

GIS/GPS Trail Condition Inventories: A Virtual Toolbox for Trail Managers

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Abstract

Trail condition assessments utilizing Global Positioning Systems and Geographical Information System software provide the opportunity and the tools to record multitudes of trail condition data which can later be utilized to make informed trail management decisions. Trail condition assessments were conducted for fourteen all-terrain vehicles (ATV) trails within the Glennallen District of the Bureau of Land Management, Alaska. Field inventory activities involved using a mapping-grade global positioning system and hand-held computer to map and characterize trail conditions for approximately 200 miles of ATV trails. Trail characterization data was supplemented using aerial and land-based digital video and still images. The data was then summarized using ArcGIS software to facilitate the development of a computer-based management tool. Incorporated into a GIS database, the trail condition inventory provides a virtual toolbox that can be used to determine maintenance needs, establish maintenance priorities, and determine funding needs for trail maintenance.

1.0 INTRODUCTION

All-Terrain Vehicle (ATV) access results in greater negative physical impact to Alaska wildlands than any other use (Bane, 2001). Many sites within the state have limited capacity to tolerate ATV use because of sensitive tundra and soils. These include alpine areas, wetlands, steep slopes and areas underlain by permafrost. ATV use in these areas can lead to rutted and muddy trail conditions that often contribute to severe trail degradation.

Once trails degrade to the point of being impassible, trail users typically abandon the degraded section and establish a new route or routes adjacent to the old trail. The newly established route can, in time, also become degraded and yet another alternate route will be established next to it. This cycle of increasing degradation has been well studied and documented (Meyer, 2001). This chain of events typically leads to the generation of large braided sections of trail that can encompass several acres of land. Degraded trails are a significant environmental liability due to their impacts on vegetation, soils, site hydrology and cultural resources.

The objective of this report is to present a comprehensive method of collecting data on trail conditions, and incorporating that data into a computer-based management tool for determining trail maintenance needs, establishing maintenance priorities, identifying trails requiring seasonal closure, and determining funding needs for trail maintenance. Data collection was performed using an abbreviated version of the classification system and procedures defined by Kevin G. Meyer of the National Park Service in his 2002 report "An Introduction to the Management of Degraded OHV Trails in Wet, Unstable and Sensitive Environments."

2.0 SITE LOCATION

The project location is within the Bureau of Land Management Glennallen District approximately 125 miles south of Fairbanks, Alaska. Figure 1 shows the location of the individual trails surveyed on USGS Gulkana and Mt. Hayes 1:250,000 maps.

3.0 FIELD METHODOLOGY

Prior to conducting ground surveys of the individual ATV trails, a helicopter reconnaissance was conducted for all trails. Digital video and still images were taken for trail documentation and review prior to field activities. Portions of that video have been included in the GIS discussed later.

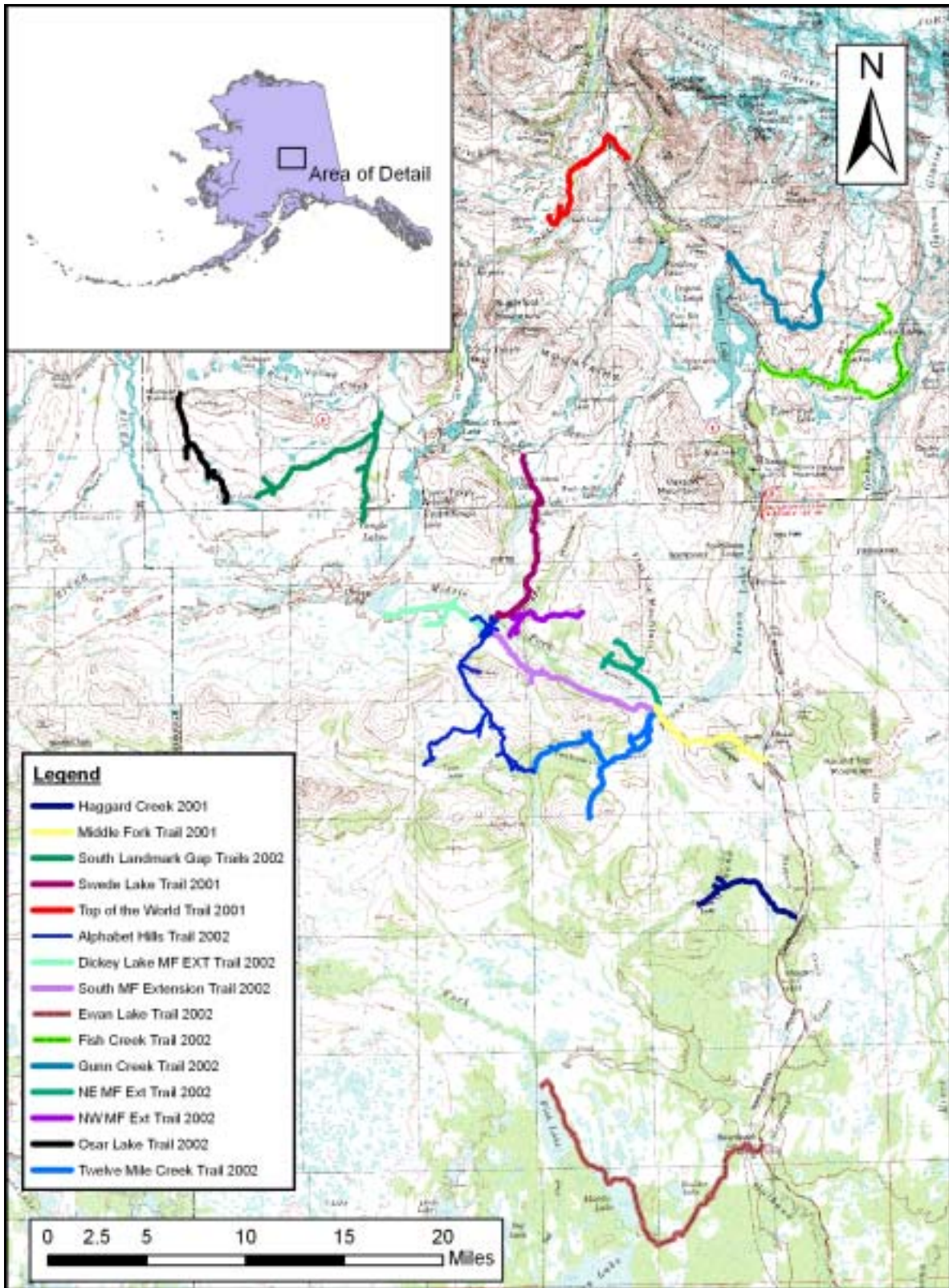


Figure 1. 2001-2002 Inventoried Trails Vicinity Map, Gulkana and Mt. Hayes 1:250,000 quadrangles, Alaska. Alaska vicinity map inset.

The Field Survey Team performed an initial traverse of each trail alignment using an ARGO® 8 wheeled amphibious vehicle or 4-wheel ATV to assess general trail conditions and establish milepost locations at 0.5-mile intervals. The team then performed a second traverse to document existing trail features using a Trimble Pathfinder Pro XR® Mapping-grade GPS receiver with a TSC1 data logger. Trimble Asset Surveyor® software version 5.01 was used with the TSC1. Trail segments, area features, and point features were characterized according to attributes described by Kevin G. Meyer of the National Park Service, Anchorage Office (Meyer, 2001). The attributes used were incorporated into a Trimble “data dictionary” format which was loaded into the TSC1 data logger allowing for real-time collection of attribute data. The individual features and associated attributes are discussed below.

3.1 TRAIL SEGMENT FEATURES

Trail segments were evaluated for segment type, track type, surface slope, trail impact rating, mud-muck index, trail drainage, surface characteristics, stone hindrance, track width, and vegetation stripping. When a major change in one of these attributes was encountered, the trail line feature was segmented and new attributes were noted. Minimum segment lengths were kept to 20 feet unless significant trail surface characteristic changes were encountered.

- **Segment Type:** Trail segment type defines the segment as single track, double track, parallel or various widths of multiple braided segments. Single track is one lane, as in a footpath or game trail. A double track has two parallel lines of vegetation stripping, one for each wheel of a vehicle. Parallel tracks are two distinct paths of travel, whether single or double track, that parallel each other and will eventually connect. Multiple braided segments are segments that have many tracks either parallel or interwoven.
- **Trail Track Type:** Trail track type defines the segment as main, secondary-active, abandoned, access, cutoff or spur. Main trail segment type refers to the primary surface of travel. Secondary-active segments are active but not used as much as the main trail path. In severely braided sections, where a secondary-active trail was not apparent, none were documented. In most cases however, the second most active trail segments appeared to be the segments on the perimeter of the braided impact areas. Abandoned segments are those segments that are unused but still evident. Access segments are those that are used to access the trail. Cutoff segments are used to shorten the path to other segments of the trail. Spur segments are a branch off of the main segment going to points of interest or other trails entirely. Spur trail segments that were not part of the inventory were surveyed for approximately 100 feet from the main trail segment in order to document their existence.
- **Trail Surface Slope:** Trail surface slope was measured in the field using an inclinometer. This value was compared with a calculated slope using GPS line altitude data. The calculated slope was determined by dividing the altitude change of the line segment by the two dimensional horizontal length of the segment. If it was found that the calculated slope measurements were more representative of the terrain, then they were used in the exported data files.

- Trail Impact Rating: Impact rating is defined as the rutting or subsidence of the trail surface in relation to the surrounding terrain. The rating was determined by either the amount of vegetation stripping or actual depth of rutting or subsidence.
- Track Width: The width of the most active portion of the segment was assigned as the track width. The width of large braided track segments was estimated. When necessary, track width was measured using a 100 ft cloth tape measure to place the trail segment in the proper category.
- Mud-Muck Index: The mud-muck index describes how rutting and drainage affect the trail surface. The index ranges from no mud to multiple muckholes. Muckholes are ponded depressions that are extremely muddy. Muckholes develop as a result of trail subsidence reaching the underlying permafrost layer or groundwater.
- Trail Drainage: The segment drainage rating was based on a visual assessment of both soil and terrain features. This rating ranged from well drained to water running.
- Trail Surface Characteristics: The type of surface that the trail is located on (e.g., native fine mineral, native organic, gravel, etc.).
- Vegetation Stripping: The amount of the vegetation on the trail that has been removed by trail usage. This ranged from vehicle wheel tracks only to the full width of the trail.

3.2 TRAIL POINT FEATURES

Point features along the trail were also documented. Point features included in the survey were stream crossings, points of interest, reference points and photo documentation points.

- Stream crossings: Stream crossings were defined as unimproved ford, improved ford, bridge, or culvert. Stream width was measured and when known, stream name was documented.
- Point of Interest: Points of interest included such things as campsites, cabins, viewpoints, etc.
- Reference points: Reference points included mileposts, trail junctions, trailheads, survey markers, etc.
- Photo points: Photo documentation points were taken at points of significant trail impact or other points of interest. A compass bearing was recorded with each photo taken. The bearing was appended to the photo file name.
- Video Points: Similar to the photo points, video documentation points were also taken at various locations to further demonstrate trail conditions. The digital video was converted to MPEG-1 (Motion Picture Experts Group) format and has also been integrated into the GIS.

3.3 AREA FEATURES

Area features measured and documented included braided impact areas and parking areas.

- Braided Impact Area: Braided impact areas were defined by driving the perimeter of the braided

area on ATV. In some severely braided sections it was necessary to walk the perimeter of the impacted section to obtain an accurate area. Only those braided impacted areas greater than 300 square feet were documented as such in the survey.

- **Parking Area:** The parking area, if present, was determined by driving the perimeter of the established parking area nearest to the trailhead.

4.0 TRAIL CONDITION RATING METHODOLOGY

The intent of this trail condition survey was not only to collect trail location and condition data, but to synthesize those data into a management tool that could be utilized for prioritizing maintenance needs, for planning maintenance activities, and for determining maintenance funding needs.

To accomplish these management goals, it was necessary to develop a scoring system for inventoried trail conditions that reflected the relative impact of each specific attribute on over-all maintenance needs, and which would allow summing individual scores to allow a total ranking.

For trail segments inventoried, each attribute was scored for each segment using the ranking scores presented in Table 1. These scores were then totaled to develop a total score for that segment that was indicative of relative priorities of trail maintenance needs.

Table 1. Trail Attribute Rating System

Segment Feature	Attribute	Rating
Surface Slope	0-6%	0
	7-20%	4
	21-40%	10
	>40%	15
Impact Rating	Minor loss of vegetation	1
	Exposed roots	2
	Less than 2 inches (rut/subsidence)	3
	2-8 in.	6
	9-16 in.	8
	17-32 in.	10
	32-60 in.	12
	> 60 in.	15
Mud/Muck Index	None	0
	Muddy	4
	Extremely muddy	6
	Muckhole	8
	Multiple muckholes	10

Table 1. Trail Attribute Rating System (continued)

Segment Feature	Attribute	Rating
	Seasonally impassable	12
Trail Drainage	Well drained	2
	Moderately Well-drained	4
	Poorly drained	6
	Saturated	8
	Ponded	10
	Water running	12
Trail Surface Characteristics	Vegetated	0
	Rock	0
	Gravel	2
	Cobble	2
	Native fine mineral	2
	Mixed fines and gravel	2
	Native organic	6
	Wetland vegetated	8
	Floating organic	12
	Track Width	1-3 ft.
3-6 ft.		0
6-12 ft.		2
12-20 ft.		4
20-30 ft.		6
30-40 ft.		8
40-60 ft.		10
> 60 ft.		12
Segment Type	Single Track	0
	Double Track	1
	Multi-braid 6-20 ft.	2
	Multi-braid 20-40 ft.	3
	Multi-braid 40-80 ft.	4
	Multi-braid 80-160 ft.	5
	Multi-braid 160-320 ft.	6
	Multi-braid 320-480 ft.	7
	Multi-braid >480 ft.	8
Stone Hindrance	None	0
	< 10%	0
	11-25%	1
	26-75%	2
	75-100%	3
Vegetation Stripping	Wheel track only	0
	Full width of trail	1

Although the scoring system provides a relative ranking by score, it is also useful to establish a range of categories of maintenance needs based on the above scoring system. These categories, to be used as an effective management tool by the BLM throughout trails in Alaska, should reflect conditions over a variety of trails.

To establish maintenance need categories based upon the total attribute scoring system, trail segments from all trails surveyed in 2001 were ranked according to their total scores. The range of scores that encompassed the 10th percentile of highest scores (scores greater than 35) were assigned to a Critical Maintenance Need Category. Similarly scores between the 10th and 25th percentile (29 to 35) were designated as High Maintenance Need, 25th to 50th percentile (22 to 28) were designated Moderate Maintenance Need, 50th to 75th percentile (16 to 21) were designated Low Maintenance Need and 75th to 100th percentile were designated as Deferred Maintenance Need. Based on this scoring system, each segment of the ATV Trails was assigned to a category.

Note that the above system addresses individual trail segments. Damaged areas created by multiple routes were also surveyed. These areas reflect substantial environmental impact and are also considered Critical Maintenance Needs locations. In most cases these areas correspond with trail segments that are categorized as Critical Maintenance Needs.

5.0 GPS/GIS INTEGRATION

All GPS data collected were post-processed using Trimble Pathfinder Office®, version 2.8. Differential correction was performed using base correction files obtained from the BLM Glennallen office base station or from Accupoint, Inc (www.acupoint.com). Data from the individual survey dates were combined and exported using the ArcView® shape file setup. All data were exported using the Universal Transverse Mercator (UTM), Zone 6 North coordinate system. Map datum used was North American Datum (NAD) 1927 for Alaska. Base map information supplied by the BLM was in United States Geological Survey digital raster graphic, UTM projected format.

Shapefiles exported from Pathfinder Office were brought into ArcMap and layers based on the individual attributes were created. Layers were also generated utilizing the ranking determinations discussed in the previous section. Lastly, hyperlinks were established for all digital photo and video points.

Once all of the trail data was integrated into ArcMap, a portable map file (.pmf) was generated using the ArcMap Publisher extension. The pmf file was placed on a compact disk with all GIS data including all photos and videos. This allows sharing of the trail data with anyone who has access to the free ESRI

software ArcReader.

6.0 FINDINGS AND CONCLUSIONS

Table 2 presents a summary for each trail surveyed during the 2001-2002 field season. Approximately, 208

Table 2. Trail Condition Summary for BLM Glennallen District Trails, 2001-2002.

Survey Year	Trail Name	Miles of Trail in each Maintenance Category					Summary		
		Critical	High	Moderate	Low	Deferred	Total Miles of Trail	Braided Areas	Acres of Braided Area
2001	Middle Fork Trail	0.9	1.4	2.1	3.9	1.7	10.00	10	4.8
2001	Swede Lake Trail	2.5	1.7	4.4	3.6	1.2	13.40	12	21.0
2001	South Landmark Gap Trail	0.7	0.8	1.3	5.6	8.2	16.60	5	19.8
2001	Top of the World Trail	0.0	1.2	1.1	1.8	5.8	9.90	3	8.0
2001	Haggard Creek Trail	0.9	1.5	2.1	0.6	2.4	7.50	15	17.2
2002	Alphabet Hills Trail	2.6	2.0	7.1	10.4	5.5	27.60	35	28.0
2002	Fish Creek Trail	1.1	0.8	3.2	6.9	8.9	20.81	18	8.2
2002	Osar Lake Trail	0.1	0.1	1.2	5.1	2.4	8.90	3	0.2
2002	Twelve Mile Creek Trail	1.6	1.6	3.5	6.5	5.1	18.30	20	4.1
2002	South Middle Fork Extension Trail	0.0	0.2	1.4	4.1	6.4	12.10	1	0.3
2002	NW Middle Fork Extension Trail	0.4	1.2	1.1	1.3	3.7	7.70	7	3.0
2002	NE Middle Fork Extension Trail	0.5	0.9	2.5	1.7	2.6	8.20	13	2.2
2002	Gunn Creek Trail	0.0	0.0	0.1	2.9	13.0	16.01	0	0.0
2002	Ewan Lake Trail	11.8	7.3	2.1	0.2	1.6	23.00	40	121.0
2002	Dickey Lake MF Ext. Trail	0.4	0.4	0.9	3.1	4.0	8.80	5	0.8
Summary		23.5	21.1	34.1	57.7	72.5	208.82	187	238.65

miles of ATV trail were inventoried within the Glennallen District of the Bureau of Land Management. Using the rating system discussed previously, individual trail segments were scored and placed into the appropriate maintenance category. A total of 11.3% (23.5 miles) of the inventoried trails have critical maintenance needs, 10.1 % (21.1 miles) high maintenance needs, 16.3% (34.1 miles) moderate maintenance needs, 27.6% (57.7 miles) low maintenance needs and 34.7 % (72.5 miles) have deferred maintenance needs. In addition to the trail segments identified above, 187 braided impact areas encompassing 238 acres of land were identified. These areas represent a major concern due to their potential to affect large areas of land.

Several printed deliverables can accompany the GIS data deliverable. These include:

- Arcview layout printouts for all segment attributes for which data was collected. The Arcview layers were printed on transparency film to allow for comparison of multiple segment attributes as well as comparison with USGS topographic data.
- Photo catalog with thumbnail images for all digital photos taken during the survey. File names are in the format PXxx00aa-bbb, where X = month, xx = day, aa = frame number, and bbb = compass bearing. Photograph locations can be located using the frame number and the photo point layer printout.
- Trail segment table listed by maintenance category. All segment attributes and attribute ratings are shown. The line ID number is a unique identifying number generated by Path Finder Office software and allows for segment location in the original data files.

The GPS/GIS trail condition inventory not only provides a baseline of trail conditions that can be used to plan and track monitoring efforts but also allows for cost analysis of various trail remedies (e.g., geotextile, geoblock, water bars, grading/leveling, etc.) Additionally, the data can be subjected to a wide variety of map and tabular analysis, including overlay with other geographic data sets like soils and terrain.

7.0 REFERENCES

1. Bureau of Land Management. Trail Information, BLM Glennallen Field Office. (<http://www.glennallen.ak.blm.gov/trails.html>). 2001.
2. Meyer, Kevin G. An Introduction to the Management of Degraded ATV Trails on Wet, Unstable & Permafrost Environments In South central & Interior Alaska. February, 2002.
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8.0 LIST OF ACRONYMS

ATV	All Terrain Vehicle
BLM	Bureau of Land Management
GIS	Geographic Information System
GPS	Global Positioning System
NAD	North American Datum
OHV	Off Highway Vehicle
USGS	United States Geological Service
UTM	Universal Transverse Mercator