Visitor Experience and Resource Protection

Formal and Social Trail Assessments for the Tuolumne Meadows Area

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INTRODUCTION

Yosemite National Park has over 800 miles of formal trails across more than 700,000 acres, the majority of which are designated Wilderness. This vast network of trails provides visitors with access to even the most remote regions of the park and ultimately the experiences for which they have come to visit. Whether for day hiking, rock climbing, or an extended backpacking trip, trails are essential parts of Yosemite's infrastructure.

Quite often non-formal or "social" trails extend from the designated formal trail network to key attraction sites or points of interest. For example, social trails often cut across meadows to access the river for fishing or lead to the base of climbing routes. Due to their non-formal nature, social trails often result in a complex network of trails of deteriorating condition creating highly impacted areas.

Maintaining such an extensive formal trail network and preventing the proliferation of social trails can be challenging. Over time the condition of both formal and social trails can deteriorate due to a variety of factors (Marion 1995; Marion and Leung 2004). For example, weather and other natural phenomenon can compromise trail structures. Heavy snow or rain can damage water-bars and cause increased erosion along the trail. Repeated visitor use can also have a dramatic impact on trail conditions. The quantity, diversity and location of visitor use on or near a trail can negatively affect not only the condition of the trail itself, but the integrity of resources in the surrounding area as well (Holmquist 2004). Formal and non-formal trail impacts have also been show to affect the quality of visitor experiences (Manning et al. 2005; Manning et al. 2006; Manning 1999).

Therefore, it is important that the park address impacts to formal and social trails. This is especially true of sensitive ecosystems like that found in the Tuolumne Meadows area where a short growing season does not allow for the rapid rehabilitation of impacted areas.

The results described in this report are intended to inform planning efforts in the Tuolumne Meadows area. Preliminary data collection of social trails in the Meadows area was conducted in 2005. This year, social trails were again mapped for those areas not included in the previous year's effort. Formal trails condition assessments were added as a pilot effort this year, building upon work conducted in other National Park units (Manning et al. 2006, Marion et al. 2006) and previous research in Yosemite (Sydoriak 1989; Sydoriak 1992). Collectively, the inventorying and assessment of formal and social trail conditions comprises an important element of the Visitor Experience and Resource Protection program documenting the extent and severity of trail impacts to inform planning and management efforts.

METHODS

Complete and detailed protocols for measuring and monitoring both formal and non-formal "social" trails are provided in an appendix to this report. The following section presents excerpts from these more detailed protocols.

(A) Formal Trails

The condition of formal trails was assessed employing a protocol developed by Dr. Jeffrey Marion of the United States Geological Survey (USGS) for the Boone National Forest. Recently a similar methodology has been applied at Acadia National Park (Manning et al. 2006) and Great Smoky Mountains National Park (Marion et al. 2006). This protocol was adapted to fit the data collection needs and operational requirements for Yosemite National Park (see appendix).

The original formal trails assessment protocol included both detailed and rapid assessment techniques. The detailed assessments included cross-sectional sampling of selected trail segments. A sampling interval of 500 ft was used to select cross-sections along each trail segment. Each cross-sectional analysis involved taking various measures including the following variables:

- Trail position
- Trail grade
- Trail alignment
- Landform grade
- Secondary treads
- Tread width
- Tread substrate characteristics
- Cross-sectional area

In addition to these detailed measurements, GPS coordinates and photo points were taken at each cross-section to further document the location and severity of conditions along the selected trail segments.

The rapid assessments involved the documentation of various problem conditions using a Trimble GPS unit and corresponding data dictionary. Problem conditions included the following:

- Soil erosion
- Muddy soils
- Social trails

The rapid problem assessment was conducted by Edward Canapary and incorporated into his annual inventorying activities for the Facilities Management Division's trails program. Due to the fact that this was a pilot year for incorporating this work into the operational efficiencies of the trails program and a limited amount of data were collected, results from this work are not included in this report.

Formal trails were assessed on six designated trails in the Tuolumne Meadows area including: 1) Cathedral Lakes Trail, 2) the Dog Lake Trail, 3) the Glen Aulin main trail, 4) the Glen Aulin Horse Trail, 5) the Glen Aulin Trail near Soda Springs, and 6) John Muir (JMT) and Pacific Crest Trail (PCT) through Lyell Canyon (see Table 1 for detailed descriptions of trail segments included in the study). Each of these trails provides access to the trail network and are highly used. They were chosen for this pilot work based on this and the fact that they are within the area currently under investigation for the Tuolumne Meadows Concept Plan and have been known by park personnel to be in deteriorating conditions.

Table 1. Formal Trail Segments Included in the Study

Trail Segment	Description of Starting Point	Description of Ending Point
Cathedral Lakes Trail	Cathedral Lakes T.H.; Mileage sign(next to map and info board); approx 50m from Hwy 120	Creek that originates in pond on the west side of Cathedral(CL8709)
Dog Lake Trail	Lembert Dome parking; next to restrooms	First turn-off to stables
Glen Aulin Main Trail	Stables Parking Lot; Glen Aulin, Parsons Lodge, Soda Springs T.H.	Delaney Creek
Glen Aulin Horse Trail	Lembert Dome Parking; next to dumpster, no trailhead marker	Stable Parking Lot
Glen Aulin via Soda Springs	Glen Aulin/Soda Springs T.H.; across Hwy 120 from Visitor Center	Parsons Lodge/Soda Springs(Parsons Lodge and water treatment access road)
Lyell Fork JMT/PCT	Across Hwy 120 from Lembert Dome Parking	-

(B) Social Trails

An inventory of existing social trails and their condition in Tuolumne Meadows was conducted in 2005. This year data collection focused on other parts of the Tuolumne Meadows area including the stables, campgrounds, and along the Lyell and Dana Forks of the Tuolumne River. The methodology employed this year was identical to that used in 2005 and is presented in the appendix to this report. This year's data collection was conducted by a team of two field staff during September and October of 2006.

Social trail sampling consisted of mapping trails using Global Positioning System (GPS) units. Trails were mapped using line features and identified as having one of five condition class ratings as follows:

- Flattened vegetation
- Stunted vegetation
- Some bare ground
- Barren (barren width in inches recorded)
- Barely discernable trail

For trails identified as barely discernable, the location was entered in the GPS unit as a point feature. The point location was taken at the place where the barely discernable trail started or intersected with another trail. A determination whether the trail was apparently caused by humans or by wildlife was noted.

An extension of the protocol noted disturbed areas. A disturbed area was considered an area with a high level of use that is not necessarily a trail or was the confluence of several trails. This area was recorded as a point feature in the middle of the disturbed area. The overall square footage of the disturbed area was then estimated.

RESULTS

(A) Formal Trails

The following series of tables and figures presents the results from formal trail assessments on the selected trail segments included in this study.

Table 2 presents a characterization of each trail segment including the number of sample points, total distance, and the use distribution along the trail segment (horse, hiker, or backpacker). The Cathedral Lakes, Glen Aulin main trail, and the Lyell Fork John Muir Trail / Pacific Crest Trail (JMT/PCT) were the principal trail segments included in this study and represented the longest segments with more than 20 sampling points each. All trails were characterized as receiving a distribution of horse, hiker and backpacker use. The Glen Aulin horse trail was characterized as receiving the most horse use, while the Lyell Fork JMT/PCT was characterized as receiving the most backpacking use.

Table 2. Characterization of sampled trail segments

Trail Segment	# of Sampling Points	Total Length (ft.)	Amount of Use (%)		
			Horse	Hiker	Backpacker
Cathedral Lakes Trail	29	14000	30	40	30
Dog Lake Trail	4	1500	30	40	30
Glen Aulin Main Trail	21	10000	40	40	20
Glen Aulin Horse Trail	8	3500	50	25	25
Glen Aulin via Soda Springs	8	3500	30	40	30
Lyell Fork JMT/PCT	29	14000	30	30	40

Tables 3a and 3b present summary data for trail tread measurements. Table 3a shows the average number of secondary trail treads found along trail segments and the average, minimum, and maximum tread width in inches. No secondary trail treads were reported for the Dog Lake Trail. The Glen Aulin Horse Trail and the trail near Soda Springs reported the highest average number of secondary trail treads with 2.6 and 1.8 respectively. All trail segments showed an average trail tread width ranging from 60.9 to 107.5 inches. In other terms, this translates to each trail segment having an average width of several feet. The narrowest trail width reported was 18 inches on the Glen

Aulin Horse Trail and the Lyell Fork JMT/PCT. The widest trail recorded was a segment along the Glen Aulin via Soda Springs at 176.0 inches.

Table 3a. Summary Trail Tread Measurements (Secondary Treads and Width)

Trail Segment	Avg. # of Secondary Treads	Avg. Trail Width (in.)	Min Trail Width (in.)	Max Trail Width (in.)
Cathedral Lakes Trail (N=29)	0.1	75.4	49	101
Dog Lake Trail (N=4)	0.0	101.3	64	124
Glen Aulin Main Trail (N=21)	0.6	83.2	43	155
Glen Aulin Horse Trail (N=8)	2.6	60.9	18	134
Glen Aulin via Soda Springs (N=8)	1.8	107.5	72	176
Lyell Fork JMT/PCT (N=29)	0.7	87.2	18	146

Table 3b presents a summary of trail tread cross-sectional area measurements. This is a measure of the total soil loss or "cut" of the trail tread, reflecting the degree of erosion or deterioration. All trail segments reported a large cross-sectional area with the Cathedral Lakes and Lyell Fork JMT/PCT reporting the highest average cross-sectional areas at 547.2 and 981.3 respectively. These trail segments also reported the smallest (min) and largest (max) areas.

Table 3b. Summary Trail Tread Measurements (Cross-sectional Area)

Trail Segment	Avg. Cross-sectional Area (in^2)	Min Cross-sectional Area (in^2)	Max Cross-sectional Area (in^2)
Cathedral Lakes Trail	547.2	38.3	1603.5
Dog Lake Trail	366.2	112.5	624.0
Glen Aulin Main Trail	581.8	194.3	2046.8
Glen Aulin Horse Trail	413.7	68.3	1180.5
Glen Aulin via Soda Springs	552.2	174.0	1449.8
Lyell Fork JMT/PCT	981.3	45.8	5469.8

Another way to consider the cross-sectional area of a trail is to measure the depth of the maximum incision. The maximum incision is the deepest vertical transect measured at a particular cross-section along the trail segment (see Figure 1 below). The following graphs show the maximum incision for each cross-sectional sampling point along the three main trail segments included in this study, the Cathedral Lakes Trail, the Glen Aulin Main Trail, and the Lyell Fork JMT/PCT. Simply put, the maximum incision is the deepest point of the trail cut at a particular point along the trail.

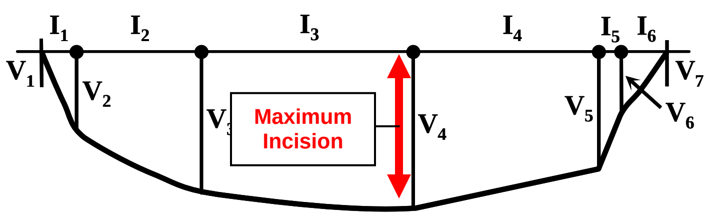

Figure 1. Cross-sectional View of Trail-tread Showing Maximum Incision (Adapted from Marion 1999).

The following graphs may be viewed in a similar fashion to the image shown in Figure 1 where the top of the graph represents the original ground surface (0) and the red bars show the depth in inches (5; 10; 15; etc.) of the maximum incision at the various sampling points along the trail segment. The X-axis shows the cross-sections from left (the beginning of the trail segment) to right (the end of the trail segment).

Figure 2 presents the maximum incisions recorded along the Cathedral Lakes Trail. The majority of the cross-sectional sampling points revealed maximum incisions of at least 5 inches, with many surpassing 12 inches in depth. Two maximum incisions were recorded over 15 inches in depth.

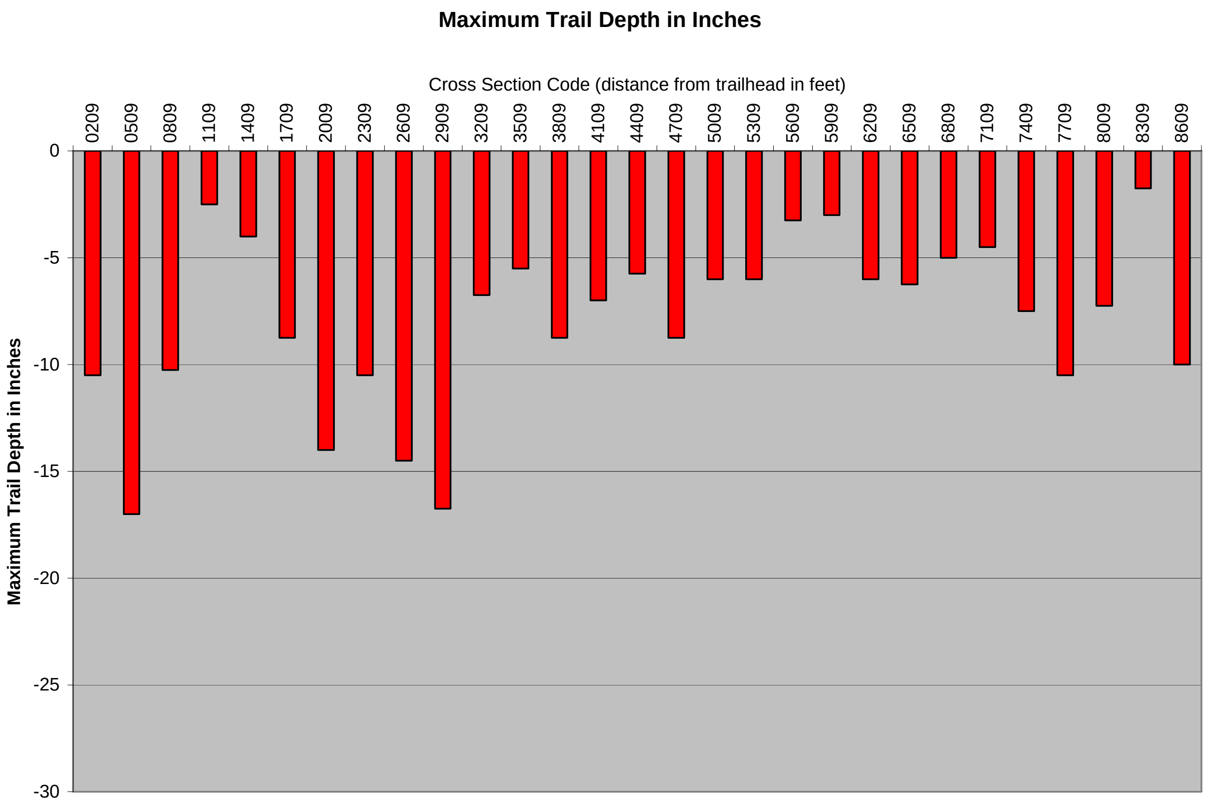

Figure 2. Maximum Incisions Recorded along the Cathedral Lakes Trail.

Figure 3 presents the maximum incisions recorded at the cross-sections along the Glen Aulin Main Trail. The majority of maximum incisions recorded revealed a depth of at least 5 inches or more. One maximum incision was recorded at 18 inches or one-and-a-half feet in depth.

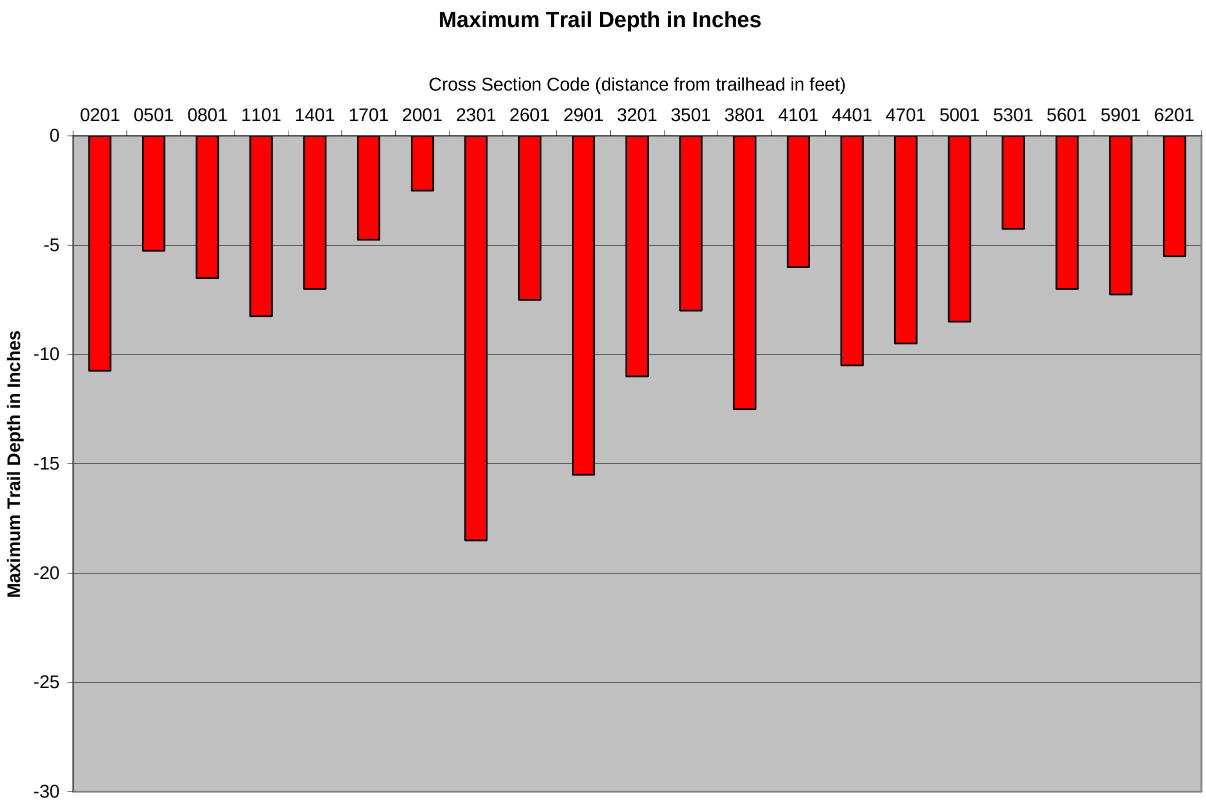

Figure 3. Maximum Incisions Recorded along the Glen Aulin Main Trail.

Figure 4 presents the maximum incisions for the cross-sections along the Lyell Fork JMT/PCT. As in the other two segments presented above, the Lyell Fork JMT/PCT had the majority of maximum incisions of at least 5 inches or more in depth. Four maximum incisions were recorded at more than 15 inches in depth, with 3 surpassing 20 inches, and two reaching more than 25 inches in depth.

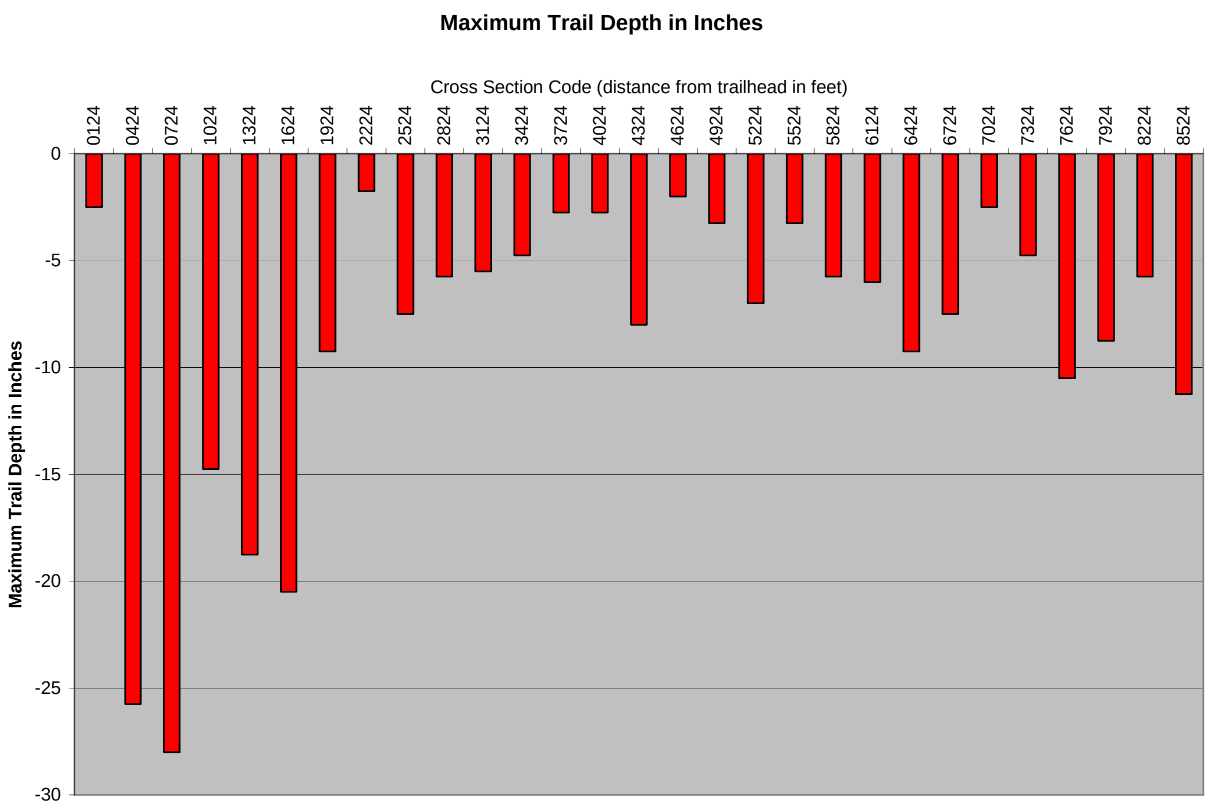

Figure 4. Maximum Incisions Recorded along the Lyell Fork JMT/PCT.

The reader will also note that as one reads the graph above from left-to-right, it appears that the Lyell Fork JMT/PCT shows deeper maximum incisions near the trailhead. The Cathedral Lakes and Glen Aulin Trails, however, appear to have relatively uniform impacts. Cross-sectional sampling points were spaced at a distance of 500 ft. The reader will also note that while one cross-section may exhibit a relatively small maximum incision, the next cross-section may have an extremely large incision. This variability suggests that while appearing relatively uniform overall, the level of impact recorded may vary along a trail segment depending on localized conditions such as the surrounding land area, trail grade, structures, etc.

The following figures present a series of photo-points taken at various sampling points along the respective trail segments. These photos provide a visual reference to the conditions represented by the data in Tables 2, 3a, and 3b above.

Figure 5. Sample Photo-point along the Cathedral Lakes Trail.

Figure 6. Sample Photo-point along the Dog Lake Trail

Figure 7. Sample Photo-point along the Glen Aulin Main Trail

Figure 8. Sample Photo-point along the Glen Aulin Horse Trail

Figure 9. Sample Photo-point along the Glen Aulin Trail via Soda Springs

Figure 10. Sample Photo-point along the Lyell Fork JMT/PCT

(B) Social Trails

Figure 11 presents a map of the social trails and disturbed areas in the Tuolumne Meadows area documented in 2006. (Note: this map and the corresponding GIS data are available from the VERP Program Coordinator in the Resources Management and Science Division.)

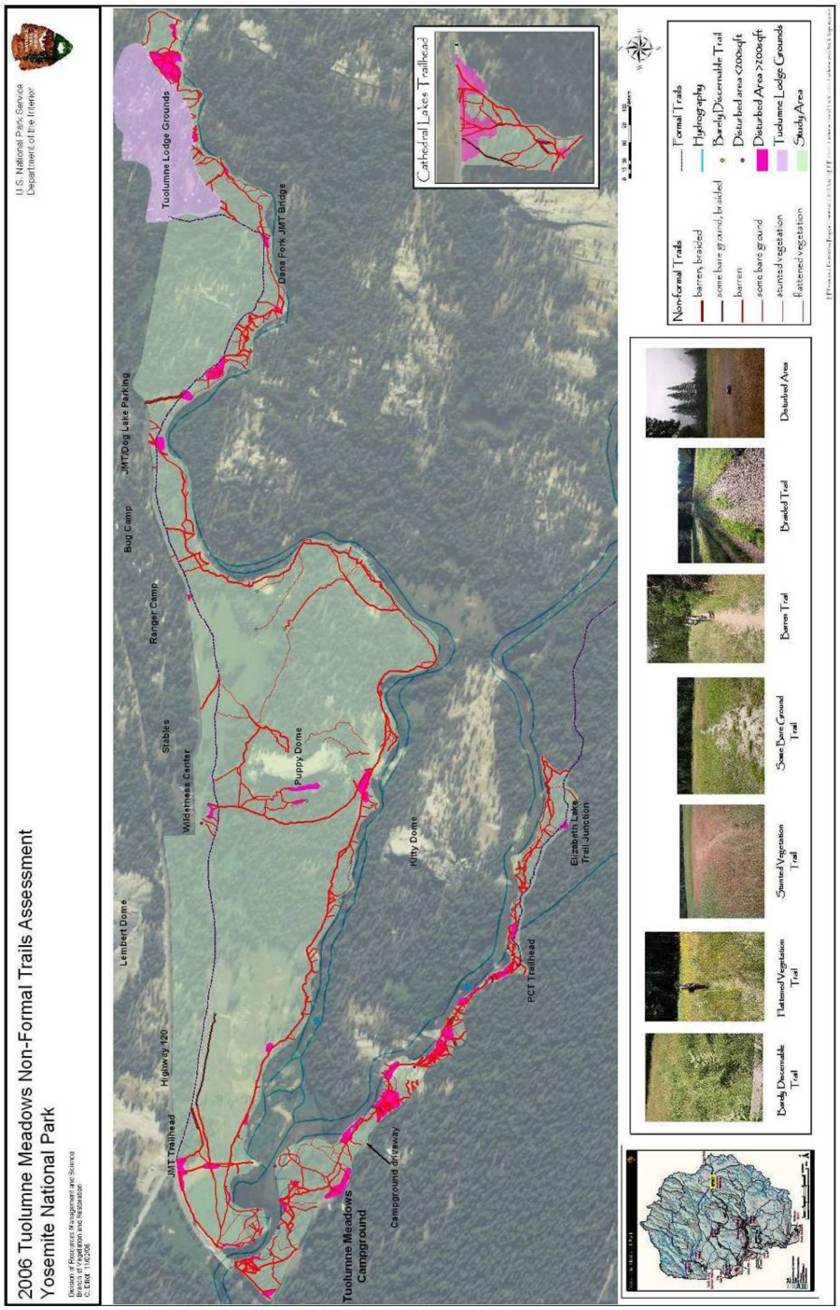

Figure 11. Map of Non-formal Trails and Disturbed Areas in the Tuolumne Meadows Area 2006.

The map presented in Figure 11 reveals a significant network of un-designated, non-formal trails in the greater Tuolumne Meadows area. On the map, the thickness of the trails corresponds to the level of impact or the condition classes as described in the *methods* section above.

It appears that social trails concentrate in principal access areas. For example, there is a high density of social trails along the northern bank of the Dana Fork of the Tuolumne River and along the southern bank of the Main Stem Tuolumne River to the east of the Tuolumne Campground.

Significant disturbed areas were also found and appear in pink on the map. Generally, a high concentration of social trails, usually reflecting the worst condition class rating, collect and merge into highly disturbed areas. Notable disturbed areas were found in the Tuolumne Lodge area; along the Dana Fork of the Tuolumne River; within the Tuolumne Campground Complex; and at the Dog Lake and JMT trailheads.

SUMMARY

Data collected in 2006 in the Tuolumne Meadows area suggest that there are significant impacts associated with formal and social trails. The highly used Dog Lake, Glen Aulin, Lyell Canyon, and Cathedral Lakes trails show significant signs of degradation. Similarly, mapping social trails and corresponding disturbed areas has revealed a significant network of non-formal “social” trails and a number of corresponding heavily impacted disturbed areas.

The degradation documented on the six formal trail segments in this study is most likely attributable to the level and diversity of use these trails receive. All three trail segments studied are heavily used by a diversity of users including day hikers, backpackers, rock climbers, and stock users. They each represent popular access areas to the high country.

The social trail impacts represent areas of existent visitor access where no formal trail exists or where a clearly designated access is not provided.

It is recommended that measures be taken to mitigate the impacts reported here. These impacts should be addressed with the appropriate level of planning and management effort still to be determined. Nevertheless, without further action it is likely that these conditions will continue to deteriorate. Toward this end, it is also recommended that monitoring of trail conditions continue in order to document further change in trail conditions, including the proliferation of social trails. What is more, monitoring efforts may speak to the efficacy of management actions once they are taken.

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APPENDIX

(A) Formal Trails Protocol

Introduction

This manual describes standardized procedures for conducting an assessment of resource conditions on recreation trails. The principal objective of these procedures is to document and monitor changes in recreational use trail conditions. Their design relies on a sampling approach to characterize trail conditions from measurements taken at transects located every 300 ft (91 m) along selected trail segments. For trails less than 2400 ft (.45 miles) consult Table 1 for reduced sample point interval distances necessary to accurately characterize conditions on shorter trails. Values are calculated to include about 8 sample points for each trail segment. Distances are assessed with a measuring wheel. Trail condition measurements are applied at sample points to document the trail's width, depth, substrate, grade, and other characteristics. These procedures take between 3 to 6 minutes to apply at each sample point. Data is summarized through statistical analyses to characterize resource conditions for each trail segment. During future assessments it is not necessary to relocate the same sample points for repeat measures. Survey work should be conducted during the middle or end of the primary use season and during the growing season. This is necessary because determinations of trail boundaries are based on trampling-related disturbance to ground vegetation and leaf litter. Subsequent surveys should be conducted at approximately the same time of year.

Table 1. Sample point intervals for trails <2400 ft (.45 mi).

Interval (ft)	Trail Length (ft)
300	>2400
250	1801-2400
175	1201-1800
100	601-1200
75	301-600
50	51-300
25	<51

MATERIALS

This manual and supply of data forms (some on waterproof paper), pencils, clipboard with compartment for forms, measuring wheel (one that removes distance when backed up), topographic and driving maps, clinometer, 12 ft tape measure (25 ft for wide trails), metal stakes (3), compass, 25 ft of thick non-stretchable line marked off every 0.3 feet on a spool, hanging line level marked to show a 3% slope.

POINT SAMPLING PROCEDURES

Trail Segments: During the description of amount and type of use (indicators 5 & 6 below) be sure that the use characteristics are relatively uniform over the entire trail segment. Some of the study trails have multiple uses. For example, a sign in the middle of a study segment restricting horse use beyond it can substantially affect visitation and impact. Even when use types are not regulated the study trail may intersect with another route that diverts one of the user groups. In such instances where substantial changes in the type and/or amount of use occur, the trail should be split in two segments and assigned separate names and forms, upon which the differences in use can be described. This practice will facilitate subsequent statistical summaries and analyses. Also collect and record any other information that is known about the trail's history, such as original construction, past uses, type and amount of maintenance, history of use, etc.

1) **Trail Segment Code:** Record a unique trail segment code (can be added later).

2) **Trail Name:** Record the trail segment name(s) and describe the segment begin and end points.

3) **Surveyors:** Record initials for the names of the trail survey crew.

4) **Date:** Record the date (mm/dd/yr) the trail was surveyed.

5) **Use Level (UL):** Record an estimate of the amount of use the trail receives (high, med., low), relative to other forest trails, from the most knowledgeable staff member. Work with them to quantify use levels on an annual basis (e.g., low use: about 100 users/wk for the 12 wk use season, about 30 users/wk for the 20 wk shoulder season, about 10 users/wk for the 20 wk off-season = about 2000 users/yr).

   NOTE: Use levels can be discerned from existing use counts such as the people at one time (PAOT), or the trailhead quota system.

6) **Use Type (UT):** Record estimates for the types of use the trail receives (including any illegal uses) using percentages that sum to 100%. These should be provided by the most knowledgeable forest staff member. Categories include: Hiking, Horseback, Backpacker (specify).

Starting/Ending Point: Record a brief but accurate description of the starting and ending points of the survey. Choose identifiable and permanent locations that others can identify in the future, like intersections with other trails, roads, or permanent trailhead signs. Using a GPS device collect an accurate fix on these locations and record the UTM coordinates on the field form.

Measuring Wheel Procedures: At the trail segment starting point, select a random number from 0 to your sample interval (300 ft). Record this number on the first row of the form. This will be the first sample point, from which all subsequent sample points will be located at whatever your interval is. This procedure ensures that all points along the trail segment have an equal opportunity of being selected. *** Once you get to the first sample point, reset the wheel counter and use it to stop at points separated by your sample interval distance thereafter.**

Push the measuring wheel along the middle of the tread so that it does not bounce or skip in rough terrain. Lift the wheel over logs and larger rocks, adding distance manually where necessary to account for horizontal distances. Your objective is to accurately measure the distance of the primary (most heavily used) trail tread. Monitor the wheel counter and stop at your sample intervals to conduct the sampling point measures. If you go over this distance, you can back the wheel up to the correct distance. If the wheel doesn't allow you to take distance off the counter then stop immediately and conduct your sampling at that point, recording the actual distance from the wheel, not the "missed" distance. Continue to the next "correct" sample point (as though you had not missed the last one).

Rejection of a sample point: Given the survey's objective there will be rare occasions when you may need to reject a sampling point due to the presence of boulders, tree falls, trail intersections, road-crossings, stream-crossings, bridges or other odd "uncharacteristic" situations. The data collected at sample points is intended to be roughly "representative" of the 150 ft sections of trail on either side of the sample point. Use your judgment but be conservative when deciding if a sample point should be relocated. Do not relocate a point to avoid longer or common sections of bog bridging, turnpiking, or other trail tread improvements. The point should be relocated by moving forward along the trail an additional 30 ft, this removes the bias of subjectively selecting a point. If the new point is still problematic then add another 30 ft, and so on. Record the distance of the actual point and continue on to the next "correct" point (as though you did not need to move the last one).

For the following data, in the field or office: If an indicator cannot be assessed, e.g., is "Not Applicable" code the data as -9, code missing data as -1.

7) **Distance:** Measuring wheel distance (ft) from the beginning of the trail segment to the sample point.

8) **Trail Position (TP):** Use the descriptions below to determine the trail position of the sampling point. Record the corresponding letter code in the TP column.
   - **R** - Ridge: Ridge-top or high plateau position
   - **CB** - Cliff base
   - **M** - Midslope/Sideslope: Mid-slope positions

V - Valley Bottom: Flatter valley bottom terrain

9) **Trail Grade (TG):** The two field staff should position themselves on the trail 5 ft either side of the transect. A clinometer is used to determine the grade (% slope) by sighting and aligning the horizontal line inside the clinometer with a spot on the opposite person at the same height as the first person's eyes. Note the percent grade (right-side scale in clinometer viewfinder) and record.

10) **Trail Alignment (TA):** Assess the trail's alignment angle to the prevailing land-form in the vicinity of the sample point. Sight a compass along the trail from a point about 5ft before the transect to about 5ft past the transect, record the compass azimuth (0-360, not corrected for declination) on the left side of the column (it doesn't matter which direction along the trail you sight). Next face directly downslope, take and record another compass azimuth - this is the aspect of the local landform. The trail's alignment angle ($<90^0$) can be computed by these two azimuths.

11) **Landform Grade (LG):** Assess an approximate measure of the landform slope in the vicinity of the sample point. Turn the clinometer perpendicular to the ground with the window facing your eye. Next orient the bottom of the clinometer in alignment with the prevailing landform slope (placing the clinometer on your clipboard and orienting the bottom of the clipboard may improve your accuracy). Record the degrees (not percent) off the scale in the window to the nearest 5^o (after data entry convert to percent slope = [tan (degrees)] x 100.

12) **Secondary Treads (ST):** Count the number of trails that parallel the main tread at the sample point. Count all treads regardless of their length, ***excluding*** *the main tread*.

13) **Tread Width (TW):** From the sample point, extend a line transect in both directions perpendicular to the trail tread. Identify the endpoints of this trail tread transect as the most pronounced outer boundary of visually obvious human disturbance created by trail use (not trail maintenance like vegetation clearing). These boundaries are defined as pronounced changes in ground vegetation height (trampled vs. untrampled), cover, composition, or, when vegetation cover is reduced or absent, as pronounced changes in organic litter (intact vs. pulverized) (see photo illustrations in Figure 1, placed at the end of the manual). The objective is to define the trail tread that receives the majority (>95%) of traffic, selecting the most visually obvious outer boundary that can be most consistently identified by you and future trail surveyors. In places where the trail boundary is indistinct at the sample point project the boundary to the sample point from immediately adjacent areas. Include the widths of any secondary treads (see #8) crossed by the transect, excluding widths of any undisturbed areas between treads (as defined by the tread boundary definition). Measure and record the length of the transect (the tread width) to the nearest inch (don't record feet and inches).

14-23) **Tread Condition Characteristics:** Along the trail tread width transect, estimate to the nearest 10% (5% where necessary) the aggregate lineal length occupied by any of the mutually exclusive tread surface categories listed below. **Be sure that your estimates sum to 100%**. Record these on the form by labeling sections of the appropriate row with the relevant code separated by marked vertical lines indicating the appropriate percentage cover for each code.

S-Soil	All soil types including sand and organic soils, excluding organic litter unless highly pulverized and in a thin layer or smaller patches over bare soil.
L-Litter	Surface organic matter including intact or partially pulverized leaves, needles, or twigs that mostly or entirely cover the tread substrate.
V-Vegetation	Live vegetative cover including herbs, grasses, and mosses rooted within the tread boundaries. Ignore vegetation hanging in from the sides.
R-Rock	Naturally-occurring rock (bedrock, boulders, rocks, cobble, or natural gravel). If rock or native gravel is embedded in the tread soil estimate the percentage of each and record separately.

M-Mud	Seasonal or permanently wet and muddy soils that show imbedded foot or hoof prints from previous or current use (omit temporary mud created by a very recent rain). The objective is to include only transect segments that are frequently muddy enough to divert trail users around problem.
G-Gravel	Human-placed (imported) gravel.
RT-Roots	Exposed tree or shrub roots.
W-Water	Portions of mud-holes with water or water from intercepted seeps or springs.
WO-Wood	Human-placed wood (water bars, bog bridging, cribbing).
O-Other	Specify.

24) **Cross-Sectional Area (CSA):** The objective of the CSA measure is to estimate soil loss from the tread at the sample point following trail creation. Accurate and precise CSA measures require different procedures based on the type of trail and erosion, some definitions:

Direct-ascent vs. side-hill trails: Trails, regardless of their grade, that more or less directly ascend the slope of the landform are direct-ascent or "fall-line" trails. Direct-ascent trails involve little or no tread construction work at their creation – generally consisting of removal of organic litter and/or soils. Trails that angle up a slope *and* require a noticeable amount of cut-and-fill digging in mineral soil (generally on landform slopes of greater than about 10%) are termed side-hill trails. The movement of soil is required to create a gently out-sloped bench to serve as a tread. Separate procedures are needed for side-hill trails to avoid including construction-related soil movement in measures of soil loss following construction.

Recent vs. historic erosion: Recreation-related soil loss that is relatively recent is of greater importance to protected land managers and monitoring objectives. Severe erosion from historic, often pre-recreational use activities, is both less important and more difficult to reliably measure. Historic erosion is defined as erosion that occurred more than 10-15 years ago and is most readily judged by the presence of trees and shrubs growing from severely eroded side-slopes.

a) Direct-ascent trails, recent erosion: Refer to Figure 2a and follow these procedures. Place two stakes and the transect line to characterize what you judge to be the pre-trail or original land surface. Place the left-hand stake beyond the trail boundary so that the 1st mark on the transect line will fall on what you believe was the "original" ground surface but at the edge of any tread incision, if present (see Figure 2a). Thus, the transect incision value you record for the 1st mark (T_1) must be 0. Stretch the transect line (marked in 0.3 ft (3 5/8 in) intervals) tightly between the two stakes - any bowing in the middle will bias your measurements. Insert the other stake just beyond the first transect line mark on the other side of the trail that is on the original ground surface and will be measured as a 0. The transect line should reflect your estimate of the pre-trail land surface, serving as a datum to measure tread incision caused by soil erosion and/or compaction.

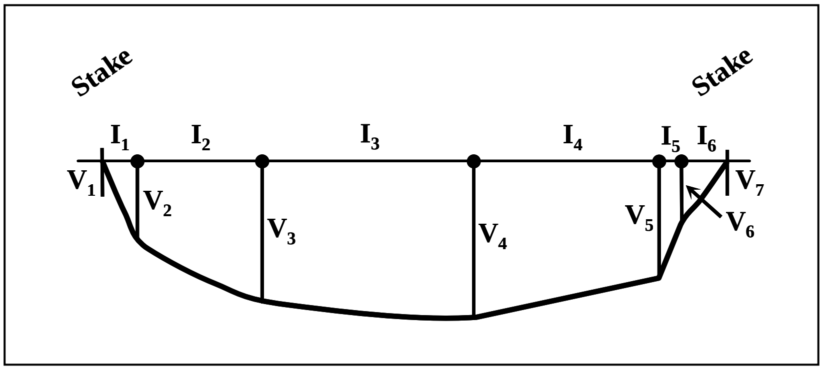
NOTE: For this and all other options (b-d), if the line cannot be configured properly at the sample point due to rocks or obstructing materials that cannot be moved, then move the line forward along the trail in one-foot increments until you reach a location where the line can be properly configured.

b) Direct-ascent trails w/historic erosion: Refer to Figure 2b – if you judge that some of the erosion is historic then follow these procedures. Generally you will find an eroded tread within a larger erosional feature. Place two stakes and stretch the transect line to reflect and allow measurements of the more recent recreation-related erosion (if present). If there is no obvious recent-erosion tread incision then position the stakes the same as for your tread width measurement and assess incision between tread boundaries (option not depicted in Figure 2b). The left-hand stake can serve as transect 1, record a 0 for this. At the right boundary you must also record a transect with a measure of 0.

c) Side-hill trail: Refer to Figure 2c. The objective of this option is to place the transect stakes and line to simulate the post-construction tread surface, thereby focusing monitoring measuresments on post-construction soil loss and/or compaction. When side-hill trails are constructed, soil on the upslope side of the trail is removed and deposited downslope to create a gently out-sloped bench (most agency guidance specify a 5% outslope) for the tread surface (see Figure 3). Outsloped treads drain water across their surface, preventing the buildup of larger quantities of water that become erosive. However, constructed treads often become incised over time due to soil erosion and/or compaction. The extent of this incision are what these procedures are designed to estimate.

Carefully study the area in the vicinity of the sample point to judge what you believe to be the post-construction tread surface. Pay close attention to the tree roots, rocks or more stable portions of the tread to help you judge the post-construction tread surface. Look in adjacent undisturbed areas to see if roots are exposed naturally or the approximate depth of their burial. Configure the stakes and transect line to approximate what you judge to be the post-construction tread surface. Note that sometimes a berm of soil, organic material and vegetation will form on the downslope side of the trail that is raised slightly above the post-construction tread surface (generally less than 6 inches in height). If present, place the stake and line below the height of the berm as shown in Figure 2c so that it does not influence your measurements. If erosion is severe and/or if the line placement is subjective, use a line level with marks on the bubble glass that allow you to configure the line as a 3% outslope (a 1 in. drop over 33 in.) to standardize the line placement and reduce measurement error. An outslope of 3% is used because actual tread construction is often somewhat less than 5%, and 3% provides a more conservative estimate of soil loss. It is generally easier and more accurate to place the downslope stake first and configure the line to a 3% outslope to reveal where the uphill stake should be placed. Measure the left-hand stake as transect 1 with a 0 measure and also record an additional transect beyond the right-hand stake with a measure of 0.

d) Side-hill trail with historic erosion: Refer to Figure 2d - if you judge that the erosion is historic then follow these procedures. Generally you will find an eroded tread within a larger erosional feature. Place two stakes and stretch the transect line to reflect and allow measurements of the more recent recreation-related erosion (if present). If there is no obvious recent-erosion tread incision then position the stakes the same as for your tread width measurement and assess incision between tread boundaries (option not depicted in Figure 2d). The left-hand stake can serve as vertical transect 1, record a 0 for this. At the right boundary you must also record a vertical transect with a measure of 0.



Vertical (cm)	Interval (cm)	Area (cm^2)
V_1: 0	I_1: 5.0	21.3
V_2: 8.5	I_2: 12.5	146.9
V_3: 15.0	I_3: 20.0	360.0
V_4: 21.0	I_4: 16.5	272.3
V_5: 12.0	I_5: 2.5	21.9
V_6: 5.5	I_6: 5.0	13.8
V_7: 0	CSA:	836.0

Figure 1. Illustration of the variable interval CSA method for assessing soil loss at each transect. Table shows data for use in the computational formula: Area = $(V_i + V_{i+1}) \times I_i \times .5$ for each row and summed to compute CSA.

Measurement Procedure: On the CSA data form, label a new row with the measuring wheel distance for the transect (e.g., D=600 ft). Starting on one side with a “zero” measurement, measure from each vertical transect line marking, a perpendicular transect down to the ground surface (nearest 1/4 in, e.g., .25, .5, .75). Record the values on the data sheet next to their labeled transect numbers (e.g., V_1, V_2, $V_3 \ldots V_n$) (see Figure 1). Continue measuring each transect height until you reach the far side of the trail and obtain a measure of 0. ***Note:*** The transect line is not likely to be “level” so be cautious in measuring vertical transects that are *perpendicular* to the horizontal transect line.

In the office, use a calculator or spreadsheet to compute and sum cross-sectional area values with the following formula for each consecutive pair of vertical transect measures as shown in the Figure 1 table and using the equation: Area = $(V_i + V_{i+1}) \times I_i \times .5$ for each row and summed to compute CSA.

25) **Trail Type (TT):** Record whether the tread at the sample point was assessed as a direct ascent or side-hill constructed trail (see definitions in #10). Record the letter code in the TT column.
DA – Direct ascent (fall-line)
SH – Side-hill trail

26) **Photo Point:** Use a digital camera to record a photo point of the transect. Stand 10 ft back from the transect facing down-trail. Hold the camera at breast-level and approximately 12 inches from your body. Aim the camera such that the transect line appears in the middle of the viewfinder and record the image. This photo will be labeled with the recorded Dist. code and associated GPS data point (i.e., LY0325).

Collect all equipment and move onto the next sample point. **NOTE: After data entry and before analysis the data for these indicators need to be corrected to add in the 1st randomly selected interval distance so that location data is accurate. In particular, examine any indicators that may begin before and end after the first sample point.**

(B) Social Trails Protocol

1.1 **Background**

Non-formal 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 non-formal trails are not planned or constructed they are usually poorly located with respect to terrain. These trails also receive no or very little maintenance. These factors substantially increase their potential for degradation in comparison to formal trails. The proliferation of non-formal trails may increase habitat fragmentation and can directly threaten sensitive habitats when crossed or accessed by unplanned trails (Tylser and Joghson 2004). From a social perspective a web of non-formal trails create a visually scarred landscape and may lead to safety and liability concerns. Due to their ecological and social significance, non-formal trails are a common indicator selected in different implementations of NPS's VERP planning framework and Vital Signs monitoring program.

Monitoring can provide timely information on the extent, distribution and condition of non-formal trail segments. Such information can serve as warning signs of resource degradation and habitat intrusion and can trigger management actions if standards established to specify minimum acceptable conditions are exceeded. Most previous monitoring studies on non-formal trails have focused on their proliferation in the park landscape rather than resource conditions on tread conditions. Three main monitoring approaches have been developed specifically for non-formal trails. Some past visitor impact studies had non-formal trails included as an indicator with the level of proliferation assessed by tallying the occurrence of non-formal trail segments extending from formal trail networks or recreation sites (Marion 1994; Leung et al. 2002). Alternatively the entire non-formal trail network of a park or selected portions of a park can be inventoried and mapped (Cole et al. 1997; Leung et al. 2002). Most of these studies have also incorporated condition class ratings to the assessments. Finally, very few studies have actually monitored non-formal trail networks more than one time to enable a temporal evaluation (YOSE 2005). Due to the extensive nature of some non-formal trail networks the efficiency of field assessments is a particular concern. The advent of geospatial techniques seems to provide potential solutions to this challenge, though such technologies benefit monitoring of formal trails as well.

Major developments are currently occurring with the rapid advancements of geospatial technologies, such as geographic information systems (GIS), global positioning system (GPS), remotely sensing and the digital spatial data. These technologies are particularly relevant to non-formal trail monitoring due to their dispersed spatial distribution. Witztum and Stow (2004) demonstrated the utility of multi-spectral imagery and digital image processing techniques in extracting non-formal trails in a coastal sage scrub community.

This field protocol presents the data requirements and data collection procedures for surveying the extent and condition of non-formal trails in selected sites in Yosemite Valley and Tuolumne Meadows, an indicator that was first implemented in 2004 and addressed total length of non-formal trails in meadows. The User Capacity Management Program identified two zones to be monitored in Yosemite Valley, 2B Discovery and 2C Day Use. The meadows to be monitored in those zones are: Stoneman, Ahwahnee, Cooks, Sentinel, Woskey Pond, Leidig, El Capitan, and Bridalveil. To add to baseline data being collected for the Tuolumne Meadows Concept plan, monitoring was expanded to the Tuolumne Meadows area in 2005, and non-formal trails were mapped in the main meadow areas on the north side of Tioga Road. In 2006, monitoring will include meadows on the South side of Tioga Road, and other areas encompassed by the Tuolumne Wild and Scenic corridor and the Tuolumne Concept Plan. The Standards presented in the User Capacity Management Program were based on 1990 data. It was decided that data on current conditions should be used as the basis for future monitoring. This methodology described will be used to determine current conditions and to monitor them in the future. The standards were revised to develop a more rigorous data set from which future monitoring efforts will be measured.

Original methodology was refined and repeated in 2005 to confirm 2004 mapping results. Particular attention was placed on clarifying condition class definitions. Resulting from workgroups in 2005 and 2006, it has been decided that the *extent* of non-formal trails (as represented by density of non-formal trails) is a more meaningful parameter than solely *length* of non-formal trails because it is relative and allows for cross-meadow comparisons. In 2006, condition classes will again be assigned to all mapped trails, and disturbed areas will be mapped, so that an integrated parameter of “density of disturbed area” can also be achieved. Otherwise, most methodologies will remain consistent with 2005 protocol.

Description of indicator and standard
Indicator: Extent (density) and condition of non-formal trails in the meadows of Yosemite Valley and in the meadows and high use areas of Tuolumne Meadows. These are specific areas of concern due to their location within the corridors of the Merced and Tuolumne Rivers, which have been given the congressional status of “Wild and Scenic”, thereby requiring compliance with the regulations protecting rivers of this designation.

Standard: No net increase in density of non-formal trails when compared with baseline (for Yosemite Valley). Baseline established in 2004 and 2005. In Tuolumne Meadows, 2006 mapping will add to data collected in 2005 to increase baseline dataset. Baseline will be updated as restoration actions are implemented and data is re-collected to reflect restoration efforts. In addition, a range of density threshold values of disturbed areas and trailing will be developed through consultation with professionals specializing in recreation and meadow ecology. The resulting standard will be developed through a combined effort from scientists and park management/planning specialists and will be based on desired conditions associated with particular management zones designed to protect Wild and Scenic River ORV’s.

Zone(s): 2B Discovery, 2C Day Use, and Tuolumne Meadows Concept Plan area.

Rationale for indicator: The extent and condition of non-formal trails is indicative of the contiguity and ecological health of meadows and wetland areas - reflecting part of the biological Outstandingly Remarkable Values of the Merced and Tuolumne River corridors. It is also indicative of impacts to wildlife habitat, including special-status species (biological Outstandingly Remarkable Value). Archeological sites and traditional gathering areas used by American Indian groups exist in some meadows, and could be affected by the proliferation and length of non-formal trails in meadows (cultural Outstandingly Remarkable Values). The proliferation of non-formal trails in meadows may affect visitor experience, as meadows are enjoyable areas in which to engage in a variety of river-related recreational opportunities—including nature study, photography, etc. (recreation Outstandingly Remarkable Value), and non-formal trails may impact the scenic interface of river, rock, meadow, and forest. In this manner, monitoring the length of non-formal trails in meadows also contributes to the protection and enhancement of the scenic Outstandingly Remarkable Value of the river corridor.

Objectives
To document the extent and condition of non-formal trails in meadows of Yosemite Valley and Tuolumne Meadows to further establish baseline data on these impacts and to compare results (where applicable) to data collected in 2004 and 2005. Results will be used to inform management decisions regarding protection of meadow health.

1.2 Sampling Design
Rationale for sampling design: In 2004, a GPS inventory of non-formal trails in the meadows of Yosemite Valley was undertaken. Monitoring was repeated in 2005 to verify results and explore potential factors that could cause variation in collected data (e.g. monitoring post-deer rut, which potentially skewed results; weather variability influencing soil moisture and trailing patterns, etc.). In 2006, investigations in the Valley will be limited to the meadows that exhibited an increase in non-formal trail length between 2004 and 2005 to confirm trends in non-formal trail development. Another meadow will randomly be chosen for monitoring to initiate the long-term monitoring project that will focus on detecting proliferation of non-formal trails. In the future, the random monitoring of meadows, in addition to

monitoring those areas exhibiting trends toward non-formal trail increases, will hopefully suffice to capturing the range of long- and short-term impacts caused by the many activities in these two very busy areas of the park. Full scale inventories of meadows in Yosemite Valley should be completed (through rotation or other procedures) every five years, as annual environmental variability is too high to accurately detect changes in meadow impacts and health over shorter time intervals.

In Tuolumne Meadows, no data existed on non-formal trails until mapping was conducted in the main meadow area (north of Highway 120, east of Pothole Dome, and west of Lembert Dome) in 2005. 2006 monitoring efforts will be focused on expanding this baseline data in high use areas to the east of the Highway 120 Bridge. This inventory of non-formal trails in the Tuolumne meadows areas is needed to create a baseline to which data from subsequent monitoring efforts can be compared. It will also be used in the Tuolumne Meadows Concept Plan planning efforts. Later assessments may involve monitoring selected meadow areas via a sampling scheme similar to the one described above for Yosemite Valley.

Site selection: In Yosemite Valley, meadows showing an increase in non-formal trail length between 2004 and 2005 that will be monitored in 2006 are El Capitan, Cooks, and Stoneman. In addition, Wosky Pond, was selected (using a random number table) to be the first meadow in the Valley on the annual circuit of monitoring. Meadows in the Tuolumne Meadows area encompassed by the Tuolumne Development Concept Plan and Wild and Scenic river corridor may be included in the 2006 monitoring. This may also include heavily used areas near the campground, lodge, and upstream on the Lyell Fork of the Tuolumne River.

Sampling schedule: In Tuolumne Meadows, monitoring will be conducted over a four-week period, between mid-July and mid-August (before the fall deer rut). In Tuolumne Meadows, monitoring will be conducted in August.

1.3 Field Methods

Preparation: Field personnel should be trained (see Training, below) and the following required tools and supplies should be acquired:

- GPS
- Clipboard and pencils
- Notebook
- Measuring tape
- Copy of indicator protocol
- Map of area of interest
- Digital camera
- Photo-documentation sheets (on waterproof paper)
- Pin flags
- Radio
- Water
- Lunch

Data collection and measurement:
Field technicians should travel to the meadow to be monitored, and turn on GPS, so that it can begin to acquire satellites. Follow “Field Instructions” for complete, step-by-step data dictionary procedures.

Non-formal trail classifications should be entered into the GPS as line features, barely discernable trail transitions as point features, disturbed areas less than 200sq. ft as point features (with the area approximated to the nearest 100sq. ft), and disturbed areas greater than 200sq. ft should be delineated with a line feature, later to be transformed to polygons. Identify which of the five different trail classifications should be applied to each section of non-formal trail encountered:

Barely Discernable Trail (point feature)
- Slight evidence of trail feature consisting of disturbed vegetation that has been pushed aside or is lying down, but is too faint to follow with a line feature.
- This may also be where a once discernable trail has now transitioned into a trail that is too faint to follow.

Flattened Vegetation (line feature)
- Distinct trail feature present.
- Light repeated human use evident.
- Vegetation has been trampled and matted down.

Stunted Vegetation (line feature
- Distinct trail feature present.

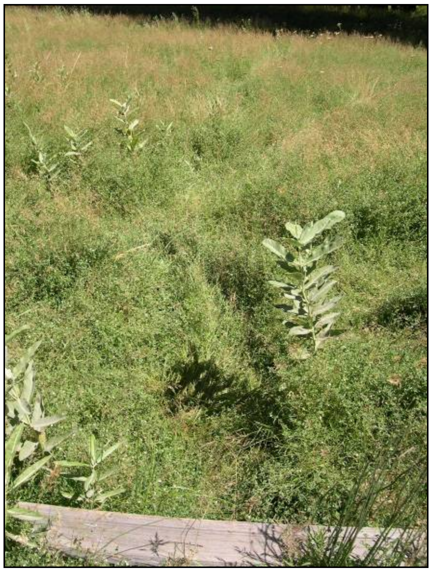
- Moderate repeated human use evident.
- Vegetation has been trampled and matted down AND vegetation growth noticeably impeded.

Some Bare Ground
- Distinct trail feature present.
- Heavy repeated human use evident.
- Vegetation has been trampled and matted down AND vegetation growth noticeably impeded AND some bare ground present in trail tread.
- Vegetation loss in trail tread evident resulting in some bare ground exposure.

Barren Ground
- Distinct trail feature present.
- Extensive repeated human use evident.
- Vegetation has been trampled and matted down AND vegetation growth noticeably impeded AND bare ground present in trail tread throughout.
- Vegetation loss in trail tread extensive, resulting in bare ground exposure throughout.

Examples of non-formal trail features and conditions

Barely Discernable Trail

Non-formal Trail: Flattened Vegetation

Non-formal Trail: Stunted Vegetation

Non-formal Trail: Some Bare Ground

Non-formal Trail: Barren

Disturbed area

General tips for mapping:

For trails identified as barely discernable, enter the location in the GPS unit as a point feature. The point location should be taken at the place where the barely discernable trail started or intersected with another trail. Make a determination on whether the trail was apparently caused by humans or apparently caused by wildlife.

All trail classifications should be entered into the GPS unit with a line feature from beginning to end, or to where that trail became barely discernable, at which time, a point feature should be recorded.

All trails should be mapped, even if they are relatively short.

Trail widths for all trails should be recorded, not just “barren” trails.

Indicate whether braiding is occurring: indicate number of braids and total width of braiding. Map parallel trails separately unless they are densely braided (i.e. within 2ft of each other), in which case, use the “braided’ field.

Indicate whether rutting is occurring and record the rutting depth in inches.

When encountering a disturbed area (high use area exhibiting stunted vegetation to barren characteristics), indicating a high level of use and it is determined that the area is not necessarily a trail, record a point feature in the middle of the disturbed area if it is less than 200ft². Estimate the approximate square footage of the disturbed area and record. If the disturbed area is greater than 200ft², use the "disturbed area" line feature and delineate it as a polygon.

If a trail changes from one classification to another, the first line feature with the first classification should be stopped, and another line feature with the new classification started. If the new trail segment's classification extends for less than 25 feet, the change in classification should be disregarded, and the original line feature continued. Similarly, if a barren trail's width changes dramatically (greater than 6 inches), a new line feature should be started with the new barren width recorded. Again, if a trail with a new barren width continues for less than 25 feet, the original line feature should be continued.

GPS mapping of trails in El Capitan meadow will be replicated by two different people, to ensure quality control of monitoring practices (i.e. a trail that one person is calling "barren" is also being called "barren" by another technician).

DATA DICTIONARY FIELDS

For all features:

- **Meadow Name:** Record the name of the meadow being monitored (in Yosemite Valley)
  1) El Capitan
  2) Wosky Pond
  3) Cooks
  4) Stoneman

- **ID number:** unique value for each trail (automatically generated)

- **Date:** automatically generated

- **Time:** automatically generated

- **Comments:** enter any comments you have about the feature, or if unique conditions exist (e.g. trash, large group of people in area, etc.)

***The following fields are unique to each specified feature**

Non-formal Trail (Line Segment):

- **Classification**: Record condition class of trail:
  1) Flattened Vegetation
  2) Stunted Vegetation
  3) Some Bare Ground
  4) Barren

- **Width**: Record the width of the trail to the nearest 6in.

- **Source:** Record whether the trail appears to caused by wildlife, humans, or origin unknown

- **Braiding:** Indicate whether braiding is occurring

- **Braiding width:** Indicate the total width of the braiding complex in feet

- **Rutting:** Indicate whether rutting is occurring

- **Rutting depth:** If rutting is occurring, indicate the rutting depth in inches

Barely Discernable Trail (Point Feature):

- **Source:** Record whether the trail appears to be caused by wildlife, humans, or origin unknown

Disturbed Area <200ft² (Point Feature):

- **Approximate size in square feet**: Record the approximate size of disturbed area

Meadow Boundary (Line feature): Delineate meadow perimeter. This task was executed in 2004 and repeated in 2005, finding little variability between the two years. For this reason, the meadow boundaries will not be re-mapped in 2006, but this task should be completed every five years

Disturbed Area Boundary (Line Feature): Delineate a polygon when the disturbed area is >200ft². These will later be converted to polygons in GIS.

Post-collection and processing: Each day following field work, technicians will return to the Vegetation and Restoration office to download the GPS (see "Downloading GPS" instructions), download photos, update photo-documentation and time spent records, and charge camera batteries.

End of season procedures: Following completion field work, data will be managed properly (see Data Management section), and a report will be compiled.

1.4 Data Management

Data entry: GPS data will be downloaded at the end of each day, and these files will be converted to GIS shapefiles for mapping purposes. All photos shall be given file names with the date collected and the condition class (e.g. 071306_barren). These photos shall be imported into a word document for photo-documentation and annotated with the day's notes. Time spent will be entered into the "time spent" word file, with a description of the work completed that day.

Data analysis: GIS data will be converted into maps depicting non-formal trails in the areas being monitored and calculations in ArcGIS 9 on non-formal trail features and meadow polygons will be completed to achieve non-formal trail density results.

Data reporting: Maps, non-formal trail density, and other data will be formalized in the 2006 VERP Report.

Data storage (meta-data): All GPS data (Trimble files) will be stored in ms01/EP Resources/Restoration Program Commons/GPS Data/VERP/2006/Non-formal Trails/Valley or Tuolumne. All GIS shapefiles will be stored in ms01/EP Resources/Restoration Program Commons/GIS Data/VERP/2006/Non-formal Trails/Valley or Tuolumne. All photos will be stored in ms01/EP Resources/Restoration Program Commons/VERP/2006/Non-formal Trails/Valley or Tuolumne/Photos

1.5 Personnel Requirements and Training

Roles and responsibilities (tasks and time commitments): A Supervisory GS-7 will be responsible for oversight of field work in Yosemite Valley, GPS mapping of non-formal trails in Tuolumne Meadows, downloading GPS data from Tuolumne Meadows, creating ArcGIS maps of results, management of GIS files and mapping, training of field personnel (GPS procedures, condition class assessment procedures, etc.), and report writing. GS-6 support personnel will serve as the point of contact for the field technician in Yosemite Valley on a day-to-day basis. The field technician will be responsible for the mapping of non-formal trails in the designated sites within Yosemite Valley, downloading the GPS, and maintaining accurate and complete records of field work.

Projected time commitments are as follows:

- Supervisory GS-7: one week for training supporting and field personnel and refining protocol, 3-4 weeks for GPS mapping of trails in Tuolumne Meadows, and three weeks for mapping and reporting
- Supporting GS-6: total of 4-6 hours per week of oversight for field tech
- Field technician (i.e. SCA intern): three to four weeks for monitoring non-formal trails in selected areas of Yosemite Valley

Qualifications: Supervisory GS-7 should be knowledgeable with the VERP program, VERP Non-formal Trails protocols, and condition class assessments. They should also be comfortable in a supervisory role and should have background in the natural sciences or resources/recreation management. The supporting GS-6 should also hopefully have experience in the fields mentioned above, be able to communicate well, and be comfortable in a leadership position. The field technician should also hopefully have experience in the fields mentioned above, as well as have the ability to pay attention to detail, follow instructions, work independently, and successfully operate a GPS and computer software for downloading and documentation.

Training procedures: Vegetation and Restoration Management staff with experience conducting non-formal trail surveys will be responsible for training any NPS staff or volunteers without prior monitoring experience. NPS staff and volunteers will be required to demonstrate the ability to:

- Ability to navigate to target sites at meadows.
- Operate a GPS device.
- Download GPS data (see attached instructions), as well documentation of time spent and photos taken using the proper forms

These skills will be verified through field training and assistance of qualified Vegetation and Restoration Management staff.

1.6 Operational Requirements

Work plan: Protocol refinements conducted prior to field season in April, May, and June over a one-week total time period. Field work conducted Mid-July through mid-August in Yosemite Valley and in August in Tuolumne Meadows on the following schedule:

Yosemite Valley:

- Week 1 (field tech and GS-7 term): training and quality assurance
- Week 2-4 (field tech): mapping and assessments of non-formal trails and disturbed areas in El Cap, Cooks, Stoneman, and Wosky Pond meadows
- End of week 4 (field tech): mapping disturbed areas found in 2005 (where only point features were taken)
- Mapping and reporting conducted over a two-week time period following field work.

Tuolumne Meadows:

- Week 1-2 (GS-7 term): mapping and assessments of non-formal trails in areas near Tuolumne Campground, south of Highway 120 bridge (areas north of bridge were mapped in 2005)
- Week 2-3 (GS-7 term): mapping and assessments of non-formal trails in areas upstream from 120 bridge on Dana Fork
- Week 3-4 (GS-7 term): mapping and assessments of non-formal trails in other areas encompassed by the Tuolumne Development Concept Plan and other high use areas (e.g. Cathedral Lakes trailhead, Tuolumne Lodge area)
- Mapping and reporting will be conducted over a one-week time period following field work.

Table X. Projected work plan.

VERP Indicator Monitoring Work Plan															
ID	**Task**	**Deliverable**	**Responsible**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1.0	**Planning and Development Phase**	**Field Monitoring Guide**	**VERP Planning Team**												
1.1	Monitoring protocol development		VERP Team												
1.2	Conduct development workshop		VERP Program Manager												
1.3	Obtain data collection permits and conduct appropriate compliance		VERP Program Assistant / Field Staff												
1.4	Acquire data collection instruments		VERP Program Assistant / Field												
1.5	Select and prepare sampling locations		VERP Team												
1.6	Field test data collection methods and		Field staff												
1.7	Conduct public meeting on indicator planning and development		VERP Program Manager												
2.0	**Implementation Phase**	**Data and Information**	**VERP Implementation**												
2.1	Conduct field data collection		Field staff												
2.2	Conduct quality control checks of data collection		VERP Program Assistant												
2.3	Enter data including		Field staff												
2.4	Conduct public meeting on data collection efforts		VERP Program Manager												
3.0	**Reporting Phase**	**Annual Report**	**VERP Management Team**												
3.1	Data analysis		VERP Team												
3.2	Prepare annual report		VERP Team												
3.3	Conduct evaluation workshop		VERP Program Manager												
3.4	Conduct public meeting on monitoring results		VERP Program Manager												

Safety: A job hazard analysis has been completed for this indicator. See table below (Table X).

Table X. Job Hazard Analysis for VERP Extent and Condition of Non-formal Trails

United States Department of Interior NATIONAL PARK SERVICE	**1. WORK PROJECT/ACTIVITY**	**2. LOCATION**	
	VERP Non-formal Trail Monitoring	Yosemite Valley and Tuolumne Meadows, YNP	
Job Hazard Analysis (JHA)	**3. NAME OF ANALYST**	**4. JOB TITLE**	**5. DATE PREPARED**
	Crystal Elliot	Technician	June, 2006

6. TASKS/PROCEDURES	7. HAZARDS	8. ABATEMENTS ACTIONS ENGINEERING CONTROLS – SUBSTITUTION – ADMINISTRATIVE CONTROLS – PPE
a. Driving to, from, and around sampling sites.	a. Collision resulting in damage, injury, or death.	a. Drive defensively, obey traffic laws, lights on, seatbelt on, be alert for pedestrians, wildlife, and distracted drivers. Know procedures for installing snow chains. Always carry and know how to use a Park radio.
b. Hiking through and working in meadows.	b. Inclement weather, heat, dehydration; poison oak; insects and snakes.	b. Dress appropriately, drink plenty of fluids, bring snacks and/or meals if out during lunch hours, carry first-aid kit including snake-bite kit and Tecnu, in case of contact with poison oak. An Epy pen may be necessary to carry as well.
c. Working and walking along riverbanks.	c. Tripping and/or falling due to wet and slippery rocks or sloping ground surfaces, contact with poison oak, etc.	c. Watch footing, know how to identify and avoid all poison oak, rinse immediately in stream if contact occurs.
d. Working outdoors in hot, dry conditions.	d. Dehydration, heat exhaustion.	d. Stay hydrated. Take frequent breaks if weather is uncomfortably warm. Use sun protection (e.g. hat).
e. Working outdoors in cold and/or wet weather.	e. Hypothermia, reduced resistance to illness.	e. Stay dry. Use rubberized raingear if possible. Stay hydrated preferably with warm liquids. Stop work to warm up if necessary. Snack often.
10. SUPERVISORS SIGNATURE	**11. TITLE**	**12. DATE**

Compliance Section: A Scientific Research and Collecting Permit for this indicator was granted on June 16, 2006.

Equipment and materials: see "Preparation" in the Field Methods section

Budget:

- Term GS-7: 8 weeks at $1000/wk=$8000
- Seasonal GS-6: 2 weeks (distribution of 4-6hr/wk over course of season) at $750/wk=$1500
- Volunteer field staff (e.g. SCA): 4 weeks at $375/week = $1500
- Vehicles: 2 vehicles for 1.0 months at $650/mo = $1300
- Equipment and materials: $200 (assuming that GPS units do not need to be purchased)

Total = $12,500

1.7 References

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