

# Rex Trail: Long Term Monitoring Report 2016



Produced by  
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Division of Mining, Land & Water  
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Photos and charts courtesy of DNR, DMLW, NRO Lands Section

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## **Introduction**

The Rex Trail is an important access route which has been in use since the 1920's and serves as a vital transportation route for mining, hunting, private property access, recreation, and trapping. A map of the trail is shown in Figure 1. Several placer mines currently operate in the vicinity of the Rex Trail and private landowners have properties in settlement areas of Gold King, Southwind, and Wood River. Both miners and residents rely heavily on the Rex Trail in the winter for hauling supplies. It is an important access route in the fall for hunting in Game Management Unit (GMU) 20A. In the mid-2000's, Rex Trail use patterns significantly changed. Intense seasonal use of standard ATV's and increased numbers of large ORV's such as Nodwells and custom-built "moose buggies" became the norm during the fall hunting season. Severe trail damage compromised the opportunity for reasonable and safe travel for some traditional trail users in the fall and in the winter when travel had historically been very dependable.

In order to slow the degradation of the trail and to reduce the potential for more significant access and resource damage, in 2008, the Division of Mining, Land and Water issued a management decision for the eastern Rex Trail restricting the use of highway vehicles between 1500 lbs. and 10,000 lbs. (previously authorized under Generally Allowed Uses), and implementing a decision not to issue permits for off-road vehicles over 1500 lbs. between the dates of April 15 and October 31 annually. This decision was subsequently amended, allowing for issuance of over-the-counter streamlined permits to rubber tracked vehicles from 1500 lbs. up to and including Nodwell RN 110 or similar sized vehicles during the fall hunting season. In conjunction with this amendment, the Division established 10 monitoring plots at which data is typically collected both pre- and post- hunting season.

The monitoring plot data collection and analysis was intended to gather baseline data to monitor the condition of the trail over time. DNR has undertaken this effort to better understand the complex trail environment and help evaluate long-term trail management options.

In December of 2007, DNR staff conducted a preliminary trail assessment of the Rex Trail. This assessment was conducted via snowmachine and 52 locations were sampled. Data were recorded that classified these locations on the trail into five categories of condition: Good, Fair, Degraded, Very Degraded, and Extremely Degraded.

In August of 2009, it was decided that long term monitoring plots should be established along the Rex Trail. Since the whole trail had previously been categorized in 2007, it was decided to build upon that dataset and choose a subsample of those sites for long term monitoring.

## **Methods**

### **Plot Site Selection**

A site reconnaissance via helicopter was flown on 08/21/2009 to ascertain which of the 52 sites among each category were suitable for inclusion in the study. Each of the 52 locations was observed and notes were taken to assess:

1. Could a helicopter be landed at the site?

2. Is the site a good representation of the condition category?
3. Were there any physical reasons that the site should or should not be included (ex. Is the site in one of the recent burns?)?

Ten locations were chosen (Figure 1) using the sites that were left after the helicopter trip (8 sites were excluded; N=44). The site selection was performed by random sample. First, the 44 locations were separated into the five condition categories that were assigned from the 2007 work and assigned a random number using MS Excel. Within each category, sites were sorted following the random order. The top four locations for each category were copied on to a spreadsheet and used in the field to navigate to plot locations. Each plot was identified and marked so that the measurements are repeatable in exactly the same location and so that any lost markers could be re-established if needed. See Figure 2, Plot Setup Diagram.

### **Plot Sampling**

The monitoring plots are designed to record three separate types of data. First, at each plot, a horizontal transect is established that directly measures the depth of ruts and the width of the trail. Each transect was identified and marked in 2009 so that the measurements are repeatable in exactly the same location. Second, sites are assessed using the same methods as were used in the 2007 trail survey. Third, photo points were also established in 2009 and pictures taken from the ground and air are recorded as a way to visually assess change in the site condition over time. The details of how each of these methods are sampled is below.

#### **Taylor Transects**

This technique is adapted from the same one as used in the winter of 2007 to conduct a preliminary assessment of trail conditions<sup>1</sup>. This method was originally used by the Knik River Watershed Group to assess trail conditions and quantify damage by using a point-value system for individual trail attributes<sup>2</sup>. At each plot, a transect of 20 meters was walked along the trail and data were recorded describing the trail along those 20 meters. Figure 3 is an example of a completed datasheet that shows the characteristics that were measured and recorded. The trail condition attributes sampled were: Track Type, Track Width, Rutting (depth in inches), Water/Ice presence, and Vegetation Type. Figure 3 also shows the original conditions of each plot from 2007.

#### **Surface Elevation Transects**

At each transect, a profile of the surface of the trail was obtained using a laser level, stadia rod, and a known bearing. Bearings in this case were nails placed in trees within the plot so that they function as a constant for each sampling event. Transects were laid out according to the width of the trail at each

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<sup>1</sup> – Taylor, Steve. 2008. "Methods for Rex Trail Condition Assessment." DNR Memorandum, Division of Mining, Land and Water, Northern Region. Submitted to: Jeanne Proulx, Northern Region.

<sup>2</sup> – Moore, N.J., Fritz, C.N., Howard, R. 2007. Trails Inventory and damage assessment report. Section 2 of the Report for Alaska Coastal Grant No. 701815G340 Wetlands inventory and damage assessment of the Jim-Swan Wetlands in the Knik River Watershed. Submitted to: US Fish and Wildlife Service, Region 7. By the Knik River Watershed Group.

plot; transects begin off the active trail, cross all of the active area, and end in the vegetation off the active area. Laser level measurements were recorded at every 0.25 meters along the transect along with surface cover and presence/absence and depth of water. Figure 4 shows a typical transect being sampled and Figure 5 shows one page of a trail surface elevation transect datasheet. A maximum transect length of 50 meters was set to stay within time constraints for the sampling efforts. Travel to the majority of the plots is by helicopter and time efficiency and day length is a factor in completing the samples. Plot 23 was the only plot whose active zone was potentially larger than this limit.

#### Photo Points

Each plot had a series of photos taken at each sampling event. These photos included the following perspectives: the transect facing north and south, the transect facing east and west, and then photos taken from the air by helicopter. Figure 6 is an example of each of these photos. At some plots extra photos were taken if there were situations of interest such as large mud holes, ruts, or standing water.

## Data Analysis

### Taylor Transect Method

Each attribute category on the Taylor datasheet was entered in a spreadsheet and each one of the categories is assigned a numerical value. The numerical values are then summed and the end values are recorded. Those values each have a corresponding condition class that rank the condition of the trail into the following categories: Good Condition, Fair Condition, Degraded, Very Degraded, and Extremely Degraded. Figure 7 shows the table of attributes and point-values assigned and an example table for the calculation of a condition score for Plot 7.

### Surface Elevation Transects

#### Elevation Normalization

To be directly comparable, elevation transects had to be normalized by a standardized elevation measurement. As described, a nail was driven into a bearing tree representing an elevation point that would not change. When a transect was sampled, a measurement of the nail elevation was recorded and used to standardize the elevation measurements of the transect. The recorded elevation at each point along the transect was standardized by the following equation:

$$y_n = 100(E - x_n)$$

where  $y$  is the standardized elevation value (converted to centimeters) at transect point  $n$ ,  $x$  is the measured elevation (in meters) at transect point  $n$ , and  $E$  is the measured elevation of the bearing tree nail (in meters).

#### Incorrect or Missing Bearing Tree Nail Elevation Values

For many plots, particularly during the years of 2009 and 2010, data collectors incorrectly entered the elevation of the bearing tree nail. Often, the nail elevation was included as a separate value, so the correct value was easily tracked down and the data corrected. On four occasions, the bearing tree nail

elevation was not recorded. This occurred in plot 23 during the August 2009 sampling period, and plots 19, 23, and 33 during the October 2009 sampling period.

In order to make use of the transect measurements, the bearing tree nail elevations had to be back-calculated. Assuming that the overall transect patterns are largely consistent between measurement periods (graphical visualization of the data confirmed the validity of this assumption), standardized transect data from the plot in question was used to back-calculate the missing bearing tree elevation according to the following process:

1. For an individual plot, where  $y$  is the elevation measured at transect point  $P$  over  $n$  points on collection period  $D$  over  $m$  periods, the data can be organized into the following matrix:

$$\begin{bmatrix} y_{D_1P_1} & y_{D_2P_1} & y_{D_3P_1} & \cdots & y_{D_mP_1} \\ y_{D_1P_2} & y_{D_2P_2} & y_{D_3P_2} & \cdots & y_{D_mP_2} \\ y_{D_1P_3} & y_{D_2P_3} & y_{D_3P_3} & \cdots & y_{D_mP_3} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ y_{D_1P_n} & y_{D_2P_n} & y_{D_3P_n} & \cdots & y_{D_mP_n} \end{bmatrix}$$

Where each row is an elevation measurement  $y$  for transect sample point  $P$  and each column is an elevation measurement  $y$  for sampling period  $D$ .

2. If the bearing tree nail elevation  $E$  for collection period  $D_1$  was omitted during data collection, it can be calculated using the data collected during other periods. Using the data matrix above two additional calculations are required:
  - a. For each row in the matrix, a per-point average  $X$  across sampling periods is calculated, excluding sampling period  $D_1$ , according to the following equation:

$$X_P = \frac{\sum_{i=2}^n y_{D_iP}}{n - 1}$$

where the average  $X$  at sampling point  $P$  is the sum of elevation measurements  $y$  from sampling period  $D_2$  through  $D_i$  (the sampling period of interest  $D_1$ , is excluded), divided by the number of sampling periods  $n$  minus 1. The per-point averages are then averaged to a single value  $\bar{X}$  according to the following equation:

$$\bar{X} = \frac{\sum X_P}{P}$$

- b. For column  $D_1$  of the above matrix, a per-transect elevation average  $\bar{y}$  according to the following equation:

$$\bar{y}_{D_1P_n} = \frac{\sum y_{D_1P_n}}{n}$$

3. Finally, the bearing tree elevation  $E$  for collection period  $D_1$  is calculated by taking the absolute value of the per-transect average  $\bar{y}_{D_1P_n}$  for sampling period  $D_1$ , minus the per-point average

across sampling periods  $\bar{X}$ , and dividing that difference by 100, according to the following equation:

$$E_{D_1} = abs \left| \frac{\bar{y}_{D_1 P_n} - \bar{X}}{100} \right|$$

## Data Outliers

Values that were clearly outside of normal (and were likely recording errors) were thrown out of the data. Identified outliers include: transect point 28.75, 30.00, 35.25, and 42.50 for Plot 23 on October 2011; transect point 7.00 for Plot 30 on October 2011; and transect point 0.50 for Plot 50 on October 2013.

## Reversed Transects

On five occasions, data inconsistencies occurred because transects were recorded from the wrong direction. These errors are easily identifiable from graphed data trends, and were identified in the following plots and dates: Plot 44 August 2012, Plot 45 August 2009, Plot 50 August 2009, and Plot 50 October 2012.

## Vegetation Cover Analysis

Along with the numerical values collected at each sample point, the presence and absence of vegetation was also sampled as well as a broad vegetation class. These data were summarized and percent cover of soil and vegetation classes were calculated in order to quantify how much the surface of the trail changed from vegetated to soil. Figure 5, the transect sampling datasheet, shows how these data were collected on the data sheet (see columns three and four).

## Photo Points

At each plot, a series of the same photos were taken at each sampling event. For each plot, there are a minimum of 5 photos for each sampling event and from 2009 to 2014 there have been 12 visits to each plot. This results in at least 60 photos per plot and over 600 photos total since the monitoring began. The photos have been compared within a single plot for a visual interpretation of trail condition and change over time. Figure 6 shows a representative of each of the photo points taken. Photos have also been used as a reference for interpreting the transect data: for those plots with higher standard deviation in the surface elevation data, photos have been reviewed as a visual check to verify levels of change.

## Results

### Taylor Transect Data

Taylor transects were completed at each plot during each sample period. Each plot had 7 sample events in August and 6 sample events in October<sup>1</sup>. The results for the Taylor transects are represented in

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<sup>1</sup> We were unable to complete an October 2015 sampling of all the plots due to early heavy snow.

Figures 9, 11, 13, 15, 17, 19, 21, 23, 25, and 27. The data are summarized into pie charts that represent the percentage of time each plot was classified into each condition category. There are three pie charts per plot, one representing the August condition category scores, the same for the October samples, and one pie chart that represents all of the data. Results for each plot are listed below.

#### Plot 7

Plot 7 is one of the most stable portions of the Rex trail, and is flat from one side to the other and the surface is hard dirt and gravel. Figure 8 is a photo of Plot 7. Plot 7 was classified into the condition category, "Good," 71% of the time in August and 33% of the time in October, as shown in Figure 9. It was classified as "Fair," 29% of the time in August and 67% of the time in October. Overall, Plot 7 was slightly more often classified as Good than Fair. No other condition classes were represented.

#### Plot 9

Plot 9 is just after the junction where the access trail from the Southwind subdivision meets the main stem of the Rex Trail. It consists of three braids and the most active braid is often filled with water though the trail surface is hard dirt when dry. Figure 10 is an aerial picture of Plot 9 from August 2014 and shows the braids and water. This plot was split between several condition classes in both August and October, as seen in Figure 11. The Extremely Degraded and Very Degraded categories both increased from August to October, from 29% to 50% and 29% to 33% respectively. Overall all the sample periods, Plot 9 was split fairly evenly between Extremely Degraded (38%), Very Degraded (31%), and Degraded (23%).

#### Plot 14

Plot 14 is just west of the Seven Mile Lake area and is characterized by many braids of varying age and use patterns. The area is a low grassy wetland and this section of the trail gets numerous wet and boggy swales, especially in high precipitation years. Figure 12 is an aerial photo of the plot from August 2014, a high rainfall year, and shows the numerous braids and water inundation. The Taylor transect results, see Figure 13, for this plot show the condition as 86% Extremely Degraded in August and 50% in the same category in October. The Very Degraded condition was 14% in August and 33% in October and there was also 17% Fair Condition in October. Across all months and years, the majority percentage was 69% Extremely Degraded with 23% Very Degraded and 8% Fair.

#### Plot 19

This plot is on the western edge of the Rex Fire boundary, east of where the Intertie crosses the trail. The plot consists of two to three braids with a vegetated island separating the two active sections, see Figure 14. On the northern end of the plot there is an old braid that consists of a steep sharp drop-off with deep eroding ruts and this area is impassable for most vehicles. The Taylor Transect data, Figure 15, places this plot in a Very Degraded condition 57% of the time in August and 33% of the time in October. Also in August, the plot condition was 29% Extremely Degraded and then increased to 67% Extremely Degraded in October. There was also 17% of the time in condition Fair in October. Overall, this plot was in the Extremely Degraded condition 69% of the time, Very Degraded 23% of the time, and Fair 8% of the time.



### Plot 23

Plot 23 is east of the Totatlanika River and is also called the Big Braid as it very recognizable from the air due to the number of braids, wet swales, and the vegetation characteristics; it is a very wide open grass and sedge meadow as shown in Figure 16 (2016). The Taylor Transect results for this plot are depicted in Figure 17. This plot was classified as Extremely Degraded 86% of the time in August and 33% of the time in October. It was also Degraded 14% of the time in August and 17% of the time in October. Also in October, this plot was classified as Very Degraded 50% of the time. For all months and years, Plot 23 was classified as Extremely Degraded 62% of the time, Very Degraded 23% of the time, and Degraded 15% of the time.

### Plot 30

This plot is just west of the Tatlanika River and is characterized by tall, thick grass and a mix of larger spruce and birch trees. Figure 18 is an aerial photo of this plot from August 2009. The Taylor Transect data classified this plot into four of the five conditions, see Figure 19. In August, the plot was classed as 29% Very Degraded, 29% Degraded, 29% Fair and 14% Good. In October the plot was an even 50% Degraded and 50% Very Degraded. Overall, the plot was classed as Very Degraded 38% of the time, Degraded 38% of the time, Fair 15% of the time, and Good 8% of the time.

### Plot 33

Plot 33 is east of the Tatlanika River and Fish Creek and is a low wetland swale where a small creek flows across the trail. It is predominately standing water with wetland obligate plants such as *Eriophorum angustifolium* and *Ledum palustre* growing along the edges, Figure 20. The soil here is very boggy and easily churned by disturbance. The Taylor Transect data classifies this plot as Extremely Degraded 57% of the time in August and 100% of the time in October, Figure 21. The second August classification is Very Degraded 43% of the time.

### Plot 44

This plot is just north of Gold King, in the flats below the plateau where the airstrip is located. There are two braids here that are usually grass covered in August and the surrounding vegetation is black spruce forest, Figure 22. This plot is classified in August as 43% Very Degraded, 29% Extremely Degraded, and 29% Fair, Figure 23. In October those values change to 50% Very Degraded, 33% Extremely Degraded, and 17% Degraded. Across all months and years, Plot 44 was Very Degraded 46% of the time, Extremely Degraded 31% of the time, Degraded 8% of the time, and Fair for 15% of the time.

### Plot 45

Plot 45 is less than a mile east of Plot 45 and is in a stand of large spruce and birch trees. Figure 24 is an aerial photo of Plot 44 from August of 2009. The Taylor Transect data classifies this plot as 57% Fair and 43% Good in August and 50% Fair, 33% Degraded, and 17% Good in October. Overall, Plot 45 was in Fair condition 54% of the time, Good condition 31% of the time, and Degraded condition 15% of the time, Figure 25.

## Plot 50

This plot is the easternmost plot in the monitoring program and is about 2 miles west of the Wood River. The plot is situated between an open wetland meadow and pond and a mixed birch spruce forest, Figure 26. The vegetation on the trail is mostly sedges and grasses and the soil is often saturated. The Taylor Transect data classifies this plot in August as 43% Very Degraded and Degraded and 14% Extremely Degraded. In October those values change to 67% Degraded and 17% Very and Extremely Degraded. During the period of this monitoring, Plot 50 was Degraded 54% of the time, Very Degraded 31% of the time, and Extremely Degraded 15% of the time, Figure 27.

### Surface Elevation Transects

The surface elevation transects for individual plots were collected each August and October from 2009 through 2015 and are shown in Figures 29 – 38 with transect interval on the x-axis (horizontal axis) in meters and depth below (negative values) the bearing tree nail on the y-axis (vertical axis) in centimeters. To allow elevation to be comparable between plots, the depth axis range was kept at a constant range. These depth plots can be thought of as a trail cross section showing the trail topography over time. The spread of the lines gathered at different sampling periods gives an idea of how much change occurs in trail elevation over time. Figure 28 depicts Plot 9 transect lines with a photo of the actual plot in the background to demonstrate this concept. Note how the dips and straighter parts of the lines depict ruts, flat trail surface, and vegetation.

The standard deviation (a measure of how much of variation there is in a data set) of each transect point across sampling periods is graphed in the upper plot of each figure, separated into variation between all sample periods, variation for sample periods that occurred in August, and sample periods that occurred in October. The transect interval (in meters) is shown on the x-axis, and the value of the standard deviation is shown on the y axis. The peaks in the standard deviation graphs represent portions of the transect that had larger variations in elevation depth, indicating that the magnitude of elevation changed more at that location than other adjacent points along the transect. Within the transect elevation plots, this is represented by the spread of the lines at a sample point across sampling periods. High values may correspond to the presence of holes, ruts, or trenches.

Trends in the elevation transects and standard are discussed for each plot below:

## Plot 7

The Plot 7 transect is 12 meters long and the elevation transects for plot 7 are shown in Figure 29. The portions of the trail with the greatest variation are along the vegetated edges, where there is little to no traffic, indicating that the trail is particularly stable in the active traffic portions. The transect photo at the top of the same figure shows Plot 7 and depicts the area where the transect is sampled. Note the hardened and dry trail surface which shows little impact from trail use.

The Standard Deviation plots in Figure 29 reflect the stability shown in the transect plot: the magnitude of the standard deviations are low with little difference between the months of August and October. The edges of the transect show the largest standard deviations, consistent with the conclusions of the elevation plot. There is only one peak with a standard deviation value greater than 5, and it is located at the edge of the trail rather than in an area of active traffic.

#### Plot 9

The Plot 9 transect is 15.75 meters long and the elevation transects are shown in Figure 30. Plot 9 is characterized by two main braids that both receive traffic with a vegetated island that separates the braids. In very wet years this island does get used and becomes another braid with ruts. The main braid of the trail is shown on the right side of surface elevation graph by the “U,” shaped trough and can also be seen in the foreground of the transect photo. This trough has been filled with water in some years. The second braid that sees traffic is shown on the left side of the graph and is denoted by a sharper “w,” shape. The middle area of the graph is where the more vegetated island is located but note the smaller “w,” shape where a third braid occurs. The bottom points of each of these W shapes denote ruts in the trail.

The Standard Deviation graphs for this plot show higher values where the troughs and ruts are located. This indicates that the active braids in Plot 9 are more variable than other parts of the transect.

#### Plot 14

The Plot 14 transect is 29.5 meters long and the elevation transects are shown in Figure 31. This plot is characterized by many braids of differing ages and use patterns. The elevation transect shows a very deep trough on the left side of the graph which is the north end of the transect. This trough was created by vehicle traffic prior to the implementation of this monitoring program and has not been an active braid during this study. In several of the sample years it has been filled with water of depths approaching 3 feet. The main braid of the trail in this transect occurs between 10 and 16 meters of the transect interval. This area is shown in the transect photo and is the area along the transect to the right of the large wet swale. In the close foreground of the photo is a braid that was not very active prior to 2014, which was a high precipitation year. The right side of the elevation transect graph depicts this area, between meters 24 and 27.

The Standard Deviation graphs for this plot show higher variation in the large trough area and in the more vegetated part of the transect on the right side of the graph, from meters 19 to 28 of the transect interval.

#### Plot 19

Plot 19 is 19.5 meters long and the elevation transects are shown in Figure 32. Plot 19 consists of two to three braids which receive varying levels of traffic. The elevation transect graph shows two larger dips or ruts at the beginning of the transect, between meters 1 and 4. This area is characterized by deep and eroding gullies that drop off steeply to the west. This section does not always receive traffic due to the nature and slope of these features. Moving to the right along the graph, there is another active braid between transect interval 4.5 and 7 and that braid is also seen in the transect photo, to the right of the tripod in the picture. The middle of this transect has a vegetated island in it followed by another active braid that begins near transect interval 14 and ends near 16. This braid is on the left side of the transect photo, where the staff member is taking measurements.

The Standard Deviation graphs for this plot show higher values towards the beginning of the transect where the gullies occur and along the vegetated island. Elevated values also occur in the area of the second braid though the deviations are not as great as the two other sections.

### Plot 23

Plot 23 is the longest plot in the study, the maximum sampling length of 50 meters. The original length of the transect totaled 75 meters in length to encompass the complete extent of trail braiding encountered at the beginning of the monitoring study, but during later sampling periods, the first 25 meters were excluded as uninformative and time intensive. The elevation transects are shown in Figure 14 along with a transect photo depicting a piece of the transect that includes the current active section. This active zone occurs between transect interval 49 and 55 in most years. Plot 23 is characterized by a very large and wide open meadow system that is predominately covered by sedges and grasses with saturated soils in an area stretching several meters on either side of the active trail. This large meadow has seen different use patterns prior to the implementation of this monitoring and photos from 2008 show a much wider impact zone with several more active braids than have occurred during this study. Figure 54 has a 2007 photo of Plot 23 with old braids and tracks which are clearly visible. This plot was also burned by the Rex wildfire in the summer of 2009.

The Standard Deviation for this plot is fairly low overall but there are elevated values near the active braid and then again between transect intervals 67 and 72 where older active areas are found.

### Plot 30

Plot 30 is 9 meters long and the elevation transects are shown in Figure 15 along with a transect photo of the plot. Plot 30 is an area with a thick grass cover on the trail in August and is surrounded by larger spruce with a mix of a few hardwoods and alder. The active part of the trail occurs between transect interval 2 and 8.5 and the trail surface slopes downward from right to left as seen in the elevation graph. There is very little change in the elevations measured on this plot, each month and year depicted on the graph fit closely with one another.

The Standard Deviation is very low in this plot, demonstrating the relative stability of the trail along the transect. There is one peak near where the trail becomes active and it may indicate a temporary hole that was present in that sample period.

### Plot 33

Plot 33 is 17 meters long and the elevation transects are shown in Figure 35 along with a transect photo depicting the plot area. This plot is a standing water wetland that is characterized by emergent wetland plants, boggy and unconsolidated soils, and there is a creek that crosses the trail here. The surrounding area is dense black spruce forest. There are many braids that cross through this area though they can be difficult to distinguish as the trail typically becomes a single expanse of churned soil by the October sampling period. The elevation transect graphs show high variability between sampling events though the magnitude of those differences seem to stay within a 50cm range. The one exception to this occurred in August of 2012 and is likely to have been a temporary hole or narrow rut in that location.

The Standard Deviation graphs also reflect a very variable surface along this transect. The soils in this plot are saturated or covered in water and the trail surface is very soft and easily disturbed. The trail along this transect is very unstable and that is reflected in the deviation values.

#### Plot 44

Plot 44 is 11.25 meters long and the elevation transects are shown in Figure 36 along with a transect photo from August 2015. Plot 44 is characterized by two main braids that both receive traffic. The trail surface here often has saturated soils and small amounts of standing water and the surrounding vegetation is black spruce forest. The first braid of this transect occurs between transect interval 1.5 and 5 meters and the second braid at about 7.5 to 10.5 meters. The transect graphs are similar over all the sampling periods with one exception in October of 2011 that occurs at 8.5 meters, near one side of the second braid.

The Standard Deviation graphs for this plot show low deviation between sample periods and indicate relative stability in the surface of this plot. There is the one exception near transect interval 8.5 which may be a narrow rut that was present at the sample period.

#### Plot 45

Plot 45 is 6.5 meters long and the elevation transect graphs are shown in Figure 37 along with a transect photo of the plot from October 2014. This plot has one active braid and is characterized by thick grass in August and is surrounded by large spruce and birch trees. Plot 45 shows very low variability in the elevation transect samples. The active part of the trail is between transect interval 1 and 4.5 meters and there is slight and shallow rutting present. The trail does slope downward from right to left but that is due to where the transect starts off the active portion of the trail.

The Standard Deviation graphs for this plot show very low deviation values among samples and are the lowest for all of the plots in the program. This indicates a very stable trail surface at this location.

#### Plot 50

Plot 50 is 6 meters long and the elevation transects are shown in Figure 38 along with a transect photo. Plot 50 consists of one braid that receives traffic and the trail surface is predominately sedges and a few grasses on saturated soil. The surrounding area is a mixed forest of smaller spruce and birch on the south side and a large meadow wetland on the north side. The transect elevation graphs are very consistent and show little variation between sampling events. The active braid of the trail is between transect intervals 2 and 5 meters and the two shallow dips in the graphs denote wide ruts that are not very deep and can also be seen in the photo.

The Standard Deviation graphs show higher deviation values on the edges of transect which are off the active trail surface and into the adjacent vegetation. The graphs indicate that the active surface of the trail was stable during this study period.

### **Vegetation Cover Analysis**

Within a sample plot, the vegetation type was recorded at each sample point along the transect according to the following categories: shrub, grass, moss/lichen, wetland plant, or bare soil. The relative abundance of each category within a sampling period (expressed as a percentage) is graphed in a bar chart for each sample plot, and are shown in Figures 39 – 48. Bar totals do not necessarily sum to 100% because a few observations of the vegetative cover do not fit the above categories and were recorded as “other” (such as burned vegetation or fallen trees). The resulting proportion of each vegetation class can be compared across seasons and years to evaluate trends over the sampling period. In addition,

within each bar chart, background color corresponds to trend lines for a given vegetation category between each sampling period to highlight how vegetation changed between subsequent sampling periods. The results of the sample plots are described individually below.

#### Plot 7

The vegetative cover of Plot 7 is shown in Figure 39 and largely consists of shrubs and bare soil. Bare soil corresponds to the surface of the active trail, and accounts for on average 45% of the transect. This proportion does not change much over the course of the sampling periods, ranging from 40% to 54% of total coverage. Shrubs (woody vegetation that includes spruce and deciduous trees) accounts for on average 40% of the transect coverage, but ranges from 25% to 54% over the sampling period, periodically giving way to grasses, and moss/lichen. Compared with other sample plots, Plot 7 is stable in vegetative cover, indicating that the trail is consistent in width, with little disturbance of the surrounding vegetation.

#### Plot 9

The vegetative cover of Plot 9 is shown in Figure 40. Bare soil accounts for a high proportion of the overall cover, 41% on average, but fluctuates year to year and season to season from 22% to 76%. However, one notable pattern is that percent bare soil increases seasonally from August to October during 2010, 2012, 2013, and 2014. This pattern coincides with periods of high traffic on the trail, and vegetation recovers some by the following sampling period (i.e. proportion bare soil declines the next sampling period). Shrub cover is a small proportion of the overall vegetative cover, but remains stable across all sampling periods (9% on average). The remainder of vegetative cover is made up of grasses which have the ability to recover seasonally from disturbances, and ranges from 17% to 59% of total cover.

#### Plot 14

The vegetative cover of Plot 14 is shown in Figure 41. The proportion of bare soil fluctuates widely across years and seasons within the sampling period, ranging from 3% to 62% of total cover, with an average of 20%. The trend noted in Plot 7 appears in this plot as well: for sampling years 2010, 2011, 2013 and 2014, the proportion of bare soil increases from August to October, coinciding with increased vehicle traffic and trail degradation, followed by some recovery of vegetation the following sampling period. In contrast to the previous plots, wetland plants make up an important proportion of the overall vegetative cover, ranging from 0% to 28% of total coverage, with 11% cover on average. The higher portion of wetland plants is related to a higher saturation of the plot as portions of the trail regularly experience ponding. The other dominant vegetation category is grass, which ranges from 19% to 76% with an average of 55%.

#### Plot 19

The vegetative cover of Plot 19 is shown in Figure 42. The proportion of bare soil fluctuates widely over the sampling periods, with a strong seasonal component. Here, the pattern of increasing prevalence of bare soil from August to October is present in every year sampled. Overall, proportion of bare soil ranges from 8% to 58% with an average of 32%. Close examination of Figure 42 shows that when the proportion bare soil is lower, the proportion of wetland plants is higher, indicating that wetland plants may be recovering in disturbed areas. The proportion of wetland plants ranges from 0% to 43% with an

average of 16%. One additional trend of note is the fact that total vegetation cover does not equal 100% for the first two sampling periods. Portion of the site experienced a fire and sampling did not include burn debris in the analysis.

#### Plot 23

The vegetative cover of Plot 23 is shown in Figure 43. This plot is dominated by wetland plants and grasses. Wetland plants ranged from 27% to 70% with an average of 51%, while grasses ranged from 8% to 50% with an average of 32%. In contrast to previous plots, in most of the sampling periods, bare soil made up a small proportion of the overall cover. Overall, bare soil coverage ranged from 2% to 41% with an average of 12%. However, the highest proportions of bare soil were found in the first two sample periods. As described in previous sections, Plot 23 had a high level of braiding at the start of the monitoring period, corresponding to a high proportion of bare soil. Through the monitoring period, the use of trail braids decreased and the old braids recovered, decreasing the proportion of bare soil in subsequent sampling periods. As a result, the decrease braiding is captured in the vegetative cover graph. As with previous plots, a pattern of increasing proportion of bare soil from August to October corresponding to increased vehicle traffic is evident in all sampling years, with a recovery period (decreasing proportion of bare soil) between years.

#### Plot 30

The vegetative cover of Plot 30 is shown in Figure 44. This sample plot is dominated by grasses which range in cover from 53% to 100% with an average of 73%. Both bare soil and wetland plants fluctuate widely across sampling periods: bare soil ranged from 0% to 39% with an average of 16%, and wetland plants ranged from 0% to 31% with an average of 11%. The pattern of a higher proportion of bare soil in October relative to August, corresponding to traffic volume, continues every year in this plot, with wetland plants being replaced by bare soil in most sampling years (the exception being August and October of 2012). Therefore, the width and vegetative cover of this portion of the trail varies seasonally and across years.

#### Plot 33

The vegetative cover of Plot 33 is shown in Figure 45. This plot is dominated by wetland plants and periods where there is a high proportion of bare soil. All other vegetation classes constitute a very small proportion of vegetative cover. The proportion of bare soil ranges from 21% to 90% with an average of 52%. The proportion of wetland plants ranges from 0% to 63% with an average of 37%. These two vegetative categories fluctuate in opposite directions: when there is a high proportion of bare soil, the proportion of wetland plants is low. This indicates that the heavily disturbed areas are dominated by wetland plants which are easily churned up by vehicle traffic. Again, consistent with patterns in all previous plots, October sampling periods have a higher proportion of bare soil relative to August of the same year for all sampled years, indicating that the heavy traffic period between August and October degrades the trail, but some recovery is evident by the following August.

#### Plot 44

The vegetative cover of Plot 44 is shown in Figure 46. The trail is dominated by grasses in the majority of sampling periods. The proportion of grass coverage ranged from 16% to 84% with an average of 61%. There are a couple of sampling periods where bare soil and wetland plants constitute a higher

proportion of overall cover, most notably during the first couple of sampling periods, but they are otherwise small. The proportion of these two categories is very similar, where bare soil ranges from 0% to 29% with an average 6%, and the proportion of wetland plants ranges from 0% to 33% with an average of 6%. Figure 46 suggests that the proportion of grasses increases in contrast to the proportions of bare soil and wetland plants, suggesting that grasses are replacing these two categories. There is an exception during sampling periods conducted in 2014, where the summer was particularly rainy. In contrast to all previous plots, Plot 44 did not have a strong annual August/October trend for bare soil coverage corresponding to high traffic periods.

#### Plot 45

The vegetative cover of Plot 45 is shown in Figure 47. The proportions of particular vegetation classes are more variable, and mosses and lichens are found in higher proportions in this plot than other plots. The proportion of bare soil ranges from 0% to 27% with an average of 8%, wetland plants range from 0% to 38% with an average of 20%, mosses and lichens range from 8% to 46% with an average of 24%, and grasses ranged from 23% to 85% with an average of 46%. Bare soil was not found in every sampling period, but a pattern of higher proportions of bare soil in October than August of a given year, consistent with higher vehicle traffic, was present in all years except 2013. This pattern is consistent with similar patterns found in previous sample plots.

#### Plot 50

The vegetative cover of Plot 50 is shown in Figure 48. In this plot, in contrast to previous plots, bare soil and grasses are a much smaller overall proportion of the vegetative cover. Bare soil ranged from 0% to 17% with an average of 6%, while grass ranged from 0% to 30% with an average of 3%. The plot was predominantly wetland plants, mosses and lichens, and shrubs. Wetland plants ranged from 0% to 52% with an average of 33%, mosses and lichens ranged from 9% to 57% with an average of 27%, and shrubs ranged from 17% to 43% with an average of 31%. While the proportions of different classes of vegetation cover varied across sample periods, overall the vegetation makeup of the plot appear consistent throughout the time of this study. The pattern of October having higher proportions of bare soil relative to August of the same year, consistent with higher traffic, was observed in the years 2009 through 2012, but not in later years.

### **Photo Point Series**

Over 600 photos have been taken during the sampling period 2009-2014. There are 70 August photos of Plot 33 alone. It is impossible to document all of the photos within this report but all of the photos in digital format are available upon request.

Figures 49 – 52 show time series sets of photos for Plots 7 and 33. These plots were chosen as examples of what the photos of plots look like throughout the study period because they are at opposite ends of the condition classes. Plot 7 was originally a Good condition plot and has maintained that condition throughout the study period. Plot 33 was originally a Very Degraded condition plot and through the Taylor transect data has been classified as Extremely Degraded 100% of the time in October. The photos of Plot 7 are taken from the same perspective every year and show how little the trail surface has changed over the six years of sampling. The photos of Plot 33 are all aerial photos, taken from a hovering helicopter, and show how this plot changes within every year from August to October and also



between sampling years (October to August). It is clear in the photos that Plot 33 is impacted every year by September trail traffic and it is also clear that there is some vegetative recovery that occurs between October of one year and the following August.

## **Discussion**

### **Taylor Transect Method**

This technique involves walking a 20-meter section of trail starting at the center of the elevation transect and walking east. As the observer covers those 20 meters, several trail condition attributes are noted and summarized over the 20 meters. For example, right next to the elevation transect there may be only one braid but ten meters away, there may be three. Those three braids are captured in this sampling method. Because this method samples a longer section of the trail, it is not appropriate to directly compare the results of this technique with the other data from elevation transects and surface vegetation.

The data collected using this method are somewhat problematic in that the transects are often sampled by different individuals. At least nine staff have performed these transects from August 2009 to August 2014. The technique itself allows for the potential of subjectivity amongst observers. It is also a coarser method of sampling trail characteristics as it averages the conditions that are present over 20 meters instead of a more exact empirical measurement.

This technique was first used on a field trip in the winter of 2007 to perform a basic trail condition assessment for the entire length of the Rex Trail. Those original sample points and condition indices were used as a starting point for the current monitoring program as explained in the Methods section. It was decided to continue to sample the trail using this method as a way to test this technique over a longer term and to maintain a continuous dataset.

Figure 53 shows the original condition classes of each plot as they were determined in 2007 and also the two majority condition classes from our sampling period of 2009-2014. It is important to note that the 2007 classes were determined in the winter with snow cover and frozen surfaces while the classes during the monitoring period were determined in a thawed and mostly snow free season. Figure 53 shows that for the condition classes on each end of the spectrum, the Taylor technique consistently classes plots the same. For the remaining three conditions there is much greater variation. It appears that this method may not be very sensitive to finer scale differences.

In 7 of the 10 plots over all the sample months and years, the condition classes get more degraded in the time period between August and October. These changes are of varying magnitude, in Plot 7 the Good condition percentage decreases by 4% but in Plot 33 the Extremely Degraded goes from 57% in August to 100% in October. The three plots that do not show this trend are Plots 14, 23, and 50. It is uncertain what is creating this difference. Both Plots 23 and 14 are classed as Extremely Degraded the majority of the time when all data are combined. In Plot 50, the percentage of time the plot is classed as Extremely Degraded does increase slightly from August to October but the percentage of time as Very Degraded decreases by 26%. Further analysis is needed to better investigate these three plots and it may be that comparisons of the plot photos for each sample would show potential sources of the variation.

Overall, the Taylor transects yield a coarse but informative assessment of trail conditions. It appears to work well as a general method of gauging basic trail conditions but it may not be as useful for long term monitoring or change detection on a finer scale due to its lack of empirical measurements.

### **Surface Elevation Transects**

The surface elevation transects are a three dimensional profile of the surface of the trail in one location. It is a very fine scale measurement technique and allows for empirical detection of change from one sample period to the next. In addition to direct elevation measurements, this sample method can be used as a point intercept transect for collecting information about the surface of the trail such as presence or absence of vegetation or water. Each of the plots in this study were designed and setup to repeat the same transect at each sampling event. This was accomplished using several reference stakes and transect markers to ensure that the same transect was sampled each time. It is reasonable to assume that the variation seen in the elevation transects between sample periods represent changes in the surface of the trail at that point.

Six of the plots during this study period have elevation transects that were stable with lower standard deviation values across the samples. Plots 7, 30, 44, 45, and 50 all have consistently low standard deviation values in the active sections of the trail, which means that the surface of the trail at these locations is not experiencing large changes in elevation. Plot 23 also has low standard deviation values but there are numerous small elevation changes across the surface of the trail. These elevation changes are primarily due to microtopography at the surface related to vegetation. Plot 23 is characterized by mostly sedges and clumping grasses with small bare soil patches scattered throughout the transect. The area of this transect was also previously more disturbed by higher traffic levels, more braids, and the 2009 wildland fire which has resulted in numerous variations of small magnitude on the surface of the ground.

The remaining four plots have higher standard deviations and much greater variability across the sample periods. Plots 9, 14, 19, and 33 demonstrate changes in the surface of the trail over time with the largest deviation values corresponding to elevation changes of 25cm to 50cm (9 to 20 inches). The majority of these deviations occur in the active areas of the trail but several are found in vegetated islands or sections in the transect. The presence of vegetation makes the surface of the trail more variable due to the physical structure and dimensions of the plants. Plot 33 has the highest standard deviation of any of the plots and shows the largest changes in surface elevation. Plots 9, 14, and 19 all have sections of the transects that receive variable use. In wetter years, such as 2014, some sections of the transects pool water to the extent that traffic is impeded, resulting in widening the zone of activity. Plot 9 for example, has two braids that are typically only used when the main trail is under more than a foot of water. Plot 14 has large boggy swales just before the transect location that impede traffic and result in vehicles going around the bogs and widening the traffic footprint. These variable use patterns may contribute to the higher standard deviations in surface elevations. Plot 33 is a little different because the transect crosses a wetland bog with inundated soils that are soft, variable and easily disturbed. From August to October in every sample year, Plot 33 ends up with many braids and a very disturbed surface devoid of any vegetation.

## Surface Vegetation Cover

While collecting elevation data along the cross-sectional transect at each sample plot, vegetation cover data was collected and the proportion of cover was graphed in Figures 39 – 48. These graphs allow for a visual interpretation of how vegetation has changed in each plot over the sample period by year and between seasons.

There is a consistent trend in the amount of bare soil exposed seasonally across the sampling period. Typically, the amount of exposed bare soil increases from August to October within a year, with a corresponding decline from October to August across years. This pattern is consistently evident in plots 19, 23, 30, and 33 (Figures 42 – 45) for all years, and plots 9, 14, 45, and 50 (Figures 40, 41, 47 and 48 respectively) for a subset of years. The seasonal increase in bare soil corresponds to an increase in motorized traffic on the trail, related to moose hunting season. The trail sees an increase in ATV traffic and the permitted use of large tracked vehicles after the August sampling period, and sampling in October is conducted to record any possible degradation of the trail after this high traffic period.

The upswing in exposed bare soil indicates that some cover vegetation is removed by vehicle use, and that the trail may experience widening and/or braiding. The monitoring study did not specifically address the impacts of vehicle use on trail conditions, and the results here cannot be used to imply a causative relationship. We can conclude that trail conditions appear more degraded in October when compared August, if we use the proportion of exposed bare soil as our metric. But, this degradation does not persist into the following year as the proportion of bare soil decreases as wetland plants and grasses recover.

Plots 7 and 44 (Figures 39 and 46) did not show any evidence of this pattern. Plot 7 is a well-established portion of the trail with a relatively hard surface and good drainage. Current vehicle use is unlikely to damage trail topography in such a way as to cause rutting or pot-holing. A lack of a pattern at Plot 44 cannot be explained since site experiences water saturation and ponding and is expected to experience similar pressures to other sample plots.

Overall, this trend suggests that while seasonal degradation of the trail occurs, the year to year condition of the trail is stable as vegetation recovers during the following year. The trail condition neither degrading or improving overall.

If sample plots were experiencing improvement in trail conditions over the sampling period, we would have expected to see a pattern of change in the proportional vegetation coverage. Specifically, we expected to see an incremental increase in shrub cover over the sampling period as woody vegetation recruited and established in previously disturbed areas. This pattern appeared in Plot 14 (Figure 41), where the proportional cover of shrubs has a consistently increasing trend across sampling periods. This pattern should be interpreted carefully since it only occurred at one sample plot and involved a vegetation category that was only a small proportion of the overall cover. It is likely that this pattern may be random, and further monitoring and/or increasing sample size will help tease out the pattern further.

## Summary

The study period for this monitoring program began in 2009 and continues through today. Each of the ten plots have been sampled 13 times, through August of 2015. October 2015 samples were not completed due to early and heavy snow. The monitoring program was initiated to establish a detailed baseline dataset of trail conditions and to document changes in those conditions over time. The program was designed to collect three different types of data; Taylor Transects, Surface Elevation Transects, and Photo Series. Each of these datasets represent a different way to quantify trail conditions and together demonstrate the complexity and variability of the Rex Trail environment.

Given that there is no discernable improvement or decline in the condition of the trail as a whole, the Rex Trail appears to be relatively stable. There is no uniform trend throughout all plots of either year over year deterioration of trail conditions, nor vegetative nor topological recovery. Each of the data types collected demonstrate that the trail varies greatly along its length. There are plots that remain fairly stable throughout time and there are plots that change. What makes a plot stable or not seems to depend greatly on the physical characteristics of each plot and how those characteristics may be impacted by weather and traffic. Those plots that had the highest standard deviations in the surface elevation transects are the plots with wetland soil types and typography features that hold water. These sites also tended to have pre-existing ruts, troughs, and braids. These plots also have the highest percentages of bare soil post disturbance and tend to be classified into the more degraded condition classes.

The trail also shows a seasonal trend of degradation from August to October, associated with the opening of moose hunting season and coinciding with increased traffic from ATVs and permitted large tracked vehicles. The proportion of bare soil tends to increase, indicating that there is removal of vegetation during this period, likely from fresh disturbance of the trail surface, and/or increased braiding as the main trail stem is avoided. This degradation does not appear to persist into the following year as vegetation tends to recover and the proportion of bare soil declines. While this pattern was not found in all sample plots, it was present in the vast majority of plots and sampling periods. In addition, this monitoring study did not specifically address the potential effects of motorized travel on the trail in the study design, but given that periods of increased traffic appear associated with seasonal trail degradation, future studies and/or monitoring could be designed to tease this pattern out further.

Figures 54 – 57 show two aerial photo series, a set of photos from Plot 23 and a set of photos from Plot 14. The photos from Plot 23 begin in 2007, the year before the 2008 trail restrictions were implemented and go through August of 2015. The photos depict some overall changes through this time period and it appears that there is a decrease in the width of the main active trail, a decrease in the number of active braids, a decrease in the amount of water present, and an increase in the vegetative cover. The series of photos for Plot 14 begin in 2009, the same year the monitoring program was implemented. This series of photos also depict overall changes over the same time period and it appears that this plot was relatively stable from 2009 to 2013 but from October of 2014 to August 2015 there is a marked increase in the width of the active trail, the number of active braids, the amount of water present, and a decrease in vegetative cover. Over the same time period, these two plots appear to have changed in opposite ways.

These examples are important to consider when discussing the impacts of trail restrictions on the condition of the Rex Trail. Plot 23 would appear to have improved over this time period where Plot 14 appears to have become more degraded. Looking at the surface elevation transects for both of these plots (Figures 12 and 14), Plot 14 has a higher standard deviation and more variability in certain parts of the transect. Note also the large and deep trough towards the left side of the Plot 14 transect that has been present since the monitoring began. For Plot 23 there is a lot of small elevational variation but low overall standard deviation values. Plot 23 does have one main trough in the middle that corresponds to the location of the active trail. Figure 32 shows the changes in vegetation cover for Plot 14 and the largest bare soil percentages occur in October of 2014, the same as seen in the photos. Figure 34 shows the vegetation cover for Plot 23 and it seems like there is an overall decrease in the amount of bare soil, which corresponds with the photo series data.

The data and photos for these two plots provide evidence that the conditions found along the Rex Trail are driven by many interacting factors that influence how locations on the trail change over time. It is important to state that these monitoring plots sample a very small percentage of the total length of this trail and making conclusions on the condition of the whole trail based on these plots alone would be inappropriate. Further study is necessary to better document what factors influence conditions on this trail and it is hoped that weather data will be incorporated into the dataset in future to assess the impact of precipitation and snow depth on trail conditions.