National Park Service
U.S. Department of the Interior

Denali National Park and Preserve
Long-Range Transportation Plan

Appendix A:
Literature Review Summary Report

1. Introduction

This baseline conditions report summarizes the findings of a literature review conducted as part of the National Park Service's (NPS) Denali National Park and Preserve (Denali NP&P) Long Range Transportation Plan (LRTP). This review will be used as the foundation for the LRTP's baseline conditions chapter and consists of existing policies, guidelines, plans, conditions, and research related to the Denali NP&P's transportation system.

The vision for the Denali NP&P LRTP reflects the values expressed in the Park's Foundation Statement and input received from Park staff and decision makers. This vision serves as the basis for the LRTP's goals and objectives. The LRTP's vision is:

> *Protect intact, the globally significant Denali National Park and Preserve ecosystems, including their cultural, aesthetic, and wilderness values, and ensure appropriate access to opportunities for inspiration, education, research, recreation, and subsistence for this and future generations.*

2. Literature Review Composition

The literature review included 16 documents as well as notes from preliminary meetings conducted as part of the early stages of the LRTP process. Documents included in the literature review are:

- Alaska Federal Lands Long Range Transportation Plan, 2012
- National Park Service Alaska Region Long Range Transportation Plan, 2012
- Denali National Park and Preserve Foundation Statement, 2014
- Alternative Funding Opportunities for National Park Service Transit, 2014
- Denali National Park and Preserve Bus Shuttle System Analysis, 2013
- Denali Park Road Visitor Survey, 2010
- Visitor Satisfaction with Transportation Services and Wildlife Viewing Opportunities in Denali National Park and Preserve, 1998
- Proposed Entrance Station Report, 2008
- Needs Assessment & Feasibility Study for a Community Transportation System, 2006
- Vehicle Management Plan (VMP), 2012
- Denali National Park and Preserve Entrance Area Environmental Assessment, 2001
- Denali National Park and Preserve General Management Plan, Consolidated, 2008
- Denali Community Transportation Study, 2006
- Denali National Park and Preserve Transportation Needs Assessment, 2006
- Denali National Park and Preserve Winter Plowing Environmental Assessment and Finding of No Significance, 2013
- Air Tour Operators Best Practices, 2012

2.1. Document Age

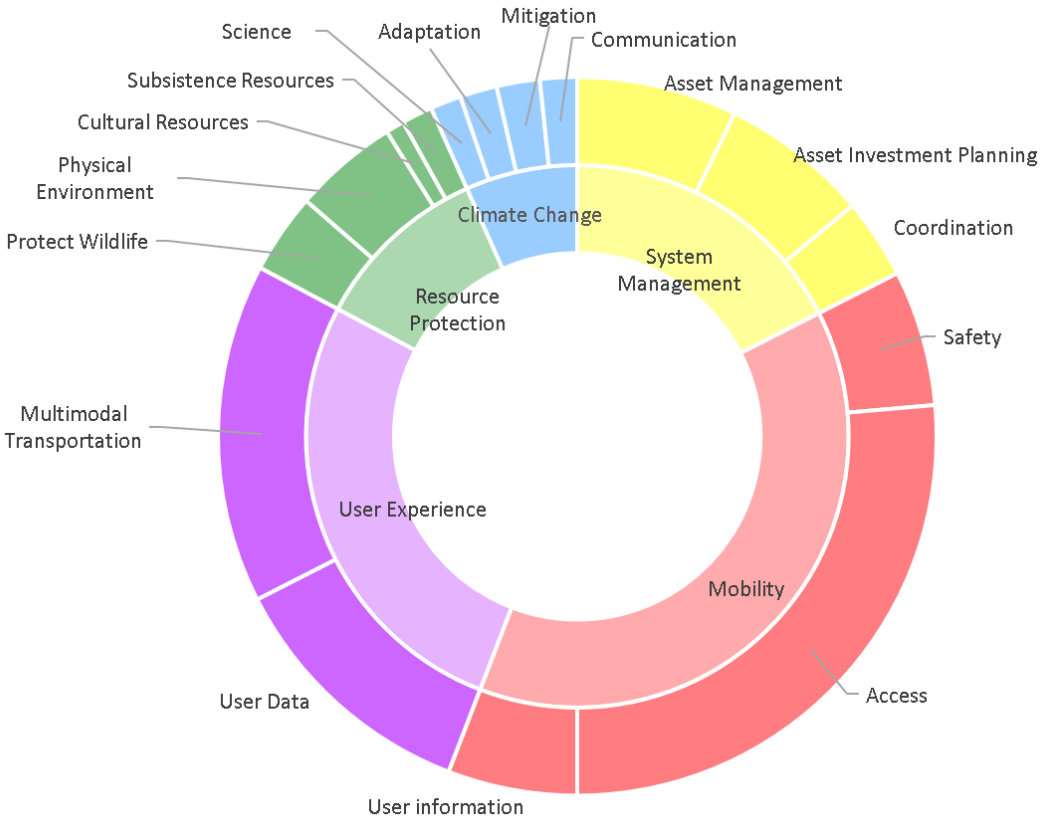
The majority of documents analyzed through the literature review were completed within the last 5 to 10 years. Occasionally, issues highlighted in older documents identify conditions or policies that have changed and are represented as such in subsequent plans and studies. These instances were tracked through the literature review process. This baseline conditions report omits conditions, policies, or other conclusions that were made irrelevant by subsequent documentation.

2.2. Goal Area/Objective Frequency Distribution

The results of the literature review focused on 90 criteria related to six LRTP goal areas and 16 objectives within those goals. A complete list of goals, objectives, and criteria are included in Appendix A. Each Denali NP&P planning document was reviewed for instances of where the criteria were met. The literature review resulted in a total of 394 instances of planning documentation relating to goal areas from which to conduct a baseline study.

The chart below shows the distribution of responses among the LRTP goal areas and objectives. The most common topics relating to goals and objectives that appeared in the documents reviewed related to mobility and user experience. These topics make up a combined 64 percent of the responses relating to goal areas. System management accounted for another 18 percent. The least frequent were resource protection and climate change.

Figure 1. Literature review response frequency by goals and objectives



3. Literature Review Results by Goals and Objectives

Literature review results are organized by goals and objectives.

3.1. Resource Protection Goal

Protect Denali National Park and Preserve's natural, cultural, and subsistence resources

Wilderness Character Objective: *Preserve wilderness character and consider cumulative impacts to wilderness in transportation planning and policy development.*

The existing literature on the protection of wilderness as it relates to coordination with neighboring transportation agencies discusses some activities that managers are engaging in to better manage wilderness within Denali NP&P.

Although Denali NP&P managers currently works with state, federal, and local agencies on issues relating to wilderness protection, there is minimal documentation of these efforts in the catalogue reviewed for this study. Documents reviewed note processes for coordination with other agencies in regards to environmental impact statements and environmental assessments and projects located on non-NPS owned transportation systems. The reviewed documents do not indicate that there is an ongoing formalized coordination process for reviewing wilderness protection as it relates to transportation impacts.

Condition
Denali NP&P managers often engage in coordination efforts with neighboring organizations (state, local, and federal agencies; local tribal groups; and tourism industry) as part of National Environmental Policy Act (NEPA) documentation, but there is no formal working group or regular forum for ongoing coordination between Denali NP&P and these groups. Increased coordination is desired.

Other wilderness protection efforts include cooperative discussions with air tour operators about measures to protect wilderness character and to minimize conflicts with land activities.

Transportation factors identified that influence Denali NP&P wilderness character primarily include interaction between buses and wildlife, specifically traffic volume, timing, and types of vehicle use on Denali Park Road. Impacts from these factors are addressed through the use of road standards, gap spacing, nighttime traffic levels, and monitoring conditions.

Natural Resources Objective: *Understand, mitigate, and protect wildlife and the physical environment from adverse transportation system effects*

Preservation of natural resources is a top priority for Denali NP&P. Therefore, management of visitor access is paramount in the discussion of resource protection, especially as it relates to transportation. In order to provide a natural environment that includes largely intact ecosystems for the enjoyment of visitors, the Park manages daily traffic along Denali Park Road as well as how it provides access to backcountry travelers. This objective is promoted by continuance of the "no formal trails in the backcountry" policy (General Management Plan, 2008) and new vehicle management strategies as discussed in the VMP (2012).

Condition
Denali NP&P is home to populations of wolf, caribou, Dall sheep, grizzly bear, moose and some of the most pristine wilderness in the NPS system. Environmental protection is the top priority of Denali NP&P in terms of appropriate and effective access and, therefore, improvements to the transportation system are subject to strict environmental considerations.

There is increased awareness of the importance of monitoring wildlife interactions with vehicles along Denali Park Road. Indirect disturbances to wilderness include noise from motorized vehicles including overflights, fugitive dust, obstructed viewsheds, social trails, trampled vegetation near transportation hubs, and increased signs of disturbance near transportation hubs.

Park staff also coordinate with land managers at other potential Denali NP&P access points, specifically addressing interest in development at the existing Stampede Road. In the 2008 General Management Plan, Denali NP&P has noted considerations for wolf, moose, and caribou habitat in this area. Opportunities for new multimodal access to the south of the Park are also documented, but no specific resource considerations were documented in this area.

The 2012 NPS Alaska Region LRTP made coordination with neighboring land and transportation managers a regional objective for all units in the state. The Alaska Federal Lands LRTP established an ongoing transportation project coordination working group to address such concerns at a regional scale. There is no similar working group for Denali NP&P specific coordination.

Cultural Resources Objective: *Mitigate negative impacts and provide appropriate access to cultural resources*

An inventory of historic properties was developed in 1983 and again in 2000. These studies have led to ongoing protection of cultural resources within the Park; this is a specific objective outlined in the 2012 VMP to protect and promote historic character.

Condition
Historic sites are well documented within Denali NP&P. Denali Park Road itself is considered an important cultural asset.

Several transportation related assets within the Park are considered to be cultural resources. The park headquarters district and dog kennels have been added to the National Register, along with the Denali Park Road.

The 2012 NPS Alaska Region LRTP cites the construction of new airstrips for backcountry access as a threat to cultural resources. These threats are of particular concern for cultural resources not only due to the physical presence of the airstrips, but because of the associated soundscape implications that

additional air traffic may have. With increasing popularity of Denali NP&P and limited vehicular access, aircraft facilities are key for accessing the backcountry, now and in the future.

Subsistence Resources Objective: *Consider impacts and access to subsistence resources in transportation planning and policy development*

Because subsistence access is authorized by Title VIII of ANILCA, most plans refer to the provisions set forth in the implementing regulations at 36 CFR 13.460. Motorboat and snow machine access is allowed for traditional subsistence activities in the "Old Park", and off-road vehicle use is allowed on 5 trails near Cantwell (General Management Plan, 2008). ANICLA does not supersede the original legislation to create Mt. McKinley National Park though it adds authorization for private and commercial air travel through permits and concessioner contracts.

Condition
Subsistence access is allowed under ANILCA. Access rights for traditional uses include traditional and modern transportation modes. Transportation impacts of these activities are not well documented.

In the "Old Park" snowmobiling was officially closed to all users in the late 90s and early 2000s. The "Old Park" was also closed to hunting previous to the passage of ANILCA. Planes are allowed in the "Old Park" but only non-commercial as it is traditional and customary to pre-ANILCA.

Transportation impacts of subsistence activities are not well documented, but most plans refer to these activities taking place.

3.2. Climate Change Goal

Plan for climate change impacts to and from the Park's transportation system through science, adaptation, mitigation, and communication

Science Objective: *Initiate, support, and participate in scientific research and assessments needed to understand and respond to relationship between transportation and climate change in Alaska*

At this time, participation in climate change science still only exists at the Alaska Region level in terms of climate action plans and regional LRTPs. Regional plans include goals and objectives for addressing climate change science. These include funding climate change research through the Transportation Research Board, establishing partnerships to test green technologies, and regional support for the Climate Friendly Parks certification. The Alaska Federal Lands LRTP also sets an objective of participating in at least one climate change effort per year with documented results. If successful, this could increase the amount of information available to Denali NP&P managers.

Condition
Participation in climate change science is mainly conducted at the regional NPS level. However, regional support for these activities has recently led to support for unit level studies.

The Alaska Region system has undergone studies to assess climate change scenarios at the unit level. These efforts may also lead to more unit-level planning for transportation assets that include climate change considerations.

Adaptation Objective: *Manage transportation assets and conduct transportation planning for climate change*

Regional transportation planning objectives call for transportation system adaptation with regard to climate change. Specific long-term climate change adaptation needs include identifying and prioritizing risk to NPS-owned and non-NPS owned transportation assets and systems likely to be affected by climate change and determine what management actions are needed; and developing adaptive management into LRTP updates as a means of assessing situations, designing, implementing, monitoring, evaluating, and adjusting management decisions to account for climate change.

Condition
Currently there is limited transportation planning documentation in regards to climate change adaptation. Regional planning objectives call for increased hazard risk assessments for strategic decision making.

There is limited language addressing climate change adaptation in plans specific to Denali NP&P.

Mitigation Objective: *Reduce Denali National Park and Preserve's carbon footprint by reducing transportation related greenhouse gas emissions from Park operations and visitation*

Denali NP&P is in the process of achieving a Climate Friendly Park (CFP) certification[1]. This program, established by the NPS, sets performance standards for sustainability in support of NPS goals for reducing greenhouse gas emissions through energy conservation and reduction in energy use, recycling, composting, technology upgrades, and other actions. The NPS Alaska Region has a goal of becoming a climate friendly region by 2030 which targets expanding regional participation in the Climate Friendly Parks program and increasing climate related data collection.

Condition
Denali NP&P is in the process of becoming CFP certified. Climate change mitigation activities include reduction in energy use and encouraging Park employees to carpool by providing carpool vehicles.

Some specific climate change mitigation activities underway in Denali NP&P include the availability of an employee carpool fleet and the use of local gravel sources to minimize maintenance vehicle miles traveled, as well as reduction of idling vehicles during transit operation and winter plowing operations. Future opportunities to reduce its carbon footprint may include upgrades to more fuel efficient transit vehicles should suitable vehicles become available someday.

Communication Objective: *Share the compelling story of climate change impacts in Alaska and Denali National Park and Preserve to the public as it relates to transportation*

[1] The CFP program is one component of the National Park Service Green Parks Plan, an integrated approach by the NPS to address climate change through implementing sustainable practices in our operations. This effort is an integral part of the larger NPS Climate Change Response Strategy. For more information on Climate Friendly Parks certification, visit http://www.nps.gov/climatefriendlyparks/

At this time there is no formal region-wide communication program to describe the relationship between transportation and climate change. At the park scale, there are interpretive programs within Denali NP&P to explain the impacts of climate change on the landscape. Because Denali NP&P extensively utilizes transit services to enhance visitor experience, opportunities exist to show air quality and other benefits of transit service as compared to personal vehicle use.

Condition
Although there is no formal guideline at the regional level for communicating climate change impacts, Denali NP&P has some programs to communicate climate change impacts to its visitors.

Regionally, there are efforts underway to communicate with both external partners and internal staff members about the successes and failures concerning environmentally sustainable transportation practices, and to develop and fund educational materials for internal and external audiences.

3.3. User Experience Goal

Proactively enhance the Denali National Park and Preserve experience

User Data Objective: *Collect, analyze, and use transportation and user information to enhance Park experiences into the future*

Most of the documents reviewed for this baseline conditions report rely on user information to determine a condition or characteristic. Within Denali NP&P, there is increased interest in collecting user information because it informs a more proactive approach to transportation system performance, visitor experience, and natural resource impacts. User data is collected through different methods and is used for numerous ends. These include:

Condition
Denali NP&P collects, analyzes, and uses transportation and user information to enhance Park experiences. The Park also has a vision for how this practice can be improved in the future.

- Visitor surveys are used to gauge visitor satisfaction as well as transportation system performance. The most recent survey was collected in 2006.
- Static visitation collection points at the Savage River Check Station, visitor centers, and other travel waypoints are used to track visitor characteristics and behavior.
- As of 2013, transit data is collected on all Park transit vehicles by bus drivers and through mobile tracking devices. On-board devices track the number of tickets sold, number of passengers, GPS locations of buses, and durations of vehicle stops. Bus drivers manually input the purpose of the stop and information about hiker wait times, which is of high importance to the Park Service. This data can be made available in real time and can be used to monitor and respond to varying travel demands. The NPS currently has staff in the Resources Division dedicated to analysis of the data collected by the transit operation.
- Permits collected for the purpose of either access by private vehicle with right-of-way authorization, for overnight backcountry access, or by commercial airplane are useful for tracking visitation to the most protected areas of the Park.
- Other information currently collected includes Service-wide Traffic Accident Reporting System (STARS) and Fatal Analysis Reporting System (FARS) data for recording vehicular accidents.

Needs and opportunities for user data include specifying visitor experience benchmarks for number of vehicles at wildlife stops and number of vehicles in a viewscape to serve as reliable baseline condition data. Other recommendations include additional road audits to reduce entrance fee non-payment. More flexibility to use franchise fees to fund comprehensive data gathering is seen as an opportunity to improve visitor experiences while protecting natural resources.

Multimodal Transportation Objective: *Provide an appropriate, effective, and conflict free multimodal transportation system to and within Denali National Park and Preserve*

For much of the Park's history, maintenance and transportation improvements focused on Denali Park Road. More recently, the emphasis includes the Park's transit system which increases access while minimizing natural resource impacts. Much of the desired future conditions are related to the Park implementing more outcome-based approaches to analyzing user information as opposed to relying solely on historic comparisons.

Condition
Multimodal access is historical, necessary, and desired by recreationalists and subsistence users. The most common multimodal conflicts are due to crowding at wildlife stops and rest stops along Denali Park Road.

Appropriate multimodal transportation service is often defined by its ability to make Denali NP&P accessible to a wide range of visitors with overarching consideration for the wilderness character that the system accesses. This definition of appropriate access relates closely to the Denali NP&P's purpose and mission as stated in its Foundation Statement. Appropriate access depends on the observed and anticipated effects to natural resources (VMP, 2012). Increased visitor access is desirable if it does not cause negative impacts on environmental conditions. At locations within the Park where the natural environment is still intact, even small increases in visitation or changes in access can have dramatic impacts on natural systems.

Multimodal issues that reoccurred in several reviewed documents and in comments from Park staff include confusion about shuttle service operation; desire for better connections between the Park, local communities, and visitor accommodations; employee travel to, from, and within Denali NP&P; safety, comfort, and quality of interpretive experience; and transportation service affordability.

Multimodal conflicts identified in plans include general congestion along Denali Park Road and in Nenana Canyon, crowding at wildlife stops and rest stops within the Park, narrow roadways for bicycling and hiking in the "front country" and at particular locations east of Savage River; and conflicts between land and air visitation in terms of soundscape impacts. Congestion challenges are anticipated to grow as visitation levels increase. As a result, Park managers may face ongoing decisions about how to balance environmental priorities and resource protection with transportation system capacity when responding to increased demand.

The Park has several efforts underway to improve multimodal travel opportunities and travel experiences within Denali NP&P. Park managers are using indicators to measure performance of the transit system and gauge overall user experience. These include hiker wait times, numbers of vehicles at wildlife stops, number of vehicles in viewsheds, numbers of vehicles at rest stops, nighttime traffic levels, large vehicle traffic, and sheep gap spacing. Proposed construction of an eight-foot gravel shoulder along sections of Denali Park Road from mile eight to Savage River cited in the Final Entrance Area and Road Corridor Development Plan could provide safety and traveling comfort for bicyclists and hikers and may improve

opportunities for wildlife viewing. Also, modifications to the general management of Denali Park Road could improve protection of natural habitats beyond Savage River.

There is an opportunity to gain efficiency in transit operations by improving consistency in transit seating and consolidating shuttle services in the entrance area and canyon. Also, expanding transit service north to Healy and south to Carlo Creek and Cantwell in addition to increasing shuttle service between the entrance area and McKinley Village is desired (Needs Assessment and Feasibility Study for a Community Transportation System, 2006).

3.4. Mobility Goal

Provide safe, efficient, and appropriate access to and within Denali National Park and Preserve

Safety Objective: *Provide safe access to and within Denali National Park and Preserve*

Condition
The historic character of Denali Park Road creates safety issues, and due to its popularity both as a visitor attraction in the Alaska Region and within Denali NP&P, most recorded accidents occur along the road. Other safety s considerations include bicycle and pedestrian access in the front country and along sections of the George Parks Highway, and increased winter access.

Between 1990 and 2006, 95 percent of all vehicular accidents in NPS's Alaska Region occurred in Denali NP&P, with 58 percent of these accidents occurring on Denali Park Road (NPS Alaska Region LRTP, 2012). Of the other accidents reported within Denali NP&P, 19 percent were located on the George Parks Highway within the Park boundaries. The remaining portion of vehicular accidents occurred near the visitor parking areas or in campgrounds. The George Parks Highway is the direct road connection between Anchorage and Fairbanks and a major travel corridor for Denali NP&P visitors. Between 2007 and 2010, 31 total fatalities were reported on the George Parks Highway (NPS Alaska Region LRTP, 2012).

As identified in the VMP, safety issues are associated with road travel along Denali Park Road. The historic nature of the road may in some locations limit sight distance, restrict width for passing vehicles, and provide inadequate surface road friction (VMP, 2012). Driver behavior is most likely a contributing factor in vehicular crashes particularly for private vehicles traveling Denali Park Road during off-peak seasons. Impacts of severe weather events for Denali Park Road travelers are another safety consideration. These issues are also a top priority of the Park's General Management Plan and although very important, must be balanced with active preservation of the road, as characterized by the philosophy to retain its telescoping from a full width paved profile at the entrance to the narrower, unpaved gravel profile at the western end.

According to the visitor survey highlighted in the VMP, the public indicates that they feel safe while using Denali NP&P's transportation system. The most notable safety consideration perceived by the public is related to travel over Polychrome Pass where Denali Park Road has steep drop-offs and the road is narrow and winding. Park management uses driver training, driver spacing, and wait times to address safety issues at this location.

Safety is also a top priority for flight operations. For example, recommended flight tour routes are subject to weather conditions and aircraft may be forced to deviate from planned routes if safety is at risk (Air Tour Operations Best Practices, 2012).

With increased opportunities for vehicular winter access, emerging safety improvements related to winter travel are a growing need. Denali NP&P has a goal of minimizing wintertime safety-related incidents and has an interest in determining baseline conditions so as to monitor future winter safety performance. With the trial winter plowing of the first 15 miles of Denali Park Road, the Park continues to monitor visitor safety during the extended period of winter and early spring driving conditions. Commercial operators also provide multi-modal access to the Park during winter months. Denali NP&P staff is working with commercial operators to implement safety measures for winter operation, such as the required use of emergency communication devices during operation.

The collection of safety data and addressing inconsistencies in safety data reporting is identified as an ongoing need.

Access Objective: *Provide appropriate and efficient access for inspiration, education, research, recreation, and other uses as provided for in ANILCA.*

Condition
Within Denali NP&P, appropriate and effective access is determined by the assessed impacts to wildlife and cultural resources. Where the environmental conditions are more intact, visitor access is more closely managed. New vehicle management strategies target this priority.

As stated in the General Management Plan, the primary historic purpose of access to Denali NP&P is to accommodate viewing of Mount McKinley and the Park's wildlife. As documented, appropriateness of access is defined by the balance between visitor accommodation with active protection of wilderness character. The NPS, therefore uses the least access restrictive management tool possible to maintain and promote the natural resources protected by the area (General Management Plan, 2008).

The level of appropriate access varies along Denali Park Road. Wildlife Viewing Subzones are used to distinguish appropriate level of access. A notable example includes the Park's VMP which allows 160 vehicles per 24 hour day through mile 15 of Denali Park Road period while monitoring for violations of user experience standards. This number was derived through extensive research and rigorous travel modeling of Denali Park Road and provides an overall increase in capacity for visitors while considering environmental impacts.

Visitors typically arrive to the Park by private vehicle, bus, or train. Many visitors arriving by bus or train are cruise ship passengers and are traveling with fellow passengers as part of cruise packages. Park management desires to provide efficient access to visitors arriving by all modes of travel while also providing for accessibility as delineated by the Americans with Disabilities Act (ADA) and Architectural Barriers Acts (ABA). For areas of the Park with additional travel requirements, this means ensuring a transportation system that provides a meaningful, high-quality opportunity for viewing scenic landscapes and wildlife, primarily through transit services (VMP, 2012). In the future, visitation is expected to grow with a large portion of visitors arriving as part of organized tour companies or organizations. Considerations of access are therefore a topic of long-range concern as Denali NP&P is committed to balancing access with the responsibilities of managing designated wilderness.

At the time that the Denali Park Road Visitor Survey (2010) was conducted, 71 percent of visitors who traveled beyond mile 15 were part of organized tours (i.e. Long Tour). These are highly interpretive trips with designated stops at rest areas and impromptu stops for wildlife viewing. Non-tour transit buses traveling past mile 15 provide less interpretation and make impromptu stops for hikers and wildlife viewing.

Coordination with the visitor services concessioner is ongoing and the relationship between Denali NP&P and any concessioner is viewed as integral to providing appropriate and effective access for Park visitors.

User Information Objective: *Provide accurate and accessible information through a variety of means about how to travel to and within Denali National Park and Preserve*.

The NPS is interested in providing information to potential and repeat users about its transportation system and services at a national, regional, and local level. The Alaska Federal Lands LRTP and NPS Alaska Region LRTP summarize objectives and strategies that specifically address providing accurate and accessible information for travel to and within federal lands, and several projects to enhance visitor information services.

Condition
Commercial and state tourism initiatives are successful in providing travel information to visitors prior to their arrival at the Park. Once at Denali NP&P, the Park, its concessioners, and local businesses provide interpretation through visitor centers, transit and tour bus operations, and many others. Interpretation and transit system visitor information improvements are desired.

Much of the marketing and development of traveler information for Denali NP&P is championed by non-NPS organizations, such as the Alaska Railroad, concessioners, and other area businesses. Because Denali NP&P is a regular destination for commercial tour operations, much of the information provided to potential visitors and visitors en route to the Park is provided by those organizations. According to the Denali Park Road Visitor Survey issued in 2010, over half of the Denali NP&P transit users had received information from a travel agent about their visit to the Park. Another third of the respondents received information over the internet. Denali NP&P maintains a website with virtual tours, guides, and resources to help visitors plan trips to the Park. Travel guides and tour books are also popular means of learning about how to travel to and within Denali NP&P (NPS Alaska Region LRTP, 2012).

Traditional means for providing information at visitor centers and Wilderness Access Center are available upon entering Denali NP&P. Once aboard the short-tour and long-tour buses, visitors have a wide range of information available. Tour bus drivers and guides provide extensive interpretation, while transit drivers may provide information upon request and at the discretion of a particular driver. Several Denali NP&P plans document the value of retaining experienced drivers. This was seen as a major enhancement to the overall visitor experience (Denali NP Bus Shuttle System Analysis, 2013).

The most common need identified in planning documents is the necessity for better wayfinding and user information about transit in hopes of reducing visitor confusion with the Park's transportation system. According to the VMP, an objective of Denali NP&P management is to "clearly communicate information about the system through a variety of means." Potential options for sharing information include improving traditional methods such as maps, brochures, and signage. The Alaska Region is also interested in newer media options such as implementing intelligent transportation systems linked with websites, mobile devices, and other personal communication technology. According to a survey in 2010, transit users were

not interested in receiving information from a recorded narrative about traveling Denali Park Road. Information delivered by bus drivers was preferred over prerecorded methods.

Also, with the introduction of enhancements to the off-season access programs, Denali NP&P management is interested in reducing the perception that the Park is closed during off-seasons by increasing communications about opportunities for visiting the Park during the winter.

3.5. System Management Goal

Develop a long-term transportation system to appropriately satisfy current and future land management needs

Asset management Objective: *Apply available financial resources to essential transportation infrastructure*

Relative to other parks in the Alaska Region, transportation assets within Denali NP&P are some of the most costly. This is primarily due to Denali Park Road maintenance needs, providing visitor transit and tour services, and experiencing the high visitation levels during a very short summer season.

Condition
The availability of funds, particularly for funding transit systems, has decreased in recent years. Denali NP&P management is using quantitative and qualitative indicators about the transportation system to prioritize transportation system improvements. With limitations to increasing system capacity Denali NP&P management is working toward increased system efficiency, and better coordination with transportation partners.

In general, transportation assets within Denali NP&P are considered to be in good condition. Road work is mainly concentrated on bridge replacement, road maintenance, and subgrade improvements. In general, road widening does not occur. However, improving pullouts on the narrowest section of the road to maintain safety standards des exist in asset planning documentation. The annual operations and maintenance budget for road assets in Denali NP&P was approximately $1.2 million in 2010 (NPS Alaska Region LRTP, 2012).

Denali NP&P management uses both quantitative and qualitative measures to prioritize transportation system improvements. The 2008 General Management Plan prioritizes road improvement projects, ranking corrective safety projects as the highest priority and other corrective maintenance and repairs as secondary priorities. The General Management Plan provides example projects from Denali Park Road where potential improvements have been identified for multiple project categories (sight distance improvements, safe vehicle passing enhancements, road surface friction improvements, culvert repairs, etc.). Denali NP&P has incorporated the NPS “optimizer band” model of asset prioritization. In this model, assets are scored by Asset Priority Index (API) to rank how critical assets are used in accomplishing the Park’s mission and goals. In this model, Facility Condition Index (FCI) indicates asset condition and is used to determine eligible fund sources. Projects are evaluated based upon their API/FCI rank. Using this method of asset evaluation, all of the high priority assets (API of 75 or higher) are in good or better condition (FCI of 0.3 or less) (Alaska Federal Lands LRTP, 2012). Finally, the asset needs are filtered through the NPS Capital Investment Strategy (CIS), which expresses priorities in the form of optimizer bands. Optimizer bands 1 and 2 are associated with assets that are essential or extremely important for a park to continue as described in its organic legislation.

There is a general funding gap projected into the future. The most recent congressionally authorized transportation funding bill, Moving Ahead for Progress in the 21st Century (MAP-21) reduces funding for the NPS transit systems by approximately 28 percent from the previous federal transportation legislature (Alternative Funding Opportunities for NPS Transit, 2014). Regional funding assessments show an annual funding gap of $720,000 for Alaskan "road parks", the category which Denali NP&P is included. Although park-level funding shortages are not yet documented for Denali NP&P, a large portion of the Alaska Region's transportation assets are located in Denali NP&P. Elimination of the Transportation Improvement Program (TRIP) has made funding multimodal systems, such as the Park's concessioner-operated transit, more challenging (Alternative Funding Opportunities for NPS Transit, 2014).

Because the transit system is operated by a for-profit concessionaire, it is not eligible for transportation funding through MAP-21, however, several FHWA funding and grant programs are still applicable and partnerships with local government cooperation and partnership could increase funding eligibility.

Park management is also very interested in finding efficiencies within its current asset portfolio, completing operational modifications that improve the transportation system, and promoting the Park's purpose. Recent examples of this include new vehicle management strategies provided in the VMP and wintertime operation improvements.

Asset Investment Planning Objective: *Consider sustainability of operation and maintenance of new and existing assets in the planning process*

The NPS includes asset investment planning in much of its recent transportation planning documentation. At a regional level, the NPS is using measurements that feed into asset planning processes, such as total cost facility ownership, as well as the project prioritization tools mentioned earlier. Several strategies identified in the Alaska Federal Lands LRTP promote asset planning through collaboration with other federal land management agencies and Alaska Department of Transportation and Public Facilities, consideration of lifecycle costs, and evaluation of maintenance costs versus investments in new infrastructure.

In 2010, deferred maintenance in Denali NP&P accounted for 65 percent, approximately $20 million, of all deferred maintenance of transportation assets in the Alaska Region. Deferred maintenance issues within Denali NP&P could be addressed by treating the underlying cause of the road failures to reduce the need for repetitive maintenance, according to the General Management Plan

Condition
Denali NP&P managers are very involved with asset planning for transportation system maintenance and operations. Relative to other parks in the region, Denali NP&P has high deferred maintenance needs resulting largely from challenges associated with maintaining Denali Park Road. Maintenance and operation are constantly weighed against environmental conservation priorities.

Documents suggest that road repairs and maintenance should follow the 2005 Denali NP&P Road Maintenance, Repair, and Operating Standards and the 2007 Denali NP&P Road Design Standards. The total planned transportation assets for Denali NP&P include improvements to access roads, parking lots, non-motorized routes and other transportation infrastructure. These planned assets are valued at $64 million (NPS Alaska Region LRTP, 2012).

In terms of operational needs, Park managers are actively participating in day to day management of transit operations and are able to make adjustments based on demand. For example, real-time monitoring of the transit system allows the concessionaire to track transit vehicle occupancy and dispatch additional vehicles during peak demand for return trips. Denali NP&P is also actively investigating opportunities for gaining efficiency in their transit and in their entrance fee collection program.

As it is with other goal area topics, effective operation and maintenance is balanced with environmental protection. In planning documents the Denali NP&P management is constantly balancing expectations of visitor experience and safety with deference to natural resource objectives.

Coordination Objective: *Coordinate with local organizations to ensure that nearby transportation projects are planned with NPS involvement to the mutual benefit of all parties.*

Coordination with federal, state, and local agencies is seen as an opportunity for funding and project implementation as well managing concessionaire services and expanding local visitor services. An ongoing federal land management agency coordination team was formed as a result of the 2012 Alaska Federal Lands LRTP. The group actively works to coordinate transportation project planning across Alaska, including in and around Denali NP&P. These efforts could help organize interest in expanding transit services outside of the Park, which is a frequently cited coordination need as determined by the literature review and comments from Park staff during LRTP discussions.

Condition
Coordination with federal, state, local and private transportation agencies is seen as a need for optimizing asset management because 21 percent of the transportation assets are owned by non-NPS agencies.

Needs and opportunities for coordinating with private entities are somewhat unique to Denali NP&P. Denali NP&P is the only park in the Alaska Region to have transportation assets that are not owned by the NPS. Twenty-one percent of the transportation assets in the Park are owned and operated by concessionaires or owned by others. There is a desire to expand partnerships to include other local businesses and eventually local government agencies. The 2006 Needs Assessment and Feasibility Study for a Community Transportation System provides alternatives for organizing such efforts.

Other coordination efforts include involving air tourism operators, regular communication with tribal organizations and land inholders, and coordinating access with other area landholders and transportation agencies such as the Alaska Department of Transportation and Public Facilities.

4. Conclusions

Common themes encountered throughout the literature review process provide several general baseline conditions for Denali NP&P. These include:

- The historic character of Denali Park Road and the management thereof are important factors influencing access and mobility.
- Denali NP&P is a primary attraction for tourists. Many visits are rushed due to the logistics of popular packaged Alaska tours. Visitation is anticipated to increase as tour companies continue to promote and expand travel options to the Park.
- With anticipated visitation increases and associated use of the transportation system, Denali NP&P managers may face ongoing decisions about how to best protect the Park's natural resources as congestion grows and the capacity of Denali Park Road and transportation system is tested.
- Travel options are sometimes viewed as limited within the Park, but some multimodal enhancements could increase safety, particularly for bicycling and hiking opportunities.
- The general condition of the transportation system is good, but priorities are complex both in terms of balancing maintenance needs with the care for natural resources and providing access to view designated wilderness areas.
- Recent changes to Denali Park Road vehicle management and operations system are intended to advance the NPS's emerging outcome-driven planning processes. As more data becomes available, Denali NP&P managers can better set performance indicators for operations.
- Existing transportation plans do not contain much information about climate change, but if the actions recommended and cited in the NPS Alaska Region LRTP are followed, there may be more opportunities to include unit-level strategies for addressing climate change into asset planning and operation. With ongoing progression toward a CFP certification, Denali NP&P is well positioned to incorporate these objectives at a unit-level.

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Denali National Park and Preserve
Long-Range Transportation Plan

Appendix B: Denali Long-Range Transportation Planning and Acoustic Resources

Denali: Long Range Transportation Planning and Acoustic Resources

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Research Sets the Stage

Author Eli Seigel wrote in 1970, "*all the opposites are two freedoms which question each other and complete each other*." Transportation and solitude likely represent such a pair of mutually-exclusive freedoms. In Denali and other Alaskan parks we can immediately recognize a tradeoff between the ability to be easily and quickly transported to a location and the ability to participate in the tranquility of wilderness beyond the reach of modern technology and crowds.

This recognition is a fundamental drive behind the work of the NPS Natural Sounds and Night Skies Division, whose vision statement is to ensure that, "*National parks are enduring sanctuaries for natural sounds and dark environments, where current and future generations have the opportunity to experience undisturbed soundscapes and an unimpeded view of the cosmos, and where the ecological roles and cultural values of acoustics and photics are understood and appreciated.*" (NPS 2014)

For the purposes of acoustic planning and research, the NPS has developed an autonomous system that can provide both American National Standards Institute (ANSI) certified acoustic levels (i.e., numeric measurements of sound pressure level in decibel units,) and audio recordings (i.e., sound that one can listen back to in headphones.) ANSI also recommends the collection of meteorological data concurrent with measurements of sound pressure level. Thus, a simple weather station incorporating wind speed, wind direction, temperature, and relative humidity is also part of the acoustic monitoring station. The photo below shows an external photograph of a typical station.

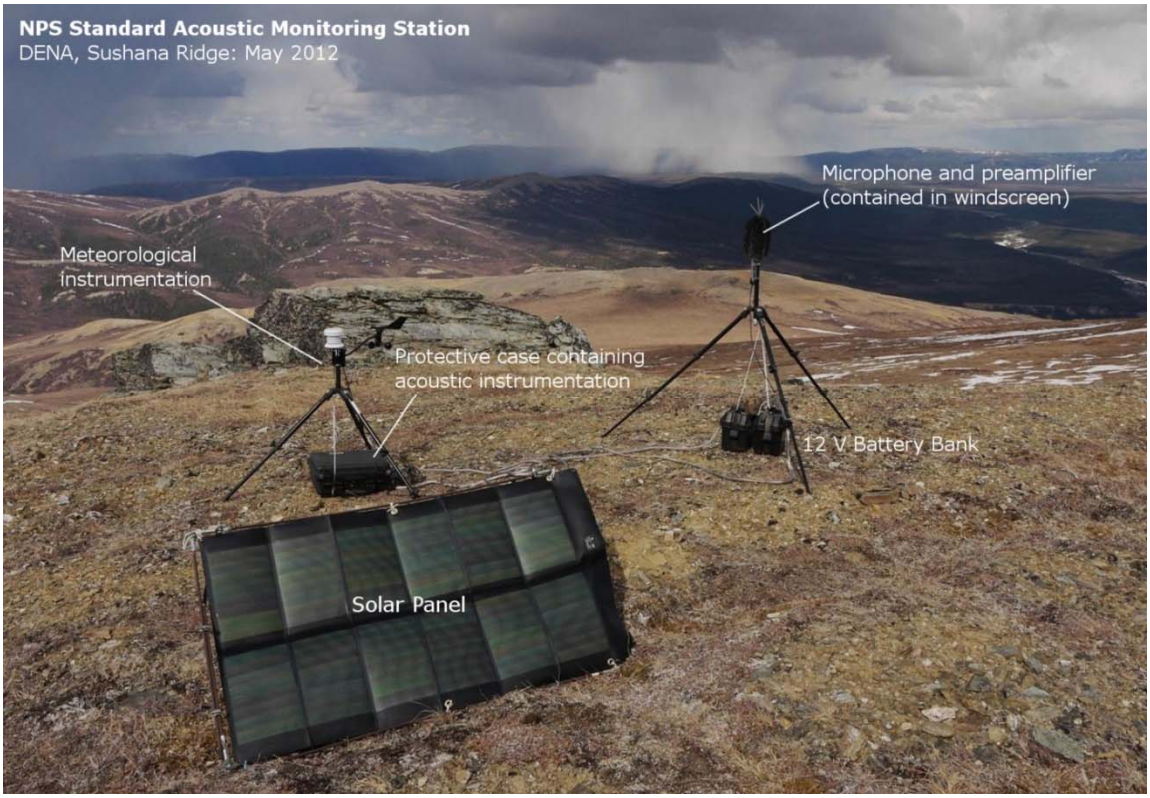


Figure 1. NPS Standard Acoustic Monitoring Station – equipment is composed of a microphone, meteorological instruments, sound level meter, digital audio recorder, battery bank and solar paneling.

Scientific work to understand Denali's acoustic environment began in 1999 in response to a large increase in aviation and snowmobile noise in the mid-1990s. (Morgan 2001) Early data were incorporated into the Backcountry Management Plan (BCMP) EIS, a supplement to Denali's General Management Plan. (NPS 2006e) After the BCMP was published, the park embarked on a decade-long inventory of the acoustic environment. The project was completed in 2015, and as of 2016 the park has moved into a monitoring phase. A basic timeline of acoustic resource management in Denali is shown below:

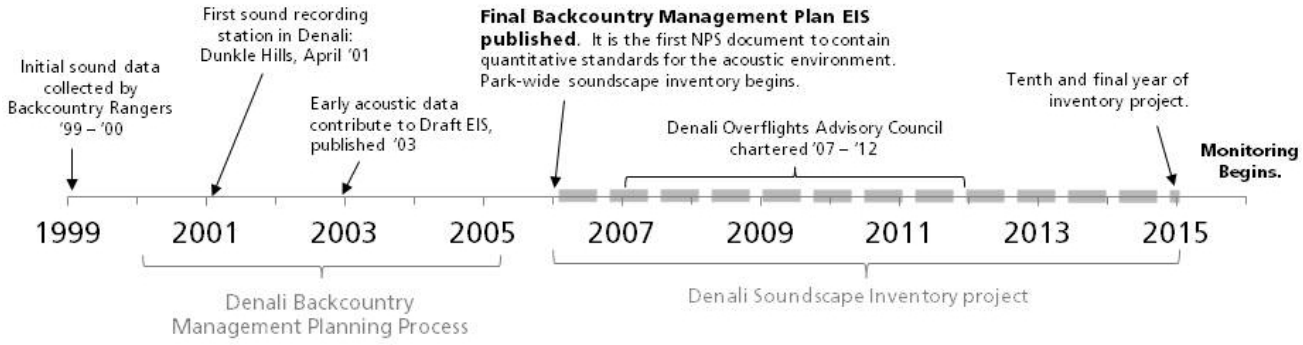


Figure 2. Timeline of acoustic resource management in Denali, 1999 – 2016.

Denali's acoustic inventory project is unique among park service units in that it was designed as a spatially random sample on a 20 by 20 kilometer grid. This allows inference beyond the local detection radius of each microphone. For example, consider the following map that depicts the acoustic metric '*daily average noise free interval*' – a measure of how long a typical quiet period is before it is broken by motorized noise. Noise free intervals in Denali are largely determined by the frequency of air traffic. Aircraft are very acoustically powerful sources that are audible at distances similar to the scale of the sampling grid, thus mapped measurements of noise free interval immediately form a discernable pattern to the human eye:

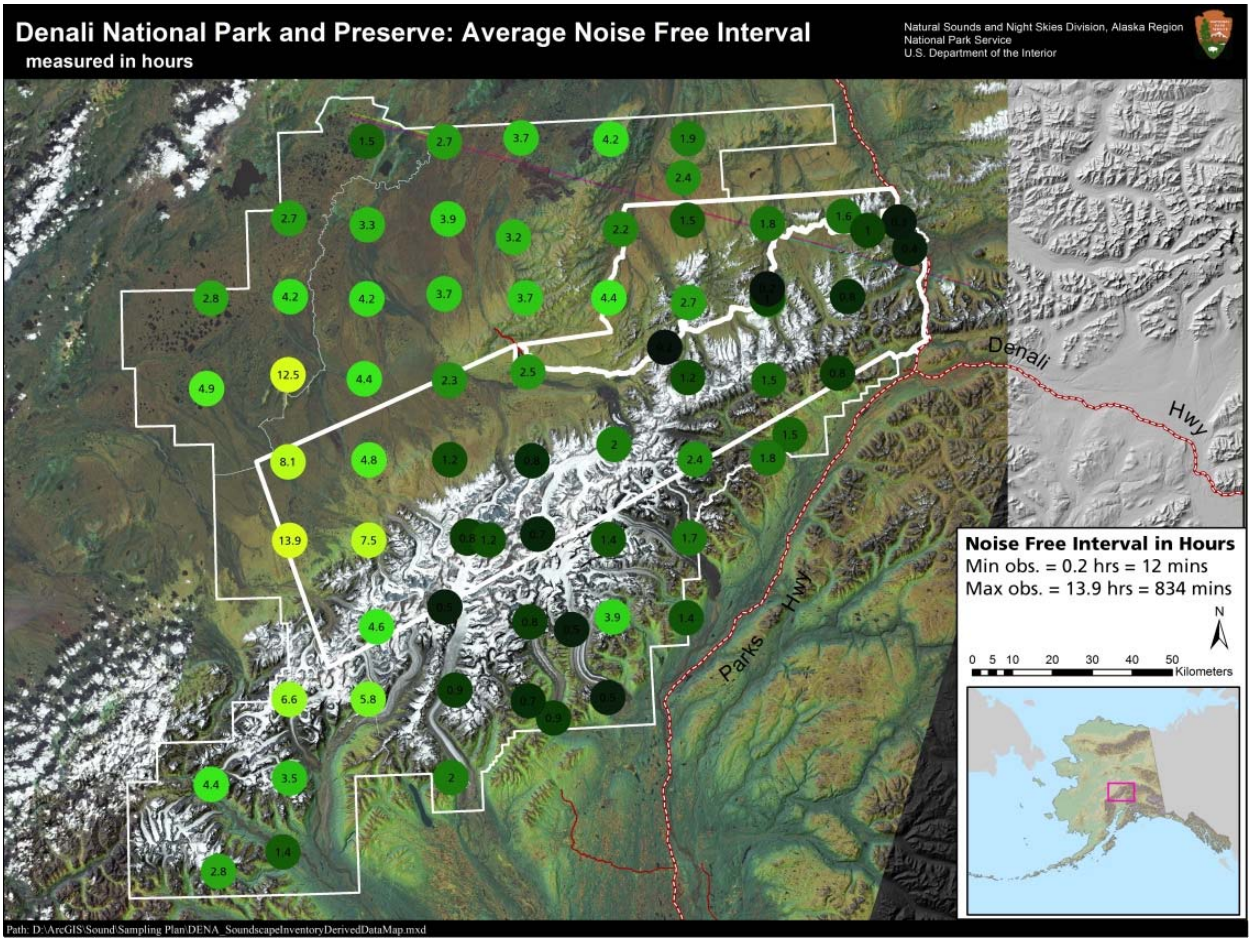


Figure 3. Daily average noise free intervals, measured in hours. Data were collected as part of Denali's Soundscape Inventory project, 2006 – 2015. Noise free interval is a measure of how long a typical quiet period is before it is broken by motorized noise.

Entering the realm of inference, the following map uses observations at specific soundscape inventory points to estimate the noise free interval at a park-wide scale. It uses a spatial smoothing technique called *"inverse distance weighting"* to construct new data points between the known values - a method known as *interpolation*. Again, because the scale of the phenomena (aircraft traffic) and the scale of the sample (20 km^2 resolution) are comparable, noise free interval is a metric well-suited to interpolation techniques. (Peterson 1998, Gergel 2006) Continuous change in the metric is physically sensible and approximate the visual effect of looking at the original point data. Denali's soundscape inventory was important for understanding which acoustic metrics are best suited to monitoring change at a landscape scale.

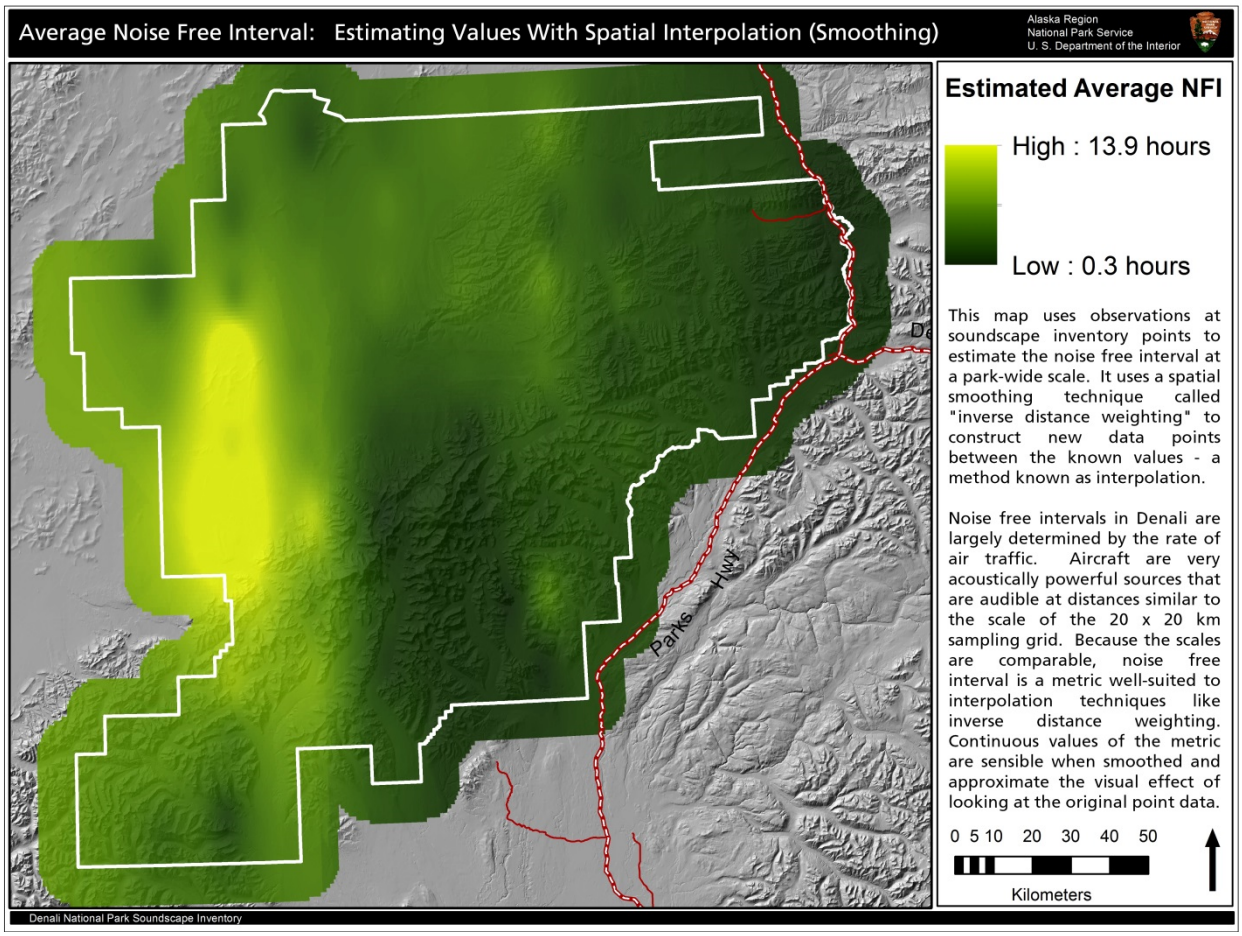


Figure 4. Average noise free interval: values estimated by spatial interpolation. Units are in hours. This map uses observations at soundscape inventory points to estimate the average noise free interval at a park-wide scale. It uses a smoothing technique called inverse distance weighting to construct new data points between the known values – a method known as interpolation.

The Denali soundscape inventory supplies spatially-rich information about the current state of the acoustic environment. It also clarifies the choices available to quiet the park, as per NPS policy. Inventory data have been:

(1) Inventory data have been used to review the indicators and standards of the BCMP:

- They explain how indicators change in response to the acoustic ambience.
- They explain the relationship between indicators (for example, NFI and event rate are inversely related, thus one can be estimated from the other.)
- They provide an understanding as to which indicators are best suited to the scale of the park.

(2) Inventory data have been used as input to the voluntary aviation best practice development process of the Denali Overflights Advisory Council (2007 – 2012):

- They provided the basis from which to monitor the effects of aviation best practices.
- They provided updates to the council directing attention to areas most in need of mitigation.
- They transcend anecdote as the sole basis for making decisions.

(3) Inventory data have been used in predictive acoustic modelling:

- They provide a means to *validate* noise models of aircraft takeoffs or overflights, road noise, or other sources.
- Data such as event rates or hourly distributions can also be used as *inputs* to models.

Aviation, Transportation, and NPS Policy

There are currently several types of aviation transport in the park. Section 1110(a) of the Alaska National Interest Lands Conservation Act (ANILCA) provides for aviation access for traditional activities and for travel to and from homesites, which will not be discussed in this document. Nor will high-altitude commercial aviation – which does impact the park, but would involve participation of the Federal Aviation Administration in the revision of Victor Airways or Jet Routes within the National Airspace System, a process well beyond the scope of this plan.

Instead, this document seeks to build on discussions of the Denali Overflights Advisory Council (https://www.nps.gov/articles/denali-aircraft-overflights.htm),a federal advisory committee chartered by the Secretary of the Interior from 2007 – 2012. The group developed a suite of voluntary aviation best practices that were adopted by both commercial and government aviators. It is fitting that these best practices were broadly adopted because NPS policy does not distinguish the obligations of governmental and Concessionaire operations with respect to resource protection. NPS Management Policies 2006 § 10.2.4.9 states:

> *Concessioners are required to comply with applicable provisions of all laws, regulations, and policies that apply to natural and cultural resource protection.*

It is relevant, then, to provide a brief policy review. NPS Management Policies 2006 § 8.2.3 addresses impacts to natural sounds directly, stating:

> *The Service will strive to preserve or restore the natural quiet and natural sounds associated with the physical and biological resources of parks. To do this, superintendents will carefully evaluate and manage how, when, and where motorized equipment is used by all who operate equipment in the parks, including park staff . Uses and impacts associated with the use of motorized equipment will be addressed in park planning processes. Where such use is necessary and appropriate, the least impacting equipment, vehicles, and transportation systems should be used, consistent with public and employee safety. The natural ambient sound level—that is, the environment of sound that exists in the absence of human-caused noise—is the baseline condition, and the standard against which current conditions in a soundscape will be measured and evaluated.*

Further guidance related to aircraft is articulated in § 6.3.4.3:

> *Managers contemplating the use of aircraft or other motorized equipment or mechanical transportation within wilderness must consider impacts to the character, esthetics, and traditions of wilderness before considering the costs and efficiency of the equipment.*
>
> *In evaluating environmental impacts, the National Park Service will take into account (1) wilderness characteristics and values, including the primeval character and influence of the wilderness; (2) the preservation of natural conditions (including the lack of man-made noise); and (3) assurances that there will be outstanding opportunities for solitude, that the public will be provided with a primitive and unconfined type of recreational experience, and that wilderness will be preserved and used in an unimpaired condition.*

Furthermore, § 6.3.7 offers and important reminder that in wilderness areas:

> *The principle of nondegradation will be applied to wilderness management, and each wilderness area's condition will be measured and assessed against its own unimpaired standard. Natural processes will be allowed, insofar as possible, to shape and control wilderness ecosystems. Management should seek to sustain the natural distribution, numbers, population composition, and interaction of indigenous species. Management intervention should only be undertaken to the extent necessary to correct past mistakes, the impacts of human use, and influences originating outside of wilderness boundaries.*

Envisioning a (Flight) Route Forward

Denali's Backcountry Management Plan (BCMP) remains the overarching unit-level policy document on the management of the natural acoustic environment. Data collection during the implementation of the BCMP has provided a robust baseline description of the resource. Transportation planning directly benefits from a synthesis of these inventory data.

One way to approach the protection of acoustic resources is through a cost-distance analysis. Cost-distance analysis balances the costs associated with travelling a certain distance (in this case, the cost of aviation fuel,) with resistances to travel. Resistances to travel can take many forms – the increased difficulty in crossing a major river or mountain range, or the difficulty of moving over muskeg as opposed to alpine tundra. In this case, we describe resistances to noise – areas sensitive to the acoustic disturbance created by mechanical transport.

What is meant by resistance? Synonymous with 'noise sensitivity' for the purposes of this discussion, the word resistance more accurately conveys the interlocked relationship between isolation and transportation. The following two definitions are applicable to the Long Range Transportation Plan:

Resistance *(noun):*

1. Resistance is the degree to which a substance prevents flow through it.
2. Resistance is the ability to prevent something from having an effect.

In this case, the *"ability to prevent something from having an effect"* describes the human ability to make choices about how to conserve the acoustic environment. In other words, we conceptualize a resistance when we answer the question, *"How do we mitigate the effects of motorized transport on the acoustic environment?"* We will later see how the *resistive* analogy between traffic flows and electrical flows can be used to the benefit of managing acoustic resources.

Resistances to noise typically fall into three basic categories:

1) Those defined by NPS policy or aviation best practices.
2) Those related to the acoustic or ecological properties of the landscape.
3) Those related to avoiding interactions between motorized and non-motorized experiences.

Resistances to noise can be assigned based on a number of different rationales. For instance, consider the following raster dataset that depicts the amount of use by backcountry unit. One long-standing approach to describing which areas should be protected from noise is to separate backcountry user groups from aviation user groups in space. Lighter areas on the map indicate more backcountry use – and thus suggest that aircraft avoid units along the Denali park road corridor.

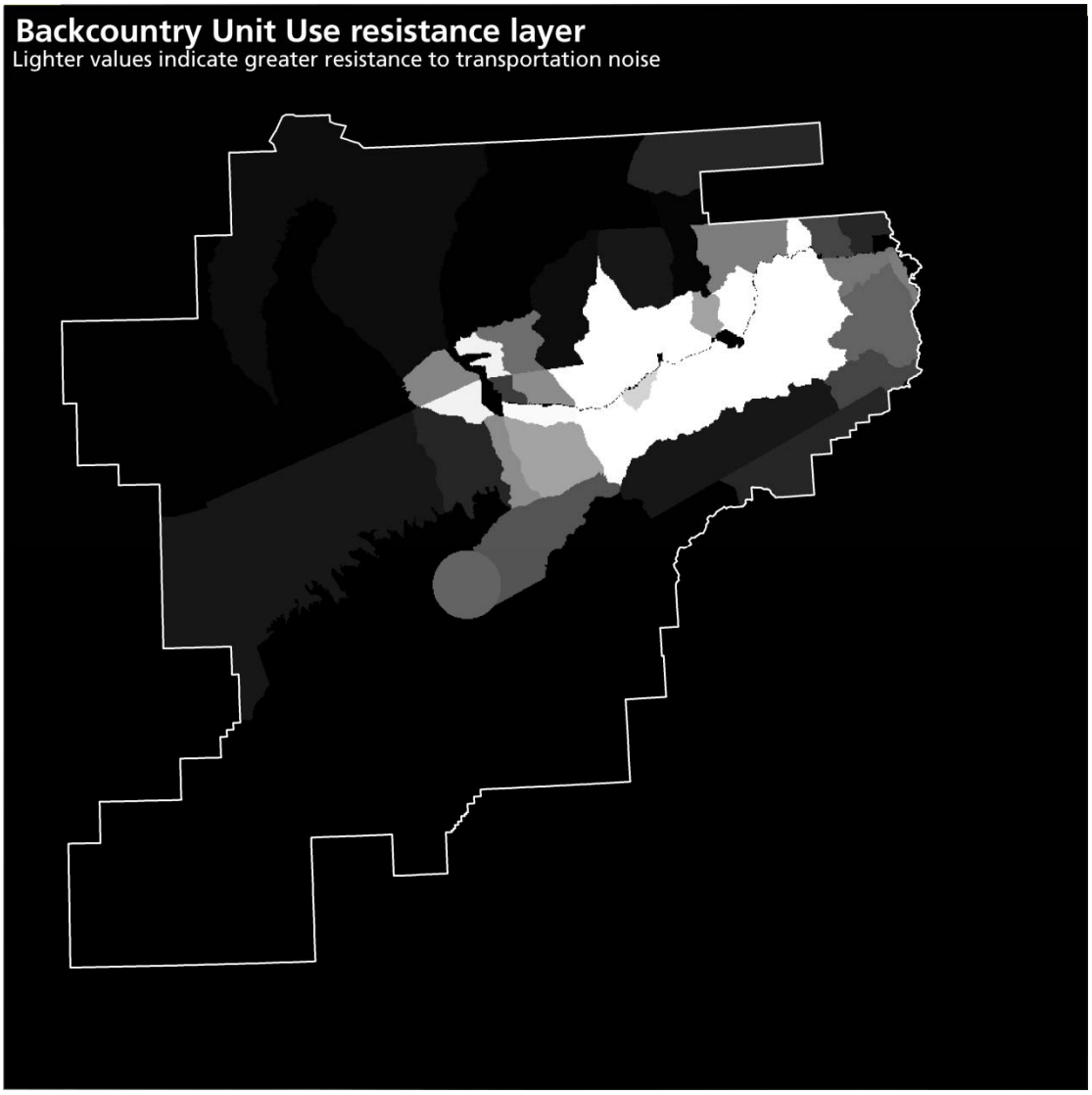


Figure 4. Backcountry Unit Use resistance layer. Lighter values indicate a greater resistance to transportation noise. This suggests that aviation routes should avoid core units around the road corridor.

Contrast this with data which show the average noise free interval across the park. The layer is normalized to the same brightness as the backcountry use layer, with lighter areas representing a greater resistance to noise and thus higher resource costs for transportation over the area.

The rationale behind the noise free interval map produces different optimal routes than the backcountry user map. This is because resistance is based on the fact that areas with long noise free intervals are sensitive to minor changes in air traffic, and thus traffic should be routed over areas that are already highly fractured. In this case,

areas that already have air traffic would continue to bear the brunt of resource damage, allowing the most pristine acoustic environments of the park to remain intact.

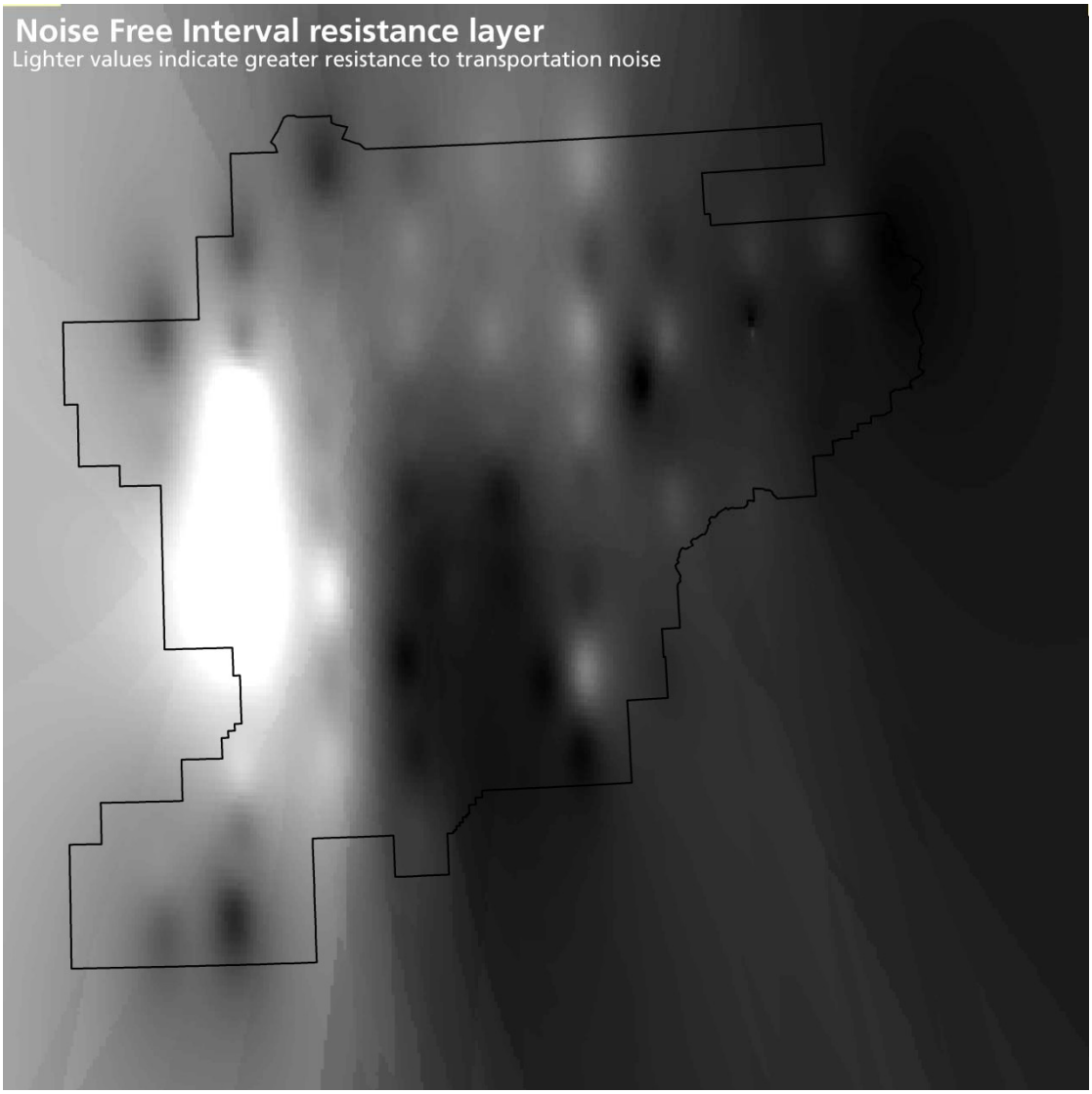


Figure 5. Noise Free Interval resistance layer: lighter values indicate greater resistance to transportation noise. This would suggest that aircraft routing remain largely the same, especially in the areas between the Kahiltna and Ruth glaciers.

Backcountry use statistics and noise free intervals are just two of many different ways of assigning resistances to aviation transport. Which strategy is best? That depends entirely on the basis of each claim. After reviewing both layers, it should be apparent that a wide range of conflicting rationales can be applied to mitigating impacts from Denali's aviation transportation network. Deciding which should be prioritized is a complex decision.

Unless the overall aviation traffic volume over the park is reduced, displacement in free space is the primary mitigation technique available to park stewards. The most substantial mitigations enacted for the park thus far – the Denali Overflights Advisory Council aviation best practices – required the council to weigh certain routing displacements over others. (DOAC 2012)

Once a weighting network of resistance layers has been distilled from public and expert opinion, it is possible to use them to envision idealized flight corridors. One useful tool for this purpose is the cost-distance modelling software *Circuitscape* (www.circuitscape.org,) which uses electrical theory to describe the travel of electrons over a semiconductor. This is analogous to a pilot with knowledge of areas resistant to noise who utilizes this knowledge while conducting their flight operations. Results of a *Circuitscape* analysis include all the possible routes a pilot might fly, but highlight stewardship-friendly corridors. It allows us to see the conclusions that follow from our rationale.

The following is an example weighting network that can be used as an input for *Circuitscape*. The weights are chosen in this case to produce a result that is realistic while avoiding the influence of hard, discrete edges. It balances nine data sets with widely varying rationales to produce a final summation that can be used to visualize flight corridors.

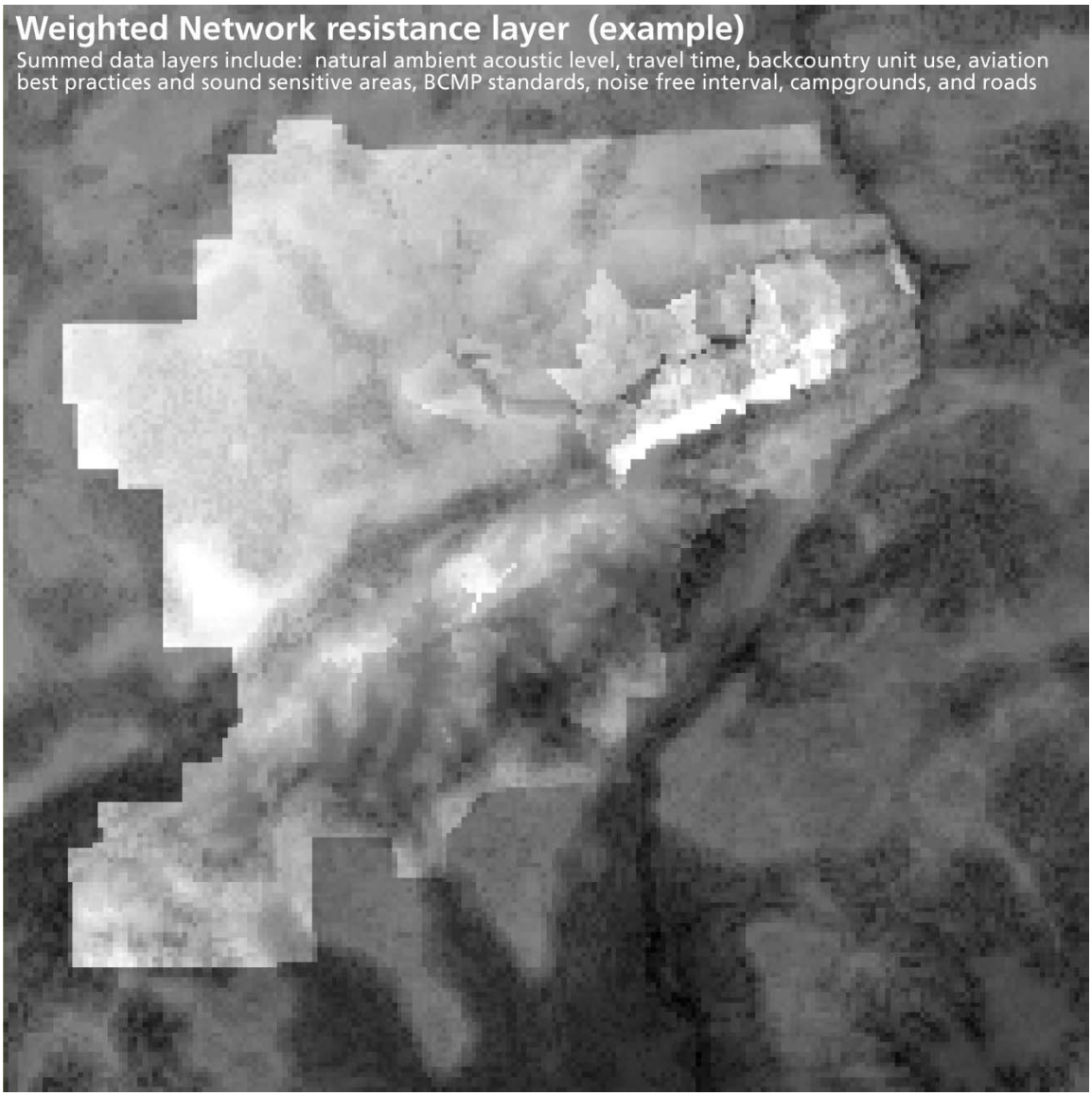


Figure 6. Example of a weighted network resistance layer. Summed data layers include: natural ambient acoustic level, travel time, backcountry unit use, Denali Overflights Advisory Committee aviation best practices and sound

sensitive areas, BCMP standards, noise free interval, campgrounds, and road corridors. The hard edges of polygon features are especially prominent in the final sum.

Dataset Name	Description of Dataset	Rationale Statement for Noise Resistance	Weight
Natural Sound Pressure Level (Median, L50)	Typical ambience of the natural acoustic environment. (Modelled)	"Listening area is reduced in more energetic acoustic environments, reducing the impact of human activities." *Less natural energy = higher resistance.*	50%
Travel Time	Estimated travel time on foot from portal areas. (Modelled)	"Backcountry users travelling in more remote areas of the park have a greater motivation to find solitude." *Greater travel time = higher resistance.*	25%
Backcountry User Days	Utilization of backcountry units of the park. (Empirical)	"Areas with a greater amount of backcountry users should be preferrentially avoided." *More users = higher resistance.*	15%
Denali Overflights Advisory Council: Aviation Best Practices	Best-practices for mitigating acoustic impacts from aviation. (Federal Advisory Committee)	"Best-practices identified by the Denali Overflights Advisory Council should be fully implemented." *Areas affected by best-practices = high resistance.*	10%
Backcountry Management Plan Soundscape Standards	Soundscape standards by spatial region of the park. (GMP)	"Adherence to NPS policy should be prioritzed." *Lower impact management zone = Higher resistance.*	5%
Noise Free Interval	Average amount of time before experiencing the next noise disturbance. (Empirical, interpolated)	"Areas with longer noise-free intervals are more sensitive to fracturing due to increases in air traffic." *Greater noise-free interval = higher resistance.*	5%
Campground Locations	Buffered campground areas. (Empirical)	"Campgrounds are places where many people spend time resting, and should be preferrentially avoided." *Closer to campground = higher resistance.*	5%
Roads	Buffered road network. (Empirical)	"Roads are already impacted by noise, so aviation noise will have a lesser impact in proximity to roads." *Beyond road noise footprint = high resistance.*	3%
Denali Overflights Advisory Council: sound sensitive areas	Areas identified by the Denali Overflights Advisory Council as noise sensitive, banded into three categories: low, medium, high. (Federal Advisory Committee)	"Sound sensitive areas should be preferrentially avoided." *Higher sensitivity band = higher resistance.*	2%

Table 1. Description of noise resistance rasters that were used to show how varying rationales can be balanced to produce an overall weighted noise resistance layer.

Once the weighted resistance layer has been created, *Circuitscape* is used to recognize ideal flight corridors. Airports with commercial use represent sources of electrical potential, and include: Talkeetna, Healy, McKinley Public / ERA helipad, McKinley Private, Cantwell, and Kantishna. The sink (ground) of electrical potential is the Denali massif. For the example weighting network in this document, the following map was produced:

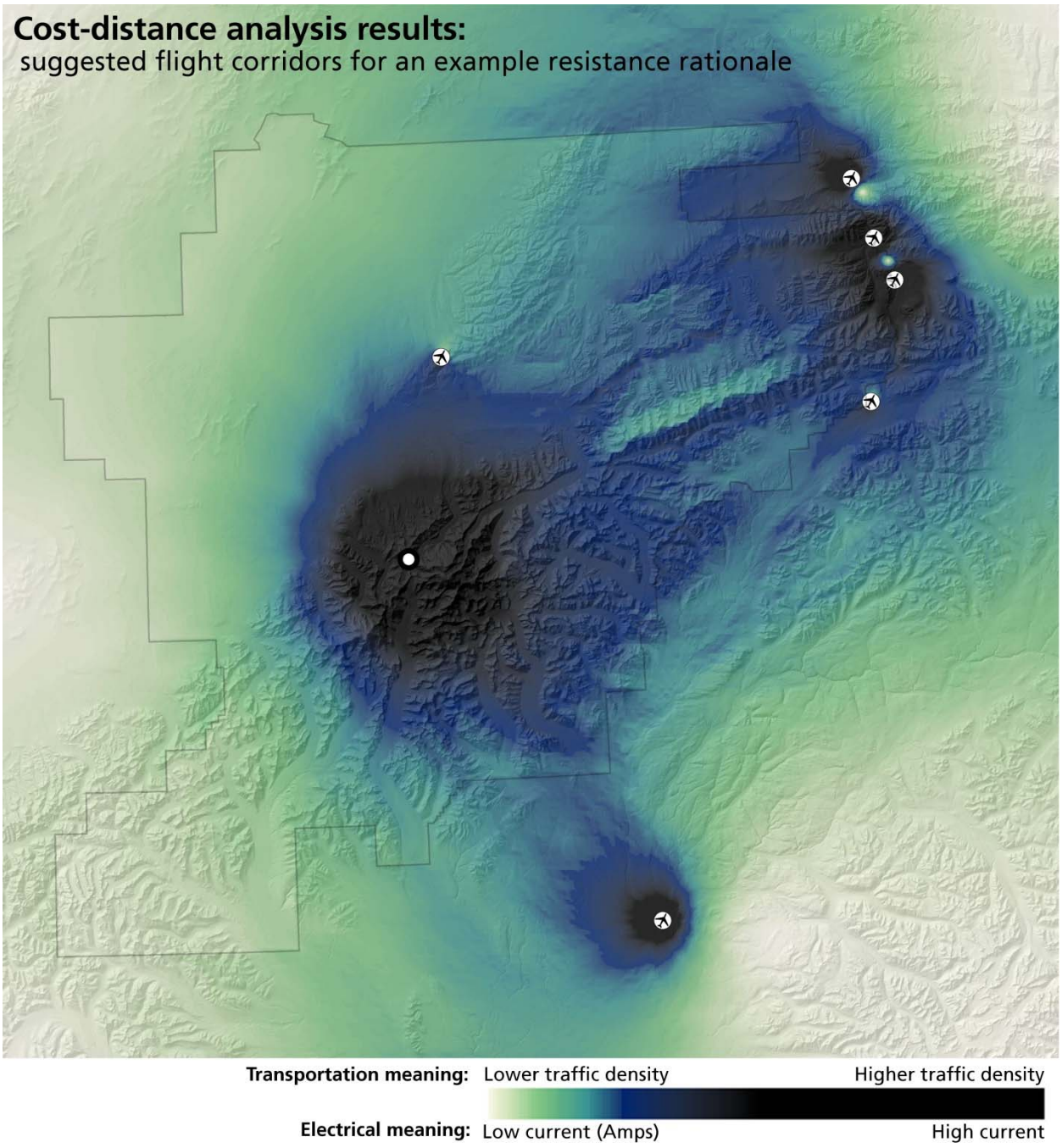


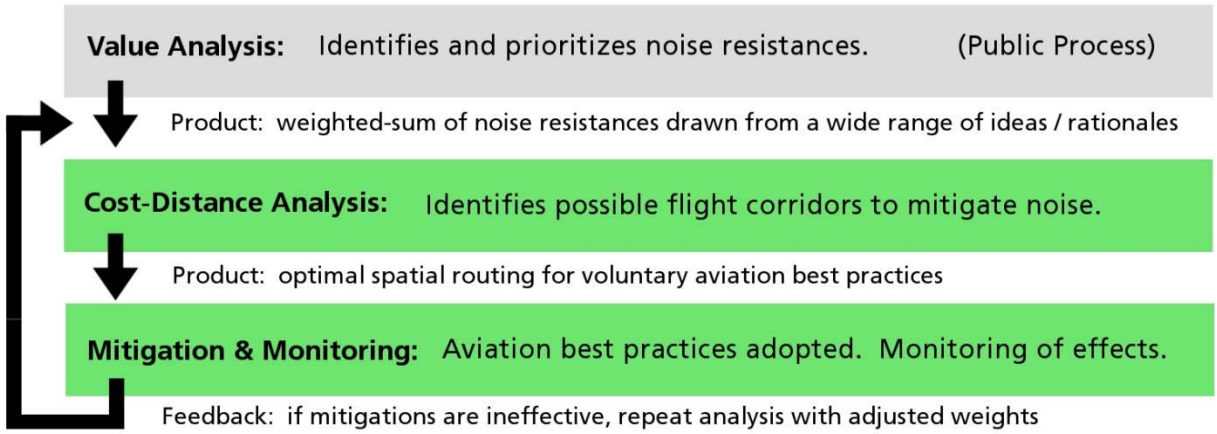
Figure 7. Cost-distance analysis results. This graphic shows current flow from electrical sources (airports) to an electrical sink (the Denali massif.) This is analogous to air traffic density.

What does the model show? It represents air traffic density as an analogy to electrical current – the greater the current, the greater the air traffic density. As a model, it is an imperfect representation of reality, but this example representation does identify flight corridors that follow from the input rationale. (These corridors include: the Denali park road corridor, the Denali Fault, a route along the outer range, and one that connects Broad Pass to the Eldridge Glacier.) Obviously the map in Figure 7 fails to capture public opinion, and for that reason it is incomplete, but the technique stands as a meaningful strategy to approach these complex decisions.

Conclusion

Data from the Denali Soundscape Inventory describe the park's acoustic environment at a landscape scale. These data can be used for many purposes but their most critical is to provide a baseline from which to monitor the effects of future noise mitigation efforts.

In the preceding section we described a cost-distance analysis technique that could be utilized to identify the most beneficial long-term mitigations for the acoustic environment. Such corridors represent opportunities for park management and the aviation community to work together as stewards. What has not been identified in this document is the "value analysis" process by which public and expert opinion can be synthesized into an appropriate weighted resistance layer for cost-distance analysis. The overall strategy may follow a form similar to this:



An informal version of this same process was used to by the twelve members of the Denali Overflights Advisory Council to develop an initial suite of aviation best practices from 2007 – 2012. Some of these best practices have produced substantial positive changes for the park, but others have failed to be acoustically effective due to their extent or timing. The strategy described in this document could be used to open the doors of conversation and improve the effectiveness of the mitigations to protect Denali's acoustic environment.

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Denali National Park and Preserve
Long-Range Transportation Plan

Appendix C: Denali Park Road Risk Assessment Utilizing the Unstable Slope Management Program

Denali National Park and Preserve – Long Range Transportation Plan

Deterministic Geologic Risk Assessment of the Denali Park Road Utilizing the Unstable Slope Management Program

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Prepared: 08/03/16

Revisions: none to date

Introduction and Project Status

The 92-mile Denali Park Road traverses a highly active geologic landscape and has experienced numerous documented mass wasting events throughout the history of the road. One of the most dramatic occurred in late October 2013 when a 600-ft-long, 110-ft-wide debris slide blocked the road near MP 38. Blocks of permafrost-frozen, unconsolidated debris up to 15 ft thick slid on weak, unfrozen clay. Frequent but less dramatic events: block traffic, undermine road surfaces, and may cause damage to vehicles or injuries. Many events, including the example above, are likely triggered or exacerbated by thawing permafrost and are consistent with the possible effects of anthropogenic climate change. With increases in road use, the uncertain effects of climate change, and possible changes to maintenance funding levels, National Park Service (NPS) and Federal Highway Administration (FHWA) staff identified the need for a comprehensive risk analysis of geologic hazards along the Denali Park Road.

The risk analysis is scheduled for completion by March, 2017 and includes five parts: (1) inventory maps and linked database that illustrate spatial/temporal distribution of geohazards, their relative activity, and geomorphic attributes; (2) beta testing and implementation of the Unstable Slope Management Program (USMP) rating criteria; (3) geohazard susceptibility models that estimate the spatial probability of occurrence; (4) geohazard risk models that illustrate the potential consequences; and (5) analyses/recommendations to park management regarding other risks the road will exhibit over the next decade (DENA-MOA-208813A/B). Currently, tasks 1 and 2 are predominately complete, tasks 3 and 4 are underway and task 5 will follow the completion of tasks 1-4. Although final results and recommendations are still forthcoming, the results of tasks 1 and 2, in particular the USMP ranking scores (discussed below), provide an inventory and a first-order, deterministic risk assessment of geologic hazards currently affecting the park road.

The results of the USMP rating criteria provide valuable information on the spatial distribution of geologic hazards, their severity, and the associated risk; however, they do not directly assess the possible impacts of climate change or provide a detailed outlook of possible future scenarios. We utilize these data to provide a preliminary identification of the areas with the highest relative risk and their spatial patterns. Consideration of this information should be valuable to this Long Range Transportation Plan (LRTP) and for park managers and planners as future infrastructure plans are being developed.

Unstable Slope Management Program Site Rankings

The USMP is a collaboration between the FHWA, many other federal agencies including the NPS, private geotechnical consultants, and the Alaska Department of Transportation & Public Facilities (AKDOT) that ranks geologically unstable slopes for the purpose of facilitating more effective long-term geotechnical asset management. USMP scores provide a deterministic ranking of agency risk associated with any particular geologic hazard site. These scores consider elements of both the severity and frequency/probability of a hazard and the exposure and vulnerability at each particular site. Example elements include: the amount of roadway affected by landslide events, the frequency of known hazard events, the impact of events on the use of the transportation corridor, the maintenance cost and complexity, and annual average daily traffic. For detailed information the USMP ranking criteria please see: (http://nl.cs.montana.edu/usmp/RatingManual.pdf).

We have currently completed a total of 141 USMP site rankings along the entire 92 miles of the DENA Park Road (Figure 1). These data represent the vast majority of known geologic hazard sites and include: landslides, debris flow drainages, rockfall areas, frost-heaves, and erosional undercutting due to fluvial processes. It should be noted, however, that these site rankings are not totally comprehensive; instead, they represent our most complete knowledge as of 06/29/2016. The DENA USMP rankings range from 164 to 948 with a mean value of 328 and more variance within higher ranking sites. To put these values in perspective immediately however, the USMP qualitatively defines sites that score less than 200 to be in “good” condition, sites that score between 200 and 399 to be in “fair” condition, and sites that score 400 or higher to be in “poor” condition.

In theory, sites in poor condition are more likely to pose persistent and/or more serious problems along the road and areas of higher risk density are more likely to see a higher concentration of problems. In DENA, the current majority of our sites, 67%, rank in fair condition, while only 9% are in good condition, and a relatively large number of sites, 24%, are in poor condition. The only significant outlier was the “Pretty Rocks” slump (Figure 3b) with a score of 948; 365 points higher than the next highest site. Spatially, regions of higher USMP risk density (Figure 2) are most pronounced along Polychrome Pass and the Eielson Bluffs areas. Individual USMP scores represent the relative risk associated with a hazard site and risk density represents the relative concentration of agency risk.

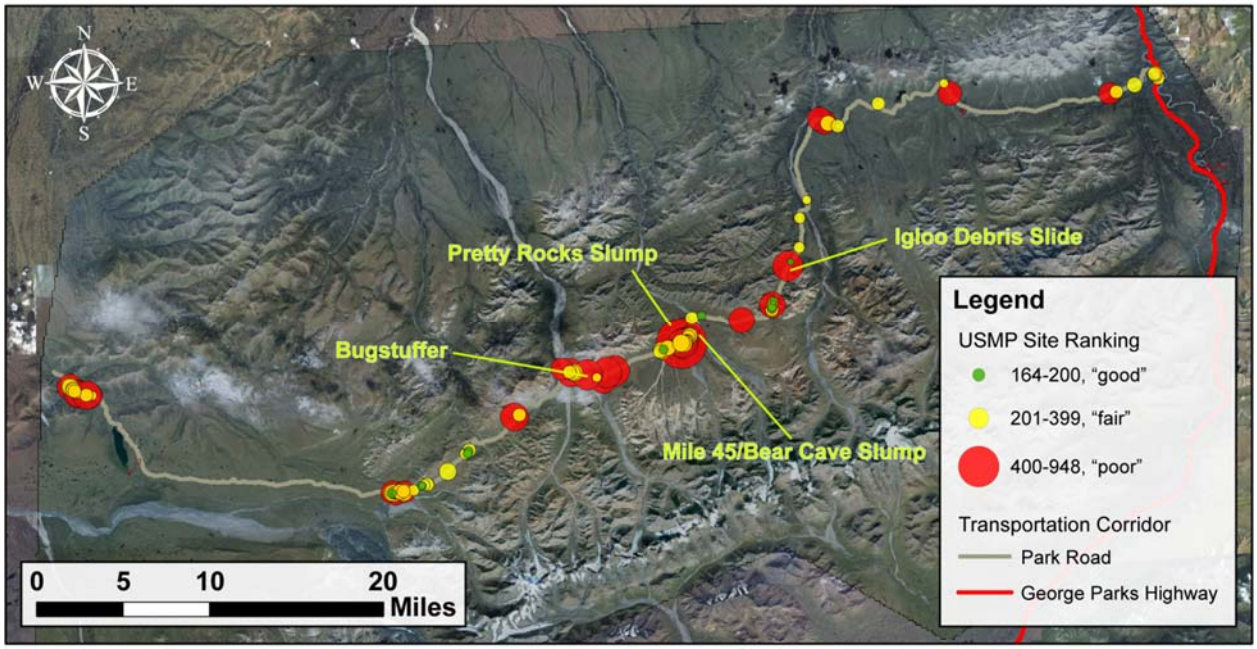

Figure 1. DENA USMP site rankings on IKONOS imagery. Icon sized is scaled by individual site rank and colored according to good, fair, or poor qualitative rank.

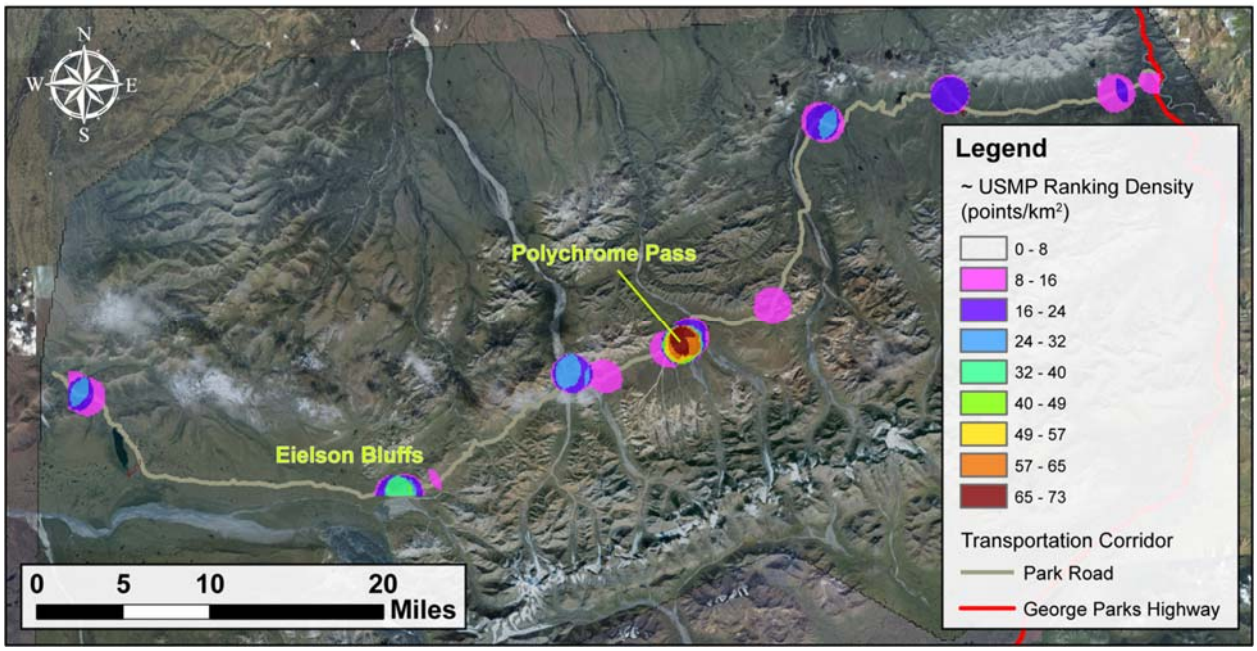

Figure 2. DENA USMP score density on IKONOS imagery. Density scaled by linear concentration and site ranking scores.

Of the sites ranked in poor in condition along the Park Road, many received prior mitigation, or were previously identified as areas of concern by maintenance or resource management personnel. Some previously noted severe geologic hazard sites in 'agreement' with poor USMP scores include: the "Pretty Rocks" slump (Figure 3a), debris flow activity at "Bugstuffer" creek (Figure 3b), the "Bear Cave/Mile 45" slump (Figure 3c), and the "Igloo Debris Slide" (Figure 3d). Additionally, Polychrome Pass is a known area of high geologic hazard occurrences. This general agreement of USMP scores and professional

judgement/institutional knowledge within DENA should be reassuring to park managers and help demonstrate that the USMP ranking scores represent useful information and are based off of many years of development from similar programs and expertise developed by FHWA, AKDOT, Oregon Dept. of Transportation, and private firms. The USMP provides an institutional framework for tracking these known problem areas and has identified other new examples.

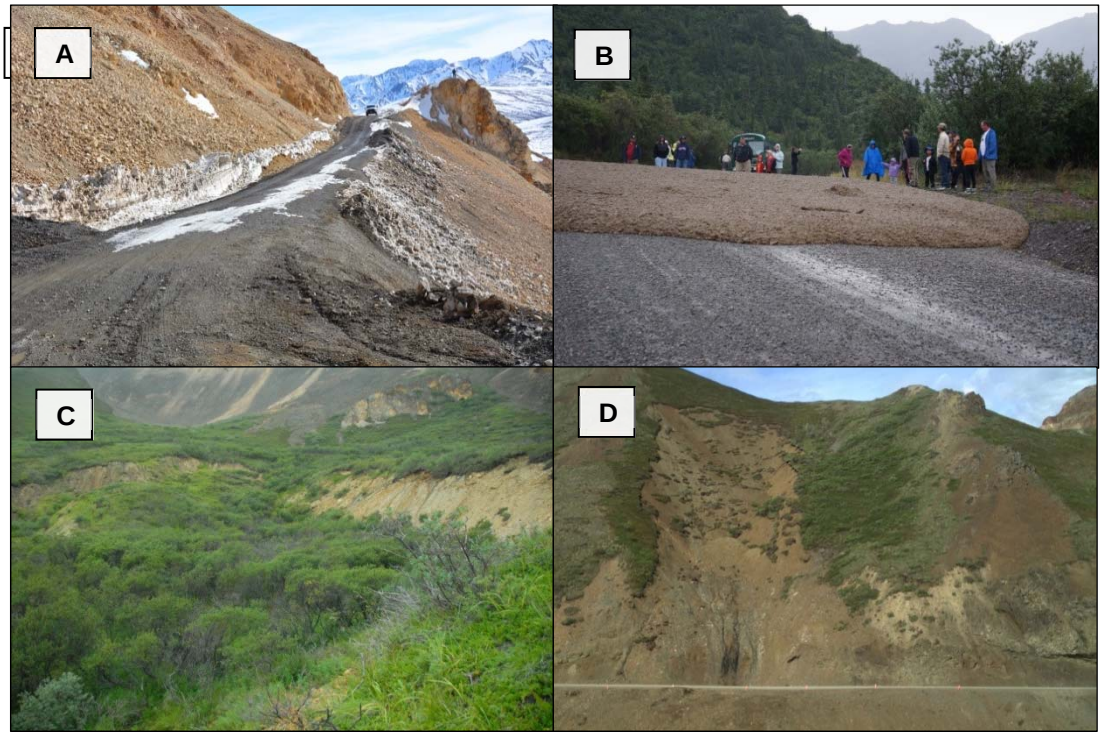

Figure 3. Previously recognized sites that rank in poor condition. A – Pretty Rocks Slump (mile 45.4, 948 points); B – Bugstuffer debris flow (mile 51.9, 575 points); C – Bear Cave Slump (mile 45, 411 points); D – Igloo Debris Slide (mile 37.7, 514 points).

Current Applications to the LRTP

The USMP rankings provide a preliminary framework for understanding the relative severity of risk associated with geologic hazards along the Park Road. Although we do not currently make recommendations tailored to specific sites or address possible future scenarios, we suggest that an awareness of the current results of the USMP rankings is beneficial to this LRTP. Likely applications of the USMP data to the LRTP would involve spatial analysis of USMP rankings as they relate to possible disruptions in traffic, programming of potential mitigation projects, and overlap with future infrastructure planning. In order to facilitate this analysis we submitted a spatial database of our USMP rankings to PaTINA (they are also available on request). We emphasize that these results are preliminary, yet they provide a method for understanding and considering geologic hazards in a broader context. Park planners and managers should continue to work with resource staff in understanding the

implications of these results; however, the following are potential applications to consider for the current LRTP:

- All geologic hazards sites, but in particular those in poor condition are more likely to pose persistent and/or serious problems along the Park Road. These are areas where the transportation corridor could experience interruptions, or incur high maintenance costs as a result of geologic activity. Sites in poor condition should be considered for mitigation and investigated in more scientific detail (see Future Work).
- The USMP rankings may help identify geotechnical assets where hazards do not appear extremely severe, but may be candidates for mitigation from a risk-based or cost-based perspective. Rockfall sites that are not capable of producing catastrophic roadway failure, but require very frequent maintenance are good examples of this. These sites also rank in poor condition, but may not otherwise receive attention from management.
- Density analysis of USMP site distribution identifies areas of non-discrete geologic hazard areas that may require alternate or more systematic mitigation efforts to increase cost effectiveness. The extreme concentration of hazard sites along Polychrome Pass is an example of such an area.

Future Applications to the LRTP

Both the LRTP and USMP have been designed to evolve as new information become available through time, thus allowing for future applications with as new data become available. Most transportation agencies apply transportation asset management (TAM) systems to transportation assets such as bridges and road surfaces; however, geotechnical assets such as rock slopes and embankments are unlikely to be considered with the same detail (Stanley, 2010). The USMP provides a system for geotechnical asset management by creating a framework to establish potential performance measures, and targets, for individual geologic hazards and the overall transportation corridor (Federal Highway Administration-DRAFT report, 2015). We plan to update USMP rankings for the DENA park road as more information is made available or new events occur, and to perform a systematic re-evaluation once every five years. By tracking USMP rankings over time the following performance measures could be considered by transportation planners and park managers:

- Establish targets to reduce the overall number of fair or poor ranking sites along the park road. This could represent a total percentage reduction, a maximum target number of poor/fair sites, or a certain number of poor/fair sites per unit distance along the road.
- Establish targets to reduce the risk at sites of particular concern (see Future Work)
- A benefit/cost analysis for all geotechnical assets along the transportation corridor could be undertaken. The USMP group is currently working on developing this tool and the effectiveness of programmed mitigation projects could be measured by tracking costs vs performance changes in geotechnical assets recorded by the USMP rankings.

- A method for tracking the performance of assets through time to establish a preferred course of action. As an example, USMP scores at the site of the October 2013 slide that blocked the road (Figure 3d), have been on a downward trend since May 2015 because of relative inactivity while scores at the Pretty Rocks slump (Figure 3a) have remained higher or increased slightly because of recent activity. Establishing trends in USMP scores through time could be useful for determining appropriate mitigation priority.

Future Work

The USMP risk matrix provides a relatively robust assessment of geotechnical assets based on their current condition and a way to track their performance through time. However, because of its deterministic nature, it does not directly consider possible or likely future conditions. We hope to address this limitation through the continued development of the geologic risk assessment. Completion of task 3-5 of the risk assessment will allow us provide data which will help determine the probability of future events based on geologic conditions and the associated risk based on transportation infrastructure and human exposure. The results of tasks 3-5 will allow us to assess the potential outlook of areas of the road based on their probability to experience new events. Additionally, we will expand on the results of the USMP to examine high ranking sites in more scientific depth. Examples of this may include: drilling bore holes at the Pretty Rocks slump to determine sub-surface conditions, examining the relative abundance of fine-grained sediment in debris flow watersheds, or repeat GPS surveys to ascertain motion rates, such as are currently ongoing at the Bear Cave/Mile 45 slump. By using all of these data sets in conjunction we plan to propose specific recommendations and mitigation considerations for sites of concern based on their current conditions and future outlook.

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National Park Service
U.S. Department of the Interior

Denali National Park and Preserve
Long-Range Transportation Plan

Appendix D:
Current and Future Partner Projects

Memo

To:	Denali National Park Long Range Transportation Plan Team		
From:	ATKINS	Email:	
Phone:	720-841-2956	Date:	Sep 19, 2014, Modified August 28, 2017
Ref:		cc:	
Subject:	Possible Foreseeable Projects/Plans near Denali National Park		

Matanuska Susitna Borough LRTP

Source: http://www.matsugov.us/plans/lrtp

This transportation plan assesses growth in the Mat-Su Borough over the next 20 years, and identifies the key elements of the Borough's future transportation system that will be needed to serve its growing communities. The transportation plan will help the residents develop a Borough that is a pleasure to live in, with public infrastructure that supports their daily lives.

Alaska Stand Alone Pipeline (ASAP)

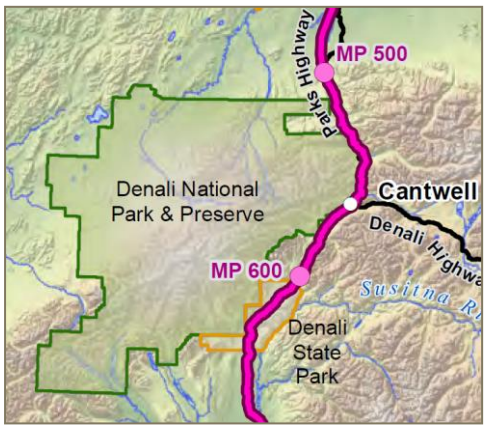
Source: http://www.asapeis.com/

The Alaska Stand Alone Pipeline (ASAP) Project is a 727-mile long, 36-inch-diameter natural gas transmission mainline extending from the GCF near Prudhoe Bay south to a connection with the existing ENSTAR pipeline system in the Matanuska-Susitna Borough. A 29-mile-long, 12-inch-diameter lateral pipeline will connect the mainline to Fairbanks. The proposed pipeline will be buried except at possible fault crossings, elevated bridge stream crossings, pigging facilities, and block valve locations.

The pipeline will bypass Denali National Park and Preserve to the east and will then generally parallel the Parks Highway corridor to Willow, continuing south to its connection into ENSTAR's distribution system at MP 39 of the Beluga Pipeline southwest of Big Lake.

The Alaska District, U.S. Army Corps of Engineers (Corps) has been designated the lead federal agency and the U.S. Bureau of Land Management (BLM), National Park Service (NPS), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS), U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA), and the Alaska Department of Natural Resources State Pipeline Coordinator's Office (SPCO) are participating as cooperating agencies in the Supplemental Environmental Impact Statement (SEIS) development process.

Memo



Alaska LNG project

Source: http://www.arcticgas.gov/alaska-lng-project

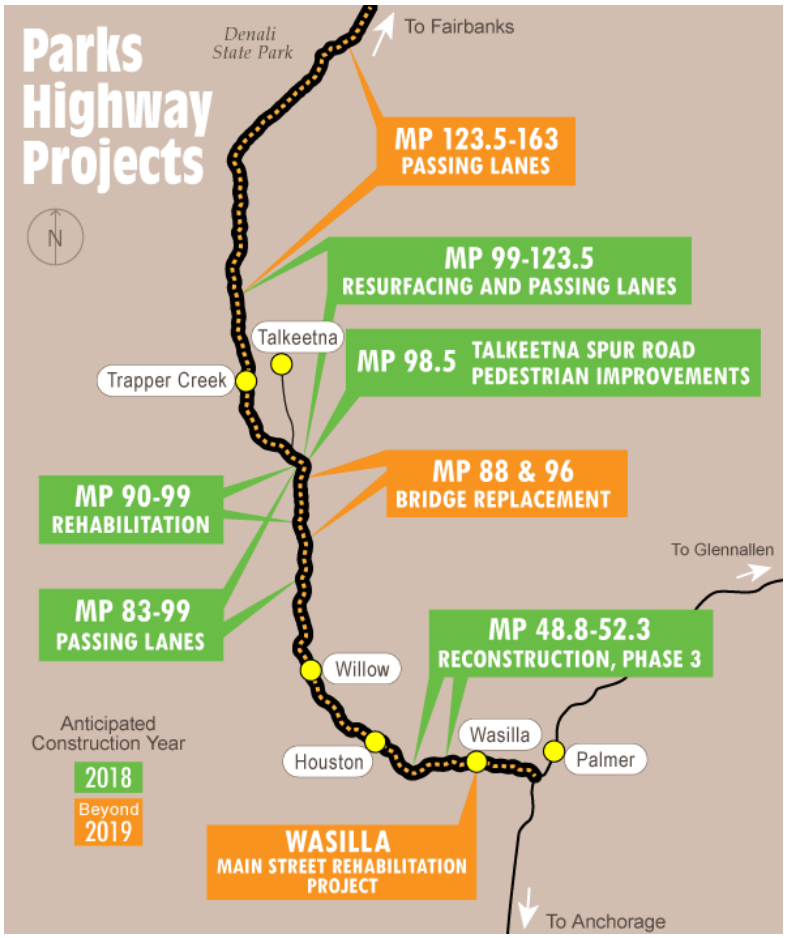
The Alaska LNG export project would be among the world's largest natural gas-development projects. The project is in the pre-front-end engineering and design phase, or pre-FEED. The project consists of constructing a 58-mile pipeline from Point Thomson gas field to Prudhoe Bay and 800-mile pipeline from Prudhoe Bay to Nikiski.

DOT Parks Highway Projects

Source: http://dot.alaska.gov/parks2014/

The Alaska Department of Transportation and Public Facilities is performing road construction on the Parks Highway during the construction season. Work includes turn lanes, passing lanes, re-surfacing, bridge repairs.

Memo



ADOT&PF Area Plans

Source: http://www.dot.alaska.gov/stwdplng/areaplans/area_regional/index.shtml

These are regional, multi-modal transportation plans developed for specific areas of the state, designed to address movement between communities in the region, and from the region to points beyond. Each of these plans incorporates economic modeling to evaluate potential projects and prioritize them to best meet state and regional goals. Denali National Park is partially included in the Interior Alaska Transportation Planning Area. The most recent plan for this area was adopted in 2010. The plan includes transportation impacts to topic areas that include:

- Gas Pipeline
- Mineral Development
- Military Training
- Railroad Development
- Tourism

Memo

The Plan examines potential impacts of these and other developments to highways, rail, aviation and local community roads, and although the plan did not fiscally constrain priority projects, several projects were identified as short-term capital improvement needs. Among these projects were recommendations for improvements on the George Parks Highway in the area of Denali National Park. This project as described by the plan includes passing lanes from MP 113 to MP 163 for an estimated cost of $15 million.

Alaska Railroad – Healy Canyon

Source: http://alaskarailroad.com/Portals/6/pdf/projects/2012_01_04_Healy_Canyon_Stabilization_FS_PROJ.pdf

Work is being proposed in Healy Canyon, between Denali Park Station at Milepost (MP) 348 and Healy (MP 358). The Alaska Railroad has proposed projects to:

- Stabilize the track bed (ongoing)
- Control the rock fall problems
- "Daylight" (remove the top) Moody Tunnel at MP 353.6 (complete).
- Realign tracks around Garner Tunnel (complete).
- Realign the tracks to enhance safety at MP 353.6 (Moody Tunnel) and MP 357 (complete).

Proposed Susitna-Watana Dam

Source: http://www.susitna-watanahydro.org/project/project-description/

Susitna-Watana Hydro could be a large hydro project on the Susitna River, upstream of Denali National Park. This project would provide long-term stable power for generations of Alaskans and have economic impacts on the area. The project would generate 2,800,000 MWh of annual energy, once it comes online in 2024. The installed capacity is 600 megawatts (MW). Environmental studies are currently underway.

DOT Mile 231 Proposed Pedestrian Project

Source: http://aws.state.ak.us/OnlinePublicNotices/Notices/View.aspx?id=173914

The project scope includes constructing a new pedestrian bridge across the Nenana River, trail connections, a rest area, and intersection improvements. Conceptual designs, preliminary engineering, and environmental studies are currently underway.

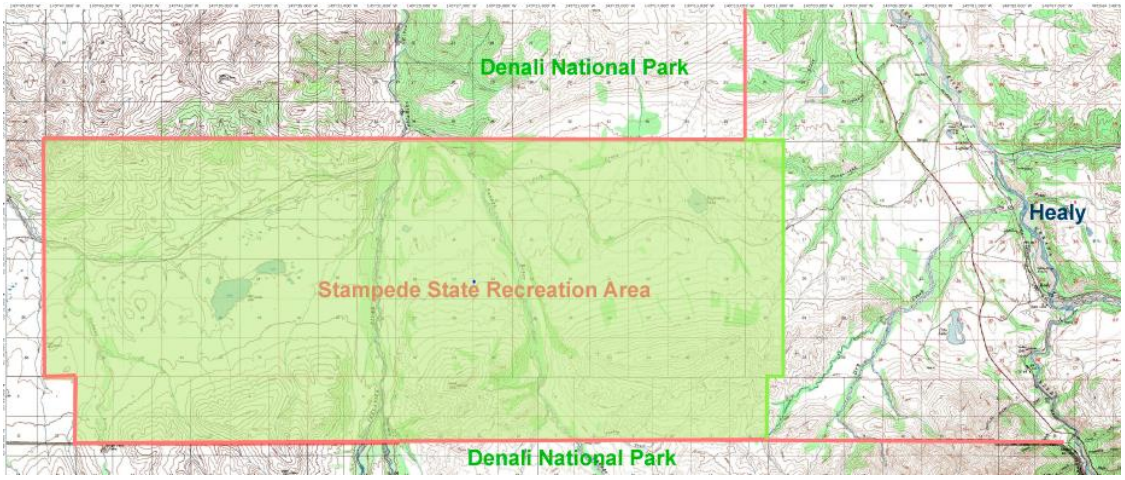
Other Area Energy Projects (Wind, Coal, Natural Gas exploration)

Eva Creek Wind Project: Eva Creek is the largest wind project in Alaska at 25-megawatts. It is located 14 miles from Healy at the top of the 10-mile Ferry mining road.

Usibelli Coal Mine Exploration License Plan of Operations: Usibelli Coal Mine Inc. has submitted a request to carry out a Coalbed Methane drilling exploration program at a prospect site approximately seven miles east of the town of Healy. The project will consist of a single vertical coal-bed methane exploratory well drilled inside the exploration license area. The exploratory well

will help determine whether sub-surface coal seams contain sufficient quantities of methane gas to justify further exploration in the area. (Source: http://dog.dnr.alaska.gov/Permitting/Documents/2014/Usibelli/Usibelli_LOCI_14_002_Drilling_at_Healy_Creek_Propect_Notice.pdf)

Stampede State Recreation Area: There is a potential designation of a Stampede State Recreation Area west of the Panguingue Creek subdivision. In March 2013, Senator Representative David Guttenberg introduced HB148 in response to requests by the Denali Borough Assembly.



Borough Planning Commissioners are currently working through recommendations for area management which include details of proposed allowed uses and a plan for land management. (Source: http://northern.org/take-action/stampede-state-recreation-area-1)

Air Traffic – Overflights council

Source: http://www.nps.gov/dena/parkmgmt/aoac.htm

The Denali National Park and Preserve Aircraft Overflights Advisory was established in 2007 to consider resource conflicts between aircraft tours and park visitors on the ground. The group is charged with advising the National Park Service (NPS) on ways to mitigate (reduce) sound impacts from aircraft flights over the park, develop voluntary measures for assuring the safety of passengers, pilots, and mountaineers, and achieve desired resource conditions at Denali as outlined in the Backcountry Management Plan (2006).

National Park Service
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Denali National Park and Preserve
Long-Range Transportation Plan

Appendix E: Park Transportation Investment Needs Analysis

Appendix E: Denali National Park and Preserve Park Transportation Investment Needs Analysis

Denver Service Center Planning Division | National Park Service | March 2017

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.

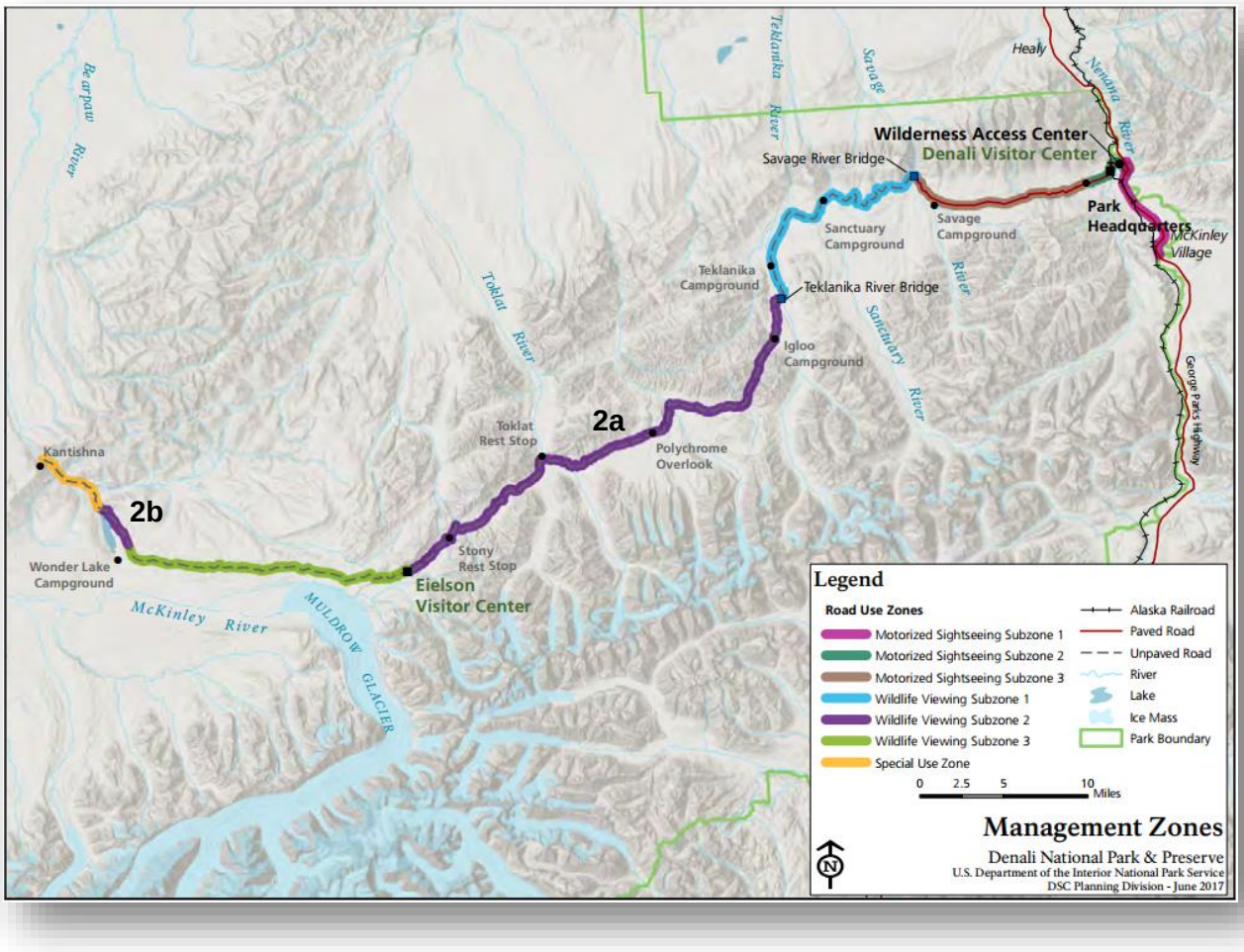

Figure 1. Road segments defined in the Denali Vehicle Management Plan and used as a basis for the PaTINA.

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.

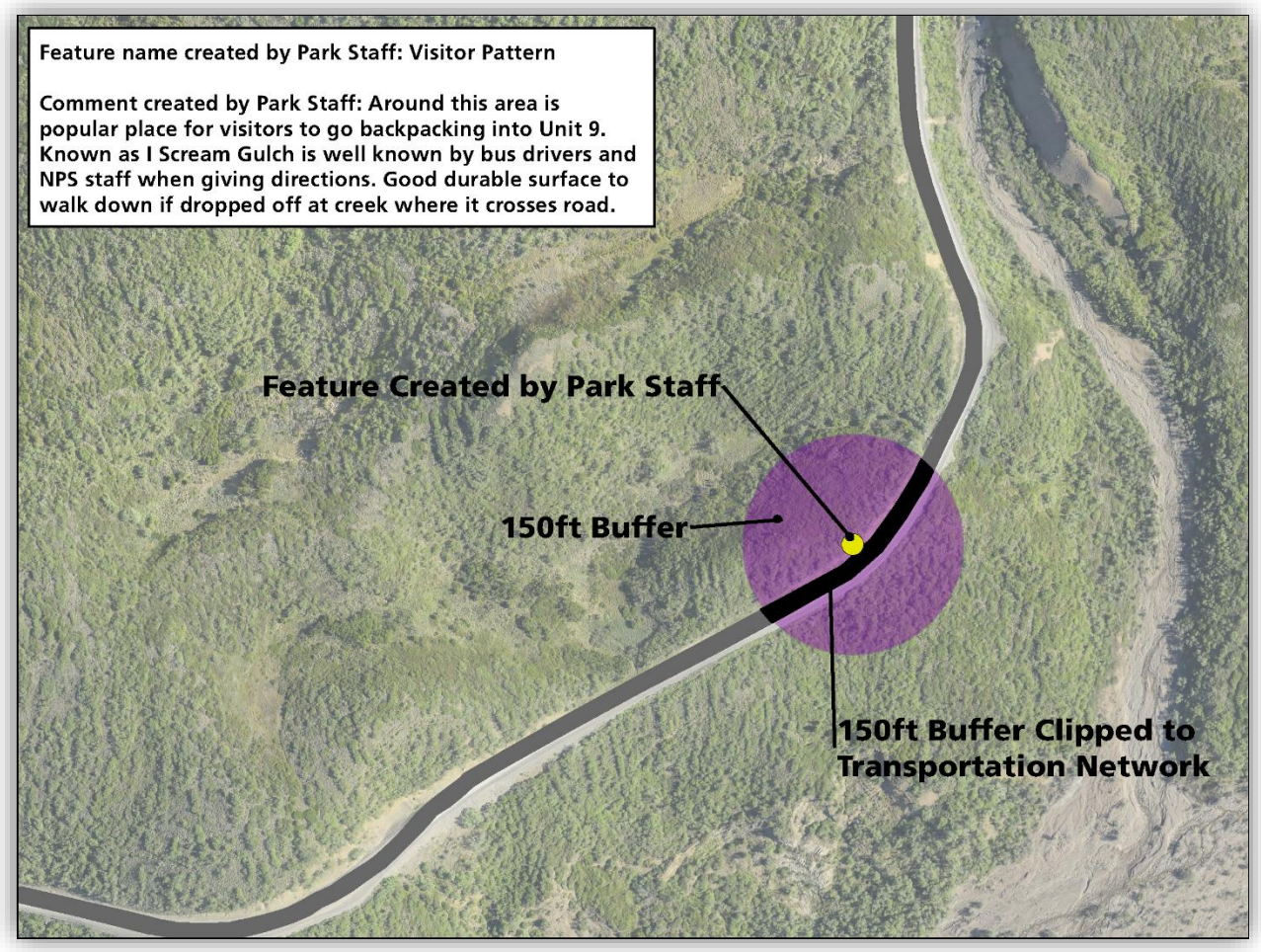

Figure 2. Example of Denali staff input used to create data for the PaTINA.

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.

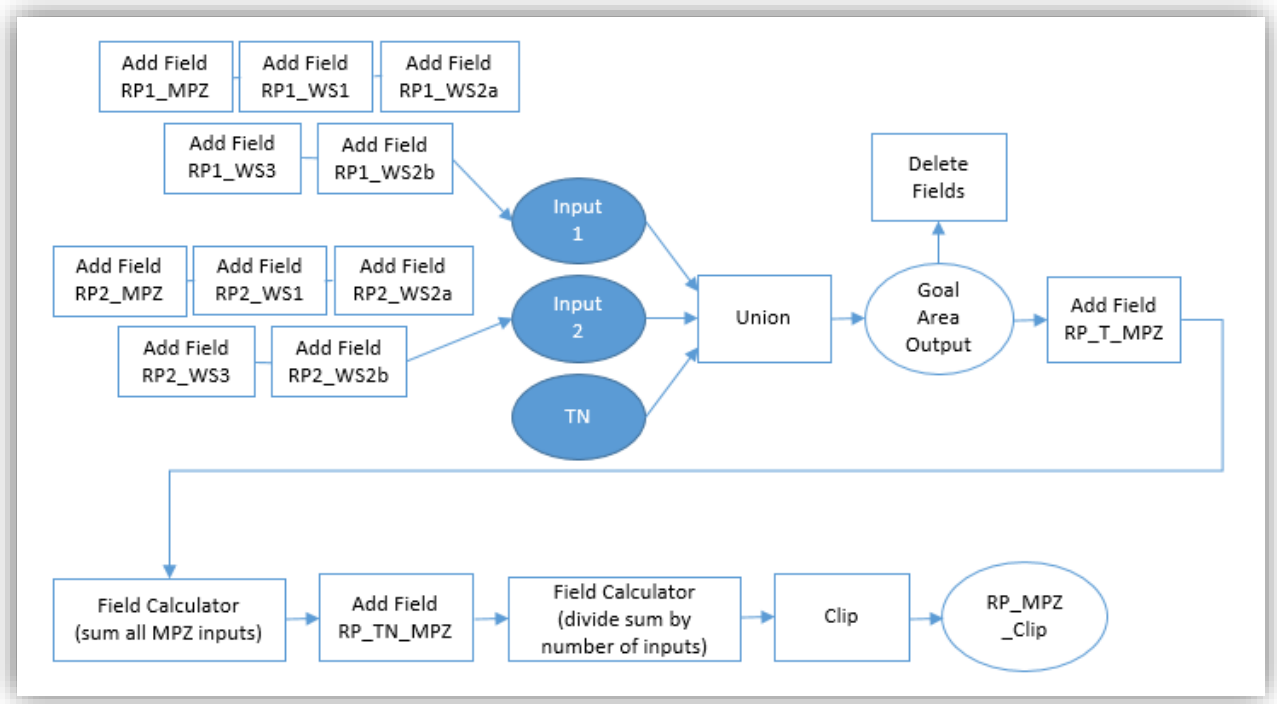

Figure 3. Process diagram for PaTINA steps 1 - 6.

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.

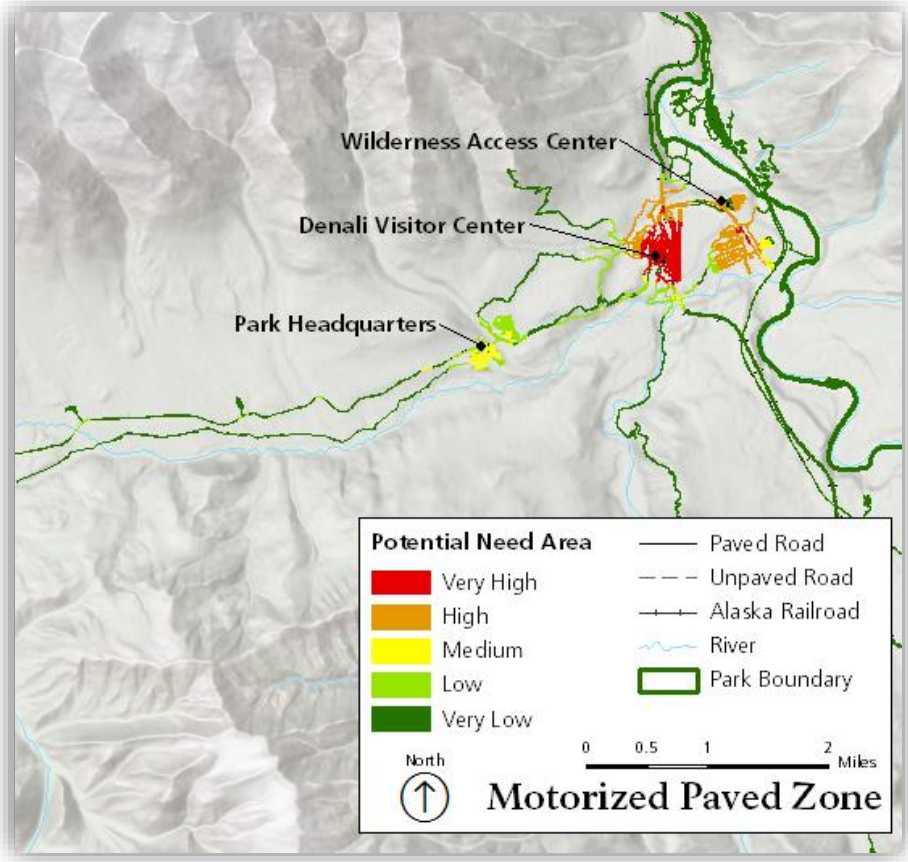

Figure 4. Mapped Potential Need Areas for the Motorized Paved Zone.

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.

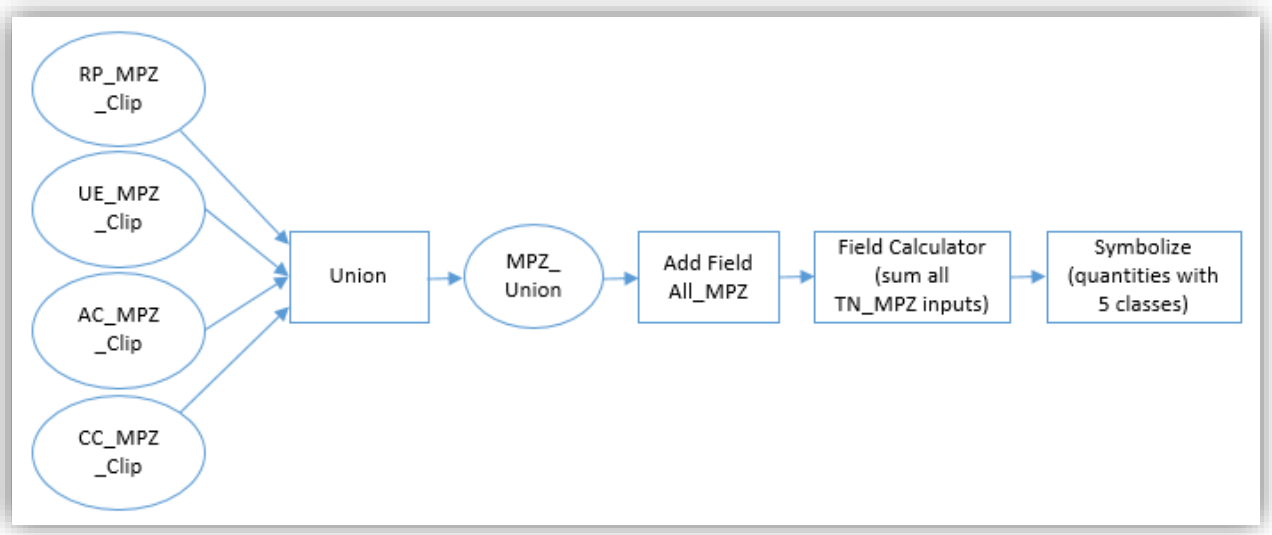

Figure 5. Process diagram for PaTINA steps 7-9.

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.

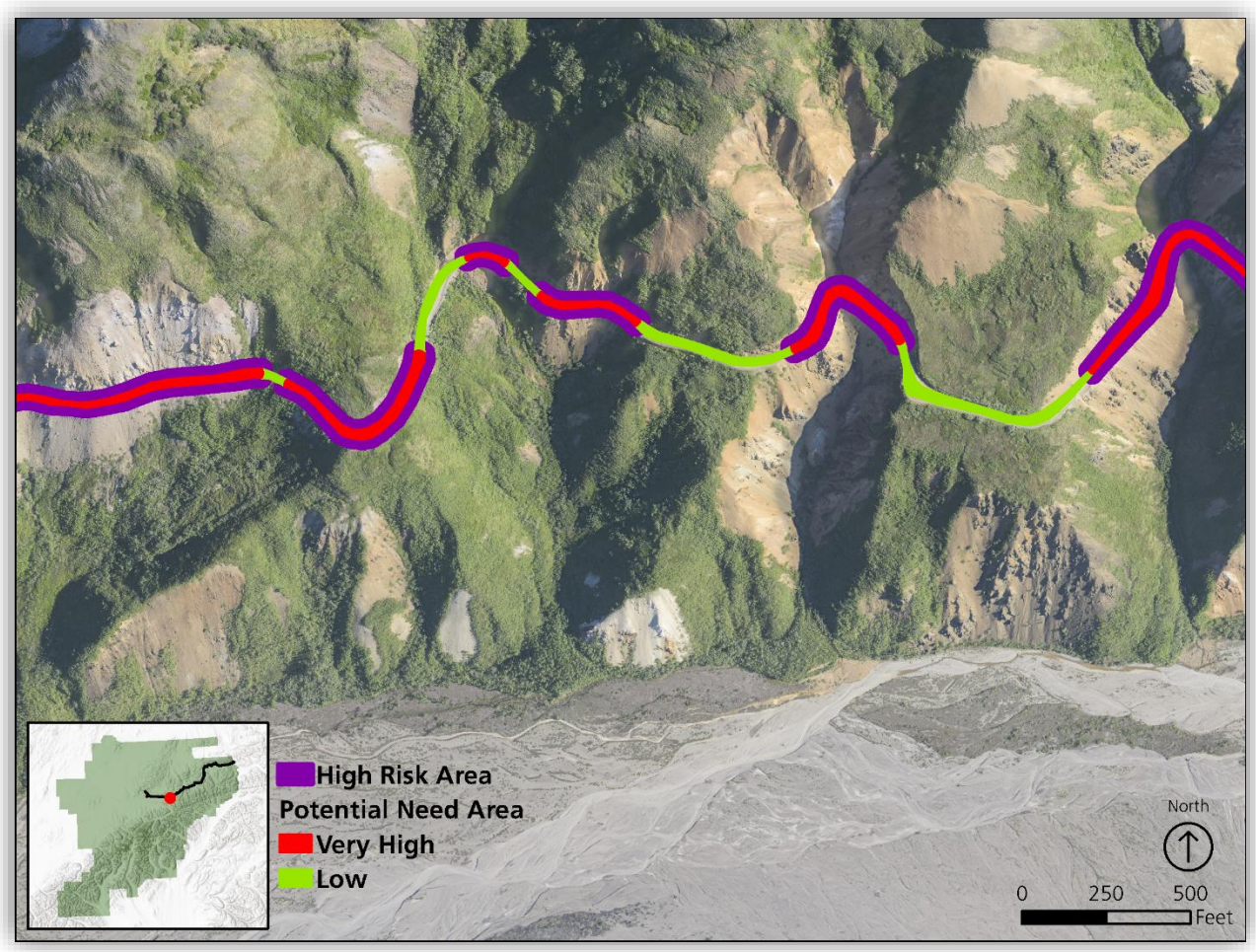

Figure 6. High Risk Areas shown with Potential Need Areas modeled in the PaTINA.

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.

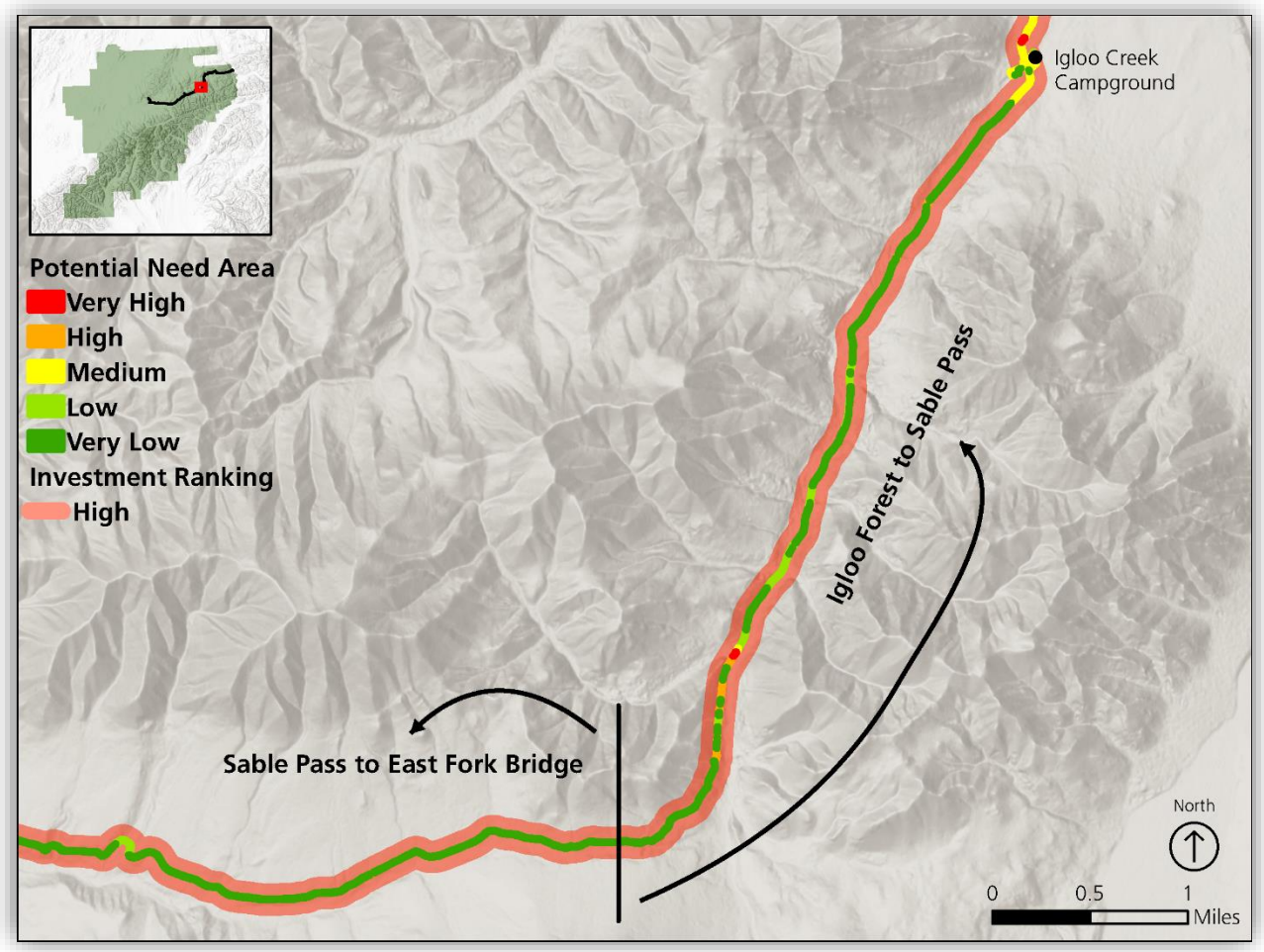

Figure 7. Example PaTINA-modeled Potential Needs Areas shown with investment ranking data.

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.

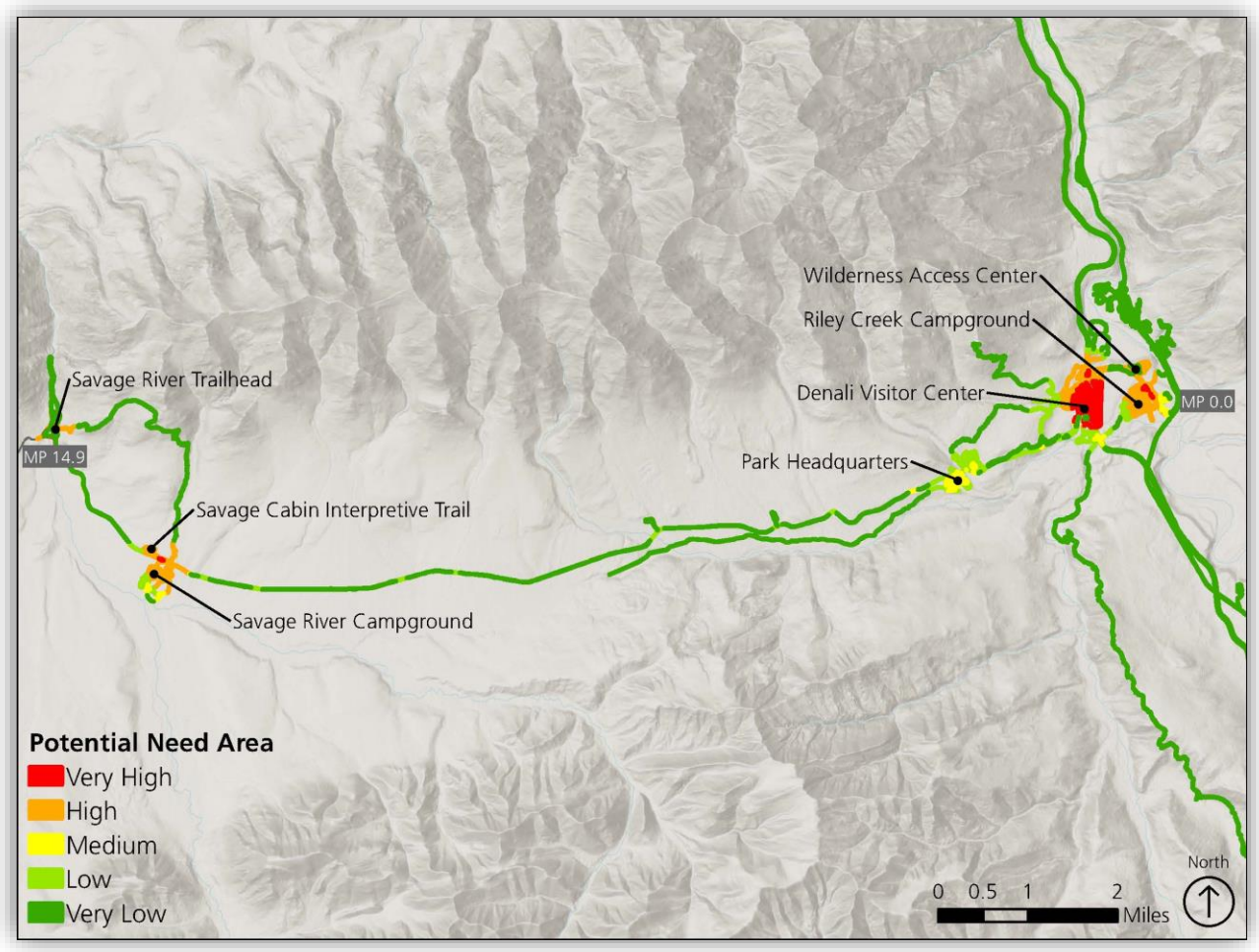

Figure 8. PaTINA-modeled potential need areas for the Motorized Paved Zone segment of the Park Road.

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.

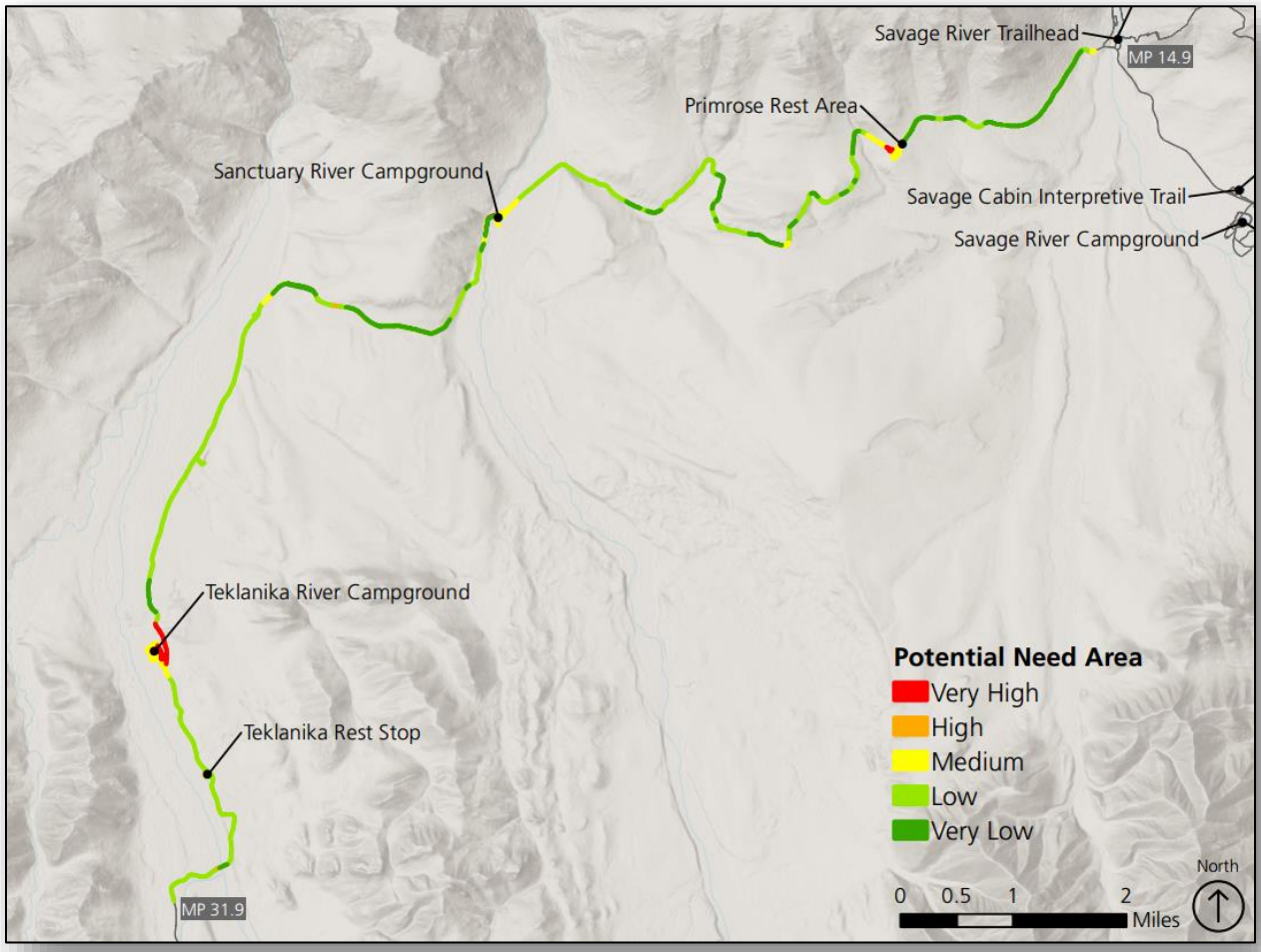

Figure 9. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 1 segment of the Park Road.

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.

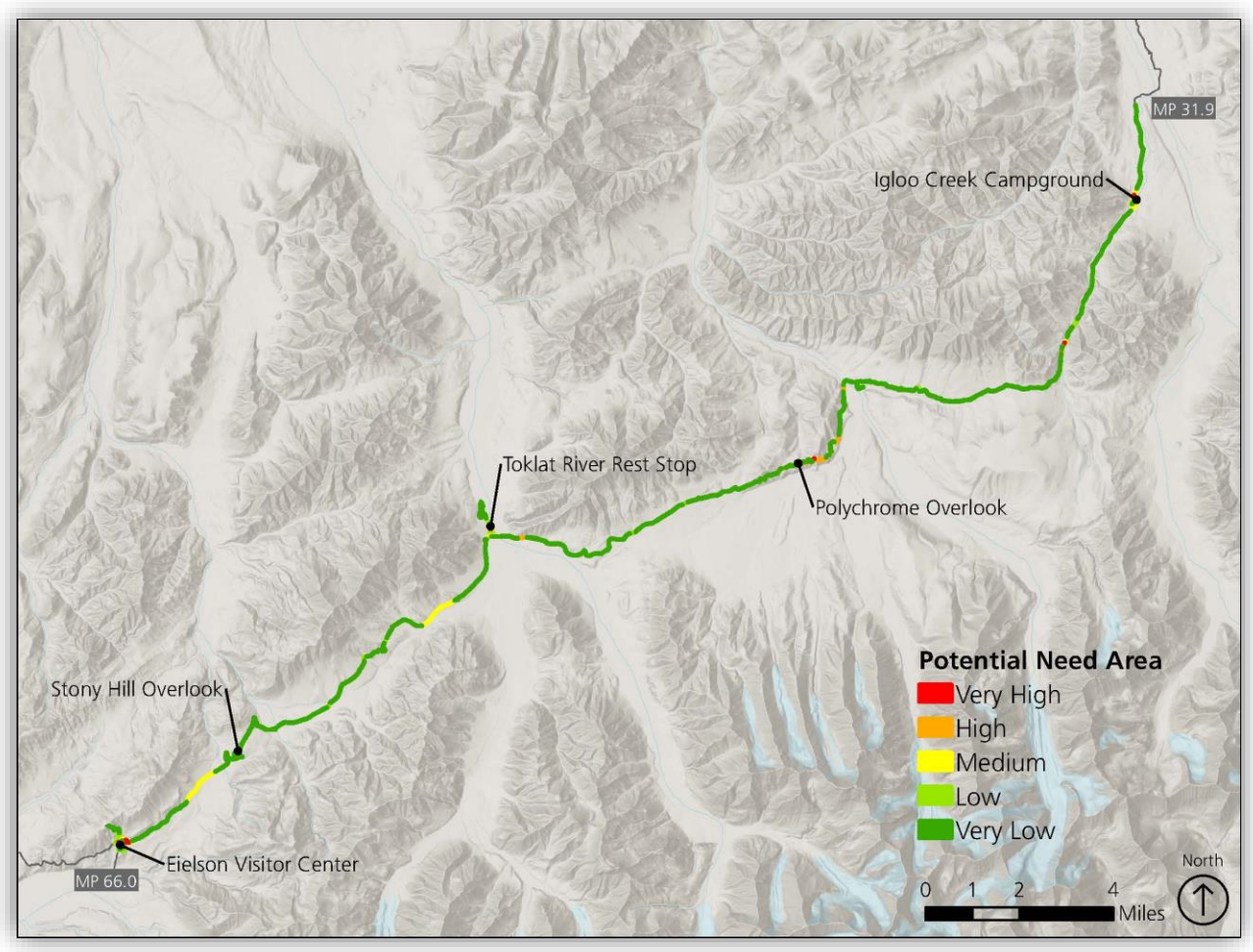

Figure 10. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 2 segment of the Park Road.

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.

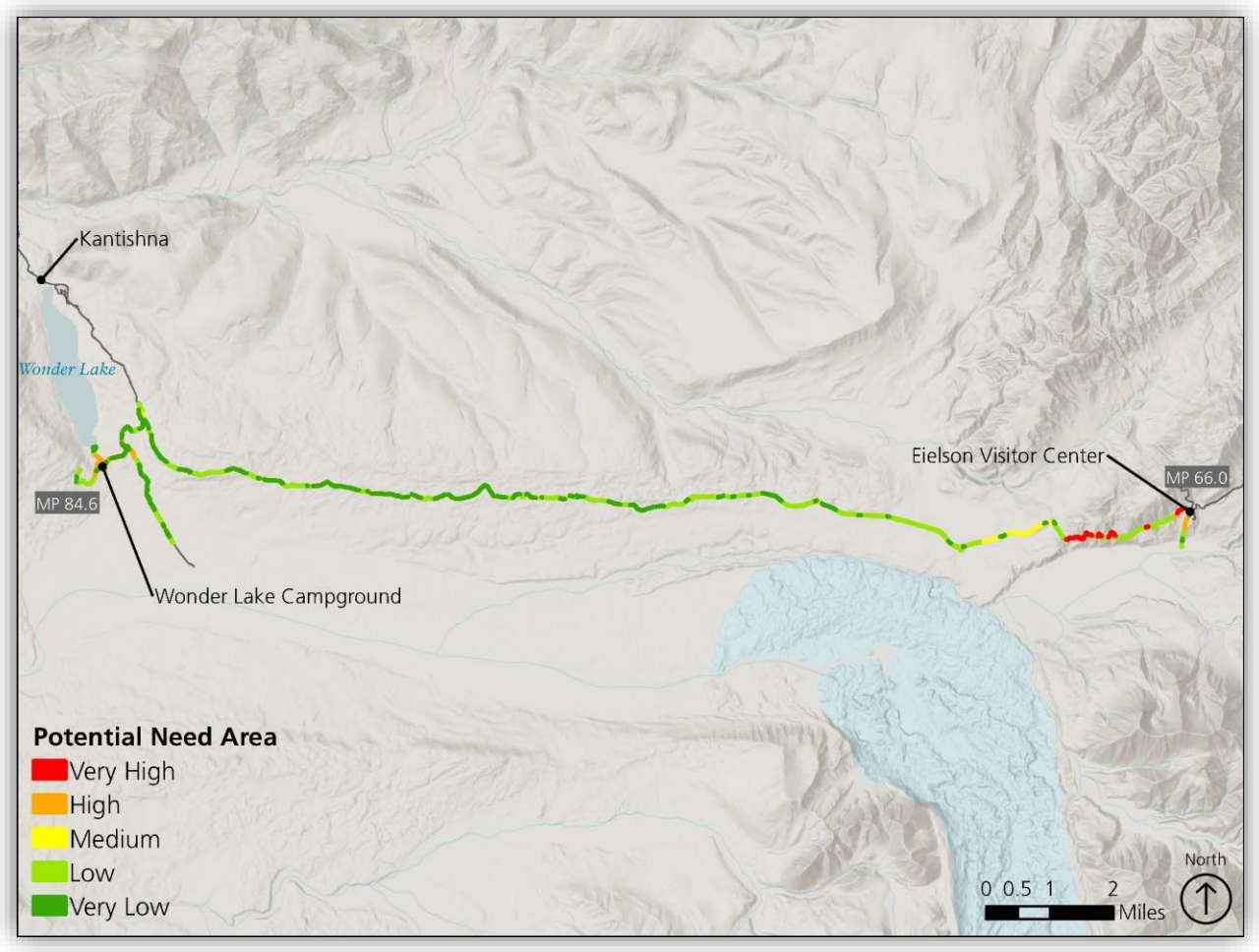

Figure 11. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 3 segment of the Park Road.

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.

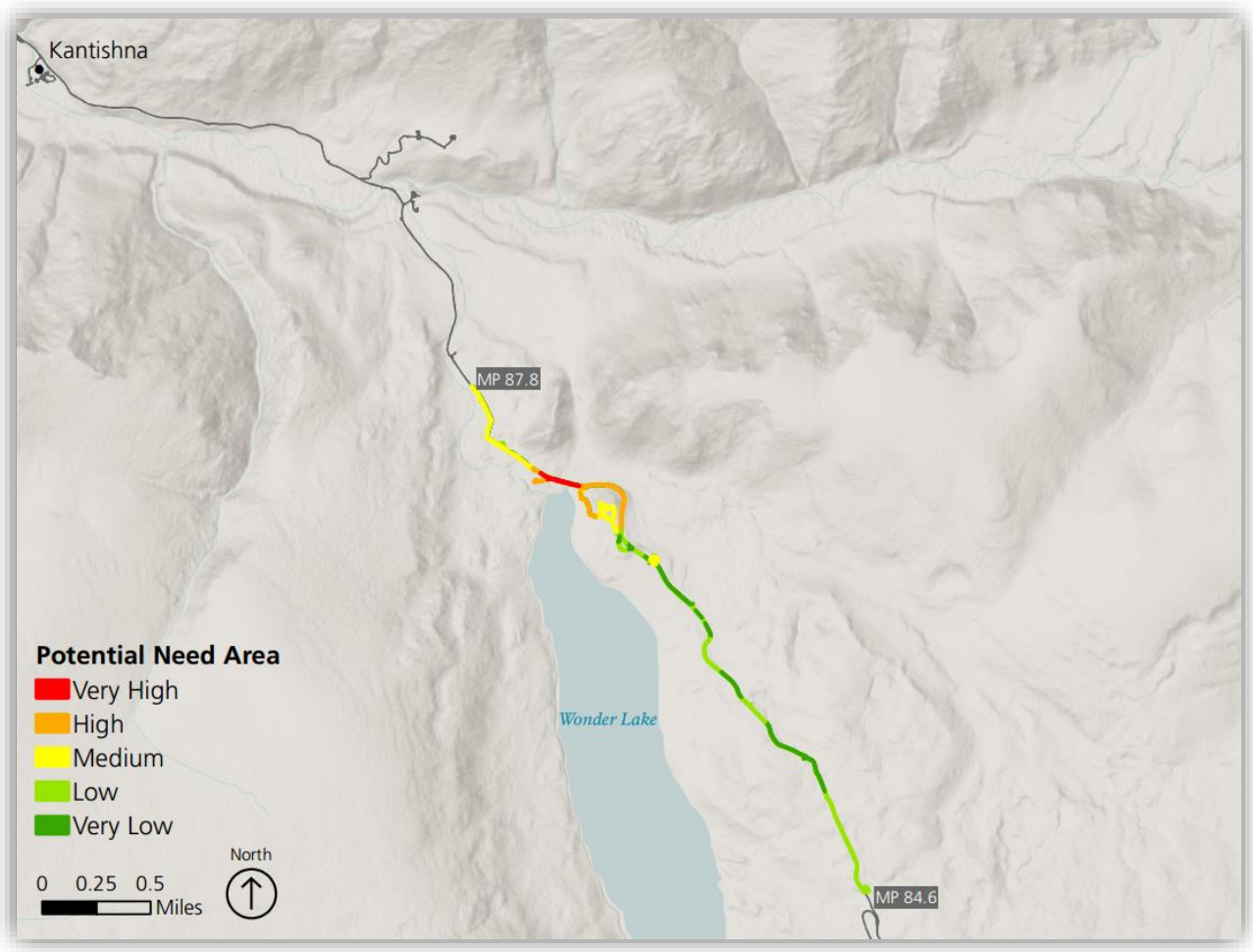

Figure 12. PaTINA-modeled potential need areas for the Wildlife Viewing Subzone 2b segment of the Park Road.

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.

National Park Service
U.S. Department of the Interior

Denali National Park and Preserve
Long-Range Transportation Plan

Appendix F:
Denali Funding Plan

Denali National Park and Preserve Financial Analysis Technical Report – FINAL DRAFT

Introduction

This report discusses the transportation funding aspects of the Denali National Park and Preserve's first Long Range Transportation Plan. It includes a retrospective of transportation funding from 2006-2013, a projection of funds expected to be available for transportation during the plan's twenty year planning horizon, and a summation of the resources necessary to return transportation facilities at Denali National Park and Preserve (Denali NPP) to ideal conditions. As is true for all of the National Park Service (NPS), the amount of funding that is needed for transportation at Denali NPP exceeds the amount that will be available in coming years, and so this report includes an investment strategy that funds the highest priority needs.

The discussion must begin with two of the NPS's guiding transportation investment principles and Denali NPP's primary existing transportation document, the Vehicle Management Plan (VMP). It then discusses Denali NPP's place in Alaska Region transportation funding and the expected increase in funding needs due to climate change impacts. The middle section of this report discusses the LRTP methodology in general, and how the Denali NPP LRTP methodology differs from those used for other NPS LRTPs. There is also a discussion of historical, forecasted, and needed transportation funding that collectively make up the baseline transportation funding report for Denali NPP.

This report concludes with a discussion of the funding strategies which were evaluated for the Denali NPP LRTP and how the final strategy was selected. The investment strategy prioritizes operations and maintenance, the rehabilitation of the paved section of the Park Road, funds the unpaved sections of the Park Road to achieve management priorities, and provides approximately $1m per year to address other transportation priorities. The Denali NPP transportation investment strategy is expressed with respect to each of the four LRTP planning scenarios to guide park management decisions during times when visitation is increasing or decreasing and when funding (or stakeholder support) is higher or lower than average. Funding shortfalls means that the condition of all transportation assets cannot be improved, but progress can be made to address the highest priorities.

Funding Denali Transportation Facilities

Capital Investment Strategy and Total Cost of Facility Ownership

As a best practice and formal policy, the NPS incorporates strategic facility planning into its asset management decision-making processes, including LRTPs. Two fundamental concepts, the NPS Capital Investment Strategy (CIS) and Total Cost of Facility Ownership (TCFO), underlie those best practices and are drivers of the investment planning and decision-making reflected in the Denali LRTP.

The NPS Capital Investment Strategy

The CIS is an NPS strategy for prioritizing project investment to ensure effective and responsible project funding. The CIS includes a scoring tool that decision-makers at all levels of the NPS have available to them to inform project investments and other asset management needs.

The purpose of the CIS is to help prioritize investments, focus on mission-critical assets, manage operations and maintenance, and ensure that the greatest impact can be made with available capital and operational funds. The CIS uses a scoring tool to evaluate projects on a number of different criteria: *Financial Sustainability*, *Visitor Experience*, *Resource Protection*, and *Health & Safety*. The four categories are weighted using a predefined algorithm to arrive at an overall project score. Projects can then be compared by score as needed; in theory the greater the score the higher the priority. The scoring strategy supports an asset management approach that emphasizes maintaining key assets and reducing the estimated value of deferred maintenance cost against those key assets.

Some of the key objectives in the *Financial Sustainability* strategy are to build only what can be maintained, right-size the asset portfolio, reduce liabilities, reduce resource consumption to promote sustainability, and eliminate non-essential development in order to emphasize the essential natural and cultural experience. The *Visitor Experience* strategy includes investment in assets or resources that enable recreation, and serve as gateways to park units, contact stations, and interpretive assets. The *Resource*

Protection strategy focuses on those historic, cultural, and natural resources that the NPS is tasked with protecting and preserving. Such tasks supported by the CIS could include preservation, repair, and restoration of assets. Finally, the *Health & Safety* strategy places an emphasis on correcting unsafe or hazardous conditions within park units that pose a threat to visitors or staff. Different parts of the Denali LRTP address these four strategies, which are used by fund program managers to allocate limited funding.

Total Cost of Facility Ownership

Applying the concept of Total Cost of Facility Ownership (TCFO) is considered by the NPS to be a vital part of a financially sustainable infrastructure strategy and practice to truly address transportation asset management.[1] It aligns closely with the intentions behind the CIS, especially the CIS Financial Sustainability component. TCFO is the full life-cycle cost of constructing, maintaining, and operating an asset until it needs replacement. This concept recognizes that assets require investment throughout their service lives until they need replacement or disposition and that preventive maintenance and facility operations activities are key to minimizing long-term costs and optimizing the life of said assets. Implementation of the TCFO concept involves a shift-away from a "just fix it" or "run to failure" mentality to more holistic planning, making cost estimates and decisions that consider not just the deferred maintenance (DM) of an asset but the ongoing O&M need over its service life, need for replacement, and ultimately disposition.

The Denali LRTP team took the concepts inherent to the CIS and TCFO and embedded them into all of its LRTP analyses and planning activities. Consequently, the resulting investment strategy selected by Denali NPP staff is consistent with the approaches and practices used across the NPS to develop, for example, the National LRTP and other unit or regional LRTPs.

The Denali Park Road and the Vehicle Management Plan

Denali NPP is one of the most visited National Park Service units in Alaska and the Denali Park Road is the means for the majority of visitors who wish to traverse deep into the interior by any mode, motorized or otherwise. For many visitors it is the most readily accessible transportation corridor for them to experience the Alaska wilderness, and for some it is their only option. Denali NPP is currently several years into the implementation of its VMP, the culmination of an intensive planning effort to balance the needs of the park's natural resources with high visitor demand. The Denali LRTP is consistent with the recommendations in the VMP.

Generally, the VMP recommends limiting vehicle traffic on the Denali Park Road in order to reduce traffic impacts on natural and cultural resources. The VMP has a "telescoping" approach where visitor activity is highest and associated development is most extensive in the paved entrance area of the park, and declines and lessens respectively as the Park Road heads west. As shown later in the section on Funding Strategies, the Denali LRTP reflects this by realigning maintenance and rehabilitation investments along the Park Road to concentrate on the areas of highest visitor activity and most extensive development.

Funding Trends

The Federal Lands Transportation Program in the NPS Alaska Region

The Federal Lands Transportation Program (FLTP) is the single largest source of transportation funding for the National Park Service and other Federal land management agencies. Project funding decisions are made at the regional level following national guidelines. The FLTP at a national scale has recently been reauthorized at a higher funding level than analyzed in this plan. However, interim program guidance suggests that the majority of the increase will be reserved for nationally significant major projects, with only a small increase to regional allocations.

Denali NPP has historically been the largest recipient of FLTP funding in Alaska, in part because 20 of the Region's 27 miles of paved roads are within Denali NPP. The unpaved Park Road may also be funded by FLTP. NPS regional staff indicate that Denali NPP has in the past received all funding from the program by default, unless another NPS Alaska Region park unit has eligible needs (which is rare), at which point that project from another park unit moves to the top of the regional FLTP program. This means that FLTP will likely be a sustainable funding source for major investments at Denali NPP into the future. The next three years of FLTP investment at Denali will be primarily used to rehabilitate the 15 mile paved section of the Park Road, from the park entrance to the Savage River checkpoint.

1 For example, reference "Memorandum: Guidance for Addressing Facilities in Planning Documents", Associate Director, Park Planning, Facilities, and Lands, National Park Service, US Department of the Interior, January 4, 2016.

Climate Change and Geotechnical Hazards

As explained elsewhere in the LRTP, current research indicates climate change is dramatically affecting transportation facilities across Alaska. The impacts of climate change relevant to Denali NPP's transportation system include thawing permafrost, unstable slopes, a lengthening shoulder season, and other change indicators. Most of these changes will result in higher costs to operate and maintain Denali NPP's transportation network, which will further stress already limited funding.

Monitoring and evaluation of climate change impacts is an ongoing need and a recommendation of this LRTP. Tracking threats and hazards to the transportation system such as unstable slopes requires funding for specialized equipment and the technicians and scientists who collect and analyze the data. Funding updates to hydrology models and monitoring permafrost thawing are other near-term, relatively inexpensive data needs that can help avoid disastrous impacts over the medium to long term. Denali NPP has initiated the effort but funding has not been identified for developing specific plans for how to adapt the transportation system in the park to these expected impacts.

In the near term, a number of susceptible areas along the Park Road will likely encounter more frequent closures due to intermittent landslides, flooding, or debris flows with each requiring cleanup and reopening. The future impacts of one of the effects of climate change, increasing precipitation in the Denali Borough region, can already be previewed during excessively wet years. 2016 was a particularly wet year and staff were faced with unstable slopes and more frequent and more severe debris flows. Beyond the cost of cleaning up after these road closures there are short-term disaster management tasks for which Denali must be ready – evacuation or care of visitors, staff, users, and inholders on the far side of an interruption.

Some dedicated funding sources are available for recovery costs, such as NPS Emergency Storm & Flood Damage and FHWA's Emergency Relief for Federally Owned Roads (ERFO). These programs have limited budgets, and will be increasingly strained in an era of continued climate change impacts, not just in Denali NPP but across the National Park Service. These funding sources are currently limited to recovery costs only, and cannot be used for monitoring or preventive work that can anticipate and avoid a future event, such as by stabilizing slopes or realigning a road.

There are several segments of the Park Road and its associated bridges and structures that may become physically or financially untenable in the next few decades. There may come a time when the park will need to consider decommissioning, rerouting, and/or relocating these facilities. These costs are not yet known, but will likely far exceed Denali's typical past annual funding and may require special major project funding. US Department of Transportation (DOT) discretionary grants such as the (unfunded) Nationally Significant Federals Lands and Tribal Projects program or Transportation Investments Generating Economic Recovery (TIGER) are possible sources, as is the NPS Line Item Construction program. However, because these needs are not yet quantified, and because they are beyond the capacity of the current funding programs to address, the costs of fully adapting the transportation system to climate change are not included in the Denali LRTP financial analysis.

Denali LRTP Funding Baseline

Financial Analysis Methodology

The financial analysis methodology for the Denali LRTP is based on the data and methods first developed for the NPS National LRTP (NLRTP). A much more detailed technical summary is available for the NLRTP and generally applicable to the Denali LRTP, but this section will cover the basic steps as well as deviations used to adapt it to the unit level.

Historical Investments

Establishing a financial baseline of the historical average annual level of regional transportation spending provides a foundation for forecasting the likely future available funding levels which can be anticipated for Denali NPP's transportation facilities. This is important information for developing a fiscally-constrained LRTP. The LRTP team analyzed all of the fund sources that had been used for transportation investments at Denali NPP from fiscal year (FY) 2006 through FY 2013. These results provide a vital context for developing the Denali LRTP investment strategy.

Annual transportation investments at Denali NPP averaged $9.23 M per year from 2006-2013 from all funding sources combined.

The financial data was extracted from various financial and project management data tracking systems.[2] The LRTP team:

- identified historical expenditures, awards and authorizations for transportation assets
- adjusted those prior year dollar values to equivalent 2014 values using GDP inflation factors, and
- calculated an annualized average transportation funding expenditure rate for the period FY 2006 – FY 2013.

This data was initially prepared by the National LRTP team, and then reviewed by the Denali LRTP team to remove any anomalies. To simplify reporting, the dataset was consolidated, coded and grouped by funding authorizations, funding programs, work types, and asset types. All identifiable American Recovery and Reinvestment Act (ARRA) investments, a one-time, extra-ordinary funding source, were removed from this analysis. A detailed technical methodology document is available from the NLRTP effort.

Because the data only includes transportation expenditures made by the National Park Service, it does not include transportation investments by third parties. The park's partners such as the Alaska Railroad, bus concessioners, Denali Borough, and the Alaska Department of Transportation and Public Facilities (ADOT&PF) all fund transportation work that helps visitors, employees, inholders, and freight carriers access the park. However, these investments are not accounted for in this analysis because these data do not enter NPS financial data systems.

Forecasted Transportation Funding

This section documents the Denali NPP financial forecast for transportation based on anticipated future funding levels that can be reasonably assumed to be available. The forecast of available funding provides the principal financial constraint against which future investment plans must be prioritized, and represents the result of the most likely funding scenario for each funding source that Denali NPP has recently used for transportation. It does not include a forecast for work done by other parties, such as the State of Alaska or Denali Borough, that may benefit Denali NPP, and it also doesn't include any unforeseen additional funding which may result in a "Popular Park" scenario (increased funding and support with an increase in visitation) or "Surplus of Money" scenario (increased funding and support with a decrease in visitation) when compared to the historical average. However, for the purposes of the investment strategy in this plan, the funding forecast is considered to be at the center of our "Management Strategies of no Regret" - those actions that make sense given a normal variation in expected support, funding, and visitation levels.

The LRTP team estimates that approximately $7.75 M per year will be available to Denali NPP for transportation purposes over the next six years.

The Denali LRTP team leveraged the approach applied in the development of the NPS National LRTP to forecast anticipated funding availability for transportation investments in the near future. There were two main sources of forecasting information:

The NPS budget office. The Budget Office conducts forecast exercises servicewide and with individual units. The Budget Office suggested the LRTP program assume a one-time reduction to Title 54 (DOI) Non-Fee program fund sources of three percent for ONPS and Cyclic Maintenance programs in the NPS National LRTP. The DENA LRTP forecast was based on a combination of actual funding program investment plans where possible and the three percent cut when it wasn't. The three percent reduction only applied to programs for which the Denali LRTP project team did not have access to an investment plan (e.g. Operational Base).

Regional Funding Programs. The Denali LRTP project team consulted several regional-level program plans to acquire information on planned investment levels: Title 54 Non-Fee programs for Cyclic Maintenance, Repair/Rehabilitation, and Line Item Construction; Title 16 / 54 Fee programs for Recreation Fee, Transportation Fee, and Concession Franchise Fees; and the Title 23 Federal Lands Transportation Program. These forecasts replaced the National LRTP-style (i.e., three percent reduction) forecasts for these programs as they provide more certainty than broad program-level authorizations and appropriation amounts.

The elimination of the Paul S. Sarbanes Transit in the Parks Program (TRIP) is another factor to note in the forecast, but the only analysis needed is to not project any future grant awards from this program. Denali made use of TRIP in the past, but will need to seek other funding sources to fund future transit and trails projects. This is also true of various grant programs formerly used by many parks, but not Denali NPP, such as Scenic Byways or the Public Lands Highway Discretionary Program.

[2] Systems used included the NPS Administrative Financial System (i.e., AFS Versions 3 and 4) and the joint Federal Highway Administration (FHWA)/NPS Park Roads and Parkways Transportation Allocation and Tracking System, a.k.a. PTATS.

Unfortunately, transportation funding for Denali NPP is expected to decline unless additional funding sources are found or funds are redirected from other critical areas. The declining funding environment coupled with historically high visitation may result in a "Losing Ground" scenario (decreased funding and support with an increase in visitation) when compared with historical averages. These conditions are not dissimilar from recent years (e.g., 2013-2015).

Transportation Investment Needs

Investment needs are defined in this plan as the amount of funding required to bring transportation assets to good condition and sustain them at that level. Investment needs also include costs to address programmatic needs such as code compliance, structural fire and accessibility. Other goal area needs such as resource protection may overlap with asset management (TCFO) needs or may be additional, potentially unfunded requirements.

The LRTP team estimated an annual need of $12.42 M to return the Denali NPP transportation system to good condition and keep it there over six years.

The Denali LRTP used a similar methodology as the National LRTP and other Regional LRTPs, using needs data from the best available data system or report that covers a particular type of transportation facility and type of work. However, many of the reports and systems available at the regional or national level do not apply to individual parks. The principal difference between the needs in the Denali LRTP is the use of automated systems. The data sources used for the Denali LRTP are:

- **Reoptimization File**: O&M needs for all facilities except the unpaved Park Road
- **2013 Alaska Region Unpaved Road Analysis (pilot)**: Detailed analysis for the unpaved Park Road
- **Facility Management Software System** (FMSS): Component renewal and programmatic needs
- **Project Management Information System** (PMIS): Capital investment needs, planning, natural/cultural resources
- **National list of megaprojects**: Paved Park Road repair project and replacement of the Toklat River Bridge

Differences between the needs sources, such as timespans and prioritization systems, were reconciled in order to create a single set of transportation facility needs for Denali NPP. Park staff also reviewed the needs data and removed several projects that were already underway or would be accomplished through partners rather than by the park. At $12.42 M per year, the estimated annual transportation investments needs exceed the annual transportation funding amount by $4.67 M per year.

Transportation Funding for Denali NPP

This section discusses the current and near future transportation funding outlook for Denali NPP. It covers where funds have come from and how they have been used in terms of what type of transportation facility was funded, what type of work was funded, and how transportation funding is prioritized.

Investments by funding source

From 2006-2013, the National Park Service as a whole used more than 60 different funding program and accounts to fund transportation activities, but only ten programs funded investments at Denali NPP. Table 1 below shows how much each funding program provided in the past, how much it is expected to provide in the future, and how much would be needed from each funding program to cover Denali's total transportation need each year if past investment patterns were continued.

Table 1: Denali NPP Transportation Investments and Needs by Funding Source (in millions of 2013 $)

Investments by funding source	Historical Average Annual Investment	Forecasted Annual Average Investment	Estimated Annual Needs
Title 54 Non-Fee	**$1.75 M**	**$1.01 M**	**$3.35 M**
Cyclic Maintenance	$0.63 M	$0.04 M	$0.01 M
Line Item Construction	$0.34 M	$0.32 M	$0.07 M
Operational Base	$0.64 M	$0.55 M	$2.70 M
Other NPS Programs	$0.07 M	$0.07 M	$0.19 M
Repair/Rehab	$0.07 M	$0.02 M	$0.39 M
Title 54 / Title 16 Fee	**$1.34 M**	**$2.11 M**	**$2.61 M**
Concessions Franchise Fees	$0.67 M	$1.44 M	$0.51 M
Recreation Fee	$0.67 M	$0.67 M	$2.10 M
Title 23	**$6.01 M**	**$4.62 M**	**$5.86 M**
FLTP	$6.01 M	$4.62 M	$5.86 M
Other/External	**$0.14 M**	**$0.01 M**	**$0.60 M**
FTA TRIP/ATPPL	$0.12 M	--	--
Reimbursable Agreements	$0.01 M	$0.01 M	$0.60 M
Grand Total	**$9.23 M**	**$7.75 M**	**$12.42 M**

Each of these funding programs have a different legislative authorization and project eligibility criteria. Title 54 programs are those authorized by Title 54 of the U.S. Code (National Park Service-specific programs). Title 16 includes other relevant Department of the Interior programs (i.e., Recreation Fee Program). Title 23 includes programs overseen by the Federal Highway Administration, and the "Other/External" category includes other funding sources, such as the discontinued TRIP program, as well as reimbursable agreements, donations, partnerships, and other less common sources.

Investments by Facility Type

Denali NPP maintains a diverse system of transportation facilities including paved and unpaved roads, bridges, paved and unpaved transportation trails, transit facilities, developed airstrips, as well as support infrastructure such as a materials (gravel) quarry. Table 2 below shows historical investments, forecasted investments, and the estimated annual investment needs for each of the park's transportation facility types.

Of all historical investments in transportation at Denali NPP in the recent past, about 55% went to the Park Road and associated structures, and 18% supported parkwide operations that include the Park Road. Less than a third was used for separate transportation facilities, such as trails and access roads. Park Road funding was oriented to the unpaved segments that require frequent repair work to remain in even fair condition given the extreme conditions and heavy vehicle traffic in Denali NPP. Recent investments in several difficult sections in the western end of the Park Road helped restore user comfort and safety.

Table 2: Denali NPP Transportation Investments and Needs by Asset Type (in millions of 2013 dollars)

Asset Type	Historical Average Annual Investment	Forecasted Average Annual Investment	Estimated Annual Needs
Unpaved Roads	$3.86 M	$2.35 M	$5.27 M
Road Bridges	$1.84 M	$0.42 M	$1.35 M
Trails and Transit	$1.47 M	$0.66 M	$1.37 M
Paved Roads	$1.44 M	$2.91 M	$2.97 M
Other[3]	$0.51 M	$0.53 M	$0.66 M
Parking	$0.11 M	$0.89 M	$0.81 M
Grand Total	**$9.23 M**	**$7.75 M**	**$12.42 M**

Investments by Asset Lifecycle stage

As discussed in the section on Total Cost of Facility Ownership, different types of work are needed at different points in a transportation facility's lifespan, from planning through to rehabilitation or disposition. Table 3 below shows historical and forecasted annual investments as well as estimated annual investment needs for each lifecycle stage, for all asset types combined.

Table 3: Average Annual Investments by Lifecycle Stage (in millions of 2013 dollars)

Lifecycle Stage	Historical Average Annual Investment	Forecasted Average Annual Investment	Estimated Annual Needs
Planning and Administration[4]	$0.58 M	$0.57 M	*
Capital Investment	$1.34 M	$2.59 M	$1.30 M
Operations and Preventive Maintenance	$0.45 M	$0.48 M	$1.86 M
Recurring Maintenance	$1.42 M	$0.83 M	$3.74 M
Component Renewal	$5.27 M	$2.59 M	$5.08 M
Grand Total	**$9.23 M**	**$7.75 M**	**$12.42 M**

Denali NPP's greatest area of transportation investment need is in heavy repair and rehabilitation work, similar to much of the rest of the National Park Service. Insufficient funding often leads to smaller, routine maintenance work being deferred, which causes transportation facilities to fall out of a state of good repair. Other significant needs at the park include annual operations and maintenance of transportation facilities and making improvements to culverts that provide for fish passage and building an aircraft hangar.

Note that some categories, such as capital investment, show "surpluses" where more funds are forecasted for investment than are needed. This is the result of project programming where several capital investment projects are scheduled for near-term construction in 2016-2021, whereas the needs represent the average annual needs over twenty years.

[3] Other category includes aviation, buildings that support transportation, equipment, and multimodal facilities. Trails and Transit notably excludes investments and O&M spending made by the transit contractors who operate within Denali NPP, but does include Denali's own investment in bus transit facilities such as buildings, lots, and experimental hybrid buses.

[4] Routine planning and administration needs are not included in NPS facilities management data systems, but can be assumed to continue at historical levels. Additional unquantified planning needs are likely in the LRTP's horizon, including work in the park's entrance area, coordination with private shuttle services and the Alaska Railroad, and transportation planning to maintain park operations in the face of climate change impacts.

Programmatic Needs

Some of the lifecycle stage needs are also considered programmatic needs for transportation facilities at Denali NPP. Programmatic needs include work necessary to meet standards set by safety, accessibility, environmental, and fire safety requirements. It is generally analogous to code compliance work that would be the responsibility of a facilities manager or an architect hired by a private business.

Figure 1 summarizes estimated programmatic needs for the Denali NPP transportation asset portfolio, which total less than $300,000. Transportation facilities generally have relatively small programmatic needs compared to facilities such as visitor centers, housing, and offices. Although not broken out in the historical and forecast data, these types of projects are included in the NPS Facility Management Software System (FMSS) as needs. Denali NPP's programmatic needs are included in the overall $12.42 M per year needs as capital investment or component renewal needs. They are classified as capital investment if plans are to proactively address them as individual projects, or as component renewal when addressed through a rehabilitation project that focuses on a low condition rating.

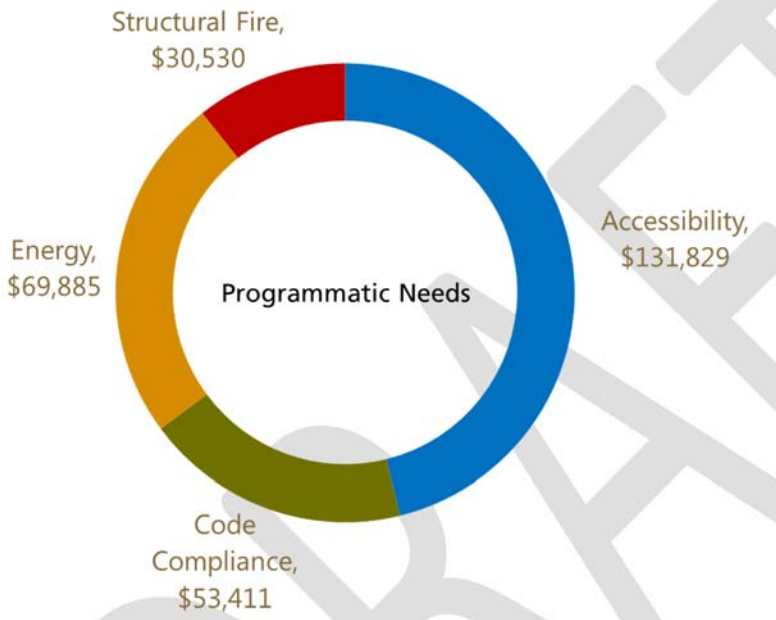

Figure 1: Denali NPP Transportation Programmatic Needs

Investments by Asset Priority

The final classification for investments is what priority of assets they were used to build, maintain, or repair. NPS financial and asset management systems do not support this analysis for the historical or forecast data. Each future investment need at Denali NPP is associated with the priority of the asset or the project itself, this is shared below in Table 4. For the purposes of this plan, Highest Priority is generally defined as Optimizer Band 1. High Priority is defined as Optimizer Band 2. Optimizer bands 3-5 are defined as "other priority." Although they are not banded as such, critical Park Road work is labeled as Highest Priority, consistent with the priorities discussed during the investment strategy section later in this report.

Table 4: Estimated Annual Needs by Priority.

Priority	Estimated Annual Transportation Needs	Optimizer Band Equivalent
Highest Priority	$3.77 M	Band 1
High Priority	$5.84 M	Band 2
Other Priority	$2.81 M	Bands 3, 4, 5

Denali NPP differs from other National Parks and the NPS as a whole due to the relatively low proportion of the total need in the highest

priority need category. Many transportation facilities in Denali NPP have been categorized in optimizer bands 2-5. This reflects the values laid out in Denali NPP's *Foundation Statement* that place a high priority on investment in resource protection, science, and other portfolio areas ahead of transportation and broader visitor use needs. As a result the park is able to cover its entire highest priority transportation needs given current funding. In fact, the $7.75 M per year in forecasted funding is enough to cover 80% of the highest and high priority transportation needs combined. However, there are still high priority transportation needs that will remain unmet unless additional funding is found, and longer-term and lower-priority needs that cannot be met with forecasted funding.

Investment Strategies

The final step of the financial planning process for NPS LRTP development is the formulation of an investment strategy. It is a synthesis of the plan's goals and objectives, already formulated projects and other transportation-related needs, and the reality of the constraints that exist in the current funding environment. This section of the report describes the process used by the Denali LRTP team to identify several potential investment strategies, including the strategy selected by Denali NPP staff for the Denali LRTP. It also discusses potential alternatives which park management may consider if future funding or visitation deviates significantly from the forecast, referencing the planning scenarios used in the development of the Denali LRTP.

Methodology

The key to understanding the funding strategy process is that funding in a constrained environment is a zero-sum game. All investment strategies make use of the same $7.8 M annual funding amount that is forecasted for the near future. Because transportation needs exceed this amount and because moving funds from other purposes deprives those projects of needed funding, all investment strategies shift funds from one set of priorities to another. The O&M strategy option shown in Table 5, for example, focuses on staying current on annual operations and preventive maintenance work at the expense of larger repair projects.

Unlike the plans for the National Capital, Southeast, Midwest Regions and the NPS as a whole, the Denali LRTP used a single modeling tool to model the results of the different funding strategies on the Denali NPP transportation system. A deferred maintenance (DM), FMSS-based tool was modified by a contractor (Booz Alan Hamilton) to work at the unit level and take into account park specific facilities such as the unpaved Park Road. This tool uses extracts from FMSS to estimate Facility Condition Index (FCI) and DM outcomes given a known annual funding level. The FCI outcomes reported for this effort are 'Adjusted FCI', which includes programmatic needs and an anticipated 35% cost markup in addition to the "raw" DM normally used in calculation of the FCI.

Strategy Development Process

Methodology and Initial Strategy Concepts

The team held several workshops and follow-up discussions with NPS stakeholders and partners to identify candidate strategies and to select the Denali NPP LRTP Investment Strategy (p. 12). Internal NPS stakeholders included Denali NPP staff, Alaska Region staff, and the Washington Support Office (WASO). Partner input included expertise from FHWA Western Federal Lands Highway Division and US DOT Volpe Center staff familiar with the NPS LRTP financial planning process.

The team worked with stakeholders to identify potential candidate strategies in light of CIS and TCFO policies, best practices, and past investment patterns (see Table 2 and Table 3). The initial investments strategies are shown in Table 5 below and were based on trends discussed by the project team early on in the Denali LRTP.

Table 5: Initial Investment Strategy Concepts

Investment Strategy Option	Invests in…	At the expense of…
Business as usual	Highest priority assets	Lower priority assets
O&M emphasis	Fund 100% of annual O&M needs for all assets	Capital investments and rehabilitation
Transit and trails	$1 M for existing transit and trails before other investments	$1 M for roads and parking
Make improvements	$1 M per year for new assets/services (e.g., employee transit, real-time bus trackers, new trails)	$1 M less for annual O&M, and rehabilitation
Safety and programmatic needs	Programmatic and safety needs before everything else (e.g. accessibility, slope stability)	$1 M less for annual O&M, rehabilitation

The reaction to the strategies from park staff indicated high interest in the O&M strategy – if the park is able to at least stem the growth in deferred maintenance using its typical transportation funding sources then the park can later seek out additional funds to rehabilitate facilities that are no longer in a state of good repair. The specificity of the three strategies that make different kinds of improvements was eliminated in favor of a general "make improvements" strategy since transit and trails, enhanced ITS, and safety and emergency response are all priorities at the park that vary from year to year. Finally, Denali NPP staff noted that, given its current condition, the unpaved section of the Denali Park Road could still be one of the best unpaved roads in Alaska even with a reduction in maintenance levels, so exploring redirecting some funding from the Park Road to other facilities in the park might be a viable option. Various sections of the Park Road meet different condition criteria, from good to fair to poor.

Refined Investment Strategies

No one strategy rose above others as a preferred strategy in the first round of modeling, but the number of strategies was narrowed to two. Both strategies funded all operations and maintenance needs and ensure that planned projects such as the paved Denali Park Road rehabilitation are completed, but one option set aside $1 M per year for improvements or new facilities. Table 6 below shows the tradeoffs of the two refined general strategies.

Table 6: Refined Investment Strategies

Strategy	Invests in…	At the expense of…
Cover all O&M, complete planned projects	O&M and critical near-term repair needs	Making improvements
Cover all O&M, complete planned projects, and reserve $1M/yr for improvements	O&M, critical near-term repair needs, and improving transportation at Denali	Buying down deferred maintenance

Unpaved Denali Park Road Analysis

In addition to these two strategies, Denali NPP staff also wanted to test whether transportation funds allocated to the unpaved Park Road in a business as usual approach could be shifted to other purposes. The LRTP team, as well as staff from Denali NPP and the Alaska Region developed five different options for unpaved road condition targets that could be modeled to estimate costs of different sets of conditions. Table 7 below summarizes these five sets of condition targets. Each of the two general strategies were tested using the five sets of condition targets, for a total of ten investment strategy and condition results. The strategies in Table 7 highlighted in red were not achievable give projected funding levels and established higher priorities.

Table 7: Unpaved Park Road Conditions

Strategy	Goals	Annual Cost
Plan A	Maintain all Park Road segments in good condition	$4.3 M
Plan B	Maintain all Park Road segments in fair condition	$3.7 M
Plan C	Set Park Road conditions from segment to segment, recognizing that some segments are costlier to maintain in good condition than others	$2.9 M
Plan D	Follow the VMP's "telescoping" approach by keeping conditions good in the first part of the road, fair in the middle part, and poor at the western end	$2.5 M
Plan E	Follow the VMP's "telescoping" approach by keeping conditions good to fair in the first to middle parts of the road and poor at the western end.	$2.7 M
Plan F	VMP "telescoping" approach as in Plan E, but with further lowered condition targets for two of the most expensive areas - MP 43-47 and MP 88-92	$2.0 M

Refined Strategy Results

Unlike the initial strategies, several of the refined strategies were not viable. None of the condition targets on the unpaved Park Road could be met if Denali NPP was to reserve $1 M per year for making improvements elsewhere on the park, and so that general strategy was discarded. Even without reserving $1 M per year, projected funding is insufficient to meet the good to fair conditions proposed under plans A and B for the unpaved park road without scaling back commitments to O&M, planned repaving of the paved sections of the Park Road, and the rest of Denali NPP's transportation facilities. Additional funding could make Plans A and B possible – about $1.3 M per year more would allow for Plan A to be achieved, and $0.7 M more per year would allow plan B to be achieved.

Plans C, D, E, and F are viable given currently constrained funding levels. Plan C shows that it is possible to meet all of the investment strategy's commitments and still maintain the unpaved Park Road on a segment-by-segment basis. The conditions explored in Plan C take the relative expensive of each segment into account, and the most difficult segments are allowed to remain in fair to poor condition. However, modeling showed that meeting these conditions would provide almost no funding for other transportation priorities.

Plan D applies the Vehicle Management Plan's "telescoping" approach to the maintenance of the unpaved Denali Park Road and targets mid-poor condition for the farthest west segments which are intended to be more rustic and less traveled, but keeps the middle and eastern segments in fair to good condition. Under this plan nearly $0.5 M per year would be available for other transportation priorities. Plan E made slight changes to keep more of the road in good condition instead of fair.

Plan F was ultimately selected as the condition target for the Denali NPP LRTP. This option retains the approach of Plan E but reduces condition targets for two sections, which are particularly challenging and expensive to maintain. Under plan F, Polychrome Pass would be improved slightly (but still be in poor condition) while the final stretch of the park road would be allowed to decline to poor condition. These two changes free about $0.6 M per year for use elsewhere on the road and in Denali NPP. More information about these two segments is provided in Appendix A at the end of this technical report.

Denali LRTP Investment Strategy

The refined strategy results narrowed down the policy options for the unpaved Park Road and led to the selection of the Denali LRTP Investment Strategy as the best fiscally-constrained option for meeting the goals and objectives of the plan. This strategy

would invest Denali's forecasted $7.75 M per year in four categories as shown below in Table 8 and **Error! Reference source not found.** below.

Table 8: Denali NPP LRTP Investment Strategy

Category	Estimated share of annual funds	Estimated annual investment	Percentage of needs met
Operations and Preventive			
Rehabilitate Paved Portion of the Denali Park Road	24%	$1.9 M	100% of needs met
Repair and Improve Other High-Priority Transportation Assets	13%	$ 1.0 M	24% of needs met

The Denali LRTP Investment Strategy strikes a balance between several different priorities for transportation at the park, and lies within the "Management Actions of No Regret" area of the Denali LRTP scenario chart. The strategy proposes to fully fund O&M needs in order to slow the decline of facilities and ensure a better visitor experience. It continues planned investments on the paved section of the Park Road to achieve a good condition rating, and continues to make funding available to address deferred maintenance on the unpaved sections of the Park Road. However, the strategy sets lower condition targets for sections of the unpaved Park Road which are further into the park and which are less traveled by visitors, in order to reserve funding for other segments of the Park Road, and for entrance area transportation facilities (e.g., aviation, parking areas, new priorities). This approach is consistent with the Vehicle Management Plan which envisions lower traffic volumes and a more rustic experience the further the road extends from the park entrance area.

Ultimately, because funding needs exceed available resources, the condition of transportation facilities at Denali NPP is expected to decline overall. FCI ratings across the Denali NPP transportation system today are modeled at 0.148, or the low end of fair condition. Continued scarce funding for transportation will reduce conditions to 0.185 by 2021[5]. However, higher priority transportation facilities are expected to remain in fair condition overall, as described by the Investment Strategy.

[5] FCI ratings are modeled on a 0-1 scale where 0.000 is perfect condition, and 1.000 is completely degraded condition.

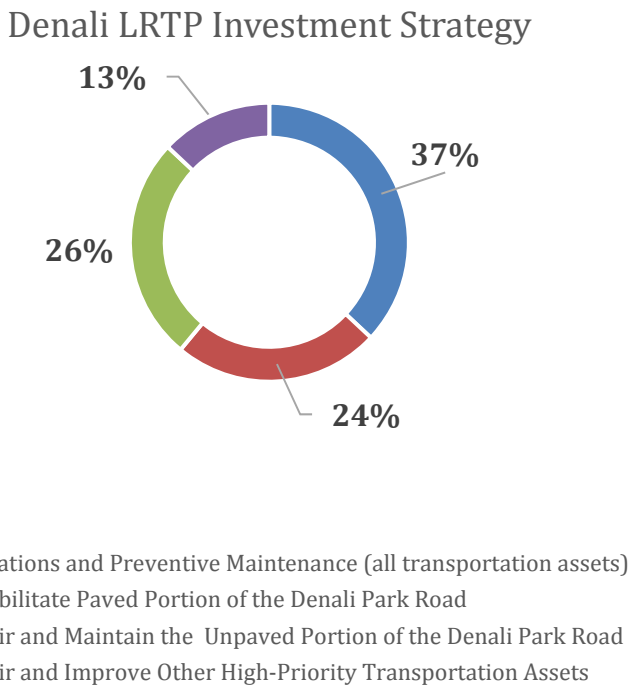

Figure 2: Denali LRTP Investment Strategy

Denali Investment Strategy and LRTP Scenarios

All of the funding strategies considered for the Denali NPP LRTP assumed the same funding forecast, and would fall within the "Management Actions of No Regret" area on the scenario planning graphic reproduced in **Error! Reference source not found.** below. This area represents a balance between times of high and low visitation, and high and low funding for the park. It is calibrated based on an average of funding and visitation over time. Years within one standard deviation of these means lie within it, if they are more than one standard deviation away from the average then they are said to be in one of the four "quadrants"

The funding forecast in the Denali LRTP is only the most likely scenario for each program, and in reality the amount of annual transportation funding will vary, as will visitation. Table 9**Error! Reference source not found.** below shares some management actions for when funding and visitation levels take Denali NPP out of the area of management actions of no regret. Generally, when visitation is lower it is a better time for disruptive work such as addressing major needs and accomplishing maintenance projects that were deferred. Times of high visitation call for more investment in O&M and investment in new services to meet emerging visitor needs. When funding prospects are good then more money is available to make improvements, catch up on deferred maintenance, and prepare plans for the future. When funding is short then many necessary improvements have to be delayed, and park staff can only fund core operations and critical repair work.

Figure 3: Denali LRTP Scenarios

Table 9: Potential Management Actions by Scenario

Losing Ground	Popular Park
Emphasize more of: Funding O&M Introducing new services **Emphasize less of:** Making improvements Funding deferred maintenance Initiating major capital/rehabilitation projects	**Emphasize more of:** Funding O&M Making improvements Introducing new services Planning for future needs **Emphasize less of:** Funding deferred maintenance Initiating major capital/rehabilitation project
Turn out the lights	**Surplus of Money**
Emphasize more of: Funding deferred maintenance **Emphasize less of:** Funding O&M Making improvements Introducing new services	**Emphasize more of:** Making improvements Funding deferred maintenance Initiating major capital/rehabilitation projects Planning for future needs **Emphasize less of:** Funding O&M Introducing new services

Appendix A: Unpaved Park Road Condition Targets

Unpaved Denali Park Road Condition Targets

Plans C, D, and E for the unpaved Denali Park Road examined options for managing each segment of the road to an individually set condition target. Each of these targets is based on the overall Vehicle Management Plan and accounts for past challenges or known issues with individual segments. Plan F was ultimately selected for its ability to maintain acceptable condition levels while also freeing up funding for other transportation needs. In particular, Plan F was selected because the condition targets reflect the overall management approach to the road, where the western-most sections are desired to be more rustic and remote-feeling and the eastern-most sections are in better conditions to handle more intensive use. Tables 10 and 11 below summarizes the conditions for the unpaved segments of the Denali Park Road under the Denali LRTP investment strategy.

Conditions are measured in FCI, where a higher value represents worse condition and a lower value represents better condition. FCI data for the unpaved Park Road is based on estimates by staff responsible for maintaining the unpaved Park Road after the 2016 opening.

Table 10: Conditions of Unpaved Segments of Denali Park Road Reflected in Denali LRTP Investment Strategy

Mileposts	Segment Name	Current Condition	Target Condition	Change in Condition
MP 15 to 32	Savage to Teklanika Bridge	Low-good	High-fair	Small decline
MP 32 to 39	Igloo Forest to Sable Pass	Mid-fair	High-fair	Small improvement
MP 39 to 43	Sable Pass to East Fork Bridge	Mid-fair	High-fair	Small improvement
MP 43 to 47	Polychrome to Plains of Murie	Mid-poor	High-poor	Small improvement
MP 47 to 62	Plains of Murie to Stony Overlook	Mid-fair	Low-fair	Small decline
MP 62 to 66	Stony Overlook to Eielson	Low-fair	Low-fair	No change
MP 66 to 70	Eielson to Grassy Pass	High-poor	Mid-poor	Small decline
MP 70 to 88	Grassy Pass to Boundary Pit	Mid-fair	Mid-poor	Moderate decline
MP 88 to 92	Boundary Pit to Kantishna	Very-poor	Low-poor	No change

Table 11: Denali Unpaved Park Road Segments -- Current Conditions and Strategy Conditions Explored During LRTP Development

			Plan A		Plan B		Plan C	
Mileposts	**Segment Name**	**Current Conditions**	Plan A Desired Conditions	Plan A Annual Needs	Plan B Strategy Conditions	Plan B Annual Needs	Plan C Strategy Conditions	Plan C Annual Needs
MP 15 to 32	Savage to Teklanika Bridge	0.09	0.109	$ 0.13 M	0.13	$ <.01 M	0.109	$ 0.13 M
MP 32 to 39	Igloo Forest to Sable Pass	0.13	0.109	$ 0.14 M	0.12	$ 0.11 M	0.129	$ 0.93 M
MP 39 to 43	Sable Pass to East Fork Bridge	0.13	0.109	$ 0 .24 M	0.13	$ 0.20 M	0.139	$ 0.19 M
MP 43 to 47	Polychrome to Plains of Murie	0.35	0.109	$ 1.20 M	0.14	$ 1.10 M	0.245	$ 0.74 M
MP 47 to 62	Plains of Murie to Stony Overlook	0.13	0.109	$ 0.70 M	0.13	$ 0.56 M	0.139	$ 0.52 M
MP 62 to 66	Stony Overlook to Eielson	0.14	0.109	$ 0.25 M	0.14	$ 0.20 M	0.139	$ 0. 20 M
MP 66 to 70	Eielson to Grassy Pass	0.17	0.109	$ 0.44 M	0.14	$ 0.37 M	0.169	$ 0.30 M
MP 70 to 88	Grassy Pass to Boundary Pit	0.12	0.109	$ 0.56 M	0.12	$ 0.51 M	0.169	$ 0. 32 M
MP 88 to 92	Boundary Pit to Kantishna	0.499	0.109	$ 0.72 M	0.14	$ 0.68 M	0.324	$ 0.43 M
Total	**MP 15 to 92 Total**		Total	$ **4.35 M**	Total	$ **3.76 M**	Total	$ **2.93 M**

			Plan D		Plan E		**Plan F (Selected)**	
Mileposts	**Segment Name**	**Current Conditions**	Plan D Strategy Conditions	Plan D Annual Needs	Plan E Strategy Conditions	Plan E Annual Needs	**Plan F Strategy Conditions**	**Plan F Annual Needs**
MP 15 to 32	Savage to Teklanika Bridge	0.09	0.109	$ 0.13 M	0.109	$ 0.13 M	.109	$ 0.13 M
MP 32 to 39	Igloo Forest to Sable Pass	0.13	0.109	$ 0.14 M	0.109	$ 0.14 M	.109	$ 0.14 M
MP 39 to 43	Sable Pass to East Fork Bridge	0.13	0.109	$ 0.24 M	0.109	$ 0.24 M	.109	$ 0.24 M
MP 43 to 47	Polychrome to Plains of Murie	0.35	0.149	$ 1.1 M	0.149	$ 1.1 M	.245	$ 0.74 M
MP 47 to 62	Plains of Murie to Stony Overlook	0.13	0.149	$ 0.47 M	0.149	$ 0.47 M	.149	$ 0.47 M
MP 62 to 66	Stony Overlook to Eielson	0.14	0.149	$ 0.18 M	0.149	$ 0.18 M	.149	$ 0.18 M
MP 66 to 70	Eielson to Grassy Pass	0.17	0.325	$ -	0.325	$ -	.325	$ -
MP 70 to 88	Grassy Pass to Boundary Pit	0.12	0.325	$ -	0.325	$ -	.325	$ -
MP 88 to 92	Boundary Pit to Kantishna	0.499	0.325	$ 0.43 M	0.325	$ 0.43 M	.449	$ 0.12 M
Total	**MP 15 to 92 Total**		Total	$ **2.66 M**	Total	$ **2.66 M**	**Total**	**$2.03 M**

Plan F Unpaved Road Segments

The final change that the LRTP team made while discussing the road strategies with park staff was to lower the condition targets for two of the most difficult segments along the unpaved Park Road. This section describes these two segments and how accepting a lower condition in these areas can allow for better conditions on other parts of the Denali NPP transportation system.

Mileposts 43 to 47: Polychrome Pass to the Plains of Murie

The unpaved Denali Park Road segment of Polychrome Pass to the Plains of Murie has been identified by Denali NPP staff as especially difficult to maintain and repair. It is facing significant geotechnical hazards that will worsen as time goes on and climate

change accelerates permafrost thaw. Making improvements to this section that would take it from the middle of the poor condition band to the low end of fair condition band as explored in Plan D is projected to cost $1.07 M per year. Making lesser improvements from the middle of the poor condition band to the high end of the poor condition band as called for in Plan C would cost $0.74 M per year instead, saving $0.33 M per year for other uses. Thus the selected strategy (Plan F) will target a condition rating at the high end of the poor band, instead of a fair rating as with other segments in the central segment of the unpaved Denali Park Road (Igloo Forest to Eielson Visitor Center). This is not an ideal or desired condition for this segment, but reflects the challenges of working in this area given limited funding.

Mileposts 88 to 92: Boundary Pit to Kantishna

The final segment of the unpaved Denali Park Road is currently at the very low end of poor condition and is bordering on severe condition. All of the alternative unpaved road plans propose to improve this section. However, improving the condition from the low end of poor condition to the middle of poor condition as explored in plans C and D is projected to cost $0.43 M per year. Investing this much in one of the least-utilized segments of the Denali Park Road would limit funds for critical investments elsewhere. As a result, the Denali Investment Strategy proposes lesser improvements at a cost of $0.12 M per year.

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Appendix G:
Project Selection Checklist

DENA LRTP Project Selection Criteria Checklist

Project Name:

PMIS: Funding Source(s):

1. Long Range Transportation Plan – the project generally adheres to the following:

   ☐ National Long Range Transportation Plan's Goals and Objectives *(see Attachment A)*.

   ☐ Asset Management ☐ Transportation Finance ☐ Resource Protection

   ☐ Visitor Experience ☐ Safety

   ☐ Alaska Regional Long Range Transportation Plan's Goals and Objectives *(see Attachment B)*.

   ☐ System Management ☐ Mobility ☐ User Experience

   ☐ Resource Protection ☐ Climate Change

   ☐ Denali NPP Long Rang Transportation Plan's "actions of no regret" *(see Attachment C)*.

   Goal Area: _____ Action of No Regret #: _____

2. Financial Strategy – the project meets the following:

   ☐ Capital Investment Strategy score _____

   - optimizer band ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   ☐ Consistent asset investment based on scenario quadrant position *(Attachment D)*

   ☐ Consistent with proportionate investment within road management zones *(Attachment D)*

   - Milepost or Road Segment _____

   ☐ Consistent with one or more of the following:

   ☐ Operations and Maintenance (O&M)

   ☐ Rehabilitated Paved Road

   ☐ Repair & Maintain the Unpaved Road

   ☐ Repair & Improve Other High-Priority Transportation Assets *(bridges, transportation/multimodal trail)*

3. Risk Priority

   - Response to current high priority risks based on documented assessment *(Attachment E)*

   ☐ Unstable Slopes

   ☐ River and Stream Flooding

☐ Permafrost Subsidence

☐ Culverts – Operations and Maintenance (O&M)

☐ Gravel Production, Processing, or Purchase

☐ Relevance or proximity to mapped hot spot *(see Attachment F)*

- *Attachment F should have all the hot spots for Park Road on a map. Is this in DNPP LRTP? Or do we give them a link for online info?*

4. Operations and Maintenance

- Investment Type – this project is a:

☐ New Investment - offset in the cost of O&M

(presumed increase has been addressed by _____)

☐ Replaced investment - offset in the cost of O&M

(presumed decrease or net zero increase has been addressed by _____)

☐ Eliminated Investment – offset in the cost of O&M

(presumed decrease has been addressed by _____)

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Appendix H:
Public Comment Summary

Public Comment Summary
Denali National Park and Preserve Long-Range Transportation Plan

Public comments are organized into two categories: common and specific. Common comments are paraphrased themes that appear in multiple comment submissions. Responses to common comments are summarized in Table 1. Specific comments request a particular change. When specific comments seek changes that are accurate, reasonable, feasible, and logically consistent, they were made and included in the final document. Other comments include general statements about the quality of the document, suggestions for future plans, or ideas for coordination, next steps, management strategies, park priorities, or projects. These comments are valued, and are available to inform other park planning efforts, and will be referenced during the leadup to this plan's eventual update.

Table 1. Common Comment

	Paraphrased Comment	Comment Response
1	Winter or offseason travel is not sufficiently represented in the plan	During the development of this plan, numerous issues and needs surfaced as topics that warrant further study and consideration. Public comments were an especially meaningful source for identifying topics in need of additional attention. These findings will be used to inform the development of the plan's update as well as other plans such as the Winter Recreation Plan.
2	There is insufficient data or information regarding specific transportation related conditions (e.g. trail crowding, locations of specific facilities, rest stop vehicle counts, large vehicle counts, winter routes locations, etc.)	The plan relied on facts, data, and concepts cited in existing park plans, studies, and other reports. No additional data collection or data analysis was conducted as part of this plan's development process. As such, present day conditions or terminology may differ from those described in the plan. Gaps in data and understanding will be reassessed in this plan's update.
3	The plan does not map specific transportation use, access, facilities for the entirety of the plan's 20-year horizon.	As a high-level strategic document, the plan is not intended to identify specific short-term or long-term project needs or changes park access locations.

	Paraphrased Comment	Comment Response
4	If a specific need is not mentioned in the plan (e.g. backcountry landing strip location), it means that the specific need will be precluded from future project selection and funding.	The plan is a high-level strategy document and is not intended to identify and prioritize specific projects. While the plan sets high-level goals that are used to evaluate the merits of future projects, it is not a project list. Whether or not a specific project idea is listed in this plan has no bearing on its ability to be developed or its funding merits.
5	The plan does not describe specific actions that the park will take to address a very specific issue (e.g. plans to address the safety of backcountry landings strips in light of climate change, cycling guidelines, commercial use authorization for guided hikes off Park Road, new parking lot locations, more tours, etc.)	During the development of this plan, numerous issues and needs surfaced as topics that warrant further study and consideration. Public comments were an especially meaningful source for identifying topics in need of additional attention. These findings will be used to inform the development of the plan's update.
6	Data, facts, or terminology used in the plan appear to be out dated.	The plan relied on facts, data, and concepts cited in existing park plans, studies, and other reports. No additional data collection was conducted as part of this plan's development process. As such, present day conditions or terminology may differ from those described in the plan.
7	The plan does not sufficiently outline specific actions to maintain and improve the park's soundscape.	During the development of this plan, numerous issues and needs surfaced as topics that warrant further study and consideration. Public comments were an especially meaningful source for identifying topics in need of additional attention. These findings will be used to inform the development of the plan's update.
8	The plan does not go far enough in offering solutions that address threats to park access created by climate change and natural disasters.	During the development of this plan, numerous issues and needs surfaced as topics that warrant further study and consideration. Public comments were an especially meaningful source for identifying topics in need of additional attention. These findings will be used to inform the development of the plan's update.
9	The plan does not go far enough to protect resources.	During the development of this plan, numerous issues and needs surfaced as topics that warrant further study and consideration. Public comments were an especially meaningful source for identifying topics in need of additional attention. These findings will be used to inform the development of the plan's update.

	Paraphrased Comment	Comment Response
10	The plan does not go far enough to protect access.	During the development of this plan, numerous issues and needs surfaced as topics that warrant further study and consideration. Public comments were an especially meaningful source for identifying topics in need of additional attention. These findings will be used to inform the development of the plan's update.
11	Goal and/or objective indicators or performance measures are too limited.	The plan relied on readily available data and findings cited in existing park plans, studies, and other reports. No additional indicator data was collected as part of this plan's development. The need for additional data for informing additional indicators will be considered for the plan's update.
12	Specific details from the Vehicle Management Plan are not reflected in this plan	The long range transportation plan does not supersede the Vehicle Management Plan in any way. Omission of Vehicle Management Plan data, indicators, and conclusions does not negate their significance in how the park is managed.