Undesignated Trails
On
Open Space and Mountain Parks Lands

Inventory Report

Prepared by:

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City of Boulder
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Cover photographs by Deonne VanderWoude and Ann Lezberg from left: Circle-shaped trail on Gunbarrel Hill, Dry Creek parallel trails.

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Executive Summary

The Visitor Master Plan (VMP) called for a program to assess and manage undesignated trails on Open Space and Mountain Parks (OSMP) every five years (City of Boulder 2005a p. 41-42, 61). In response, staff conducted the first comprehensive system-wide inventory (post-VMP) of all undesignated trails on OSMP-managed property from June 2006 to May 2007. This inventory included collection of baseline information on the location, linear extent and condition of undesignated trails using new methods (Lenth 2006) intended for periodic repeat monitoring every five years. During development of the 2011-2012 protocol, staff determined that repeating the previous methods with an acceptable level of inter-observer variability was not possible, and a new methodology was created based upon a literature review, departmental needs and professional judgment. *Because these two system-wide inventories were conducted with different methodologies, no attempt will be made to quantitatively compare the results of each iteration within this report.*

Objectives of the 2011-2012 system-wide undesignated trail monitoring program were to:

1. Map the linear extent and spatial distribution of undesignated trails and road-like pathways on OSMP managed lands and identify those used by cattle;
2. Map the location of constructed features in the vicinity[1] of undesignated trails and road-like pathways; and
3. Map the location of signs and sign structures in the vicinity of undesignated trails and road-like pathways.

Results from this project will also be used to generally describe the success of undesignated trail guidance found within other OSMP plans.

Methods

All undesignated trails and road-like pathways meeting the mapping criteria on OSMP-managed properties through the Weiser acquisition of 2011were surveyed between July 2011 and November 2012. Using a Global Positioning System (GPS), OSMP staff mapped and documented attributes of start, end and interior points spaced at approximately 200-foot intervals along undesignated trails and road-like pathways. A Geographic Information System (GIS) map of undesignated trails and road-like pathways was created by digitizing segments between the start, interior and end GPS points. The GIS map and associated database of attributes provided tools for visualization and analyses. GIS spatial analysis techniques were developed to determine the size of trail and road-free OSMP blocks, to quantify the density of undesignated trails and roads across the OSMP system and to evaluate spatial patterns of undesignated trails and roads in proximity to designated and undesignated access points.

Major Findings

Location, linear extent and concentration of undesignated trails and roads

- Just over 181 miles of undesignated trails and roads were documented.
- A GIS database was developed to store and analyze characteristics of 2,399 undesignated trail and road segments representing 1,809 unique numeric Trail IDs (i.e. pathways, some

[1] In the vicinity of undesignated trails and road-like pathways means that, in the opinion of the field technician, the sign or constructed feature is meant to inform, facilitate, confine or prevent travel along the specific pathway.

with 2 or more mapped segments).

- While the highest proportion (34.2%) of the undesignated trail mileage occurred in Natural Areas, Agriculture Areas had the lowest proportion (8.8%) of undesignated trails;
- Among Trail Study Areas (TSAs) , the highest proportion of mapped miles was found in the East TSA (37.5%), followed by the West (31.5%), North (17.0%) and South (13.7%) TSAs.
- Of the four TSAs, the East TSA also had the highest concentration of undesignated trails (40.0 feet/acre), followed by the West (26.4 feet/acre), North (21.8 feet/acre) and South (15.5 feet/acre) TSAs. The Buckingham property (no TSA assigned) concentration exceeded all TSAs with 58.1 feet/acre.
- In areas with no or few designated trails, the average ratio of undesignated trail to designated trail miles is highest as in the East TSA where the ratio equals 3.6 undesignated miles for every 1.0 mile of designated trail.
- Where the most designated trail miles are provided (West TSA = 82 miles), this average ratio drops to 0.7 undesignated mile for every designated trail mile.

Spatial analyses of density, concentration and fragmentation

Within GIS, a 300x300 meter grid cell (22.24 acres) was created to standardize density calculations across the entire study area.

- Across all grid cells, density ranged from 0 to 2,253 feet/acre, but density tended to be higher in grid cells of less than the full 22.24 acres; these cells were clipped where they crossed an OSMP boundary. All grid cell density values greater than 525 feet/acre were in polygons of less than 1 acre.
- For grid cells less than the full 22.24 acres, undesignated trail density was locally highest in the vicinity of the Cottonwood Grove , Mt. Sanitas, Sombrero Marsh, Dry Creek, Gunbarrel Hill, Richardson I property , Andrus property and adjacent to the Red Rocks Trails. Only one of these high density areas was attributed with cattle.
- For full grid cells (around 22 acres in size), density was greatest at Red Rocks, Gunbarrel Hill, Flagstaff Mountain and in the vicinity of the High Plains Trail and Sawhill Pond. As in the partial grid cells, only one of these high density areas was attributed with cattle.

The average concentration was calculated by dividing the total acreage within a given area by the total linear feet of undesignated trails and roads within that area. Concentrations vary across any area, and are not uniform for an entire geographic area.

- Of the four management area designations, Passive Recreation Areas had the highest average concentration (60.4 feet/acre) of undesignated trails and Habitat Conservation Areas had the lowest (15.2 feet/acre).
- Areas with no management area designation had a concentration of 71.0 feet/acre (greater than all areas with a designation) across 811 acres including the Buckingham, Boulder Falls, NIST, BC Hospital and Sawhill Ponds areas.

Remaining un-fragmented polygons on OSMP lands

OSMP lands were fragmented using roads, undesignated trails and designated trails as input layers. Designated trails included those from OSMP, the City of Boulder, Boulder County and other municipalities.

- The results of the GIS fragmentation analysis yielded 1,101 polygons of "un-trailed" OSMP lands ranging from <1 acre to approximately 2,013 acres. Polygons less than 0.01 acres (136 total) were excluded from the results.
- There were a total of 565 out of the 1,101 that were <1 acre and these are generally biased toward buffered inputs/near property boundaries/THs.

Proximity of OSMP land to nearest designated or undesignated trail or road
Within GIS, a 100x100 foot grid cell was created to standardize proximity calculations across the entire study area. The value of each cell determines how far it is from a trail or road.

- Designated trails and roads were used in the first proximity cell-based analysis. Again, designated trails included those from OSMP, the City of Boulder, Boulder County and other municipalities. Cell values ranged from zero to 4,851 feet. The majority of cells had values between zero and 1,000 feet.
- When undesignated trails/roads were included along with designated trails/roads as a landscape feature in the proximity analysis of OSMP lands, the majority of the land was less than 1,000 feet from a road, designated trail or road, or undesignated trail or road. Cell values ranged from zero to 3,609 feet.

Constructed features, signs and road barriers

- A total of 438 constructed features were mapped during the inventory. The majority of these were identified as steps, waterbars, fences, culverts or check dams. The West TSA had the greatest number of constructed features and the South TSA had the least.
- A total of 506 signs were mapped during the inventory. Most of these signs were classified as regulatory, boundary, restoration or closure/danger/warning in message theme.
- The West TSA had the most signs followed by the East, North and South TSAs.
- A total of 23 road barriers were mapped during the inventory and the greatest number of these was attributed to slash large enough to block vehicular travel unless moved.

Recommendations

The VMP's proposed standards of less than 50 total miles and 0 new miles of undesignated trails on OSMP lands were both exceeded and a plan of action is recommended. OSMP managers and other pertinent staff should consider strategies to reduce visitor travel on undesignated trails and the overall undesignated trail mileage. Additionally, managers could consider revising the standards initially included within the VMP – using the 2006 and 2011 data as guidance. Some suggested steps recommended to reduce undesignated trail mileage include the following:

- Utilize the spatial and attribute information in the undesignated trail database to guide TSA planning for undesignated trails and follow the decision-making process outlined in the Eldorado Mountain/Doudy Draw Trail Study Area (TSA) Plan to prioritize undesignated trails for management actions (restore, retain or designate).
- Continue development of a comprehensive undesignated trail closure and restoration program that:
  - Prioritizes undesignated trails for timely closure based on priorities established in the decision making process;
  - Collaborates with other staff teams to determine best management practices;
  - Maintains staff dedicated to planning undesignated trail closures; and
  - Maintains a crew leader and crew to implement trail restoration treatments.

- Consider "re-branding" of signs and other visitor infrastructure to be used on undesignated trails so visitors have physical and visual cues to decipher between undesignated and designated trail signs and infrastructure.
- Implement strategies to educate visitors about the need to close and reduce travel on undesignated trails. Strategies might include:
  - Creating an educational module designed to inform visitors of OSMP trail closure and resource protection objectives;
  - Conducting educational hands-on workshops or hikes that highlight typical physical sustainability and/or potential visitor safety problems on undesignated trails;
  - Creating signage for installation along newly closed undesignated trails that display persuasive messages based on social science research deterring undesignated trail travel;
  - Training volunteers and staff to conduct on-trail education about area closures and designated alternatives.
- Review and update undesignated trail mapping protocols to facilitate efficient undesignated trail monitoring at 5-year intervals. Revisit the objectives of undesignated trail monitoring with input from a broad group of OSMP staff. When working on revisions to existing protocols, consider the possibility of a critical peer-review by experts in the Recreation Ecology field.
- Develop additional indicators/spatial and non-spatial analyses techniques to evaluate the undesignated trail data including:
  - Spatial analysis techniques assessing the location of undesignated trails with respect to sensitive resource areas; and
  - Undesignated trail indicators or metrics that integrate information on undesignated trail location with spatial information on sensitive resources.
- Refine the undesignated trail GIS database to provide quick and easy reporting and display of the extent of undesignated trails. Further develop the functionality of the database to report on individual trails, changes in closed or restored trails, trails by management area and specific queries needed to determine trail sustainability and suitability for designation during the TSA planning processes.
- Develop potential new social impact/visitor quality undesignated trail indicators using a social norm curve (Adapted from Manning 2011)

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1.0 Introduction

1.1. Undesignated trail development and managerial significance

Undesignated trails (e.g., unofficial, informal, visitor-created or social trails) are those trails typically formed by repeated visitor travel[2] in parks, natural areas, open spaces and other public land landscapes. Undesignated trails arise because trail systems developed by land managers usually cannot lead to all the destinations or create all of the travel experiences (e.g., opportunities for solitude, exploration or nature observation) that visitors seek (Byers et al. 2000; Park et al. 2008; Hockett et al. 2010; Marion et al. 2011; Wimpey & Marion 2011). Undesignated trails may develop when visitors lose the formal trail and/or inadvertently travel along wildlife or cattle trails. They may also develop when visitors choose to follow alternative routes to short cut trail switchbacks, avoid muddy, rutted or crowded conditions or bypass obstacles or rough patches on the formal designated trails (Turner & LaPage 2002; Park et al. 2008; Hockett et al. 2010).

Undesignated trails are of concern to public land managers because their development can result in unwanted changes to the landscape through vegetation loss, soil erosion, weed proliferation, disturbance to wildlife and fragmentation of habitat blocks (National Park Service 2008; D'Antonio 2010; Wimpey & Marion 2011). Undesignated trails also tend to have unplanned or historically planned (e.g., deer trail, old wagon road bed or railroad track excavation) alignments that can make them particularly unstable physically and susceptible to erosion with repeated human travel. From a social perspective, a web of informal trails creates a visually scarred landscape and may lead to safety and liability concerns (Marion et al. 2006). These conditions can create confusing conditions for visitors and preventable maintenance expenses for land managers. Such concerns have prompted national park managers to choose undesignated trail development as one of several key indicators of the contiguity and ecological health of an ecosystem and the quality of visitor experiences (Leung et al. 2002; Marion et al. 2006; Monz & Leung 2006; National Park Service 2008, 2010).

1.2. OSMP undesignated trail inventory background

The undesignated trails on the OSMP lands warn of recreational desires not met by the designated trail system or redundancies in recreational opportunities. In 2006-2007, over 170 miles of these trails were mapped on OSMP-managed lands (O'Malia 2011). From 2004 to 2005, OSMP received an estimated 4.7 million visits (Vaske et al. 2009) to the approximate

[2] For the purposes of this project, undesignated trail was defined to also include any closed formally designated trail or section of trail.

43,000 acre land system. If visitation increases, the extent of undesignated trail development is also likely to increase in the absence of a plan for managing for and meeting (when feasible) the unmet recreational desires of visitors on the OSMP system. OSMP's Visitor Master Plan (VMP) mandates the use of a program to assess undesignated trails (City of Boulder 2005a, p. 42) and periodic assessment of the extent of undesignated trails across the system (City of Boulder 2005a, p. 61). Undesignated trail mapping is a crucial step in developing strategies to manage these trails and in evaluating activities that occur off designated trails (i.e., off-trail activities) on OSMP lands.

In 2006-2007, OSMP staff conducted an intensive system-wide survey of undesignated trails on OSMP-managed lands that assessed the location, extent, condition (e.g., trail width, trail incision) and function (e.g., climbing access, ditch access or livestock water access) of undesignated trails using a systematic point-sampling monitoring technique (O'Malia 2011). Review of the literature and extensive testing of the 2006-2007 methods and alternative monitoring techniques highlighted the need to clarify criteria used for identifying and mapping pathways as undesignated trails. Field testing during the development of 2011-2012 methods also revealed the difficulty of consistently determining trail edges, trail width and categorical assessments of tread condition under the wide range of undesignated trail conditions that exist on OSMP lands. OSMP staff also voiced a desire for mapping of road-like pathways on our system. The resulting 2011-2012 mapping methods for undesignated trails retain only a small subset of attributes measured and recorded during the 2006-2007 undesignated trail survey (**Table 1**), focusing effort instead on identification and mapping of undesignated pathways (i.e., trails and roads). Additional data was collected to meet staff interest in the location of constructed features and signs that were found along the corridors of undesignated trails or road-like pathways[3] (hereafter referred to as just "roads").

Table 1. Comparison of data collected during 2006-2007 and 2011-2012 mapping

Collected Data Type	2006	2011
Location of undesignated trails	Yes	Yes
Undesignated trail width, incision and tread cover	Yes	No
Undesignated trail alignment and slope	Yes	No
Undesignated trail purpose and function	Yes	No
Areas of concentrated use locations and purpose	Yes	No
Location of roads	No[4]	Yes
Road barriers	No	Yes
Sign structure and messages along undesignated trails	No	Yes
Constructed features along undesignated trails	No	Yes

[3] For this project, road-like pathways included any pathway meeting the mapping criteria and not already included in the existing "Roads" GIS layer (OSMP in-house).
[4] Some roads were mapped in 2006-2007 if they were also considered undesignated trails.

Introduction

Because these two system-wide inventories were conducted with different methodologies, no attempt will be made to quantitatively compare the results of each iteration within this report.

Since 1983, partial surveys by Boulder Mountain Parks (MP), Boulder Open Space (OS) and OSMP in heavily travelled portions of the system and the first comprehensive system-wide survey (Jones 2002) have documented the magnitude and dynamic nature of undesignated trails (**Table 2**). For details on these earlier projects, see the references listed in **Table 2**.

Table 2. History of undesignated trail surveys on MP, OS and OSMP

Year	Who*	Scope of Survey and Results	Reference
1983	Parks & Recreation/MP Steve Ross	Survey of Flagstaff Mountain, Flagstaff Summit, Chautauqua Meadow, Flatiron and Bluebell Canyon, Enchanted Mesa, and NCAR found 15 miles of designated trails and 28.7 miles of undesignated trails	City of Boulder 1983
1992	Parks & Recreation/MP Unknown	Surveys of undesignated trails in Flatiron, Dinosaur Mountain, and Fern Canyon areas revealed many-fold increase in problems related to undesignated trails	Brown et al. 1992
1998	Open Space & Real Estate/OS Brett Wheeler	First comprehensive inventory of undesignated trails on Open Space land mapped 116 miles of undesignated trails	M. Jones, personal communication
2001	Parks & Recreation/MP Matt Jones	Mapped 86 miles of undesignated trails on Mountain Parks lands and 8 miles on NCAR lands using a GPS	M. Jones, personal communication
2002	OSMP Matt Jones	First comprehensive survey and GPS mapping on newly merged OSMP lands identified 300 miles of undesignated trails, subjectively classified into categories of relative use based on width class and condition	M. Jones 2002
2005	OSMP Matt Jones	Mapped, photographed, and assessed condition and width class of undesignated trails in Elephant Buttresses and Dome Rock areas using the 2002 mapping methods	VanderWoude, D. and M. Jones 2008

*City of Boulder department and project manager

1.3. Guidance from Visitor Master Plan

Open Space and Mountain Park's Visitor Master Plan (VMP) includes undesignated trail monitoring as a key performance measure, enabling OSMP to assess progress towards

implementing goals and objectives of the trails and facilities initiative. The VMP outlines strategies to assess, plan for and manage undesignated trails (City of Boulder 2005a, p. 41-42). The VMP (p. 50) identifies varying management strategies for existing undesignated trails that differ by the four management area designations (i.e., Passive Recreation Area, Natural Area, Agricultural Area and Habitat Conservation Area) (**Appendix A**). The VMP established the four management area designations based upon characteristics of visitation and resource status, and describes general management objectives for each.

1.4.Goals and objectives

The goal of undesignated trail mapping was to depict the extant location of undesignated trails in relation to OSMP's cultural and natural resources and developed infrastructure. Mapping was also intended to provide a snapshot in time depicting the extent of informal trail development. Undesignated trail mapping aimed to collect data needed to make informed decisions regarding management of undesignated trails during OSMP's trail planning processes (Lenth 2006). Specific objectives of the 2011-2012 system-wide undesignated trail monitoring program were to:

1. Map the linear extent and spatial distribution of undesignated trails and roads on OSMP managed lands and identify those used by cattle;
2. Map the location of constructed trail features in the vicinity of undesignated trails and roads; and
3. Map the location of trail signs in the vicinity of undesignated trails and roads.

All objectives were met concurrently by using GPS technology to map and attribute point features.

Results from this project will also be used to generally describe the success of undesignated trail guidance found within other OSMP plans.

2.0 Methods

The methods presented below represent a general description of the methods used during this project. A glossary of terms used in this report can be found in **Appendix B**. *Definitions used in this report are modified specifically for the purpose of the undesignated trail mapping project and should not be considered universal.* For further explanation on any topic, a detailed protocol for 2011-2012 undesignated trail mapping is available from OSMP upon request.

2.1. Undesignated trail and road-like pathway definitions

For this mapping project, an undesignated trail is defined as 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 (**Appendix C**) on the earth's surface (i.e., 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.

For this mapping project, a road-like pathway is defined as 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 an OSMP 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.

These definitions were developed in 2011 and were not in place when surveyors made decisions during previous inventories.

2.2. Study area

The 2011-2012 study area included all OSMP-managed lands through the Weiser acquisition of 2011 excluding two small properties that were unintentionally missed - New Pearl Street Industrial Park Open Scenic Easement and Rocky Mountain Outdoor Advertising properties (**Appendix D**). These properties included primarily those owned in fee along with a few conservation easements that OSMP retains management responsibility for. Elevations in the mapped area ranged from approximately 5,100 to 10,100 feet in a topographically diverse setting that includes mountain slopes, summits, mesas, bottomlands, canyons and plains. The approximate 35,657 acres included in the study area occurred in riparian, grassland, foothill scrub, ponderosa pine, Douglas-fir and sub-alpine spruce-fir forest vegetation falling within the Central Shortgrass Prairie and Southern Rocky Mountains eco-regions as defined by the Nature Conservancy (Bunin 1985; Cooper 1984; Nied et al., 2009).

The 2011-2012 study area included OSMP lands:

- Equaling approximately 35,657 acres;
- Including approximately 146 miles of designated trails and numerous access points and

areas of concentrated use (e.g., picnic and shelter areas) providing recreational opportunities for the approximate 4.7 million visits per year (Vaske et al. 2009);
- Within all four OSMP management areas (**Appendix E**) as well as a few parcels that were not assigned a management area designations because designation was not yet assigned or because joint management agreements or ownership status precluded assignment of a management designation;
- Within all four Trail Study Areas (east, north, west, south) used to guide the cycle of recreational and resource planning (**Appendix F**). Two properties with no TSA status were also included (Buckingham Campground and Boulder Falls).

The study area can be found in GIS here:
E:\MapFiles\Trails\Undesignated_Trails\Undesignated_Trails_2012\GIS_Analyses\Data\EndProducts\Analysis_2012UDTs.gdb

2.3. Office preparation for mapping

A preliminary system-wide map of potential undesignated trails and access points was compiled by updating the existing map from the 2006-2007 system-wide survey with undesignated trails officially surveyed post-2007 and adding new property acquisitions not previously surveyed. Before beginning fieldwork, specially prepared GPS receivers were uploaded with a data dictionary for each feature class (i.e., undesignated trails, constructed features, signs and road barriers) and background files (e.g., OSMP lands, fences and gates) intended to aid field technicians in locating property boundaries, trails and access points. Field technicians also printed and prepared their map tiles (**Appendix G**) created by Resource Information Staff (RIS) for use when navigating and mapping in the field.

2.4. Field methods

2.4.1. *Mapping undesignated trails and roads*

From July 2011 to November 2012, an extensive and systematic field survey was conducted on OSMP-managed lands within the study area by three trained field technicians to determine if undesignated trails mapped in 2006-2007 persisted and to search for any new undesignated trails and roads. The 2011-2012 mapping protocol (Lezberg 2012) followed a systematic point-sampling method commonly used to inventory and assess designated trails (Cole 1983; Marion et al. 2006; Marion et al. 2008).

Field staff searched for previously mapped undesignated trails and new undesignated trails in the vicinity of all previously identified undesignated trails and near roads, designated trails, access points and other visitor use areas. Undesignated trails greater than 20 feet long were mapped by collecting fixed-interval positions and attribute data using a Trimble® GPS receiver. GPS points were at mapped at the start, end and at 200-foot intervals in the interior of the undesignated trail (**Figure 1**).

Interior points at 200-foot intervals were located by walking the appropriate number of steps from the last measured point based on a previously calibrated stride length for each field technician. If needed, additional interior points were taken on curved trails to maintain accuracy. Interior "Change" points were mapped when the "Cattle" or "Pathway" status changed (e.g., at

the point a road ended and became an undesignated trail). Change points were also taken to represent the start and end of parallel or braided undesignated trails along a pathway.

Figure 1. An example undesignated trail with typical GPS mapped points (red stars) shown at the start, mid-point and end of the trail

Field staff searched for roads near each access point and within areas with observable road-like characteristics (i.e., two-tracks, width feasible for vehicle travel) in the aerial imagery used for creating map tiles. Roads were then mapped using the same methods as those used for undesignated trails. Barriers to vehicle access were GPS'd and assigned a barrier type using the road barrier feature class on the data dictionary.

Field technicians documented all undesignated trails and roads mapped and/or visited during each day's survey on a field tracking sheet (**Appendix H**).

2.4.2. *Attributes of mapped points along undesignated trails and roads*
All mapped points along undesignated trails were assigned a set of attributes using the undesignated trail data dictionary on the GPS to facilitate data processing and mapping (**Table 3;** see **Appendix I** for additional details). Field mappers were able to enter notes about any attribute or point in an open-ended comments field within the data dictionary. When encountered, any road barrier was mapped and attributed by type of barrier (such as a fence line or large downed tree).

Table 3. Attributes assigned at mapped points along undesignated trails and roads

Attribute	Definition	Procedure
Trail ID	Integer assigned to the undesignated trail	Number assigned as 2006 ID if previously mapped in 2006 or given new ID
Point ID	Consecutively numbered points along an undesignated trail	Numbers start at 1 and assigned consecutively in the order mapped along each numbered pathway
Point Type	Point type with respect to location on the undesignated trail	Category assigned in field: a. Start c. End b. Mid d. Change
Surveyor	Name of surveyor conducting trail mapping	Name assigned in field: a. AL c. DM b. DV
Cattle	Status of cattle use in the preceding trail segment	Category assigned in field: a. Yes b. No
Pathway	Status of preceding trail segment	Category assigned in field: a. Trail c. Road and trail b. Road

2.4.3. *Determination of "Not a Trail" (NAT) status*

Any segment of 20 feet or more in length embedded in a mapped undesignated trail that failed to meet the undesignated trail definition was defined as "Not a Trail" or a "NAT" for the purpose of this mapping project. Additionally, any pathway of similar length traversing a resistant surface (e.g., bedrock), for which trail edges were not discernible and no other clues of visitor travel were evident was considered a NAT. NAT segments were annotated on map tiles but were skipped over when GPS mapping, leading to discontinuous pathways. Pathways meeting the NAT descriptions above but with a length of less than 20 feet were typically included as part of the mapped segment (i.e., embedded NAT). Field technicians individually made these decisions in the field and thus some subjectivity remains in this categorization.

2.4.4. *Constructed features and signs*

When a constructed feature or sign was encountered within the corridor of an undesignated trail or road, GPS points were collected at the location of the feature or in the middle if the feature was linear (e.g., fence section or side ditch). The trail ID of the nearest undesignated trail, the constructed feature type or the sign structure/sign type were entered into the GPS using the appropriate feature class within the project's data dictionary. Constructed feature, sign structure and sign types given in the data dictionary are described in the protocol and generally correspond to those tracked during OSMP designated trail condition monitoring. For those constructed features and signs categorized as "other", field staff used the open-ended comments field within the data dictionary or took photographs to describe what was encountered.

2.4.5. *Photo documentation*
Field technicians photographed undesignated trails and roads opportunistically to create a catalogue representing the breadth and extremes of conditions across OSMP. Photographs were also taken to clarify elements of the protocol for future use or to provide examples to share with other surveyors to help insure inter-observer consistency. Constructed features and signs were also photographed in this same manner, particularly if the feature represented something that could not be identified (fell into the "other" category) or otherwise seemed unique to the field technician. Photographs were systematically documented and electronically saved for future reference.

2.4.6. *Documenting new or novel field situations*
Throughout the year, undesignated trail mapping staff encountered situations not yet documented in the protocol and occasionally had questions about which pathways to map. Ad-hoc office meetings occurred regularly to resolve new or novel situations and address questions. The goal of these meetings was to develop guidelines for handling these situations, insuring that every field technician had the least ambiguous tools for making decisions in the field in a consistent way. To be consistent with decisions made, mapping staff followed up on these meetings by changing the data dictionaries as needed, editing previously-collected GIS data, editing electronic versions of and field tracking sheets and revising the protocol. In addition to these office meetings, mapping staff also met in the field whenever in-person observation was desired to facilitate resolutions.

2.5. GIS digitizing methods

2.5.1. *Creating initial GIS maps of undesignated trails, roads, and mapped features*
GPS points collected along undesignated trails and roads were downloaded into a GIS to facilitate digitizing of undesignated trail and road segments. Zoomed in and using the mapped GPS points with aerial photographs as a reference, staff digitized segments between the start, mid-trail and end points (**Figure 1**) for each undesignated trail and road, thus creating a polyline feature class. A sub-set of the variables recorded at GPS points (**Table 3**) were assigned to the corresponding line feature (i.e. Trail ID, Cattle and Pathway). Mapping date and comments were added to the GIS attribute table by joining the GIS feature with the electronic (MS Excel) version of the field tracking sheets. Line feature lengths were calculated using XTools Pro© for ArcGIS. The resulting polyline feature class of undesignated trails and roads (sdeTrails.DBO.Undesignated_Trails_2012_Original) comprised the original map and attribute table used for further feature class and map development.

Mapped points for constructed features, signs, and road barriers were downloaded into GIS shape files and merged to create separate point feature classes for each category of features after reviewing the data according to quality assurance procedures outlined in the protocol.

2.5.2. *Creating final 2011-2012 GIS maps of undesignated trails, roads, and other mapped features for analyses* (**Appendix J**)
The original data was grouped by Trail ID and clipped to OSMP lands within the project area. The TSA (i.e., North, South, West, East) in which the trail existed was added to aid in interpretation and analysis. In creating the final 2011-2012 undesignated trail and road layer**,** a

number of universal data reviews and changes were implemented by monitoring and RIS staff including clipping the original data to the OSMP boundary and project area feature classes, merging line segments by Trail ID into a single feature that occasionally resulted in multipart features and recalculating length of merged line features. Details of these steps are documented in the monitoring protocol.

Final GIS data used to conduct analyses can be found here (accessed October 2014): E:\MapFiles\Trails\Undesignated_Trails\Undesignated_Trails_2012\GIS_Analyses\Data.

Surveyed properties:
E:\MapFiles\Trails\Undesignated_Trails\Undesignated_Trails_2012\GIS_Analyses\Data\EndProducts\Analysis_2012UDTs.gdb

Undesignated trails and roads:
sdeTrails.DBO.Undesignated_Trails_2012_OriginalGrouped

Constructed features:
E:\Layers\Trails\UndesignatedTrailMonitoring\Undesignated Trails Constructed Features - 2012 Inventory.lyr.

Signs: E:\Layers\Trails\UndesignatedTrailMonitoring\Undesignated Trails Signs - 2012 Inventory.lyr.

2.6. Analyses methods

2.6.1. *Location, linear extent and spatial distribution*

Mileage of undesignated trails and roads by TSAs and management areas
Spatial analyses were conducted to determine the distribution of undesignated trails and roads among the TSAs and management area designations. Undesignated trails or roads crossing a boundary were split into multiple segments using the identity or the intersect tool in ArcGIS. Segment lengths in each TSA and management area designation were summed using queries in an Access database. These steps were repeated to derive summed segments lengths for each pathway category (undesignated trail, road, undesignated trail/road), and with and without cattle.

A small percentage of the project area had no management area designation because the designation was not yet assigned or because joint management agreements or ownership status precluded assignment of a management designation. These properties are included as a TSA=none category. Parcels intended to have a management area designation but not yet officially assigned were given a conditional management designation. For the purpose of this report, conditional management designations have been included in the four management area acreages.

2.6.2. *Spatial analyses*
Given the diverse data that were collected as part of this project, a number of spatial analyses are possible. GIS analyses examined the spatial distribution of undesignated trails and roads in

relation to management area designations, TSAs, designated trails and roads and access points. These analyses were intended to provide managers with spatial information that could be used to:

1. Locate areas on OSMP lands with an extensive or unacceptable level of undesignated trail development;
2. Relate the location of undesignated trails to areas with high ecological/habitat or visitor access value;
3. Prioritize undesignated trails for restoration, closure or designation; and
4. Visually represent the extent of undesignated trails as an educational tool.

Density of undesignated trails and roads

Grid cell analysis

Staff conducted a GIS analysis showing the spatial variability in density of undesignated trails and roads (feet/acre) within gridded cells across the project area (**Appendix K).** A GIS shapefile of grid cells (300 meters on a side or 22.24 acres/grid cell) was overlain on the project area and undesignated trails and roads GIS layer. Using the identity tool, undesignated trail and road segments extending across multiple grid cells were split at the cell boundaries. Access database queries were used to summarize lengths of the split undesignated trail and road segments within grid cells. Density for each grid cell was calculated as the summed undesignated trail and road length (feet) for each grid cell divided by the acreage of each grid cell. Many grid cells had acreages less than 22.24 acres because they were clipped along the study area boundaries. These "partial" grid cells were retained in the density analyses with the exception of grid cells of less than one acre. These 142 polygons less than one acre were not included in the density analysis because of their potential to inflate density values when calculated for very small areas.

Kernel density analysis

To determine the relative lowest to highest density of undesignated trails and roads, staff conducted a GIS analysis showing the relative spatial variability in density across OSMP lands. Using the Kernel Density GIS tool, the relative density was calculated with a search radius of 750 feet emanating from any undesignated trail or road segment. The results of this analysis displayed the density in a grid of 50 foot cells (**Appendix L).**

Remaining un-fragmented polygons on OSMP lands

Of concern to OSMP managers and other staff is the idea that roads and trails, whether designated or undesignated, may functionally fragment contiguous blocks of wildlife habitat and plant communities. A GIS analysis was conducted using linear access routes (i.e., roads, designated trails, undesignated trails and roads) clipped to the surveyed OSMP-managed properties data (i.e., the project area). Then the project area was dissolved so that internal boundaries were removed. To determine how the project area was fragmented by the linear access routes, the lines were buffered by 40 feet on each side so that we could erase their outlines from the project area. They were buffered to ensure polygons were completed bisected by the actual line feature, primarily in cases where the actual line feature mostly but not completely extended across a polygon to fully bisect it. The analysis resulted in the fragmentation of the dissolved project area boundary by the buffered lines. The resulting maps (**Appendix M**) were visually compared to evaluate differences in the sizes of un-fragmented areas.

Proximity of OSMP land in the project area to nearest designated or undesignated trail or road

To evaluate the proportion of the OSMP landscape that were relatively near and far from designated and undesignated roads and trails, a GIS analyses was conducted comparing the distance from all grid cells on OSMP lands to access routes with and without the inclusion of undesignated roads and trails. Analysis was conducted using shapefiles representing linear access routes (i.e., roads, designated trails, undesignated trails and roads) clipped to the project area. Within GIS, the Euclidian distance tool with 100x100 foot grid cells was used to calculate trail and road proximity across the entire project area. This tool determined the straight line distance in feet from each cell to the nearest designated or undesignated trail or road and assigned the associated integer to that cell.

2.6.3 *Count analyses*

In addition to undesignated trail and roads, data was collected on constructed features, signs and road barriers. These data were collected to understand how these types of features are distributed across OSMP.

Constructed features, signs and road barriers

To understand the total number and spatial distribution of mapped constructed features, signs and road barriers, a number of analyses were done. A spatial join was performed on the constructed features shapefile to assign the type of management area and which TSA each one fell into. Using an Access database and the imported constructed feature attribute table the total number of each feature class was summed for the entire study area, by management area designation and by TSA.

2.7. Data interpretation cautions and limitations

Any person using any data/map products produced by this project should be aware of the following:

2.7.1. *Technical limitations*

- Poor GPS accuracy at different times may lead to inconsistency in the mapped locations and lengths of undesignated trails. Standards for GPS accuracy (i.e., requiring a maximum PDOP of 6 and requiring use of either the GeoXH or the ProXH antennae) were used to lessen this problem for this project.
- Hand-drawn segment alignments between points when digitizing may lead to some error in line feature creation. However, these segments are grounded at points of at least 200-foot intervals and their accuracy was improved by using aerial photos to follow the mapped pathway (if visible) to guide digitization.

2.7.2. *Inter-observer variability*

While calculations of total undesignated trail length and/or new undesignated trail length may be of interest and were identified as a measure for monitoring the effectiveness of OSMP management in the VMP, *any such calculations should be interpreted with caution for the following reasons*:

- Despite repeated training, inter-observer testing, written definitions, use of photographic examples and frequent discussions during the mapping project, surveyors likely exhibit variability in determining which pathway segments:

- Meet the criteria for undesignated trails or roads and are therefore mapped;
- Are braids of designated trails and therefore not mapped as opposed to parallel trails that are mapped.

These differences can lead to differences in measurements of total length among observers.

2.7.3. *Differences between 2006 and 2011*

- Similarly, despite efforts to understand and repeat the methods used during the 2006-2007 mapping of undesignated trails, no criteria is available defining which undesignated trails or roads were mapped in 2006-2007. Given the subjectivity associated with determining which pathways to map, it is unlikely that the decisions made by the 2011-2012 field surveyors were always consistent with the decisions made by the 2006-2007 field surveyors. This inhibits OSMP's ability to quantitatively compare total length of undesignated trails between these years.
- Additionally, it is known that during the 2006-2007 mapping of undesignated trails, field staff mapped braids of designated trails, while staff did not map braids of designated trails in 2011-2012. This inhibits OSMP's ability to quantitatively compare total length of undesignated trails between years.
- In 2006-2007, any "undesignated roads" that were mapped were removed from the data base if OSMP field staff (rangers, lease managers, etc.) determined that these pathways were maintained and regularly used roads (fire or emergency access). This step did not occur during the 2011-2012 project.

3.0 Results

Caution should be used when interpreting the total length of undesignated trails on OSMP-managed land given the many decisions surveyors make when determining whether to include or exclude a segment from mapping.

Notes on interpreting results:

1. Unless otherwise stated, results represent features mapped within the study area at the system-wide extent.
2. Individual or summed values less than .05 are typically not included; totals represent rounding to the nearest tenth of a mile, tenth of percent, or to the nearest whole count, percent or acre.
3. Slight differences in individual values and/or sums are due to rounding and small variations in the GIS layers used to conduct analyses.
4. This report does not intend to determine which area of OSMP has the highest number or proportion of miles of cattle trails. Results represent only those trails within the study area that met the mapping criteria on the day the field technician came across them and are not meant to be exhaustive of cattle trails across the entire OSMP land system.

3.1. Location, linear extent and spatial distribution of undesignated trails and roads

3.1.1. *Linear extent of undesignated trails and roads*

System-wide, there were a total of 181.3 miles of undesignated trails and roads mapped during the 2011-2012 inventory. Of these, 3.6 miles were mapped outside of the 35,657 acre study area. While outside the study area, these 3.6 miles were mapped because the field technician believed they led directly to OSMP visitor infrastructure, were directly adjacent to the study area, would be helpful when interpreting adjacent mapped pathways or because of discrepancies between GPS background files and observed field conditions (e.g. OSMP boundary on GPS does not match signed boundary in field). Attributes and spatial information for all mapped pathways are stored in a GIS and a Microsoft Access® database developed as part of a long-term strategy for monitoring and managing undesignated trails.

Within the study area, undesignated trails represent close to three quarters of mapped pathways (72.7%) while pathways categorized as both road and undesignated trail comprised slightly less than one quarter (24.2%) (**Table 4**). Mapped roads made up approximately three percent of the total miles. The proportion of each pathway type mapped within and outside of the study area was very similar.

Table 4. System-wide undesignated trail and road miles and percent of total by pathway type in and outside of study area

	In Study Area		Outside Study Area		Combined Total	
Pathway Type	**Miles**	**Percent of Total**	**Miles**	**Percent of Total**	**Miles**	**Percent of Total**
Undesignated trail	129.2	72.7	2.7	73.4	132.0	72.8
Road	5.4	3.1	0.1	1.7	5.5	3.0
Road and undesignated trail	43.0	24.2	0.9	25.0	43.9	24.2
Total	**177.7**	**100.0**	**3.6**	**100.0**	**181.3**	**100.0**

Note: From this point forward, results represent features mapped only within the study area boundaries unless otherwise noted.

3.1.2. *Distribution of undesignated trails and roads among Trail Study Areas*
Trail Study Areas include a "None" category for those properties that currently are not expected to ever be assigned to any TSA process. The greatest percent (37.5%) of mapped undesignated trails and roads occurred across 8,791 acres of the East TSA and the least percent (13.7%) occurred in the South TSA (**Table 5 or Figure 3**, excluding the no TSA assigned areas).

Table 5. System-wide miles and percent of total by Trail Study Area

Trail Study Area (acres surveyed)	**Miles**	**Percent of Total**
North (7,308)	30.2	17.0
South (8,291)	24.4	13.7
East (8,791)	66.6	37.5
West (11,223)	56.1	31.5
None assigned (45)	0.5	0.3
Total	**177.7**	**100.0**

When examining the distribution of pathway types (i.e., undesignated trail, road or road and undesignated trail) within each TSA, the West TSA had the greatest proportion of undesignated trails (92.5%) and the least roads (1.1%) compared to other TSAs (**Table 6**). The North and East TSA mileages included approximately two-thirds undesignated trails, with the remaining thirds composed primarily of roads/undesignated trails. The South TSA had the greatest proportions of roads (4.5%) and roads/undesignated trails (36.8%) compared to the other TSAs.

Table 6. System-wide miles and percent of total by Trail Study Area and pathway type

Trail Study Area	Pathway Type	Miles	Percent of Total
North	Undesignated trail	20.2	66.7
	Road	1.2	3.9
	Road and undesignated trail	8.9	29.3
	Total	**30.2**	**100.0**
South	Undesignated trail	14.3	58.7
	Road	1.1	4.5
	Road and undesignated trail	9.0	36.8
	Total	**24.4**	**100.0**
East	Undesignated trail	42.6	64.0
	Road	2.5	3.8
	Road and undesignated trail	21.5	32.2
	Total	**66.6**	**100.0**
West	Undesignated trail	51.9	92.5
	Road	0.6	1.1
	Road and undesignated trail	3.6	6.4
	Total	**56.1**	**100.0**
None	Undesignated trail	0.3	68.6
	Road and undesignated trail	0.2	31.4
	Total	**0.5**	**100.0**

3.1.3. *Distribution of undesignated trails and roads among management areas*
Management area designation includes a "None" category for a total of 811 acres as some properties will never have a designation because OSMP does not have reason/direction to do so or does not own the property. Management area designations also include some properties with a "conditional" designation assigned using existing documentation for each property. Approximately 551 of the 35,657 surveyed acres (about 1.5% of study area) were given these conditional designations. Habitat Conservation Areas include both active and non-active HCAs.The greatest percent (34.2%) of mapped trails and roads occurred in the 12,955 acres surveyed within Natural Areas and the least percent (8.8%) occurred in the 3,650 acres of mapped Agricultural Areas (excluding the no designation areas) (**Table 7, Figure 2**). Passive Recreation and Habitat Conservation Areas had close to one quarter each of the total miles, with 28.5% and 22.4% respectively.

Table 7. System-wide miles and percent of total by management area designation

Management Area Designation (acres surveyed)	Miles	Percent of Total
Passive Recreation Area (4,434)	50.7	28.5
Natural Area (12,955)	60.7	34.2
Habitat Conservation Area (13,807)	39.8	22.4
Agricultural Area (3,650)	15.6	8.8
None (811)	10.9	6.1
Total	**177.7**	**100.0**

A total of 811 acres currently with no OSMP management area designation included the Boulder Falls, Buckingham Campground, Boulder Community Hospital, NIST, NCAR, IBM, Sawhill Ponds and numerous small acreage properties.

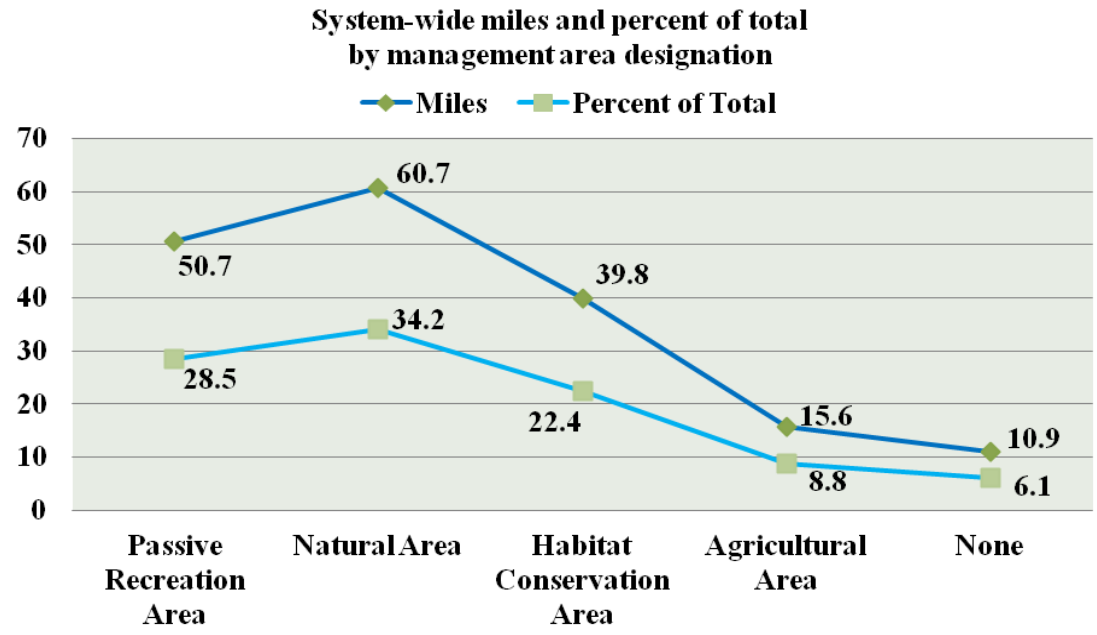

Figure 2. System-wide miles and percent of total by management area

When broken down by pathway status for each management area designation (excluding no designation areas), Passive Recreation Areas had the highest proportion of undesignated trails (94.5%) and the lowest proportion of roads/undesignated trails (5.4%) (**Table 8**) compared to the other management area designations. Agriculture Areas had the highest proportions of roads (7.9%) and roads/undesignated trails (68.5%) and the lowest proportion of undesignated trails (23.6%). The total miles mapped in Habitat Conservation Areas were nearly equally split between undesignated trails (52.6%) and those categorized as either roads (6.4%) or

roads/undesignated trails (41.0%). Natural Areas had the lowest proportion of roads (2.7%) and the second highest proportion of undesignated trails (78.1%).

Table 8. System-wide miles and percent of total by management area designation and pathway type

Management area Designation	Pathway Type	Miles	Percent of Total
Passive Recreation Area	Undesignated trail	47.9	94.5
	Road and undesignated trail	2.8	5.4
	Total	**50.7**	**100.0**
Natural Area	Undesignated trail	47.4	78.1
	Road	1.6	2.7
	Road and undesignated trail	11.6	19.2
	Total	**60.7**	**100.0**
Habitat Conservation Area	Undesignated trail	21.0	52.6
	Road	2.5	6.4
	Road and undesignated trail	16.3	41.0
	Total	**39.8**	**100.0**
Agricultural Area	Undesignated trail	3.7	23.6
	Road	1.2	7.9
	Road and undesignated trail	10.7	68.5
	Total	**15.6**	**100.0**
None	Undesignated trail	9.3	85.2
	Road and undesignated trail	1.6	14.8
	Total	**10.9**	**100.0**

3.1.4. *Distribution of surveyed acres and mileage among management areas*
Of the four management area designations, Habitat Conservation Areas encompassed the most surveyed acres (13,807). Natural Areas followed closely with 12,955 acres and Agricultural Areas included the least surveyed acres (3,650) (**Table 5**). The Habitat Conservation Area designation contained the most conditional areas with 267 acres.

When total miles of undesignated trails and roads are considered relative to the total acres surveyed for each management area designation, Passive Recreation Areas have 2.3 times the proportion of mapped miles relative to their proportion of the total acreage. Natural Areas and Agricultural Areas had similar relative proportions of miles and acreages, and Habitat Conservation Areas had the smallest proportion of miles relative to their proportion of total surveyed acreage (**Table 9**).

Table 9. Ratio of the percent of total miles to the percent of total acres surveyed by management area designation

Management Area Designation	Percent of Total Miles	Percent of Total Acres	Miles/Acres Ratio
Passive Recreation Area	28.5	12.4	2.3
Natural Area	34.2	36.3	0.9
Habitat Conservation Area	22.4	38.7	0.6
Agricultural Area	8.8	10.2	0.9
None	6.1	2.3	2.7
Total	**100**	**100.0**	**n/a**

3.1.6. *Cattle attribution*

Approximately one-third (33.5%) of all mapped trails were attributed with evidence of cattle use (**Table 10**). Of the 59.6 miles documented with cattle evidence, the greatest number of miles (33.9) occurred along pathways categorized as undesignated trails and the least number of miles occurred along roads (3.3) (**Table 11**). Within each pathway type category, roads had the highest proportion of miles attributed with cattle use (59.9%) and undesignated trails had the lowest proportion of miles attributed with cattle use (26.2%).

Table 10. System-wide miles and percent of total by cattle evidence

Cattle evidence	Miles	Percent of Total
Yes	59.6	33.5
No	118.1	66.5
Total	**177.7**	**100.0**

Table 11. System-wide miles and percent of total by pathway type and cattle evidence

Pathway Type	Cattle evidence	Miles	Percent of Total
Undesignated trail	Yes	33.9	26.2
	No	95.3	73.8
	Total	**129.2**	**100.0**
Road	Yes	3.3	59.9
	No	2.2	40.1
	Total	**5.4**	**100.0**
Road and undesignated trail	Yes	22.5	52.2
	No	20.6	47.8
	Total	**43.0**	**100.0**

3.2. Spatial analyses of undesignated trail patterns

3.2.1. *Density of undesignated trails and roads across the 300 x 300 meter (22.24 acre) grid cells*

Density of undesignated trails and roads ranged from 0 to 2,253 feet/acre across all 2,387 grid cells, with an average density of 35.8 +/- 2.3 feet/acre. The majority of grid cells (1,399 cells) had a density of zero feet/acre (i.e. median density = 0 feet/acre) (**Appendix K**). Across the entire study area, grid cell size ranged from 0.001 to 22.24 acres. More than half of all grid cells (56%) were partial cells (less than 22.24 acres) that were clipped to be within the project area. Partial cells had the potential to inflate density results due to reduced cell size and the reduced available acreage upon which to average existing pathways. As the grid cell size decreased from the full cell size of 22.24 acres, the feet/acre generally rose in an inverse trend (**Table 12**, **Figure 3**).

Table 12. Range of density of undesignated trails and roads for different size classes of grid cells and number of cells within each cell size range

Grid Cell Size (acres)	Range of Density (feet/acre)	Number of cells (n=2,387)
>.001 - <.5	0-2253	98
>.5 - 5.5	0-1142	380
>5.5 - 10.5	0-432	287
>10.5 - 15.5	0-308	273
>15.5 - 20.5	0-223	297
>20.5 - 22.24	0-262	1,052

Results

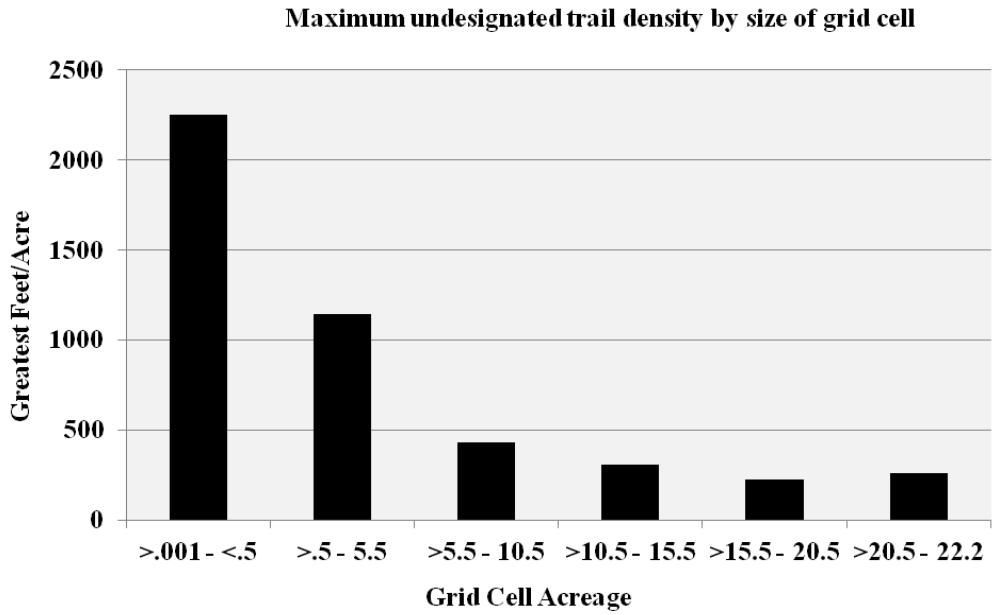

Figure 3. Greatest feet/acre by size of grid cell

Across all 2,387 cells, the cells with the greatest densities were all partial cells (less than 22 acres) and typically were located near the OSMP boundary or contained small "island" or peripheral OSMP properties. There were a total of 1,469 partial cells, 142 of which were less than one acre in size (down to .001 acre). These cells of less than one acre were not included when determining the cells with greatest density because of the potential for inflating density results due to reduced cell size and the available acreage upon which to average existing pathways. There were a total of 1.07 miles mapped within these 142 partial cells.

To determine areas within the study area with the highest and lowest densities, density was visually analyzed in GIS and then confirmed using the attribute data within GIS.

For partial grid cells of at least one acre (1,327 of 2,387 cells) density was highest in the vicinity of Cottonwood Grove Mt. Sanitas Sombrero Marsh, Dry Creek, Gunbarrel Hill, the Richardson I property, the Andrus property and adjacent to the Red Rocks Trails. Of these high density areas, only the Richardson I property was attributed with cattle. Of the partial cells, 586 (44%) had a zero feet/acre density.

For full grid cells (918 cells) density was greatest at Red Rocks (no cattle), Gunbarrel Hill (no cattle), Flagstaff Mountain (no cattle) and in the vicinity of the High Plains Trail (yes cattle) and Sawhill Ponds area (no cattle). Of the full cells, the majority (55%) had a zero feet/acre density.

For partial grid cells of at least one acre, areas with the lowest density (not including density values of zero) were in the vicinity of the Jewel Mountain property (yes cattle), Flatirons Vista Trails (yes cattle), Rice property (no cattle), South Boulder Creek West Trail (yes cattle), Suitts-South property (yes cattle) and the U.S. Patent-Green Mountain property (no cattle). For full grid cells around 22 acres in size, density was lowest (not including density values of zero) at the Superior Associates property (yes cattle), South Boulder Creek West Trail (yes

cattle), Lower Big Bluestem Trail (yes cattle), Bear Peak West Ridge Trail (no cattle), B.L.I.P. property (yes cattle) and Beech-West property (no cattle).

Across the entire study area, the majority of grid cells (91%) contained a density of 100 or less feet/acre (**Table 13**). Only 13 of 2,387 cells had a density of 500 or more feet/acre. Twelve of these cells were less than one acre in size and one cell was 3.4 acres in size.

Table 13. Range of density (feet/acre) of undesignated trails and roads for all 2,387 grid cells and number of cells within each feet/acre range

Feet/Acre Range	Number of Cells	Percent of Cells
0	1,399	59
1-100	768	32
101-200	145	6
201-300	39	2
301-400	14	<1
401-500	9	<1
501-2253	13	<1
Total	**2,387**	**100**

Average density values were lower in full cells (**Table 14**) than in partial cells (**Table 15**). Median values including zero value cells were the same (zero) and the median values without zeros were also lower in full cells.

Table 14. Full cell average and median density (feet/acre) with and without zero values

Average with zero values	21
Average without zero values	48
Median with zero values	0
Median without zero values	44

Table 15. Partial cell average and median density (feet/acre) with and without zero values

Average with zero values	45
Average without zero values	114
Median with zero values	0
Median without zero values	65

3.2.2. *Remaining un-fragmented polygons on OSMP lands*
The fragmentation analysis resulted in 1,101 remaining un-fragmented polygons. A majority of the polygons ranging from .01-99.99 acres are located near adjacent development, OSMP property boundaries or trailhead areas where fragmentation is typically higher than other OSMP areas.

Cumulatively, less than one third of the land within the study area is represented by those polygons less than 100 acres in size and over two-thirds of the study area land is made up of un-fragmented polygons greater than 100 acres in size (**Figure 4**).

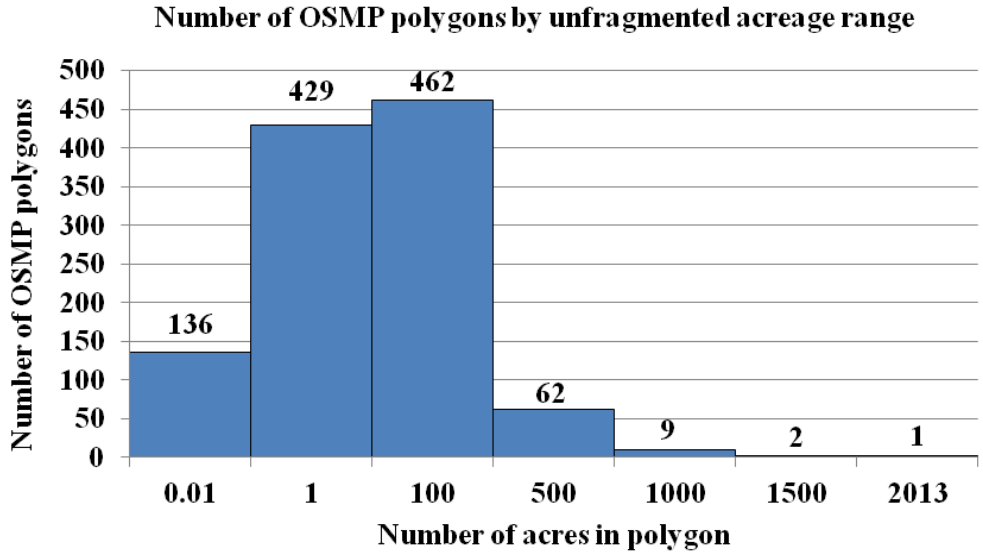

Figure 4. Number of remaining OSMP polygons by un-fragmented acreage range

3.2.3 Proximity of OSMP land to any designated or undesignated trail or road
Within GIS, a 100x100 foot grid cell was created to standardize proximity calculations across the entire study area. Using the standardized cells, an analysis was conducted to determine the distance from each cell to the nearest designated or undesignated trail or road. The value of each cell determines how far it is from a trail or road (**Appendix N**).

- Designated trails and roads were used in the first proximity cell-based analysis. Again, designated trails included those from OSMP, the City of Boulder, Boulder County and other municipalities and counties. Cell values ranged from zero to 4,851 feet. The majority of cells had values between zero and 1,000 feet.
- When undesignated trails/roads were included along with designated trails/roads as a landscape feature in the proximity analysis of OSMP lands, the majority of the land was less than 1,000 feet from a road, designated trail or road, or undesignated trail or road (Appendix N). Cell values ranged from zero to 3,609 feet (n=310,774 [271,539 with zero values removed]).
- A visual scan of the map data indicates that the OSMP areas with the greatest distance to any designated or undesignated trail or road are in the western edges of the Western

Mountain Parks and Eldorado Mountain HCAs, in portions of the Southern Grasslands HCA and on the Jewel Mountain property

3.3. Visual comparisons of undesignated trail distribution over time

The system-wide data layers from 2006 and 2011 were overlaid (**Appendix O**) to visually explore differences in undesignated trail extent and to brainstorm the underlying causes for these differences. The best available knowledge of OSMP staff was used to evaluate the likely causes of change and included:

1. Restoration or closure actions;
2. Cattle activity;
3. Methodological differences in mapping;
4. Seasonal changes associated with the time of year the mapping was completed;
5. Mapping of roads in 2012 not included in 2006 mapping efforts;
6. New properties not previously mapped or areas skipped in 2006 mapping.

A specific example of how undesignated trails have been mapped over time in a particular geographic area is included for a sub-set of the Eldorado Mountain/Doudy Draw TSA in **Appendix O**.

3.4. Counted features

3.4.1. Constructed features

A total of 438 constructed features were inventoried with 433 within the study area (**Table 16**; See **Appendix P** for the breakdown of constructed features by the original 27 feature types) and 5 features mapped outside of the study area. While outside the study area, these 5 features were mapped because the field technician believed they supported the visitor infrastructure leading to or were directly adjacent to the study area. The majority of constructed features were identified as steps, waterbars, fences, culverts or check dams.

Table 16. System-wide constructed features summed by similar feature types in and outside of the study area

Constructed Feature Type	Count in Study Area	Count Outside Study Area
Barricade	5	
Bridge	16	
Check dam*	27	1
Culvert, steel	45	1
Drain/ditch	2	
Fence	62	
Footbridge	16	
Geotextile	5	
Other**	14	1
Step***	125	
Stepping stones	2	1
Wall	22	
Waterbar*	92	1
Total	**433**	**5**

*Some of these represent the center point of a linear feature containing more than one individual feature
**Examples of "other" features include hydrological management structures and a series of trailside guide rocks
***Majority of these represent the center point of a linear feature containing more than one step

Five constructed features were mapped adjacent to the study area and these were found within the North (3), South (1) and East (1) TSAs.

3.4.2. Signs

A total of 506 signs were inventoried with 449 within the study area and 57 signs mapped outside of the study area. While outside the study area, these 57 signs were mapped because the field technician believed they intended to inform visitors at an access point or on a pathway leading to or directly adjacent to the study area (**Figure 5**). Most inventoried signs contained regulatory, boundary, restoration or closure/danger/warning messages (**Table 17**).

Figure 5. Mapped sign just outside of the East TSA project area and directly adjacent to OSMP undesignated trail; sign is a regulatory sign telling the reader that cycling is not allowed

Table 17. Sign type count and percent of all signs mapped within study area

Sign Type	Count	Percent of Total
Boundary/Property	62	14
Closure/Danger/Warning	46	10
Cows	3	1
HCA Boundary	28	6
Informational	12	3
Interpretive	3	1
No sign on sign structure	11	2
Regulatory	190	42
Restoration	55	12
Seasonal Closure	25	6
Unknown (aging)	8	2
Wayfinding/Direction	6	1
Total	**449**	**100**

A total of 57 signs were mapped outside of the study area (outside of OSMP boundary). While outside the study area, these 57 signs were mapped because the field technician believed they intended to inform visitors at an access point or on a pathway leading to or directly adjacent to the study area. Nearly half of these signs (49%) contained a regulatory message and one-quarter included boundary/property messages (**Table 18**).

Table 18. Sign type count and percent of total outside of study area

Sign Type	Count	Percent of Total
Boundary/Property	14	25
Closure/Danger/Warning	4	7
Cows	1	2
Regulatory	28	49
Restoration	4	7
Seasonal Closure	3	5
Unknown (aging)	3	5
Total	**57**	**100**

The East TSA included the most signs (22) mapped outside of the study area, followed by the West (17), North (14) and South (4) TSAs (**Table 19**).

Table 19. Sign count outside study area by Trail Study Area

Trail Study Area	Count
North	14
South	4
East	22
West	17
Total	**57**

3.4.3. Road barriers

A total of 23 road barriers were mapped. Of these, 3 were mapped outside of the study area. These 3 barriers were included in the inventory because the field technician believed they prohibited travel at a vehicle access point a driver would have to go through to reach OSMP lands. The majority of recorded road barrier types were downed slash and/or fences noted as being movable with some physical effort or a chainsaw. A few locked gates were documented at access points managed by another agency, but adjacent to OSMP.

3.4.4. Additional data for each TSA and management area

Additional data, not presented within the body of this report, for each TSA and management area can be found in **Appendix Q**.

4.0 Discussion

4.1. Location and linear extent of undesignated trails on OSMP lands

With 181 miles of undesignated trails mapped on OSMP lands, proposed standards set forth in the VMP have been exceeded. These unofficial trails can functionally fragment the landscape, and have the potential to negatively impact the natural, cultural and recreation resources that OSMP strives to protect under the direction of the OSMP charter. Undesignated trails also have the potential to detract from the quality of the visitor experience and in some locations could be considered unstable and/or unsafe. Conversely, the extent of undesignated trails across the OSMP system speaks to visitor travel patterns not met by the designated trail system and the need for visitor travel patterns to continually be reviewed during future planning processes.

The availability of spatial data documenting undesignated trail location and extent allows OSMP to measure success with their objectives of reducing undesignated trails to fewer than 50 total miles, with no new miles developing, across the Open Space and Mountain Parks system. Future monitoring should use a similar protocol to locate and record location and extent of undesignated trails but may need to be tailored to reflect revisions of undesignated trail standards originally documented within the VMP.

4.2.Undesignated trail management: Guidance from OSMP management plans

Several OSMP plans contain direction for the management of undesignated trails. The 2011-2012 results provide information on undesignated trail extent and location that can be interpreted in the context of management areas, likely quality of visitor experience and ecological surroundings. Thus the undesignated trail inventory provides information to OSMP managers and other staff that is useful for assessing the implementation success of past undesignated trail actions and guiding future decisions about closing, restoring, rerouting and designating undesignated trails within various management areas.

4.2.1. Boulder Mountain Parks Resource Protection and Visitor Use Plan (1999)

One of the more significant problems requiring management attention identified in the Boulder Mountain Parks Resource Protection and Visitor Use Plan was an expanding network of undesignated trails (p. 17). Management strategies for undesignated trails were identified as an outcome from monitoring to be conducted upon those trails within the adaptive management program proposed for the Mountain Parks (p. 23). Between 1983 and 1999, Mountain Parks staff had mapped undesignated trail networks in the area of the Flatirons and other popular climbing and hiking areas to develop plans to allow access to popular climbing routes while diminishing impacts to ecological resources. This plan recommended conducting a full inventory of undesignated trails, a determination of appropriate closures and mitigation measures to direct visitors to stay on designated trails and revegetating areas impacted by undesignated trail use with native plants.

A few of the trails previously mapped within the Boulder Mountain Parks have been officially designated as climbing or hiking access trails. However, during the 2011-2012 mapping effort, many miles of undesignated trails were documented within this historic planning area and require management action as outlined within the plan.

4.2.2. Visitor Master Plan (2005)

The VMP called for a program to assess and manage for undesignated trails on OSMP every five years. The VMP also detailed management strategies for undesignated trails within each management designation area and assigned each management area a relative level of priority for managing undesignated trails (City of Boulder 2005a p. 52; **Appendix A**). Habitat Conservation Areas were given a high level of priority followed by Natural and Agricultural Areas with variable priority and Passive Recreation Areas with a low priority. Passive Recreation and Natural and Agricultural Areas were also given the management option of "retain" and Passive Recreation and Natural Areas included the option to "monitor newly established or developing undesignated trails".

Given that Habitat Conservation Areas have the highest relative priority for undesignated trail management, the 39.8 miles of undesignated trails found within them require timely management action. The collective 76.3 miles in Natural and Agricultural Areas also require action in the near future due to their assigned variable management priority (**Appendix A**). The 50.7 miles contained in Passive Recreation Areas have the lowest relative management priority, but some areas may need timely action based upon localized visitor safety, ecological sustainability or other natural, recreation or cultural resource problems.

4.2.3. Marshall Mesa/Southern Grasslands Trail Study Area Plan (2005)

The Marshall Mesa/Southern Grasslands TSA Plan was the first plan completed after Boulder City Council approval and acceptance of the VMP, and this plan included several undesignated trail management strategies. Using the guidance contained in the VMP, the Marshall Mesa/Southern Grasslands TSA Plan called for implementing a program to manage undesignated trails that included tiered priorities for management action based upon management area designation (City of Boulder 2005b, p. 13). As such, the Southern Grasslands HCA has the highest management priority followed by the East Marshall and Doudy Draw Natural Areas and the West Marshall Passive Recreation Area. Plan direction for the Southern Grasslands HCA, East Marshall Natural Area and the Doudy Draw Natural Area includes elimination and reclamation of existing undesignated trails and the active prevention of new undesignated trails.

In 2011 to 2012, most of the miles of undesignated trails in the Marshall Mesa/Southern Grasslands TSA are attributed with evidence of cattle use and remain likely because of on-going cattle grazing and placement of cattle feeding and watering areas. When these cattle trails remain visible on the landscape, visitor travel on these trails is also more likely to continue. Because all but one of the trails within this TSA were attributed with cattle use and the vast majority of the TSA is currently leased for cattle grazing, any undesignated trail management strategy implemented here, particularly those strategies aimed at addressing ecological impacts, will need to include existing direction for agricultural leases in the area.

A few of the undesignated trails in the East Marshall Mesa Natural Area were to be considered for designation to provide viewpoints or interpretive opportunities and to contribute to the enjoyment of and stewardship by visitors. As of April 2013, none of these designations or improvements has occurred. Because these were commitments made within a plan vetted with public process and OSBT approval, OSMP staff should consider adding these tasks to the current work plan.

4.2.4. Eldorado Mountain/Doudy Draw Trail Study Area Plan (2006)
The Eldorado Mountain/Doudy Draw TSA Plan recommended closure of 14 undesignated trail miles (City of Boulder 2006 pg. 18). Many of these miles have been successfully closed and are on their way to vegetative recovery due to implementation of restoration actions. The majority of the remaining miles can be attributed to cattle grazing in the area, are short spurs off designated trails or represent unofficial roads intended for ongoing authorized vehicle access. Additionally, a few new segments have developed since the TSA Plan was completed and these will need to go through an undesignated trail management review process.

4.2.5. Grassland Ecosystem Management Plan (2010)
The Grassland Ecosystem Management Plan included direction for managing undesignated trails within identified northern leopard frog habitat blocks (p. D-78). Highest undesignated trail density areas for staff to consider reviewing include the Sawhill #6, Lehigh Connector Pond, Teller Lake, Boulder Creek @ Arapahoe Road, Kaufmann, Davidson Ditch @ Cherryvale, South Boulder Creek/Fancher Ponds, Davidson Ditch @ Marshall, South Boulder Creek on Burke I, Teller Lake North, McKenzie and Coal Creek East habitat sites as identified in the Leopard Frogs GIS layer. Staff review should include a current condition analysis and whether or not these sites meet the long-term condition standard as set forth in the Grassland Ecosystem Management Plan (p. 113).

4.2.6. West Trail Study Area Plan (2011)
The West TSA Plan provided direction for the management of the 57.7 undesignated miles (from data collected during 2006-2007 inventory) contained within the planning area.
Of these:

- 43.4 miles of the 57.7 miles or 75 % of the undesignated trails were to be restored/closed
- 14.3 miles of the 57.7 miles or 25% of the undesignated trails will be designated (with 2.8 miles or 5% of those being retained)

The 2012 results include 56.0 undesignated miles spatially distributed similarly to those mapped in 2006. These 56.0 miles include a few new miles not mapped in 2006 and these new miles will need to be evaluated using the undesignated trail classification and rapid assessment matrix or some other OSMP undesignated trail management assessment process. There were also a few miles of previously mapped trail that were not re-mapped because they no longer met our mapping criteria or they were officially designated.

Based upon VMP direction, the 4.7 miles of undesignated trails or roads within the Western Mountain Parks HCA should receive the highest management priority. Of these 4.7 miles, 1.6 miles are considered roads either currently used by residents and or intended for ongoing forest management or emergency access use by OSMP staff (some of these roads are now considered official roads in GIS).

The 24.9 miles of undesignated trails or roads contained in the West Sanitas, Anemone Hill, Flatirons Mountain Backdrop and the Shanahan Natural Areas are the next highest management priority. In the West TSA Plan several of these miles were recommended for designation, were meant to be retained or are service roads meant for ongoing use. All of the other miles will need to be addressed to meet the plan's commitments.

Discussion

The 20.5 miles within the Sanitas Valley/Red Rocks, Flagstaff/Chautauqua and South Mesa Passive Recreation Areas have the lowest management priority. However, because these areas contain some of the most dense undesignated trail networks, the priority could be to treat those places with the highest ecological value or where ecological management targets have been compromised.

4.3. Constructed features, signs and road barriers: Management implications

Across the 181 undesignated trail and road miles are 506 signs, 438 constructed features and 23 barriers to vehicle access. It's likely that a small number of these were inherited when the property was acquired and were never intentionally installed by an OSMP staff member.

The majority of constructed features were identified as steps, waterbars, fences, culverts or check dams. The most constructed features (209) were recorded within Passive Recreation Areas, areas which covered the least amount of surveyed acres (4,434) but are managed for the highest levels of visitation. At times, constructed features along undesignated trails can look very similar to those that would be intentionally installed along designated trails (**Figure 6**).

Figure 6. Example of steps along undesignated trail

While likely installed to facilitate visitor travel and reduce ecological impacts, these can contribute to visitor confusion and the inability to decipher between undesignated and designated trails. Furthermore, constructed features along undesignated trails are unlikely to be maintained (or lower priority for maintenance) leading to unsafe conditions and encouraging braiding as visitors try to avoid ineffective constructed features.

OSMP has also used some of the same signs along designated and undesignated trails. While necessary to relay messages such as regulations, property boundaries and seasonal closures, these

too can contribute to visitor confusion and the inability to decipher between trails that are designated and those that are not. Passive Recreation Areas also had the greatest number of signs which was expected given these areas are managed for high visitor volume.

4.4. Undesignated trail restoration strategies implemented since 2006-2007 inventory

OSMP reinvigorated a restoration program in 2009 to assess and prioritize needs from a system-wide perspective and develop a coordinated restoration approach. One of the goals of the program is to address restoration actions outlined in TSA plans, primarily in the form of undesignated trail closure and ecological restoration. An interdisciplinary team began efforts in the Eldorado Mountain/Doudy Draw TSA, focusing on ten priority undesignated trails in the Goshawk Ridge and Spring Brook Loop Trail areas during 2008-2010 as part of the plan implementation effort. In general, efforts were prioritized to facilitate sensitive natural resource recovery and visitor compliance with area closures. Treatments included signage to signify efforts and request visitors refrain from travel along these paths; fencing or other barriers to block passage; and erosion control, tread scarification, seeding/planting and/or mulching to initiate revegetation. Similar strategies were later employed in subsequent years in the West TSA following approval of the plan in 2011. Additional efforts are planned in priority restoration areas across the OSMP system for 2013-2015.

4.5. Ecological resource and visitor quality concerns

4.5.1. Ecological resource concerns

Since undesignated trails are typically not intentionally designed, constructed or maintained to OSMP trail sustainability standards, they often have greater impacts on natural and cultural resources than trails that are consciously engineered, constructed or maintained (Cole 2004; Marion & Olive 2006). Undesignated trails often have steeper slopes and less sustainable topographic alignments than designated trails (Wimpey & Marion 2011). Repeated travel contributes to changes in the biophysical properties of soils through loss of vegetation, loss of substrate cover, soil erosion and soil compaction. Plants, invertebrate and wildlife communities may also change with the development of undesignated trails. OSMP ecologists could use the undesignated trail data to determine areas of high ecological/habitat value with unacceptable levels and/or densities of undesignated trails.

If OSMP staff decided to close any undesignated trails due to unacceptable plant and wildlife impacts, City of Boulder residents do approve of this management strategy. In 2010, 91% of Resident Survey respondents believed these types of actions were “very” or “somewhat” appropriate (National Research Center 2010)

4.5.2. Visitor quality concerns

Proliferation of undesignated trails has both direct and indirect effects on the overall quality of visitor experiences. An expanded network of undesignated trails may increase the number of wildlife/human interactions, either enhancing or reducing the quality of visitor experience to the potential detriment of wildlife. Visitor surveys have demonstrated that the visitor experience can be negatively impacted by visible evidence of off-designated trail visitor travel (Cole et al. 1997; Rochefort & Swinney 2000; Lynn & Brown 2003; D’Antonio 2010).

Discussion

The extent of undesignated trails across the OSMP speaks to visitor travel patterns not met by the designated trail system. Particularly in areas serviced by few or no designated trails, such as Gunbarrel Hill or Sawhill Ponds, visitors continue to use a network of undesignated trails likely created out of convenience and/or the desire for recreational experiences not yet possible upon designated trails. Because undesignated trails typically develop through repeated travel, careful review of their locations and destinations along with a thorough evaluation of nearby ecological and cultural resources could determine how to best service these unmet needs.

5.0 Recommendations

Adaptive management often necessitates adjustments to initial management strategies based on information acquired through monitoring. This monitoring project evaluated undesignated trails across the OSMP system. The results presented in the preceding sections are intended to help identify areas for improvement with current visitor and undesignated trail management and undesignated trail closure strategies. The recommendations outlined below are provided to help refine these strategies to move toward success with undesignated trail management objectives while maintaining high quality visitor experiences on OSMP.

5.1. Refine decision-making strategies for managing undesignated trails

As part of the Eldorado Mountain/Doudy Draw TSA Plan (City of Boulder 2006), a systematic approach was developed to assess and develop management strategies for undesignated trails on OSMP lands (**Appendix R**). Initially used for addressing the undesignated trails within the Eldorado Mountain/Doudy Draw planning area, this approach was intended to be used during future TSA planning efforts. If staff currently working on undesignated trail classification and management determine that the matrix developed in 2006 is no longer feasible or useful, a new systematic approach could be developed.

To facilitate tracking of the management strategy determined for undesignated trails, a new "status" attribute was added to 2011/2012 undesignated trail layer. OSMP staff working on planning for undesignated trails through the TSA planning process should consider working with the RIS data steward to insure these fields are filled in or updated with the current management status (i.e., retain, restore, designate, no decision) or that another method has been developed to accurately capture the status of each undesignated trail.

5.2. Implement strategies to close and minimize visitor travel on undesignated trails

A few recommended strategies to close and minimize visitor travel on undesignated trails include:

1. Continue development of a comprehensive undesignated trail closure and restoration program and conduct a purposeful review of undesignated trail closure and restoration projects to include: what has been done, staff's best judgment of what has been successful and development of a suite of preferred treatments for future projects.
2. Re-brand undesignated trail signs and infrastructure to structurally decipher between undesignated and designated trails, thus giving visitors physical and visual clues of which trails are designated and which are not.
3. Undertake a visitor study to determine the underlying reasoning, rationale, beliefs, attitudes and values contributing to visitor travel upon undesignated trails. An understanding of why visitors travel on undesignated trails is vital to developing strategic management actions aimed at their successful closure.
4. Implement strategies to educate visitors about the need to close and reduce travel on undesignated trails. Strategies might include new education modules, hands-on workshops or hikes or new message and sign development for installation along undesignated trails.
5. Encourage reporting by rangers, other field staff and volunteer trail guides of the development of new undesignated trails (i.e., trails first observed by staff after the last monitoring interval) or the degradation of existing undesignated trails, particularly near

their intersection with designated trails where they are obvious to visitors. Such reporting can provide a rapid means to alert managers to problems before they become irreversible and can facilitate prioritization for management.

6. Develop guidance (including staff responsibilities) for assessing and managing newly developed undesignated trails. Consider taking prompt action on newly developed undesignated trails considering there potential to invite additional visitor travel. Alternatively, staff should consider informally tracking the condition of new trails to see if they are ephemeral, persistent and/or displaying evidence of human or animal companion travel.

5.3. Revise field methods, document changes in protocol, and plan repeat monitoring every five years

During the 2011-2012 undesignated trail inventory design phase, staff conducted lengthy field tests to establish the level of difficulty in reducing inter-observer variability. However, not every type of situation encountered while out monitoring could be covered, and additional training could help reduce mapping variability between field technicians. Additionally, as new field technicians are hired, re-testing and revisions to field methods will need to occur based upon the variability observed between the new set of field staff assigned to the inventory. The inventory should occur every five years as outlined in the Visitor Master Plan and should include a revisit of the objectives of undesignated trail monitoring with input from a broad group of OSMP staff. Revisions to field methods and monitoring objectives should be documented in the protocol and data should clearly reference the version of the protocol used in its associated metadata. When working on revisions to existing protocols, consider the possibility of a critical peer-review by experts in the Recreation Ecology field.

Two specific methodological changes are recommended:

- Consider bringing back documentation and mapping of areas of concentrated use or nodes of intense visitor activity (previously mapped in 2006). This would be useful to look at trends over time in their frequency along trails and size. This data could also be used when we do analyses like fragmentation or density. These could be rated using a condition class rather than trying to put boundaries around them.
- Consider bringing back a width/condition class assessment (used in 2006) but still retaining the basic mapping methods – this might help use look at trends over time in a qualitative way and relative impacts of these trails. We could have a lowest category that doesn't meet the trail definition but allows for continuity between linear trail fragments.

5.4. Consider new undesignated trail indicators and analyses related to ecological health and/or visitor quality

The potential for undesignated trails (and visitor travel upon them) to negatively impact ecological resources and the visitor experience are primary factors driving the need for their successful management. This project included habitat fragmentation as a proxy for ecological health , but other metrics considered to be indicators of ecological health could be developed. It is important that the assumed relationship between undesignated trails and ecological impact be tested and explored. For example, OSMP could consider developing new undesignated trail monitoring indicators that would test the relationship between pertinent components of ecological health in relation to trail location and extent such as: dominant species cover and

condition; total non-native species cover; bare ground cover; soil moisture; wildlife status, water quality and undesignated trail cover and condition classification. Relationships between the ecological data sets and undesignated trail data could be explored with geospatial and statistical analyses (see Leung et al 2011 as an example). Similarly, some researchers have developed indices of visitor experience based on the types of human-induced change visitors perceive and their acceptability standards for these changes (D'antonio 2010; Manning 2011). A social impact undesignated trail indicator could be developed based on a visitor's acceptability for the number, quality or appearance of undesignated trails and the actual likelihood of encountering these undesignated trail conditions based on mapping data (Adapted from Manning 2011) (**Appendix S**).

- Develop additional spatial and non-spatial analyses techniques to evaluate the undesignated trail data including:
  - Spatial analysis techniques assessing the location of undesignated trails with respect to sensitive resource areas; and
  - Undesignated trail indicators or metrics that integrate information on undesignated trail density with spatial information on sensitive resources.
  - Calculations of undesignated trail mileage and density by habitat type (perhaps vegetation alliances), distance from water sources or wetlands
- Refine the undesignated trail GIS database to provide quick and easy reporting and display of the extent of undesignated trails. Further develop the functionality of the database to report on individual trails, changes in closed or restored trails, trails by management area and specific queries needed to determine trail sustainability and suitability for designation during the TSA planning processes.
- Assuming mapping methods are comparable between intervals, develop GIS techniques to analyze and map locations of increased or decreased lengths of undesignated trails.

5.5. Overarching direction from all plans for managing undesignated trails

Use the undesignated trail suitability criteria (City of Boulder 2006) to evaluate how to manage specific undesignated trails

Created duirng the Eldorado Mountain/Doudy Draw Trail Study Area planning process, these criteria address factors related to the quality of visitor experience, physical sustainability, environmental sustainability and cultural/paleontological resources. They can be used to analyze the existing and planned visitor use patterns in an area and evaluate how undesignated trails can be managed within a broader context.

These criteria are useful in evaluating the relative merits of alternative trail improvement, resource protection and activity-specific management actions. These criteria can be adapted for use in evaluating alternatives for undesignated trail management where there is a complex situation such as multiple destinations and/or undesignated trails.

Evaluate and implement strategies to minimize undesignated trails created by leased cattle grazing and management

One of the OSMP charter purposes is preservation of agricultural activities and this includes cattle management. As such, leased cattle grazing and related cattle management activities

contribute to networks of undesignated trails and roads across the North, East and South TSAs. When located near recreation areas, visitors can be drawn to these pathways and visitor travel upon them can lead to further development and additional vegetation loss. OSMP has committed to explore ways of minimizing cattle trails and allowing revegetation of them as a way of reducing vegetation loss, soil loss and/or compaction and visitor travel on cattle trails. A few suggested strategies include: 1) develop a multi-year grazing rotation that provides adequate rest periods (both duration and seasonality) to allow the vegetation to recover; 2) move salt supplements to reduce cattle travel; and 3) intentional placement of water and feed areas to reduce cattle travel.

6.0 Summary

From July 2011 to November 2012 OSMP staff conducted a system-wide inventory of undesignated trails, road-like pathways, constructed features, signs and road barriers along mapped corridors. The inventoried properties included primarily those owned in fee along with a few conservation easements that OSMP retains management responsibility for.

Specific objectives of the 2011-2012 system-wide undesignated trail monitoring program were to:

1. Map the linear extent and spatial distribution of undesignated trails and road-like pathways on OSMP managed lands and identify those used by cattle;
2. Map the location of constructed features in the vicinity of undesignated trails and road-like pathways; and
3. Map the location of signs in the vicinity of undesignated trails and road-like pathways.

All objectives were met concurrently by using GPS technology in the field and a GIS in the office to digitize collected data.

System-wide during the 2011-2012 inventory:

- A total of 181.3 miles of undesignated trails and roads were mapped and approximately one-third were attributed with evidence of cattle use;
- A total of 438 constructed features were inventoried; and
- A total of 506 signs were inventoried.

Attributes and spatial information for all mapped pathways, constructed features and signs are stored in a GIS and an Access database developed as part of a long-term strategy for monitoring and managing undesignated trails.

With 181 miles of undesignated trails mapped on OSMP lands, proposed standards set forth in the VMP have been exceeded. There are also numerous other commitments within existing OSMP plans that have not been met. The availability of spatial data documenting undesignated trail location and extent allows OSMP to measure success with existing objectives and commitments for reducing undesignated trails.

A few suggestions recommendations for undesignated trail management include:

- Utilize the spatial and attribute information in the undesignated trail database to guide TSA planning for undesignated trails and follow the decision-making process outlined in the Eldorado Mountain/Doudy Draw Trail Study Area (TSA) Plan to prioritize undesignated trails for management actions (restore, retain or designate).
- Continue development of a comprehensive undesignated trail closure and restoration program that:
  - Prioritizes undesignated trails for timely closure based on priorities established in the decision making process;
  - Collaborates with other staff teams to determine best management practices;
  - Maintains staff dedicated to planning undesignated trail closures; and
  - Maintains a crew leader and crew to implement trail restoration treatments.
- Consider “re-branding” of signs and other visitor infrastructure to be used on undesignated trails so visitors have physical and visual cues to decipher between undesignated and designated trail signs and infrastructure.

Summary

- Implement strategies to educate visitors about the need to close and reduce travel on undesignated trails. Strategies might include:
  - Creating an educational module designed to inform visitors of OSMP trail closure and resource protection objectives;
  - Conducting educational hands-on workshops or hikes that highlight typical physical sustainability and/or potential visitor safety problems on undesignated trails;
  - Creating signage for installation along newly closed undesignated trails that display persuasive messages based on social science research deterring undesignated trail travel;
  - Training volunteers and staff to conduct on-trail education about area closures and designated alternatives.
- Review and update undesignated trail mapping protocols to facilitate efficient undesignated trail monitoring at 5-year intervals. Revisit the objectives of undesignated trail monitoring with input from a broad group of OSMP staff. When working on revisions to existing protocols, consider the possibility of a critical peer-review by experts in the Recreation Ecology field.
- Develop additional indicators/spatial and non-spatial analyses techniques to evaluate the undesignated trail data including:
  - Spatial analysis techniques assessing the location of undesignated trails with respect to sensitive resource areas; and
  - Undesignated trail indicators or metrics that integrate information on undesignated trail location with spatial information on sensitive resources.
- Refine the undesignated trail GIS database to provide quick and easy reporting and display of the extent of undesignated trails. Further develop the functionality of the database to report on individual trails, changes in closed or restored trails, trails by management area and specific queries needed to determine trail sustainability and suitability for designation during the TSA planning processes.
- Develop potential new social impact/visitor quality undesignated trail indicators using a social norm curve (Adapted from Manning 2011)

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Appendix A. Management strategies and actions for undesignated trails by management area designation (City of Boulder 2005, p. 52, Table 4.1).

Passive Recreation Area Strategies	Natural Area Strategies	Agricultural Area Strategies	Habitat Conservation Area Strategies
Lower priority for management of undesignated trails. Minimize new undesignated trails. Management actions for existing undesignated trails include: • Evaluate best management actions • Designate • Re-route • Close and reclaim • Retain undesignated trails • Monitor newly established or developing undesignated trails	Variable priority for management of undesignated trails. Minimize new undesignated trails. Management actions for existing undesignated trails include: • Evaluate best management actions • Designate • Re-route • Close and reclaim • Retain undesignated trails • Monitor newly established or developing undesignated trails	Variable priority for management of undesignated trails. Minimize new undesignated trails. Management actions for existing undesignated trails include: • Evaluate best management actions • Designate • Re-route • Close and reclaim • Retain undesignated trails	High priority for management of undesignated trails. Minimize new undesignated trails. Management actions for existing undesignated trails include: • Evaluate best management actions • Designate • Re-route • Close and reclaim

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Appendix B. Glossary of terms
Definitions used in this report were developed specifically for the purpose of the undesignated trail mapping project and should not be considered universal.

Access point: A location on or off OSMP lands (including a designated trailhead, facility, parking area, business, residence, vehicle or pedestrian gate, junction with a designated trail, undesignated trail or road) from which a visitor or vehicle can reach an undesignated trail or road without going off the access pathway.

Closure: Intentional OSMP effort to eliminate the use of a trail by humans and their non-human companions such as dogs or horses. Closure methods may include fencing, slash or rock placement, signage and revegetation.

Constructed feature: A human-made structure designed to help maintain a trail's sustainability, such as to divert water or retain sediment, enhance visitor travel or raise the level of the tread (e.g., retaining walls, turnpikes, waterbars, steps and culverts).

Data dictionary: An automated tool for describing, recording and organizing spatial and attribute information on objects of interest (e.g., sample points along undesignated trails). The data dictionary for this project is an electronic file accessed in the field on a Global Positioning System (GPS) device and created using Trimble GPS Pathfinder® Office software (Pathfinder).

Designated trail: A trail that is officially approved and maintained by a public land management agency including other agencies managing land adjacent to OSMP.

Dilution of Precision (DOP): A measure of the quality of GPS positions, based on the geometry of the satellites used to compute the positions, where a lower DOP value indicates greater accuracy (less error) of the position when satellites are widely spaced relative to each other. PDOP is a DOP value that indicates the accuracy of three-dimensional measurements whereas HDOP gives the horizontal position accuracy (adapted from TerraSync™ Software Reference Manual, March 2007 Release [Revision A]).

Global Positioning System (GPS): A world-wide radio-navigation system formed from a constellation of satellites and their ground stations that can be used as reference points with a GPS receiver to calculate accurate positions of locations on earth.

Inter-observer variability: Variation which occurs between observers when collecting and interpreting field data.

Map tile: The undesignated trail survey area subdivided into smaller gridded sections for field mapping. RIS staff developed and added an index or tile layer to the map document. The tile layer is comprised of data driven pages, used to produce a series of output pages formatted with a single layout. Each output page shows one of the total 240 different spatial extents across the study area (each 1.0 x 0.6 mile), as defined by the polygon features (gridded rectangles) in the tile layer. See Appendices G1 and G2.

Mid-trail point: A sample point mapped along the undesignated trail that falls between the start and end points of the trail where GPS locations and attributes are recorded. Mid-trail points are taken every 200 feet along the trail or more often as needed to map curves and turns along the trail.

Off-trail: Travel off of officially designated trails and roads.

OSMP management areas: Four unique management areas with general descriptions, particular and/or typical regulations, typical visitation levels and management strategies. Current management areas include Passive Recreation, Natural, Agriculture and Habitat Conservation areas.

OSMP Trail Study Area: Geographic sub-division of OSMP into 4 unique planning areas currently representing the 4 cardinal directions (North, South, West, East); **Appendix F**.

Pulverized litter: Organic litter (e.g., pine needles, pine cones) within the trail tread with discernable crushing.

Recovered trail segment: A portion of an undesignated trail that was visible during the 2006 baseline survey but no longer meets our definition of undesignated trail due to vegetation regrowth on the trail tread.

Roadbed: The earth or rock foundation supporting a road or the surface acting as a road upon which vehicles travel.

Road-like path: A continuous linear or curvilinear pathway that is wide enough for a vehicle, driveable (with some maintenance if needed) and exhibits evidence of repeat vehicle use. Road-like pathways could include any pathway meeting the mapping criteria and not previously included in the GIS "Roads" layer (i.e., mapped roads, named roads).

Standard: The standard defines the minimum or maximum acceptable condition of each indicator variable. A standard does not define an intolerable condition (National Park Service 2008, p. 96).

Trampled vegetation: Vegetation observed within the trail tread with discernable crushing.

Trail boundary: The most pronounced outer boundary of visually obvious human disturbance created by trail construction or travel (not trail maintenance like vegetation clearing) used to delineate the trail tread that receives the majority (>95%) of traffic. These boundaries are defined by pronounced changes in ground vegetation height (trampled vs. untrampled), cover, or composition; or, when vegetation cover is reduced or absent, as pronounced changes in organic litter (intact vs. pulverized) (Marion & Hockett 2008, **Appendix C**).

Trail braiding: A specific type of secondary trail tread branching from the trail (designated or undesignated) near an apparent obstacle and looping back to the trail; typically, but not always, within sight distance.

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Trail corridor: The full dimensions of a travel route including the tread and a zone on either side (usually three feet) and above the tread from which brush will be removed to meet the trail design parameters.

Undesignated trail: Unofficial, but discernable and continuous linear trail (Leung et al. 2002) typically created by repeated visitor activity and not officially authorized or maintained by OSMP. For the purposes of this project, undesignated trail was defined to also include any closed formally designated trail or section of trail and to exclude trail braiding within the designated trail corridor.

Waypoint: A geographic point of interest, captured and stored on a GPS as latitude-longitude coordinates, but not associated with any attribute information beyond a name and location. For this project, waypoints could be used to navigate back to points surveyed in previous years along undesignated trails (adapted from TerraSync™ Software Reference Manual, March 2007 Release [Revision A].

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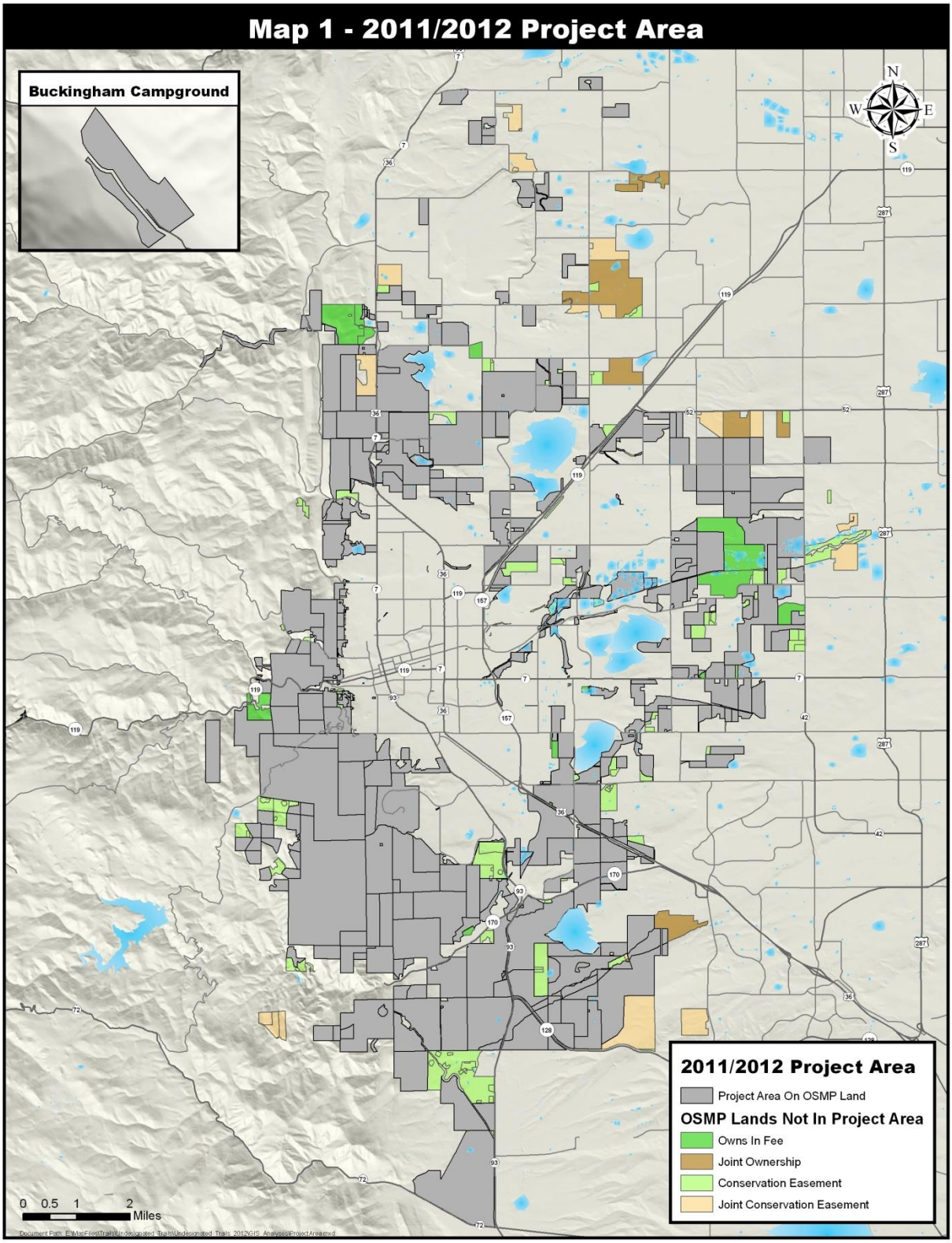
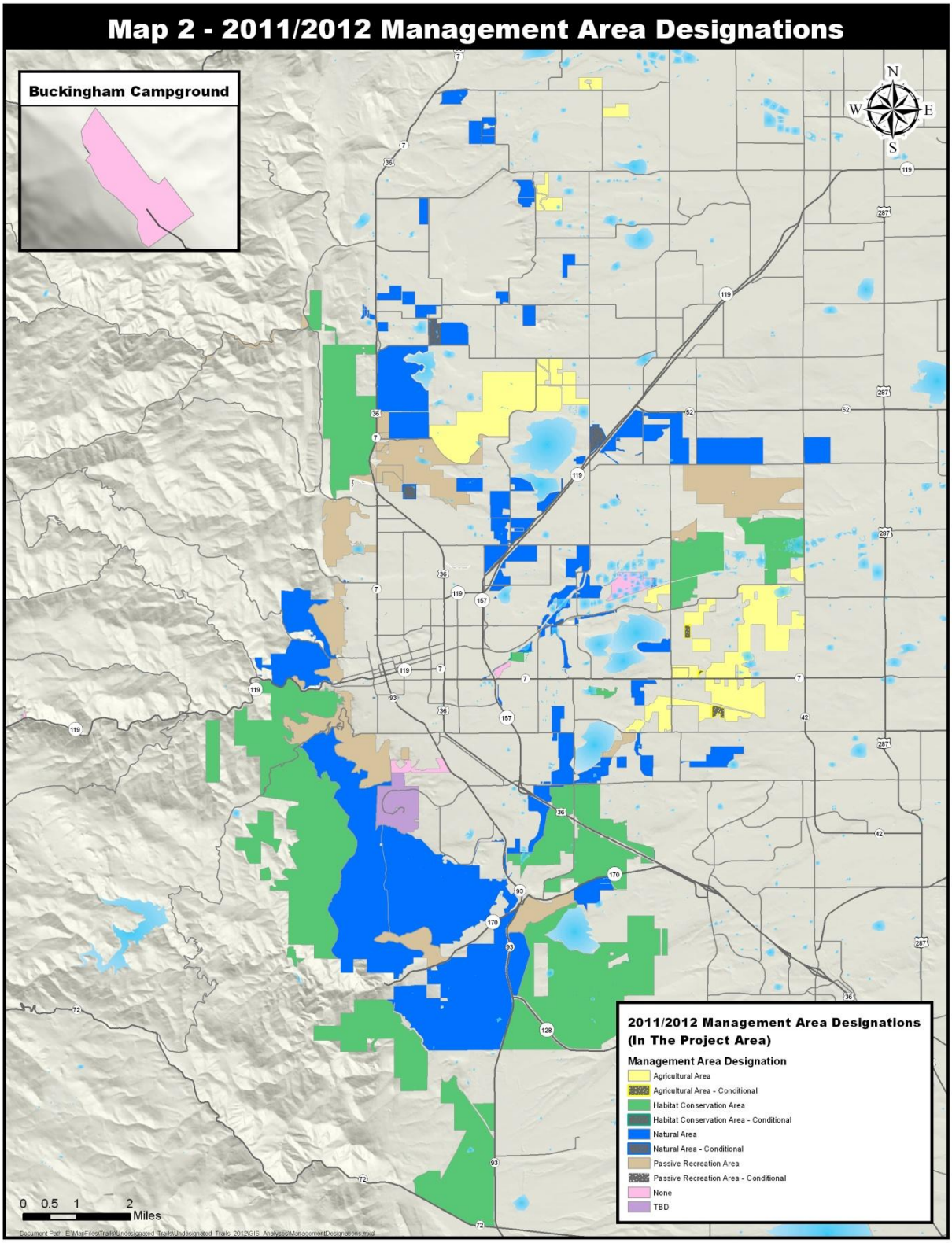
Appendix C. Trail tread boundary illustrations (Marion & Hockett, 2008).

Trail tread boundaries are defined as the most pronounced outer boundary of visually obvious human disturbance created by trail construction/travel (not trail maintenance like vegetation clearing) used to delineate the trail tread that receives the majority (>95%) of traffic. These boundaries are defined by 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).

Appendix D. 2011-2012 undesignated trail surveyed properties shown in gray



Appendix E. OSMP management area designations



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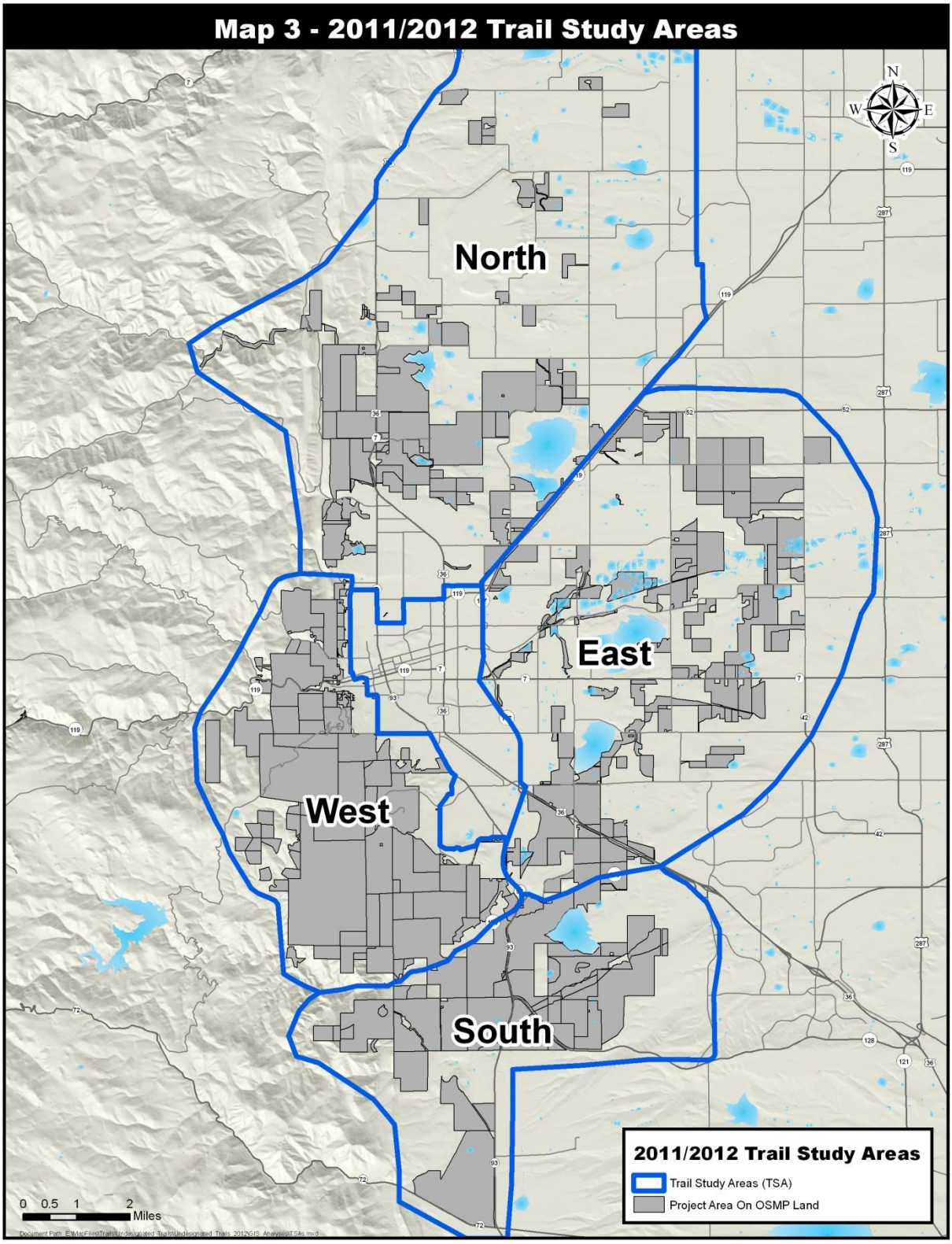
Appendix F. OSMP Trail Study Areas



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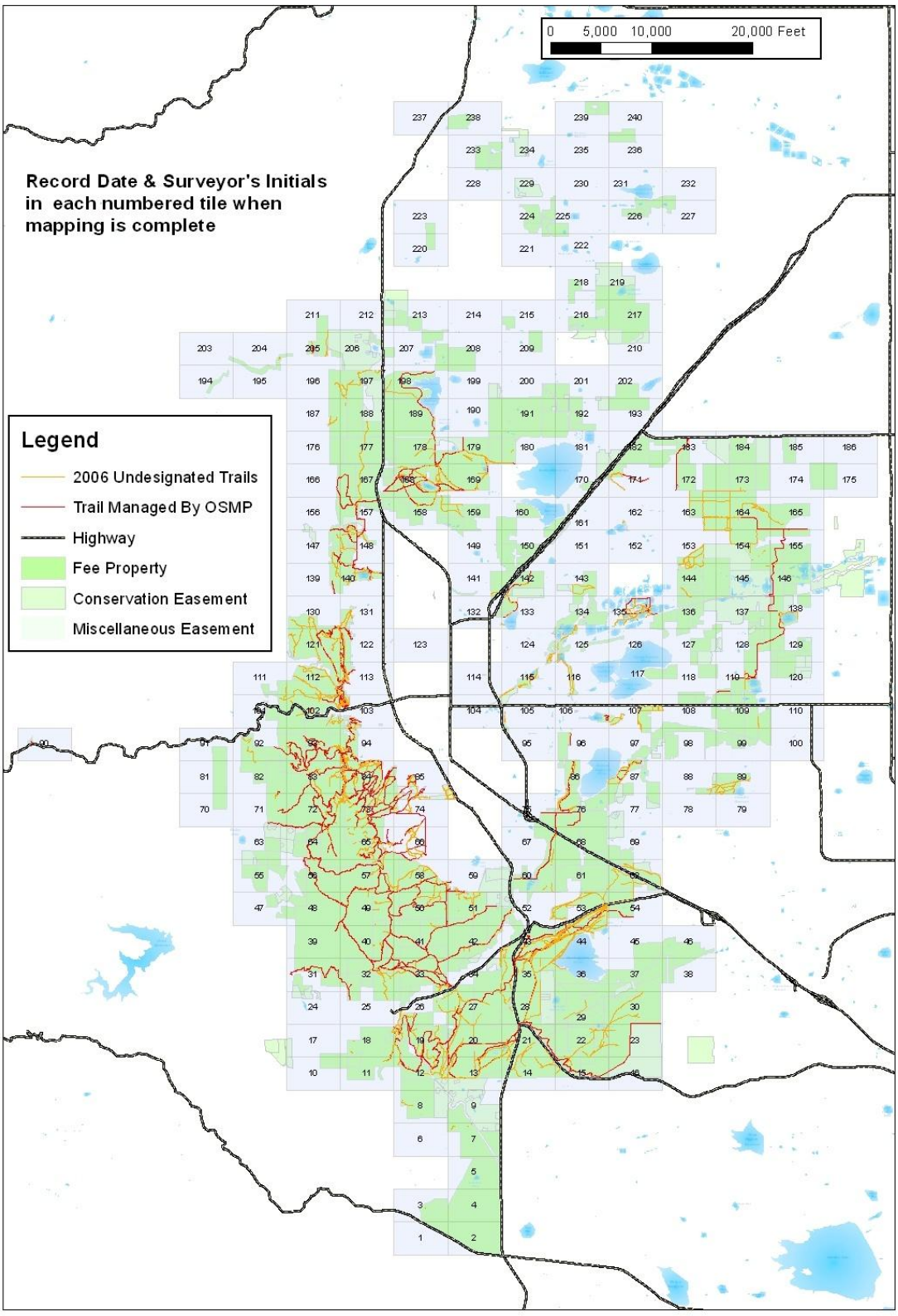
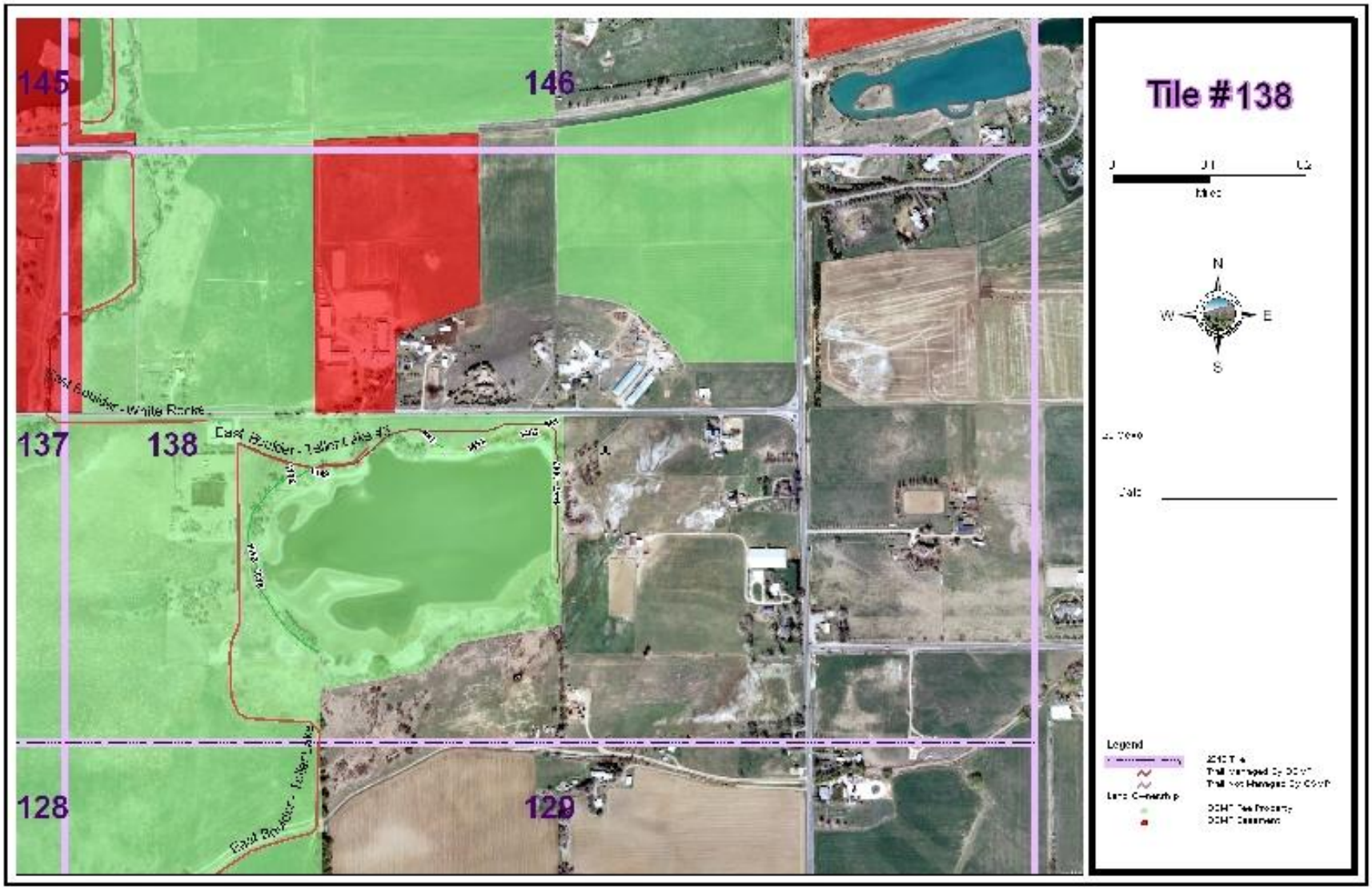
Appendix G1. Map tile index map



Appendix G2. Map tile example



Appendix G3. Checklist for reviewing completeness of mapped tiles (Lezberg 2012)

Tile Review Checklist	Data Review Stage	√
Tiles initialed and dated	Office	
Date of completion for all data management documented	Office	
All 2006 UTs visited and checked	Field	
Potential roads checked, mapped, and destination described	Field	
Excel hard copy tracking sheet filled in for each UT, Road, and NAT	Field	
Gates checked for potential UTs	Field	
Constructed features mapped	Field	
Sign structures and messages mapped	Field	
Road barriers mapped	Field	
Potential new UTs seen in aerial photo checked	Field	
Known visitor attractions checked for UTs	Field	
UT point file reviewed	Office	
Unmapped UT field points (due to poor GPS coverage) digitized manually as needed	Office	
Unmapped braids and parallel trails digitized manually as needed	Office	
Signs data reviewed/edited	Office	
Constructed features data reviewed/edited	Office	
Road barriers data reviewed/edited	Office	

UTs digitized and labeled	Office	
Excel tracking sheet filled out electronically	Office	
Photos downloaded, labeled and organized into appropriate directories	Office	
Floaters deleted and explained in tracking sheets	Office	
Remaining questions documented	Office	
GPS and GIS computer files organized	Office	
GPS files deleted from GPS	Office	

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Appendix H. Field tracking sheet

Surveyor	Date	Trail ID	Tile(s)	Path status	Cattle	Renamed	Digitized	Notes

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Appendix I. Detailed attribute choices in the undesignated trail data dictionary

Attribute	Definition	Procedure
Trail_ID	Integer assigned to an undesignated trail/pathway or trail cluster, typically emerging or ending at an access point such as a road or designated trail	For trails previously mapped in 2006, use 2006 Trail_ID in the "grouped sections" undesignated trail layer. For new extensions, braids, parallel trails or short branches of 2006 undesignated trails, use the Trail_ID assigned to the 2006 primary trail. For new trails/pathways, assign a unique number from the new Trail_ID list
Point_ID	Integer assigned to the mapped points at the GPS-mapped start, end, change, and mid-trail locations along an undesignated trail or pathway	Numbers start at 1. Assign the next consecutive number to each point in order mapped along each numbered pathway, even if there is a change in pathway status, cattle status, or intervening gaps of revegetated trail.
Point Type	Point type with respect to location on the undesignated trail segment or pathway	Attribute type assigned in field from data dictionary menu: a. Start: one end of an undesignated trail or pathway arbitrarily assigned as the start point for mapping convenience b. Mid: points mapped along the undesignated trail or pathway, other than end, start, or change points c. Change: point along an undesignated trail or pathway where the status of an attribute or number of adjacent, parallel or braided pathways changes d. End: final mapped point associated with a Trail_ID
Surveyor	Name of surveyor mapping and measuring undesignated trail points	Chosen from data dictionary menu: a. Deonne: D. VanderWoude b. Donna: D. Middleton c. Ann: A. Lezberg
Cattle	Indication of whether pathway was developed or used by cattle	Assign attribute to describe preceding segment from menu to describe if segment receives cattle use, choosing from menu options "Yes" or "No". If the trail lies in an areas on the map tiles identified as a "grazed area" and if the surveyor observes cattle directly or encounters indirect evidence of cattle presence (e.g., cow pies, cattle hoof prints, salt licks, trail goes to a water

Attribute	Definition	Procedure
		tank or feeding area), the surveyor will consider the trail to be used by cattle The surveyor does not need to see cattle or specific evidence of cattle such as cattle excrement. Noting the trail is used by cattle does not mean the trail is used exclusively by cattle.
Pathway	Type of pathway mapped	Assign attribute to describe preceding segment, choosing from data dictionary menu as either undesignated trail (only), road (only) or road and trail. Multiple pathways within a roadbed or road corridor otherwise meeting the definition of undesignated trail will be mapped as a single pathway in the field and assigned the attribute "road and trail". Enter a comment noting the number of pathways embedded in the road corridor
Comments		Describe problem mapping situations, unusual feature conditions, adjustments to PDOP Max, or presence of parallel trails not directly mapped but sketched in the field. Include other notes to be added to tracking sheets

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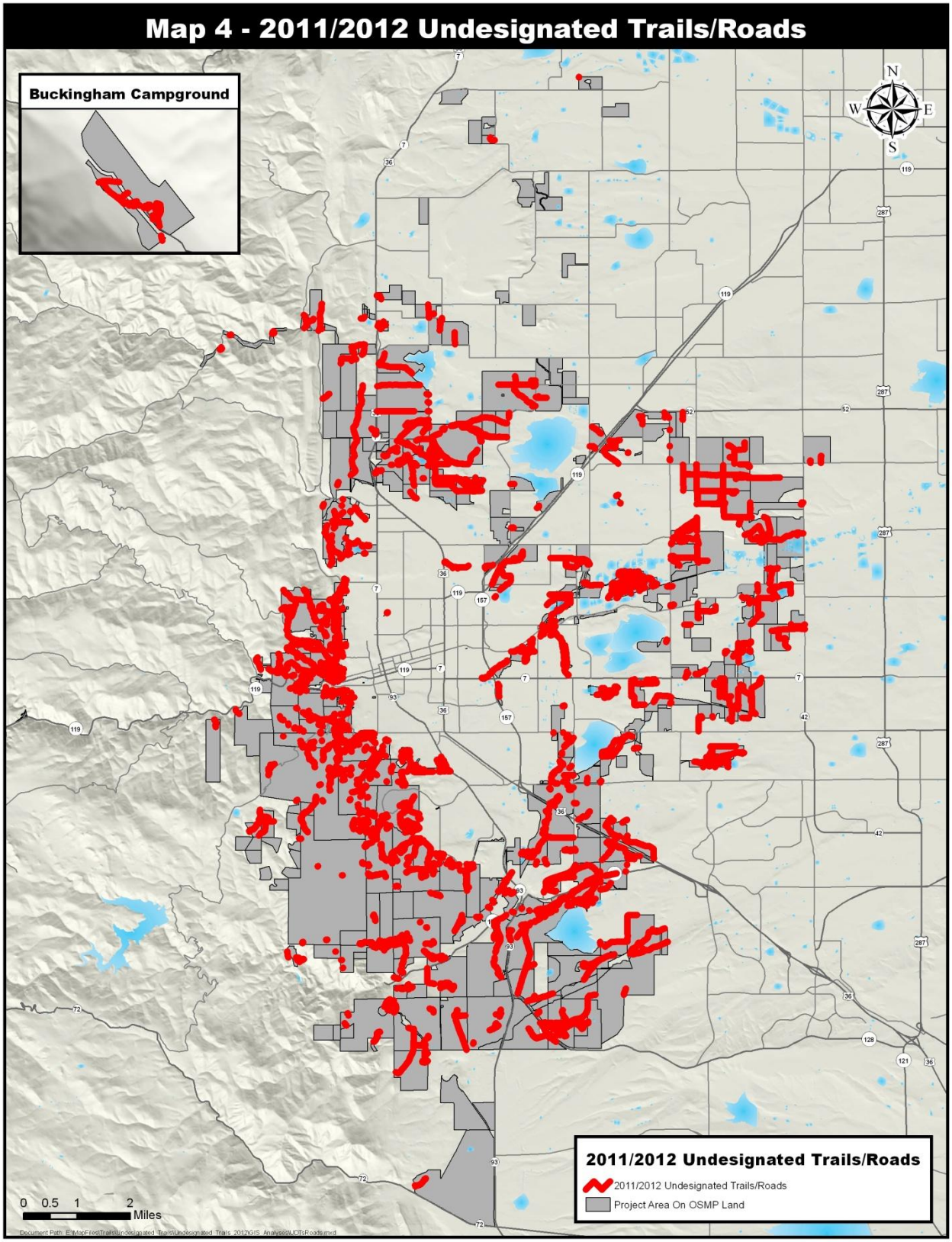
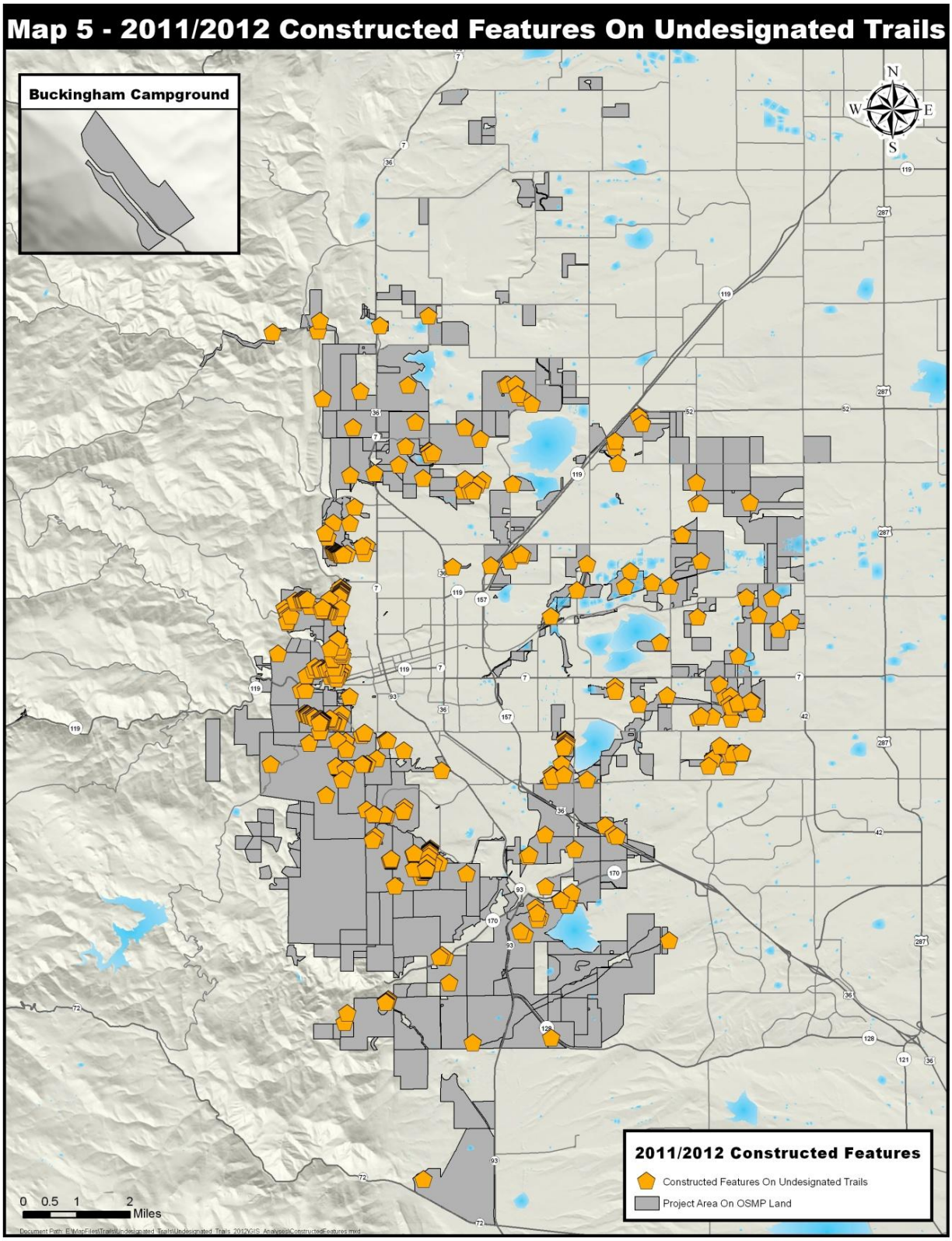
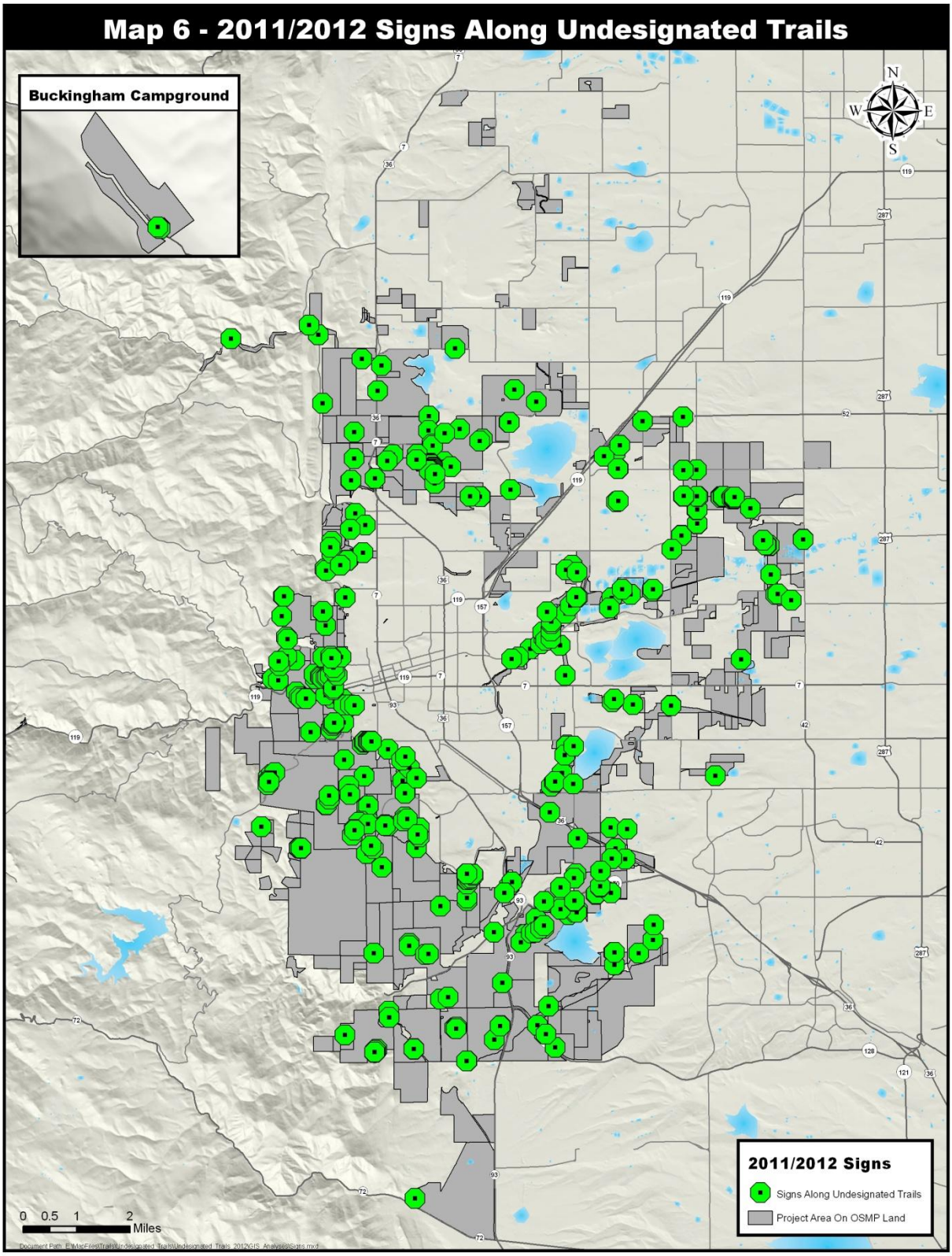
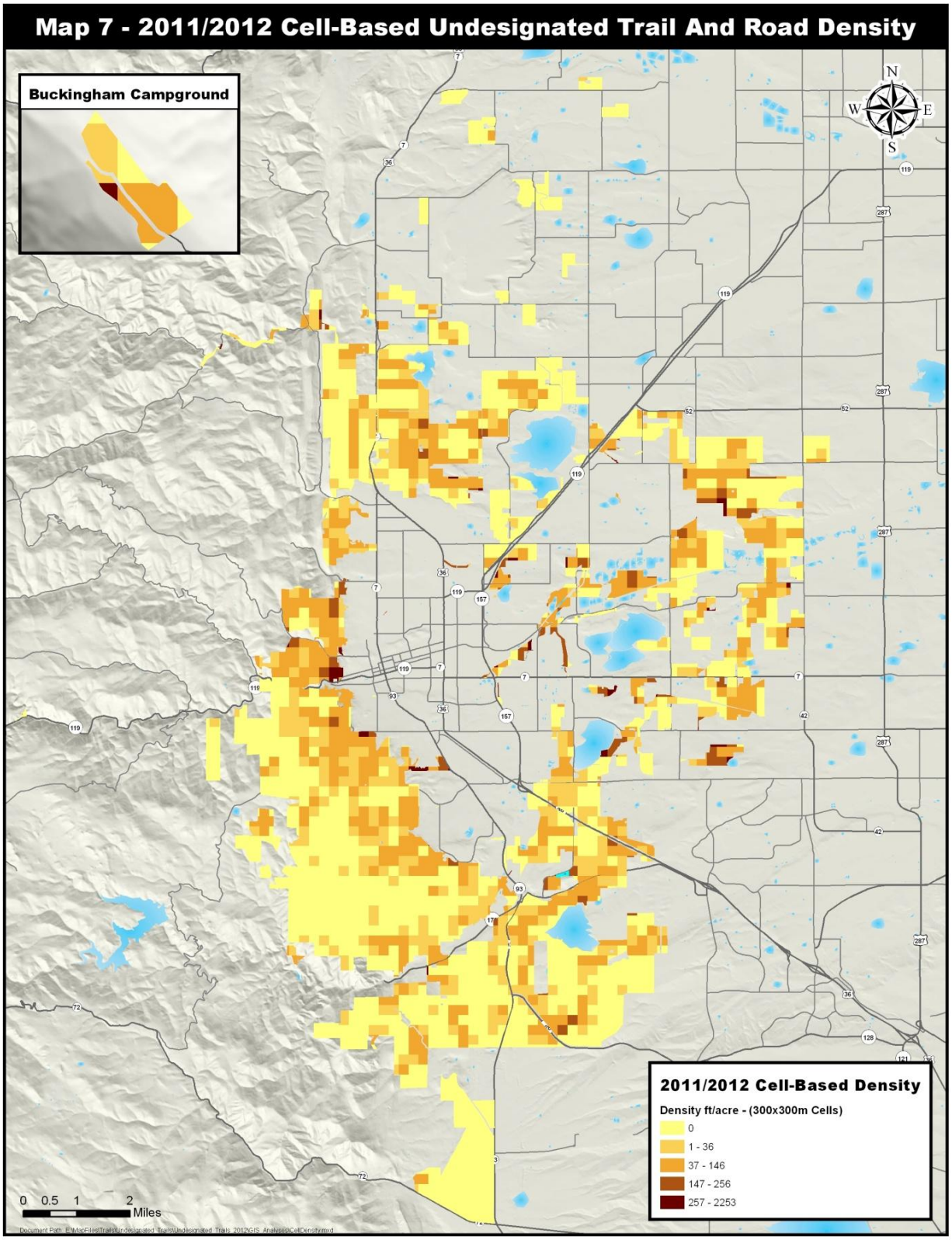
Appendix J. Maps of 2011-2012 undesignated trails/roads, constructed features and signs



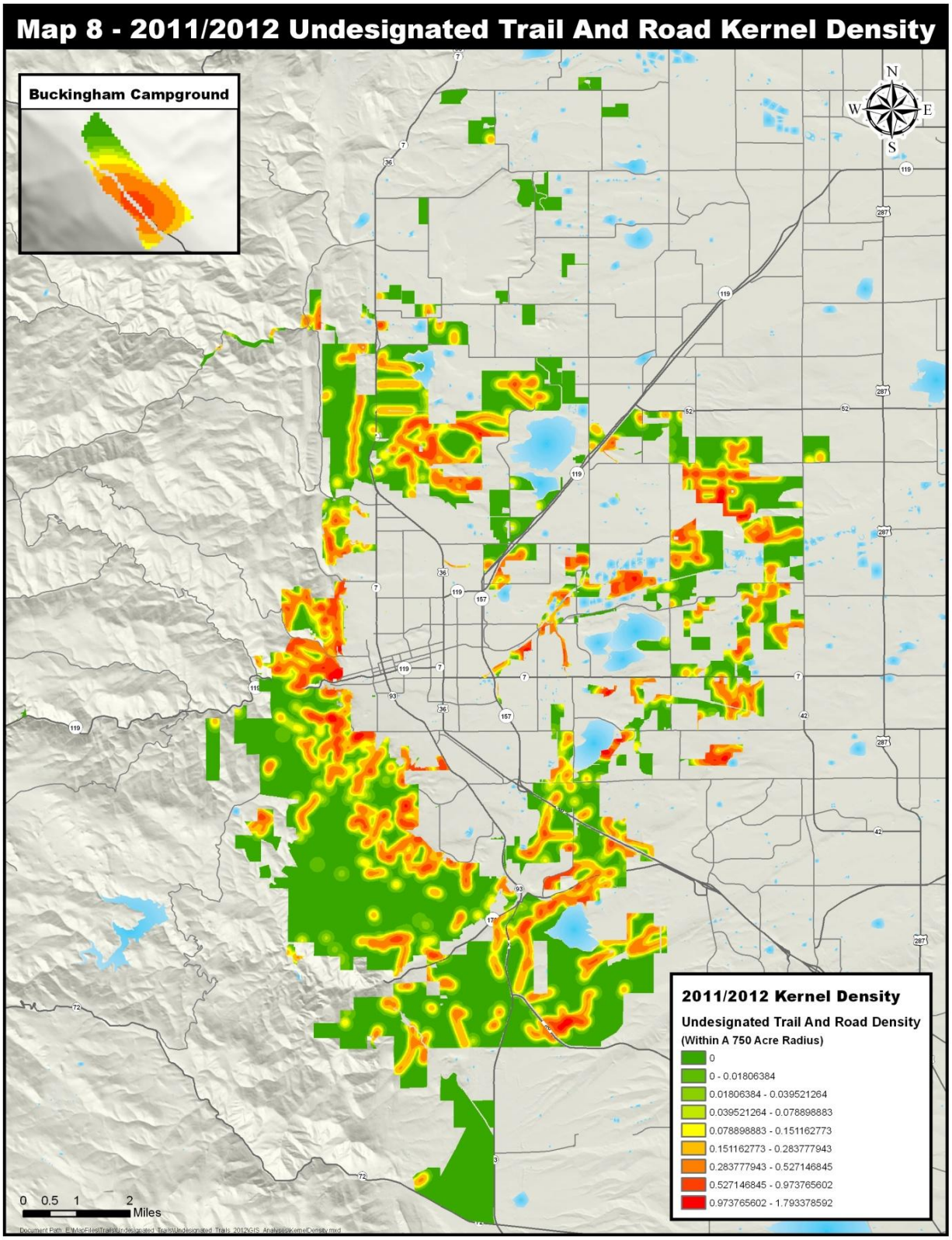

Map 5 - 2011/2012 Constructed Features On Undesignated Trails
Buckingham Campground
N
W
E
S
0 0.5 1 2
Miles
2011/2012 Constructed Features
Constructed Features On Undesignated Trails
Project Area On OSMP Land


Map 6 - 2011/2012 Signs Along Undesignated Trails
Buckingham Campground
N
W
E
S
0 0.5 1 2
Miles
2011/2012 Signs
Signs Along Undesignated Trails
Project Area On OSMP Land

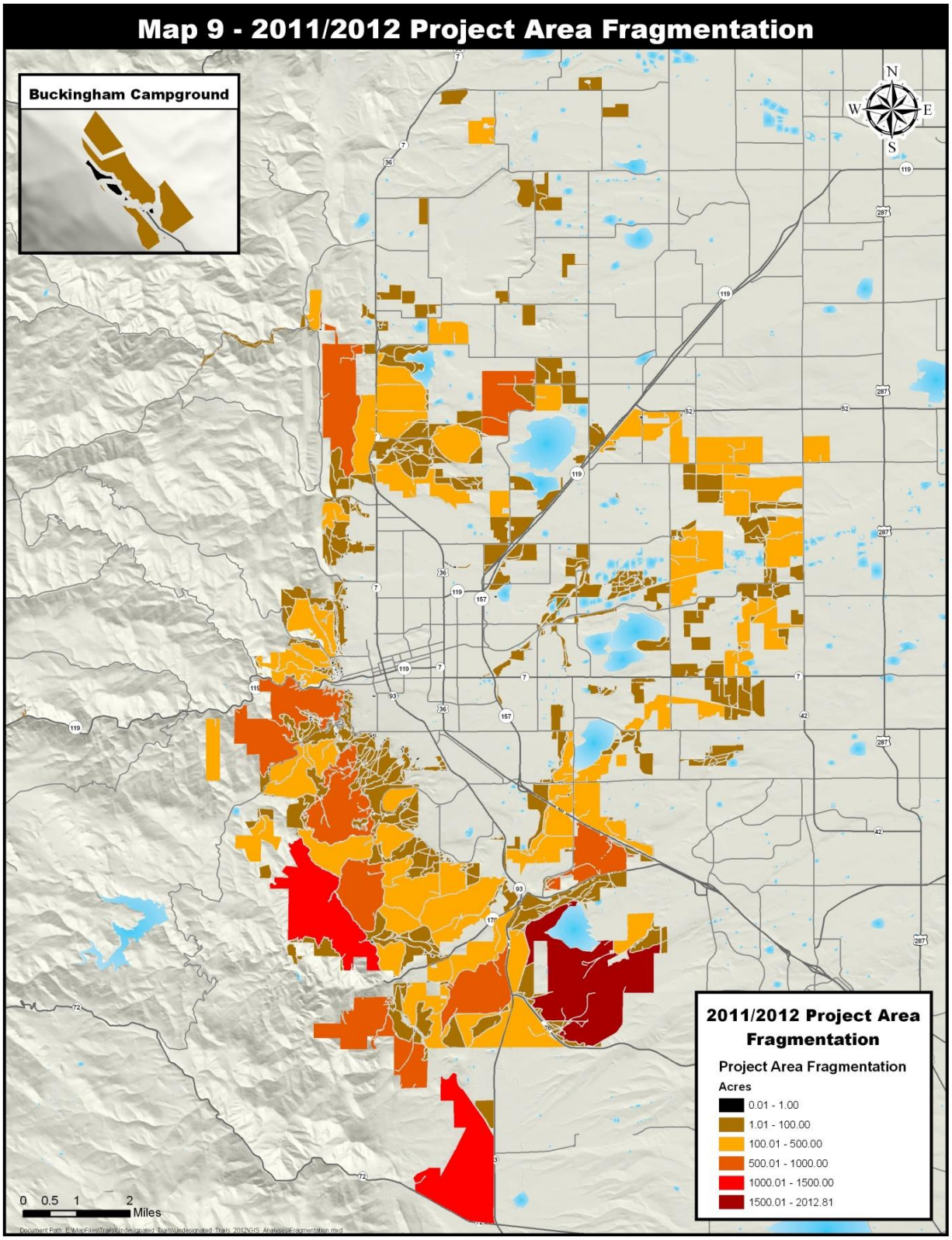
Appendix K. Grid cell-based undesignated trail/road density map



Appendix L. Kernel-based undesignated trail and road density map



Appendix M. Grid cell-based fragmentation map



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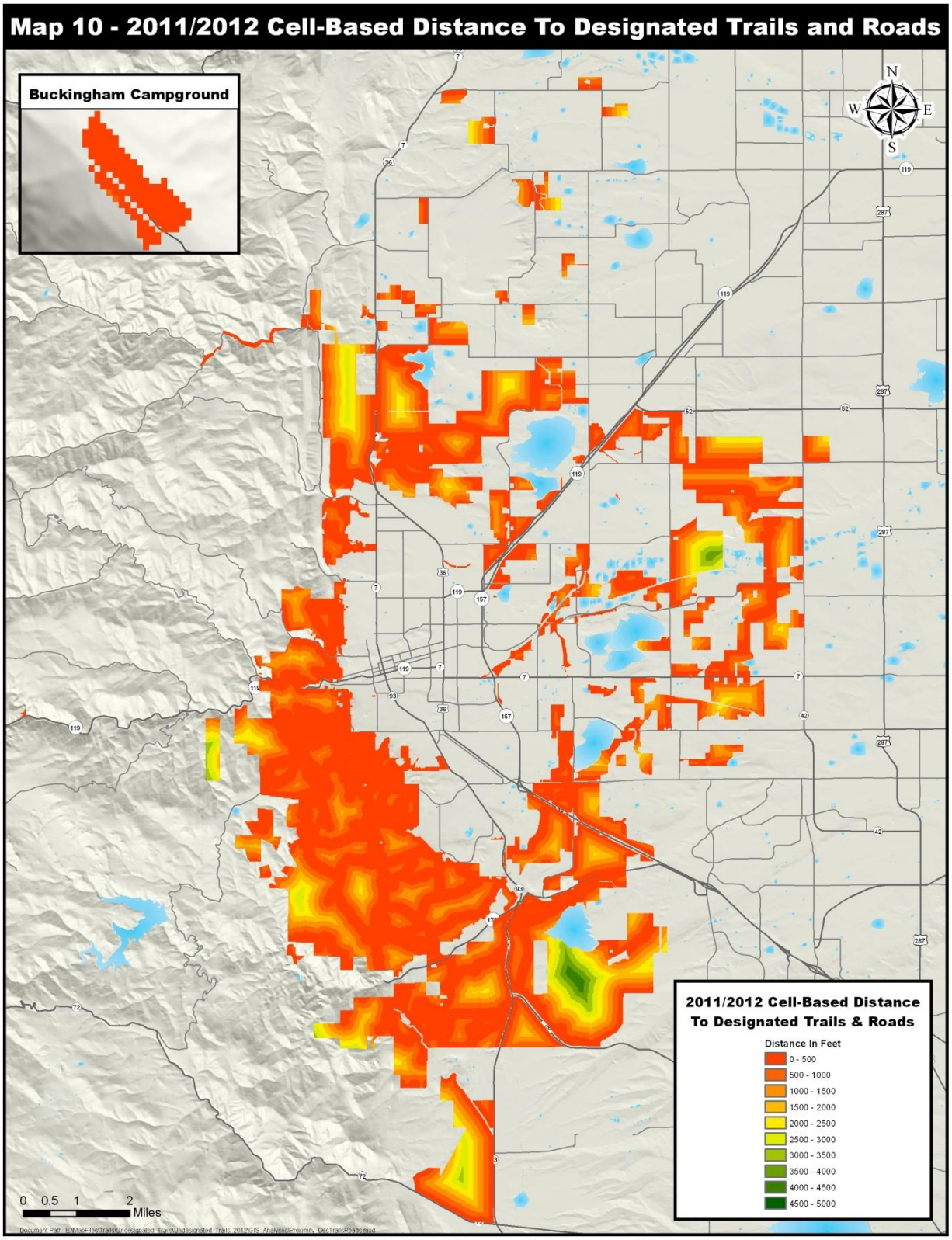
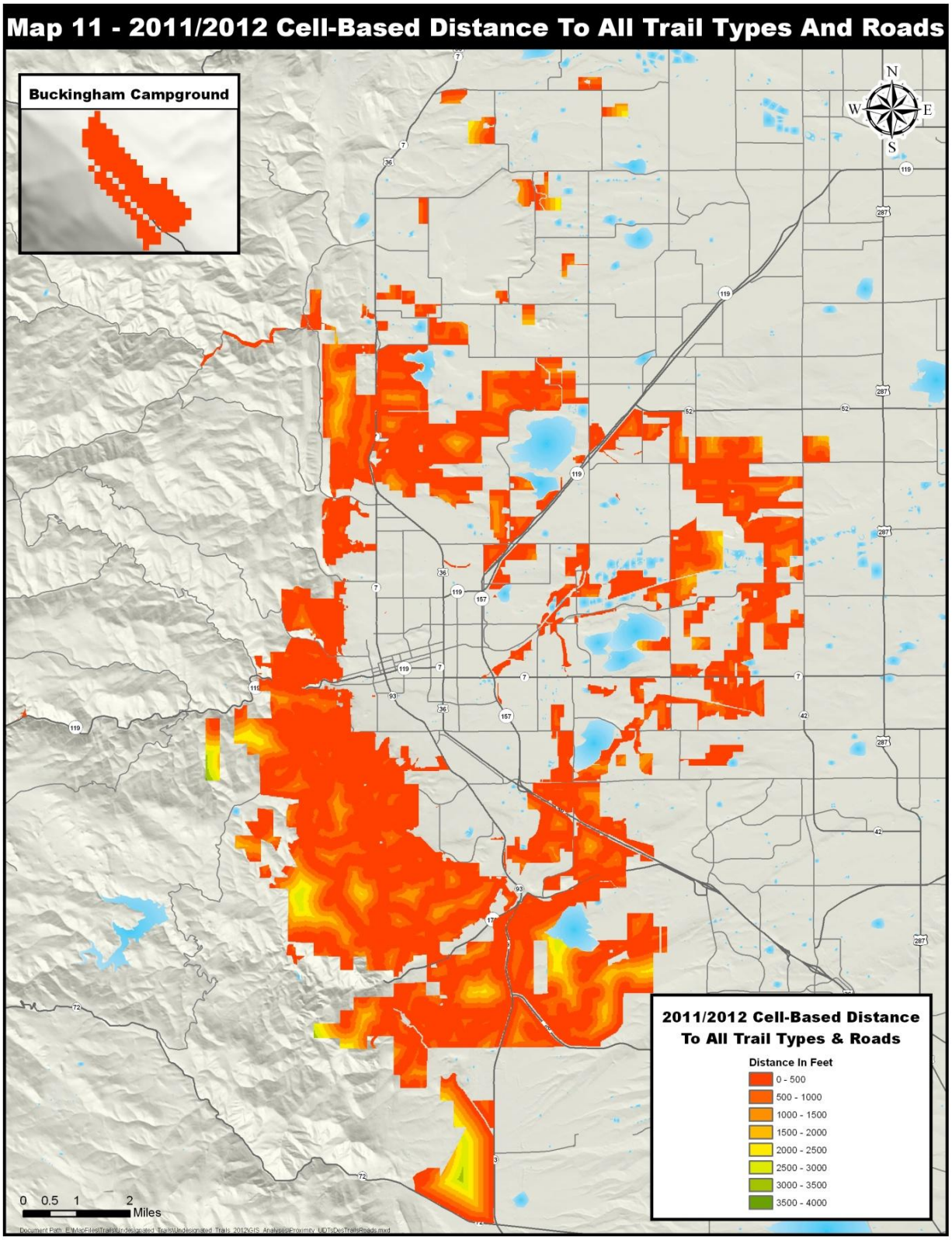
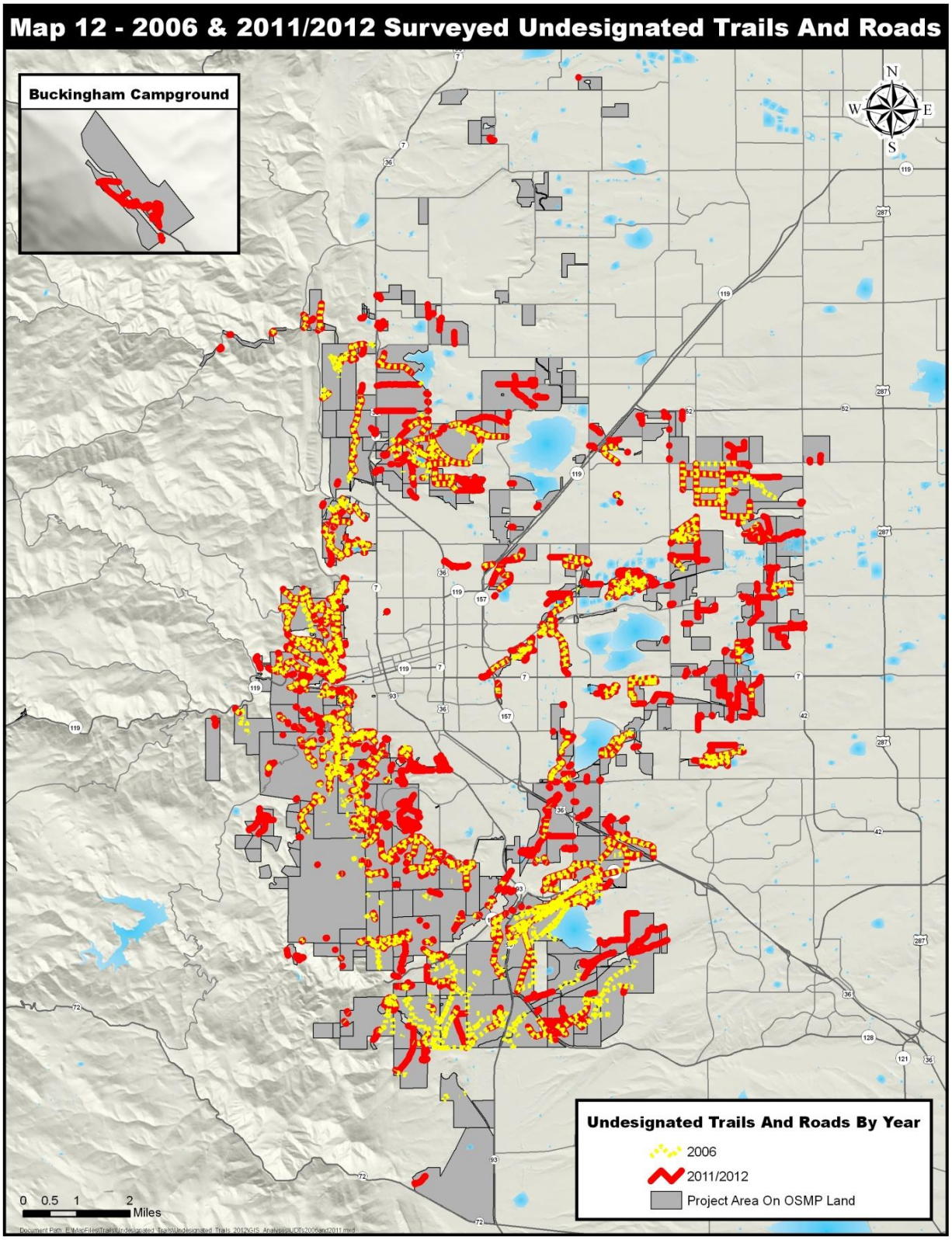
Appendix N1. Proximity map with only designated trails and roads



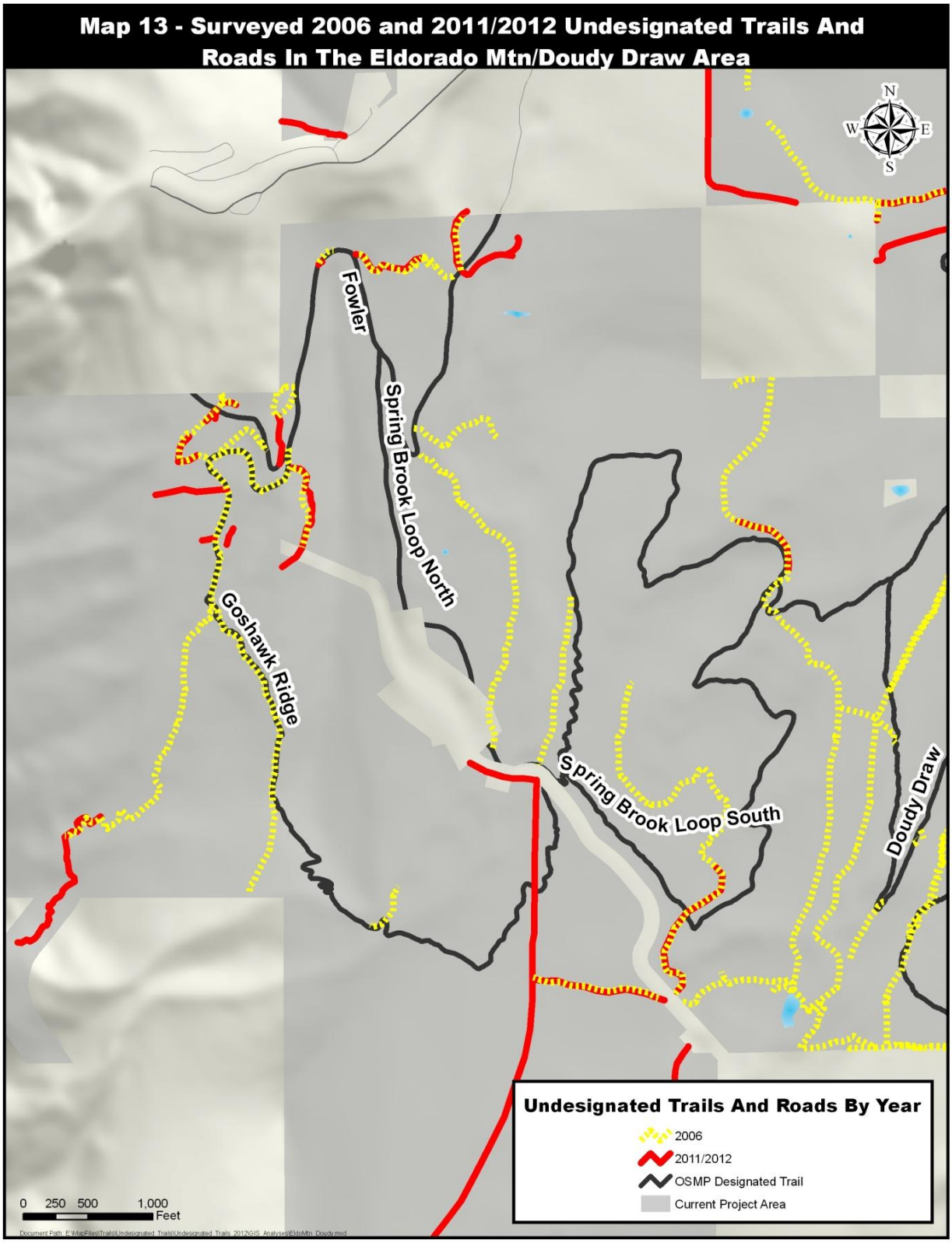
Appendix N2. Proximity map with designated and undesignated trails and roads



Appendix O1. Surveyed undesignated trails in 2006 and 2011



Appendix O2. Surveyed undesignated trails over time in Eldorado Mountain/Doudy Draw area



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Appendix P. Constructed features mapped by all 27 categories

Table 23. Constructed features by **type** in and outside of the study area

Constructed Feature Type	Count in Study Area	Count Outside Study Area
Barricade, boulder	5	
Bridge	16	
Check dam, log	6	
Check dam, rock	21	1
Culvert, corrugated plastic	2	
Culvert, PVC	2	
Culvert, steel	41	1
Drain, French drain	1	
Drain, side ditch	1	
Fence, buck & rail	16	
Fence, wood	46	
Footbridge	16	
Geotextile synthetic mat	5	
Other	14	1
Step, crib ladder	1	
Step, individual log step	41	
Step, individual rock step	72	
Step, individual timber step	7	
Step, overlap rock	4	
Stepping stones	2	1
Wall, post/plank	1	
Wall, rock monowall	5	
Wall, stacked rock	16	
Waterbar, native log	11	
Waterbar, natural	9	1
Waterbar, rock	42	
Waterbar, treat log	30	
Total	**433**	**5**

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Appendix Q. Additional results by TSAs and management areas

Table Q1. Acres surveyed and percent of total by Trail Study Area, management area designation and property type; total acres surveyed = 35,657

Trail Study Area	Acres Surveyed	Percent of Total
North	7,308	20
South	8,291	23
East	8,791	25
West	11,223	31
None	45	<.1
Management Area Designation	**Acres Surveyed**	**Percent of Total**
Passive Recreation Area	4,434	12
Natural Area	12,955	36
Habitat Conservation Area	13,807	39
Agricultural Area	3650	10
TBD	0.6	<.1
None	811	2
Property Type	**Acres Surveyed**	**Percent of Total**
OSMP Fee	34,818	98
OSMP Conservation Easement	199	1
OSMP Miscellaneous Easement	190	1
Non-OSMP (NCAR)	451	1

Table Q2. Distribution of mileage by designated and undesignated miles among TSAs (calculated from miles/acres not density data)

Trail Study Area	UT Miles	% UT Miles	DT Miles	% DT Miles	UT/DT Miles	Acres Surveyed	UT Feet/Acre
North	30.2	17.0	19.9	13.4	1.5	7308	21.8
South	24.4	13.7	27.5	18.6	0.9	8291	15.5
East	66.6	37.5	18.3	12.4	3.6	8791	40.0
West	56.1	31.5	82.1	55.5	0.7	11223	26.4
None	0.50	0.3	0.1	0.1	4.5	45	58.1
Total	**177.8**	**100.0**	**147.9**	**100.0**		**35,657**	

Table Q3. Constructed feature count and percent of total by Trail Study Area and management area designation

Trail Study Area	Management Area Designation	Count	Percent of Total
North	Passive Recreation Area	55	68
	Natural Area	13	16
	Habitat Conservation Area	4	5
	Agricultural Area	9	11
	Total	**81**	**100**
South	Passive Recreation Area	12	46
	Natural Area	3	12
	Habitat Conservation Area	11	42
	Total	**26**	**100**
East	Passive Recreation Area	5	6
	Natural Area	38	48
	Habitat Conservation Area	11	14
	Agricultural Area	22	28
	None	3	4
	Total	**79**	**100**
West	Passive Recreation Area	137	55
	Natural Area	99	40
	Habitat Conservation Area	4	2
	None	7	3
	Total	**247**	**100**

Appendices

Table Q4. Distribution of mileage by designated and undesignated miles among management areas (calculated from miles/acres not density data)

Management Area Designation	UT Miles	% UT Miles	DT Miles	% DT Miles	UT/DT Miles	Acres Surveyed	UT Feet/Acre
Passive Recreation Area	50.7	28.5	65.0	44.0	0.8	4,434	60.4
Natural Area	60.7	34.2	52.1	35.2	1.2	12,955	24.7
Habitat Conservation Area	39.8	22.4	19.6	13.2	2.0	13,807	15.2
Agricultural Area	15.6	8.8	3.4	2.3	4.6	3650	22.6
None	10.9	6.1	7.8	5.3	1.4	811	71.0
Total	**177.7**	**100.0**	**147.9**	**100.0**		**35,657**	

Table Q5. System-wide constructed features count and percent of total by management area designation

Management area Designation (acres surveyed)	Count	Percent of Total
Passive Recreation Area (4,434)	209	48
Natural Area (12,955)	153	35
Habitat Conservation Area (13,807)	30	7
Agricultural Area (3,650)	31	7
None (811)	10	2
Total	**433**	**100**

Table Q6. System-wide constructed features count and percent of total by Trail Study Area

Trail Study Area	Count	Percent of Total
North	81	19
South	26	6
East	79	18
West	247	57
Total	**433**	**100**

Table Q7. Sign count and percent of total by Trail Study Area and management area designation

Trail Study Area	Management area Designation	Count	Percent of Total
North	Passive Recreation Area	62	68
	Natural Area	12	13
	Habitat Conservation Area	8	9
	Agricultural Area	9	10
	Total	**91**	**100**
South	Passive Recreation Area	13	21
	Natural Area	20	32
	Habitat Conservation Area	30	48
	Total	**63**	**100**
East	Passive Recreation Area	34	26
	Natural Area	51	39
	Habitat Conservation Area	32	25
	Agricultural Area	6	5
	None	7	5
	Total	**130**	**100**
West	Passive Recreation Area	58	37
	Natural Area	44	28
	Habitat Conservation Area	41	26
	None	14	9
	Total	**157**	**100**
None	N/A	**8**	**100**

Table Q8. Sign count and percent of total by Trail Study Area

Trail Study Area	Count	Percent of Total
North	91	20
South	63	14
East	130	29
West	157	35
None	8	2
Total	**449**	**100**

Table Q9. Sign type count and percent of total by management area designation

Management area Designation	Count	Percent of Total
Passive Recreation Area	167	37
Natural Area	127	28
Habitat Conservation Area	111	25
Agricultural Area	15	3
None	29	6
Total	**449**	**100**

Table Q10. Distribution of signs across TSAs and average signs per mile

Trail Study Area	Count	Percent of Count Total	Miles	Percent of Miles Total	Average #Signs/Mile
North	91	20	30	17	3
South	63	14	24	14	3
East	130	29	67	38	2
West	157	35	56	32	3
None	8	2	1	0	16
Total	**449**	**100**	**178**	**100**	**3**

Table Q11. System-wide miles and percent of total by management area designation and cattle evidence

Management area Designation	Cattle evidence	Miles	Percent of Total
Passive Recreation Area	Yes	7.6	15.0
	No	43.1	85.0
	Total	**50.7**	**100.0**
Natural Area	Yes	17.2	28.3
	No	43.5	71.7
	Total	**60.7**	**100.0**
Habitat Conservation Area	Yes	22.3	56.0
	No	17.5	44.0
	Total	**39.8**	**100.0**
Agricultural Area	Yes	12.5	80.3
	No	3.1	19.7
	Total	**15.6**	**100.0**
None	No	**10.9**	**100.0**

Table Q12. System-wide miles and percent of total by Trail Study Area and cattle evidence

Trail Study Area	Cattle Evidence	Miles	Percent of Total
North	Yes	9.6	31.9
	No	20.6	68.1
	Total	**30.2**	**100.0**
South	Yes	20.8	85.4
	No	3.6	14.6
	Total	**24.4**	**100.0**
East	Yes	26.3	39.5
	No	40.2	60.5
	Total	**66.6**	**100.0**
West	Yes	2.8	5.1
	No	53.2	94.9
	Total	**56.1**	**100.0**
None	No	**0.5**	**100.0**

Appendices

Appendix R. Undesignated trail classification and rapid assessment matrix (City of Boulder 2006, Appendix 1)

Undesignated Trail Classification on Opens Space and Mountain Parks Lands

Background

The Open Space and Mountain Parks Department manages over 138 miles of designated trails and over 300 miles of undesignated trails. While designated trails are shown on trail maps and are maintained, management of undesignated trails is less clear. This can lead to visitor and staff confusion, resource damage, and the creation of more undesignated trails. The Trail Study Area planning process provides an opportunity to decide how to manage undesignated trails to both enhance visitor opportunities and protect resources.

The Visitor Master Plan includes a management strategy to assess and manage undesignated trails that is integrated with other strategies to provide a sustainable and maintainable trail system and to provide adequate protection of natural resources. Trail Study Area plans provide the opportunity to develop a comprehensive set of recommendations on how to manage undesignated trails. These recommendations will help decide where new trails should be built and where resource protection measures should be implemented.

Primary uses for this information include:

- Provide appropriate visitor access and resource protection.
- Communicate to the public the status of undesignated trails and how they are managed.
- Provide clear trail management and maintenance direction to staff based on the undesignated trail classification.

Project Goal

The goal of this project is to provide appropriate visitor access and reduce resource damage by:

1. Assigning each undesignated trails to one of three categories, which indicate the appropriate range of management actions:

    - designate
    - authorized vehicle access
    - close and revegetate

2. Provide a high or low management priority for those trails listed as “close and revegetate.”

Appendices

Definitions

Trail categories are defined as:

1. Designate – These undesignated trails become part of the designated trails system by constructing a sustainable designated trail in the same general location as the undesignated trail. In some cases, rerouting of the undesignated trail may be required to meet sustainability standards, protect resources or enhance the visitor experience.

Undesignated trails will be designated where trails provide a physically and environmentally sustainable route to an OSMP-designated destination, provide a good-quality visitor experience, and are not duplicated by other designated trails.

Sustainable trails are built and maintained to meet standards for physical and environmentally sustainability with these characteristics:

- **Physical Sustainability:** Physically sustainable trails support current and planned visitor uses and volumes with minimal impact to the surrounding area. Physical sustainability for trails involves building a durable trail with design features and materials that allow it to accommodate all physical forces acting upon it (both natural and human-caused), drain water with negligible soil loss, and be maintained with minimal regular maintenance over extended periods of time.
- **Environmental Sustainability:** These trails support current and planned visitor uses and volumes with minimal damage and cumulative impacts to natural resources. Environmental sustainability for trails involves building a trail that ensures continued ecosystem and biological integrity and protects important plant and wildlife species and communities.

Some undesignated trails that provide limited access to specific destinations may be retained to meet management objectives. These limited access trails are intended to sustain low levels of use and will not necessarily be promoted or shown on official maps. Limited access trails will be part of the department's official designated trail system and monitored periodically to determine their condition and status.

2. Authorized vehicle access - Vehicle access occurs on OSMP lands for a variety of official land management purposes. Some of the vehicle access is on "roads" owned and maintained by OSMP. Legal access to private entities or government agencies is authorized through ownership of the road right-of-way or an access easement on OSMP lands.

Vehicle access serves a variety of purposes to support activities related to firefighting, emergency or rescue response, forest management, agricultural management, and maintenance of facilities. Other agencies use vehicle access to support maintenance activities for utility lines, ditches, and canals.

Areas authorized for vehicle access and use are either open to the public for non-motorized visitor access or will require an off-trail permit in HCAs for visitor access, unless specifically closed to visitor access.

3. Close and Revegetate – These undesignated trails are physically or environmentally unsustainable and /or duplicate other designated trails. They are physically closed to visitor use and re-vegetated to natural conditions. Examples of management actions to close and restore undesignated trails include: signs, fences, obstructions with rocks and logs and branches, soil scarification and planting of native vegetation, area closures, and modifications in livestock grazing. Management actions will vary depending on site specific issues.

High and low priorities are assigned to undesignated trails in this category depending on site-specific circumstances. Resource protection, minimization of impacts and levels of visitor use of a route or destination are the main issues considered in the priority rating. Other issues such as livestock grazing may result in a lower priority rating because of the difficulty in changing grazing patterns. A high priority rating for closure and revegetation may be assigned where undesignated trails receive a high level of visitor use and require management actions to physically remove the undesignated trail and restore the area using ecological restoration techniques. Closure and revegetation of undesignated trails where a lower level of visitor use and natural revegetation can occur may also receive a higher priority rating to accomplish management objectives.

Periodic inspection and maintenance will occur to determine the success of closing and revegetating undesignated trails. Management actions may be adjusted over time to achieve the management goals for specific undesignated1 trails.

Mapping and Classifying Undesignated Trails

Undesignated trails used by visitors were mapped in July 2006. Cattle or wildlife trails that do not appear to have recreational use were not mapped. Roads used by pedestrians, equestrians, or bicyclists were included in the undesignated trails mapping. Trail width was measured to help determine the level of visitor use on different trail segments. Other map coverages were used when classifying trails. Examples include: old undesignated trails mapping, vegetation, weeds, and cultural resources. For more information on the methodology used to map undesignated trails see Monitoring Protocol for Undesignated Trails (2006 City of Boulder Open Space and Mountain Parks).

Undesignated trails were categorized and prioritized using a rapid assessment protocol. This streamlined process was designed to accomplish the goals of managing undesignated trails, recording decisions, and categorizing undesignated trails for appropriate management actions.

The TSA was analyzed by subareas based on patterns of visitor use and distribution of resources. A subset of the OSMP Trail Suitability and Evaluation Criteria was used to classify undesignated trails. The criteria include visitor experience, physical sustainability, environmental sustainability, and cultural/paleontological resources on a scale of high, medium, or low suitability. A composite suitability rating for each category was recorded in the GIS database for

the trail segment. A brief narrative was included in the database describing the most pertinent decision making issues. A map coverage showing the classified undesignated trails was created to display the results.

Detailed field inspections and reports will guide management of undesignated trails. These reports will be drafted as part of the Trail Study Area plan implementation.

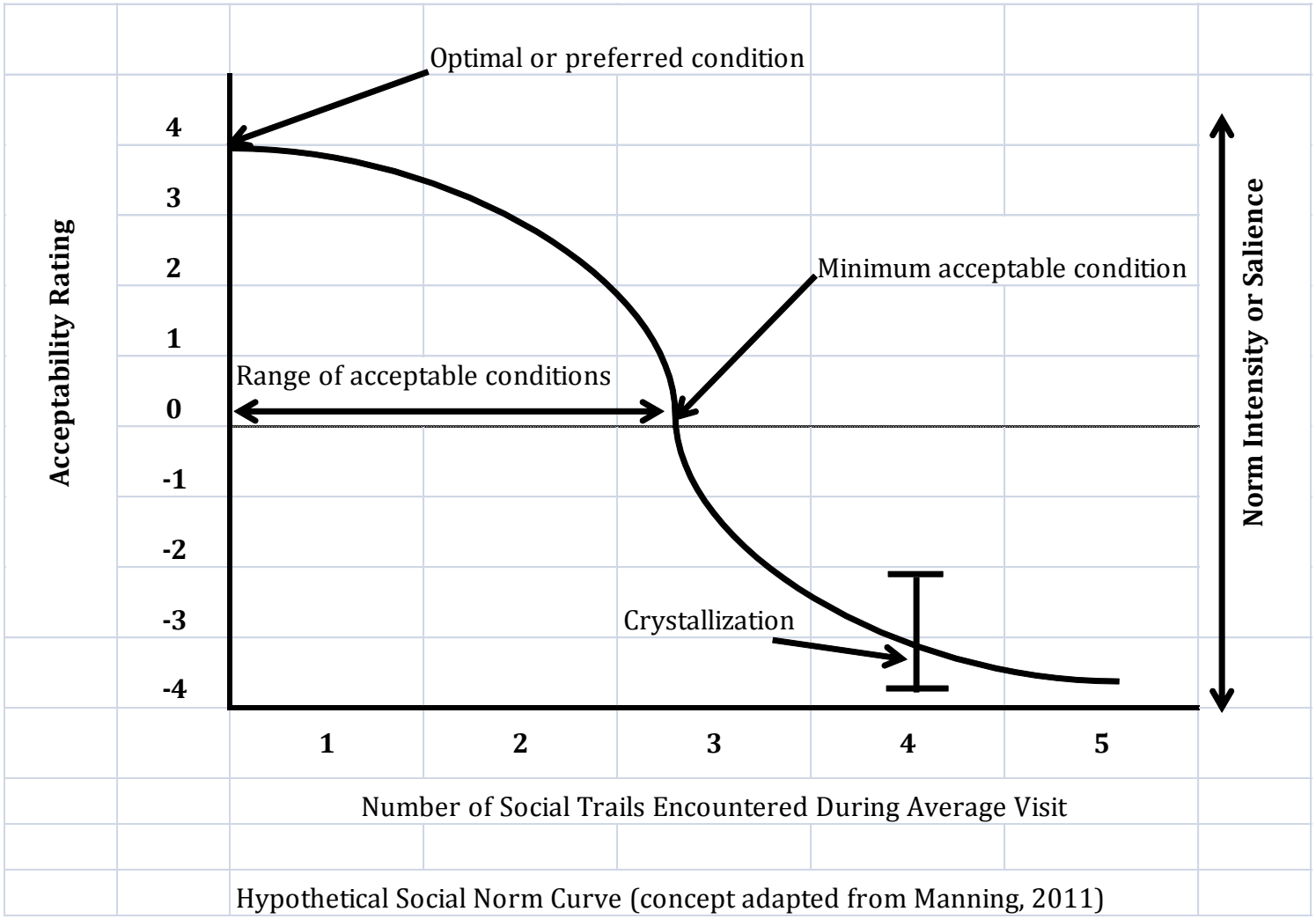
Rapid Assessment Undesignated Trail Suitability and Evaluation Criteria Matrix
Revised for undesignated trails 8/9/06

Quality of Visitor Experience				
Suitability Criterion	**High Suitability**	**Medium Suitability**	**Low Suitability**	**Not Suitable**
A. Trail Connections / Enhanced Trail Opportunity	Critical link to the existing trail system; possible opportunity for longer-distance trail, loop trail, or improved access to existing destination.	Important link to the existing trail system or planned trail system; possible opportunity for longer-distance trail, loop trail, or improved access to existing destination.	Less important trail connection or trail enhancement.	
B. Visual Quality	Dramatic vistas or high interest scenic features.	Partial vistas or high interest scenic features.	Few or no vistas or high interest scenic features.	
C. Access to Water Resources	Direct access to water in an area not prone to erosion or vegetation trampling.	Limited access to water in an area prone to erosion or vegetation trampling.	No access to water or ephemeral water source.	
Physical Sustainability				
Suitability Criterion	**High Suitability**	**Medium Suitability**	**Low Suitability**	**Not Suitable**
A. Trail Grade	Gentle grades between 2 and 7%.	Moderate grades between 7 and 14%.	Steep grades greater than 14% or flat grades less than 2%.	
B. Cross Slope .	Moderate slopes of 10 to 70%.	Gentle slopes (between 0 and 10%) or Steep slopes (between 70 and 90%).	Very Steep slopes (exceeding 90%).	
C. Soil Types	A good mixture of fines and small angular rock.	A good mixture of soil and small rock intermixed with	Soils with uniformly fine texture with little	

		larger cobbles or small boulders or mostly rock of uniform or varying size containing little or no soil.	or no rock content or material with uniform sand-grain texture with few fines.	
Environmental Sustainability				
Suitability Criterion	**High Suitability**	**Medium Suitability**	**Low Suitability**	**Not Suitable**
A. Rare and Imperiled Species, Habitats, or Communities (listed as rare or imperiled on federal, state, county, Colorado Natural Heritage Program, or OSMP lists)	Impacts no rare and imperiled species or habitats.	Impacts few rare and imperiled species or habitats.	Impacts several rare and imperiled species or habitats.	Legal requirements are met to avoid impacts to the habitat of threatened or endangered species (designated by state or federal agencies).
B. Size and Functioning of Habitat Blocks	Maintains or increases the size and functioning of habitat blocks.	Moderately decreases the size and functioning of habitat blocks.	Significantly decreases the size and functioning of habitat blocks.	
C. Presence, Introduction, or Spread of Priority Weed Species (due to construction and visitor use)	Has low potential to contribute to the introduction, spread, or continued presence of OSMP priority weeds.	Has moderate potential to contribute to the introduction, spread, or continued presence OSMP priority weeds.	Has high potential to contribute to the introduction, spread, or continued presence of State A and B Listed weeds or OSMP priority weeds.	
Cultural / Paleontological Resources				
Suitability Criterion	**High Suitability**	**Medium Suitability**	**Low Suitability**	**Not Suitable**

A. County, State (State Historic Preservation Officer), or Federal (National Register of Historic Places) Historic Designation	Designated and protected; may be interpreted.	Designated and needs protection; interpretation potential moderate.	Needs protection; no interpretation potential.	Trail will not violate legal requirements to avoid or not create significant impacts to federal-, state-, or county-regulated historic resources.
B. Known Cultural Sites with Documented Artifacts or Evidence of Human Habitation	Protected, may be interpreted.	Needs protection.	Needs protection.	
C. Known Paleontological Locality with Documented Fossil Occurrences	Protected, may be interpreted.	Protected, may be interpreted.	Needs protection.	

Appendix S. Potential new "social impact" undesignated trail indicator using a social norm curve (Adapted from Manning 2011)



Hypothetical Social Norm Curve (concept adapted from Manning, 2011)

Crystallization refers to the level of agreement or consensus around norms and is defined as the dispersion around the points defining a norm curve.