National Park Service
U.S. Department of the Interior

Denali National Park and Preserve
Long-Range Transportation Plan

Appendix E: Park Transportation Investment Needs Analysis

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Contents

ABSTRACT
A Park Transportation Investment Needs Analysis (PaTINA) was performed in support of the Denali National Park and Preserve, Long Range Transportation Plan. The PaTINA spatially models areas of potential investment need by using a Geographic Information System to overlay geographic data. The data overlays are assigned a weight and added together where they are coincident in space. The resulting model visually depicts areas where multiple complexities occur. This is compared with transportation facility data to inform investment strategies. The PaTINA results are shared in an interactive web mapping environment and may be added to other mapping tools as a map service.

INTRODUCTION
The Park Transportation Investment Needs Analysis (PaTINA) synthesizes geospatial information to inform transportation planning and investment. PaTINA takes into consideration the goals of the National Park Service (NPS) service-wide goals, the goals of individual NPS units, and the requirements of the Federal Highway Administration. The combination of these goals is expressed in the Long Range Transportation Goals.

PaTINA creates geospatial-based analyses related to these goals and produces high-resolution outcomes that are site specific within the park unit. PaTINA models use compiled data sources to create models related to transportation needs and restraints. The vision, goals and objectives established in the park unit's Long Range Transportation Plan (LRTP) determine the input data for PaTINA.

As an analysis, PaTINA is accomplished by overlaying map themes important to park management within a Geographic Information System (GIS) and spatially comparing the overlay results to the transportation network. Metrics used by facility managers to rank assets of the transportation network in terms of needed maintenance are then compared to the PaTINA results. The analyses demonstrate where priority areas may be located and can be compared to financial recommendations of LRTP. The resulting analyses can spatially inform the condition performance assessment, needs identification, funding strategies and even funding prioritization.

Modeled PaTINA results are shared as map services and presented in an interactive web mapping application along with park facility and other relevant data. The PaTINA process can be repeated with model inputs and weights adjusted to reflect current park management needs.

The PaTINA was originally developed as part of the Golden Gate National Recreation Area LRTP to help identify key areas where a confluence of conditions highlighted the need for investment consideration. The recognized utility of the analysis led the Denali National Park and Preserve (Denali or park) LRTP team to request a PaTINA to help identify areas of concern that may not be readily discovered without geospatial tools.

PaTINA Design

Overview

The following are steps used to design, create, and implement PaTINA for the Denali LRTP. At the beginning stages of the LRTP, goals are established for the Park Unit which includes Washington, Federal Highways, and the Park Unit input. Goal areas for Denali were; system optimization, resource protection, user experience, access, climate change, and partners. Each goal area was assigned applicable GIS data layers which establish elements of the goal. The data layers were given priority weights depending on their importance on how it affects or is affected by the transportation network. Priority weights were determined with input from Denali park staff specialty experts.

Once weights were established, spatial analysis was performed to determine the overlap of each input data layer within each goal area. The weights of each input layer were added together where overlap occurred. The overlaying process identified areas where multiple inputs are spatially concurrent as well as where inputs deemed as a higher priority—more heavily weighted--occur.

The overlay results of each goal area were combined to generate the overall PaTINA composite denoted as “Potential Need Areas”. Throughout the LRTP process, additional data themes outside the goal areas were identified as a need and were categorized into three parts; asset metrics, high risk, and investment ranking. These data were later added to the final web mapping product to compare to the Potential Need Areas.

Vehicle Management Plan

In 2012 Denali prepared a Vehicle Management Plan (VMP) to evaluate alternatives for managing vehicle use along the Park Road. The preferred alternative of the plan proposed new management zoning to include additional wildlife viewing subzones. According to the VMP, these subzones would be implemented to clarify management objectives necessary to achieve desired conditions within specific road sections. Due to the significance of the segments for management purposes (Figure 1), it was important to incorporate the sections into the initial design of the Denali PaTINA. To do so, the PaTINA was applied independently to each road segment resulting in five separate sets of analyses. Wildlife viewing subzone 2 is split between 2a) from Teklanika River Bridge and the Eielson Visitor Center and 2b) east of Wonder Lake.

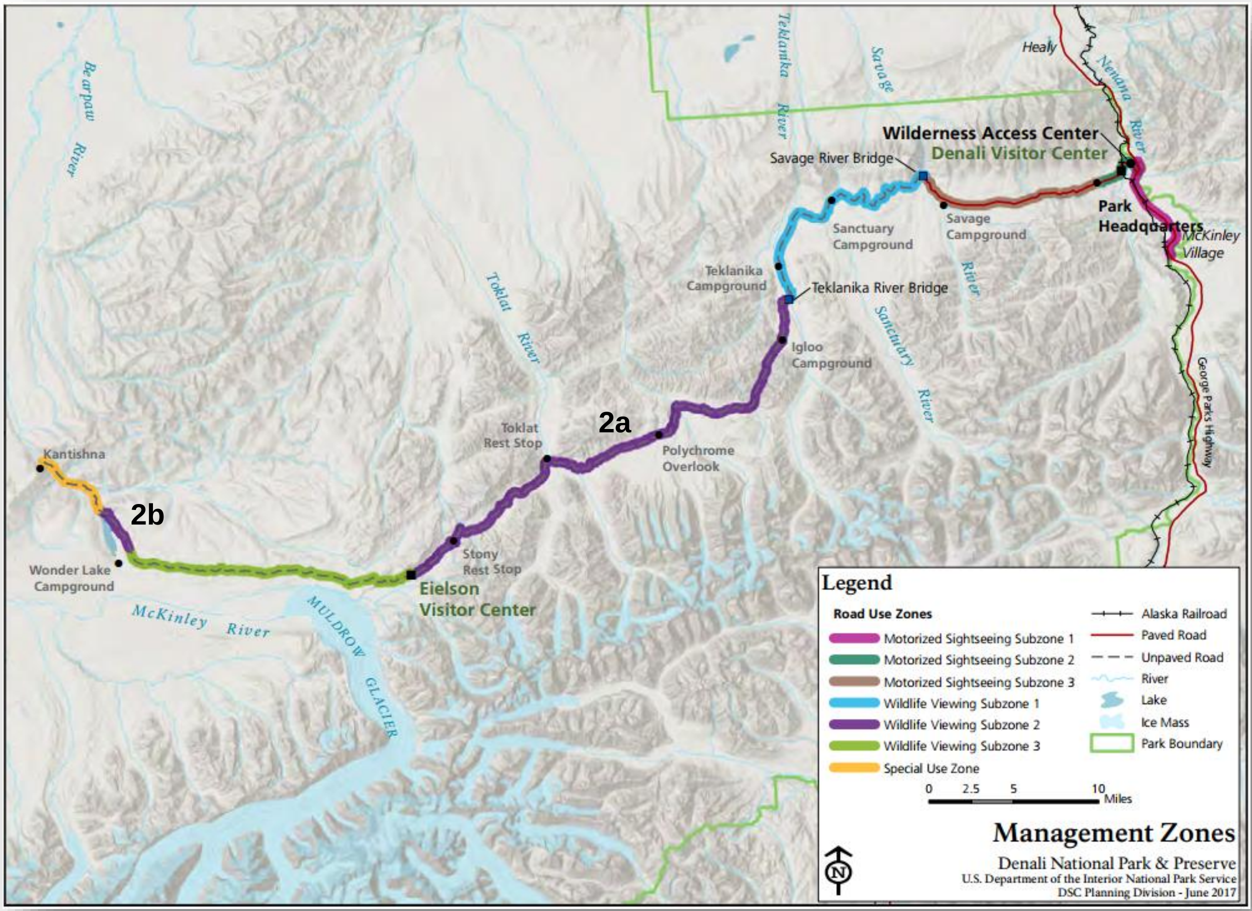

Figure 1. Road segments defined in the Denali Vehicle Management Plan and used as a basis for the PaTINA.

Vector Analysis

Following the methodology of the Golden Gate PaTINA, the Denali PaTINA was completed as a vector analysis. Golden Gate was the pilot for the PaTINA effort which led to expectations that the process be replicable at additional park units. Vector analysis also has the added benefit of preserving spatial geometries and attribution. Attribution allows web map users to deconstruct the results to verify inputs contributing to the composite result.

Data Collection

The following sections describe the categories of data that make up PaTINA and are included in the final product.

Transportation Network

The transportation network for Denali first needed to be defined to create a spatial basis for the overlay analysis. For Denali, the transportation network consists of roads, trails, parking lots, railroad, and airstrips. Each polyline transportation network features were assigned a width (Table 1) and then buffered to that width to create a polygon input. All polygon inputs were merged together to create a final transportation network data layer.

Table 1. Buffers applied to the Denali transportation network.

Transportation Feature	Width
Roads	11’
Trails	8’
Railroad	100’

Asset Metrics

Asset metrics included in the Denali PaTINA show facility condition index (FCI) and optimizer bands. The FCI rates the condition of a facility or asset using a numeric rating system. This system reflects the current replacement value of an asset and its projected cost of repairs. Optimizer bands were developed to divide a park’s asset portfolio into five bands to represent the level of maintenance that each asset should receive. The metrics help staff make informed decisions about the allocation of limited funding and staff time for maintaining park infrastructure.

The FCI and optimizer band data were derived from the facility management software system (FMSS). Assets in the transportation network data layer were joined together with the FMSS spreadsheet to be able to show the asset metric information spatially. The join was based on the Location ID attribute in both the spreadsheet and spatial data. A number of records in the spatial data were missing Location ID’s so manual matching had to take place. This was done by using aerial imagery to identify assets based off of the FMSS location descriptions. Assets that still couldn’t be identified through this method received input from park staff via the web mapping tool by using create new features capability.

Create New Features Tool in Web Map Site
The Create New Features tool allows users to generate data within the web map interface. The user creates the geometry of the data and can also include information in predefined text boxes that gets added to the feature class attribute table. Once the new feature has been created and saved, it is automatically stored as a new record in a feature class that sits on a local server. This benefits the GIS staff by having quick access to newly created data. Because the data is automatically stored, users can revisit the web map and see previous created features. Geometry and text changes can be made to the feature after it has been created.

High Risk

In winter of 2016 NPS regional and park staff as well as Federal Highway Administration (FHWA) conducted a risk assessment workshop for Denali. The purpose was to identify risk types and areas to mitigate risk and provide recommendations to park management. Those findings will be included in the Denali LRTP. There were a total of 28 identified risk types that were ranked into prioritization categories from low to high. Because of the importance of understanding where risk occurs and to mitigate future events, it was decided to include this information as spatial data into the PaTINA web map. Only the high risk category was added to the analysis due to the significance of these risks on Denali's resources, visitors, and staff.

In total, there were eight high risk types identified, only six of which could be mapped. Out of the six remaining risk types, three had data available. The Create New Feature tool was used by park staff to generate a data layer identifying locations of gravel production sites, but was later omitted by the LRTP team. It was concluded that the site itself is not a risk to the transportation network but rather the absence of gravel in these pits are. The in holder access data was gathered from the NPS Lands Resources Division to show tracts within Denali. Culvert locations were derived from an excel spreadsheet provided by FHWA – Western Federal Lands by plotting X,Y coordinates. Lastly, the unstable slopes data was provided by park staff and was originally generated through FHWA in collaboration with NPS. Table 2 summarizes the risk data included in the PaTINA web map.

Table 2. Summary of risk data used in the Denali LRTP.

Risk Type	**Can it be mapped?**	**Is data available?**	**What is the source of the data?**
Inholder Access	yes	yes	NPS Lands Resources Division
Implementation of LRTP	no	n/a	
Staff Level Changes	no	n/a	
Gravel Production, Processing, or Purchase	yes	no	
Culverts (M&O)	yes	yes	FHWA– Western Federal Lands
Permafrost degradation	yes	no	
River and Stream Flooding	yes	no	
Unstable Slopes	yes	yes	NPS, FHWA– Western Federal Lands

Investment Ranking

A financial analysis was completed for the Denali LRTP resulting in development of investment strategies. An investment strategy combines goals and objectives of the LRTP, agreed upon investments and other transportation needs, and constraints in the current funding environment. One investment strategy category is to Repair and Maintain the Unpaved Portion of the Denali Park Road and focuses on desired condition targets, which change depending on the Park Road segment. This strategy aligns with the VMP's concept that the Park Road is less traveled by visitors farther into the park and those segments with lower desired conditions can help reserve funding for other transportation asset priorities.

Due to the importance of financial analysis results, it was decided to include the information as a spatial component to PaTINA. A table showing current and desired conditions for each segment with associated milepost numbers was provided by one of the contractors working on the LRTP. A GIS layer of mile markers was used to correlate data from the table and create a new layer representing the financial analysis. Attribute information was added and the layer was symbolized by segment showing highest priority and lowest priority. Table 3 shows current and desired condition information that was incorporated into the new investment ranking GIS layer. These results can easily be compared to other components such as high risk areas or goal area composites.

Table 3. Financial analysis data based on mile markers.

Mile Post	Segment	Current Condition	Desired Condition	Annual Needs	Priority Ranking
0 to 15	Entrance area to Savage River Trailhead	n/a	0.0	n/a	5
15 to 32	Savage River Trailhead to Teklanika Bridge	0.09	.109	$0.13 M	4
32 to 39	Igloo Forest to Sable Pass	0.13	.109	$0.14 M	4
39 to 43	Sable Pass to East Fork Bridge	0.13	.109	$0.24 M	4
43 to 47	Polychrome to Plains of Murie	0.35	.245	$0.74 M	2
47 to 62	Plains of Murie to Stony Overlook	0.13	.149	$0.47 M	3
62 to 66	Stony Overlook to Eielson	0.14	.149	$0.18 M	3
66 to 70	Eielson to Grassy Pass	0.17	.325	$ -	2
70 to 88	Grassy Pass to Boundary Pit	0.12	.325	$ -	2
88 to 92	Boundary Pit to Kantishna	0.499	.449	$0.12 M	1

Goal Areas

During the early development of the Denali LRTP, team members created six goal areas each with an associated statement. The goal statements represent aspects of the NPS mission and Denali vision statements to help guide future transportation decisions. These goal areas serve as a basis throughout the LRTP for identifying baseline conditions, performance management, and implementation. Table 4 shows the six goal areas and goal statements.

Table 4. Denali LRTP goal statements.

Goal Area	Goal Statement
Resource Protection	Understand and protect Denali NPP's fundamental Park resources and values as they relate to the transportation system
Climate Change	Plan for climate change impacts to the Park's transportation system
User Experience	Provide a quality, multi-modal Park experience for users
Access	Provide safe, efficient, and appropriate Park access
System Optimization	Develop a long-term transportation system to appropriately satisfy current and future Park needs
Partnership	Manage formal and informal commercial partnerships to provide a viable transportation system

These goal areas served as a guide for GIS data collection. Datasets related to each goal area were identified, collected, and formatted as needed for the composite analysis. The Partnership goal area is not included in the PaTINA since no map-able data were identified. Future iterations of the Denali PaTINA may include the Partnership goal area if new data are obtained. The System Optimization goal was also not included in the analysis, but rather it was called out separately for comparison in the final model results. This category is referred to as Asset Metrics (described above) and include FMSS-specific data. The purpose of this was to be able to spatially detect and understand the correlation between FMSS data and the Park's values stated from the LRTP goal areas. In total, 26 GIS layers were used as input layers for the analysis. Layers from each goal area were overlaid upon each other so that the goals could be visualized for the LRTP. Listed below are the input layers for each of the goal areas used for the analysis.

Resource Protection

- Sheep Gaps
- Exotic Species
- Stream/Road Intersections
- Vegetation Monitoring Marker
- Sheep^
- Moose^
- Bear^
- Wolves^
- Caribou (Aug-Sep)^
- Caribou (July-Aug)^
- Caribou (May-June)^
- Wetlands
- National Register Structures
- Historic Districts

User Experience

- Viewscapes
- Visitor Services
- Social Trails*
- Visitor Pattern*
- High Visitor Use Area*

Access

- Safety Areas of Concern*
- Railroad Depot
- Bus Stops

Climate Change

- Geohazards
- Permafrost

^Based on extrapolated observation data reported in the Denali VMP
**New data created by park staff for the PaTINA*

During the process of collecting data, data needs were recognized and collated. Identified data gaps included; permafrost degradation, river and stream flooding events, informal aviation landing areas, congestion hotspots, and wildlife patterns. To fill certain gaps, the Create New Features tool in the web map was utilized by park staff. Layers in the list above with an asterisk represent the ones created by park staff. Other identified data gaps focused on visitor use statistics. Examples included dependable traffic counts, visitation numbers by area, and visitor numbers on bus types beyond front country area.

Methodology

Data Prep

All input data layers were projected to NAD_1983_Alaska_Albers. Point and polyline datasets were buffered and converted to polygon features and then clipped to the transportation network. Figure 2 shows an example of a point layer created by park staff using the Create New Feature tool that was later buffered and clipped. Once the polygon data was created per input layer, they were merged together to create a single polygon layer. For example, park staff created multiple polylines and points to capture visitor patterns along the Park Road. The polygons were merged together to create a single visitor pattern input layer under the User Experience goal area.

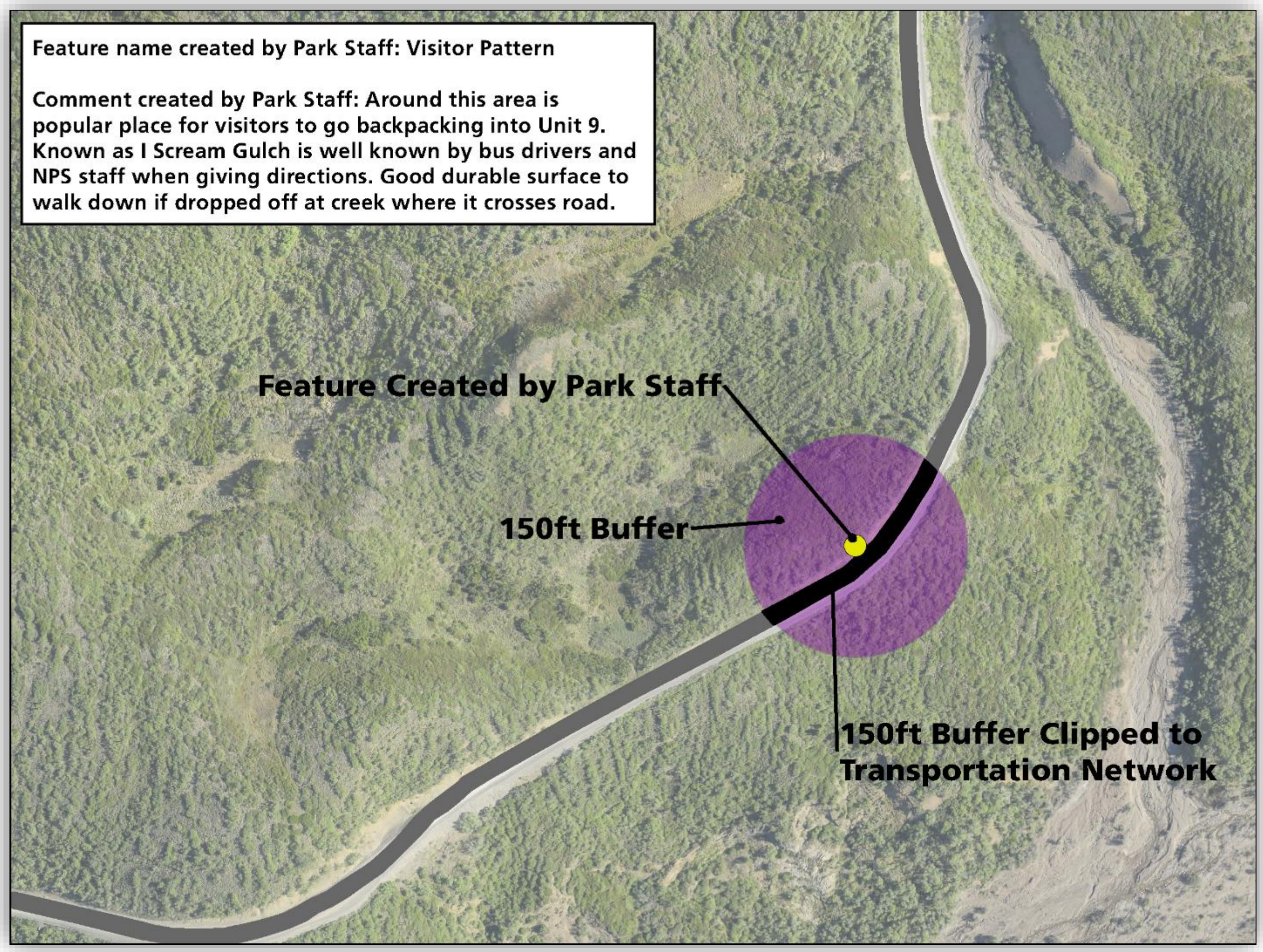

Figure 2. Example of Denali staff input used to create data for the PaTINA.

Layer Weighting

Within the goal areas each input polygon layer was assigned a value. The values ranged from 0 (no impact) to 0.5 (lesser impact) to 1 (full impact) and was assigned by park staff. Table 5 shows each goal area and associated weighted values for each road segment. The term “impact” in this setting may refer to impact the input layer has on the transportation network or, conversely, impact the transportation network has on the input layer. To align with the VMP’s subzones of the Park Road, each input layer was weighted separately for individual road segments. Weighted per segment reflects park management priorities which may vary for a particular input by road segment. The High Visitor Use Area input layer is an example of this where the impact is higher in the front country compared to further west on the Park Road. Therefore, the High Visitor Use Area input layer received a higher impact value in the front country road segment.

Table 5. Layer input ranks assigned by park staff.

RESOURCE PROTECTION GOAL AREA	**Motorized Sightseeing Subzone**	**Wildlife Viewing Subzone 1**	**Wildlife Viewing Subzone 2a**	**Wildlife Viewing Subzone 3**	**Wildlife Viewing Subzone 2b**
Sheep Gaps	0	0.5	1	0.5	0
Exotic Species	1	0.5	0.5	0.5	0.5
Stream/Road Intersections	1	1	1	0.5	1
Vegetation Monitoring Marker	0	1	1	0.5	0
Sheep	0.5	0.5	1	0	0
Moose	1	0.5	0.5	1	0.5
Bear	0.5	0.5	1	0.5	0.5
Wolves	1	0.5	0.5	0.5	0.5
Caribou (Aug-Sep)	0	0	0.5	1	0
Caribou (July –Aug)	0	0.5	0.5	1	0
Caribou (May – June)	0	0	0	0.5	0
Wetlands	1	0.5	1	1	0.5
National Register Structures	1	1	1	1	1
Historic Districts	1	1	1	1	1

USER EXPERIENCE GOAL AREA	**Motorized Sightseeing Subzone**	**Wildlife Viewing Subzone 1**	**Wildlife Viewing Subzone 2a**	**Wildlife Viewing Subzone 3**	**Wildlife Viewing Subzone 2b**
Viewscapes	0	0.5	1	0.5	0
Visitor Services	1	1	1	1	1
Social Trails	1	1	1	1	1
Visitor Pattern	1	1	0	0	0.5
High Visitor Use Area	1	0.5	0.5	0.5	0.5

ACCESS GOAL AREA	**Motorized Sightseeing Subzone**	**Wildlife Viewing Subzone 1**	**Wildlife Viewing Subzone 2a**	**Wildlife Viewing Subzone 3**	**Wildlife Viewing Subzone 2b**
Safety Areas of Concern	0.5	0	0.5	0.5	0
Railroad Depot	1	0	0	0	0
Bus Stops	1	0	0	0	0

CLIMATE CHANGE GOAL AREA	**Motorized Sightseeing Subzone**	**Wildlife Viewing Subzone 1**	**Wildlife Viewing Subzone 2a**	**Wildlife Viewing Subzone 3**	**Wildlife Viewing Subzone 2b**
Geohazards	0.5	0.5	1	1	0.5
Permafrost	0.5	0.5	1	0	0.5

Composite Analysis Steps

1. Once the input layers were weighted, the values were added into new fields in the attribute table. The new field names were abbreviated with each goal area name and input layer number. For example, Resource Protection/sheep gaps would read as RP1, since sheep gaps was listed

first in the data collection table. Another example would be Resource Protection/exotic species shown as RP2. The following shows goal area abbreviations:

   a. Resource Protection – RP
   b. User Experience – UE
   c. Access – AC
   d. Climate Change – CC

2. Within each goal area the input layers were combined with the transportation network layer using the UNION tool creating a goal area output layer. This resulted in the following layers: RP_Union, UE_Union, AC_Union, and CC_Union
3. Using the DELETE tool, all fields were deleted except for the five road segment fields. This reduced the file size of the output layer for future geoprocessing steps and faster speeds once added to the web map.

Steps 4-6 refer to only one goal area and one road segment. For example, Resource Protection (RP)/Motorized Paved Zone (MPZ).

4. A new field called RP_T_MPZ was added to the RP goal area output layer to sum the total values. This was completed by using the FIELD CALCULATOR tool and summing the MPZ value for each input layer (RP1_MPZ + RP2_MPZ).
5. Due to the goal areas having a different number of inputs, the total sum value was normalized to avoid skewing the outputs to goal areas with more input layers. By normalizing, the total values could be shown on a common scale. A new field was added and called RP_TN_MPZ. Using the FIELD CALCUALTOR tool, the RP_T_MPZ value was divided by the total number of inputs resulting in a normalized number (RP_T_MPZ/14= RP_TN_MPZ).
6. The RP goal area output layer was then clipped to a previously created MPZ road segment layer (RP_MPZ_Clip).

Steps 1-6 were repeated for each goal area and road segment. In total, twenty clipped output layers were created. Figure 3 shows steps 1-6 in a flowchart.

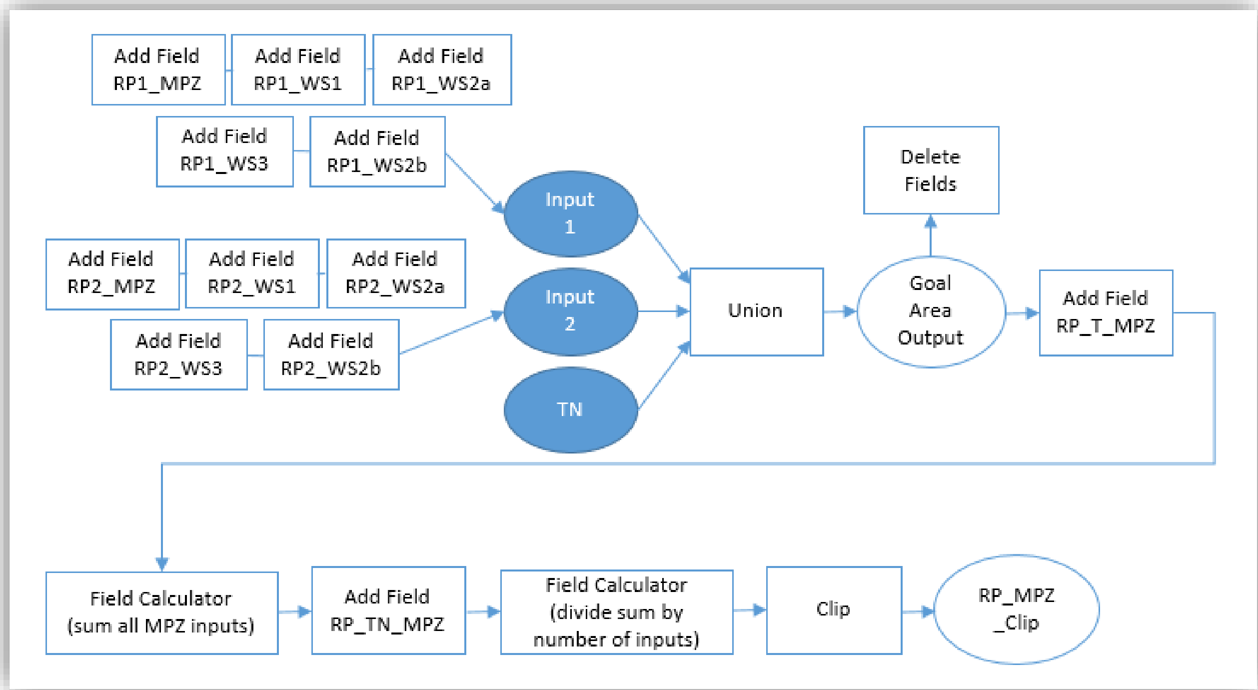

Figure 3. Process diagram for PaTINA steps 1 - 6.

Steps 7-9 refer to only the MPZ road segment.

7. The next step utilized the UNION tool to union each clipped goal area output layer by road segment (RP_MPZ_Clip, UE_MPZ_Clip, AC_MPZ_Clip, CC_MPZ_Clip = MPZ_Clip).
8. Once the MPZ_Clip layer was created, a new field called All_MPZ was added to sum the total normalized numbers. The FIELD CALCULATOR tool was used and summed each goal areas normalized number (RP_TN_MPZ + UE_TN_MPZ + AC_TN_MPZ + CC_TN_MPZ = ALL_MPZ)
9. The overall MPZ composite was then symbolized based on the total MPZ normalized values (ALL_MPZ) and was shown with five classes using Natural Jenks classification. The five classes were symbolized from very low (dark green), low (light green), medium (yellow), high (orange), to very high (red) which identified potential need areas throughout the transportation network. Figure 4 shows symbolization for the front country area in road segment MPZ.

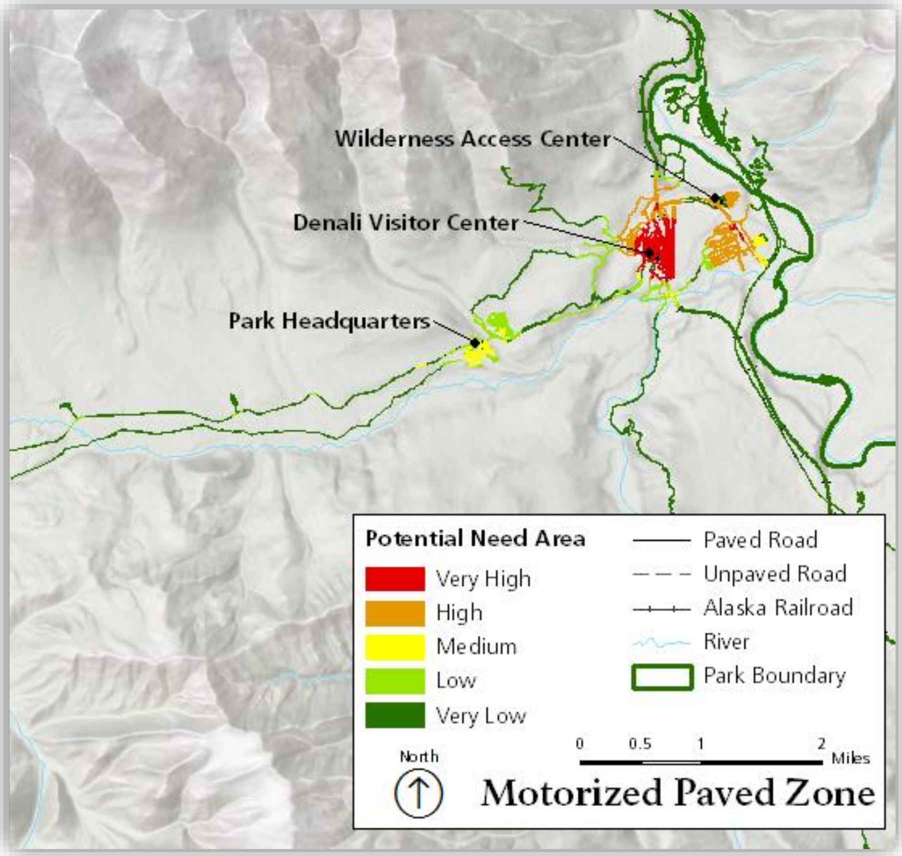

Figure 4. Mapped Potential Need Areas for the Motorized Paved Zone.

Steps 7-9, shown in Figure 5, were repeated for each road segment. In total, five segments showed very low to very high potential need areas.

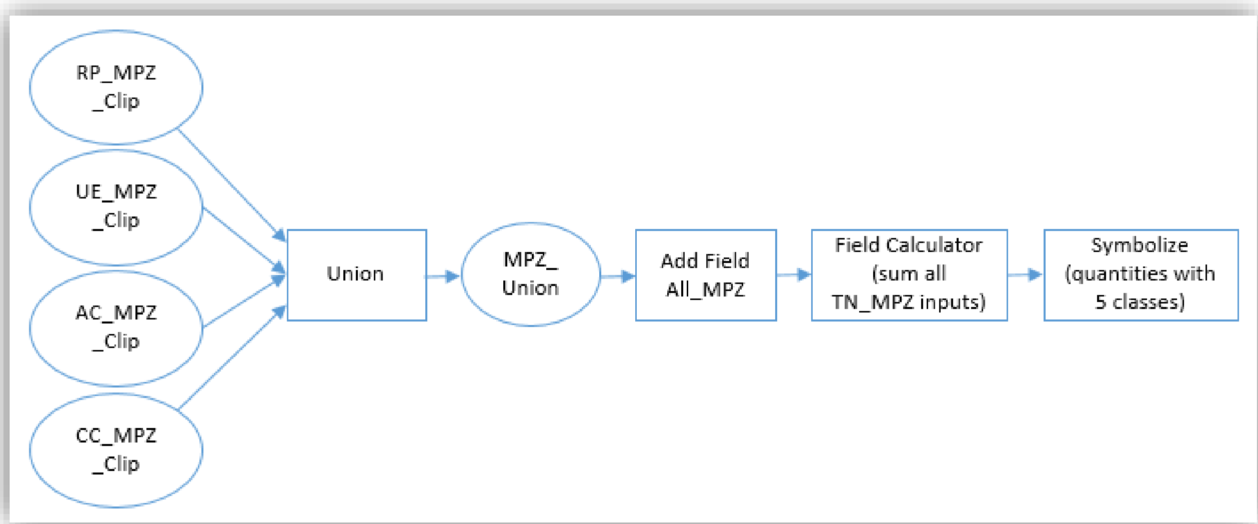

Figure 5. Process diagram for PaTINA steps 7-9.

Selected Results

Outputs

The PaTINA analysis resulted in four main output groups which may be viewed individually or compared to one another. These groups are: asset metrics, high risk areas, investment rankings, and potential need areas. See the Data Collection section for review of these groups.

Figure 6 shows potential need areas against high risk areas located in Wildlife Viewing Subzone 3 segment of the Park Road. The results appear to have several high risk areas spatially coincident with high need areas highlighting locations that may be considered for financial investment. Doing so may help protect park resources and visitor safety.

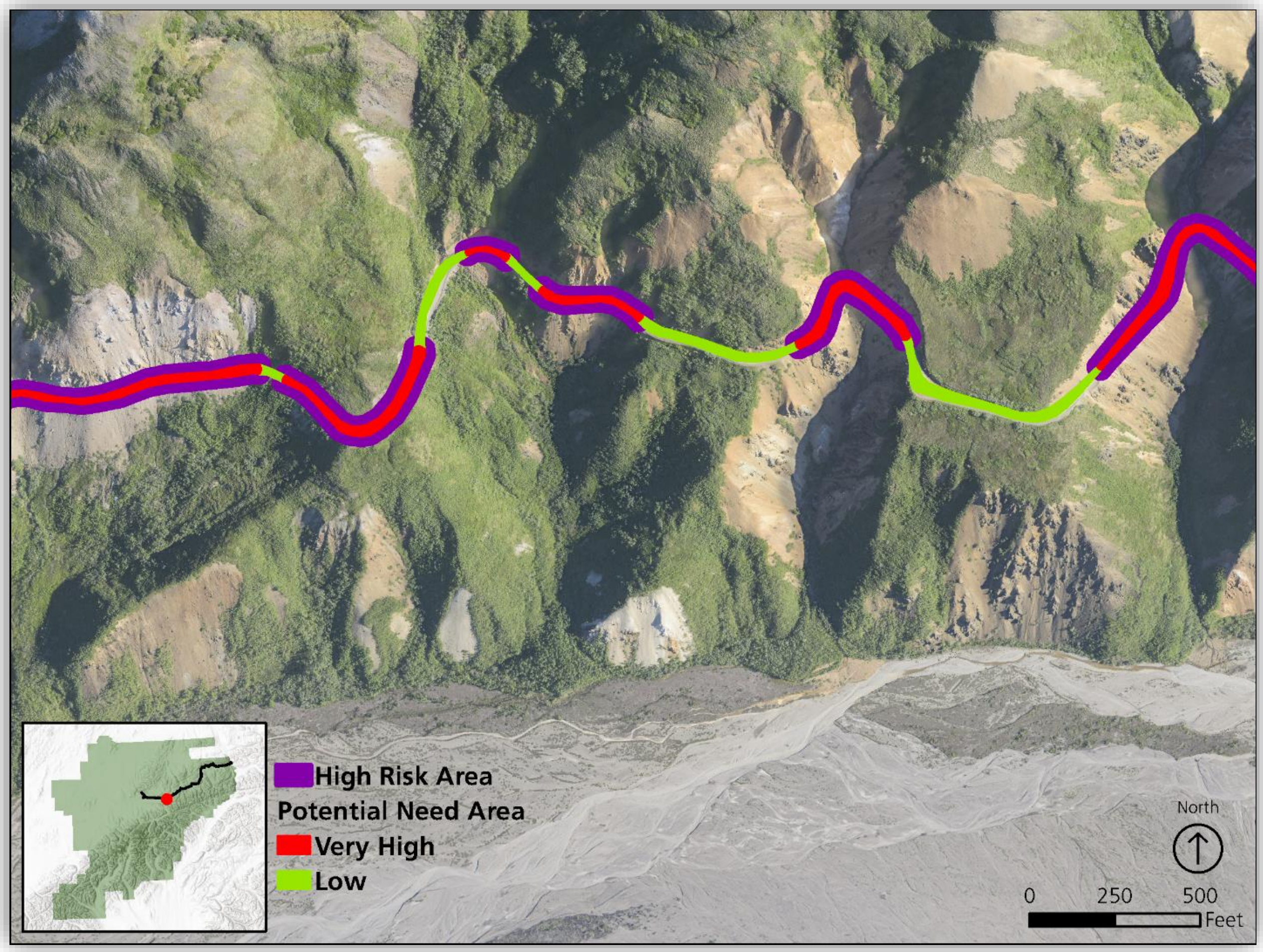

Figure 6. High Risk Areas shown with Potential Need Areas modeled in the PaTINA.

Figure 7 shows potential need areas against high investment ranking along the Wildlife Viewing Subzone 2 segment of the Park Road. The investment ranking displays two sections which are, Igloo Forest to Sable Pass (MP 32 to 39), and Sable Pass to East Fork Bridge (MP 39 to 43). Within the high investment sections, potential needs can be identified for further examination for future investment.

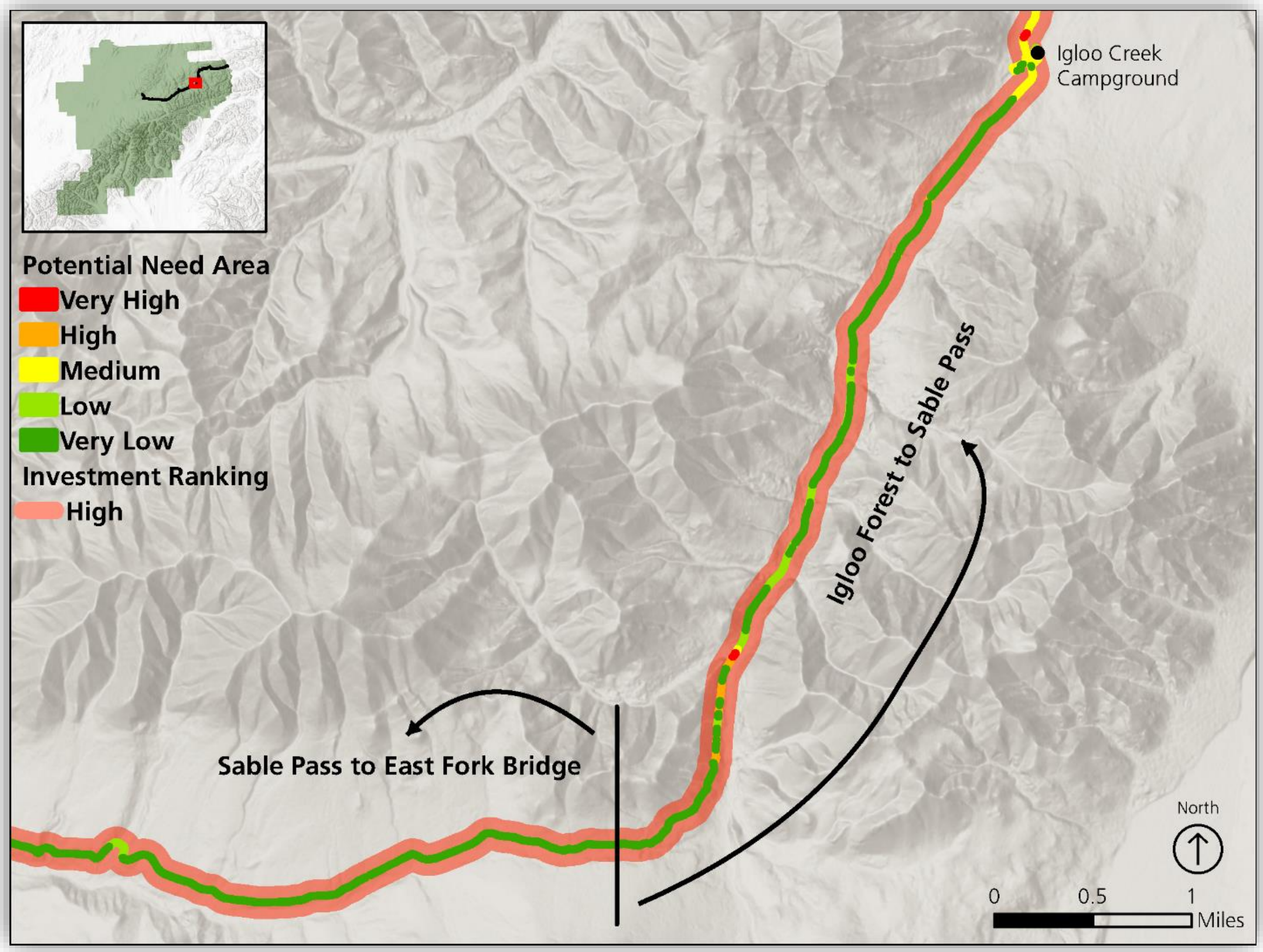

Figure 7. Example PaTINA-modeled Potential Needs Areas shown with investment ranking data.

Road Segment Findings

Motorized Paved Zone

The motorized paved zone starts at the park entrance at mile post 0 and ends at mile post 14.9 (Figure 8). In this segment, it appears that the greatest amount of very high potential need areas are concentrated around the Denali Visitor Center and high potential need areas are located just east of that, surrounding the Riley Creek Campground. These potential need areas consist of up to twelve input layers, each of which fall within all goal areas. Findings also show the Park Headquarters and Savage River to be potential need areas with values of medium and high.

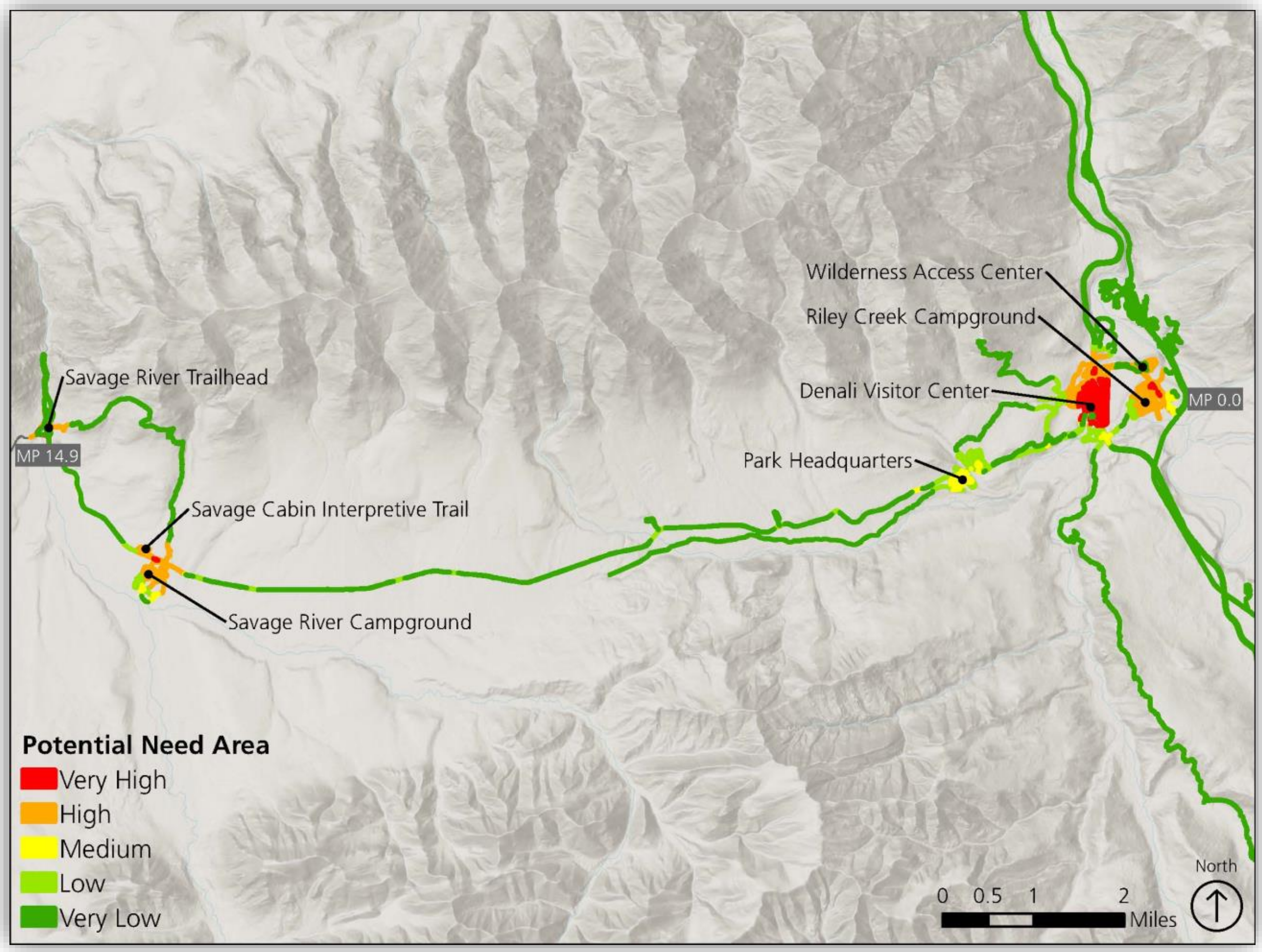

Figure 8. PaTINA-modeled potential need areas for the Motorized Paved Zone segment of the Park Road.

Wildlife Viewing Subzone 1

The wildlife viewing subzone 1 spans the distance between mile post 14.9 to mile post 31.9 (Figure 9.) and includes the Sanctuary River campground and the Teklanika River campground and rest stop. The Teklanika River campground shows the largest very high potential need area. Up to twelve input layers from three of the goal areas cover this segment. The access goal is not included. Findings also show the Sanctuary River campground and west of the Primrose Ridge and Mount Margaret rest stop to be a very high potential need area though the spatial area is smaller compared to the Teklanika River campground. This location is comprised of up to thirteen input layers from all goal areas.

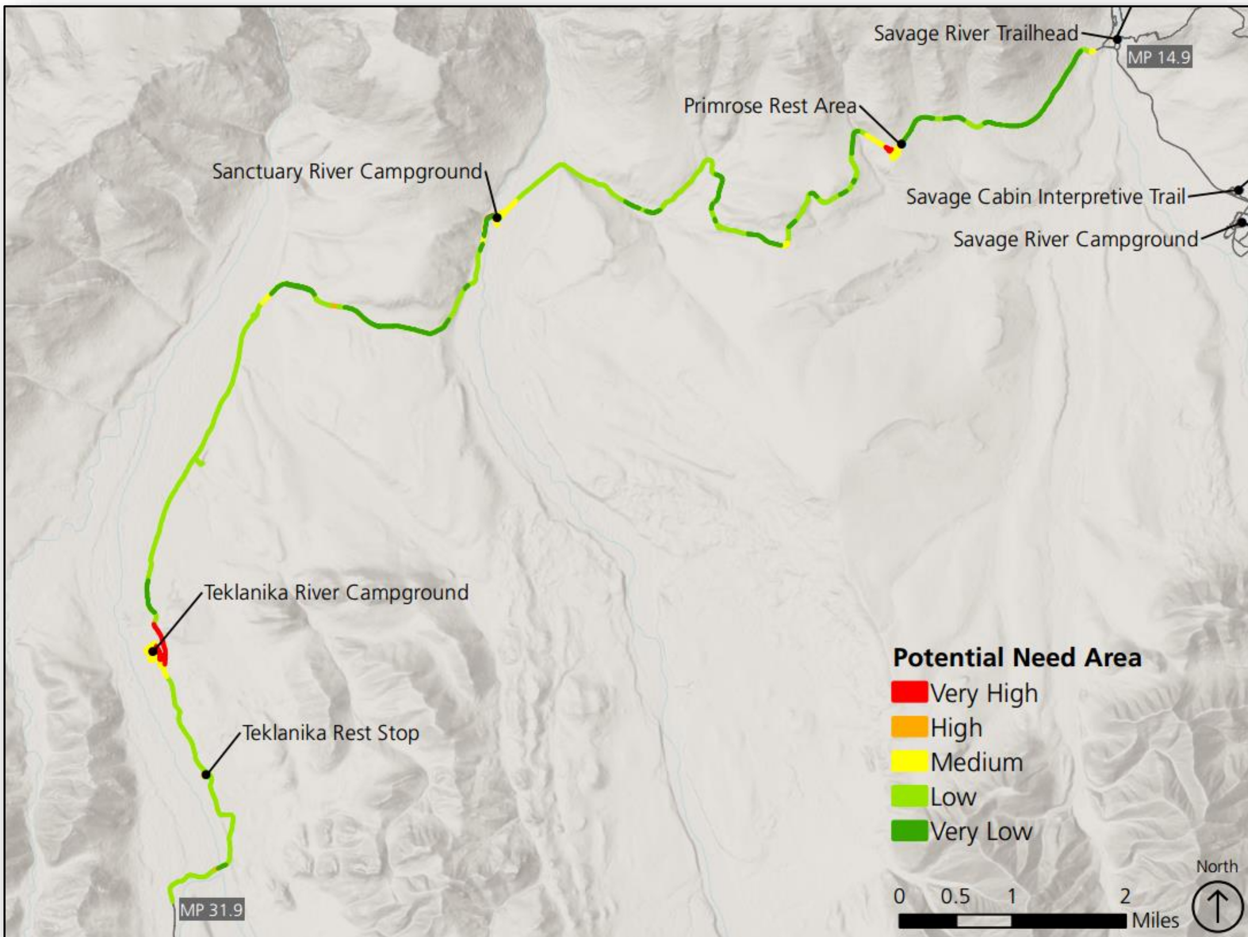

Figure 9. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 1 segment of the Park Road.

Wildlife Viewing Subzone 2a

The wildlife viewing subzone 2a ranges from mile post 31.9 to mile post 66 (Figure 10.) and includes locations from Igloo Creek campground to Eielson Visitor Center. The findings suggest that there are many high potential need areas along this segment of road. The most prominent areas are located before and after Polychrome Overlook and includes up to ten input layers along this stretch. The Eielson Visitor Center shows very high potential need areas, with up to twelve input layers from three goal areas. These findings may suggest future investment at this location due to high use at the visitor center.

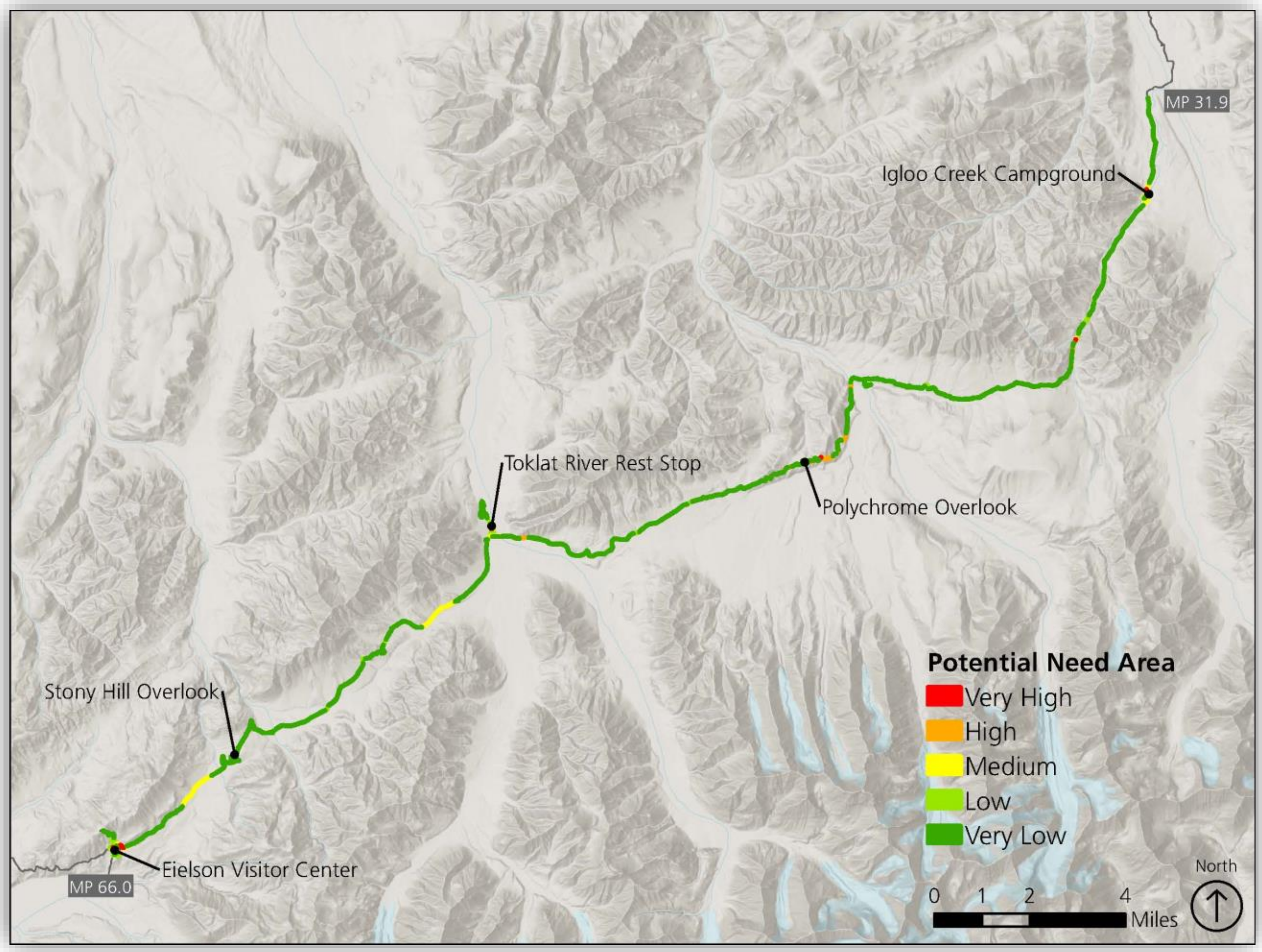

Figure 10. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 2 segment of the Park Road.

Wildlife Viewing Subzone 3

Milepost 66 to mile post 84.6 is the wildlife viewing subzone 3 segment (Figure 11.) which begins east of the Eielson Visitor Center and goes to the Wonder Lake campground. Results show west of the Eielson visitor center with the greatest concentration of very high potential need areas. A majority of this segment ranges from very low to medium potential need areas until farther west near Wonder Lake. Wonder Lake campground consists of up to ten input layers from three goal areas.

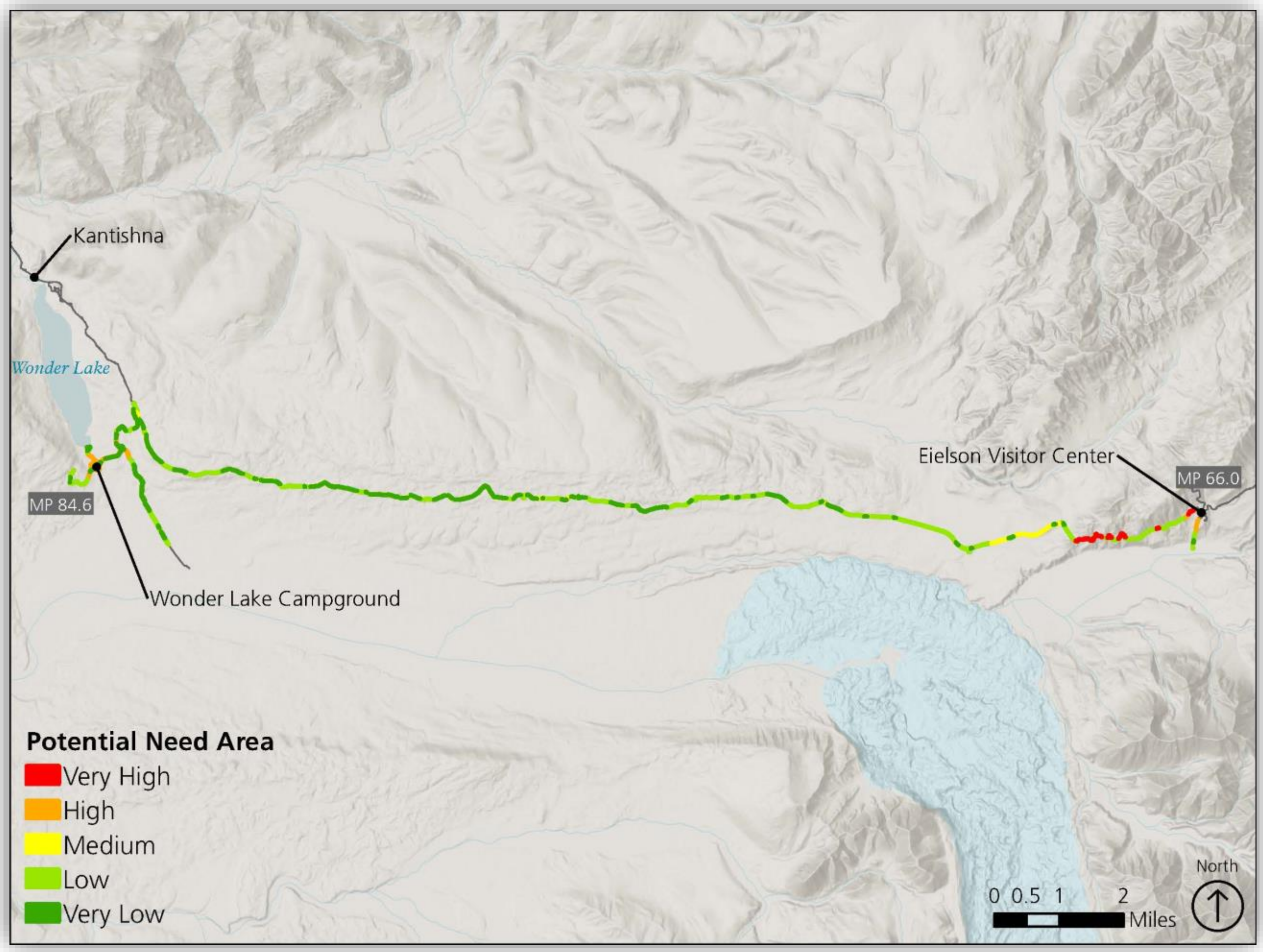

Figure 11. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 3 segment of the Park Road.

Wildlife Viewing Subzone 2b

The wildlife viewing subzone 2b starts at milepost 84.6 to mile post 92.0 being the farthest west of all road segments (Figure 12.). The only very high potential need area in this segment is located east of Kantishna. Results display that the very high area has up to 12 input layers from three goal areas. The east side of this area shows high potential need suggesting that this stretch could be identified as an area for potential future investment.

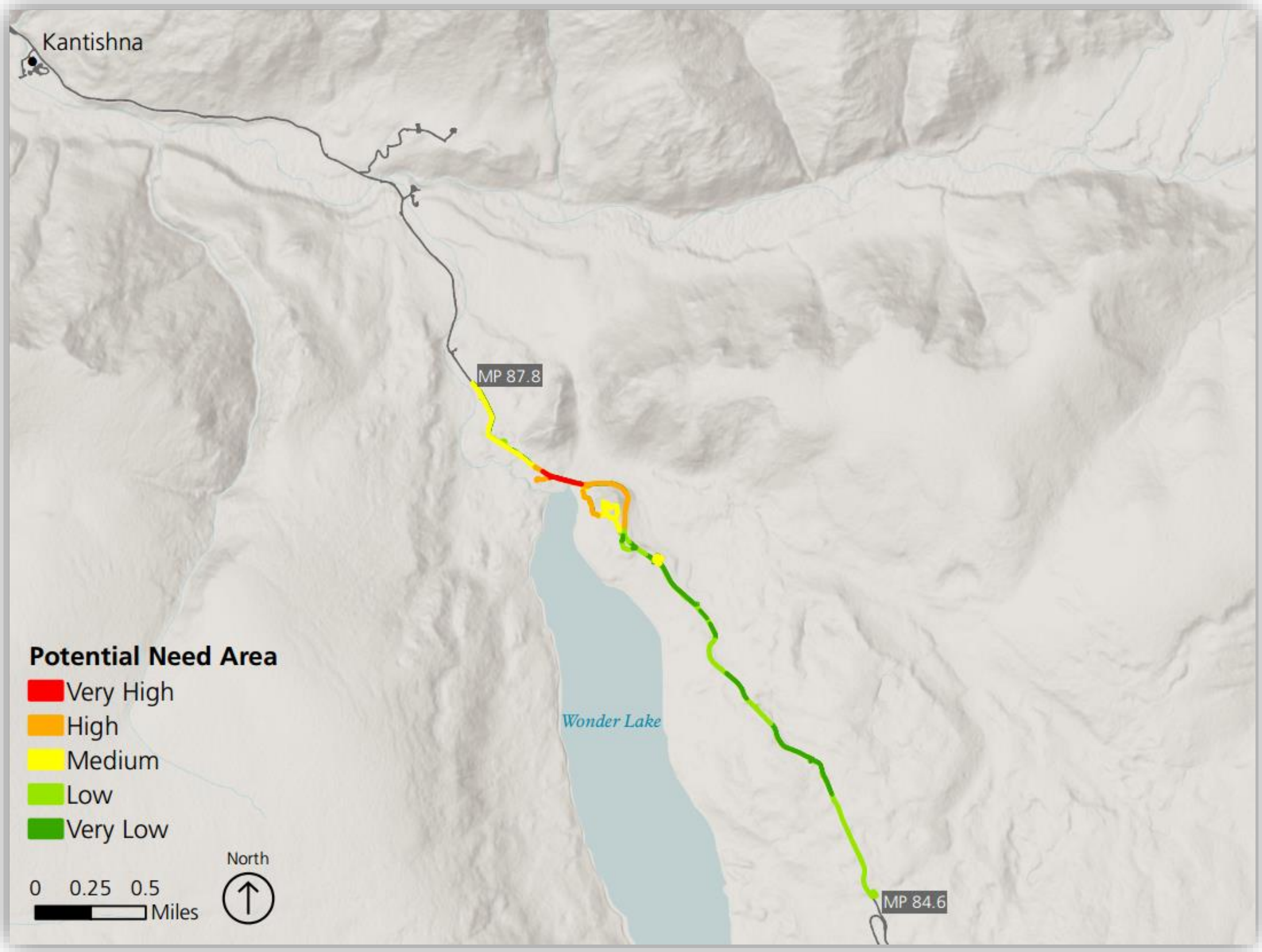

Figure 12. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 2b segment of the Park Road.

Discussion

The Park Transportation Investment Needs Analysis (PaTINA) employs standard geospatial methods that can be repeated to reflect changing management goals as well as be applied in different facility management situations and scales. The web mapping application deployed with the data allows for frequent review and consultation of the results to inform management decisions.

Execution of the methods, however, requires intensive data gathering and formatting. Further, the weighting process is currently accomplished in a desktop GIS after subject matter experts are polled for input weights. This process could be improved with tool development in either the desktop environment or the online web map, to streamline how GIS data are included and weighted in the model. While the process in its current state is repeatable, in most cases it requires a GIS specialist and a desktop GIS to complete. We foresee improving either the desktop or online tool (or both) to make the process more accessible and rapid. Depending on the data inputs, however, the overlaying process may still require extensive data collection and preparation. Additionally, the overlaying process can be computer intensive--again, depending on the data inputs--and may be prohibitive due to available resources.
The data collection process in this analysis identified data needs which are collated separately and listed above under Goal Areas. Acquisition and incorporation of these data may improve the PaTINA results. Visitor use statistics are an especially glaring omission which, if obtained, will improve future PaTINA modeling.

Seasonal variations in some inputs are not well represented in the analysis. Further work may entail modeling specific seasons to help inform investment strategy throughout the year.

Internal Weighting

The PaTINA applied to Denali NP&P weighted each input layer uniformly across the spatial extent of the layer. However, some data contained attributions that could be weighted differently. Because the weights were assigned by park staff for each input layer based on the road segments, further weighting based on attributes internal to a layer would unnecessarily complicate the composite scoring. Future iterations of the model for Denali may consider applying layer attributes to vary weights across the layer instead of applying weights per road segment. Alternatively, the weights assigned by road segment could be normalized against the attribute weighting but the statistical validity of this needs to be explored.

Skewed Data

The initial run of the PaTINA model showed skewed results within the front country segment. NPS staff clarified that specific locations within the front country segment should have been identified as very high or high potential need areas instead of low and medium rankings. The main concern was around the Denali Visitor Center and vicinity that included the railroad depot, trailheads, and visitor amenities. As a known high visitor use area, the visitor center and surroundings should be considered a high potential for investment. The data and associated weights were examined and it was concluded that the user experience goal area was lacking desirable input layers to validate higher rankings. Once the additional input layers were identified they were added to the next run model and results showed important locations, such as the Denali Visitor Center, with higher rankings.

Spatial Spread of Data

Input layers across the goal areas differ spatially within the road segments. The resource protection goal area is the only goal area in which input layers coincide with the transportation network within all five road segments. User experience and climate change goal areas are within four segments, with no data in the last segment, wildlife viewing subzone 4. The access goal area contains data only within the first segment, motorized sightseeing subzone. Although input weights are normalized for each goal area, the spatial spread of the data influences the results where more inputs are occurring.

The results show classes of potential need areas throughout the entire transportation network due to some input layers completely overlaying it. These layers are: exotic species, each of the mammal layer inputs excepting sheep, and permafrost. Due to the spatial spread of these data, every area of the transportation network can be classified as at some level of potential need for investment.

Next Steps

The data and web mapping interface will require maintenance as updated or new data and web mapping tools become available. We see the initial release of the web map for the Denali PaTINA as a first step toward a more comprehensive tool to aid the park in investment decision making. As noted above, stream-lining the weighting and model execution processes would improve the overall utility of the PaTINA.

Additional development of the PaTINA web map may include incorporation of other map services such as the NPS Road Inventory Program and data services from the Inventory and Monitoring network. Conversely, the base PaTINA results can be added to other web map applications that may focus on other issues.

Finally, development of instructional materials and accompanying training sessions would bolster and help maintain the utility of the PaTINA results and its application to park management.