

Trail Condition Monitoring

Boulder Open Space and Mountain Parks

West Trail Study Area



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Trail Condition Monitoring Report
West Trail Study Area

Background & Intent

Boulder's Open Space and Mountain Parks (OSMP) department manages over 140 miles of designated trails. OSMP lands receive an estimated 5.3 million visits each year (OSMP 2005). Trends indicate that visitation will continue to increase into the future (OSMP 2004). Existing and increasing levels of visitation are high enough to result in significant wear and tear on the trail system. OSMP seeks to have well designed and maintained trails to minimize impacts to resources and visitors. When trail conditions become degraded, they can decrease the quality of the visitor experience, and adversely affect natural resources.

One of the goals of the OSMP Visitor Master Plan (VMP) is to ensure that the designated trail system provides a high quality visitor experience while protecting and preserving environmental resources (Page 6). To achieve this goal, it is essential to provide and maintain a sustainable trail system. The VMP calls for annual designated trail condition monitoring (Page 61).

Trail condition monitoring identifies portions of trail segments that are out of compliance with OSMP developed guidelines for sustainability (Attachment A), documents the location and condition of constructed features and provides management recommendations or prescriptions for trail maintenance and sustainability. The purpose of this monitoring project was to assess the compliance of trails within the West Trail Study Area (West TSA) against these guidelines.

This monitoring report provides information to assist OSMP managers in the strategic allocation of staffing and resources, and to prioritize trail maintenance projects. Trail monitoring also describes the condition of trails and trail features, enabling OSMP to document and communicate the extent and location of regular trail maintenance needs. This information can be used in conversations with the Open Space Board of Trustees, City Council and interested members of the community.

Methods¹

Trails were divided into segments based upon their combined *trail class* and *designed use* (Appendix A). Trail class refers to a trail's level of development and designed use refers to the one allowed trail use for which the trail is designed, built and maintained. Each segment was visited in the field. OSMP staff measured trail parameters (Table 1) and compared the measurements to trail sustainability guidelines for a given trail class and designed use. Sections of the trail out of compliance with guidelines require maintenance or, in some cases, a more significant response such as reconstruction.

In addition to measuring characteristics related to the trail guidelines, OSMP also collected information about maintenance issues (Table 1) such as drainage problems, erosion and trail braiding. These were detected by direct observation of evidence such as muddy areas, gullies and loose rocks. The department has a zero tolerance standard for erosion, drainage problems or trail braiding because they are undesirable *wherever* they occur and always require management.

For ease of communication, the term “**area of concern**” refers to portions of trail that are either out of compliance or exhibit maintenance issues. The following table lists the indicators that were monitored to identify areas of concern.

Table 1: Trail Characteristics and Maintenance Issues

Trail Characteristics	Maintenance Issues
Trail grade	Drainage
Tread width	Erosion
Outslope	Braiding
Clearing width, height	
Surface material	
Turn radius	

Staff also inventoried and evaluated constructed features as part of this project. Constructed features are human-made structures designed to help maintain a trail's sustainability, by diverting water, retaining sediment, or raising the level of the tread. Examples include retaining walls, turnpikes, bridges, waterbars, steps, or culverts. Constructed features condition classes are described in Table 2 (USFS 2001). Each feature was documented and the condition of each feature was recorded.

¹ A detailed protocol for trail condition monitoring is available upon request from the OSMP department.

Table 2: Condition Classes and Descriptions for Constructed Features

Condition Class	Description
Routine Maintenance	Feature is FUNCTIONING WITHIN STANDARD as designed and is within normal maintenance cycle (generally at a cost of less than 20% of replacement)
Repair/Rehab	Feature is in DISREPAIR , may or may not be useable, but needs to be repaired to bring feature to standard (generally at a cost between 21% & 50% of replacement)
Replace in-kind	Feature is DYSFUNCTIONAL and beyond it's designed lifecycle or has deteriorated to a point where unable to perform as designed or constructed (generally at a cost of over 51% of new construction and includes demolition and removal of existing)
Decommission	Feature is NOT NEEDED for the operation of the trail or is inappropriate for the setting and should be removed from system with no replacement planned.
Expansion	Feature is basically functioning as designed but is UNDERSIZED . Would typically be lengthened or widened, but in some cases size may be reduced.
Alter Function	Modify feature to CHANGE FUNCTION to either increase capacity, change function, or durability.
Install New	NEW Feature is needed.

Trail condition monitoring was conducted in the **West Trail Study Area (TSA)** (for a map of the TSA, see Figure 1) from March to August of 2008. Database development time for this project was a one-time cost shared across all TSA planning projects. Estimates of time to complete monitoring are given below:

Preparation:	45 days - Trails Management Framework and Protocol development (one time) 4 days - Data dictionary and TMO development (Trail Design Guidelines) (one time) <hr/> Subtotal: 49 days
Fieldwork:	45 days - Survey West TSA (110 trails ~ 75 miles) <hr/> Subtotal: 45 days
Post-processing:	10 days - GPS export to GIS, editing 5 days - GIS map production 1 day - database reporting <hr/> Subtotal: 16 days
GRAND TOTAL	110 days = 24 weeks inclusive 61 days for West TSA specific work

West TSA

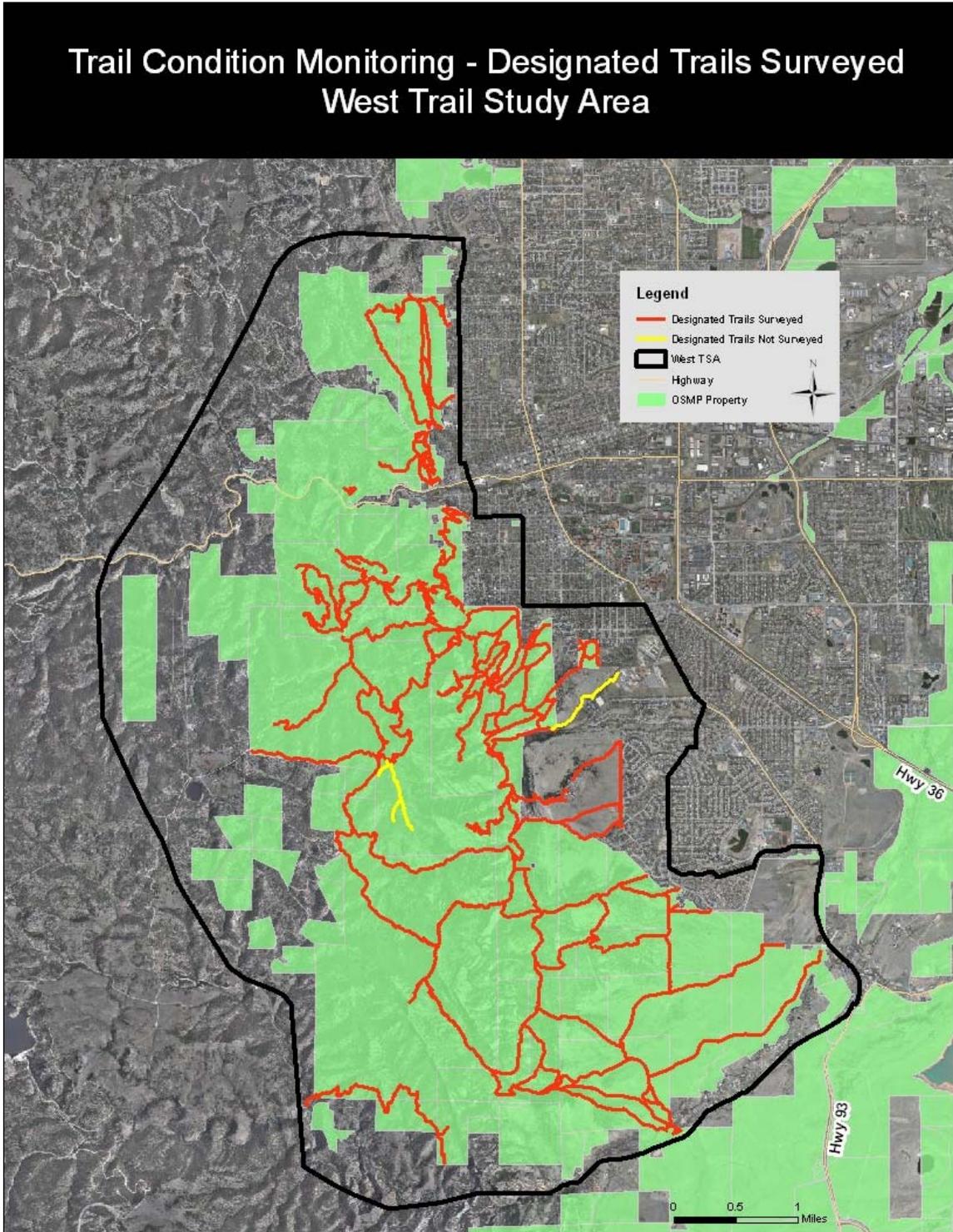


Figure 1: Designated trails surveyed for trail condition monitoring in the West TSA.

Results

Trail Condition

OSMP divided the West TSA into six smaller subareas (see Attachment C). Trail segments within these subareas are described in further detail in the West TSA Subarea Report.

Due to the overwhelming amount of time needed to produce individual maps of trail segments showing areas of concern and constructed features (included as appendices in the other TSA Trail Condition Reports), these maps were not produced, instead analysis was conducted to produce a map showing a more generalized view of trail condition (see Attachment B).

Approximately seventy-three miles of trail were surveyed in the West TSA. Forty-two percent of this trail mileage (30.7 miles) was identified as either out of compliance with sustainability guidelines or exhibiting other maintenance issues.

Trail segments for which at least 75% of their total length were identified as areas of concern are shown in Table 3. Percentages were determined as the total length of non-compliance and maintenance issue portions along a trail segment divided by the total length of that trail segment. Since non-compliance and maintenance issue portions may co-occur, the percentage can exceed one hundred percent.

Table 3: Trail segments in the West TSA where areas of concern were recorded for at least 75% of the segment length (see text for description).

Trail Name	TrISegID	Percent of Trail Segment Length with Areas of Concern
East Ridge	293.01	144%
Red Rocks Spur	308.09	135%
Goat Trail	291.02	127%
Fern Canyon	223.02	124%
Green Mountain West Ridge	228.02	120%
Red Rocks Spur	308.06	119%
Saddle Rock	267.01	112%
Royal Arch	257.01	109%
Green Mountain West Ridge	228.01	104%
Shanahan - Mesa	222.01	103%
Amphitheater	263.01	102%
Goat Trail	291.01	102%
Red Rocks Spur	308.02	93%
Ranger	269.01	91%
Gregory Canyon	266.01	85%
Dakota Ridge	290.02	85%
Mesa Connector	306.01	82%
N.C.A.R. Trail	235.05	81%
Four Pines	292.01	80%
Serpentine	258.01	80%
Red Rocks Spur	308.08	79%
N.C.A.R. Trail	235.03	78%
Red Rocks Spur	308.01	78%
Lehigh Connector - North	220.01	76%
Crown Rock	282.01	75%

There are approximately 180 trail segments in the West TSA. Figure 2 shows the number of trail segments exhibiting areas of concern within certain percentage ranges.

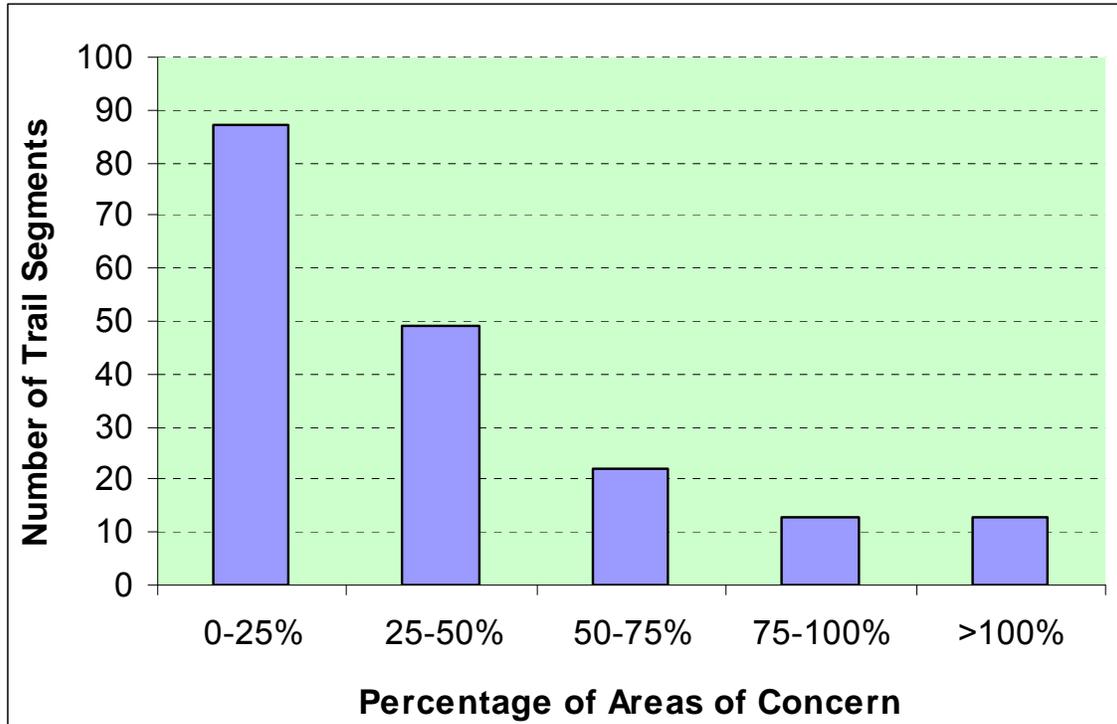


Figure 2: Number of trail segments within percentage ranges of areas of concern.

OSMP staff developed a ranking system based upon the percentage of the trail that is designated as an area of concern. In this system “Good” refers to trail segments which exhibit areas of concerns along less than 25% of their total segment; “Fair” means approximately 25% to 75% of the segment length exhibits an area of concern; “Poor” means 75% to 100% of the segment length exhibits an area of concern; “Very Poor” means there are overlapping areas of concern and summing to a coverage of greater than 100% of the trail segment. Attachment B contains a map showing the condition by color for the trail segments in the West TSA.).

Trail grade was responsible for over 80% of the non-compliance (Figure 3a). The total length of all non-compliant trail grade portions was fifteen miles. This is twenty-one percent of the trail system in the West TSA. These issues occurred mostly in the mountain backdrop and canyons where the terrain is steep and confined. However, many grade issues also occur on gentler terrain as well.

Tread width accounted for 14% of the non-compliant portions. The total length of all non-compliant tread width portions is two and a half miles. Most of these width issues are likely due to the tread being located on old roadbeds.

Figure 3 shows the factors most responsible for non-compliance with sustainability guidelines.

Maintenance issues were identified totaling 12 miles of trail in the West TSA. Erosion was the primary problem identified. Erosion was noted as a problem for about nine miles of trail or twelve percent of the West TSA trail system. Most eroded portions occur in the following areas: Kohler Mesa, mountain backdrop, Flagstaff Road area, Red Rocks and Mount Sanitas. Most eroded sections co-occur with areas that are too steep. Figure 3b shows the relative proportion of different types of maintenance issues and highlights the significance that erosion represents in the TSA.

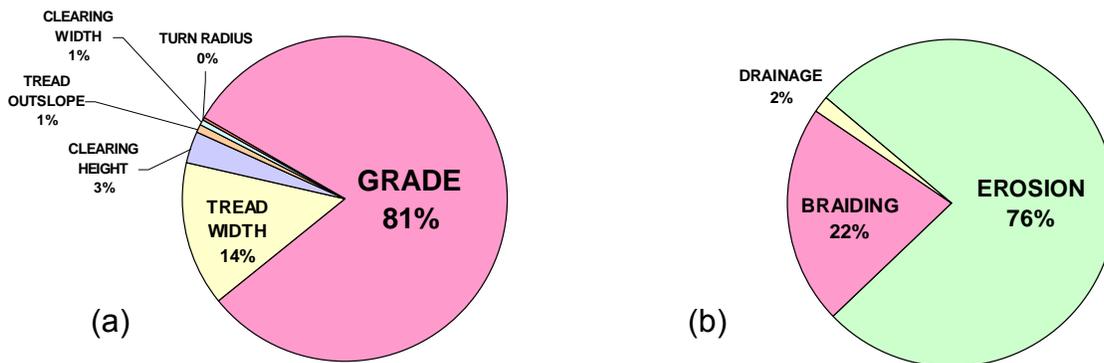


Figure 3: (a) Contribution of various trail sustainability factors to **non-compliance** in the West TSA. (total distance of trail out of compliance = 97,562ft or 18.5 miles)
 (b) Contribution of various **maintenance issue** categories in the West TSA. (total distance of trail with maintenance issues = 64,344ft or 12.2 miles)

Constructed Features

A total of 4,295 constructed features are associated with trails in the West TSA. Thirty percent of these features are natural waterbars, 20% are rock steps, 15% are stacked rock retaining walls, 10% are log steps, 10% are rock waterbars and the remaining 15% are other features. Figure 4 shows the condition class distribution of the constructed features associated with trails in the West TSA. Three-fourths of the features are functioning within standard. Thirteen percent of the features are in need of repair. The bulk of the features in need of minor repair are natural and rock waterbars which need extensive rehabilitation. Also, various rock and log steps and stacked rock retaining walls are in need of repair. Many have loose logs and/or rocks and need to be secured. The major features recommended to be installed are natural waterbars and steps to assist with grade or erosion issues associated with certain trail segments.

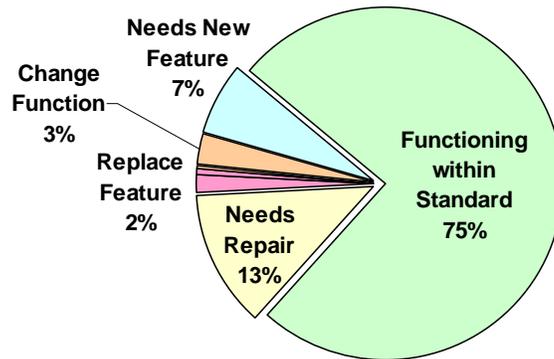


Figure 4: Condition class of constructed features in the West TSA.

Discussion

Trail condition

Although popular among visitors, the trail system in the West TSA is not sustainable and is in poor condition. The situation is due to a variety of factors including the steep terrain, erodable substrate, lack of sustainable trail design, high levels of visitation and insufficient maintenance. Conditions are worst on heavily used trails in steep terrain.

Restoring the trail system to good or acceptable condition will require that OSMP:

- Address the underlying environmental constraints of grade and substrate
- Address high levels of visitation
- Overcome preferences for past practices, especially using routes that are not sustainable

Past management has focused upon fixing the symptoms, rather than these root causes (e.g. install stairs rather than re-route trail). Unfortunately, but predictably, these efforts have been inadequate to address the key issues, expensive to implement, and costly to maintain. To make matters more serious, the rate of trail condition degradation is likely to quicken over time. The initial effects of erosion or widening tend to lead to greater erosion or trail widening as part of a positive feedback loop, or self-reinforcing “vicious circle”. OSMP will need to take significant action to improve trail condition in the West TSA.

Recommended reroutes or major re-construction locations are discussed in the West TSA Subarea Report.

Seventy-three miles of designated trails in the West TSA were surveyed to assess trail condition. Forty-two percent of this trail system is either out of compliance with standards or exhibits other maintenance issues! A total distance of thirty-one miles falls into an area of concern. Roughly a quarter of all trail segments in the West TSA include areas of concern for at least half their length.

There are several possible explanations for the extensive poor conditions of trails in the West TSA. First, much of the trail system was never designed for long-term sustainability. Many, if not most trails came about because of repeated travel along game trails and temporary roads used for forestry and quarrying. Other trails in the TSA were established to access climbing routes as quickly as possible. Trails constructed by civic groups served specific destinations (view points, natural features of interest, etc.) but typically were not designed with an understanding of sustainable trail design and engineering. Many trails in the West TSA are not in sustainable locations. They are either located on the fall line or in a drainage or along the ridgeline, instead of a more sustainable location along the hillside.

In addition to the lack of design, the West TSA is characterized by steep grades and highly erodable substrates. Under these conditions, trails built without appropriate design and engineering are especially vulnerable to degradation. A third factor responsible for the poor trail condition is the high level of visitation. Wear and tear to trails is directly related to the amount of foot/hoof traffic. The West TSA receives considerable year round activity. Lastly, the trails in the West TSA have not been regularly maintained. Extended periods of low, or no routine maintenance have resulted in accelerated degradation of trails in West TSA—especially in steep, highly erodable areas where visitation levels are high.

The trail segments with the highest percentages in areas of concern are generally, located along the mountain backdrop. Trail grades are commonly very steep and erosion issues are more frequent. Consequently, many of these trail segments are associated with significant resource damage. For example, some of the highest proportions of area of concern are found on the trails in the Red Rocks and Mount Sanitas areas. High levels of visitor activity have overwhelmed Open Space and Mountain Parks ability to maintain the trails in these areas, and resource damage occurs in these areas.

A tremendous amount of work has gone into trying to make this trail system sustainable. Thousands of rock and log steps and other structures have been installed on sections prone to erosion. Consequently, many trails have become steep staircases. The investment in a trail system heavily dependent upon constructed features is not only time consuming and costly to construct, it is similarly expensive to maintain.

Attachments

- A. Trail Design Standards
- B. Trail Segment Condition
- C. West TSA subareas

Literature Cited:

City of Boulder Open Space and Mountain Parks (OSMP). 2005 Visitor Master Plan. Accessed 6/19/2007.

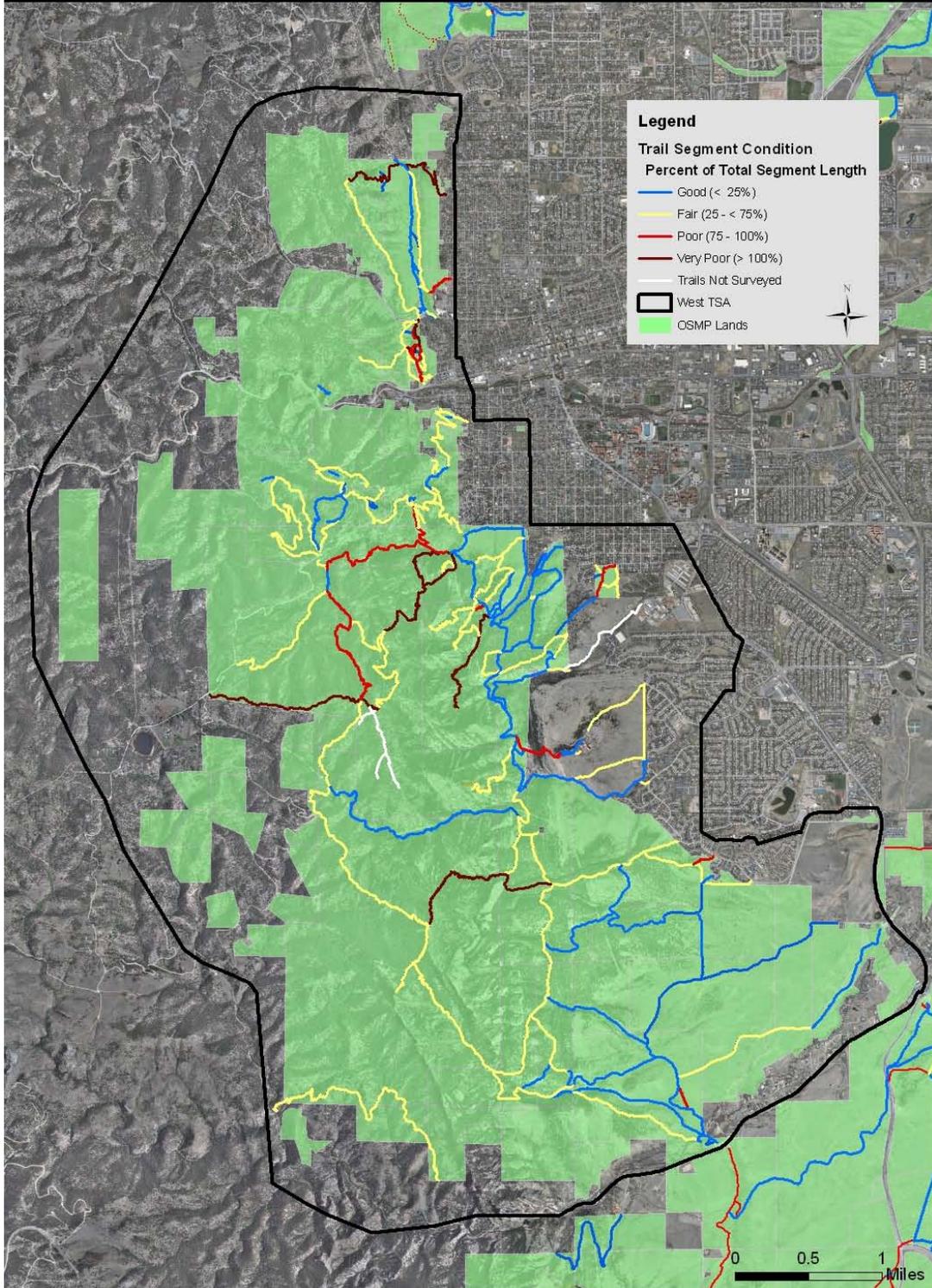
United States Forest Service (USFS). 2001. Makin' TRACS, Forest Service Guide to Trail Assessment and Condition Surveys. Accessed 6/19/2007.

Attachment A: Trail Sustainability Guidelines

		Trail Design & Management Guidelines Matrix													
		X-Slope Range	Tread Width	Max. Sustained Grade	Max. Sustained Outslope	Clearing		Turn Radius	Surface Materials						
						Width	Height		Natural	Gravel	Crusher	Roadbase	Concrete	Asphalt	
Accessible		0-50%	>=3'	8.33%	<2%	8'	8'	4'	ok	No	ok	ok	ok	ok	
Class 5 <i>Fully Developed</i>	Hiking	0-30%	3-5'	8%	<=5%	6'	8'	2'	ok	ok	ok	ok	ok	ok	
	Biking	0-30%	3-8'	8%	<=5%	10'	10'	6'	No	ok	ok	ok	ok	ok	
	Equestrian	0-30%	3-8'	8%	<=5%	10'	10'	8'	No	ok	ok	ok	No	No	
	Official Vehicle	N/A	8-10'	8%	<= 8%	28-40'	12'	10-12'	No	ok	ok	ok	ok	ok	
Class 4 <i>Highly Developed</i>	Hiking	0-50%	2.5-5'	10%	<=5%	6'	8'	2'	ok	ok	ok	ok	No	No	
	Biking	0-50%	3-8'	8%	<=5%	6-10'	10'	6'	ok	ok	ok	ok	No	No	
	Equestrian	0-50%	3-8'	8%	<=5%	6-10'	10'	8'	ok	ok	ok	ok	No	No	
	Official Vehicle	N/A	8-10'	6%	<= 6%	28'	12'	10-12'	No	ok	ok	ok	ok	ok	
Class 3 <i>Developed/ Improved</i>	Hiking	0-75%	1.5-3'	15%	<= 8%	4-6'	8'	2'	ok	ok	ok	ok	No	No	
	Biking	0-75%	1.5-5'	12%	<=5%	4-6'	10'	6'	ok	ok	ok	ok	No	No	
	Equestrian	0-75%	1.5-6'	12%	<=5%	6'	10'	8'	ok	ok	ok	ok	No	No	
	Official Vehicle	N/A	8-10'	6%	<=5%	12'	10'	10-12'	ok	ok	ok	ok	No	No	
Class 2 <i>Minor Development</i>	Hiking	0-75%	1.5-2.5'	15%	<=10%	4'	8'	2'	ok	No	No	No	No	No	
	Biking	0-75%	1.5-3'	12%	<= 8%	4-6'	10'	6'	ok	No	No	No	No	No	
	Equestrian	0-75%	1.5-2.5'	12%	<= 8%	6'	10'	8'	ok	No	No	No	No	No	
	Official Vehicle	N/A	8-10'	5%	<=5%	10'	10'	10-12'	ok	N/A	No	No	No	No	
Class 1 <i>Primitive/ Undeveloped</i>	Hiking	0-90%	1.5-2'	15%	<=10%	N/A	N/A	2'	ok	No	No	No	No	No	
	Biking	0-90%	1.5-2'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	N/A	N/A	
	Equestrian	0-90%	1.5-2'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	No	N/A	N/A	
	Official Vehicle	N/A	8-10'	4%	<= 3%	N/A	N/A	10-12'	ok	N/A	No	No	No	No	
Climbing Access	Climbing	N/A	0-2'	N/A	<=15%	N/A	N/A	N/A	ok	No	No	No	No	No	
Trail Design Parameters provide guidance for the assessment, survey and design, construction, repair and maintenance of trails, based on the Trail Class and Designed Use of the trail.															
Exceptions and variances to these parameters can occur when site-specific circumstances demand such exceptions. These exceptions should be noted in the TMO for the trail.															
* Accessible is currently a separate Trail Class. If assessing/designing trails for accessibility, refer to current Agency trail accessibility guidance.															
Finalized 12/04/07															

Attachment B: Trail Segment Condition

Trail Segment Condition - West Trail Study Area



Attachment C: West TSA subareas

West Trail Study Area - subAreas

