

Undesignated Trail Monitoring Report

2019-2023 Survey



Prepared by Jake Engelman
City of Boulder Open Space and Mountain Parks
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Individually, and collectively, we thank you.

Executive Summary

Undesignated trails are pathways created by repeated visitor use that are sometimes referred to as social, unauthorized, informal or rogue trails. City of Boulder Open Space and Mountain Parks (OSMP) staff have completed four rounds of systemwide monitoring since adoption of the 2005 Visitor Master Plan (VMP) which directed staff to conduct extensive monitoring. This report presents the results of the 2019-2023 survey effort and evaluates trends from past surveys. Undesignated trails and roads were surveyed by recording GPS points at 200ft intervals and when pathway attributes changed. Information collected at each point includes condition, function, pathway type, and a photograph.

Key findings:

- 117.7 miles were recorded in the 2019-23 Survey:
 - 98.4 miles were classified as undesignated trails
 - 9.4 miles were classified as undesignated trails/roads
 - 9.8 miles were classified as undesignated roads
- The total mileage has decreased by 60 miles since 2012 and 45.8 miles since 2018. Accounting for reclassified mileage, the decrease in mileage is still significant at 29 and 14 miles respectively.
- 55.4 miles are classified as high impact, meaning there is no vegetation cover and active erosion.
- In addition to the total undesignated trail mileage, 340 concentrated-use areas were identified. These are sites that are heavily impacted and where significant areas of vegetation have been impacted and erosion observed.

Background

Trails are a critical infrastructure component of protected areas. Well-designed and well-managed trails provide surfaces that can sustain substantial traffic and minimize visitor impact by concentrating traffic onto durable surfaces (Wimpey & Marion, 2011; Soulard, 2017). Designated trails are designed and constructed to support recreational use while limiting impacts on natural and cultural resources. Repeated trampling, soil destabilization, and loss of vegetation and topsoil from undesignated pathways can impact vegetation and lead to a further fragmented and impacted land system. The creation of undesignated trails (UTs) can also contribute to confusion among visitors, leading to further use and impact in areas not designed for visitor travel. On the other hand, undesignated trails and roads can also reveal unserved destination points that could be designed into the designated trail system. The City of Boulder Open Space and Mountain Parks (OSMP) aims to sustainably design and manage designated trails to support safe and enjoyable recreational use and limit impacts on natural and cultural resources.

Plan Guidance and Past Undesignated Trail Monitoring

The 2005 Visitor Master Plan (VMP) established standards for several key community initiatives and services that support and enhance visitors' experiences and protect the natural values of the Open Space and Mountain Parks lands. The VMP called for ongoing undesignated trail monitoring to be completed every five years with a proposed standard of less than 50 miles of undesignated trails systemwide and 0 new miles created between surveys.

OSMP has been monitoring undesignated trails since 2002, with comparable monitoring methodologies used in the 2011-12 (2012), 2017-18 (2018), and 2019-23 undesignated trail surveys. Prior to 2019, both designated and undesignated trail monitoring were conducted as two-year projects intended to be repeated every 5 years. In 2019, the monitoring cycle was updated to survey a fifth of OSMP lands each year to be repeated every 5 years. This change allows staff to better apply monitoring results to management decisions.

The more recent 2019 OSMP Master Plan also includes two priority strategies in the Ecosystem Health and Resilience Focus Area aimed at managing undesignated trails:

- **REDUCE UNDESIGNATED TRAILS (EHR4):** Guided by best practices or area-specific plans, mitigate resource impacts by restoring, designating, re-routing, or recategorizing undesignated trails, especially in sensitive habitat areas while considering appropriate routes to serve desired destinations for visitors.
- **EXTEND ON-TRAIL REQUIREMENTS (EHR5):** Through future area planning, reduce off-trail travel in targeted locations, especially in sensitive habitat areas.

Guidance from the Master Plan emphasizes managing visitor travel and reducing the overall extent of undesignated trails on the OSMP system. This report aims to provide reliable data to inform future trail planning and prioritization of restoration efforts and to evaluate management techniques' effectiveness.

Methods

The 2019-23 undesignated trail survey was designed to detect changes in extent and condition over time compared to the 2012 and 2018 undesignated trail surveys. The inventories have all used the same criteria to define undesignated trails and reduce inter-observer variability. The 2019-23 survey introduced minor changes to the protocol to further improve the understanding and management of undesignated trails while maintaining methods that allow for the comparability of results from the 2012 and 2018 surveys. An important note should be made that some roads mapped as undesignated in the 2012 and 2018 surveys were determined to be important service roads to various agricultural and other key OSMP management activities and were reclassified as permanent (non-trail) authorized vehicle access roads before the 2019-23 inventory. These roads were not mapped as undesignated in the 2019-23 survey and thus represent a significant change in the results.

Data Collection

The survey used an EOS Arrow 100 GPS antenna connected by Bluetooth® to a cell phone using the ESRI Field Maps Application. The Arrow 100 GPS unit provides sub-meter accuracy and real-time differential correction. The survey utilized Avenza Maps® to track a background line to help digitize undesignated trail alignments and accurately depict undesignated trails' alignment. Points were collected any time the trail had a change in condition, width, or pathway type. If width, condition, and pathway type remained constant, points were collected at 200-foot intervals. Each data point includes an attached photo depicting the tread conditions of the trail. A related table stored the photos for ease of reference. The 2012 survey utilized a Trimble GeoXT GPS unit to collect data, and the 2018 survey utilized a Trimble R1 GPS antenna to collect data. The 2012 and 2018 surveys collected data as points and later digitized them into lines. Undesignated pathways are defined as:

- An **Undesignated Trail** is a continuous linear or curvilinear pathway on the landscape that:
 1. Is not a designated trail;
 2. Is greater than 20 feet long;
 3. Has a continuous trail boundary on the earth's surface (i.e., the width of disturbance stays relatively constant rather than appearing to be a series of foot, paw, or hoof prints); and
 4. Has evidence of repeated use.
- An **Undesignated Road** is a continuous linear or curvilinear pathway on the landscape that:
 1. Is not a designated trail or designated road;
 2. Is greater than 20 feet long;
 3. Is wide enough to accommodate a vehicle;
 4. Is connected to an access point that accommodates vehicles or to another drivable pathway (includes those off OSMP property);
 5. Is drivable or drivable with "some" maintenance and
 6. Has evidence of repeated vehicle use.

- An **Undesignated Trail/Road** is a pathway type that primarily meets the criteria for an undesignated trail but has some evidence of vehicle use.

The 2012 survey classified trail/road pathway types by the presence of continuous boundaries (distinct edges) capturing linear extent but failing to categorize the type of use. The 2018 survey classified trail/road pathway types by primary use, such as agricultural access, fire access, or water infrastructure access, resulting in the reclassification of many undesignated trail/roads as undesignated roads. By reclassifying these features as roads, OSMF was better able to understand system maintenance needs. The change in definition prevents a direct comparison of road and trail/road pathway types between the 2012 and 2018 surveys. After 2018 but before the 2019-23 survey, OSMF evaluated undesignated trails/roads and undesignated roads classified in the 2018 survey and reclassified a subset as permanent access roads (i.e., not undesignated) in recognition of their important ongoing function serving as agricultural, emergency, or other permanent access. This reclassification resulted in a significant change to the undesignated mileage on the system (discussed below). The 2019-23 survey followed the 2018 survey’s classification methodology (categorizing by primary use), and the results by pathway type can be directly compared between these two surveys. The net linear extent of undesignated trail mileage can still be compared among all three surveys.




		
<p>Pathway primarily used as a trail but has evidence of repeated vehicle use. Classified as an undesignated trail/road in 2012, 2018, and 2019-23 surveys.</p>	<p>Pathway primarily used for vehicles, in this case temporary access for forest restoration work with the intent of closing and restoring upon completion of work. Classified as an undesignated road in 2012, 2018, and 2019-23.</p>	<p>Pathway showing consistent and repeated vehicle use with the intent of continuing use for agricultural purposes. Classified as an undesignated trail/road in 2012, an undesignated road in the 2018 survey, and reclassified as a permanent (non-trail) authorized vehicle access prior to the 2019-23 undesignated monitoring.</p>

Table 1: The different types of roads found in past undesignated trail datasets with representative photos. The table's main objective is to show what types of roads will no longer be included in undesignated monitoring efforts.

In addition to pathway type, condition classifications were assigned during the 2018 and 2019-23 as adapted from Jeffery Marion et al. 2009 (Table 2):

	<p>Class N – Recovering or emerging trail that does Not meet mapping criteria (This class will not be used for trend analysis but will be used for trail and visitor management.)</p>
	<p>Class L (Low Impact) – Noticeably impeded vegetation growth; some vegetation cover loss; some organic litter pulverized within tread; some bare soil exposed; tread intact.</p>

	<p>Class M (Moderate Impact) – Nearly complete or total loss of vegetation cover; nearly complete or total loss of organic litter within tread; bare soil widespread; tread mostly intact; some rills evident</p>
	<p>Class H (High Impact) – Vegetation and organic litter are rare or nonexistent within the tread; active tread erosion evident (indicated by exposed or undercut roots, loose or undercut rocks, gullying, rutting, widespread rills, incised tread, or sloughing banks)</p>

Table 2: The possible condition classifications of undesignated trails with a representative photo of each. The table aims to show the progression of condition classes and how that reflects increased impacts on the ground.

Condition class can be used to make inferences about levels of use on undesignated trails. However, the same level of use may lead to undesignated trails with different condition classes due to differences in grades, vegetation, soil erodibility, and vegetation sensitivity (Engelman, 2018).

The 2019-23 survey collected tread width measurements, adding to the 2012 and 2018 methodologies. Tread width was measured to the nearest foot, and changes in tread width resulted in the collection of a new data point.

Trail function data was again collected in 2019-23 to assist management decisions. Trail functions included:

- Cattle
- Climbing access
- Unserved visitor destination (viewpoint)
- Wildlife/Livestock (Note: When Selected with the addition of
- “cattle” in comments. There is no evidence of visitor travel)
- Historic (defined by visible bench cuts and grades)
- Community trail to neighborhood

- Shortcut
- Parallel trail to designated trail
- Water Access
- Other/unknown
- Other/ unknown road
- Agricultural road
- Fire road
- Ditch road

Constructed features often occur on undesignated trails and were collected in the survey. Definitions of these features can be found in the glossary of terms. The features included in the survey are:

- Stone Paving
- Culvert
- Ditch – Bar
- Ditch – Side
- Waterbar – Unreinforced
- Waterbar – Stone
- Waterbar – Wood
- Nick
- Grade Reversal
- French Drain
- Check Step – Wood
- Check Step – Stone
- Staircase – Stone
- Staircase – Wood Crib
- Ford
- Stepping Stones
- Causeway – Wood
- Causeway – Stone
- Corduroy
- Puncheon
- Retaining Wall – Stone
- Retaining Wall – Wood
- Backwall – Stone
- Switchback
- Cattle Guard
- Bridge
- Other

The 2018 survey introduced areas of concentrated use as a feature. These areas have trampled vegetation, bare soil, loose or undercut rocks, exposed roots, and rills but lack continuous trail boundaries. The 2019-23 survey also recorded these areas of concentrated use.

Inventory Analysis

Mileage of Undesignated Trails: The net linear distance was calculated using digitized undesignated trail alignments in ArcGIS Pro summary tables. Trails classified as condition class N were not included in the total distance analysis, so changes in linear extent could be compared between surveys. Class N trails are important to document because they represent use patterns but are more variable and do not meet the full definition of a trail. The same analysis process was used to calculate subsets of undesignated trail mileage in Trail Study Areas (TSAs), Management Area Designations, and trail maintenance zones. The average width of these trails was also calculated using ArcGIS Pro summary tables.

Signs in Proximity to Undesignated Trails: OSMP's signs team keeps an inventory of all sign structures on OSMP lands current. Using this data set, signs along an undesignated trail corridor can be identified. Each sign structure has associated sign types, which can then be selected to approximate the number and type of signs along undesignated trails.

Additional Analysis

Grid Cell Density: The Identity tool was used in ArcGIS Pro with 300x300 meter grid cells. The tool breaks undesignated trails and roads at grid lines and adds a unique ID to each with the trail segment that matches the grid cell. Density is then calculated on a cell-by-cell basis where the length of undesignated trails and roads divided by cell area gives a grid cell density. Cell size is based on cell sizes used in 2012. Results from 2012, 2018, and 2019-23 could be compared. Cell density can be used to compare undesignated trails' relative prevalence (i.e., density) across the system.

Kernel Density: The Kernel Density ArcGIS tool was used to determine the relative density of undesignated trails and roads and spatial variability of density across OSMP lands. Following the 2012 undesignated trail report as a guideline, the density was calculated using a search radius of 750 feet emanating from any undesignated trail or road segment. Results were then displayed in a grid of 50-foot cells. Cell size and search radius were based on cell sizes used in 2012 so that results from 2012, 2018, and 2019-23 could be compared. Kernel density is an analysis that can identify areas where undesignated trail density is relatively higher. Kernel density is an excellent visual representation of undesignated trail and road density, but the results are hard to quantify. A map can be found in the appendix.

Project Area Fragmentation: A GIS analysis was conducted to determine how undesignated trails fragment continuous land blocks on OSMP lands. The analysis used designated trails, roads, undesignated trails, and OSMP property data. A “dissolve” tool was utilized on the properties to eliminate internal property boundaries, creating larger land blocks. The trails and roads were then buffered by 40 feet on either side and erased from the project area. Buffers were based on 2012 parameters so that results from 2012, 2018, and 2019-23 could be compared. However, not part of this analysis, species or habitat-specific buffers could be used to evaluate habitat block size based on site-specific conditions. Using the explode tool, the singular properties polygon was split up into smaller pieces by the buffered line features. The resulting map could then be compared visually and statistically to determine how much the undesignated trails fragment the project area.

Euclidean Distance from Undesignated Trails: An analysis was run in ArcGIS Pro to measure the distance of OSMP lands from the nearest designated trails, roads, and undesignated trails and roads. The Euclidean distance tool cell size was based on using 100x100-foot grid cells. The grid cell size was based on the 2012 analysis so that results from 2012 and 2018 could be compared. The Euclidean distance tool determines the straight-line distance from the nearest trail or road to any point on the land system managed by Open Space and Mountain Parks.

Results & Discussion

Inventory Analyses

Mileage of Undesignated Trails

The net linear extent of undesignated trails surveyed in 2019-23 is 117.7 miles, down from 163.4 in 2018 and 177.7 in 2012 surveys.

Survey Year	Mileage
2012	177.7
2018	163.4
2019-23	117.7

Table 3: The net linear extent of undesignated trail mileage throughout the survey years. Note that approximately 30 miles of undesignated roads were reclassified as permanent infrastructure after the 2018 survey but before the 2019-23 survey.

The total mileage of undesignated trails surveyed in 2019-23 decreased by 60 miles since 2012 and 45.7 miles since 2018. While this decrease in mileage is significant, a large portion of the reduction in mileage can be attributed to a change in how OSMP manages roads. 30.8 miles of roads previously mapped as undesignated trails were determined to serve important charter purposes (e.g. access for agriculture, water, safety, fire) or to have easements and prescriptive access rights, prompting updates to infrastructure management objectives and removal of these roads from the undesignated trail dataset.

Accounting for the portion of undesignated mileage reclassified as permanent access roads, there still was a 29.2 mile and 14.9 mile decrease in undesignated trail mileage from 2012 and 2018, respectively. The decrease in mileage reflects an increased focus on managing visitor use patterns on OSMP lands. OSMP created a new undesignated trail crew whose sole focus is the management of undesignated trails. Additionally, 729 feet of trail have been designated since the 2018 survey as a result of previous planning efforts. The undesignated trail crew has applied over 10 miles of active and passive restoration treatments since 2022. Additional restoration treatments, both active and passive, have been applied by contractors and other OSMP workgroups.

Mileage of Undesignated Trails by Condition Classification

The net linear extent of undesignated trails by condition class is shown in the table below. Most mileage was classified as condition class H, while class M and L trails have similar mileage totals (Table 4). An additional 19.4 miles of class N trails were mapped, which is not calculated into the total mileage number (Table 4). The 2019-23 survey also collected tread width data. On average, trails with higher impacts were wider (Table 4).

Condition Class	Mileage	Average Width (Feet)	Percent of Total Mileage
H (High Impact)	55.4	3.4	47%
M (Moderate Impact)	30.6	2.1	26%
L (Low Impact)	31.7	2.0	27%
Total	117.7	2.8	100%
Class N (Does not meet the definition of a trail)	19.4	NA	NA

Table 4: Undesignated trail mileage with calculated by condition classification, and the average tread width is listed for each condition class.

As in past surveys, most of the new mileage was classified as condition class H (high impact), further supporting that once a trail is established, vegetation is removed rapidly, and erosion processes begin quickly. Trails that have been established tend to stay on the landscape without active restoration work; nearly 78 miles (66%) of the trails surveyed in 2019-23 were also present in 2012 and 2018. Nearly 19 miles of trails (16%) were not mapped in 2012 or 2018, meaning that they were new in the 2019-23 survey.

As expected, the average measured width of condition class H trails was the highest (3.4 feet). Condition class M and L trails had similar average widths (2.1 and 2.0 feet, respectively) (Table 4). Class H and M trails had the same median width of two feet, while class L trails had a median width of 1 foot. Class H trails had a much higher variance of tread widths than the other condition classes. Width was only measured in the 2019-23 survey and thus cannot be compared to previous surveys. Future surveys could provide valuable width data trends showing how width changes with amount of use, restoration practices, and an increased focus on UT management.

Mileage of Undesignated Trails by Pathway Type

The majority of UTs surveyed fall into the trail pathway type (Table 5).

Pathway Type	2018 Mileage	2019-2023 Mileage	Change
Trail	100.9	98.5	-2.4
Trail/Road	17.3	9.4	-7.9
Road	45.4	9.8	-35.6*

Table 5: Change in mileage by pathway type. *Note that 30 of the 35 miles of roads that did not appear in the 2019-23 survey were determined to be permanent infrastructure and thus reclassified prior to the survey.

Again, a large decrease in overall road mileage can be attributed to the reclassification of 30.8 miles of undesignated roads that occurred after the 2018 survey. Even accounting for this reclassification, there was still a decrease of 4.8 miles of undesignated roads. The decrease in road mileage can largely be attributed to the restoration of access roads for management work such as accessing forestry thinning projects.

Mileage of Undesignated Trails by Function

Starting with the 2017-2018 monitoring each undesignated trail was assigned one of 14 functions: cattle, climbing access, unserved visitor destination (viewpoint, water), wildlife/livestock, historic, community trail to neighborhood, shortcut, parallel trail, water access, other/unknown, other/unknown road, agricultural road, fire road, or ditch road. Different functions of trails can give insights for determining what appropriate management actions would be most effective.

Community trail was the most commonly assigned trail function and the function type with the most increase since the last survey (Table 6). The agricultural road, other/unknown road, and other/unknown functions saw the largest decrease in mileage. Climbing access trails increased by 1.1 miles to a total of 7.5 miles a notable increase considering the typical terrain climbing access trails are found in (Table 6).

Function	2018 Mileage	2019-2023 Mileage	Change
Community Trail	15.9	28.7	+12.8
Unserved Visitor Destination	19.0	18.1	-0.9
Parallel Trail to Designated Trail	16.6	15.3	-1.3
Other/Unknown	29.0	14.0	-15
Shortcut	11.6	7.8	-3.8
Climbing Access	6.4	7.5	+1.1
Wildlife/Livestock	10.8	7.1	-3.7
Agricultural Road	21.1	6.0	-15.1*
Other/Unknown Road	21.4	5.7	-15.7*
Water Access	4.0	4.3	+0.3
Ditch Road	5.6	2.2	-3.4*
Fire Road	0.9	1.0	+0.1

Table 6: The mileage of undesignated trails by the main function the trails serve. The table also shows the change in mileage between the 2018 and 2019-23 surveys. *Approximately 30 miles of trails were reclassified as permanent infrastructure.

The trail function category that saw the greatest increase in mileage was community trails (+12.8 miles) (Table 6). However, the increase in mileage can be attributed to improved knowledge of use patterns since most of this mileage was reclassified from the Other/Unknown category (-15

miles). (Table 6). Community trails are found near neighborhoods and see frequent use patterns by the surrounding community. Management actions that aim to provide the surrounding community access to maintained and designated trails could help prevent the creation of undesignated trail systems.

A major survey finding that needs more management focus is the increase of climbing access trails (+1.1 mile). While the increase may seem relatively small, it represents a 15% increase in mileage for that trail function category over the five-year survey cycle. Often, climbing formations have networks of undesignated trails accessing them, so more focus on providing climbers with designated access routes to climbing formations might help reduce impacts in some areas.

Agricultural and other/unknown roads saw the largest decrease in mileage (-15.1, -15.7 miles). These miles represent many of the miles now managed differently by OSMP.

A portion of the trails previously mapped in monitoring efforts may not be used by visitors but rather are used by wildlife or livestock. These trails sometimes attract visitors who use them as alternatives to the designated trail system but these trails often dead-end at salt licks, stock tanks, and other destinations of little interest to humans. After reviewing these miles of trail with agricultural staff, it was determined that minimal infrastructure improvements or changes would impact and change these behaviors. Removing internal fences and moving stock tanks were both explored. However, it was determined that most internal fences with undesignated trails are needed for breaking up large, grazed plots into smaller areas, and stock tanks are filled by existing water infrastructure would be costly or impossible to move. Therefore, these trails will continue to be monitored, and when appropriate, fencing and signs may be employed to deter visitor use.

Unserved visitor destinations and shortcuts should be examined further to ensure the designated trail system adequately serves our visitors using best trail design practices while protecting sensitive resources.

Mileage by Management Area Designation

The Visitor Master Plan (2005) provides guidance on the Management Area Designations (MADs) for OSMP properties. Each management designation has recommended strategies for guiding the management of undesignated trails. Natural and Passive Recreation areas, where off-trail travel is generally allowed, contain the largest amount of undesignated trail mileage (Table 7). Habitat Conservation Areas, where off-trail travel must be permitted, represent 40% of OSMP managed land and 21% of total UT mileage (Table 7). Agricultural areas contain a relatively low UT mileage (Table 7).

Management Area Designation	Mileage	Percent of Total Undesignated Trail Mileage	Management Area Size (Percent of total managed acres)
Agricultural Area	3.0	2%	3,724 (10%)
Habitat Conservation Area	24.3	21%	14,838 (40%)
Natural Area	42.6	36%	13,121 (35%)
Passive Recreation Area	39.7	34%	4,162 (11%)
Unassigned	8.1	7%	-

Table 7: Undesignated trail mileage in the various management area designations that Open Space and Mountain Parks assigns to properties.

Natural Areas and Passive Recreation Areas contain the highest mileage of undesignated trails (42.6 miles and 39.7 miles, respectively) (Table 7). It should be noted that Natural and Passive Recreation Areas also contain the highest mileage of designated trails (62.3 and 55.7 miles, respectively, of the total 160 miles on the system). Passive Recreation Areas only account for 11% of the total acres managed by OSMP but contain 34% of the undesignated trail mileage while also containing a large amount of designated trail mileage. The higher mileage totals could result from proximity to areas with higher visitor use but could also result from regulations allowing off-trail travel. Despite regulations prohibiting off-trail travel, Habitat Conservation Areas still contained a significant portion of undesignated trail mileage (24.3 miles) (Table 7). The mileage in Habitat Conservation Areas should be a focus for restoration efforts, and more understanding is still needed as to why visitors might be accessing certain locations. Agricultural areas saw a significant decrease that can again be attributed to the change in management of agricultural roads previously included in undesignated trail surveys.

An interesting pattern also emerges when undesignated trail mileage is broken down by condition class in the various management area designations (Figure 1). Both Passive Recreation and Natural Areas contain high numbers of high-impact trail miles, while HCAs exhibit the opposite pattern, containing more mileage of low-impact trails. While this finding could be due to management practices, including the increased restoration focus of undesignated trails in HCAs and the prohibition of off-trail travel, the results could also be due to the HCA’s increased distance from access points. Along with the high number of designated trails, these findings suggest that most recreational impacts are centered within Natural and Passive Recreation Areas.

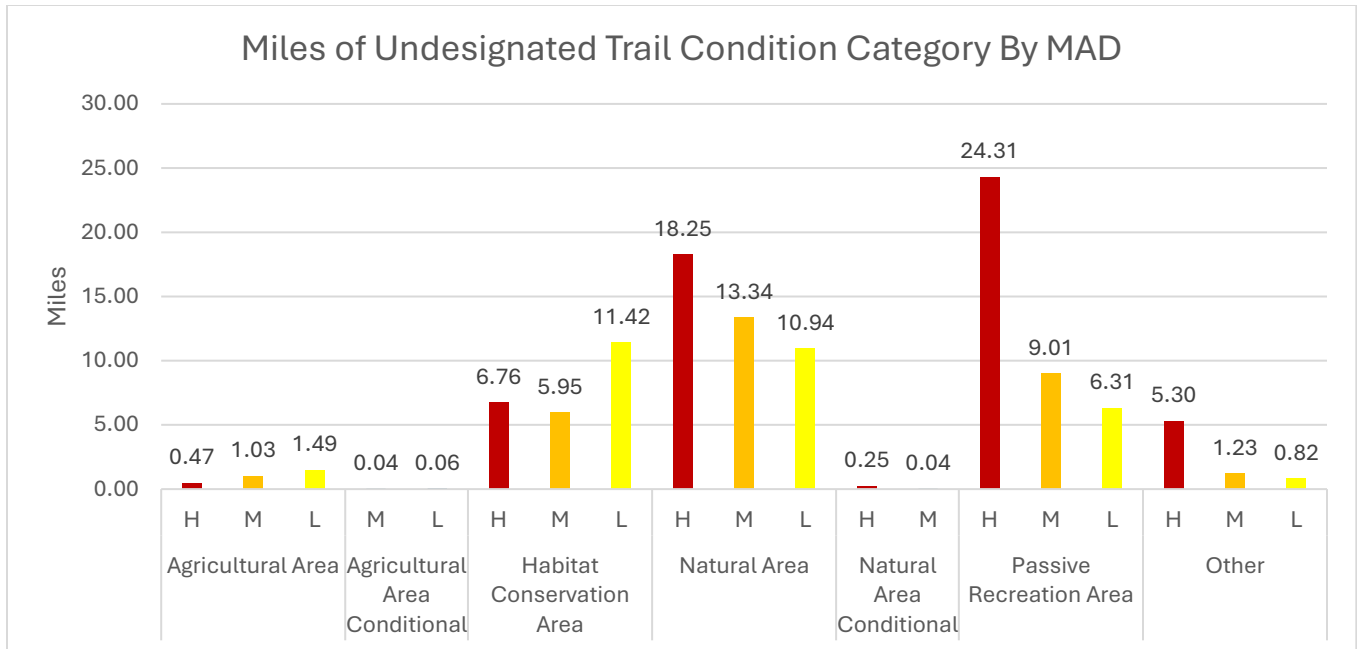


Figure 1: Graph showing the breakdown of mileage and condition classification by Management Area Designation

Mileage by Trail Study Area (TSA)

The West Trail Study Area (WTSA) has the most undesignated trail mileage (52.5 miles) (Table 8). The WTSA is also the largest TSA by area and contains some of the most visited trailheads (Chautauqua, Centennial, NCAR, South Mesa, etc.) surrounded by some of the higher undesignated trail densities on the system (Figure 4). The WTSA contains several miles of undesignated trails that are called to be designated but have not yet been designed and built. Additionally, most climbing access trails fall within the WTSA, which would benefit from the designation and restoration of redundant trails that access climbing formations with multiple trails.

TSA Area	2012 Mileage	2018 Mileage	2019-2023 Mileage	TSA Area (acres)
South	24.4 (14%)	23.8 (15%)	20.5 (17%)	7,346 (20%)
West	56.1 (32%)	53.9 (33%)	52.5 (45%)	11,250* (31%)
North	30.2 (17%)	21.9 (13%)	15.5 (13%)	7,700* (21%)
East (No plan completed)	66.6 (37%)	63.6 (39%)	29.2 (25%)	9,982 (28%)

Table 8: Undesignated trail mileage in the four Trail Study Areas on Open Space and Mountain Park managed land. **as reported in the TSA plans.

Each TSA specified guidance on future management actions for undesignated trails identified at the time the plan was written. Of the current survey, 31.4 miles of undesignated trails are identified to be restored and closed, and 11.2 miles of trails are planned to be designated (Table 9). Trails that fall into the “restore/close” category have been prioritized in restoration efforts and will continue to be prioritized. The 11.2 miles of trails called to be designated still need to be designed and built before they are recategorized as designated trails. Some trails in the West TSA were assigned a “no recommendation” management strategy. OSMP’s climbing access

management team is currently reevaluating many trails in this category and will receive new guidance based on the results of those discussions. If a trail was not physically present when a plan was written, then it does not have plan guidance. 74.8 miles of undesignated trails are not contained within a TSA planning document. Of that mileage, 29.2 miles is in the East TSA area which does not yet have a plan. The default management action on these trails is to restore and close them unless specified in an area-specific plan or by the undesignated trail management team.

TSA Recommendation	Total Mileage
Restore/Close	31.4
Designate	11.2
No Recommendation	0.3
Not in plan	74.8

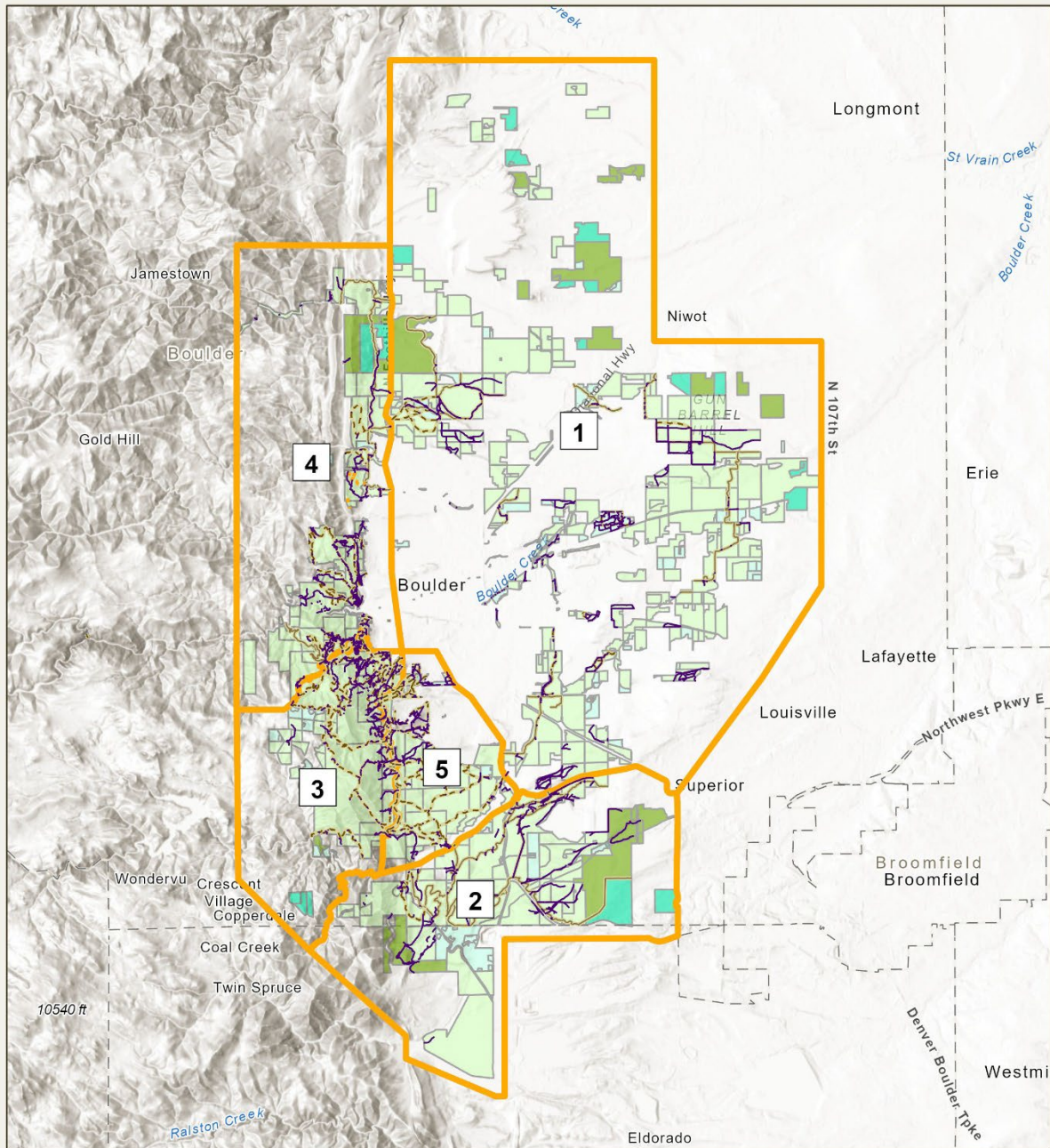
Table 9: Mileage of undesignated trails that were included in TSA planning efforts

Mileage by Trail Maintenance Zone

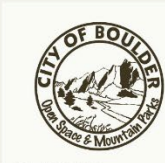
Trail maintenance zones are areas that OSMP uses to manage and maintain designated trails (Figure 2). Each of the five zones contains approximately 30 miles of trail and is managed by Trail Program Manager staff who oversee maintenance in each zone. Trail Maintenance Zone 1 contained the greatest mileage of undesignated trails prior to the most recent survey and showed the most significant decrease in mileage in the current survey, largely due to the re-categorizing of permanent roads (Table 10). Trail Maintenance Zone 3 was the only trail maintenance zone to see an increase in undesignated trail mileage (Table 10). Figure 2 below shows the location of the trail maintenance zones. While trail maintenance zones are managed to contain equal mileage of designated trails, it should be noted that they were not created to contain equal areas of OSMP land.

Trail Maintenance Zone	Zone Area (acres)	2018 UT Mileage	2019-23 UT Mileage	Change
1	16,381	79.9	38.3	-41.6*
2	8,969	23.7	20.5	-3.2
3	5004	18.2	21.2	+3.0
4	5230	25.3	23.0	-2.3
5	3056	16.4	14.7	-1.7

Table 10: Undesignated trail mileage by trail maintenance zone. *Note that most undesignated roads that were reclassified out of the 2019-23 survey were reclassified out of Zone 1.



	2019-23 Undesignated Trails
	Trail Maintenance Zones



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Figure 2: The map shows the geographic regions of the trail maintenance zones. The map also displays designated trails, OSMP Properties, and Undesignated Trails.

Built Infrastructure on Undesignated Trails and Roads

The survey found a total of 461 built structures on undesignated trails. The most common type of structure was steps (stone or wood) (Table 11). 388 individual steps were recorded, making up 84% of all built structures on undesignated trails (Table 11).

Feature	Quantity
Check Step - Wood	173
Check Step - Stone	156
Staircase - Stone	6 (42 Stairs)
Culvert	34
Waterbar - Wood	24
Bridge	17
Staircase - Wood	2 (17 Stairs)
Retaining Wall - Stone	16
Stepping Stones	9
Waterbar - Stone	9
Drain Dip	6
Ford	3
Stone Paving	3
Retaining Wall - Wood	2
Causeway - Wood	1
Ditch - Side	1

Table 11: Quantities of various built infrastructure types found on Undesignated trails

461 total structures were recorded during the 2019-23 survey. There was an observed decrease in the number of structures recorded since 2018, when 662 structures were recorded, and a slight increase since 2012 when 433 structures were recorded. The decrease from 2018 could be attributed to the department's focus on asset management and improved infrastructure management objectives. Despite the decrease in structures, the existence of built infrastructure on undesignated trails creates an appearance that some of these trails are built and maintained by OSMP, which is likely to confuse visitors and contribute to the persistence of undesignated trails on the landscape.

Areas of Concentrated Use

In addition to recording built infrastructure along undesignated trails, areas of concentrated use were tracked as point features. 340 areas of concentrated use were recorded, including a rough estimate of their size. Only 166 areas of concentrated use were recorded during the 2018 surveys. The significant increase in areas of concentrated use should be examined, and more in-depth monitoring could be a focus to further determine the factors that lead to the development of these areas. These areas often function as viewpoints or belay/bouldering areas for rock climbing and are often heavily impacted.

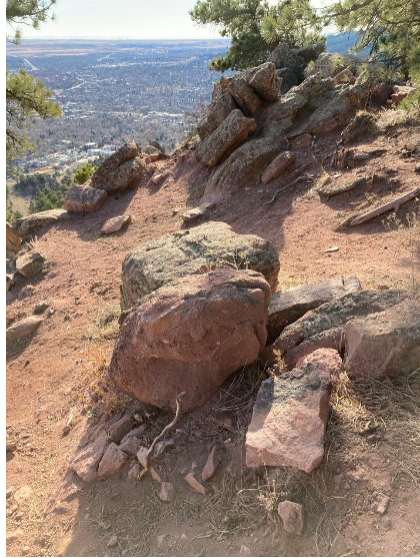


Figure 3: An example of an Area of Concentrated Use

Signs in Proximity to Undesignated Trails

The analysis found 272 sign structures (e.g., sign posts) in proximity (10 feet) to undesignated trails (Table 12). Those sign structures display 352 signs. The 2012 survey recorded 449 signs along undesignated trails, while the 2018 survey recorded 347 sign structures with 460 signs along undesignated trails. The decrease in signs along undesignated trails could be attributed to the overall decrease in mileage. The decrease could also be attributed to the increased focus of the OSMP signs group on reducing sign clutter.

Sign Type	Count
Wayfinding/Directional	69
Regulatory - Dog	59
Regulatory - Bike	45
Interpretive	24
Informational	23
Parking	17
Maps	17
Regulatory - Rules and Regs	16
Property Boundary	13
Other	12
Regulatory - Horse	12
HCA Boundary	9
Fee	8
Regulatory - Limited Access/Closure	8
Livestock	7
Restoration	6
Trailhead ID	4
Ditches	2

Table 11: Sign types and quantities found along undesignated trails.

The analysis of signs near undesignated trails provides some interesting context for managing undesignated trails. While most signs in proximity to undesignated trails do not relate directly to those trails, such as wayfinding or directional signage for designated trails in proximity, many regulatory signs still apply directly to undesignated trails. Signage can be of great benefit to closing and restoring undesignated trails, but signage can also make undesignated trails look like official infrastructure maintained by OSMP and be confusing to visitors.

Additional Analysis

Grid Cell Density

The density of undesignated trails ranges from 0 to 1,004 feet of undesignated trail per acre, as analyzed in 300x300 meter grid cells across the OSMP system. The average density of undesignated trails was 18 ft/acre. Most (84%) grid cells contained less than 32 ft/acre. There were 947 full grid cells and 1,698 partial grid cells. 58% of the grid cells were greater than 15 acres, and 19% of the grid cells were less than 5 acres in size.

The average grid cell density of undesignated trails dropped from 35.8 ft/acre in 2012 to 32.9 ft/acre in 2018 to 18 feet per acre in 2019-2023. Much of this decrease can be attributed to the change in the management of roads formerly mapped within the undesignated data sets. As shown in Figure 4, areas of the west and south have similar densities, with major changes in the east and north. The maximum grid cell density of undesignated trails decreased from 2,253 ft/acre in 2012 and 2,733 ft/acre to 1004 ft/acre in 2019-2023 (Figure 4).

Areas with high undesigned trail densities have been similar throughout the surveys (Figure 4). Chautauqua and the surrounding flatirons, Sanitas, Red Rocks, NCAR, and Gunbarrel Hill, are all areas that have had high undesigned trail densities since 2012 (Figure 4). These areas did see some changes in patterns of densities, especially in the greater Chautauqua/flatirons area (Figure 4). Densities have shifted closer to the flatirons away from the Chautauqua meadow (Figure 4). The shift away from the meadow directly results from management action based on the 2012 and 2018 undesigned trail surveys. Managing climbing access and restoring undesigned trails that function as shortcuts or parallel trails to designated trails could help lower densities around this area. Other areas could use more site-specific planning to lower densities, while other areas, such as Gunbarrel Hill, should see lower densities after implementing plans. Implementing planned trail construction and restoration outlined in the Gunbarrel Hill ISP should improve density in that area. Additionally, several properties in the Eastern OSMP land system require some planning effort to establish acceptable visitor use patterns and close/restore undesigned trails.

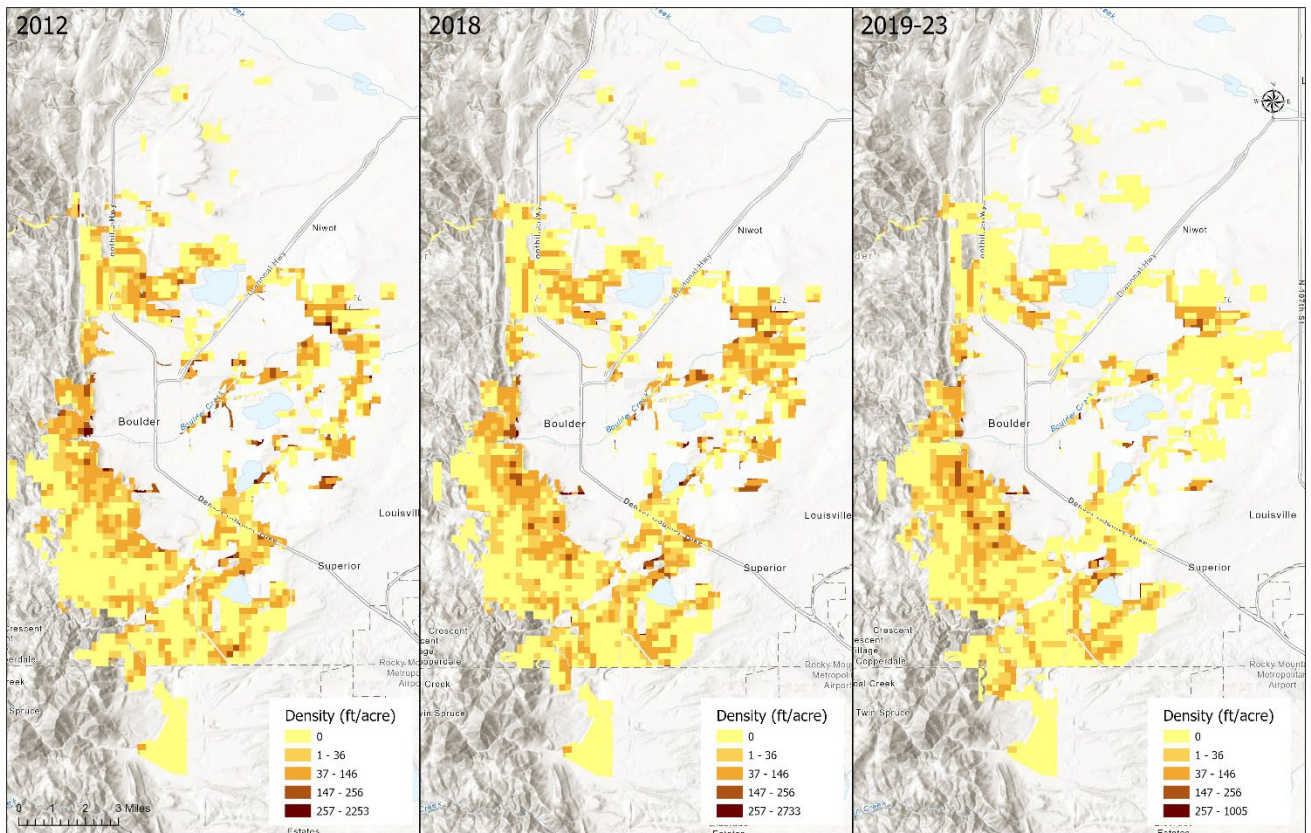


Figure 4: A map displaying grid cell density of undesigned trails. Darker cells indicate a higher density of undesigned trails.

Project Area Fragmentation

When factoring in roads, designated trails, and undesignated trails and roads, the average unfragmented block size is 47.7 acres (26.1 acres in 2018) compared to an average block size of 73.6 acres (74 acres in 2018) when only factoring in roads and designated trails (Figure 5). While the effect of undesignated trails on wildlife likely varies by factors including wildlife species, the condition class of the undesignated trail, and the amount and timing of use on the undesignated trail, the apparent implication is that undesignated trails contribute significantly to habitat fragmentation, which likely adversely impacts at least some wildlife species.

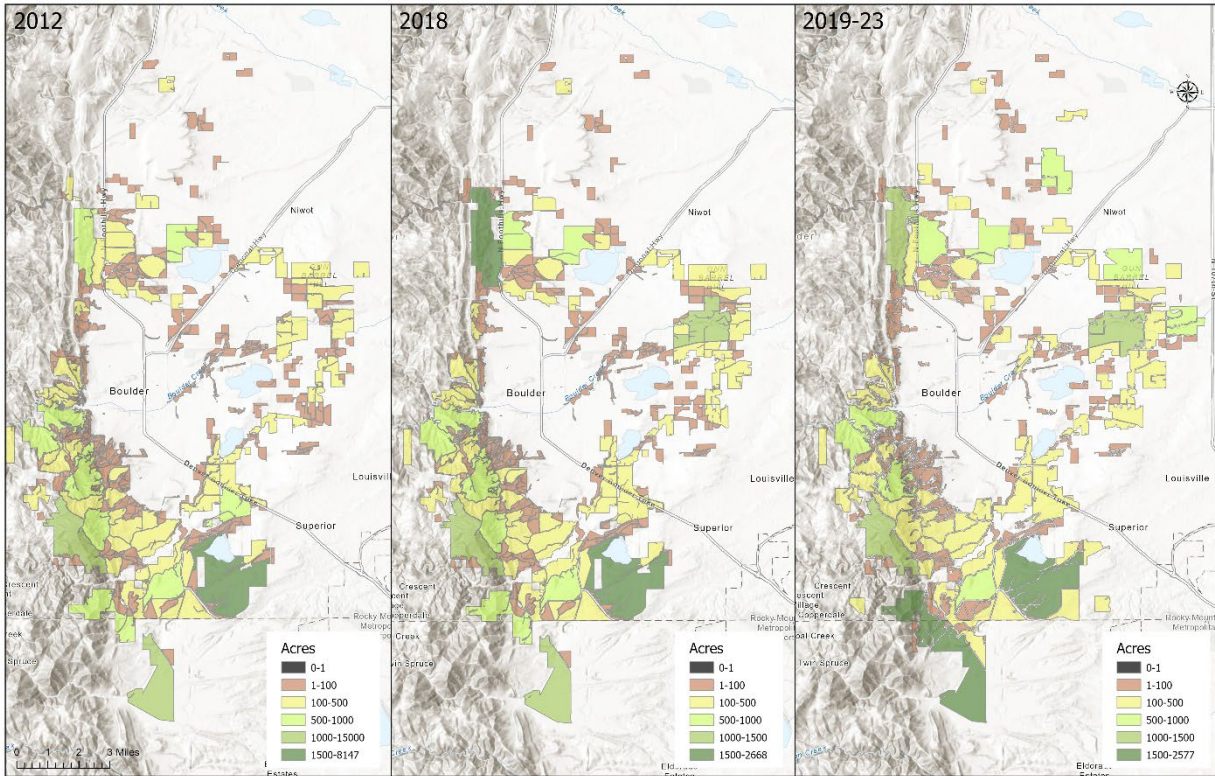


Figure 5: The map shows how trails, roads, and undesignated trails fragment the land managed by Open Space and Mountain Parks. The map shows the land fragmentation in the 2012, 2018, and 2019-23 surveys.

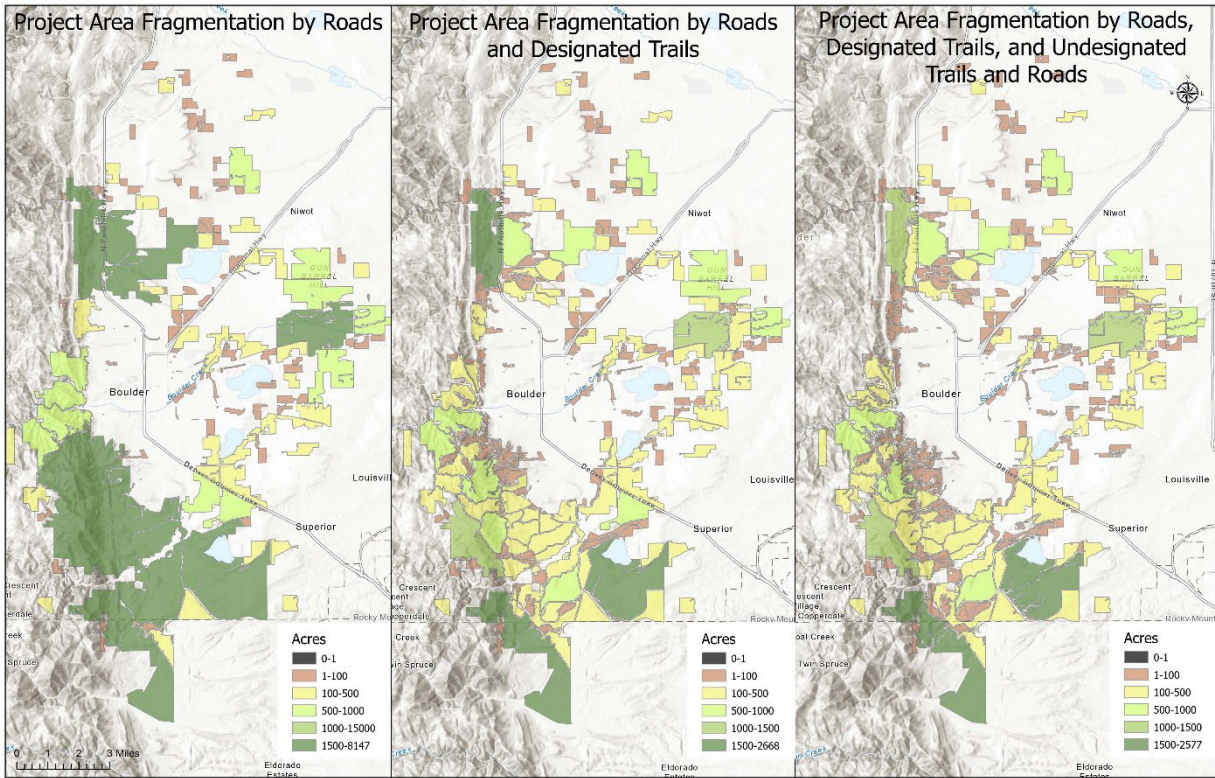


Figure 6: The map shows land fragmentation on Open Space and Mountain Parks. The first map panel shows fragmentation by roads, the second shows fragmentation by roads and designated trails, and the third shows fragmentation with undesigned trails.

Euclidean Distance from Undesignated Trails:

Euclidean distance represents the distance any cell is from a road, designated trail, or undesigned trail. In Figure 7, yellow cells represent areas that are at a greater distance from trails or roads. Several areas in the eastern and northern parts of the project area saw increased distance from roads and trails, both designated and undesigned. The greatest distance from roads or trails increased in the 2019-2023 survey to 4,442 feet versus 3,609 feet in 2012 and 3,585 feet in 201, a promising finding indicating a larger unfragmented area of Open Space and Mountain Parks land. The average distance from roads or trails remained similar to past surveys at 528 feet (2012 – 506 feet, 2018 – 493 feet).

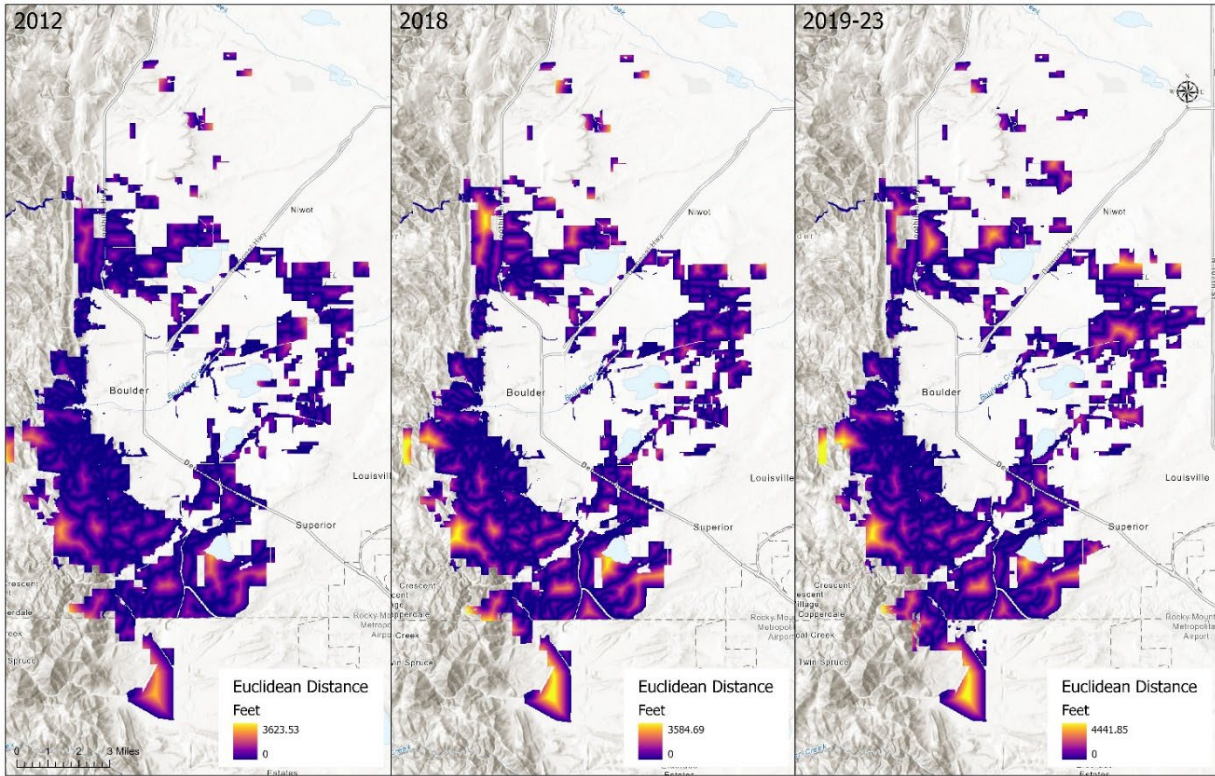


Figure 7: The map shows the Euclidean distance from both undesignated and designated trails on Open Space and Mountain Parks managed lands. Conceptually this means that if you were dropped onto the map areas of yellow would indicate further distance from trails.

Conclusion and Management Applications

A significant portion of the decrease in undesignated trail and road mileage resulted from the reclassification of 30.8 miles of formerly undesignated roads. By reclassifying these roads, staff can better plan to manage and maintain service roads that support important charter purposes (City of Boulder 2019). Additionally, despite the reclassification, a decrease of 29.2 miles since 2012 and 14.9 miles since 2018 represents significant progress in reducing undesignated trails and roads. While the total extent of undesignated pathways still exceeds the proposed threshold for under 50 miles in the 2005 Visitor Mater Plan, the progress in undesignated trail management and general downward trend in mileage is notable given the challenges of managing undesignated trails in a land system with increasing visitation, many access points, and regulations that allow off-trail travel.

Results from this study are interconnected with the increased staff focus on systemwide management of undesignated trails and roads. From 2022-2023, the trail program included a temporary crew lead and assistant crew lead who facilitated restoration work with youth corps and volunteers. In 2024, the temporary crew lead was converted to a regular crew lead position and is supported by an assistant crew lead and several crew members. Since 2022, the undesignated trail crew has applied restoration treatments to 10 miles of trail and designated another 729 feet. Other work groups and crews also support undesignated trail management through project work, contracting, and volunteer events. Additional significant restoration treatments and designations, as driven by plan guidance and ongoing monitoring results, will continue to be prioritized and implemented.

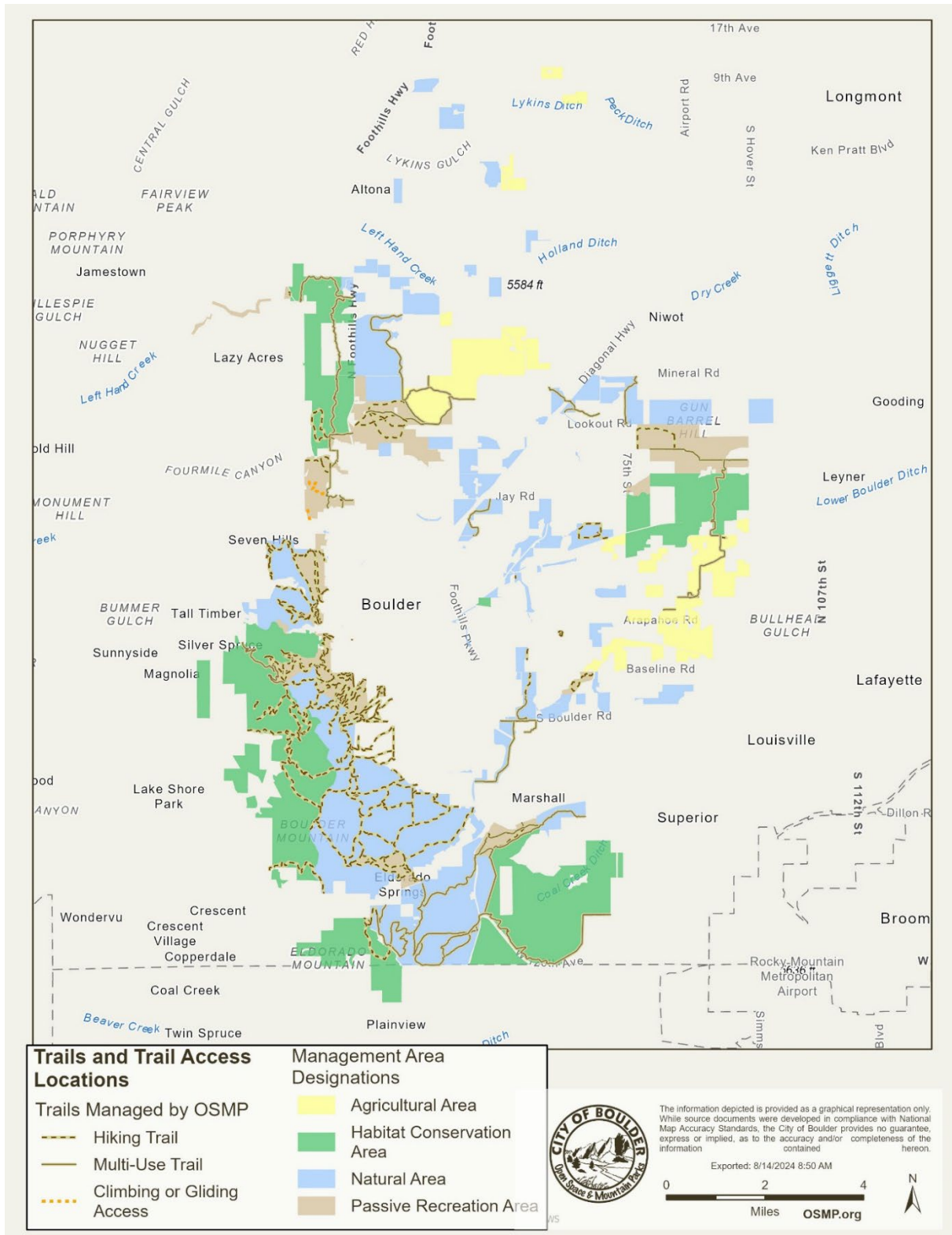
Undesignated trail condition monitoring will continue on a five-year cycle. The next trail condition report will be published in 2030.

References

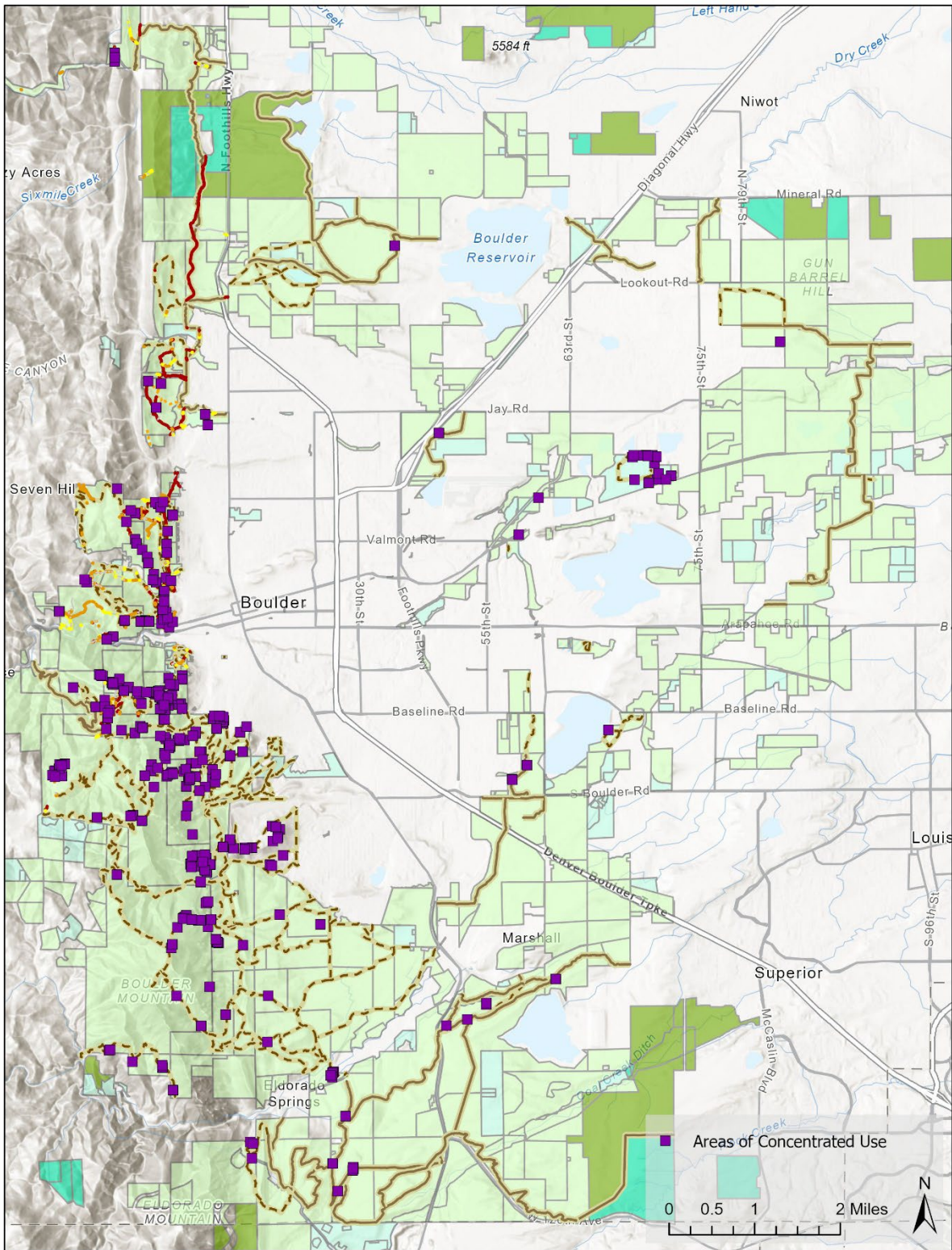
- City of Boulder. 2005. Visitor Master Plan. City of Boulder Open Space and Mountain Parks Department, Boulder, Colorado. Available from https://www-static.bouldercolorado.gov/docs/final-vmp-1-201304101621.pdf?_ga=2.230667420.1258262893.1554732368-549956238.1547562558
- City of Boulder. 2012. System-Wide Undesignated Trail Mapping on Open Space and Mountain Parks Lands 2011/2012 Protocol. City of Boulder Open Space and Mountain Parks Department, Boulder, Colorado.
- City of Boulder. (2019). Master Plan. City of Boulder, Open Space and Mountain Parks Department, Boulder, Colorado.
- Havlick, D.G., Billmeyer, E., Huber, T., Vogt, B., & Rodman, K. (2016). Informal trail creation: Hiking, trail running, and mountain bicycling in shortgrass prairie. *Journal of Sustainable Tourism*, 24, 1041-1058.
- Lawhon, B., Taff, B. D., & Schwartz, F. (2016). Undesignated Trail Management and Messaging *Study Report*. The City of Boulder, Department of Open Space and Mountain Parks. Boulder, Colorado.
- Leslie, C. (2018). 2016-2017 Visitation Estimate Report. The City of Boulder, Open Space and Mountain Parks Department. Boulder, Colorado.
- MacArthur, R.A., Geist, V., & Johnston, R.H. (1982). Cardiac and behavioral responses of mountain sheep to human disturbance. *Journal of Wildlife Management*, 46(2), 351–358.
- Manning, R., Jacobi, C., & Marion, J. (2006). Recreation monitoring at Acadia National Park. *The George Wright Forum*, pp. 23, 59–72.
- Marion, J. L., & David N. Cole. (1996). "Spatial and Temporal Variation in Soil and Vegetation Impacts on Campsites." *Ecological Applications*, vol. 6, no. 2, 1996, pp. 520–530. *JSTOR*, [JSTOR](http://www.jstor.org/stable/2269388), www.jstor.org/stable/2269388.
- Miller, S.G., Knight, R.L., & Miller, C.K. (2001). Wildlife responses to pedestrians and dogs. *Wildlife Society Bulletin*, 29(1), 124–132.
- Rice, W. L., Mueller, J. T., Graefe, A. R., & Taff, B. D. (2019). *Journal of Park and Recreation Administration*. doi: 10.18666/JPRA-2019-8998.
- Schultz, R.D., & Bailey, J.A. (1978). Responses of national park elk to human activity. *Journal of Wildlife Management*, 42, 91-100.
- Soulard, Danielle. "Impacts of Recreational Trails on Wildlife Species: Implications for Gatineau Park." (2017).
- Taylor, A.R., & Knight, R.L. (2003). Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications*, 13(4), 951–963.

Wimpey, J., & Marion, J.L. (2011). A spatial exploration of informal trail networks within Great Falls Park, VA. *Journal of Environmental Management*, 92, 1012-1022.

Appendix



Appendix A: A map of the Management Area Designations as assigned by OSMP



Appendix BB: A map displaying the locations of Areas of Concentrated Use

Glossary of Terms

Back wall: Wall built to reinforce hillside above trail tread.

Cattle Guard: a metal grid shaped guard that runs over a ditch and prevents cattle and other animals from crossing but allows pedestrians or vehicles to pass over the ditch

Causeway: Retaining structure on trail edges to hold raised tread material.

Check step- stone: Individual step placed perpendicular to trail to prevent erosion.

Check step- wood: Individual step placed perpendicular to trail to prevent erosion.

Climbing turn: Change of direction on hillside without a platform.

Corduroy: Several logs buried or half-buried in tread perpendicular to trail through a low-lying area.

Culvert: A structure that allows water to flow under the trail

Designated Trail: A trail built and maintained by City of Boulder Open Space and Mountain Parks

Ditch- bar: Excavated channel running parallel to trail on both sides of trail

Ditch-side: Excavated channel running parallel to trail on one side of trail only.

Drain dip (waterbar-unreinforced): An excavated triangular area in the tread at a 45 degree angle to trail.

Ford: Armored stream crossing

French drain: An excavated ditch alongside and across trail filled with rocks.

Grade Reversal: Points along the trail where the trail grade descends from both directions.

Puncheon: Timber planks running parallel to trail set on mud sills to elevate tread. Puncheon is distinguished from bridges by low ground clearance.

Retaining wall- stone: Stacked rocks built to reinforce trail tread

Retaining wall- wood: Tiered timber built to reinforce trail tread

Sensitive Areas - A GIS layer representing the combination of raptor closures, Preble's jumping mouse habitat, New Zealand mud snail closures, burrowing owl habitat, northern leopard frog breeding sites, prairie dog colonies, wetlands, rare plant species and communities, and cultural resources.

Staircase- stone: Multiple stone steps structurally connected.

Staircase- wood: Multiple wood steps structurally connected.

Stepping Stones: Individual rocks placed in a low-lying area or stream for stepping across.

Stone Paving: Tread surface in made up of set stones

Switchback: Built structure to create a platform for a trail to switch directions on a hillside.

Trail corridor: The area on both sides of the centerline of a trail that includes the trail tread. Typically includes a vegetation clearing zone.

Trail Grade: The rise of a trail over the length of a trail expressed as a percentage

Undesignated Pathway: A term used to describe the combination if undesignated roads, trails, and trail/roads.

Undesignated Road: A road that is not represented in OSMP roads GIS data. Could represent access roads for ditches, oil and gas, agriculture, or emergencies. Could also represent temporary access roads that are not permanent infrastructure.

Undesignated Trail: A trail not built or maintained by OSMP. Represents a use pattern by OSMP visitors, staff or cattle.

Undesignated Trail/Road: An undesignated trail that has some evidence of use by vehicles and is connected to an area accessible by vehicles.

Waterbar- stone: An excavated triangular area in the tread reinforced by rocks at a 45 degree angle to the tread.

Waterbar- wood: An excavated triangular area in the tread reinforced by rocks at a 45 degree angle to the tread.