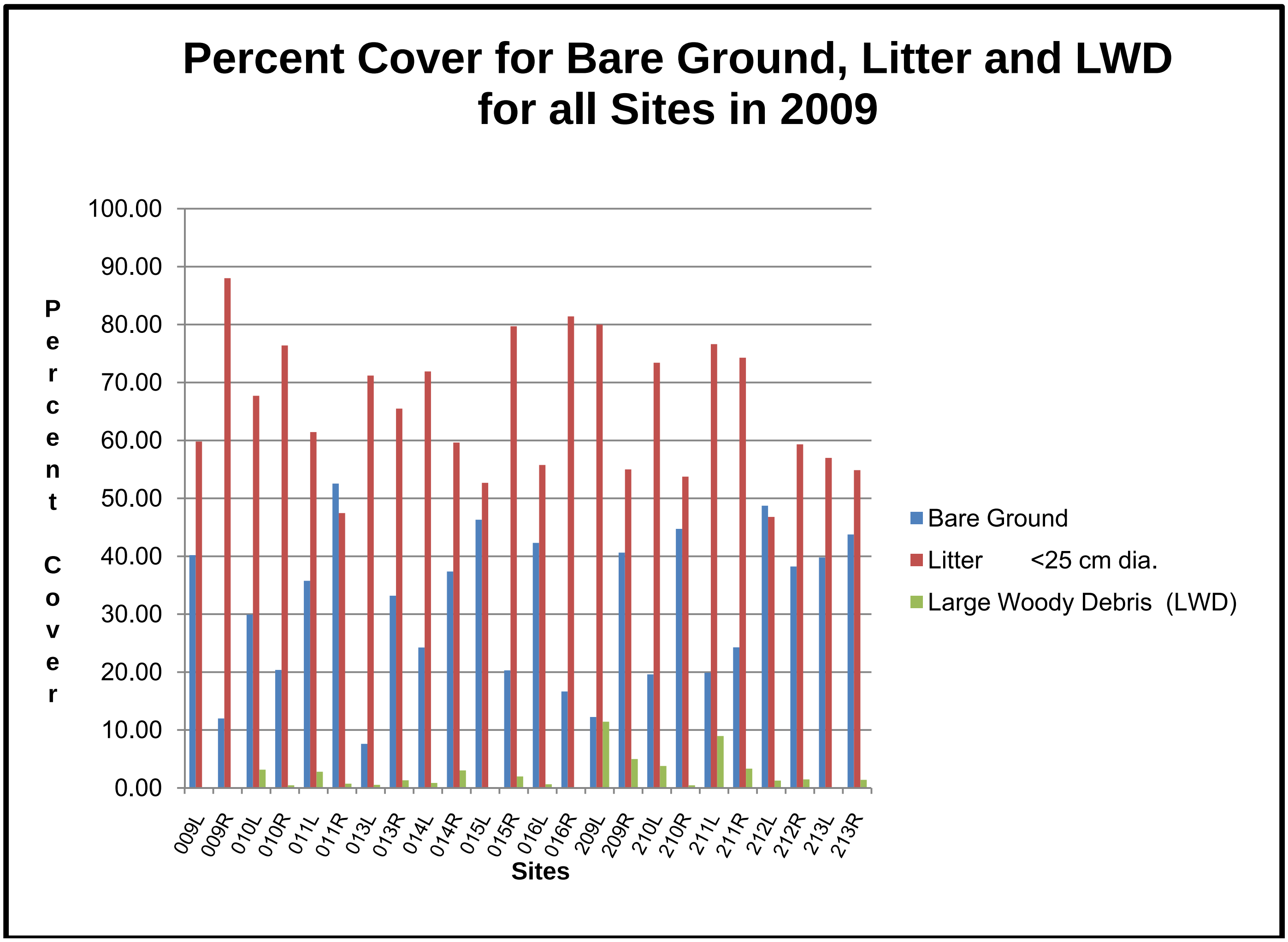

Figure 2.2.21 shows several functional groups and the percent cover for those groups at all sites monitored in 2009.

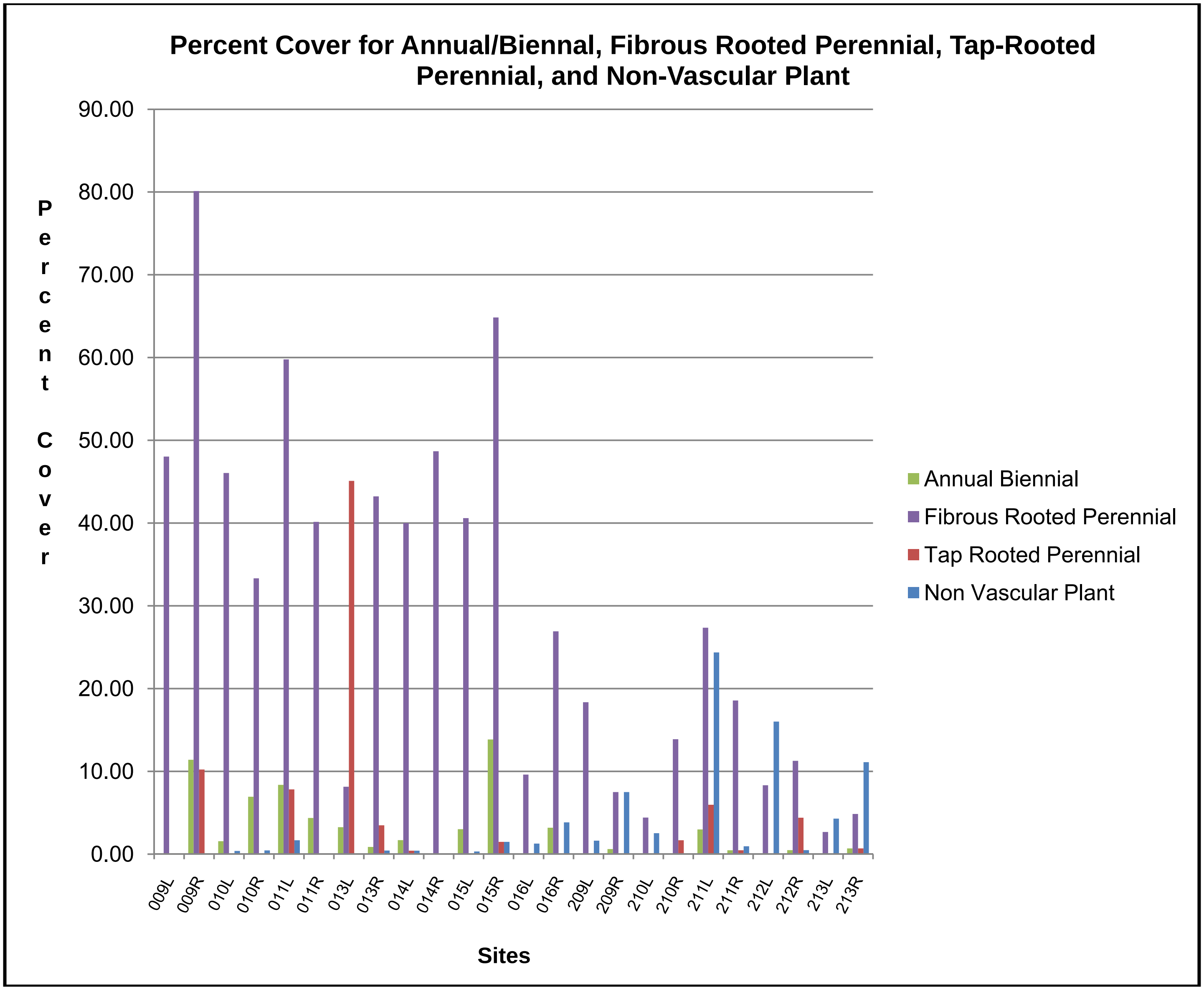

Figure 2.2.22 shows several functional groups and the percent cover for those groups at all sites monitored in 2009.

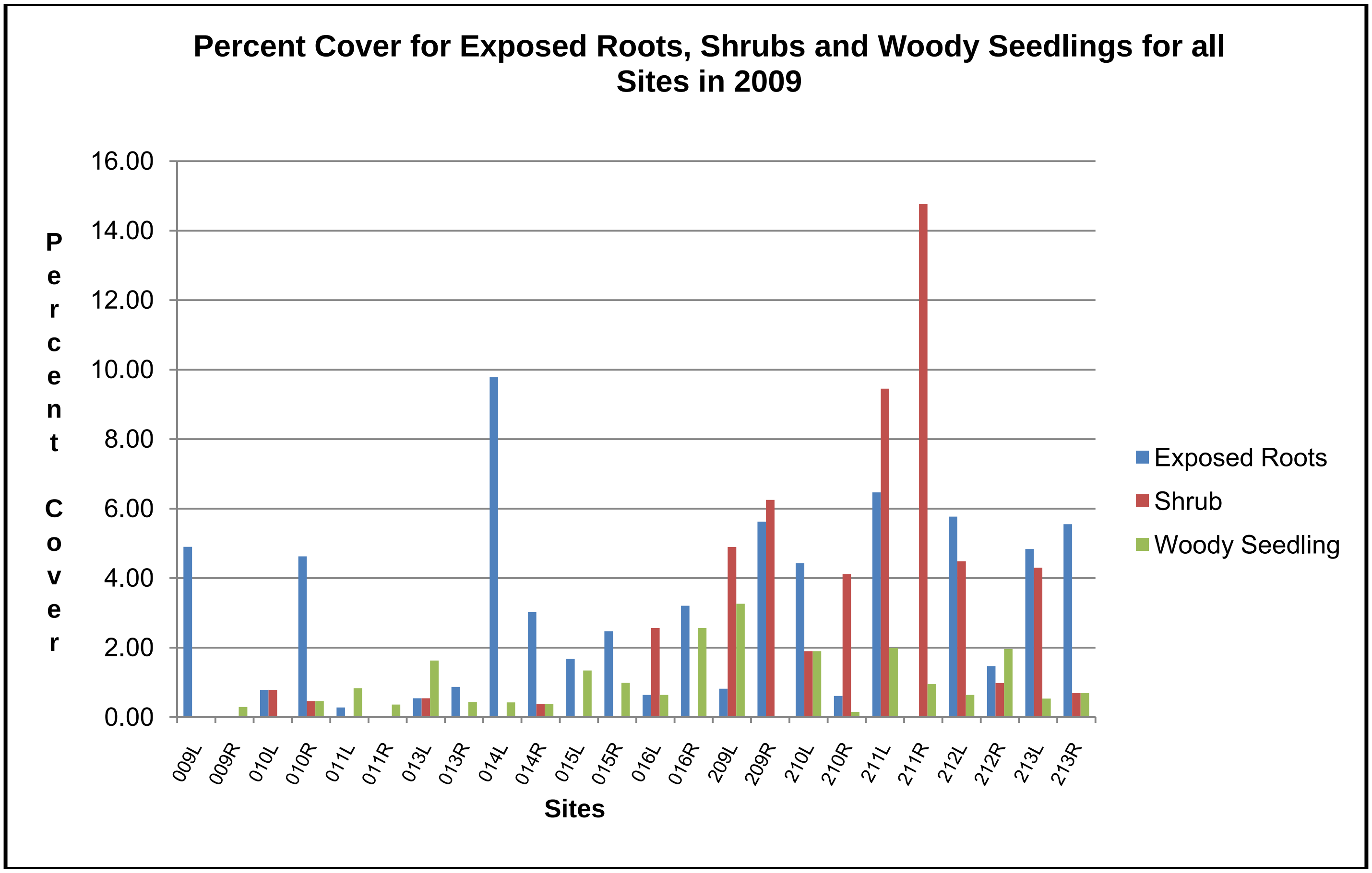

Figure 2.2.23 shows several functional groups and the percent cover for those groups at all sites monitored in 2009.

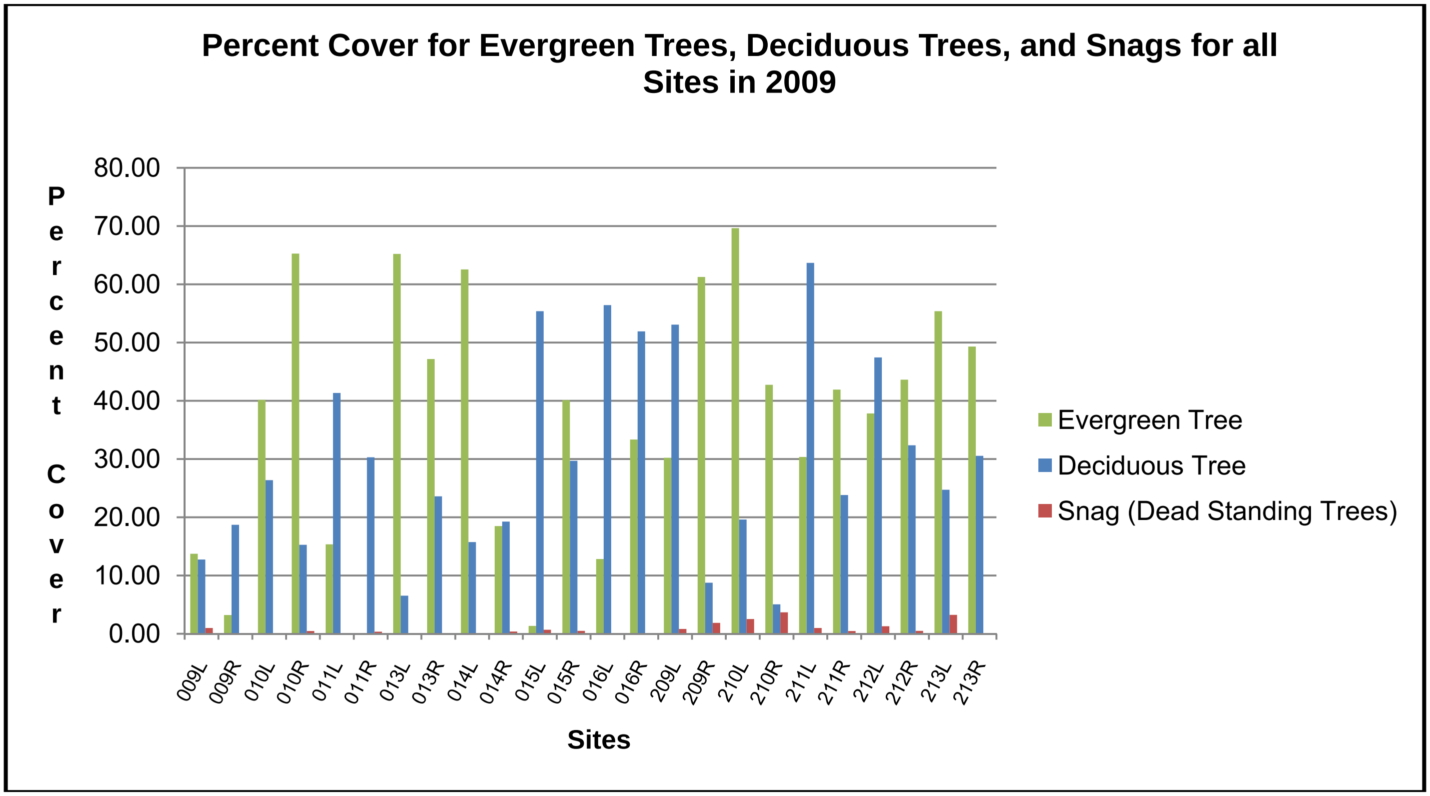

Figure 2.2.24 shows several functional groups and the percent cover for those groups at all sites monitored in 2009.

Photo Documentation

Photographs are archived for all individual sites, cross-section locations and vegetation plots. Photo point analysis will be performed after repeat measurement is performed in 2013.

Discussion

The continued focus of 2009's efforts has been on developing stronger protocols and experimental design. We have refined sampling techniques, training for employees, and strategy for data collection. At the end of the 2008 field season various adjustments were made to the sampling protocol and overall experimental design. The most drastic change was the application of the GRTS model for sampling random locations from two slope-determined strata along the river. Additionally, we sampled from two deliberately chosen low-use sites, and two deliberately chosen high-use sites. In 2009, further refinements were made in vegetation sampling design, in order to assure independence between vegetation sampling points. These changes are noted in the 2009 Visitor Use and Impact Monitoring Program Field Guide (NPS, 2009). Due to constraints in staffing and sampling timing, we have broken up the sampling schedule into two cycles. Currently, we have only completed two years of sampling. In order to reflect changes implemented in 2009, additional vegetation sampling will occur in 2010, with a major focus given to establishing the repeatability of our measurements. All vegetation plots will be further detailed and mapped in order to ensure the highest degree of documentation and repeatability. When the second stage of sampling has ended, all data will be further analyzed for relationships between vegetation status, channel morphology, and visitor use levels. During 2010, we will further collaborate with statisticians to better analyze all findings in preparation of repeat sampling in 2013. In 2010, more sites will be selected from the randomized GRTS sample for visitor use estimation. An additional four sites will be randomly selected for further study. This will allow us to better understand the relationships between our findings and visitation at individual sites.

Future Directions

This indicator has gone through several variations before reaching its current methods and approach. Although this indicator proves to be fairly labor intensive and complicated, we are optimistic about the potential behind the data for demonstrating the current condition of the Merced River banks and channel. The survey will be repeated using all existing permanent sites, starting in three to five years. With repeat data, we will be able to assess vegetation trends as well as vegetation status. Continuous monitoring is planned in order to study changes to bank condition and to evaluate whether standards are being met. We will continue to improve this indicator as other research and methods are developed. With the improvement of visitor use data collection in Yosemite, we will develop ways to correlate visitation numbers with the status of riverbank condition.

2.3 WILDLIFE EXPOSURE TO HUMAN FOOD

Introduction

The Merced River corridor provides habitat for a variety of animal species. A myriad of insects, birds, amphibians and mammals depend on the river and its surroundings for survival. This wildlife is part of the Merced River's Biological Outstandingly Remarkable Values. Studies have shown that human-use may have an adverse impact on wildlife (Decker et al. 1992, Manfredo et al. 1995). Impacts include loss of habitat and food, predation, habituation, and others.

A particular concern in many National Park units is the feeding of wildlife. In Yosemite Valley human-bear interactions have been of particular concern. The Black Bear (*Ursus americanus*) is common in Yosemite and human interaction with them is frequent. These interactions, however, have not always been positive. Often, visitors will make their food available to bears by leaving it unattended at their campsite or in their car. There are documented instances of bears breaking into visitors' vehicles or rummaging through their camp to obtain this food. Bears can become conditioned to human food, and are intelligent enough to pursue this food source to the detriment of both the animal and the visitor. A bear's ability to successfully survive in the wild is diminished when it becomes conditioned to human food. Bear "break-ins" to visitors' vehicles and campsites can cause significant impacts to personal property and the quality of the visitors' experience.

Therefore, an indicator was developed in 2004 to measure visitor compliance with food storage regulations. Compliance rates provide meaningful information as the extent to which human food may be available to bears. This indicator is thought to be the best proxy to understand the extent to which human-use in the Merced River corridor is causing negative impacts to bear populations.

Measurement

Percent compliance with food storage regulations at selected sites.

Draft Standards

The draft standard is set for 95% or greater compliance with food storage regulations in selected campgrounds and parking areas.

Sampling

The monitoring data for this indicator was collected and incorporated into the Bear Patrol Log Database (BPLD). The BPLD was developed for the Human-Bear Management Program (HBMP) in 2005 to ensure accountability with HBMP-funded employees and to collect data on bear monitoring and management activities in the field. In Yosemite Valley, there is an average of 15 HBMP-funded employees that spend at least 80% of their time on bear-related issues between the months of May and September. These employees include Visitor Protection, Campground and Interpretation Rangers, and Wildlife Technicians. While the primary duties differ among work units, all employees share the common goal of mitigating human-bear conflicts and protecting wildlife from exposure to human food. This is accomplished through proactive patrols between the hours of 5 p.m. and 4 a.m., when bear activity is the greatest. During patrols, visitors are educated about proper food storage through one-on-one interpretive contacts, campsites and vehicles are checked for food storage compliance, and food storage regulations are enforced through verbal or written warnings and citations. Non-compliance includes the following violations:

1. Feeding human food to wildlife – Knowingly offering human food or baiting wildlife.
2. Improper food storage – Human food stored in locations that are considered inappropriate, such as inside vehicles after dark or in containers that are not approved by the park as wildlife resistant.
3. Improper use of food locker – Food is put in food locker but the locker is wide open, unlocked, or not latched in a way consistent with the instructions provided, and the visitors are either away from their site or asleep.
4. Leaving food unattended – Food left in open locker, out in campsite, or other location where the food is out of arms reach, is not actively being prepared or eaten, and/or the food is not visible to any of the camp occupants.

Campground inspections to determine compliance rates are, generally, conducted after 10 p.m. when most visitors were finished eating dinner and food was put away. Inspections conducted earlier than 10 p.m. often resulted in a very low compliance rate, because most people preparing dinner had their food lockers open and food items out of arms reach. These incidents were documented in the BPLD as educational contacts rather than violation or inspection records.

Parking lot inspections were conducted throughout the night. Because food stored inside vehicles during daylight hours is legal, compliance checks on vehicles could only be performed after dark.

Figure 2.3.1 Bear control food storage lockers (Photo: NPS).

Results

1. General Compliance:

The primary measure for this indicator is *compliance rate*, or the extent to which visitors comply with Yosemite's food storage regulations. Table 2.3.1 presents results of compliance analysis based on the wildlife patrol log database. Data represents inspections and violations that occurred between May 15, 2009 and November 10, 2009. Inspections included only those with over 50% of the average units inspected. Among these ten locations, a total of 675 inspections were conducted in 2009. During these inspections 35,554 vehicles and 28,384 campsites were inspected. The results show that Upper Pines and Lower Pines Campgrounds and the Yosemite Lodge Parking Lot had the highest overall compliance rates of 96%, whereas Camp 4 Campground had the lowest overall compliance rate of 91%.

Table 2.3.1 shows results of general compliance analysis.

Location	Inspection Type	# Inspected	Overall Compliance Rate (Red indicates location did not meet 95% standard)
Ahwahnee Parking Lot	Vehicle	2317	93%
Camp 4 Parking Lot	Vehicle	10123	94%
Curry Village – DNC	Vehicle	3752	95%
Wilderness Lot	Vehicle	3605	93%
Yosemite Lodge Parking Lot	Vehicle	15091	96%
Camp 4 Campground	Campsite	6965	91%
Housekeeping Camp	Campsite	14605	94%
Lower Pines Campground	Campsite	1301	96%
North Pines Campground	Campsite	1744	95%
Upper Pines Campground	Campsite	3839	96%

2. Monthly Compliance:

Detailed results of monthly compliance are provided in Table 2.3.2. None of the ten locations exceeded the 95% standard during all five months.

Table 2.3.2 shows monthly compliance rates by location.

Location	Inspection Type	# Inspected	Compliance Rate
May			
Ahwahnee Parking Lot	Vehicle	207	91%
Camp 4 Parking Lot	Vehicle	1288	95%
Curry Village – DNC	Vehicle	370	94%
Wilderness Lot	Vehicle	436	94%
Yosemite Lodge Parking Lot	Vehicle	1962	97%
Camp 4 Campground	Campsite	455	89%
Housekeeping Camp	Campsite	1692	93%
Lower Pines Campground	Campsite	78	97%
North Pines Campground	Campsite	86	100%
Upper Pines Campground	Campsite	240	93%
June			
Location	**Inspection Type**	**# Inspected**	**Compliance Rate**
Ahwahnee Parking Lot	Vehicle	393	93%
Camp 4 Parking Lot	Vehicle	1848	94%
Curry Village – DNC	Vehicle	338	96%
Wilderness Lot	Vehicle	581	96%
Yosemite Lodge Parking Lot	Vehicle	4676	97%
Camp 4 Campground	Campsite	1680	92%
Housekeeping Camp	Campsite	2871	93%
Lower Pines Campground	Campsite	148	93%
North Pines Campground	Campsite	250	88%
Upper Pines Campground	Campsite	240	97%
July			
Location	**Inspection Type**	**# Inspected**	**Compliance Rate**
Ahwahnee Parking Lot	Vehicle	547	94%
Camp 4 Parking Lot	Vehicle	2111	93%
Curry Village – DNC	Vehicle	713	95%
Wilderness Lot	Vehicle	550	89%
Yosemite Lodge Parking Lot	Vehicle	5509	96%
Camp 4 Campground	Campsite	2030	90%
Housekeeping Camp	Campsite	5054	95%
Lower Pines Campground	Campsite	464	94%
North Pines Campground	Campsite	333	95%
Upper Pines Campground	Campsite	908	94%

Table 2.3.2 shows monthly compliance rates by location (continued)**.**

Location	Inspection Type	# Inspected	Compliance Rate
August			
Location	**Inspection Type**	**# Inspected**	**Compliance Rate**
Ahwahnee Parking Lot	Vehicle	386	93%
Camp 4 Parking Lot	Vehicle	1854	93%
Curry Village – DNC	Vehicle	487	91%
Wilderness Lot	Vehicle	848	93%
Yosemite Lodge Parking Lot	Vehicle	1315	97%
Camp 4 Campground	Campsite	1470	91%
Housekeeping Camp	Campsite	3924	94%
Lower Pines Campground	Campsite	281	95%
North Pines Campground	Campsite	490	95%
Upper Pines Campground	Campsite	653	95%
September			
Location	**Inspection Type**	**# Inspected**	**Compliance Rate**
Ahwahnee Parking Lot	Vehicle	470	94%
Camp 4 Parking Lot	Vehicle	1818	96%
Curry Village – DNC	Vehicle	1104	94%
Wilderness Lot	Vehicle	868	93%
Yosemite Lodge Parking Lot	Vehicle	666	94%
Camp 4 Campground	Campsite	630	93%
Housekeeping Camp	Campsite	1064	98%
Lower Pines Campground	Campsite	408	96%
North Pines Campground	Campsite	585	96%
Upper Pines Campground	Campsite	1097	98%
October			
Location	**Inspection Type**	**# Inspected**	**Compliance Rate**
Ahwahnee Parking Lot	Vehicle	314	94%
Camp 4 Parking Lot	Vehicle	1204	96%
Curry Village – DNC	Vehicle	740	96%
Wilderness Lot	Vehicle	322	95%
Yosemite Lodge Parking Lot	Vehicle	783	93%
Camp 4 Campground	Campsite	630	95%
Housekeeping Camp	Campsite	532	95%
Lower Pines Campground	Campsite	263	98%
North Pines Campground	Campsite	210	94%
Upper Pines Campground	Campsite	701	98%

Table 2.3.2 shows monthly compliance rates by location (continued).

November			
Location	**Inspection Type**	**# Inspected**	**Compliance Rate**
Ahwahnee Parking Lot	Vehicle	0	0%
Camp 4 Parking Lot	Vehicle	162	93%
Curry Village – DNC	Vehicle	371	96%
Wilderness Lot	Vehicle	0	0%
Yosemite Lodge Parking Lot	Vehicle	180	96%
Camp 4 Campground	Campsite	70	89%
Housekeeping Camp	Campsite	0	0%
Lower Pines Campground	Campsite	0	0%
North Pines Campground	Campsite	0	0%
Upper Pines Campground	Campsite	0	0%

Figure 2.3.2. portrays the overall compliance rates of vehicle inspection locations from May through October. Data was incomplete for some locations in November; therefore, that month was eliminated from the graph. The parking lots exhibited less stability compared to campground compliance rates. Upper Pines Campground (campsite inspection) exhibited high levels of stability during the summer and fall seasons, while the compliance at the other five locations was less stable. For example, the Wilderness Parking Lot ranged from 89% to 96% throughout the season.

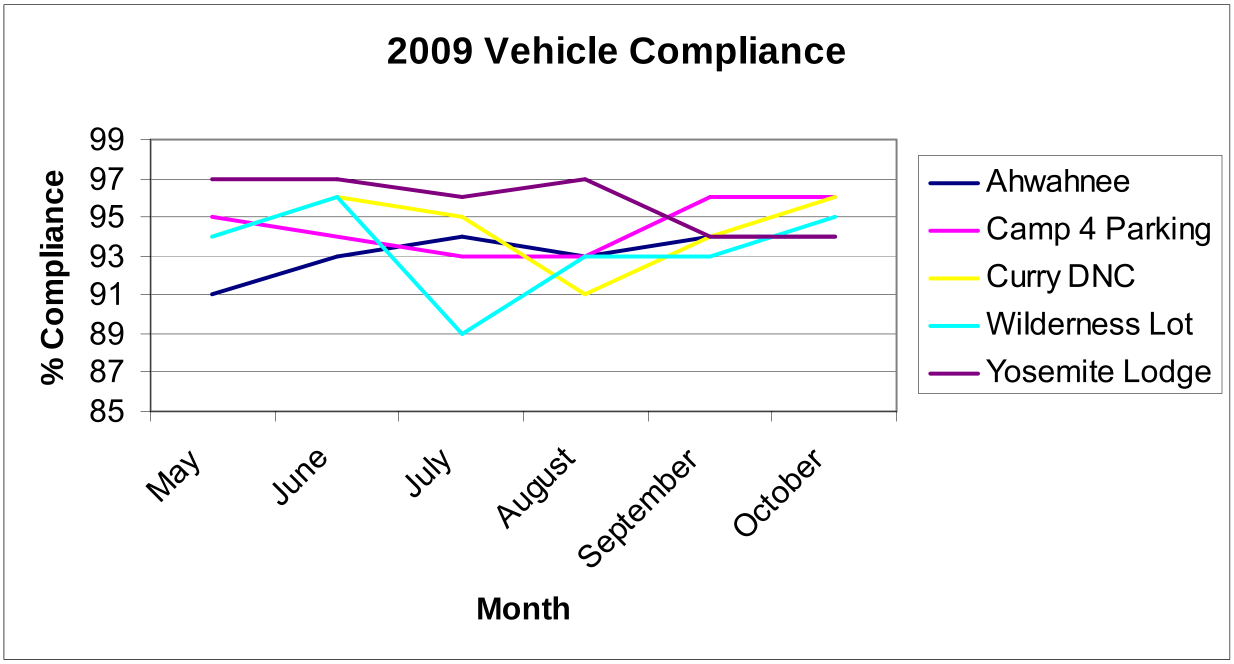

Figure 2.3.2 shows overall vehicle compliance rates by month and location.

Figure 2.3.3. Portrays the overall compliance rates of campsite inspection locations from May through October. Data was incomplete for some locations in November due to campground closures; therefore that month was eliminated from the graph. The campsites exhibited higher levels of stability compared to vehicle compliance rates.

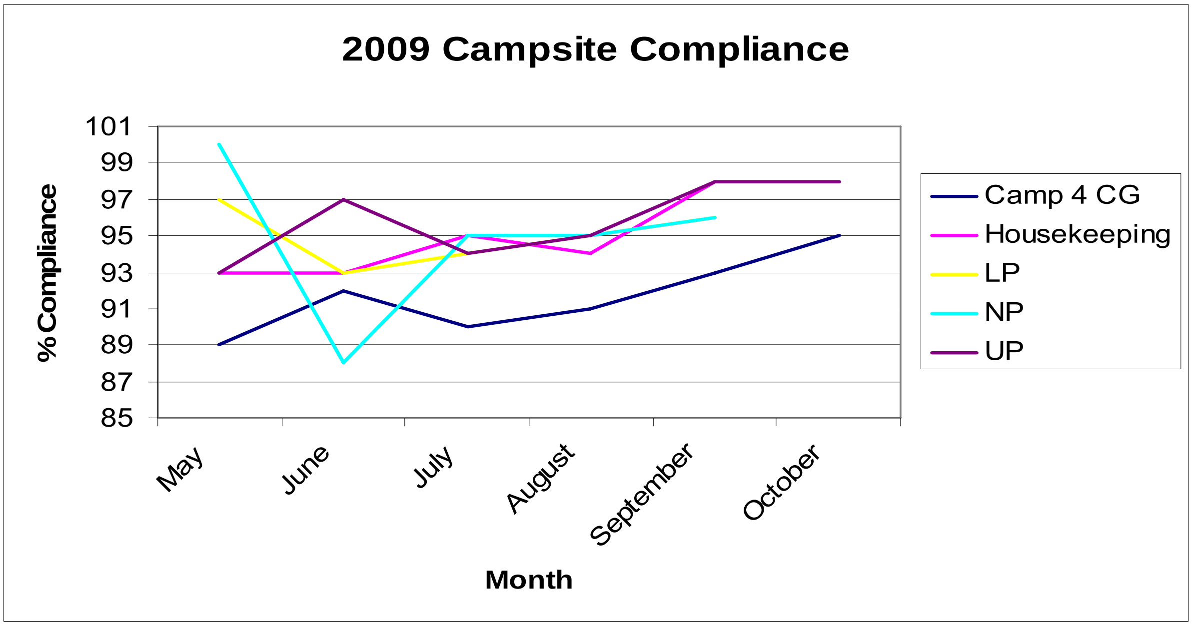

Figure 2.3.3 shows overall campsite compliance rates by month and location

3. Types of Violations:

The BPLD documented the type of violation for each non-compliance record. An understanding of the distribution of violation types in different locations can help customize management and public communication strategies at specific facilities and visitor use areas. Table 2.3.3. displays the distribution of violation types across five vehicle inspection locations and across the seven different violations that are tracked during inspections.

Table 2.3.3 shows frequencies of violations by type and location for vehicle inspections.

Violation Type	Ahwahnee	Camp 4 Parking	Curry Village	Wilderness Lot	Yosemite Lodge	Total (Type)
Unattended food or attractant in vehicles	155	582	220	246	538	1741
Unattended food or attractant	0	0	0	0	0	0
Food Locker/left open	0	0	0	0	0	0
OB camper w/ food in vehicle	0	2	0	1	0	3
Visitors too far from food	0	0	0	0	0	0
Food Locker/Improperly locked	0	0	0	0	0	0
Baiting	0	0	0	0	0	0
Total *(Location)*	**155**	**584**	**220**	**247**	**538**	**1744**

The results indicate that unattended food or attractant in vehicles was the most common type with 1741 violations. Camp 4 and Yosemite Lodge Parking Lots appear to have a significant problem with visitors leaving their food or an attractant unattended in vehicles.

Table 2.3.4 shows frequencies of violations by type and location for campsite inspections.

Violation Type	Camp 4 CG	Housekeeping Camp	Lower Pines	North Pines	Upper Pines	Total (Type)
Unattended food or attractant in vehicles	0	0	0	0	0	0
Unattended food or attractant	54	358	26	58	46	542
Food Locker/left open	26	63	4	3	10	106
OB camper w/ food in vehicle	0	0	0	0	0	0
Visitors too far from food	311	93	15	22	71	512
Food Locker/Improperly locked	226	389	28	22	21	686
Baiting	0	1	0	0	1	2
Total *(Location)*	**617**	**904**	**73**	**105**	**149**	**1848**

Campgrounds had a wider range of violations, especially those related to food locker use and unattended food. Food lockers improperly locked, visitors leaving food unattended, and visitors too far from their food were the most common violations. Housekeeping Camp appears to have the most significant problem with visitors not storing food properly.

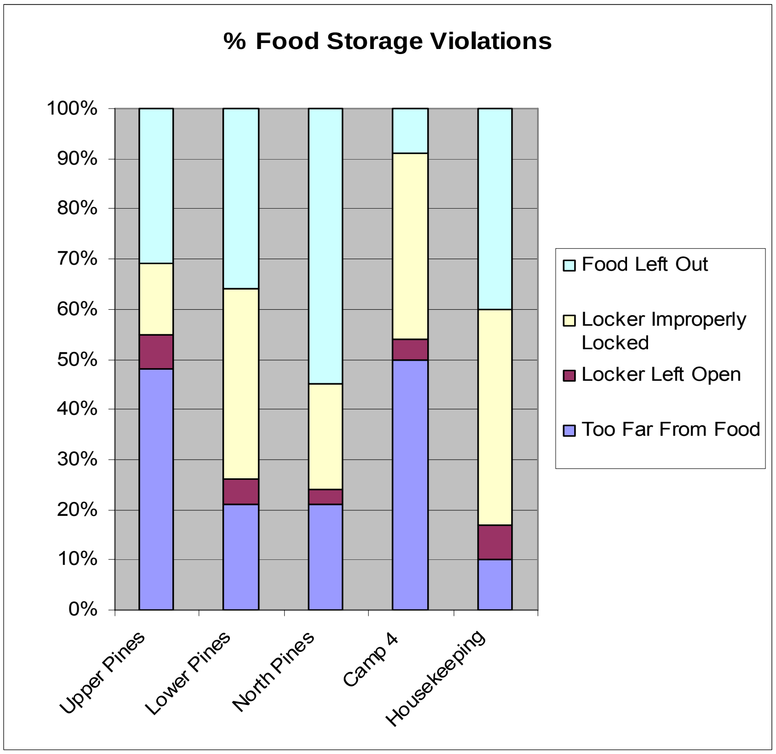

Figure 2.3.4 shows percentage of campground food storage violations.

Year to year comparison

In 2009, compliance rates were up only slightly compared with 2008 compliance rates. Four locations increased their compliance rates while four other locations decreased their compliance rates from 2008. Factors that could have influenced the increased compliance rates include better messaging at certain locations and increased patrols. Since 2007, the Interpretation staff has reduced its patrols in the Pines campgrounds, which could explain the decrease in compliance rates at those locations.

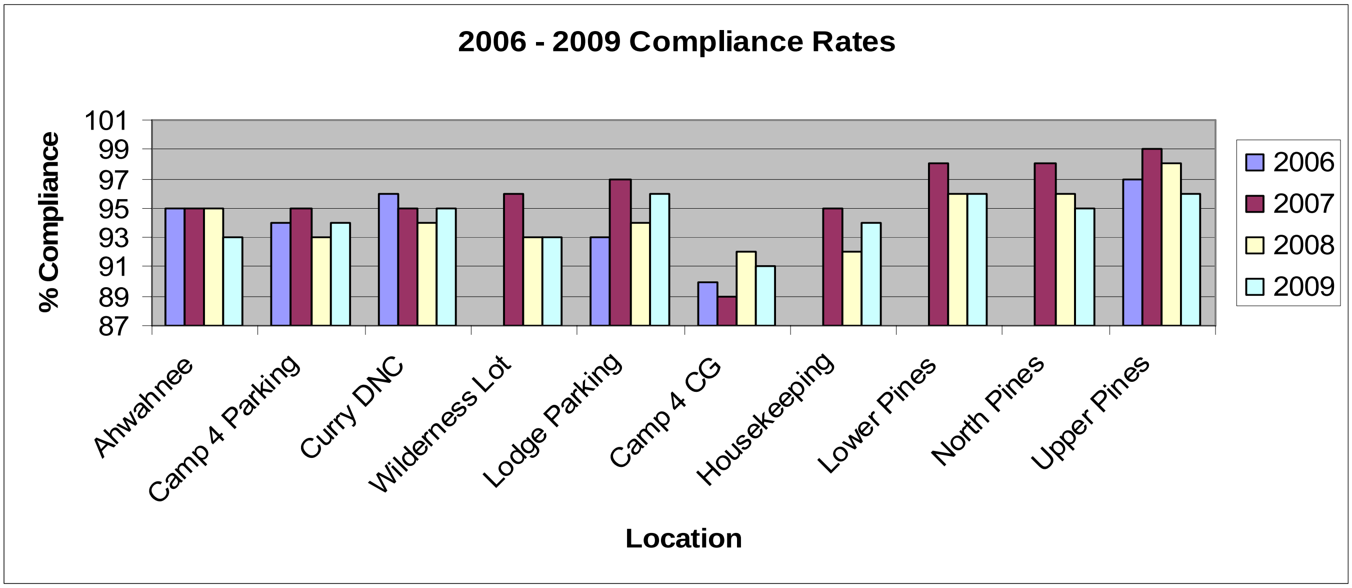

Figure 2.3.5 shows overall comparison of compliance rates from 2006 - 2009.

Discussion

Results from the 2009 field season suggest that food storage compliance rates at five out of the ten inspection locations either met or exceeded the proposed standard of 95%. The three campgrounds that met the standard are located in close proximity to one another and are heavily patrolled by the Interdivisional Bear Team. Management attention is needed for certain locations, such as Camp 4 Campground, Housekeeping Camp, and the Wilderness Lot. An increase in public contacts by Interpretation staff during early evening hours could help increase compliance at Camp 4 and Housekeeping Camp. In addition, the presence of a campground host in Housekeeping Camp could also be beneficial in increasing food storage compliance. A greater emphasis should be placed on the importance of properly latching food lockers in campgrounds, either through public contacts or improved signage. The compliance rate in the Wilderness Lot could be increased by improved messaging through the Wilderness Office, when visitors obtain their backcountry permits or through improved signage in the parking lot.

In 2010, accomplishing the following objectives may improve food storage compliance rates:

- Campground hosts for Housekeeping Camp to patrol the area during the early evening hours to give educational bear and food storage messages, and to perform a later patrol to ensure food lockers have been latched properly and all food has been stored.
- Improved messaging through the Wilderness Office by educating visitors picking up backcountry permits about removing all food from vehicles while parked in the Wilderness Lot overnight. Better signage in the parking lot may also help increase compliance.
- Recognizing the importance of good training, DNC employees at front desks will again be trained to give effective wildlife messages to visitors checking into lodging.
- Increased messaging through Interpretation and Campground staff, on the importance of ensuring food lockers are latched properly.
- The procurement and installation of new food storage lockers that hold more food and are easier to latch.

2.4 EXTENT AND CONDITION OF INFORMAL TRAILS

Introduction

Informal trails (or visitor-created "social" trails) may be defined as discernible and continuous trail segments that were created by visitors and which do not follow a park's formal trail system (Leung et al. 2002). Since informal trails are not planned or constructed, they are usually poorly located with respect to terrain. These trails also receive very little or no maintenance. These factors, substantially, increase their potential for degradation in comparison to formal trails. The proliferation of informal trails may increase habitat fragmentation and can directly threaten sensitive habitats (Marion et al. 2006). From a social perspective, a web of informal trails creates a visually scarred landscape and may lead to safety and liability concerns.

Monitoring can provide timely information on the extent, distribution and condition of informal trail segments. The findings from data collection combined with established minimum acceptable conditions, can serve as warning signs of resource degradation and habitat intrusion. In turn, such information can trigger management action.

This report presents the findings from the data collected through surveying the extent and condition of informal trails in selected sites in Yosemite Valley and Tuolumne Meadows. In 2009, repeat data was collected in five Yosemite Valley meadows and three meadows in the Tuolumne Meadows area. Baseline data was further expanded with monitoring conducted in a meadow near the Tuolumne Ranger Station.

The data collection methods from 2008 were repeated in both Yosemite Valley and Tuolumne Meadows. A new informal trail condition-classification described as "adapted vegetation", was observed and recorded in a few meadows to facilitate future investigation, but was not ultimately included in the final data analysis. This new condition-classification is also discussed in the 2009 Field Monitoring Guide.

Description of Indicator and Standard

Indicator

This indicator monitors the proliferation and condition of informal trails in meadows and the resulting fragmentation of meadow habitat. Informal trail monitoring has been applied to both river corridors to identify trampling related impacts to Yosemite's unique meadow habitat.

Draft Standards

Numerical standards are currently in development for this indicator in Yosemite Valley Meadows. Two draft standards have been developed for the Tuolumne River Corridor.

Fragmentation Standard: Meadows with informal trailing in the Tuolumne River Corridor will display fragmentation represented through a specific landscape index: the Largest Patches Index Five (LPI5) of no more than 92.84%. Decreasing percentages will indicate an increased degree of fragmentation.

Meadow Condition Standard: Trend data will demonstrate improvement of condition for recorded informal trails in meadows

Objectives

To document the extent and condition of informal trails in meadows of the Merced River Corridor and the Tuolumne River Corridor; to further establish baseline data on these impacts; and to compare results (where applicable) to data collected in 2004 through 2009. The results will be used to inform management decisions regarding protection of meadow health. Documentation of informal trailing impacts is currently confined to meadows in order to efficiently monitor visitor impacts to important ecological components.

Sampling

For the past six years, eight meadows in Yosemite Valley have been monitored to inventory and assess the presence and condition of informal trails therein. These eight meadows were selected because they lie within the Merced River corridor. All meadows have been measured since the 2007 refinement of data collection methods, methods of analysis and the overall scope of the indicator. Several meadows in the Tuolumne River corridor have been monitored since this refinement as well. With the establishment of permanent long-term indicators in the Tuolumne River Corridor, more specific attention has been placed on the indicators within the Tuolumne Corridor. In 2009, the focus in the Tuolumne River Corridor has been to collect the most accurate baseline data available for meadows identified as priorities. In 2010, emphasis will be placed on collecting data in meadows beyond our scope of the Tuolumne and Merced River Corridors and expand to other sensitive meadows within Yosemite National Park. As we continue to refine the draft standard for the Tuolumne River Corridor, meadows will be repeatedly measured in order to better understand variability and to clearly define the numerical standards.

Site Selection

In 2009, five Yosemite Valley meadows were monitored: Cooks, El Capitan, Leidig, Stoneman and Slaughterhouse (previously and erroneously referred to as Woskey Pond). Meadow selection every field season adheres to a three to five year monitoring rotation. Additionally, meadows with management concerns are more frequently monitored.

In Tuolumne Meadows, four areas were monitored: Tuolumne Meadows, the small meadow near the Tuolumne Ranger Station, the meadows of Lyell Canyon, and Dana Meadows. For Dana Meadows, Tuolumne Meadow and the meadow in Upper Lyell Canyon, this represents the second consecutive season of monitoring.

Sampling Schedule

In Yosemite Valley, monitoring was conducted over a four-week period, from mid-June into early July. In Tuolumne Meadows, monitoring was conducted in mid-July and in mid-August.

Data Analyses

Fragmentation Analyses

Due to the many variables that may influence the integrity, functioning and quality of landscape, ecosystem or park environment, indices are commonly used to integrate various attributes for data reporting and communication in such fields as ecology, landscape ecology, conservation studies and environmental sciences. There is a large body of literature on landscape indices (Chust et al. 2004; Forman 1995; McGarigal & Mark, 1995) as well as indices developed for characterizing visitor impacts (Leung & Marion, 1998). One of the most comprehensive references on this topic was published by McGarigal and Marks (1995) in which more than 50 landscape indices were identified and described.

An initial review of landscape indices suggested that *three* indices were closely related to the key issues and concerns about informal trails. The indices were chosen due to their reflection of *proliferation* and *fragmentation* in a landscape (meadow), and for their relative ease to derive from Geographic Information System (GIS) and Global Positioning System (GPS) data using common GIS software such as ESRI ArcGIS. These three indices, Mean Patch Size, Core Area Index and Largest Patch Size (McGarigal and Marks, 1995), were tested in ArcGIS with El Capitan Meadow's 2006 data and results reported to the Park staff in October 2007.

Based on the discussion with park staff and the GIS specialist, two of the three indices, Mean Patch Size and Largest Patch Size, were modified to better reflect the nature of informal trail impacts. The modified indices are named *(1) Weighted Mean Patch Index (or WMPI) and (2) Largest Patches Index (or LPI-5)*. The Core Area Index was eliminated from consideration because of the difficulties of its interpretation. Efforts will continue to be made to identify other appropriate metrics so that the most informed choice of informal trail indices can be made at the end of the pilot monitoring program (2009). The following is a description of each selected index:

A. Weighted Mean Patch Index (WMPI)

Definition: This index was built on the Mean Patch Size (MPS) metric described in McGarigal and Marks (1995). Despite its intuitiveness, this index proved to be less effective in capturing the effect of informal trails and disturbed areas on patch size. To address this limitation, a weighting factor (wf) was added to adjust for the spatial extent of informal trail network. It is defined as the average area (in square meters) of all patches without informal trails in a landscape, weighted by the extent of disturbed areas associated with informal trail impacts. In other words, this index is indicative of the average size of patches without informal trails with consideration of the dominance of informal trail features in a landscape.

Metric: $WMPI = wf * (\sum a_{ij} / n) * (1/10000)$

where $wf = (\sum a_{ij} / A)$

Notations: a_{ij} = area (m2) of patch ij, n = total # of patches without informal trails, wf = weight factor, A = landscape/meadow area
Unit: square meters
Range: 0 to infinity
Interpretation: Decreasing values indicate increasing degrees of fragmentation. Increasing spatial extent of informal trails would result in reduced index values even if the average patch size does not change.

B. Largest Patches Index – Five (LPI-5)

Definition: Adapted from the concept of Largest Patch Index (McGarigal and Marks 1995), this index is derived from the sum of areas of the five largest patches without informal trails, divided by total landscape (meadow) area. The main purpose of including the largest patches as a group, rather than merely the largest patch, is to reduce the index's over-sensitivity to changes in one single patch. Three and ten largest patches (LPI-3, LPI-10) were also considered, and five was chosen by the research team and park staff to achieve a balance between simplicity and representativeness. This index could be easily adapted if a different number of patches was desired in a later date.

Metric: $LPI\text{-}5 = \sum max5 (a_{ij}) / A * 100\%$

Notations: maxi = the largest i patches; a_{ij} = area (m2) of patch ij, A = area (m2) of the landscape (meadow)
Unit: Percent
Range: 0-100
Interpretation: Decreasing values would suggest increasing degrees of fragmentation.

Extent and Proliferation Analyses:
Additional indices are used to determine the change in trail density and proliferation when compared with previous data. The following are descriptions of the additional indices:

C. Median Patch Size: the average median patch size; decreasing value suggests increasing fragmentation

D. Total Extent of Impact: the length and density of informal trails; increasing value suggests increased proliferation of informal trailing.

E. Total Percent of Impact: the extent of impact divided by the total meadow area; increasing value suggests increasing trailing.

For detailed data analysis procedures see the Informal Trails section of the 2009 Field Monitoring Guide.

Meadow Boundary

Field GPS surveys of Tuolumne Meadows and the eight Yosemite Valley meadows occurred in 2005. The boundary locations were determined through a combined consideration of vegetation types, the location of structural barriers (e.g., roads), and referencing historic meadow boundaries.

In order to capture potential changes in the extent of these meadows, improving GPS technology, and updated orthophotos; the meadow boundaries will be remapped every four to five years. Updated boundary files are also necessary to ensure study area accuracy, for cartographic display and data analysis purposes. During the 2009 field season, staff began the remapping process. All boundaries were updated for meadows that were also monitored for informal trails in 2009. The remaining meadow boundaries will continue to be updated as they are monitored for informal trails in subsequent years.

When data is presented for determination of evaluation of standards, the 2005 data layer will be used. For this purpose, the original 2005 layer serves as the best example of a permanent plot, which data can be compared and trends most accurately examined. We will continue to remap boundaries of meadows in order to best reflect any changes that might occur to meadows. When data is presented individually for a current year, the most recent boundary file will be used.

Notable adjustments in meadow boundary occurred in El Capitan, Tuolumne, Dana, and Upper Lyell Meadows. A stand of California black oak (*Quercus kelloggii*), which forms a woodland on the west end of El Capitan Meadow was recognized, and considered to be an upland area. This information was cross-referenced with and confirmed by the 1997 Yosemite Vegetation Map; it was, therefore, excluded from the meadow area. A total of 1.8 hectares were subtracted from the final meadow area of El Capitan Meadow. In Tuolumne Meadows, the Tuolumne River bisects the entire study area in a general east-west direction. The area of the river segment, along with a network of formal trails, were removed from the meadow area, decreasing the total area of Tuolumne Meadows by 10.8 hectares. The 2009 boundary of Dana Meadow was also modified by removing a section of the Tuolumne River (Dana Fork) that bisects the meadow from east to west and decreased the meadow's total area by 0.123 hectares from the 2008 boundary. The 2008 meadow boundary for Upper Lyell was also updated by removing the section of the Tuolumne River (Lyell Fork) that bisects it from north to south. Total area for Upper Lyell Meadow was reduced by 1.9 hectares. The areas of the oak woodland and both river segments were determined using GIS software by referencing 2005 and 2009 aerial imagery from the National Agriculture Imagery Program (NAIP). Efforts will be made to reduce any potential impact these adjustments would have on previously recorded data sets. Original meadow boundaries will be used in all cases where trend data is assessed, in order to most accurately represent change.

Beginning in 2007, infrastructure such as formal trails, boardwalks, and roads were used to determine meadow boundaries, and some cases resulted in meadows being divided into sub-meadows for analysis purposes. Also, infrastructure was not included as part of the meadow since infrastructure does not fit the definition of a meadow nor are they informal trails or disturbed areas. These procedures can be viewed in more detail in the Informal Trails section of the Visitor Use and Impact Monitoring Field Guide.

In the results section of 2009's document, data is presented in several ways to demonstrate the differences found when meadow boundaries are remapped. For the meadows that have had boundaries remapped during the 2009 field season, results are portrayed as a comparison of 2005 and 2009 boundary files.

Influence Zone

Based on work by Jeff Holmquist (Holmquist and Schmidt-Geggenbach 2007), a five-meter buffer was added to the informal trails and disturbed areas. This influence zone allows us to take into account areas beyond the measureable impacts that could reflect disturbance to vegetation and animal communities. This influence zone is included as a measure for discussion and future analysis of undetected impacts. Future study to meadows will focus on refining the influence zone for the specific ecological communities of both Yosemite Valley and Tuolumne meadows.

Results

The monitoring results are presented here in three formats – graphical data, tabular data, and cartographical data - and are separated by region (Yosemite Valley and the Tuolumne Meadows).

The first set of graphs show each meadow's rank of concern (lower numbers on the y-axis demonstrate greater concern). Ranking each meadow by its index value provides an objective way to determine monitoring priorities as well as relative meadow condition. The second series of tables display fragmentation and trail density data for each meadow or meadow section (where appropriate), for all years of comparable data. The last figures are individual meadow maps displaying the extent and condition of informal trails and disturbed areas (including the potential impact extent of a five-meter influence zone). The purpose of the maps is to provide a visual reference to accompany the tabular data. The maps also provide a means to clearly display the current state of informal trails in the meadows included in this study.

When monitoring meadows, we consider each metric separately to have a broader understanding of the effect of informal trail impacts on current conditions. Restoration or infrastructure in meadows can sometimes affect how the results may appear. For example, Cooks meadow is broken up into three sections due to boardwalks and paved trails in the meadow. The smallest segment, Cooks A, shows the highest concern due to the proliferation of impacts in the decreased size of that particular segment.

Meadow name abbreviations used here are as follows:

AHWA	Ahwahnee	LEID	Leidig	TUOL	Tuolumne (A/B)
BRID	Bridalveil	RAST	Ranger Station (A/B)	TWBR	Twin Bridges
COOK	Cooks (A/B/C)	SENT	Sentinel (A/B)	UPLY	Upper Lyell (A/B)
DANA	Dana (A/B)	SLAU	Slaughterhouse (A/B)		
ELCA	El Capitan	STON	Stoneman (A/B)		

Results for Yosemite Valley Meadows

The following graphs display the index ranking results for all Yosemite Valley meadows under the Weighted Mean Patch Index WMPI (Figure 2.4.1), the L5PI (Figure 2.4.2) and an average ranking index (Figure 2.4.3) where the ranking numbers of four indices (WMPI, L5PI, Total Extent of Impact, and Total Percent of Impact) were combined and averaged for each meadow.

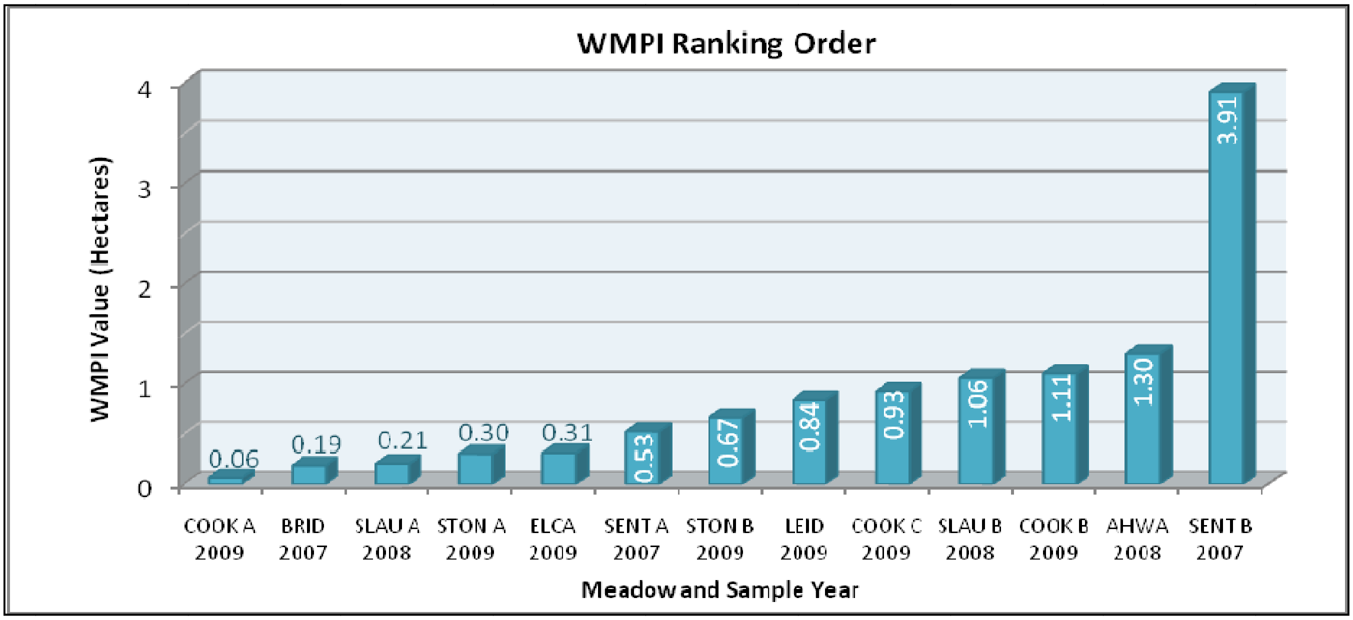

Figure 2.4.1 shows Yosemite Valley meadows ranked from greatest to least concern using the Weighted Mean Patch Index.

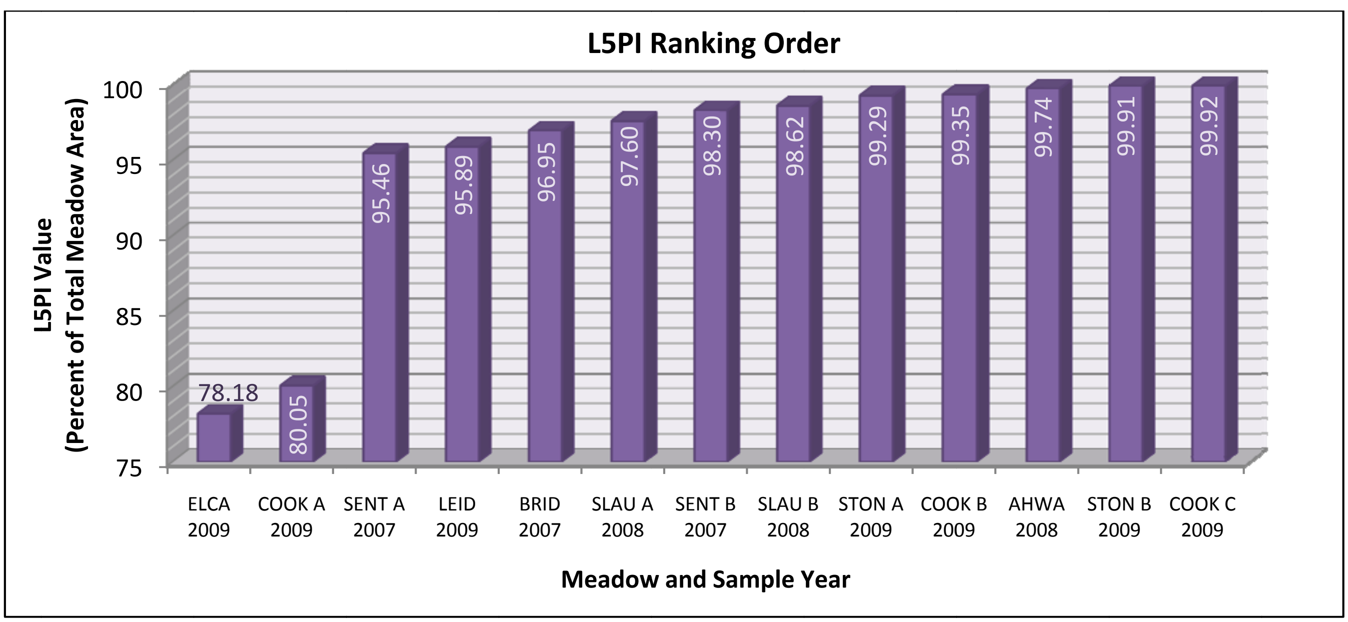

Figure 2.4.2 shows Yosemite Valley meadows ranked from greatest to least concern using the Largest 5 Patches Index.

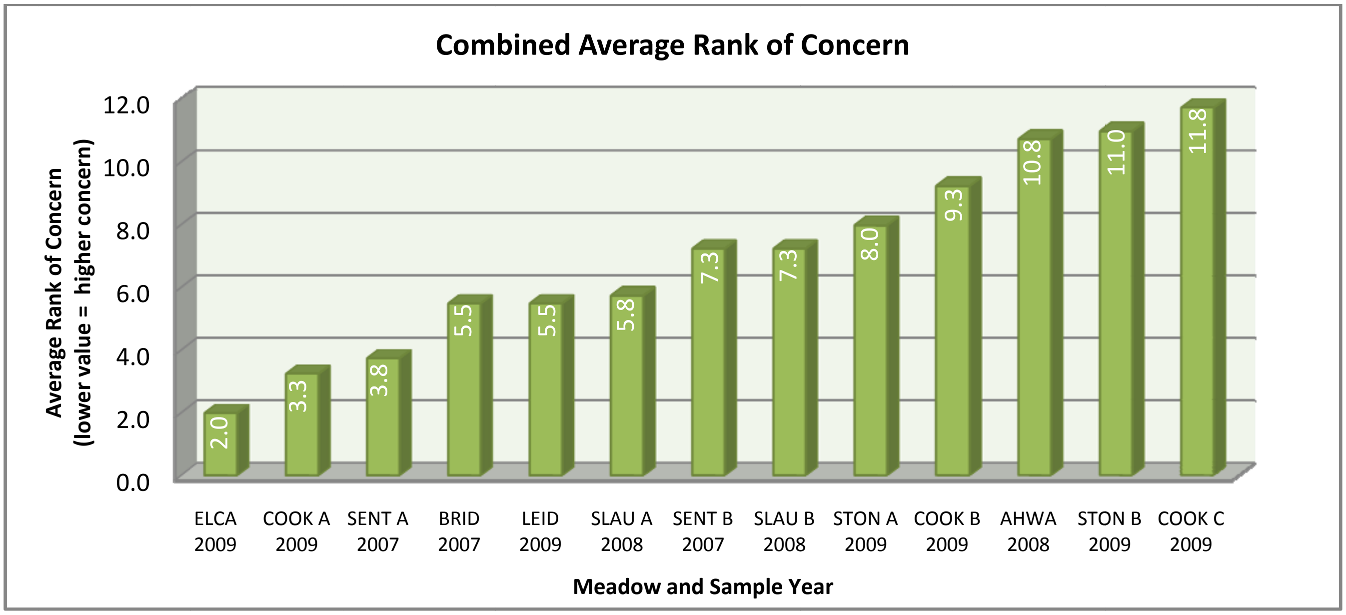

Figure 2.4.3 shows Yosemite Valley meadows ordered by average index ranking of these indices: WMPI, L5PI, Total Extent of Impact, and Total Percent of Impact.

Meadow Maps

The following maps (Figures 2.4.4-2.4.7) illustrate the extent and condition of informal trails as recorded during the 2009 field season, as well as resulting meadow fragmentation and a representation of the five-meter influence zone.

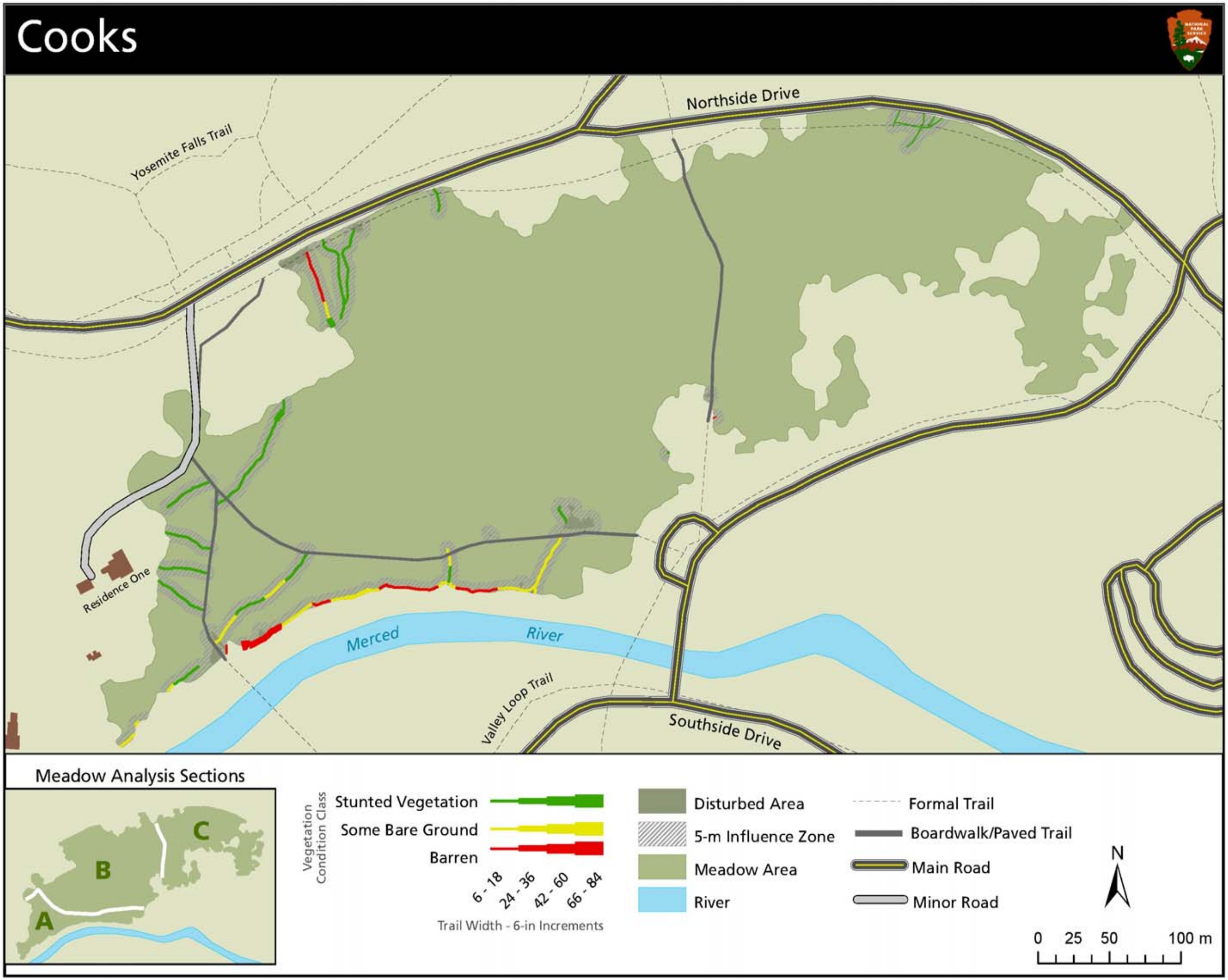

Figure 2.4.4 shows extent and condition of informal trails and disturbed areas in Cooks Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

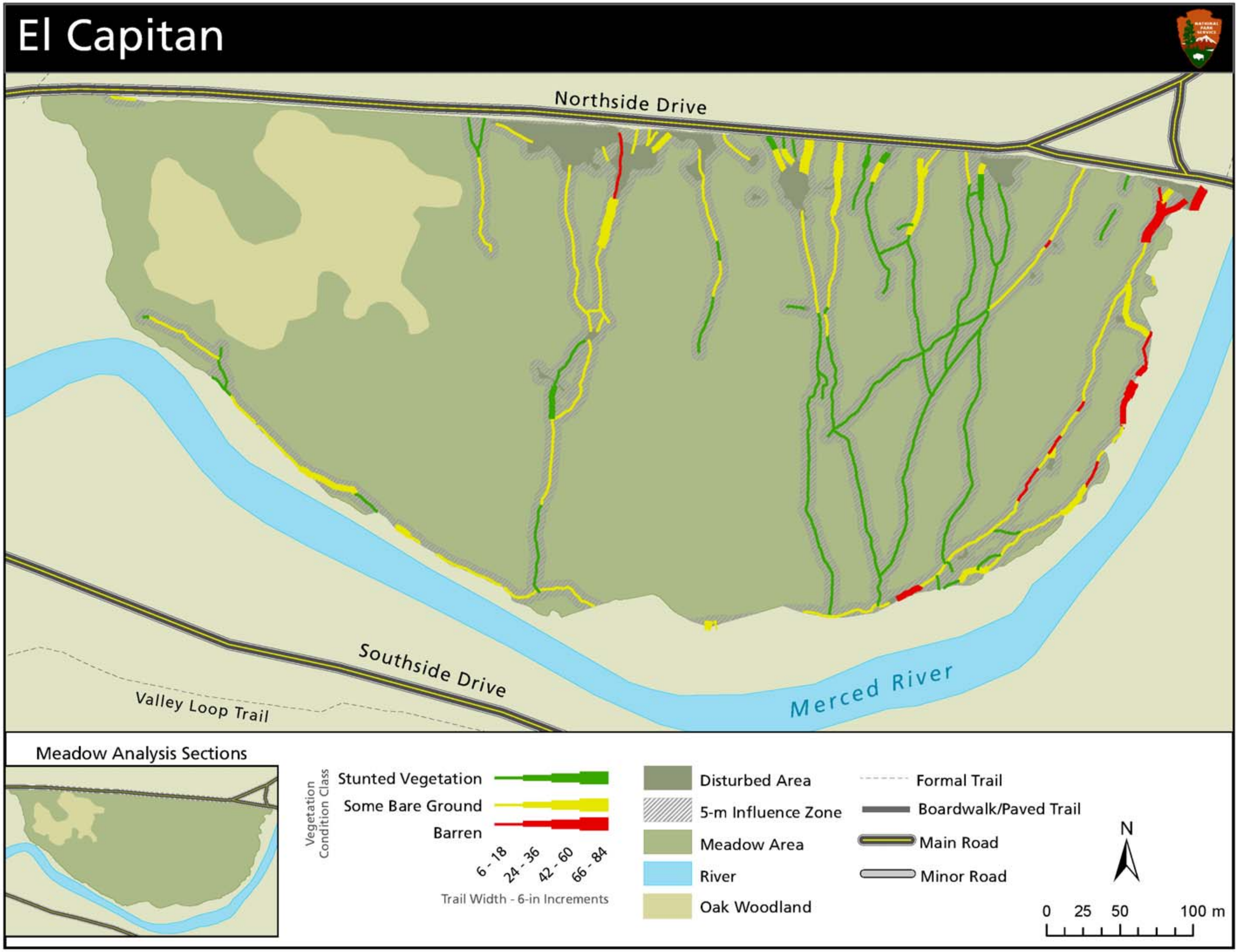

Figure 2.4.5. Extent and condition of informal trails and disturbed areas in El Capitan Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

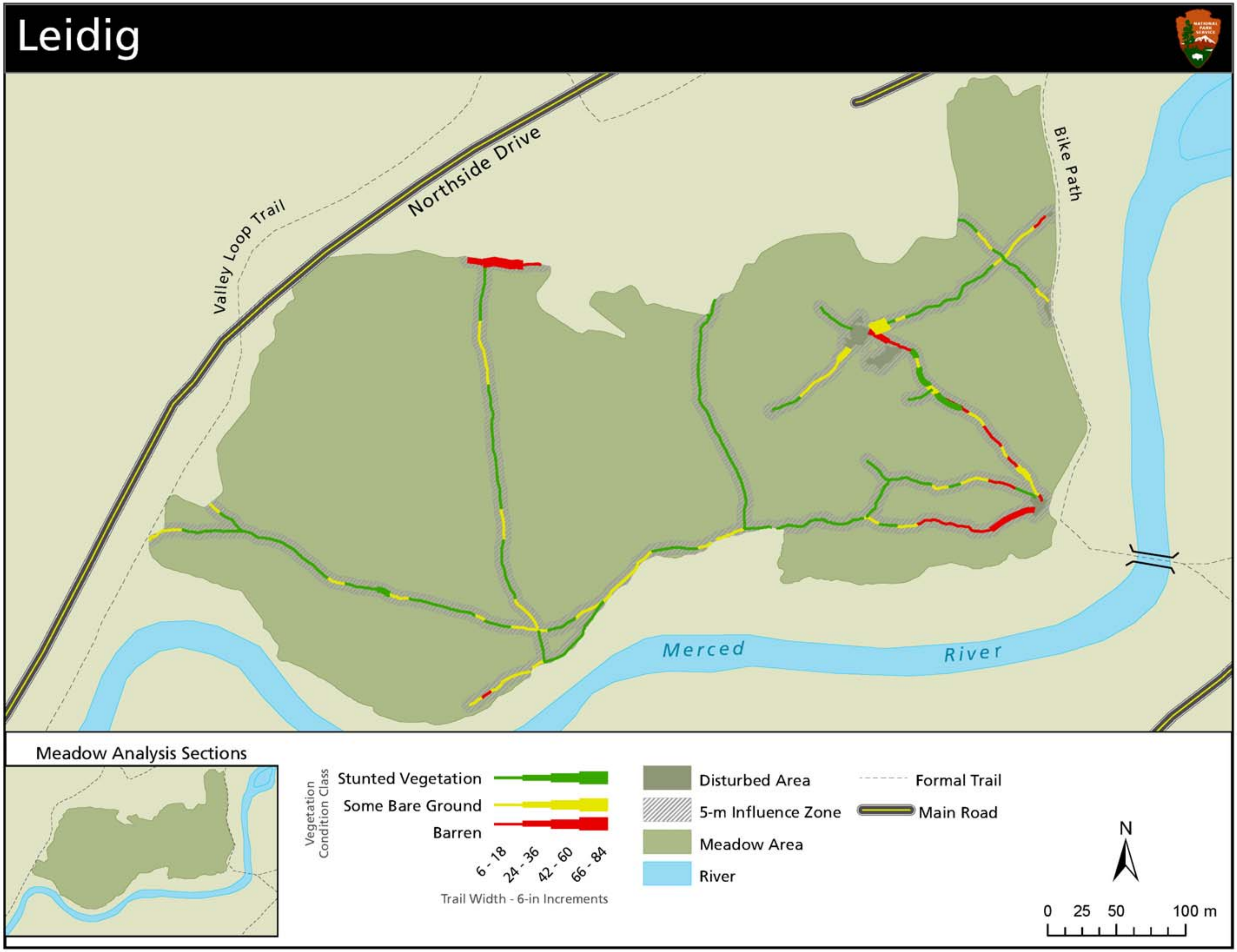

Figure 2.4.6. Extent and condition of informal trails and disturbed areas in Leidig Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

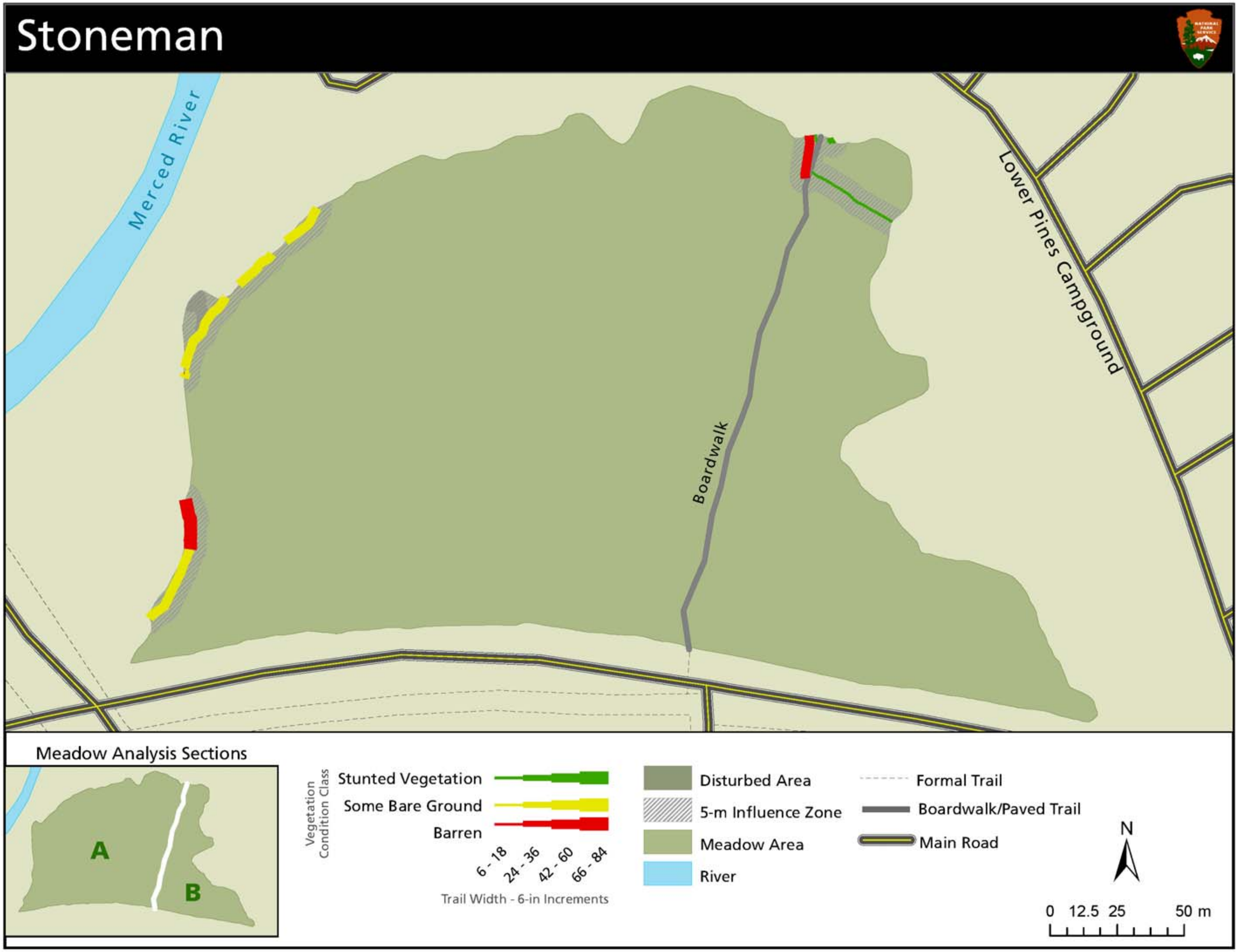

Figure 2.4.7. Extent and condition of informal trails and disturbed areas in Stoneman Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

The following tables (2.4.1 - 2.4.6) present the findings for all years of monitoring in Yosemite Valley meadows which were mapped and analyzed in 2009. Results are included for analysis both with and without the theorized five-meter influence zone; wf = weighting factor. This year, several Yosemite Valley meadow boundaries have been remapped. These meadows have their current meadow boundaries as well as the 2005 boundaries shown to compare how meadow boundaries have changed, and to demonstrate what our analysis will show with different boundaries shown.

Table 2.4.1 shows analysis results for Cooks Meadow Section A.

Cooks A						
Index	**Values**					
	No influence zone			**5-m influence zone**		
Year	**2006**	**2008**	**2009**	**2006**	**2008**	**2009**
Weighted Mean Patch Index (WMPI)	0.161 ha (wf = 0.963)	0.061 ha (wf = 0.963)	0.063 ha (wf = 0.981)	0.13 ha (wf = 0.963)	0.074 ha (wf = 0.656)	0.087 ha (wf = 0.700)
Largest Patches Indices (LPI-5)	95.68%	79.12%	80.05%	79.12%	56.04%	60.25%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	10 106.71 m² 277.22 m/ha 540 m² (3.15% of meadow area)	26 8.66 m² 318.49 m/ha 633 m² (3.68% of meadow area)	27 11.66 m² 332.89 m/ha 341 m² (1.93% of meadow area)	8 1670.05 m² 277.22 m/ha 3811 m² (22.19% of meadow area)	10 972.29 m² 318.49 m/ha 5911 m² (34.42% of meadow area)	10 1321.29 m² 332.89 m/ha 5306m² (30.01% of meadow area)

Table 2.4.2 shows analysis results for Cooks Meadow Section B.

Cooks B						
Index	**Values**					
	No influence zone			**5-m influence zone**		
Year	**2006**	**2008**	**2009**	**2006**	**2008**	**2009**
Weighted Mean Patch Index (WMPI)	0.949 ha (wf = 0.993)	0.262 ha (wf = 0.977)	1.110 ha (wf = 0.994)	0.848 ha (wf = 0.938)	0.596 ha (wf=.880)	0.998 ha (wf = 0.942)
Largest Patches Indices (LPI-5)	99.24%	97.49%	99.35%	93.80%	87.88%	94.10%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	8 112.18 m² 62.92 m/ha 545 m² (0.71% of meadow area)	28 1.66 m² 65.41 m/ha 1804 m² (2.34% of meadow area)	6 973.25 m² 42.32 m/ha 433 m² (0.64% of meadow area)	8 42.88 m² 62.92 m/ha 4754 m² (6.17% of meadow area)	10 55.28 m² 65.41 m/ha 9278 m² (12.04% of meadow area)	6 820.37 m² 42.32 m/ha 3913 m² (5.80% of meadow area)

Table 2.4.3 shows analysis results for Cooks Meadow Section C.

Cooks C						
Index	**Values**					
	No influence zone			**5-m influence zone**		
Year	**2006**	**2008**	**2009**	**2006**	**2008**	**2009**
Weighted Mean Patch Index (WMPI)	2.882 ha (wf = 1.000)	0.237 ha (wf = 0.993)	0.925 ha (wf = 0.999)	2.882 ha (wf = 1.000)	0.378 ha (wf = 0.887)	1.779 ha (wf = 0.980)
Largest Patches Indices (LPI-5)	100.00%	98.74%	99.92%	100.00%	88.75%	98.02%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 1 28820.00 m² 0.00 m/ha 0 m² (0.00% of meadow area)	 12 55.05 m² 103.13 m/ha 209 m² (0.73% of meadow area)	 4 101.61 m² 22.40 m/ha 30 m² (0.08% of meadow area)	 1 28820.00 m² 0.00 m/ha 0 m² (0.00% of meadow area)	 6 83.89 m² 103.13 m/ha 3243 m² (11.25% of meadow area)	 2 18154.57 m² 22.40 m/ha 735 m² (1.98% of meadow area)

Table 2.4.4 shows analysis results for El Capitan Meadow (All data analyzed using 2005 Boundary).

El Capitan						
Index	**Values**					
	No influence zone			**5-m influence zone**		
Year	**2006**	**2008**	**2009**	**2006**	**2008**	**2009**
Weighted Mean Patch Index (WMPI)	0.551 ha (wf = 0.977)	0.397 ha (wf = 0.975)	0.395 ha (wf = 0.972)	0.377 ha (wf = 0.796)	0.399 ha (wf = 0.781)	0.367 ha (wf = 0.773)
Largest Patches Indices (LPI-5)	91.23%	84.30%	79.49%	72.61%	71.07%	67.63%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 34 162.07 m² 207.51 m/ha 4535 m² (2.31% of meadow area)	 47 79.49 m² 202.57 m/ha 4916 m² (2.50% of meadow area)	 47 142.65 m² 206.57 m/ha 5549 m² (2.83% of meadow area)	 33 163.27 m² 207.51 m/ha 40000 m² (20.37% of meadow area)	 30 277.83 m² 202.57 m/ha 43083 m² (21.94% of meadow area)	 32 241.27 m² 206.57 m/ha 44572 m² (22.70% of meadow area)

Table 2.4.5 shows analysis results for El Capitan Meadow comparing findings using the remapped 2009 boundary and the 2005 boundary.

El Capitan (2009 data, 2005 vs. 2009 boundaries)				
Index	**Values**			
	No influence zone		**5-m influence zone**	
Year	**2009 data/ 2005 bndry**	**2009 data/ 2009 bndry**	**2009 data/ 2005 bndry**	**2009 data/ 2009 bndry**
Weighted Mean Patch Index (WMPI)	0.395 ha (wf = 0.972)	0.312 ha (wf = 0.968)	0.367 ha (wf = 0.773)	0.287 ha (wf = 0.747)
Largest Patches Indices (LPI-5)	79.49%	78.18%	67.63%	64.64%
Other relevant metrics:				
- Number of patches	47	54	32	35
- Median patch size	142.65 m²	94.34 m²	241.27 m²	198.37 m²
- Density of informal trails	206.57 m/ha	235.67 m/ha	206.57 m/ha	235.67 m/ha
- Total impact extent (informal trails + disturbed areas)	5549 m² (2.83% of meadow area)	5800 m² (3.22% of meadow area)	44572 m² (22.70% of meadow area)	45540 m² (25.31% of meadow area)

Table 2.4.6 shows analysis results for Leidig Meadow.

Leidig				
Index	**Values**			
	No influence zone		**5-m influence zone**	
Year	**2007**	**2009**	**2007**	**2009**
Weighted Mean Patch Index (WMPI)	0.527 ha (wf = 0.966)	0.836 ha (wf = 0.991)	0.499 ha (wf = 0.798)	1.008 ha (wf = 0.865)
Largest Patches Indices (LPI-5)	74.05%	95.89%	56.78%	76.34%
Other relevant metrics:				
- Number of patches	25	19	18	12
- Median patch size	671.78 m²	49.57 m²	4116.47 m²	6496.86 m²
- Density of informal trails	189.36 m/ha	132.63 m/ha	189.36 m/ha	132.63 m/ha
- Total impact extent (informal trails + disturbed areas)	4769 m² (3.38% of meadow area)	1401 m² (0.87% of meadow area)	28.491 m² (20.20% of meadow area)	21804 m² (13.49% of meadow area)

The following four tables display four years of data for Stoneman Meadow. Figures 2.4.7 through 2.4.10 represent the fragmentation analysis for Stoneman Meadow. These are included to demonstrate changes that have occurred in Stoneman Meadow since 2006. Currently, Stoneman Meadow is the only meadow for which four years of repeat data exists.

Table 2.4.7 displays analysis results for Stoneman Meadow Section A (no influence zone). Data is represented to show differences between analysis with both 2005 and 2009 boundary files.

Stoneman Meadow A					
Index	**Value (No influence zone)**				
Year	**2006**	**2007**	**2008**	**2009 data/ 2009 bndry**	**2009 data/ 2005 bndry**
Weighted Mean Patch Index (WMPI)	1.207 ha (wf = 0.996)	0.902 ha (wf = 0.995)	0.602 ha (wf = 0.995)	0.304 ha (wf = 0.993)	0.589 ha (wf = 0.999)
Largest Patches Indices (LPI-5)	99.64%	99.47%	99.49%	99.29%	99.91%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	3 332.83 m² 30.83 m/ha 131 m² (0.36% of meadow area)	4 235.12 m² 35.80 m/ha 194 m² (0.53% of meadow area)	6 18.64 m² 37.82 m/ha 185 m² (0.51% of meadow area)	12 8.43 m² 36.95 m/ha 244 m² (0.66% of meadow area)	2 5899.45 m² 28.55 m/ha 10 m² (0.09% of meadow area)

Table 2.4.8 Analysis results for Stoneman Meadow Section A (with 5-meter influence zone). Data is represented to show differences between analysis with both 2005 and 2009 boundary files.

Stoneman Meadow A					
Index	**Value (5-m influence zone)**				
Year	**2006**	**2007**	**2008**	**2009 data/ 2009 bndry**	**2009 data/ 2005 bndry**
Weighted Mean Patch Index (WMPI)	1.670 ha (wf = 0.957)	1.637 ha (wf = 0.948)	1.115 ha (wf = 0.958)	3.448 ha (wf = 0.966)	1.718 ha (wf = 0.971)
Largest Patches Indices (LPI-5)	95.71%	94.75%	95.76%	96.59%	97.06%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	2 17452.18 m² 30.83 m/ha 1563 m² (4.29% of meadow area)	2 172.26 m² 35.80 m/ha 1913 m² (5.25% of meadow area)	3 66.74 m² 37.82 m/ha 1546 m² (4.24% of meadow area)	1 35691.70 m² 36.95 m/ha 1258 m² (3.41% of meadow area)	2 17698.30 m² 26.05 m/ha 1071 m² (2.94% of meadow area)

Table 2.4.9 demonstrates analysis results for Stoneman Meadow Section B (no influence zone). Data is represented to show differences between analysis with both 2005 and 2009 boundary files.

Stoneman Meadow B					
Index	**Value (No influence zone)**				
Year	**2006**	**2007**	**2008**	**2009 data/ 2009 bndry**	**2009 data/ 2005 bndry**
Weighted Mean Patch Index (WMPI)	0.586 ha (wf = 0.996)	0.589 ha (wf = 0.999)	1.181 ha (wf = 1.000)	0.668 ha (wf = 0.999)	0.589 ha (wf = 0.999)
Largest Patches Indices (LPI-5)	99.60%	99.90%	100.00%	99.91%	99.91%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	2 5880.82 m² 36.68 m/ha 48 m² (0.40% of meadow area)	2 5898.66 m² 28.27 m/ha 12 m² (0.10% of meadow area)	1 11809.20 m² 0.00 m/ha 0 m² (0.00% of meadow area)	2 6688.81 m² 27.94 m/ha 12 m² (0.09% of meadow area)	2 5899.45 m² 28.55 m/ha 10 m² (0.09% of meadow area)

Table 2.4.10 displays analysis results for Stoneman Meadow Section B (with 5-meter influence zone). Data is represented to show differences between analysis with both 2005 and 2009 boundary files.

Stoneman Meadow B					
Index	**Value (5-m influence zone)**				
Year	**2006**	**2007**	**2008**	**2009 data/ 2009 bndry**	**2009 data/ 2005 bndry**
Weighted Mean Patch Index (WMPI)	1.059 ha (wf = 0.947)	0.550 ha (wf = 0.965)	1.181 ha (wf = 1.000)	0.628 ha (wf = 0.969)	0.554 ha (wf = 0.969)
Largest Patches Indices (LPI-5)	94.71%	96.48%	100.00%	96.86%	96.89%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	1 11184.80 m² 36.68 m/ha 624 m² (5.29% of meadow area)	2 5696.84 m² 28.27 m/ha 416 m² (3.52% of meadow area)	1 11809.20 m² 0.00 m/ha 0 m² (0.00% of meadow area)	2 6484.68 m² 27.94 m/ha 420 m² (3.14% of meadow area)	2 5721.17 m² 28.55 m/ha 367 m² (3.11% of meadow area)

Results for Tuolumne Meadows Region

Presented in this section are the data for all meadows monitored in 2009 within the Tuolumne Meadows region of the park; Dana Meadows along Tioga Road, those in Upper Lyell Canyon, near the Tuolumne Ranger Station, and Tuolumne Meadows. All of these meadows are bisected by natural features such as the Tuolumne River or man-made infrastructure such as maintained park trails.

Prior to the field season of 2009, some meadows in Yosemite Valley had been separated for analysis due to natural or unnatural significant division such as maintained park structures and boardwalks. With the commencement of a focused effort to monitor meadows within the Tuolumne River Corridor, this same procedure was applied to study meadows within the Tuolumne River Corridor.

The following graphs display the index ranking results for all meadows in the Tuolumne Meadows region under the Weighted Mean Patch Index (WMPI) (Figure 2.4.9), the Largest Patches Index-Five [LPI-5] (Figure 2.4.10) and an average ranking index (Figure 2.4.11) where the ranking numbers of four indices (WMPI, LPI-5, Total Extent of Impact, and Total Percent of Impact) were combined and averaged for each meadow.

The following maps (Figures 2.4.8 through 2.4.15) illustrate the extent and condition of informal trails as recorded during the 2009 field season, as well as resulting meadow fragmentation and a representation of the five-meter influence zone.

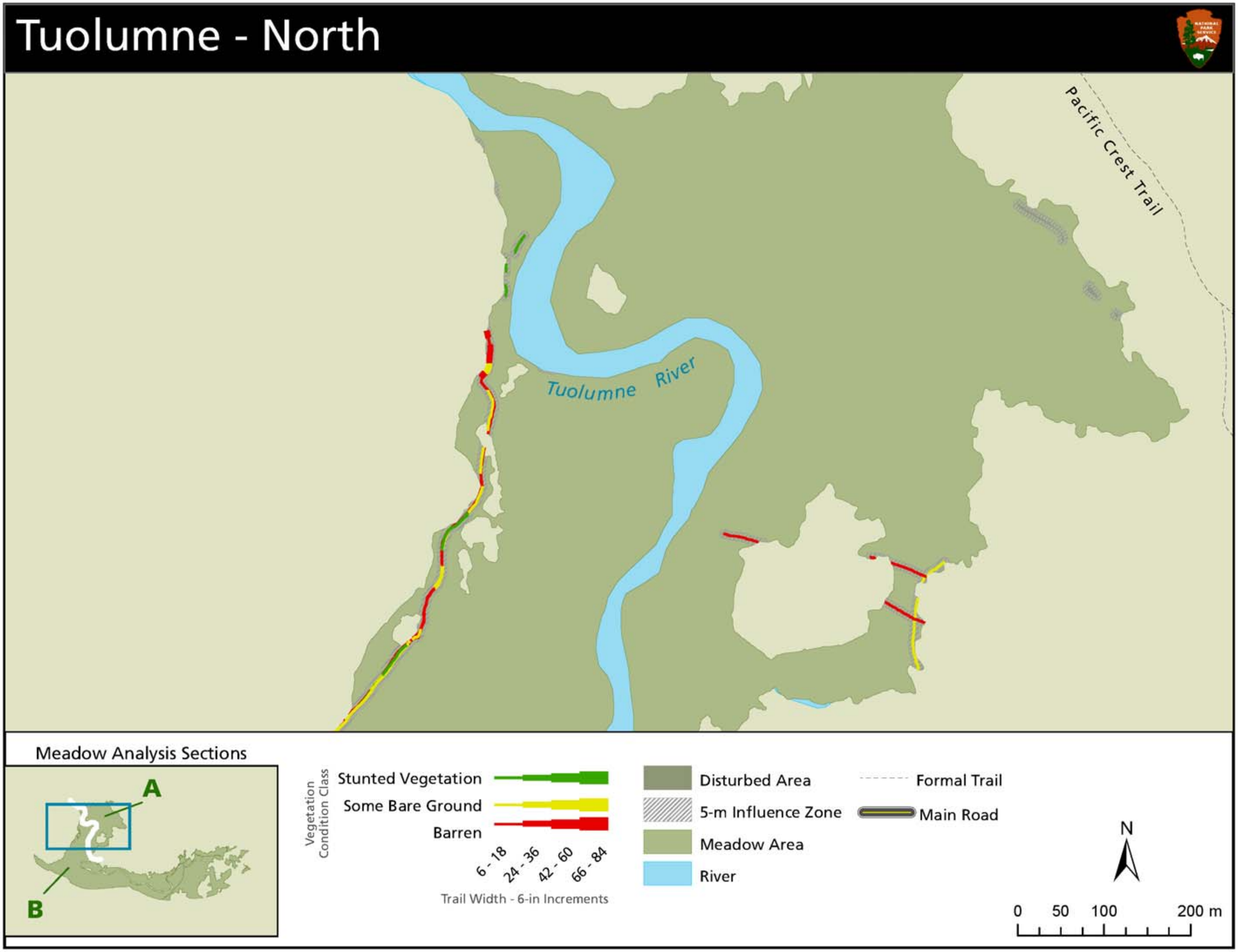

Figure 2.4.8. Extent and condition of informal trails and disturbed areas in the northern region of Tuolumne Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

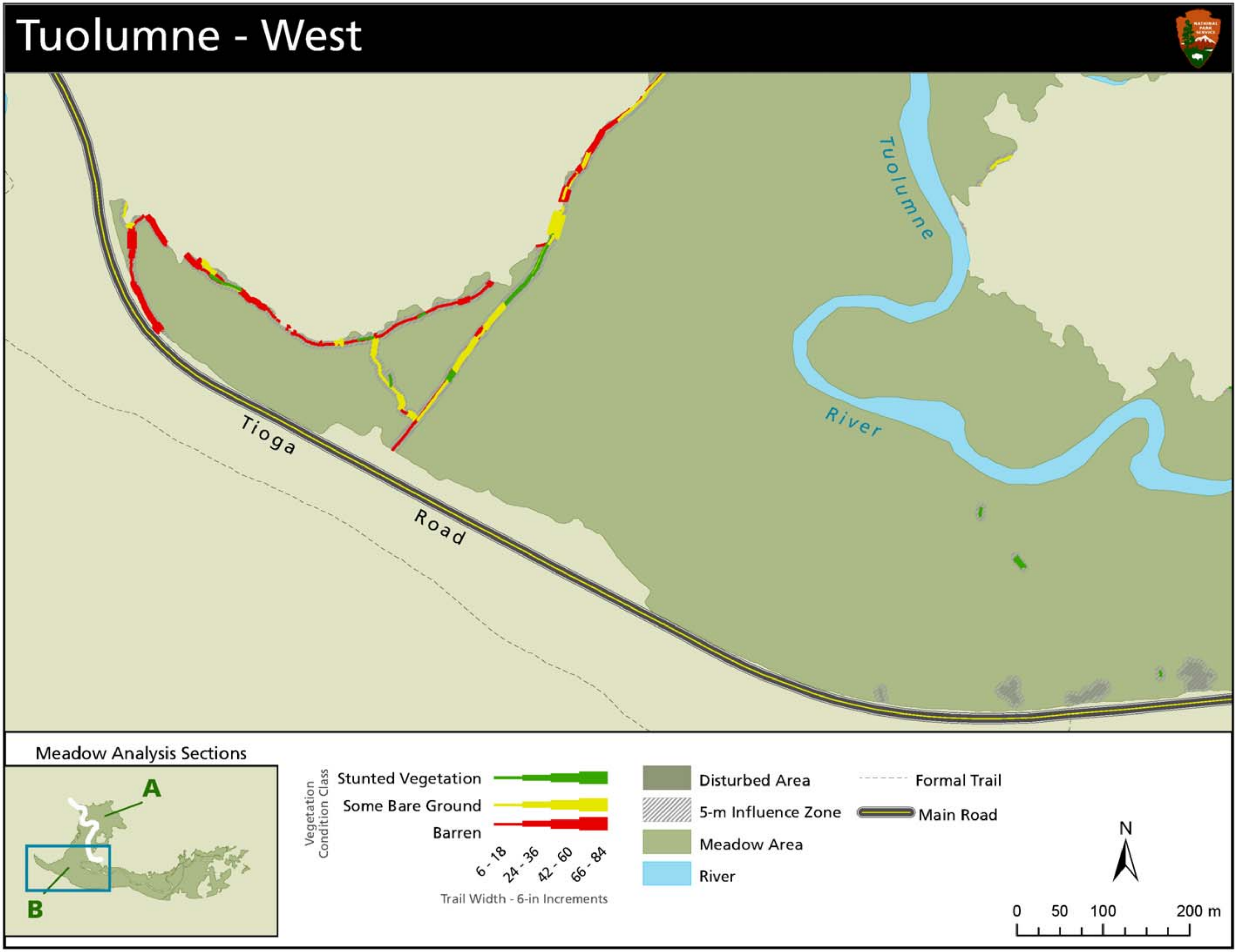

Figure 2.4.9. Extent and condition of informal trails and disturbed areas in the western region of Tuolumne Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

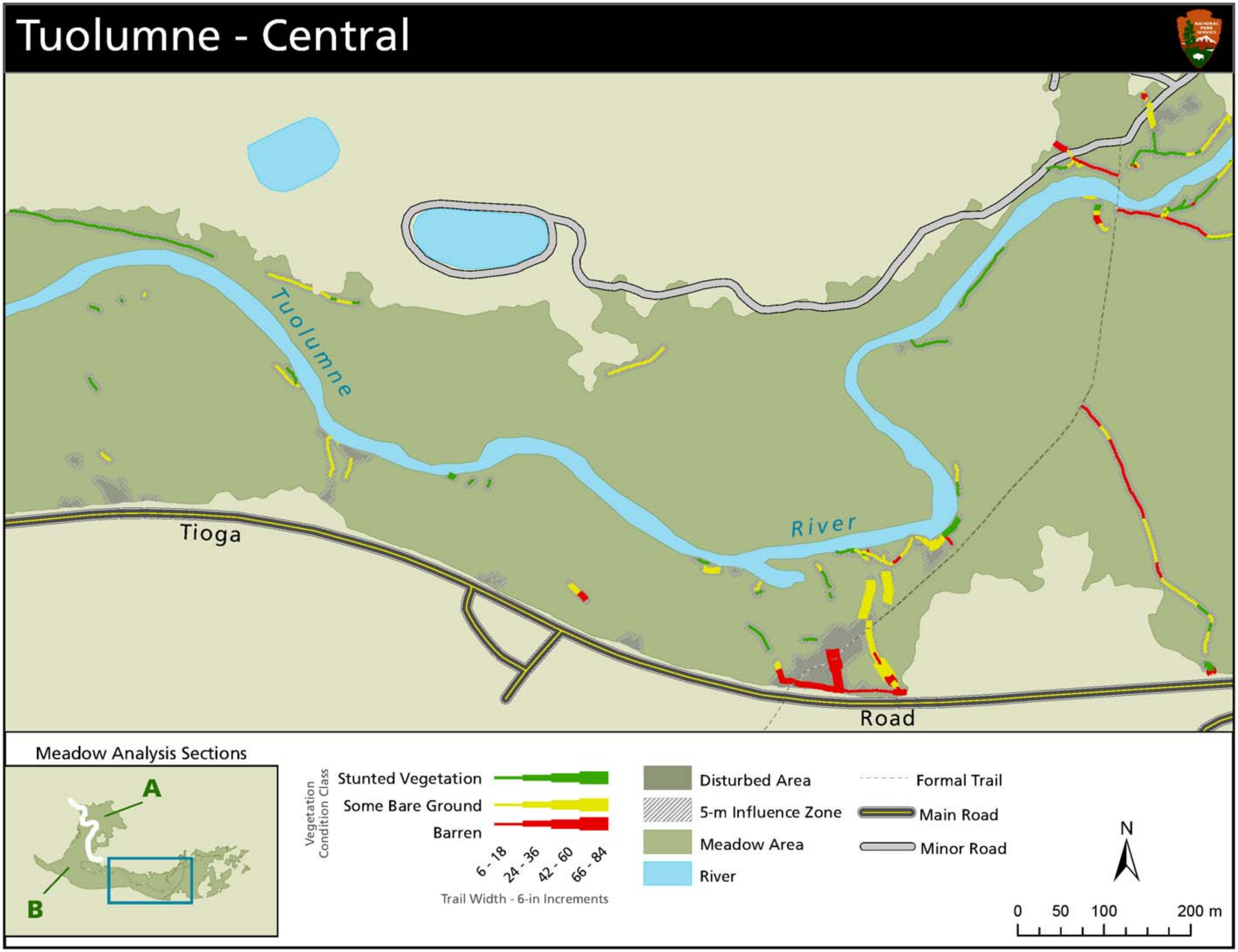

Figure 2.4.10. Extent and condition of informal trails and disturbed areas in the central region of Tuolumne Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

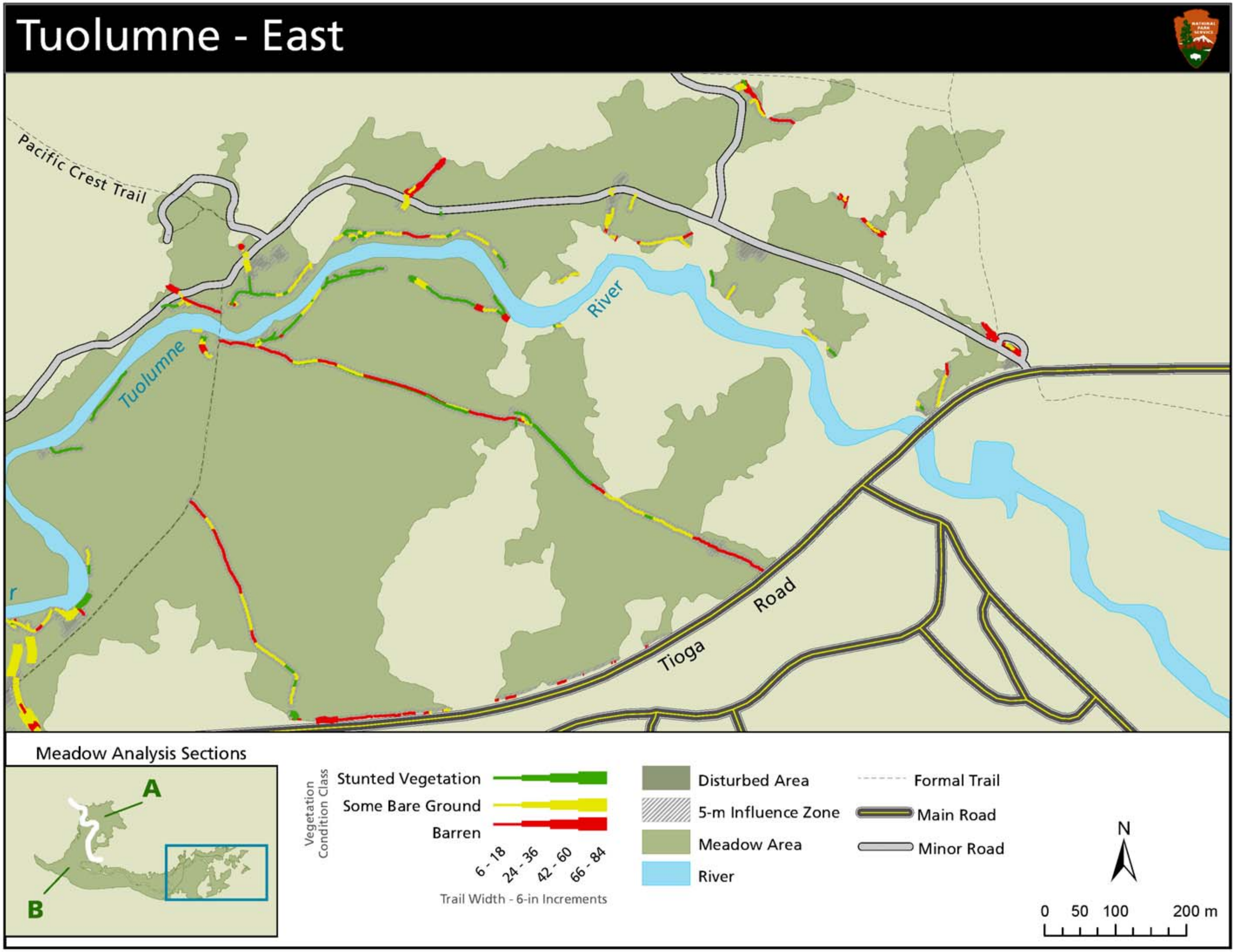

Figure 2.4.11. Extent and condition of informal trails and disturbed areas in the eastern region of Tuolumne Meadow (including five-meter influence zone). Inset shows meadow analysis sections**.**

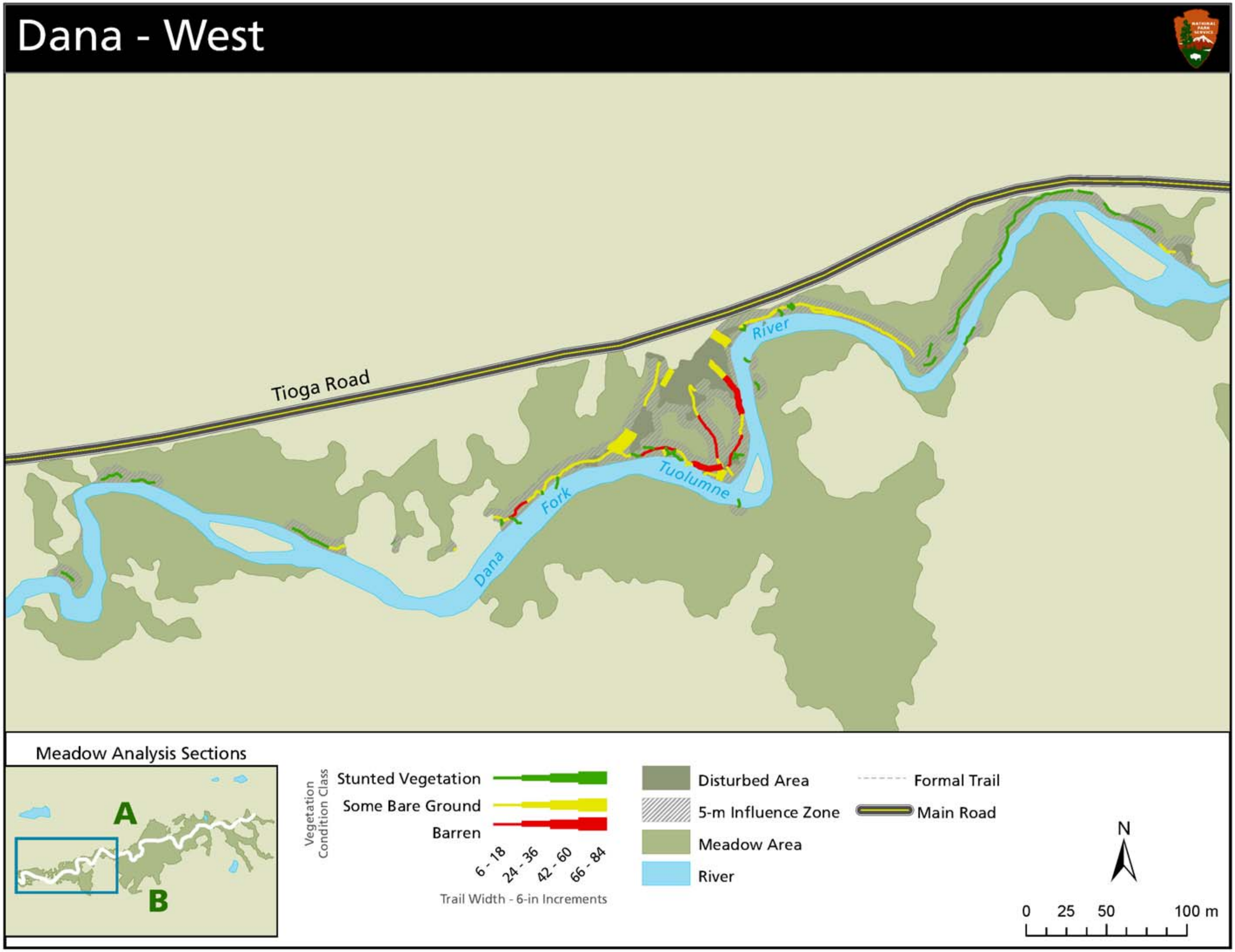

Figure 2.4.12. Extent and condition of informal trails and disturbed areas in the western region of Dana Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

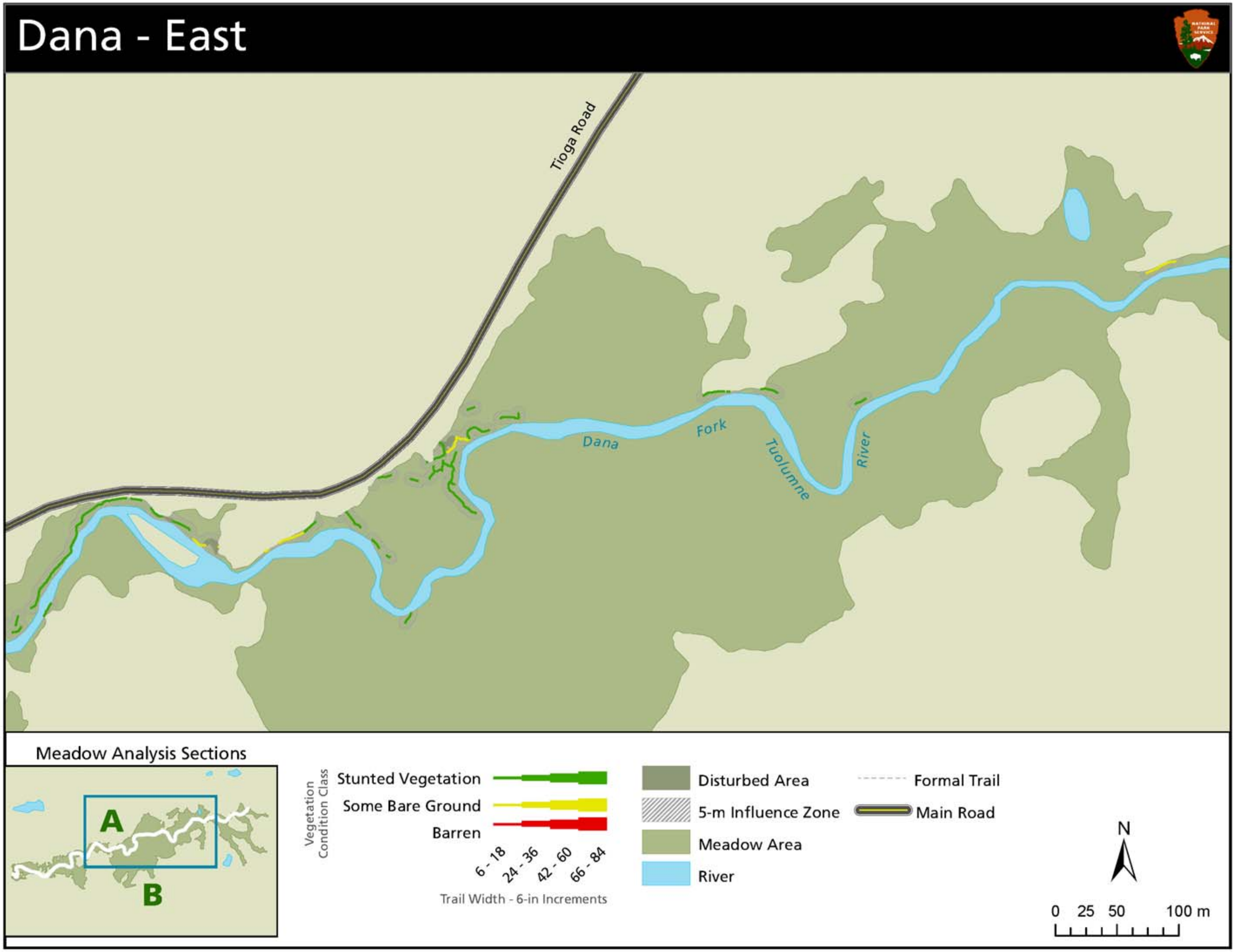

Figure 2.4.13. Extent and condition of informal trails and disturbed areas in Dana Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

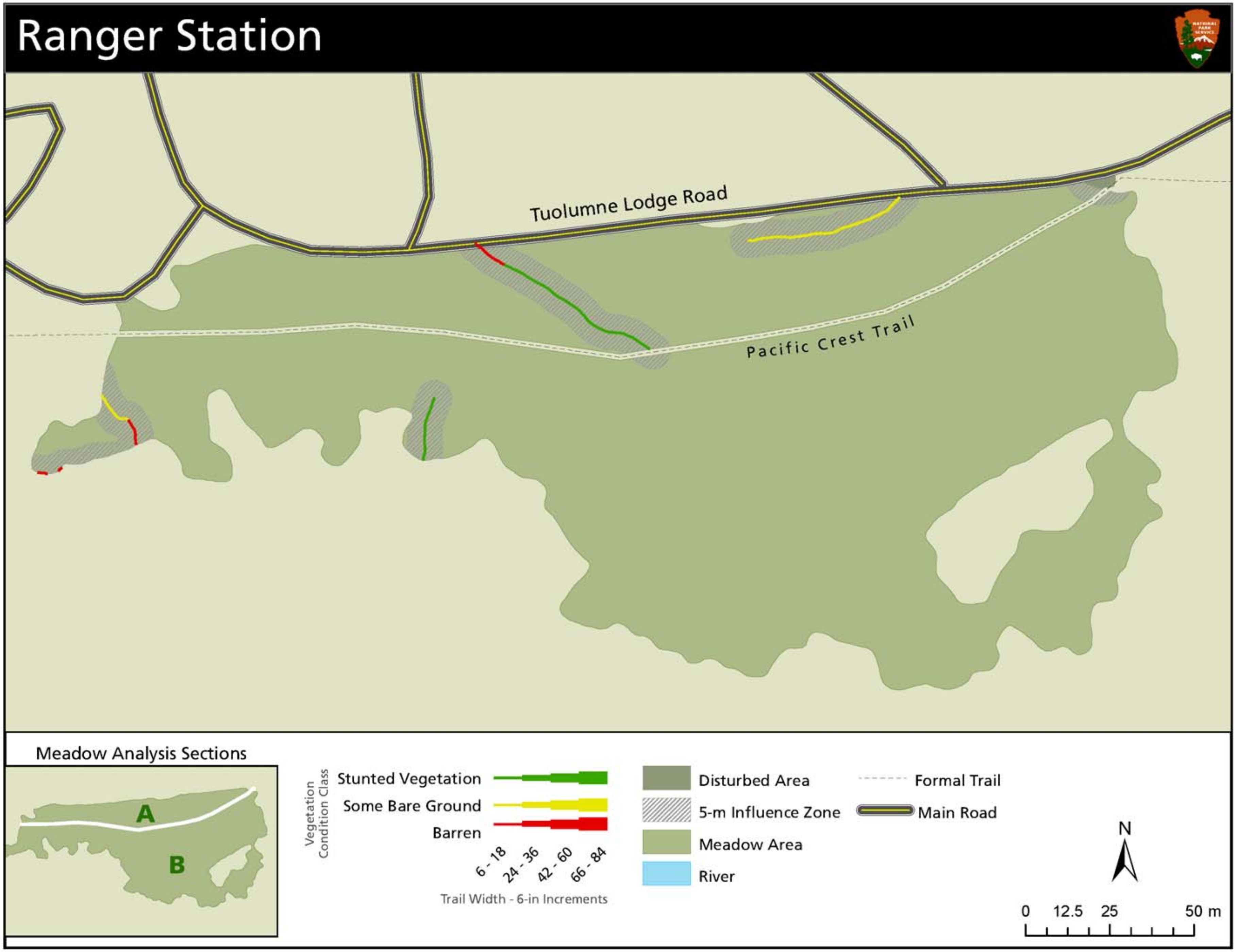

Figure 2.4.14. Extent and condition of informal trails and disturbed areas in Ranger Station Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

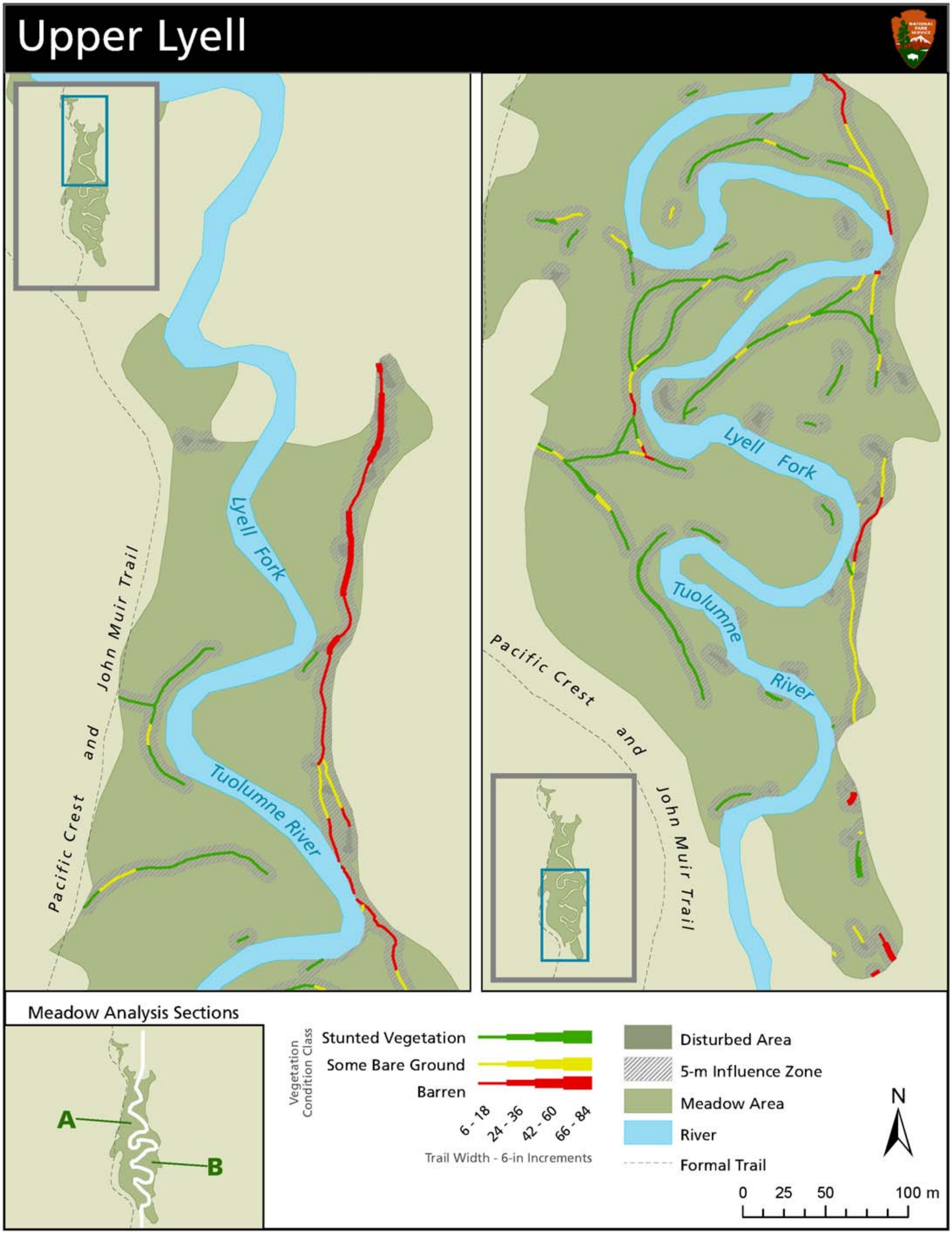

Figure 2.4.15. Extent and condition of informal trails and disturbed areas in Upper Lyell Meadow (including five-meter influence zone). Inset shows meadow analysis sections.

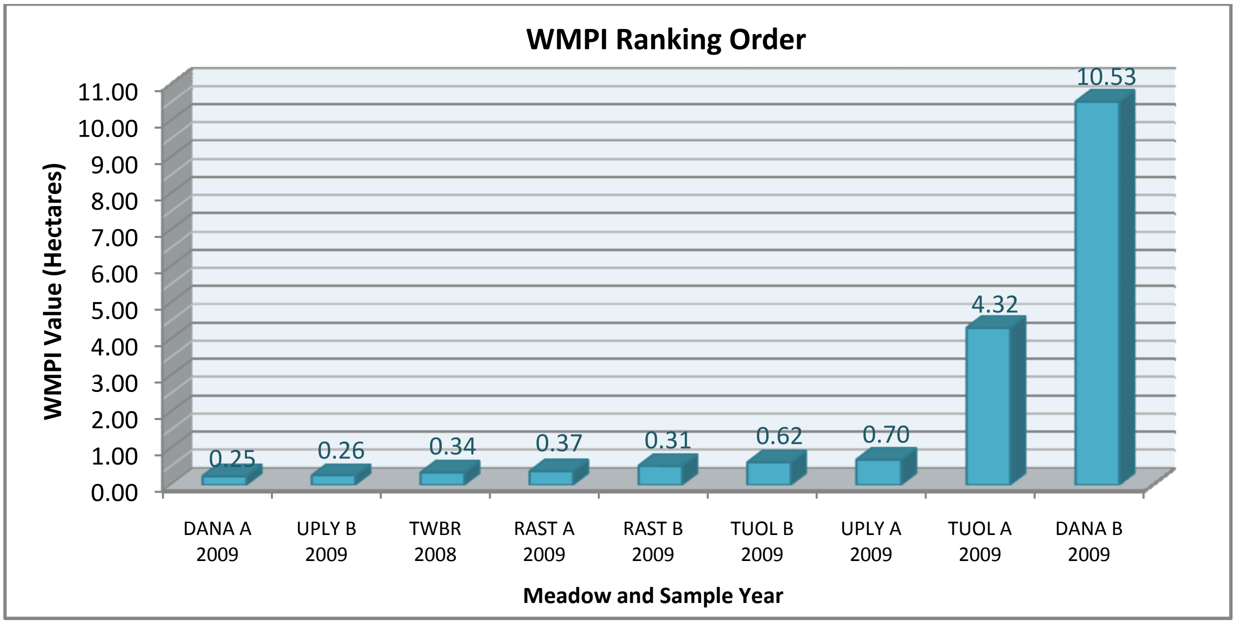

Figure 2.4.16 shows the Tuolumne Corridor meadows ranked from greatest to least concern using the Weighted Mean Patch Index.

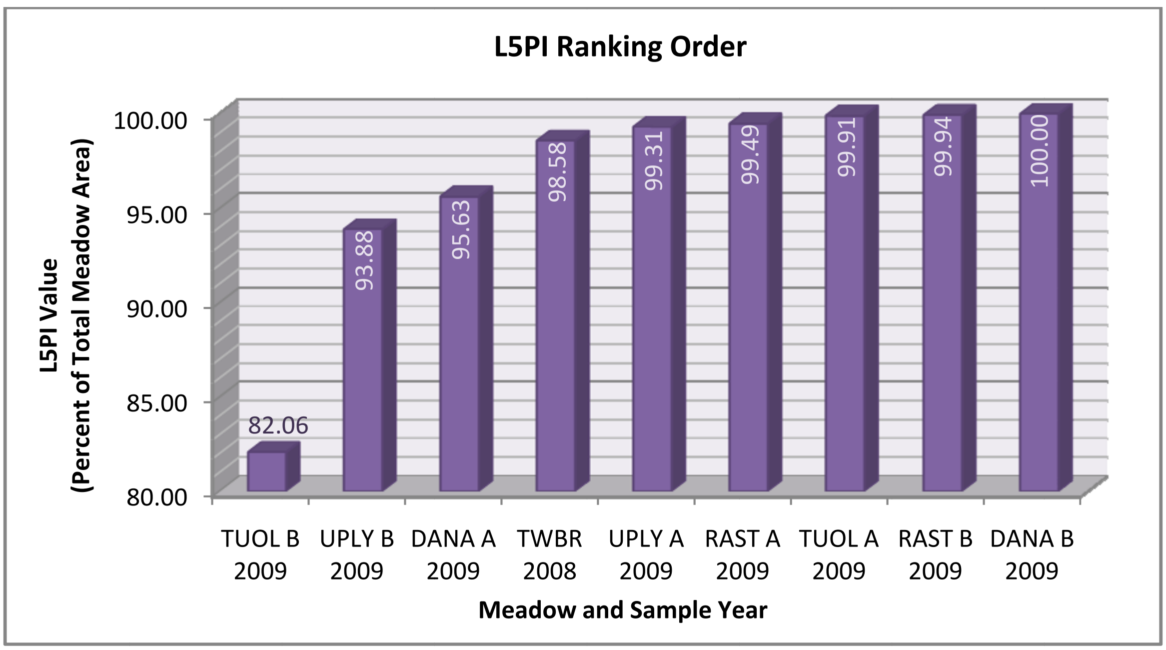

Figure 2.4.17 shows Tuolumne Corridor meadows ranked from greatest to least concern using the Largest 5 Patches Index.

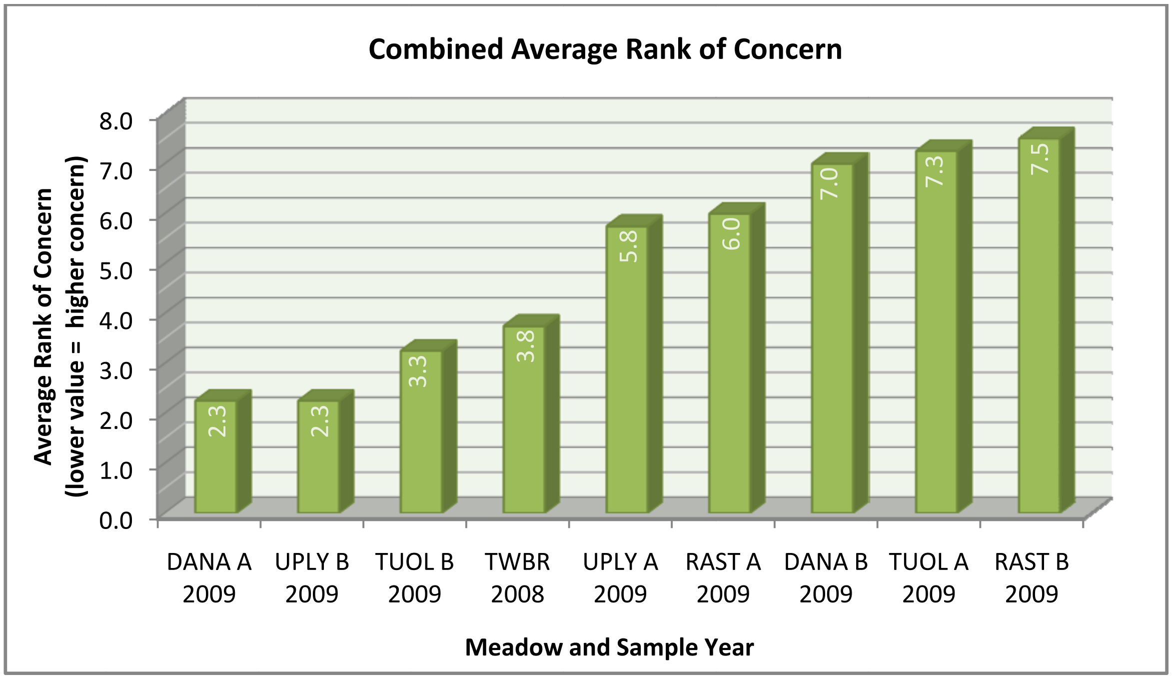

Figure 2.4.18 shows Tuolumne Corridor meadows ordered by average index ranking of these indices: WMPI, L5PI, Total Extent of Impact, and Total Percent of Impact.

The following tables (2.4.11 - 2.4.19) present the findings for meadows in the Tuolumne Region which were mapped and analyzed in 2009. Results are included for analysis both with and without the theorized five-meter influence zone; wf = weighting factor.

Table 2.4.11 shows analysis results for Tuolumne Meadow Section A.

Tuolumne A		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	4.322 ha (wf = 0.999)	4.913 ha (wf = 0.986)
Largest Patches Indices (LPI-5)	99.91%	98.63%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 7 63.05 m² 9.75 m/ha 239 m² (0.08% of meadow area)	 6 30.64 m² Same as left 4155 m² (1.37% of meadow area)

Table 2.4.12 shows analysis results for Tuolumne Meadow Section B.

Tuolumne B		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	0.621 ha (wf = 0.991)	1.746 ha (wf = 0.941)
Largest Patches Indices (LPI-5)	82.06%	75.45%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 234 6.78 m² 62.27 m/ha 13061 m² (0.88% of meadow area)	 75 320.33 m² Same as left 88027 m² (5.95% of meadow area)

Table 2.4.13 shows analysis results for Tuolumne Meadows without sub-meadow delineation.

Tuolumne Meadows				
Index	**Values**			
	No influence zone		**5-m influence zone**	
Year	**2008**	**2009**	**2008**	**2009**
Weighted Mean Patch Index (WMPI)	0.740 ha (wf = 0.995)	0.729 ha (wf = 0.993)	3.003 ha (wf = 0.938)	1.980 ha (wf = 0.948)
Largest Patches Indices (LPI-5)	96.03%	81.88%	90.29%	76.06%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 233 2.64 m² 381.34 m/ha 8409 m² (0.48% of meadow area)	 241 7.28 m² 53.35 m/ha 13297 m² (0.75% of meadow area)	 51 219.47 m² Same as left 108422 m² (6.22% of meadow area)	 81 249.28 m² Same as left 92179 m² (5.17% of meadow area)

Table 2.4.14 shows analysis results for Dana Meadow Section A.

Dana A		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	0.246 ha (wf = 0.976)	0.217 ha (wf = 0.867)
Largest Patches Indices (LPI-5)	95.63%	80.87%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 38 7.08 m² 130.94 m/ha 2314 m² (2.36% of meadow area)	 34 18.90 m² Same as left 13043 m² (13.30% of meadow area)

Table 2.4.15 shows analysis results for Dana Meadow Section B.

Dana B		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	10.533 ha (wf = 0.999)	6.996 ha (wf = 0.998)
Largest Patches Indices (LPI-5)	99.99%	99.81%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 2 105330.36 m² 0.85 m/ha 2 m² (0.001% of meadow area)	 3 26965.30 m² Same as left 399 m² (0.19% of meadow area)

Table 2.4.16 displays analysis results for Ranger Station Meadow Section A.

Ranger Station A		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	0.374 ha (wf = 0.995)	0.133 ha (wf = 0.839)
Largest Patches Indices (LPI-5)	99.49%	83.86%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 2 3761.36 m² 145.55 m/ha 39 m² (0.51% of meadow area)	 4 1321.22 m² 145.55 m/ha 1211 m² (16.14% of meadow area)

Table 2.4.17 shows analysis results for Ranger Station Meadow Section B.

Ranger Station B		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	0.531 ha (wf = 0.999)	0.672 ha (wf = 0.974)
Largest Patches Indices (LPI-5)	99.94%	97.36%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 4 179.02 m² 20.41 m/ha 14 m² (0.06% of meadow area)	 3 155.45 m² Same as left 562 m² (2.64% of meadow area)

Table 2.4.18 demonstrates analysis results for Upper Lyell Meadow Section A.

Upper Lyell A		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	0.696 ha (wf = 0.993)	0.501 ha (wf = 0.843)
Largest Patches Indices (LPI-5)	99.31%	81.87%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 11 12.86 m² 147.12 m/ha 506 m² (0.65% of meadow area)	 11 1325 m² Same as left 12212 m² (15.74% of meadow area)

Table 2.4.19 shows analysis results for Upper Lyell Meadow Section B.

Upper Lyell B		
Index	**Values**	
	No influence zone	**5-m influence zone**
Year	**2009**	**2009**
Weighted Mean Patch Index (WMPI)	0.260 ha (wf = 0.966)	0.074 ha (wf = 0.672)
Largest Patches Indices (LPI-5)	93.88%	54.54%
Other relevant metrics: - Number of patches - Median patch size - Density of informal trails - Total impact extent (informal trails + disturbed areas)	 17 46.43 m² 1221.16 m/ha 1597 m² (3.37% of meadow area)	 29 19.18 m² Same as left 15527 m² (32.77% of meadow area)

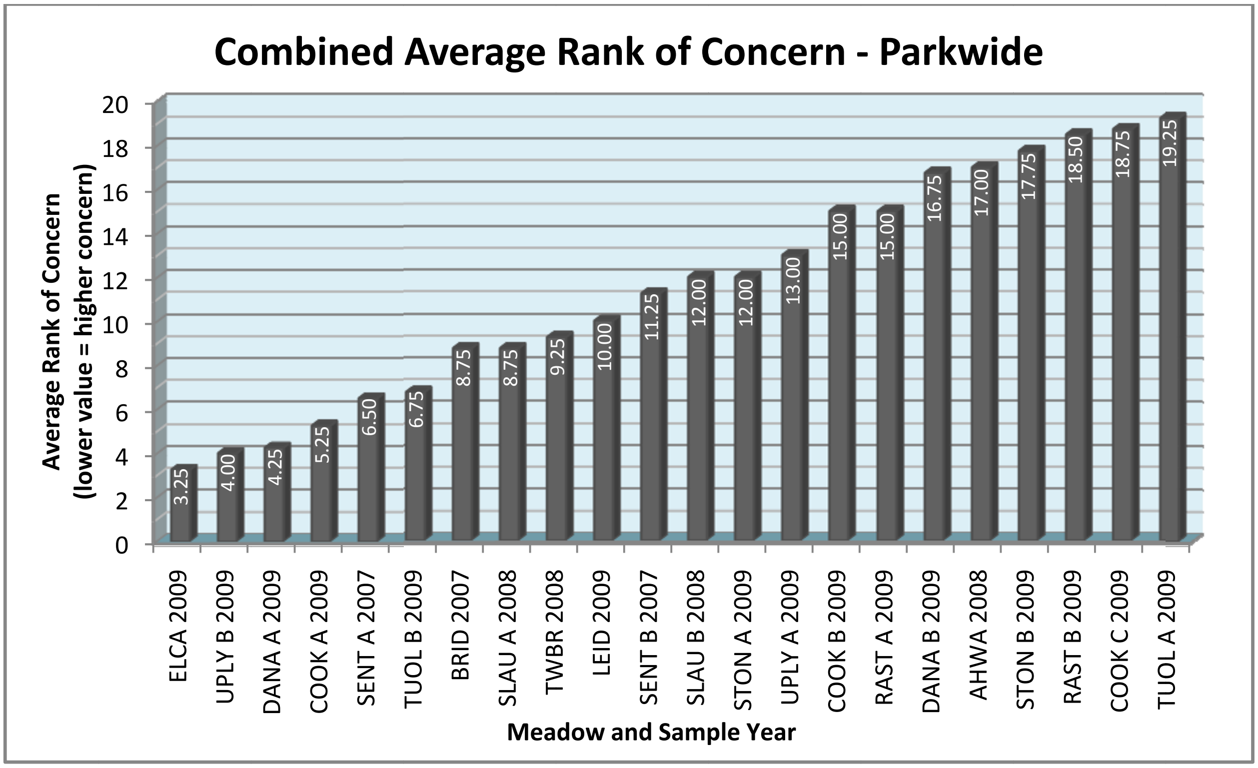

Figure 2.4.19 displays all Yosemite meadows ordered by average index ranking of these indices: WMPI, L5PI, Total Extent of Impact, and Total Percent of Impact.

Discussion

As we continue to monitor already established sites and additional meadows using current methodology, we will acquire trend data which will allow a better understanding of the changes occurring in meadows in relation to informal trailing impacts. Currently, park managers and subject matter experts are refining the standard for this indicator within Yosemite Valley Meadows. The standards will be based on several years of data collection as well as a review of the literature on informal trails. Emphasis will be placed on the evaluation of multiple standards in order to address concerns at varying levels. In addition to acquiring trend data, our findings allow us to understand which meadows to focus on in subsequent monitoring efforts. The graph in Figure 2.4.16 shows the increasing levels of concern for all evaluated park meadows, as determined by several geospatial metrics. Those meadows that consistently show high levels of fragmentation and higher levels of concern will be selected for more frequent monitoring. For example, El Capitan meadow will be monitored again in 2010 because of its subsequent rating.

The discussion of this year's findings will focus on findings from our recent survey of meadows in the Tuolumne Meadows area of Yosemite National Park. With the new draft standard development in these meadows and the subsequent increased effort to monitor these meadows, our data acquisition and understanding of these meadows has improved. We have also tightened our data collection efforts, improved our training regime for mapping technicians, and decreased the number of observers to one in order to greatly decrease the amount of observer error. In 2008, our data collection in the main Tuolumne meadow complex was carried out by two SCA interns and one GS-05 biological technician. In 2009, on GS-06 biological technician carried out the data collection duties. Table 2.4.13 demonstrates this possible observer bias with a finding of 8409m^2 for total impact extent in 2008, and 13297m^2 for total impact extent in 2009. In 2010, technicians will monitor this meadow subsequently to further understand changes that could be occurring in this meadow, and to increase repeatability while reducing potential observer bias.

Of important note for discussion in 2009's data set is the addition of the draft standard for the Tuolumne River Corridor. The meadow condition standard will only be evaluated after significant trend data is acquired. The fragmentation standard is easily evaluated and can demonstrate how specific meadows of concern will be designated. Figure 2.4.17 specifically shows the L5PI index for all Tuolumne Meadows monitored in 2009. The highest rank of concern for L5PI and the only meadow currently exceeding the draft standard is Tuolumne section B with an L5PI rating of 82.06%. This demonstrates several improvements for our understanding of meadow impacts. In 2009, we have streamlined our understanding of informal trails by separating meadows by infrastructure, major topographic boundaries or access points. This applies to Tuolumne meadows by separating the study area into two discrete sections divided by the Tuolumne River.

Figure 2.4.18 demonstrates how Tuolumne meadow section B falls into the third most meadow of concern for the combined metrics. This is of interest because this underlies the importance of measuring the total selection of metrics and not entirely focus on one particular metric for evaluation. The choice of the L5PI metric is based on its specific connection to the ecological integrity of meadows and its representation of fragmented habitats. The group of experts that developed the standards for this indicator also felt that it was important to represent the other impacts to meadows that might not be represented by just utilizing the L5PI index, therefore the condition measure is also included as a draft standard for this indicator.

Another important aspect of 2009's findings is within the results from the Upper Lyell meadow. Figure 2.4.16 lists the eastern portion of this meadow as the second ranked meadow of concern for the park. This meadow is the only study site in our survey that represents a remote backcountry meadow. Lyell canyon is a very popular backpacking destination as well as an extremely popular destination for commercial stock use. Lyell canyon represents a unique intersection between stock use-impacts and those created by hikers and backpackers. As demonstrated in Figure 2.4.19, there is a larger concentration of use and more degraded conditions on the eastern meadow. Despite the fact that it is required to cross the Tuolumne River to access this meadow, we are recording worse conditions and a larger extent of trailing impacts: 506m^2 of total impact extent in the western meadow compared with 1597 m^2 in the eastern meadow. It is most likely due to the fact that horses are pastured on this side of the meadow, and most of the backcountry campsites are concentrated here as well. In 2010, this effort will be expanded to more backcountry meadows that exemplify a similar intersection of use types and user groups.

Future Direction

In the upcoming year, as we continue work on this indicator, we will refine methods to increase efficiency and consistency (both on extent and condition measures). We will continue to annually collect field data as more data are needed to detect trends and provide full evaluation of different indices. We will continue to broaden our application of WMPI and LPI-5 in more sites, with a specific effort in 2010 to examine the utility and sensitivity of these metrics. We will continue to build a research foundation to support implementation of the fragmentation indices and establish their validity. For example, more research into the ecological effects of informal trailing would help the determination of influence zone. This continued research would also help showing the relationship (correlation or causal) of informal trail extent and ecological consequences (vegetation, soil hydrology, soil flora and fauna). Once we have more data for individual meadows that is repeatable after 3-5 years then we will be able to determine the true extent of trail proliferation and degradation.

2.5 WILDERNESS ENCOUNTERS

Introduction

Expectations for solitude, actual numbers and types of groups encountered have been shown to have a significant effect on the quality of visitors' experiences (Patterson and Hammitt 1990, Vaske et al. 1986, West 1982, Newman 2002). Encounters are also an excellent way to assess use levels and density, which can affect other Outstandingly Remarkable Values such as the biological, cultural, and scientific values set for the river corridor. For example, higher levels of use may result in compromised water quality.

Measurement
The number of encounters with parties on and off trails in designated Wilderness.

Standards
Within the Tuolumne River Corridors no more than two encounters with another party per hour 80% of the time.

Standards are still in the development phases for sites sampled within the Merced River corridor.

Sampling

Encounters were recorded by a National Park Service Ranger hiking or on horseback along trails. Encounter monitoring was conducted as part of the Ranger's routine patrol of the backcountry along the Merced River corridor. Encounters have been recorded into a field notebook, and subsequently transferred into a database by the program manager. Additional data was collected by students from the Yosemite Institute. Over the last two field seasons, efforts have been made to improve participation in data collection through collaboration with local non-profit organizations and volunteer groups. This particular indicator has proven to be an excellent opportunity for such partnerships to develop and flourish.

This indicator has suffered for the past two seasons due to low sample size and inconsistent scheduling of data collections. In order to improve our confidence in this indicator for the upcoming years, we are placing significant efforts towards indicator improvement. In 2009, graduate students from the University of Idaho conducted an in-depth study of encounter rates in the Tuolumne River Corridor. From this data, new sample sites will be selected, standards refined and methods will be improved. A subsequent report detailing results from the 2009 University of Idaho research will be made available in late spring of 2010. During the field season of 2010, SCA interns and park volunteers will continue to monitor sampling sites within the Tuolumne and Merced River corridors.

In 2009, a cooperative agreement with University of Idaho allowed researchers to complete an evaluation of Wilderness Encounters monitoring within the Tuolumne River Corridor. This study will greatly influence the way that these encounters are monitored in Yosemite National Park, and how they are analyzed and presented. This study will be reported upon in Spring of 2010.

2.6 Extent of Visitor Use

Introduction

The extent of visitor use was selected as an indicator, because of the need to understand the relationship among overall use levels, visitors' experience, and natural resource conditions along the Merced River. This indicator directly represents both the Recreation and Scenic Outstandingly Remarkable Values (ORV) and is correlated to all other values established for the river corridors. Visitor use monitoring serves as an indicator of overall visitor use levels at points of interest including trails, attraction sites, and in-river recreational sites. Crowding and congestion have been shown to degrade the quality of visitor experiences (Manning 1999; Manning 2007) and can have a negative impact on the park's resources (Hammit and Cole 1998).

One of the main challenges to estimating visitor use in natural areas is the dispersed and expansive nature of recreation areas. The main challenge in estimating dispersed recreational use is defining applicable use areas to sample. Typically, the number of people-at-one-time (PAOT) is sampled in clearly defined discrete plots. PAOT is a measure that is used as a proxy for overall visitor use and conditions of crowding, and has been used successfully in previous studies (Lawson et al. 2008; Pettebone et al. 2009). PAOT is not a measure of the total number of people who visit a recreation site. Rather it is a measure of use levels across time that can be used to understand social conditions related to the visitors' experience (Manning 1999; Manning 2007).

One of the central goals of estimating visitor use for the monitoring program is to correlate visitor use data to ecological conditions. The purpose of this study was to develop protocols to estimate visitor use levels in order to achieve this goal.

Measurement
Visitor use was estimated at four areas along the Merced River where riverbank and vegetation condition data were previously collected. Through anecdotal knowledge,

areas were classified as “low-use” and “high-use”. For this study, two ”low-use” and two “high-use” areas were chosen as study sites to estimate visitor use. The Tenaya Creek and Fern Springs study sites were chosen as the two “low-use” study sites and the Sentinel Beach and Swinging Bridge study sites were chosen as the two “high-use” study sites (Figure 2.2.2). These sites were deliberately chosen because of the stark differences in visitor use and natural resource conditions.

In order to compare visitor use data to vegetation conditions, visitor use needs to be measured in the same plots where vegetation data are collected. The corners of the vegetation study plots were permanently marked with subsurface pins that can be easily identified. Unique study plots were identified for each side of the river, thus, visitor use data were collected on both sides of the river, for all study sites, resulting in eight sites where visitor use data were collected.

The number of visitors at each study site was observed on five randomly selected days from July 19 –August 15. Sample days were stratified by weekdays (Monday – Friday) and weekends (Saturday and Sunday). Three weekdays and two weekends were selected in this sample for each study area. On each sample day, two observers were assigned to a study site in order to collect visitor use data on each side of the river. On each sample day, observers documented PAOT at a study site from 10:00 am – 5:00 pm using a clustered sampling design. Specifically, observations began at a randomly selected time between 10:00 am and 10:15 am and were repeated every 15 minutes. Thus, four sets of observation periods (clusters) were conducted each hour. Each set of observations consisted of five counts recorded every minute beginning at the prescribed 15 – minute interval. For example, a count that begins at 10:05 am consisted of observations at 10:05, 10:06, 10:07, 10:08, 10:09, and 10:10. This process was then repeated at 10:20 am with counts at 10:20, 10:21, 10:22, 10:23, 10:24, and 10:25. This approach was taken in order to account for the variability of visitor use at both the small and large time scales, and resulted in 700 observations at each study site for a total of 5,600 observations in the study.

The Swinging Bridge study site was further stratified into specific visitor use sites. The river-right study site offers visitors opportunities to recreate on beaches or hike along the riverbanks. In addition, the river-left study site consists of a busy picnicking area adjacent to a relatively quiet single track trail that parallels the river. Anecdotal information suggested that visitor use was very different at these different locations, and PAOT was documented separately for the beach, riverbank, picnicking area, and the trail.

It is important to note that the geographic size of each study site differed, and PAOT statistics derived from these data should not be compared among areas. To provide a basis for comparison, we estimated the area of each study area based on GIS data and normalized the use data by estimating average and maximum PAOT per acre. Area was estimated for all sites including the Swinging Bridge study site, however, area was not estimated for the stratified locations at the Swinging Bridge study site due to the resolution of the GIS data. The normalized data produced from this analysis provides a way to compare the density of visitor use among study sites.

Visitor Use Estimation Results for Riverbank Condition Indicator

Summary Statistics are provided in Table 2.6.1 and 2.6.2. For each study site, results are presented for all sample days, weekdays, and weekends for each riverbank (i.e. left and right). The results for the Swinging Bridge study site are further stratified by location. On the river-left side of the Swinging Bridge study site data are presented for the picnic and trail segments of the vegetation plots. On the river-right side of the Swinging Bridge study site data are presented for the beach and riverbank segments of the vegetation plots. Minimum values were not included in these tables because the minimum PAOT observed at all sites was 0.

Table 2.6.1 shows PAOT results for “low use” study sites.

Location (Acres)	Avg	Error	Median	Max	Avg/Acre	Max/Acre
Tenaya Creek Left (1.05)						
All Days	0.04	0.04	0	3	0.04	2.86
Weekend	0.00	0.00	0	0	0.00	0.00
Weekday	0.08	0.08	0	3	0.08	2.86
Tenaya Creek Right (0.26)						
All Days	0.00	0.00	0	0	0.00	0.00
Weekend	0.00	0.00	0	0	0.00	0.00
Weekday	0.00	0.00	0	0	0.00	0.00
Fern Springs Left (0.58)						
All Days	0.33	0.11	0	9	0.56	15.45
Weekend	0.15	0.09	0	4	0.25	6.87
Weekday	0.45	0.18	0	9	0.77	15.45
Fern Springs Right (1.01)						
All Days	0.06	0.07	0	4	0.06	3.97
Weekend	0.01	0.03	0	4	0.01	3.97
Weekday	0.10	0.11	0	4	0.09	3.97

Table 2.6.2 displays PAOT results for "high use" study sites.

Location (Acres)	Avg	Error	Median	Max	Avg/Acre	Max/Acre
Sentinel Beach Left (2.75)						
All Days	32.35	4.66	24	146	11.77	53.14
Weekend	48.26	9.15	50	146	17.56	53.14
Weekday	21.74	3.65	14	123	7.91	44.77
Sentinel Beach Right (0.74)						
All Days	0.72	0.24	0	11	0.98	14.95
Weekend	1.03	0.46	0	11	1.40	14.95
Weekday	0.51	0.23	0	8	0.70	10.87
Swinging Bridge Left-Total (0.40)						
All Days	6.96	0.81	0	24	17.35	59.84
Weekend	9.24	1.77	1	17	23.04	42.38
Weekday	5.44	0.92	2	24	13.55	59.84
Swinging Bridge Left-Trail (N/A)						
All Days	0.48	0.19	0	11	N/A	N/A
Weekend	0.44	0.25	0	11	N/A	N/A
Weekday	0.51	0.27	0	9	N/A	N/A
Swinging Bridge Left-Picnic (N/A)						
All Days	6.48	0.80	6	24	N/A	N/A
Weekend	8.81	1.23	6	17	N/A	N/A
Weekday	4.93	0.91	6	24	N/A	N/A
Swinging Bridge Right-Total (1.43)						
All Days	30.17	2.42	10	61	21.05	42.55
Weekend	35.47	7.87	9	44	24.74	30.69
Weekday	26.64	5.18	11	61	18.58	42.55
Swinging Bridge Right-Beach (N/A)						
All Days	23.30	1.91	24	63	N/A	N/A
Weekend	26.43	3.24	23	57	N/A	N/A
Weekday	21.21	2.20	24	63	N/A	N/A
Swinging Bridge Right-Bank (N/A)						
All Days	6.87	0.81	6	32	N/A	N/A
Weekend	9.04	1.30	6	25	N/A	N/A
Weekday	5.43	0.91	6	32	N/A	N/A

These results show that visitor use is higher in the "high-use" areas compared to the "low-use" areas. Average visitor use at all "low use" sites was less than 1 PAOT for both observed and normalized results. Only the Fern Springs river-left site was statistically greater than 0 PAOT. The highest maximum PAOT occurred on the river-left side of Fern Springs where the maximum observed use was 9 PAOT (approximately 15 PAOT/acre).

In contrast, PAOT at the Sentinel Beach and Swinging Bridge sites was quite variable with times of low and very high PAOT levels. At Sentinel Beach, PAOT levels were very different on the left and right banks of the river. The left river bank received highest observed PAOT levels with an average daily PAOT of 32 and an average weekend PAOT of 48. PAOT can be very high at times on the river-left bank, the highest observed PAOT on the left bank of the river was 146. In contrast, visitor use on the right bank of the river at the Sentinel Beach study site was the lowest PAOT of the “high-use” study sites. Average daily PAOT was less than 1 and average weekend PAOT was just over 1 on the right bank of the river. PAOT observed on the right bank of Sentinel Beach was most like PAOT levels observed at the river-left study site at the Fern Springs study site at approximately 15 PAOT/acre. The highest levels of PAOT/acre occurred at the Swinging Bridge study site. On the right bank of the Swinging Bridge study site average PAOT/acre was about 21 and maximum PAOT/acre was about 43. On the left bank of the Swinging Bridge study site, average PAOT was 17 and maximum PAOT was about 60. Thus, average PAOT/acre on the left bank was higher than the right bank, but maximum PAOT/acre was higher on the left bank than on the right bank. In addition, visitor use was very concentrated at the Swinging Bridge study site. On the left bank, the vast majority of use occurred in the picnicking area (river-left east). Similarly, most visitor use on the right bank of the river occurred on the beaches.

Discussion

This study provides two important contributions to Yosemite’s monitoring program. First, the methods developed to estimate visitor use at discrete study sites along the Merced River provide a protocol for future visitor use estimation research. This study purposively chose study sites with extremely high and low-use conditions and the sampling methods used here captured visitor use conditions with reasonable level of precision (approximately 10 – 20% error). Used in conjunction with biological inventories, data can be analyzed to understand the relationship between visitor use and ecological condition. Second, the results from this study provide a baseline of visitor use conditions along the Merced River. These data are spatially and temporally explicit and provide insights into the variability of visitor use across space and time.

It is also important to note that sites with low PAOT levels are as important to document as sites with high PAOT levels. Monitoring sites where PAOT levels are low allows park managers to detect changes in visitor use patterns and the resulting development of impacts. Such knowledge is integral to resource monitoring programs and provides a defensible base for management actions to protect park resources.

2.7 ARCHEOLOGICAL SITE CONDITION, STABILITY, AND INTEGRITY

Introduction

Archeological sites, recognized as part of the Cultural Outstandingly Remarkable Value (ORV) for the Merced and Tuolumne Wild and Scenic Rivers, were monitored in 2009 under the Visitor Use and Impact Monitoring program.

Measurement

This indicator measures the extent to which visitor use can cause impact to the condition, stability, and integrity of archeological sites. Archeological site integrity represents the ability of the site to demonstrate its significance. Archeological sites are nonrenewable resources, and site integrity is a nonrenewable aspect of a site. It is important to retain those aspects of an archeological site that can demonstrate its significance.

Standards

For the Tuolumne River Corridor, draft standards have been defined as follows: Assuming archeological sites are assessed per the established Archeological Sites Management Information System (ASMIS) inspection schedule, no more than 10% of current, unmitigated impacts from visitor use on archeological sites visited within each season display a *Disturbance Effect to the Resource* category higher than *Negligible* or *Partial Loss-Repairable* on individual sites assessed with a low estimated data potential.

Additionally, no current, unmitigated impacts from visitor use on archeological sites visited within each season display a *Disturbance Effect to the Resource* category higher than *Negligible* or *Partial Loss-Repairable* on individual sites with an estimated moderate or high data potential.

For the Merced River Corridor, baseline data are currently being collected, upon which standards can be developed.

Sampling

Previously documented archeological sites were divided across the two river corridors according to their estimated vulnerability, categorized into “high and low”. Vulnerability was, in turn, estimated based on a calculated research potential of the site, determined from the site’s surface constituents, and the site’s ability to answer important questions. The estimates of vulnerability and research potential were made based on information contained in the park’s Archeological Sites Management Information System (ASMIS) database, and are considered preliminary and are subject to change based on future research. High vulnerability would define a site that likely has an estimated “medium” to “high” data potential, and/or the constituents of the site would likely be impacted by most types of visitor use of a site. Low vulnerability would define a site that likely has “low” data potential, and the site’s constituents would not likely be negatively impacted by most types of visitor use.

As a regular part of archeological research, inventory, and Sections 110 and 106 of the National Historic Preservation Act (NHPA) compliance, Yosemite National Park utilizes a required management tool, the Archeological Sites Management Information System (ASMIS).

A 15% overall sample was selected, stratified by river corridor, and divided equally (as opposed to proportionally) among the low and high vulnerability sites within each river corridor. The sample was chosen in this manner, because the high vulnerability sites number much fewer than low vulnerability sites. This resulted in a total of 53 archeological sites chosen to assess visitor use impacts across four zones (Table 2.7.1). Additionally, a sample of sites visited within the last two field seasons was chosen to monitor in 2009. A total of 20 sites were randomly chosen in Yosemite Valley, Wawona, Tuolumne Meadows, and Lyell Canyon to determine if any changes in sites' condition could be observed (Table 2.7.1).

Table 2.7.1 lists Archeological Sites visited and monitored.

Merced River Corridor sites (n=28)	Tuolumne River Corridor sites (n=26)	Sites Selected to Monitor (N=20)
CA-MRP-0050	CA-TUO-0112	CA-MRP-0008
CA-MRP-0051/H	CA-TUO-0113	CA-MRP-0052
CA-MRP-0068/H	CA-TUO-0118	CA-MRP-0053
CA-MRP-0070	CA-TUO-0147	CA-MRP-0076
CA-MRP-0081	CA-TUO-0167/H	CA-MRP-0082/H
*CA-MRP-0084	CA-TUO-0490	CA-MRP-0186
CA-MRP-0161/H	CA-TUO-0493	CA-MRP-0190/191
CA-MRP-0171/172	CA-TUO-0496	CA-MRP-0216
*CA-MRP-0183/H	CA-TUO-0530	CA-MRP-0336
CA-MRP-0187/1745/H	CA-TUO-0754	CA-MRP-0734H
*CA-MRP-0207	CA-TUO-0758	CA-TUO-0119
CA-MRP-0214	CA-TUO-2813	CA-TUO-0132
CA-MRP-0241	CA-TUO-2816	CA-TUO-0201
CA-MRP-0306	CA-TUO-2825	CA-TUO-2824
CA-MRP-0307	CA-TUO-2830	CA-TUO-2835
CA-MRP-0312	CA-TUO-2833	CA-TUO-3838
CA-MRP-0316	*CA-TUO-2841	CA-TUO-3845
CA-MRP-0318	CA-TUO-3561	CA-TUO-3944
*CA-MRP-0360	*CA-TUO-3846	CA-TUO-4436
CA-MRP-0369/H	*CA-TUO-3849	CA-TUO-5001
CA-MRP-0373	CA-TUO-3939	
CA-MRP-0374	CA-TUO-4056	
CA-MRP-0651	CA-TUO-4265	
CA-MRP-0824	*CA-TUO-4664	
CA-MRP-0825/H	CA-TUO-4665	
CA-MRP-0902	CA-TUO-4975	
CA-MRP-1724H		
*YOSE 1999 L-05		

*Note: * indicates the site was not visited for one of the following reasons, the site was not eligible for inclusion in the NRHP, the site could not be relocated, or timing considerations precluded visiting the site. When this occurred, another site was chosen from the sample to visit.*

Sampling

Field work was conducted from July 1, 2009 through August 31, 2009 by program archeologists and Student Conservation Association intern. NPS archeological technicians completed site assessments on a handful of sites located in Lyell Canyon, and accompanied the program archeologist during site assessments for three days of fieldwork.

Sixty-five archeological sites were visited during the 2009 field season. Data were collected at each site and recorded on an ASMIS field form, supplemented with additional data collection specific to visitor-related impacts. Data collection was guided by the objectives discussed in the *2009 User Capacity Management Field Monitoring Guide* (NPS 2009b), toward the primary goal of determining the extent to which archeological sites are being impacted by visitor use.

For a definition and discussion of ASMIS, see the *2007 VERP Annual Summary Report*, or the *ASMIS 3.01 User Guide* (NPS 2007b and 2008a). Archeological S*ite Condition* was evaluated according to variables defined for ASMIS as *Good*, *Fair*, *Poor*, *Unknown*, and *Not Relocated* (for a definition of these conditions, see the *2007 VERP Annual Summary Report*, NPS 2008a). Archeological site condition, according to the ASMIS definition, is largely an estimate of current site stability. A more accurate description of the cumulative impacts at an archeological site is reflected in the site *Disturbance Severity Level*.

A site *Disturbance Severity Level* documents the cumulative negative effects of both threats and disturbances to the site's data potential for scientific research, as well as the physical stability of the site (Table 2.7.2).

Table 2.7.2 defines disturbance severity levels.

Severity Level	Definition [a]
Low	-No major disturbances or threats present -Minor natural disturbances and threats, such as limited slope wash or rodent activity not yet resulting in significant damage to the site -In general < 15% of site impacted -Continuing effects are minimal and not resulting in significant damage to site
Moderate	-Disturbances are causing or a threat may soon cause significant site damage such as trail construction or sporadic camping, moderate slope wash or rodent activity -The site or a portion thereof will likely be irretrievably lost if actions are not taken in 5 years -In general 15-50% of site area impacted
Severe	-Evidence of recurrent, intensive camping, illegal excavation or surface collection. -Sites in developed areas recurrently subjected to modern disturbances -Disturbances or threats to the site will cause significant damage, and the site or parts thereof will likely be irretrievably lost if actions are not taken in 2 years -In general >50% of site area impacted.
NA/Destroyed	-The site has been completely excavated or destroyed.

[a]*ASMIS 3.01 Data Dictionary*, NPS 2007a.

Disturbances and threats are measured first, site condition is determined next, and the overall site Disturbance Severity Level is measured last (which also takes into effect the threats to sites).

Collected Data

Baseline disturbance data were collected at each site selected. Baseline disturbance data collection consisted of a site visit with current observed threats and disturbances recorded in the field. Additionally, previous disturbances to each site listed in the ASMIS database were assessed to establish a complete history of disturbances to a site's condition, data potential, and integrity. At each site visit, photopoints were established, and photographs were taken of overall site's conditions and any observed disturbances. Each site's proximity to an access point (road or trail, parking lot, lodging, etc.) was recorded into one of six categories as follows: 0 to 25 meters, 26 to 50 meters, 51 to 75 meters, 76-100 meters, 101 to 200 meters, and 201 to 500 meters away. For a list of all available values of disturbances and threats to choose from, see the *2008 User Capacity Annual Report* (NPS 2009).

Measurement

(Table 2.7.3) The measurement of disturbances and threats observed within archeological site boundaries are those utilized for ASMIS data collection. These are qualitative in nature; however, in an attempt to improve the objectivity of the observations more objective, the qualitative-class assigned to each disturbance was based on an estimate of percentage of the archeological site affected. The measurement for each threat or disturbance on an archeological site consists of assigning an effect on the resource (Negative, Partial loss Repairable (PLR), Partial loss Irretrievable (PLI), or Total loss Irretrievable (TLI)); and a severity level of the effect (Low, Moderate, Severe). In a further attempt to quantify threats and disturbances, a score was assigned to each threat or disturbance for:

- the effect to the information potential of the archeological site (removal of archeological matrix, removal of artifacts/features, etc);
- the severity of the disturbance or threat (Disturbance Effect);
- the extent of the disturbance (Disturbance Level); and
- visitor-related disturbances or threat observed was visitor-related, a weight factor of two was applied.

These measurements produced an "impact score", which, in turn, was used along with the overall site condition and site vulnerability to determine the site *Disturbance Severity Level* and site *Inspection Schedule*. Additional information recorded at each site to supplement the standard ASMIS data collection were the type of landform, the depositional setting of the site, and the type of use the site is exposed to – both direct and secondary (e.g., camping, climbing, hiking, river recreation).

Table 2.7.3 lists variables measured at archeological sites.

Variable	Value	Points (if Applicable)
Current ASMIS Site Condition	Good	0
	Fair	1
	Poor	2
ASMIS Disturbance Severity Level	Low	2
	Moderate	4
	Severe	3
Previous ASMIS Disturbance Severity Level	Unknown	2
	Low	5
	Moderate	10
	Severe	15
Proximity to Public Access Category (Distance to access point in meters (from GIS))	0-25m, 26-50m, 51-75m, 76-100m	3
	101-200m, 201-500m	2
	500-1000m	1
	>1km	0
Rock Art Presence/Absence	Yes	1
	No	0
Features Presence/Absence	Yes	1
	No	0
Natural and Visitor-related (weighted by 2) Impact Category Disturbances and Threats		
Effect on Integrity of Site	Removal of Archeological Matrix	2
	Removal of Feature/Artifact	2
	Destabilization of Feature or Element	2
	Destruction of Feature/Artifact	2
	Displacement of Feature/Artifact	2
	No Effect	0
	Other	0
Effect on Resource	Negligible	1
	Partial Loss Repairable	2
	Partial Loss Irretrievable	3
	Total Loss Irretrievable	4
Effect Level	Low	1
	Moderate	2
	Severe	3
	Destroyed	0
Time Frame (if threat)	Immediate	2
	1 Year	1
	5, 10, 20 years	0

Monitoring/Inspection Schedule

Establishing a monitoring schedule continued this season, following the guidance created for ASMIS, and based on the quantitative “impact score” that a site received for all of the indicators on the field form (see NPS 2007c). This score is based on a combination of factors including, but not limited to, site condition, proximity to developed areas, and National Register eligibility. Accordingly, sites for this field season were placed into one of four monitoring priority categories – 5 years, 10 years, 15 years, and 15+ years.

Results

Frequencies and percentages of site condition, disturbance severity level, and select impacts by geographic region are listed in Table 2.7.4. Though not statistically valid due to small sample sizes, depicting frequencies of impacts geographically reveals the possibility of impact and condition trends.

Lyell Canyon
Seven sites were visited in Lyell Canyon in 2009. The majority of these sites were in good condition (57%), but exhibited severe and moderate disturbance severity levels. Commonly observed impacts were *erosion, camping, social trails,* and *park operations*. The lower Lyell Canyon is a popular, heavily-visited area, which is reflected in the higher numbers of social trails and camping impacts.

Tuolumne Meadows
Twenty-five sites were visited in the greater Tuolumne Meadows area. The majority of these sites are in good condition (56%), however, 44% have severe disturbance severity levels. Commonly observed disturbances were *erosion, bioturbation, artifact movement, park operations,* and *social trails*. As in the Lyell Canyon, many locations in the greater Tuolumne Meadows area, especially adjacent to the Tuolumne River are popular and receive high levels of use in the summer months.

Yosemite Valley
Twenty-three sites were visited within Yosemite Valley. Most of these sites are in good condition (48%), and while the disturbance severity levels are evenly spread across all categories, there are high numbers of sites in the low and severe categories (39% for both). Commonly observed impacts include *erosion, bioturbation, social trails*, *artifact movement*, and *park operations*.

Wawona
Ten sites were visited in the Wawona area. Sixty percent of these sites are in poor condition, and the all sites in Wawona have a moderate or severe disturbance severity level. All of the sites assessed this season exhibited visitor-impacts, including *social trail proliferation, camping*, along with *erosion*, *bioturbation*, and *artifact movement*.

Table 2.7.4 shows results by geographic region for sites sampled in 2009.

Location	ASMIS current	N	%	Change In Site Condition	N	%	Disturbance Severity Level	N	%	Change in Severity Level	N	%	Impacts	Visitor Impacts	Erosion	%	Bioturbation	%	Social trails	%	Camping	%	Artifact Movement	%	Park Operations	%	Visitor use	%	Use by hikers horses	%
Lyell Canyon (7)	Good	4	*57*	Impr.	0	*0*	Low	0	*0*	Impr.			23	7	5	*71*	1	*14*	2	*29*	4	*57*	2	*29*	4	*57*	0	*0*	0	*0*
	Fair	3	*43*	Degr.	**2**	***29***	Moderate	2	*29*	Degr	5	71																		
	Poor	0	*0*				Severe	**5**	***71***																					
Yosemite Valley (23)	Good	11	*48*	Impr.	4	*17*	Low	9	*39*	Impr.			60	21	4	*17*	14	*61*	9	*39*	3	*13*	4	*17*	5	*22*	0	*0*	2	*9*
	Fair	8	*35*	Degr	**1**	***4***	Moderate	5	*22*	Degr	7	30																		
	Poor	**4**	***17***				Severe	**9**	***39***																					
Tuolumne Meadows (25)	Good	14	*56*	Impr.	6	*24*	Low	5	*20*	Impr.			75	15	17	*76*	18	*72*	6	*24*	2	*8*	10	*40*	9	*36*	1	*4*	2	*8*
	Fair	7	*28*	Degr	**3**	***12***	Moderate	9	*36*	Degr	8	32																		
	Poor	**4**	***16***				Severe	**11**	***44***																					
Wawona (10)	Good	3	*30*	Impr.	0	*0*	Low	0	*0*	Impr.			84	11	5	*50*	4	*40*	8	*80*	1	*10*	5	*50*	1	*10*	0	*0*	1	*10*
	Fair	1	*10*	Degr	**3**	***30***	Moderate	5	*50*	Degr	3	30																		
	Poor	**6**	***60***				Severe	**5**	***50***																					

The following tables and graphs present the results of archeological site assessments and monitoring in 2009. An ASMIS assessment was completed for all 65 sites visited and all site records were updated and input into the Yosemite Archeology Office (YAO) site record database. Additionally, two artifacts were collected for curation at the Yosemite National Park Museum. The sites were located in the following geographic areas of the park: in the Merced River corridor - Yosemite Valley and Wawona; and in the Tuolumne River corridor - Tuolumne Meadows and Lyell Canyon. Figures 2.7.1 through 2.7.8 Illustrate descriptive information for all data collected in 2009.

Site Condition and Disturbance Severity Levels
Within both river corridors, the majority of sites assessed were recorded in *Good* condition according to ASMIS definitions (n=32, 49% total in both corridors) (Table 2.7.5). ASMIS site condition is only loosely associated with the visitor-related impacts to site integrity or the collective condition of the site. This is largely due to the fact that ASMIS site conditions are related to current site stability rather than cumulative level of disturbance.

Another measure of condition is the ASMIS *site disturbance severity level* (Table 2.7.6). This variable is a cumulative evaluation of the overall condition of the site, taking into account the collective value of all threats and disturbances documented for a site. Disturbance severity levels were distributed inversely to site conditions, with *Severe* disturbance severity levels observed most frequently, at 46% (n=30) of sites assessed this season.

Table 2.7.5 shows the current ASMIS site conditions.

Site Condition	n	%
Merced River Corridor	33	
Good	14	42
Fair	9	27
Poor	10	31
Tuolumne River Corridor	32	
Good	18	56
Fair	10	31
Poor	4	13

Table 2.7.6 shows the current ASMIS Site Disturbance Severity Levels.

Disturbance Severity Level	n	%
Merced River Corridor	33	
Low	9	27
Moderate	10	31
Severe	14	42
Tuolumne River Corridor	32	
Low	5	16
Moderate	11	34
Severe	16	50

Proximity

The proximity of each site in this study to an access point was determined from the Yosemite Archeology Offices' GIS database. This information continued to be recorded in 2009 for each site with the assumption that correlations can be determined between observed impacts and site proximities to access points, as was indicated in chi-square analysis from the 2007 collected data (Middleton 2008: 95). The distribution of proximity categories are displayed below (Figure 2.7.1). As shown, sites were overwhelmingly located within 25 meters of an access point (n=42, 65%).

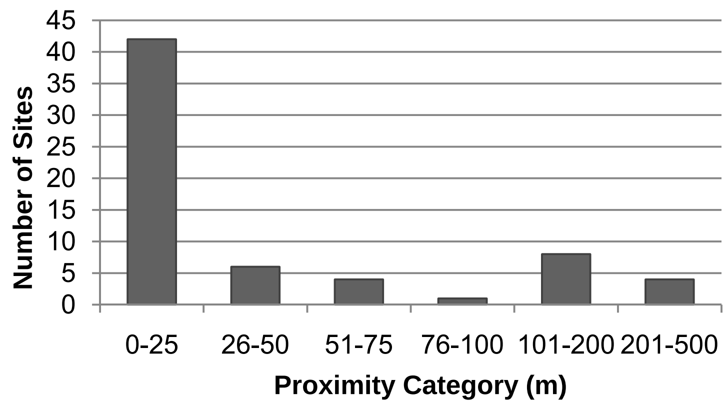

Figure 2.7.1 represents distribution of site proximity to access points when n=65.

Impacts

Two archeological sites assessed this season had no observable impacts present (CA-MRP-0161/H, CA-MRP-0734H). Figure 2.7.2 illustrates the distribution of the number of impacts observed at sites this year.

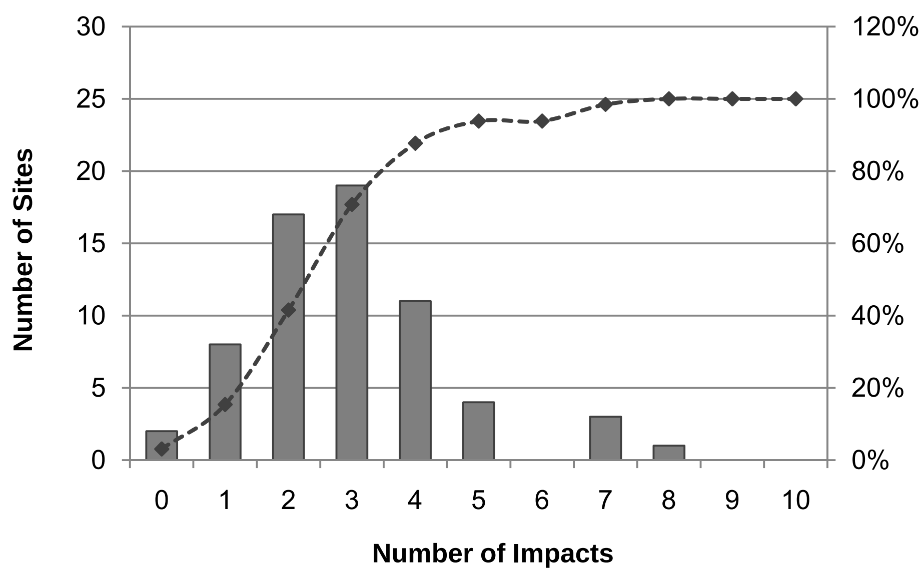

Figure 2.7.2 shows distribution of the number of impacts per site when n=65.

Natural impacts were common at sites monitored this season, observed at 87% (n=56) of sites, only nine sites had no observable natural impacts. Similar to data collected in 2008, out of those sites that did contain natural impacts, *erosion* and *bioturbation* were the most prevalent types (n=33, 51% each), followed by *hazard fuel buildup*, *animals*, and *fire* (Table 2.7.7).

Table 2.7.7 shows observed natural impacts.

Natural Impact	n	*% of Sites*
Erosion	33	*51*
Bioturbation	33	*51*
Hazard Fuel Buildup	8	*12*
Animals	4	*6*
Fire	3	*5*
Flooding	2	*3*
Tree Fall	1	*2*
Inundation	1	*2*
Modification – Structural	1	*2*
Structural Deterioration	1	*2*

Also, very similar to data collected in 2008, visitor-related impacts were prevalent on archeological sites assessed in 2009, documented at 52% (n=34) of sites visited. Figure 2.7.3 illustrates the distribution of the number of visitor-related impacts observed on sites, divided by river corridor. Of those sites with visitor-impacts present, many only contained one or two visitor-impacts. Generally, more sites within the Merced corridor exhibiting visitor-impacts, than in the Tuolumne corridor.

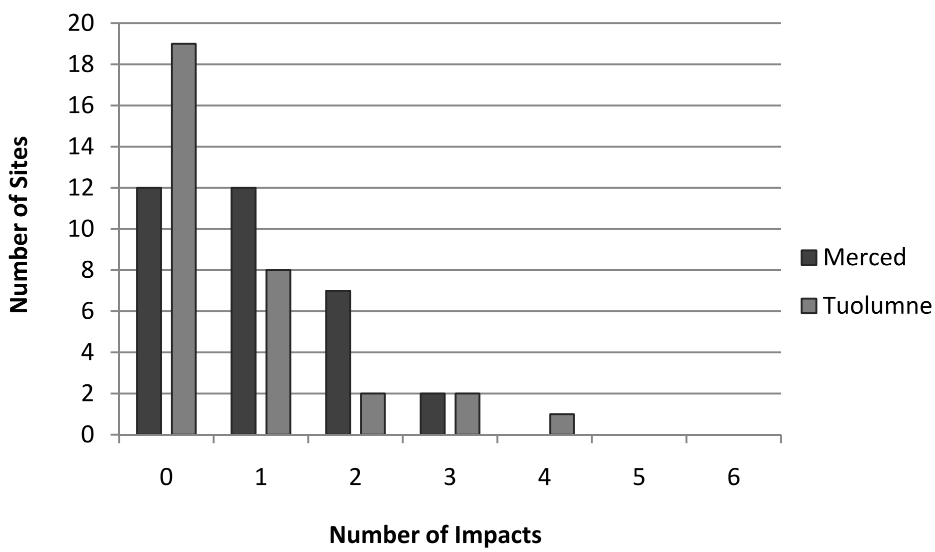

Figure 2.7.3 shows number of visitor-related impacts observed on sites in 2009 when n=65.

Table 2.7.8 displays the range of observed disturbances on archeological sites. As can be seen, the visitor-related disturbance observed most frequently within archeological site boundaries is *social trail proliferation* (n=24). The second most frequent impact observed on site is *camping* (n=10). These disturbances are followed in frequency by *use by hikers/horses* or *stock use*, *campfire building*, and *climbing*. Only one site contained an impact with a *Disturbance Effect to the Resource* of Partial-Loss Irretrievable (CA-TUO-3939, a site in the Tuolumne corridor with estimated high vulnerability), well within the standard set for the indicator. Table 2.7.9 lists recorded impacts on sites that are not clearly caused by natural or visitor-related forces. These include park-related construction impacts such as road construction and utilities construction; park-related operations impacts including trail maintenance, resource management, scientific research, or fire suppression; and a third impact, artifact movement from unknown causes. In most instances of artifact movement on a site, the actual cause cannot be determined because artifacts can easily move as a result of erosion, bioturbation, freeze/thaw actions, as well as removal and movement due to visitor collection. Information regarding artifact movement can only be accurately captured when there is explicit documentation of previous artifact locations.

Table 2.7.8 shows observed visitor-related impacts.

Impact	Effect Level to Resource	n	Total Number of sites	%
Social Trail	Negligible Partial Loss – Repairable	22 2	24	*37*
Camping	Negligible Partial Loss-Repairable	9 1	10	*15*
Use by Hikers/Horses	Negligible	6	6	*9*
Campfire Building	Negligible	4	4	*6*
Climbing	Negligible	4	4	*6*
Vegetation Damage	Negligible	2	2	*3*
Off-road Vehicle Use	Negligible Undetermined	1 1	2	*3*
Visitor Use	Negligible	1	1	*2*
Grazing/Trampling	Negligible	1	1	*2*
Modification – Structural	Partial Loss – Irretrievable	1	1	*2*
Soil Compaction	Partial Loss – Repairable	1	1	*2*
Dumping	Negligible	1	1	*2*

Table 2.7.9 shows additional observed impacts.

Other Impact	n	% of Sites
Park Operation	30	65
Unknown Causes	22	21

As stated earlier, the most important aspect of disturbances to archeological sites is not the presence of the disturbance alone, but the impact that disturbance has to the archeological integrity and significance of the site. Table 2.7.10 lists the effect to integrity for all disturbances present on sites assessed in 2009. The most common impact to the integrity of archeological sites is from the displacement of artifacts or archeological features; caused by natural forces on 78% of sites visited this season, and caused by visitor forces on 42% of sites.

Table 2.7.10 displays effects to aspect of site integrity for all observed disturbances**.**

Impact Category	Effect to Integrity	# of Instances	# of Sites	*% of Sites*
Natural	Removal of Archeological Matrix	0	0	*0*
	Removal of Artifact/Feature/Element	3	3	*5*
	Destabilization of Feature/Artifact/Element	2	2	*3*
	Destruction of Artifact/Feature	0	0	*0*
	Displacement of Artifact/Feature	**70**	**51**	***78***
	No Effect	2	2	*3*
	Other	7	7	*11*
Visitor	Removal of Archeological Matrix	0	0	*0*
	Removal of Artifact/Feature/Element	0	0	*0*
	Destabilization of Feature/Artifact/Element	4	4	*6*
	Destruction of Artifact/Feature	0	0	*0*
	Displacement of Artifact/Feature	**38**	**27**	***42***
	No Effect	2	2	*3*
	Other	13	11	*17*

Impact Scores

Each site received an aggregate impact score based on the points assigned (see Table 2.7.3) to baseline threats and disturbances within archeological site boundaries, weighted by a factor of two for visitor-related impacts. Figure 2.7.4 shows the distribution of impact scores in the Merced River Corridor, and Figure 2.7.5 shows the distribution of impacts scores in the Tuolumne River Corridor. The visitor-impact score was used to determine the site *Disturbance Severity Level* and the site *Inspection Schedule*.

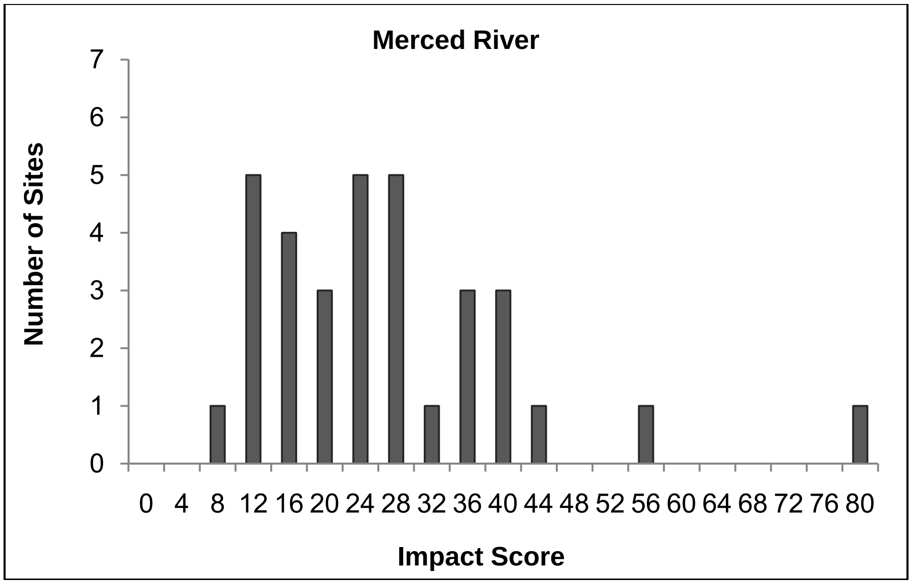

Figure 2.7.4 shows distribution of impact scores at archeological sites in the Merced River Corridor.

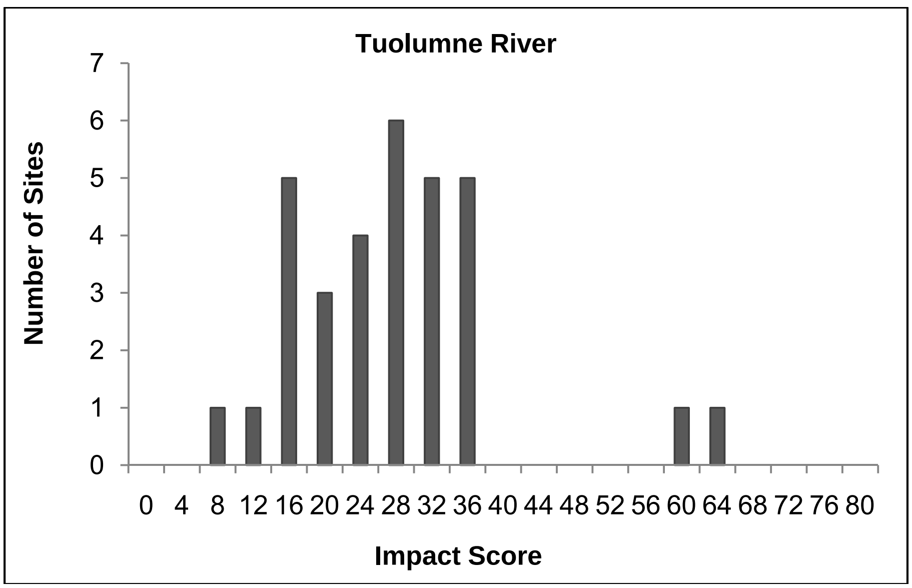

Figure 2.7.5 displays distribution of impact scores at archeological sites in the Tuolumne River Corridor.

Analysis

In order to determine if visitor-related impacts occur more frequently in areas that are either easy to access, or are closer to developed areas, Figure 2.7.6 illustrates the correlation between the presence of *visitor impacts*, and the sites' *proximity to an access point* (in categories *near*-within 50 meters, and *far*-more than 50 meters away). The data collected in 2009 show an overwhelming number of sites that are near access points contain visitor-related impacts.

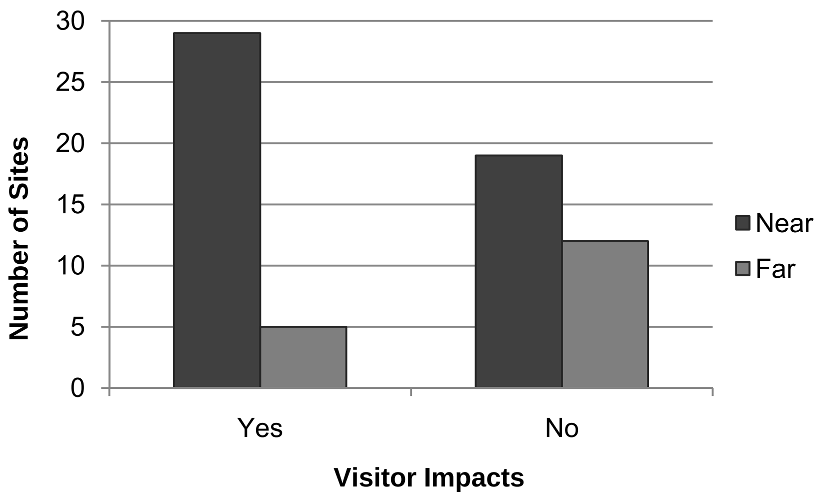

Figure 2.7.6 shows number of visitor impacts per proximity to access points in 2009 whereas n=65.

As was shown earlier in Table 2.7.8, the presence of social trails on sites is fairly widespread. Table 2.7.11 lists categories (number) of social trails on sites. The majority of sites that were impacted by social trails, contained one or two trails on site (n=16, 25%), while only eight sites (12%) contained more than two social trails.

Table 2.7.11 represents the number of social trails observed on visited sites.

Category	# of Sites	*% of Sites*
None	41	*63*
1 – 2	16	*25*
More than 2	8	*12*
Total	65	*100*

In an attempt to explore correlations between impacts to sites and factors such as proximity to an access point, the presence of social trails was charted against the proximity of the site from an access point. Figure 2.7.7 illustrates the distribution of observed social trails on sites, grouped by the site proximity to an access point. Similar to findings from the 2008 field season, it was observed in 2009 that no site more than 50 meters away from an access point contained more than two social trails, and only four sites within the far category contained one or two social trails on site. Only eight sites in the Tuolumne River corridor contained social trails, compared with 16 sites in the Merced River Corridor.

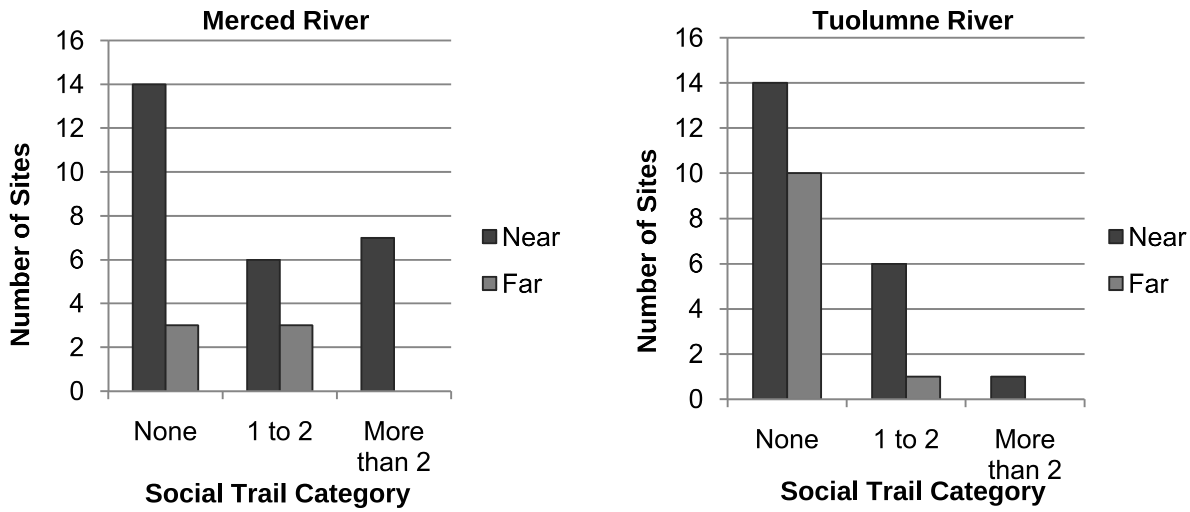

Figure 2.7.7 shows social trails by proximity to access points in the Merced and Tuolumne River Corridors in 2009 whereas n=65.

To further investigate the possible associations between the condition and cumulative disturbance levels at sites, and proximity to an access point, site *disturbance severity level* was plotted against site *proximity* (Figure 2.7.8). As can be seen, a higher percentage of sites located within 50 meters of an access point are more disturbed than those located over 50 meters away from an access point.

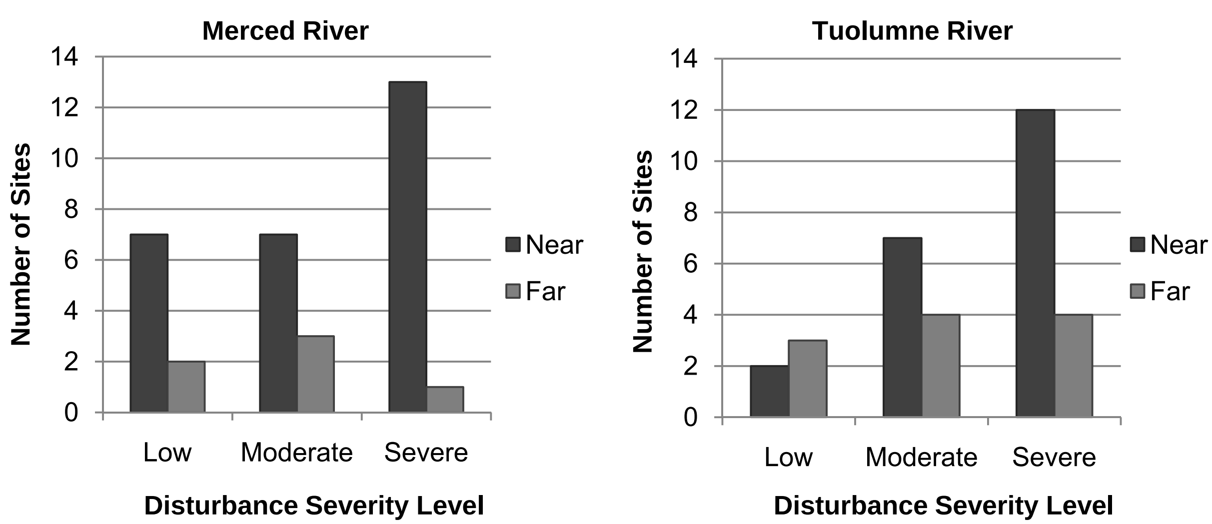

Figure 2.7.8 shows disturbance severity levels by proximity to access points in the Merced and Tuolumne River Corridors in 2009 whereas n=65.

Monitoring

Twenty archeological sites were monitored for changes in site condition in 2009. No site had an increase in impacts from the year before; however all sites exhibited ongoing impacts from the previous year, primarily from *erosion*, *bioturbation*, continuous use of *social trails*, and *camping*. Additionally, two sites exhibited a decrease in site condition (CA-MRP-734H and CA-TUO-3838), and eight sites exhibited a change in disturbance severity levels (CA-MRP-0076, CA-MRP-0190/191, CA-MRP-0216, CA-TUO-2824, CA-TUO-2835, CA-TUO-3838, CA-TUO-3944, CA-TUO-5001)

Discussion

Baseline archeological site condition was assessed at 45 sites this field season, and 20 archeological sites were monitored for changes in condition since the 2007 and 2008 field seasons in Yosemite Valley, Wawona, Tuolumne Meadows, and Lyell Canyon. Most sites contained both natural and visitor-related impacts (Table 2.7.12 lists all impact data for all sites visited). The most prevalent forms of current visitor-related disturbances observed in 2009 proved to be *social trail proliferation, camping*, and *stock use*. Associations between the proximity of sites to access points, and variables of disturbance and condition of archeological sites, show that overwhelming numbers of sites within 50 meters of access points have more disturbances present. As sample size increases within defined geographic areas, trends in impact data may begin to emerge that would allow for a clearer picture of visitor-use at archeological sites within certain areas of the park

Conclusion

Continued efforts toward refinement of ASMIS data collection protocols within the Yosemite Archeology office will allow for further objective site assessments park-wide. These continuing efforts on the part of the archeology staff to ensure that the data are collected in a more replicable manner by means of augmenting standard ASMIS data collection, will ensure the reliability of future data collection efforts and valid assessments of archeological site condition and disturbance assessment.

Draft standards have been developed for the Tuolumne Wild and Scenic River Corridor, and these will likely be refined in the next field season. Standards development is ongoing for the Merced River Corridor, and will be established in future field seasons.

Ongoing impact assessment and monitoring of archeological site condition through the Visitor Use and Impact Monitoring program in both river corridors is recommended to ensure that visitor-related disturbances do not negatively impact archaeological site condition, integrity, and significance. In addition to site-specific treatment recommendations, archeological testing should occur at archeological sites containing estimated high data potentials (therefore high vulnerability ratings) to determine impacts to the cultural deposits at those sites. This is important information to collect and can help guide management actions to develop treatments of archeological sites within the Wild and Scenic River corridors.

2.8 PARKING AVAILABILITY

Introduction

Transportation has long played an important role in the National Park system (Percival 1999). Transportation issues have recently been studied at such parks as Yellowstone (Mings et al. 1992), Smoky Mountains (Sims et al. 2005), Blue Ridge Parkway (Vallier et al. 2003), Acadia (Hallo and Manning 2009), as well as in Yosemite (Nelson and Tumlin 2000, YOSE 1999, White et al. 2006). Traffic congestion was identified in Yosemite's General Management Plan (YOSE 1980) as one of the principal human-use impacts to mitigate.

The vast majority of visitors to Yosemite arrive in private vehicles, and more than a million vehicles enter Yosemite Valley each year, resulting in significant traffic congestion. Traffic congestion can cause a variety of impacts to the Tuolumne River's and Merced River's Outstandingly Remarkable Values including natural and cultural resources as well as the quality of the visitor experience. Specific impacts include increased travel and waiting times, wildlife depredation, air pollution, noise, vegetation loss, and others. Therefore, an indicator was piloted in 2005 measuring the availability of parking facilities at the day use parking area. Parking availability has served as an indicator of overall traffic congestion in Yosemite Valley and, therefore, has served as an early warning sign suggestive of the extent to which the Merced corridor can be affected by human vehicular use. In 2009, we have combined this indicator with other ongoing traffic research to understand the temporal and spatial flow of vehicle traffic. In addition, park researchers have been developing this indicator for inclusion into the Tuolumne River Plan. This will greatly improve our understanding of this indicator and generate improved data collection and analysis. For 2009 and 2010, we are continuing to develop the protocols of this indicator and plan to fully implement the parking availability indicator in 2010 within both the Tuolumne and Merced River Corridors.

Description of Indicator and Standard

Indicator

This indicator is used to evaluate the conditions of the transportation system in Tuolumne Meadows and Yosemite Valley. In Tuolumne Meadows, the visitor center and the wilderness parking lots will be monitored to document the amount of time that they are at full capacity, forcing them to be shut down to incoming visitors. In Yosemite Valley, the Camp 6, Wilderness, and Camp Four parking lots will also be monitored for the same values.

Draft Standard

Standards are being developed utilizing past data, and other ongoing traffic related research in Tuolumne Meadows. Standards should reflect maximum capacity from the document of decision for 2 to 3 centralized parking areas in the Tuolumne Meadows area. Standards for Yosemite Valley parking lots are currently being developed.

2.9 NATURAL SOUNDSCAPES

Introduction

The following indicator is being proposed in the Draft Tuolumne River Plan: Soundscapes as measured by (1) the change in sound levels from natural ambient in areas more than 100 feet from roads, and (2) the amount of time above speech interference thresholds in areas more than 100 feet from roads

Proposed Standard

The proposed standard will look at hourly change in sound level changes exceeding 3 dB(A) and 6dB(A) to assess cumulative sound impacts, and at sound events exceeding 60 dB(A) to assess speech interference. Different standards will be proposed for frontcountry vs. backcountry areas, and for day-time vs. night-time hours.

In 2009, park staff initiated a pilot project to collect and analyze data to inform a draft standard, and to test data collection and data analysis methodologies. The following descriptions outline potential indicators and standards considered for application within the Tuolumne River Corridor.

Time Above Speech Interference

For all areas of Yosemite National Park, the Code of Federal Regulations establishes a maximum sound level for human-caused sounds of 60 dB(A) at 15 meters. This coincides with the sound level that allows for normal-voice communications with 95% sentence intelligibility over a 2-meter distance, or raised-voice communication (i.e. interpretive program) over a 4-meter distance (Fristrup 2009). Analysis of 2009 data in the Tuolumne Meadows campgrounds shows that sound events exceeding 60 dB(A) were largely due to commercial aircraft overflights, with a few loud vehicles such as recreational vehicles and garbage trucks. Although sound from commercial aircraft is not caused by visitor use and is not under the jurisdiction of the NPS, the NPS is actively communicating with the FAA on this issue. Loud vehicles operated by visitors can be controlled by law enforcement action, and loud vehicles operated by the National Park Service can be controlled by administrative action.

Naturally-occurring sounds, such as thunder and the roar of a river, can exceed 60 dB(A). Sometimes, a combination of naturally-occurring sounds can exceed 60 dB(A), such as a river combined with insects or bird calls. The 2009 data shows that water is a significant source of sound energy, and water (along with wind) can be an effective masking mechanism for anthropogenic sounds.

Because visitors expect night-time to be quiet, a more-protective night-time standard for loud noises is being explored. The most likely basis for this standard would be research into physiological effects of noise at night. For example, Haralabidis et. al. (2008) measured statistically significant heart rate and blood pressure increases in urban areas near airports at night due to noise.

Change in Sound Levels

While sounds that interfere with speech are relatively straight-forward to understand and analyze, minimizing loud sounds alone would not necessarily protect the visitor experience. For example, a chainsaw generating a 50 dB(A) sound for long periods of time would probably be annoying to visitors, even though it does not exceed the proposed standard of 60dB(A). Change in sound level (or exposure) compares natural and human-caused sound over time, and hourly time increments are used in the analysis. An increase of 3 dB(A) is significant, and an increase of 6 dB(A) represents a doubling of sound pressure, or sound energy. Data from the 2005 Yosemite Acoustic Monitoring Report shows significant hourly changes in sound levels, at times exceeding 3 dB(A) and 6 dB(A). Analyzing hourly change in sound levels is technically challenging. The NPS Natural Sounds Program is developing automated tools to assist with this analysis, in order to better capture the dynamic nature of sounds at different locations and at different times of the year.

Road Corridors

The proposed indicator does not currently address areas within 100 feet of a road corridor. Road corridors have to be treated differently because they have inherently more frequent occurrences of unnatural sounds. The maximum sound level for human-caused sounds specified in the Code of Federal Regulations remains applicable in road corridors – minimizing loud sounds in road corridors would also protect the natural soundscapes in the campgrounds, backcountry areas, etc.

Sampling

Data was collected at six locations:

Tuolumne Grill	front country zone
Tuolumne Campground	front country zone
Lembert Dome	transitional zone
Pothole Dome	transitional zone
Mono-Parker Trail	backcountry zone
Rafferty Creek	backcountry zone

Data was collected using an H2 Zoom digital audio recorder (DAR). Power was supplied by a solar panel and rechargeable battery, and a memory card was used to store the data. The instruments were maintained roughly every two weeks, except during late August and early September when the Big Oak Flat Road and Tioga Road were temporarily closed due to a fire.

A supplemental data set was collected in the Tuolumne Campground for a research project. This data set is similar, with the noteworthy exception that Sound Level Meter (SLM) data was collected in conjunction with the DAR data, making this data set very powerful for analysis.

The data collected in 2009 occupies hundreds of gigabytes of storage. Moreover, significant pre-processing has to occur before the automated tools can be utilized.

Preliminary Results

In summary, the 2009 pilot program demonstrated that time above speech interference is feasible and effective as a metric. Change in sound level presents challenges due to inter-site and seasonal variability.

Discussion

Based on the pilot program of 2009, the following changes in data collection will be implemented in 2010:

- Improved calibration of the digital audio recorders, or simultaneous data collection with sound level meters
- Additional memory cards to make data transfer more efficient

In addition, the NPS Natural Sounds Program will continue with development of automated data analysis tools and assist with development of the proposed sound standard for the Draft Tuolumne River Plan.

APPENDICES

APPENDIX A: REFERENCES

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APPENDIX B: LIST OF ACRONYMS & TERMS

ACRONYMS

ANOVA	Analysis of Variance
ASMIS	Archeological Sites Management Information Systems
BPLD	Bear Patrol Log Database
°C	Degrees Centigrade.
CA	California
CCC	Continuing Calibration Check
CD	Compact Disc
cfs	cubic feet per second
cm	centimeter
CMP	(Merced Wild and Scenic River) Comprehensive Management Plan
DAR	digital audio recorder
dB(A)	A-Weighting Decibel
DH-81	Standard USGS wading sediment / water sampling device
DH-95	Standard USGS suspended sediment / water sampling device
DI	Deionized Water
DO	Dissolved Oxygen
DOQs	Digital Orthophotos
EPA	Environmental Protection Agency
EDI	Equal Discharge Increment
EWI	Equal Width Interval
ft.	Foot
GIS	Geographic Information System
GPS	Global Positioning System
GRTS	Generalized Random Tessellation Stratified
HBMP	Human-Bear Management Program
HCl	Hydrochloric Acid
Hg	Mercury
ICC	Initial Calibration Check
KCl	Potassium Chloride
km	Kilometer
l	Liter
LAC	Limits of Acceptable Change
LiDAR	Light Detection and Ranging
LPI-5	Largest Patches Index minus Five
LWD	Large Woody Debris
m	Meter
MDL	Method Detection Limit
mg/l	Milligram per Liter
ml	Milliliter
mm	Millimeter
MLRS	Merced Lake Ranger Station
MPN	Most Probable Number (of bacterial colonies)
MPS	Mean Patch Size
NAD27	North American Datum 27
NAD83	North American Datum 83

NAIP	National Agriculture Imagery Program
NELAP	National Environmental Laboratory Accreditation Program
NFM	National Field Manual
NIST	National Institute of Standards and Technology
NO3 + NO2	Nitrate plus Nitrite
NPS	National Park Service
NWQL	National Water Quality Laboratory
PDA	Personal Data Assistant
PAOT	People at one time
pH	Potential Hydrogen
PLI	Partial Loss Irretrievable
PLR	Partial Loss Repairable
QAPP	Quality Assurance Project Plan
QC	Quality Control
SLM	Sound Level Meter
SOP	Standard Operating Procedure
TDN	Total Dissolved Nitrogen
TDP	Total Dissolved Phosphorous
TLI	Total Loss Irretrievable
TP	Total Phosphorous
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
µS	Micro-Siemens (a measure of electrical conductivity)
µS/cm	Micro-Siemens (a measure of electrical conductivity)
VERP	Visitor Experience Resource Protection
VOG	Vehicles On the Ground
wf	Weighted Factor
WIMS	Wilderness Impacts Monitoring System
WMPI	Weighted Mean Patch Index
WY	Water Year
YAO	Yosemite Archeology Office

TERMS

Azimuth: This is the direction of a celestial object, measured clockwise around the observer's horizon from north. So an object due north has an azimuth of 0°, one due east 90°, south 180° and west 270°. Azimuth and altitude are usually used together to give the direction of an object in the topocentric coordinate system.

Carrying Capacity: As it applies to parks, carrying capacity is the type and level of visitor use that can be accommodated while sustaining the desired resource and social conditions that complement the purpose of a park unit and its management objectives.
dB(A): A commonly used curve for measuring noise as a sound pressure level.

Geographic Information System (GIS): A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a Geographical Information System (or Spatial Information System) is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image of a map.

Global Positioning System (GPS): The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

Indicator: Indicators are specific, measurable physical, ecological, or social variables that reflect the overall condition of a management zone. Resource indicators measure visitor impacts on the biological, physical, and/or cultural resources of a park; social indicators measure visitor impacts on the park visitor experience.

Management zone (zone): A geographical area for which management directions or prescriptions have been developed to determine what can and cannot occur in terms of resource management, visitor use, access, facilities or development, and park operations.

Outstandingly Remarkable Values (ORVs): Those resources in the corridor of a Wild and Scenic River that are of special value and warrant protection. ORVs are the “scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values…that shall be protected for the benefit and enjoyment of present and future generations” (16 USC 1272).

River corridor: The area within the boundaries of a Wild and Scenic River (e.g., the Merced River corridor).

Standard: Standards define the desired condition of each indicator variable. A standard does not define an intolerable condition, but rather the minimum acceptable condition.

User capacity: As it applies to parks, user capacity is the type and level of visitor use that can be accommodated while sustaining the desired resource and social conditions based on the purpose and objectives of a park unit.

Visitor experience: The perceptions, feelings, and reactions a park visitor has in relationship with the surrounding environment.

Wetland: Wetlands are defined by the U.S. Army Corps of Engineers (CFR, Section 328.3[b], 1986) as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wild and Scenic Rivers: Those rivers receiving special protection under the Wild and Scenic Rivers Act.

Wilderness: Those areas protected by the provisions of the 1964 Wilderness Act. These areas are characterized by a lack of human interference in natural processes.

Wilderness Impact Monitoring System (WIMS): An inventory process that monitors campsite and trail conditions in Yosemite National Park backcountry and Wilderness.

APPENDIX C: LIST OF PREPARERS

NATIONAL PARK SERVICE

Core Team:

- Sue Beatty, Restoration Ecologist, Vegetation and Ecological Restoration, Resources Management and Science
- Mark Fincher, Wilderness Specialist, Visitor Protection
- Dave Henderson, Traffic Supervisor, Visitor Protection
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- Bret Meldrum, Branch Chief, Visitor Use Social Sciences, Resources Management and Science
- Joe Meyer, Branch Chief, Physical Science and GIS, Resources Management and Science
- Jessica Middleton, Archeologist, Archeology and Anthropology, Resources Management and Science
- Todd Newburger, Visitor Use and Impact Monitoring Program Manager, Visitor Use and Social Science, Resources Management and Science
- Dr. Niki Stephanie Nicholas, Chief, Resources Management and Science
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North Carolina State University:

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APPENDIX D: IMPACT TOTALS FROM ALL SITES VISITED (ARCHEOLOGICAL SITE CONDITION, STABILITY, AND INTEGRITY)

Site Number	Erosion	Bioturbation	Tree Fall	Hazard Fuel buildup	Animals	Flooding	Aggregation	Fire	Inundation	Dumping	Sedimentation	Structural	Vegetation Growth	Park Operations	Artifact Movement	Social Trail	Use by Hikers/Horses	Visitor Use	Camping	Campfire Building	Stock Use	Climbing	Grazing/Trampling	Vegetation Damage	Off Road Vehicle Use	Unauthorized	Modification –	Soil Compaction	Building Removal	Structure	Tenants	Unauthorized	Fire	Erosion	Hazard Fuel Buildup	Camping	Flooding	Social Trail	Park Operations	Use by Hikers/Horses	Firering Construction	Sedimentation	Artifact Movement	Condition	Severity Level	Vulnerability	Impact Score	Inspection Schedule
CA-MRP-0050		X		X																																								Good	Low	L	9	10
CA-MRP-0051/H					X											X	X																											Fair	Moderate	H	22	5
CA-MRP-0068/H	X														X							X						X																Good	Severe	H	37	5
CA-MRP-0070/H		X													X																	X												Good	Moderate	H	23	5
CA-MRP-0081				X												X																	X											Good	Low	L	9	10
CA-MRP-0161/H																																		X	X	X								Good	Moderate	L	18	5
CA-MRP-0171/172/516/254/H	X	X						X								X									X																			Fair	Severe	H	36	5
CA-MRP-0187/1745		X						X																																				Good	Low	L	11	10
CA-MRP-0214	X	X		X												X																	X											Good	Moderate	L	21	5
CA-MRP-0241	X																																											Fair	Moderate	L	15	5
CA-MRP-0306	X																																											Good	Low	L	7	10
CA-MRP-0307		X						X		X																																		Good	Low	H	12	10
CA-MRP-0312				X	X																															X								Good	Moderate	H	21	5
CA-MRP-0316		X												X																														Fair	Low	L	14	5
CA-MRP-0318			X			X																																						Fair	Severe	L	28	5
CA-MRP-0369/H		X												X		X													X			X												Fair	Severe	H	43	5
CA-MRP-0373															X	X																												Poor	Moderate	L	21	5
CA-MRP-0374				X											X	X																	X											Poor	Moderate	H	20	1
CA-MRP-0651														X	X															X														Poor	Moderate	L	25	5
CA-MRP-0824				X	X											X						X																						Good	Moderate	L	18	5
CA-MRP-0902/H	X														X	X																					X							Poor	Severe	L	33	5
CA-MRP-1724H																X																												Good	Low	L	13	10
CA-MRP-825/H		X												X	X	X			X	X				X																				Poor	Severe	L	54	5
CA-TUO-0112		X												X	X																													Poor	Moderate	L	16	5
CA-TUO-0113	X	X												X		X																												Good	Severe	H	33	5
CA-TUO-0118	X	X																																				X						Good	Moderate	H	16	5
CA-TUO-0147					X									X					X																				X					Good	Moderate	L	21	10
CA-TUO-0167/H		X													X	X					X											X												Fair	Severe	H	32	5

Site Number	Erosion	Bioturbation	Tree Fall	Hazard Fuel buildup	Animals	Flooding	Aggregation	Fire	Inundation	Dumping	Sedimentation	Structural	Vegetation Growth	Park Operations	Artifact Movement	Social Trail	Use by Hikers/Horses	Visitor Use	Camping	Campfire Building	Stock Use	Climbing	Grazing/Trampling	Vegetation Damage	Off Road Vehicle Use	Unauthorized	Modification –	Soil Compaction	Building Removal	Structure	Tenants	Unauthorized	Fire	Erosion	Hazard Fuel Buildup	Camping	Flooding	Social Trail	Park Operations	Use by Hikers/Horses	Firering Construction	Sedimentation	Artifact Movement	Condition	Severity Level	Vulnerability	Impact Score	Inspection Schedule
CA-TUO-0490														X		X																												Good	Severe	L	27	10
CA-TUO-0493		X													X																							X						Poor	Severe	L	27	5
CA-TUO-0496	X	X													X																													Fair	Moderate	L	22	10
CA-TUO-0530	X	X												X	X		X															X												Poor	Severe	H	35	5
CA-TUO-0754/H	X													X						X												X												Good	Severe	H	27	5
CA-TUO-0758	X																																					X					X	Fair	Severe	H	28	5
CA-TUO-2813	X	X		X											X												X													X				Fair	Severe	H	30	5
CA-TUO-2816	X																																											Good	Low	H	6	10
CA-TUO-2825	X													X																		X						X						Fair	Severe	H	27	5
CA-TUO-2830	X	X												X																														Good	Low	L	12	10
CA-TUO-2833	X	X														X																												Good	Moderate	H	18	5
CA-TUO-3561	X	X												X	X	X			X	X				X																				Poor	Severe	H	60	5
CA-TUO-3939	X																	X	X								X																	Fair	Severe	H	31	5
CA-TUO-4056																X			X				X																					Fair	Severe	H	34	5
CA-TUO-4265	X													X	X				X																						X			Good	Severe	L	27	10
CA-TUO-4665	X											X		X	X				X	X												X												Fair	Severe	H	61	5
CA-TUO-4975	X																																			X								Good	Moderate	L	23	10
XCA-MRP-0008	X	X													X	X	X		X		X						X					X												Poor	Severe	H	78	5
XCA-MRP-0052		X															X																											Fair	Severe	L	31	5
XCA-MRP-0053				X																																		X						Good	Low	L	14	10
XCA-MRP-0076		X														X						X																						Fair	Severe	H	26	5
XCA-MRP-0082/H	X	X														X						X																						Poor	Severe	L	37	5
XCA-MRP-0186		X												X		X			X																									Poor	Severe	L	37	5
XCA-MRP-0190/191														X					X																			X						Fair	Severe	H	26	5
XCA-MRP-0216		X							X							X																												Good	Severe	L	27	10
XCA-MRP-0336	X															X															X													Poor	Severe	L	34	5
XCA-MRP-0734H																																												Poor	Low	L	10	10
XCA-TUO-0119	X	X																																										Good	Low	L	13	15
XCA-TUO-0132	X	X																																										Good	Low	H	14	10

Site Number	Erosion	Bioturbation	Tree Fall	Hazard Fuel buildup	Animals	Flooding	Aggregation	Fire	Inundation	Dumping	Sedimentation	Structural	Vegetation Growth	Park Operations	Artifact Movement	Social Trail	Use by Hikers/Horses	Visitor Use	Camping	Campfire Building	Stock Use	Climbing	Grazing/Trampling	Vegetation Damage	Off Road Vehicle Use	Unauthorized	Modification –	Soil Compaction	Building Removal	Structure	Tenants	Unauthorized	Fire	Erosion	Hazard Fuel Buildup	Camping	Flooding	Social Trail	Park Operations	Use by Hikers/Horses	Firering Construction	Sedimentation	Artifact Movement	Condition	Severity Level	Vulnerability	Impact Score	Inspection Schedule
XCA-TUO-0201		X													X																													Good	Low	L	14	10
XCA-TUO-2824	X	X													X																	X												Good	Moderate	H	25	5
XCA-TUO-2835	X	X																														X												Good	Moderate	H	17	5
XCA-TUO-3838	X					X								X																		X										X		Good	Severe	H	32	5
XCA-TUO-3845	X															X																X												Fair	Severe	H	35	5
XCA-TUO-3944	X	X												X		X																X												Fair	Severe	H	34	5
XCA-TUO-4436	X																															X												Good	Moderate	H	22	10
XCA-TUO-5001	X	X													X																													Good	Moderate	L	17	10