Sam Robbins
Spring 2018, 327G Final Project
May 3, 2018

Using ArcGIS to determine erosion susceptibility within Denali National Park, Alaska, USA

Sam Robbins

Sam Robbins
Spring 2018, 327G Final Project
May 3, 2018

Introduction

Denali National Park is six million acres of wild land with only one road and one road entrance. If you travel along it you'll see the relatively low-elevation taiga forest give way to high alpine tundra and snowy mountains, culminating in Denali, the highest mountain in North America. Landslides are a common occurrence in the park. While they do not tend to be exceptionally dangerous, they occur often and have both man-made causes and natural causes, with naturally occurring landslides being much more prevalent. Since parts of the park are heavily covered with thick glaciers and snow, permafrost is present throughout much of the park. When the ground thaws toward the spring time, the ground becomes unstable and susceptible to landslides. The melting of glaciers causes large amounts of running water to stem from the melting glaciers and the thawing of the ground makes it unstable. With the combination of the effects of warming, landslides are a significant risk for many areas of the park. In this project, I will attempt to assess the relative risk of landslides throughout the park and determine which areas are most prone to landslides based on a number of factors. Ultimately, this project aims to determine which areas of Denali National Park are most susceptible to erosion and, in turn, landslides.

Data Collection and Pre-Processing

Data for this project came from several sources. First, I obtained files for the park boundary, park and area roads, and trails from the National Park Service GIS and GPS Data collection (https://www.nps.gov/dena/planyourvisit/gis_gps_data.htm). This data was downloaded as KMZ files, so I converted them to KML files in Google Earth, and then ultimately converted them into layer files using the *KML to Layer* tool.

Next, I found statewide precipitation data from the USGS (https://agdc.usgs.gov/data/usgs/water/statewide.html). This data set is a 1:2,000,000 scale map showing lines of equal annual precipitation.

Data for the slope, land cover, and geology of Denali was downloaded from the Integrated Resource Management Applications Data from a search with the keywords "Denali" and "GIS" (https://irma.nps.gov/DataStore/Search/Quick).

A table of files and their original sources is presented below.

<table>
<tr><th>Data</th><th>Source</th><th>Website</th></tr>
<tr><td>area roads</td><td>NPS</td><td rowspan="4">https://www.nps.gov/dena/planyourvisit/gis_gps_data.htm</td></tr>
<tr><td>park outline</td><td>NPS</td></tr>
<tr><td>park boundary</td><td>NPS</td></tr>
<tr><td>trails</td><td>NPS</td></tr>
<tr><td>Denali National Park and Preserve landcover</td><td>IRMA Data Store</td><td rowspan="3">https://irma.nps.gov/DataStore/Search/Quick</td></tr>
<tr><td>Digital Geologic map of Denali National Park and Preserve</td><td>IRMA Data Store</td></tr>
<tr><td>60 Meter Hillshade of the NED for Denali</td><td>IRMA Data Store</td></tr>
</table>

Sam Robbins
Spring 2018, 327G Final Project
May 3, 2018

Data	Source	Website
60 Meter Hillshade of the NED clipped to Alaska	IRMA Data Store	
Alaska Native Regional Corporations Boundary File	US Census Bureau	https://www.census.gov/geo/maps-data/data/cbf/cbf_anrc.html
Alaska Precipitation Data	USGS	https://agdc.usgs.gov/data/usgs/water/statewide.html

Data Processing

For all files, the first step I took to process the data was to define a common coordinate system across the board. In this case, I chose the NAD_1983_211_Alaska_Albers projection from the Projected State Systems folder within ArcGIS (Figure 1).

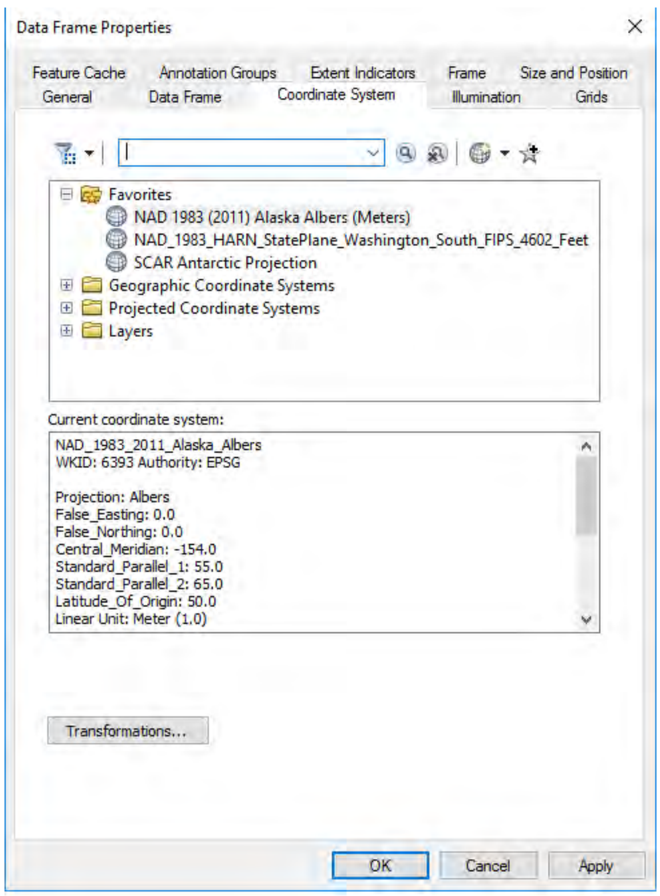


Figure 1: Information for the NAD_1983_2011_Alaska_Albers Coordinate System

Precipitation Data

The precipitation data came in a tar.gz file format so the first step I took was to unzip the file twice with WinZip (Figure 2).

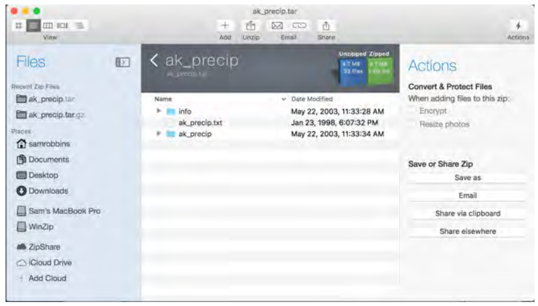


Figure 2: WinZip window; used to extract shapefiles from the larger precipitation data set.

Upon opening the unzipped file, the data shows a statewide map of precipitation. The next step I took was to clip the statewide map to the park boundary using the *"Clip (Analysis)"* tool (Figure 3). After the data was clipped I used the "Feature to Raster" tool to create a raster for the data (Figure 4).

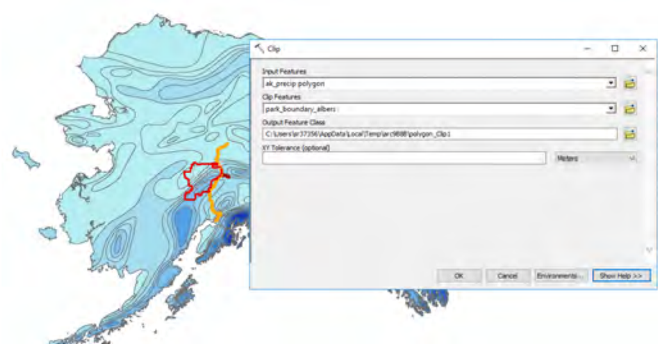


Figure 3: Clip (Analysis) tool

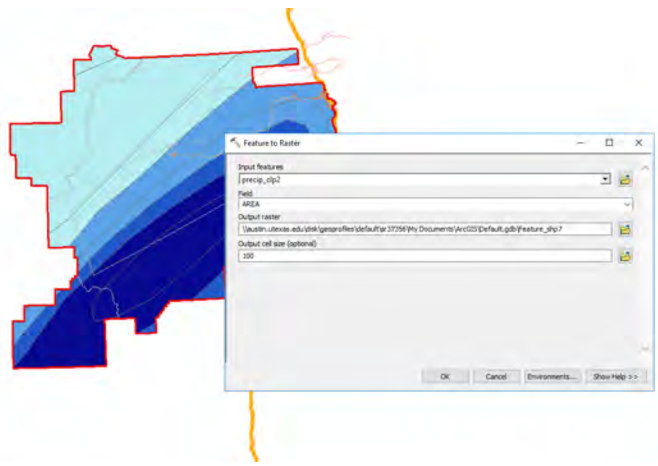


Figure 4: Feature to Raster tool

To evaluate precipitations effect on erosion I reclassified the new precipitation raster to the values presented below (Figure 5):

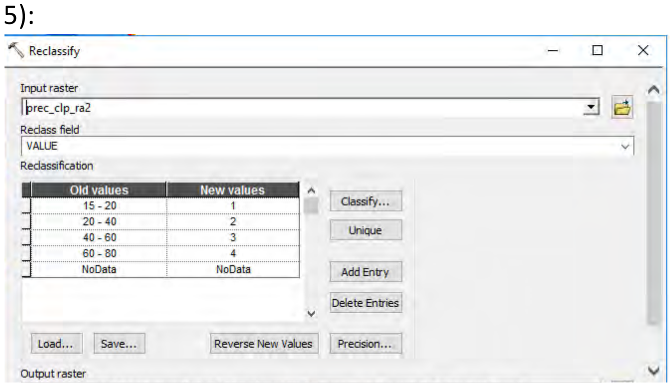


Figure 5: Reclassification values for the precipitation raster

Sam Robbins
Spring 2018, 327G Final Project
May 3, 2018

Slope Data

To evaluate the slope component of erosion susceptibility I started with the 60 meter DEM file I downloaded from the IRMA Data Store. I first used the "Clip (Data Management)" tool to clip the DEM to the park boundary (Figure 6).

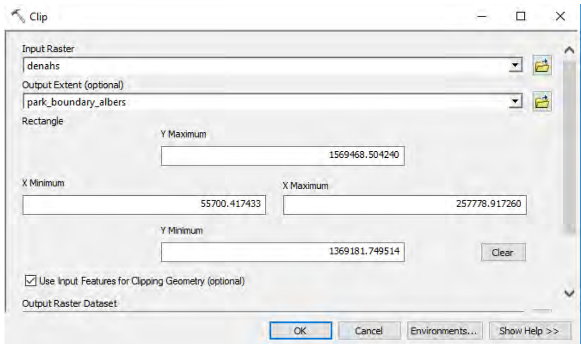


Figure 6: Clip (Data Management) tool to clip raster data

Next, I used the "Slope" tool to convert the hillshade into a slope raster (Figure 7).

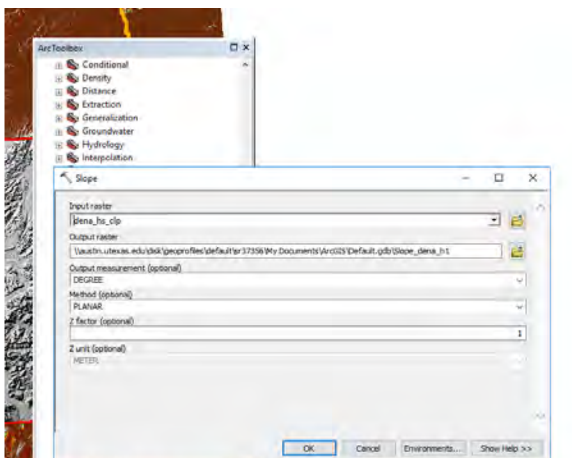


Figure 7: Converting the Denali hillshade raster into a slope raster

I then reclassified the new raster to the following values (Figure 8):

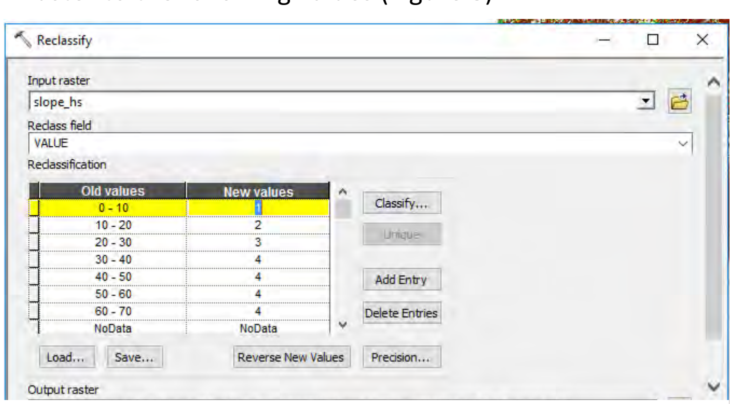


Figure 8: Reclassification values for the slope raster

Land Cover Data

As with the slope data, the land cover data was downloaded from the IRMA store. I started by clipping the data to the park boundary (using the Data Management Clip tool). I then looked at the attribute table for the data and determined that it could be split, broadly, into the following categories and reclassification values: 1 - forests and trees; 2 - shrubs; 3 - sparse vegetation; 4 - bare ground and burned with 1 being the least susceptible and 4 being the most susceptible to erosion (Figure 9).

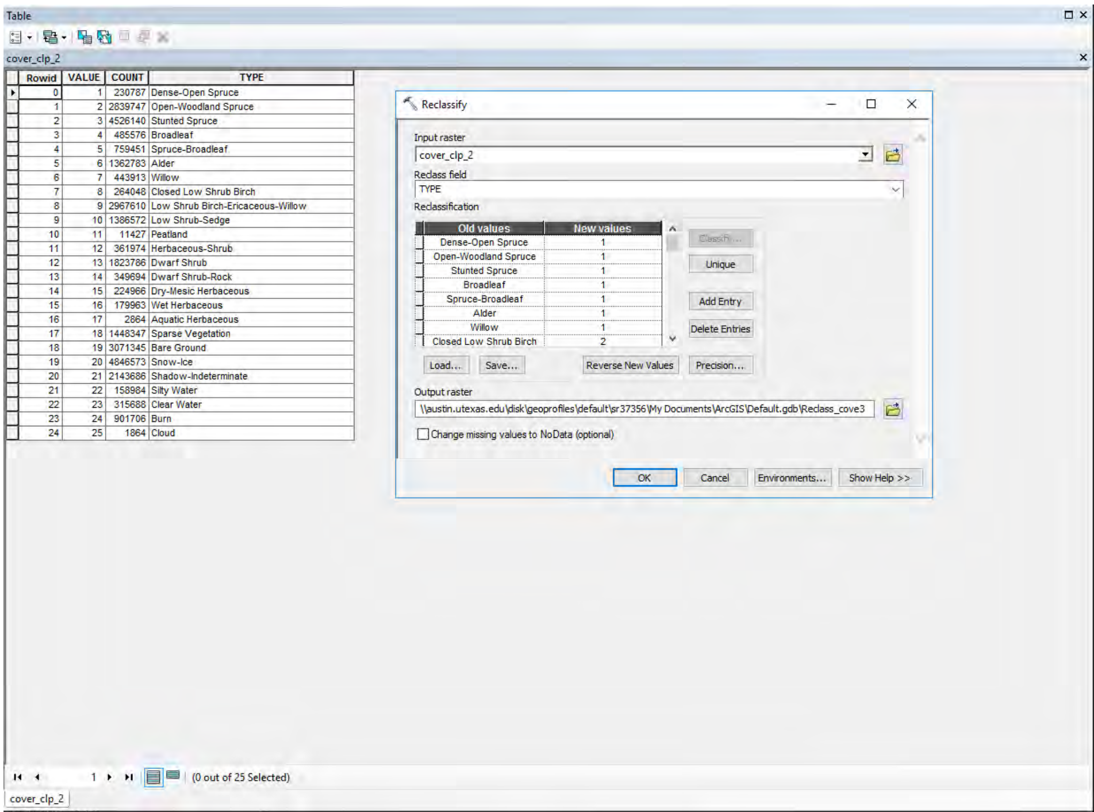


Figure 9: Reclassification values for the land cover data raster

Geology Data

The geology data set was downloaded from the IRMA Data Store as part of a Digital Geologic Map of Denali National Park and Preserve. The data was in the form of a geodatabase with several layer files such as faults, contacts, glacial features, etc. For the purposes of my project I only used the *dena_geologic_units_gdb.lyr* file. Next, I converted the layer file into a raster using the "Feature to Raster" tool with 100 as the Cell Size. I then clipped the new raster to the park boundary using the Clip (Data Management) tool.

To reclassify the data, I first examined the attribute table for the raster to determine which units were present in my study area. I then exported the attribute table to Excel to keep track of the reclassification values for each unit. I used the associated Map Units Properties Table to determine each unit's susceptibility to erosion. All units within the study area, their erosion susceptibility rankings, and their reclassification values are presented below (Figure 10).

Attribute Table Info	Unit Abbrev.	Rock Type/Description	Erosion Resistance	Reclass value
,45,8129,CZw	CZw	quartzite, sand/siltstone	moderate	3
,36,2082,DCd	DCd	shales, siltstones, cherts	moderate	3
,78,62,Dsb	Dsb	serpentine, basalt, chert, gabbro	moderate	3
,35,3813,DSmdl	DSmdl	limestone	moderate	3
,6,352225,GLACIER	GLACIER		---	0
,31,83253,JCmd	JCmd	siliciclastic, basalt, limestone, sandstone	moderate	3
,54,4746,JTRct	JTRct	tuff, argillite, chert, limestone	moderate	3
,86,493,JTRsu	JTRsu	sed. Rocks and basalt	moderate	3
,37,2262,JTRtv	JTRtv	volcaniclastics, lower volcanic rocks, silty shale	moderate	3
,42,68704,Kcs	Kcs	conglomerate sandstone	moderate	3
,19,206064,KJf	KJf	metamorphosed trubidites	moderate	3
,43,36612,KJfn	KJfn	metamorphosed trubidites	moderate	3
,90,664,KJs	KJs	argillite, chert, sandstone, limestone	moderate to moderately high	2
,39,5330,Kmar	Kmar	chert, argillite/shale, limestone, UM rocks	moderate to high	2
,57,28670,MDt	MDt	schist	moderate	3
,29,288,MZPZi	MZPZi	intrusive and volcanic rocks	high	1
,34,695,MZZum	MZZum	UM and mafic rocks	moderately high	2
,58,1854,Oc	Oc	chert	moderately high	2
,75,14848,PDsc	PDsc	sandstone, conglomerate, siltstone	moderate	3
,64,19758,PZk	PZk	phyllite, quartzite, marble, metavolcanic rocks	moderate	3
,63,14498,PZsc	PZsc	mafic to felsic metavolcanic rocks	moderate	3
,50,85,PZvs	PZvs	volcanic and sedimentary rocks	moderate	3
,59,146521,PZZaqs	PZZaqs	pelitic and quartzose schist	moderate	3
,9,1083666,Qs	Qs	layered peat	low	4
,71,1065,SCpl	SCpl	shales, siltstones, cherts	moderate	3
,53,5579,Tcb	Tcb	siltstone, claystone, shale, sandstone, coal	high	1
,93,18827,Tcv	Tcv	andesite, basalt, rhyolite, pyroclastic flows	high	1
,41,5418,Tegr	Tegr	granite and granodiorite	high	1
,55,789,Tfv	Tfv	conglomerate, sandstone, mudstone, basalt-andesite flows	moderate to moderately high	2
,28,50,Thf	Thf	felsic and intrusive rocks	moderate to high	2
,65,245,Thm	Thm	diorite porphyry, diabase, basalt	moderate to high	2
,47,1049,Tk	Tk	pebble and cobble conglomerate	moderately low to moderate	3
,11,1652,TKg	Tkg	biotite-hornblende granite	moderately high to high	2
,18,344,TKgd	TKgd	monzonite bodies	moderately high to high	2
,17,942,TKi	TKi	intrusive rocks	moderately high to high	2
,56,102671,Tn	Tn	poorly consolidated pebble and boulder conglomerate	moderately low	3
,30,58597,Toem	Toem	granodiorite to tonalite	moderate to high	2
,26,84581,Tpgr	Tpgr	biotie-muscovite granite	high	1
,40,19793,TRcs	TRcs	calcareous sedimentary rocks	moderate	3
,79,156,TRDv	TRDv	volcanic and sedimentary rocks	moderate	3
,83,1645,TRlb	TRlb	basalt, basaltic tuff, limestone	moderate	3
,32,13049,TRn	TRn	greenschist facies	moderate to moderately high	2
,91,13197,TRPNas	TRPNas	flysch-like sedimentary rocks	moderate	3
,85,127,TRr	TRr	sandstone, argillite, conglomerate	moderate	3
,38,256,TRSl	TRSl	limestone	moderately high	2
,23,195,Tsf	Tsf	coarse conglomerate, clay, coal seams	moderately low to moderate	3
,24,606,Tty	Tty	sandstone, siltstone, shale, claystone	low to moderate	1
,89,5987,Tvb	Tvb	andesite and basalt	moderate high to high	2
,14,1464,Tvu	Tvu	volcanic flows from basalt to rhyolte	moderate	3
,69,2110,UNKbu	UNKbu	mixed rubble of metasiltstone	moderate	3
,92,192,UNKmlu	UNKmlu	serpentinized UM rocks, altered basalts	moderate	3
,1,13079,WATER	WATER		---	0

Erosion Resistance	Erosion Susceptibility (reclass value)
low	4
moderate	3
moderately high	2
high	1
water	0
glacier	0

Figure 10: Excel table used to organize geologic unit data and reclassify the geology raster

Raster Calculation and Results

To determine the overall erosion susceptibility of the area within Denali National Park I used the "Raster Calculator" tool to combine the four erosion risk factors into a single value from 1 to 16 (Figure 11).

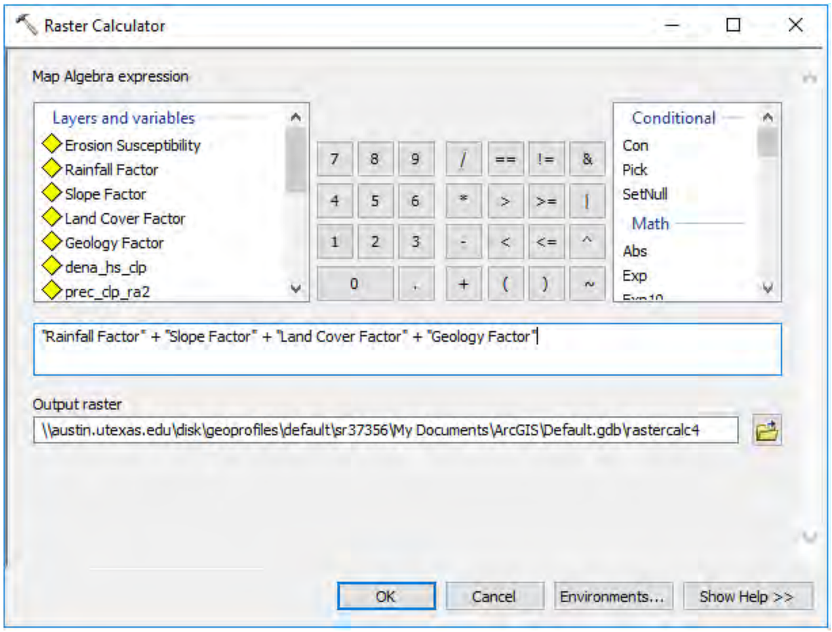


Figure 11: Raster Calculator

The resulting raster (Figure 12) is presented on the next page.

To further analyze the data, I reclassified the resulting raster to have four categories of erosion susceptibility: 1 – low; 2 – moderately low; 3 – moderately high; 4 – high. Each interval is 4 units i.e. interval 1 contains values 1-4 from the initial raster calculation, interval 2 contains values 5-8, etc. From this new raster (Figure 13) we can see the relative erosion susceptibility across the park area.

The individual risk factors affecting erosion/landslide susceptibility are presented in Figure 14.

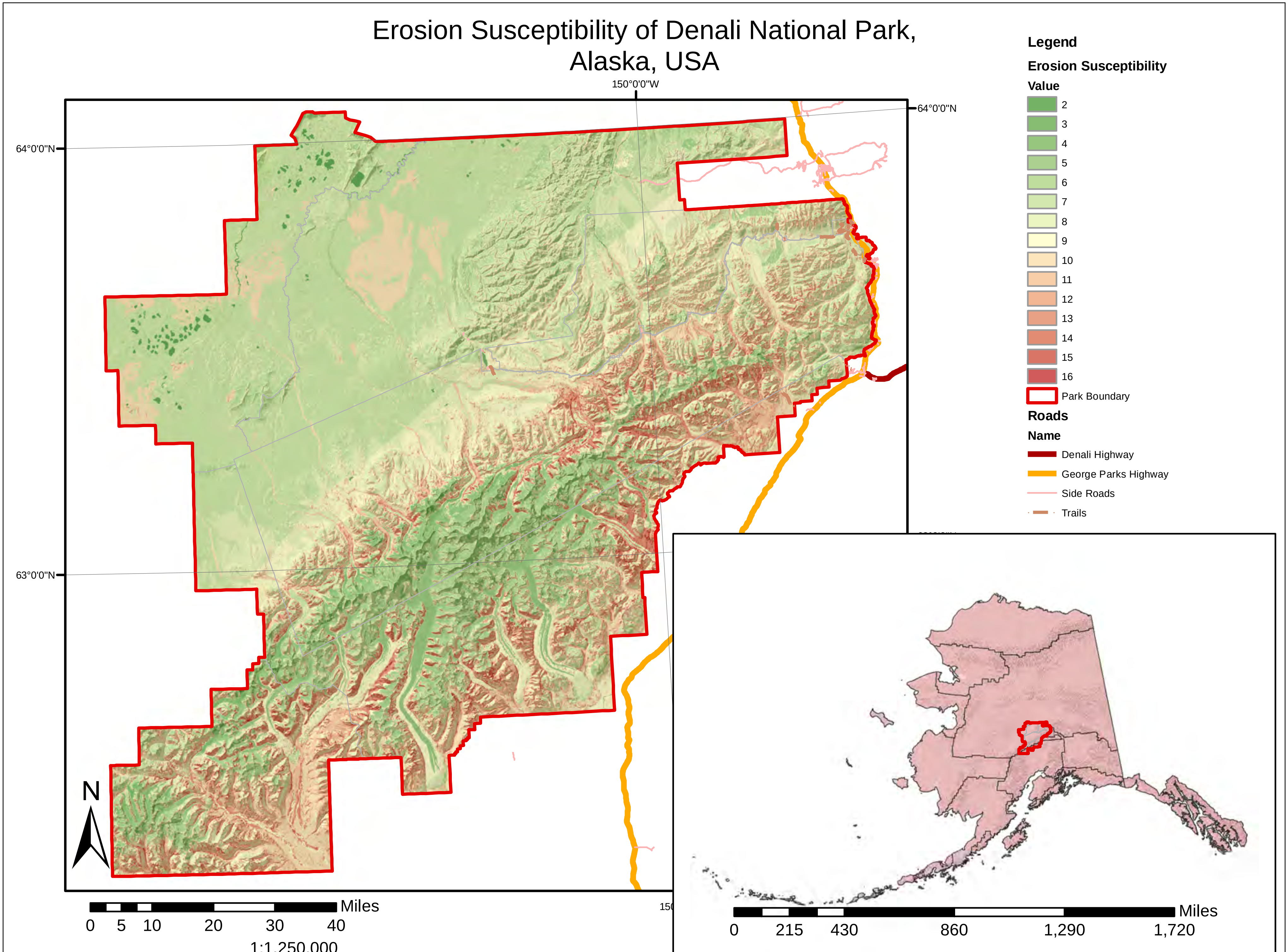


Figure 12: Erosion Susceptibility Map of Denali National Park

Erosion Susceptibility of Denali National Park, Alaska, USA

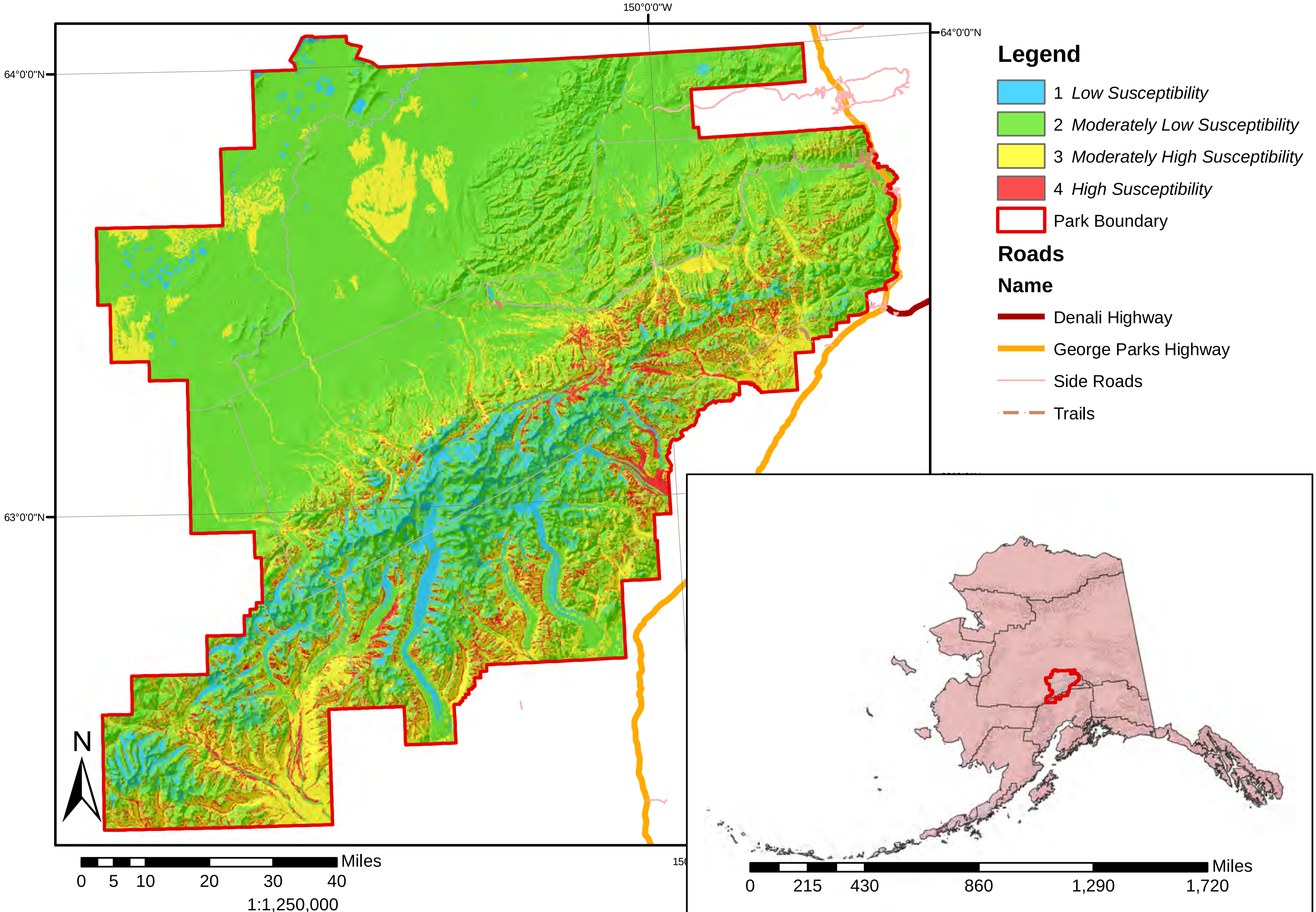
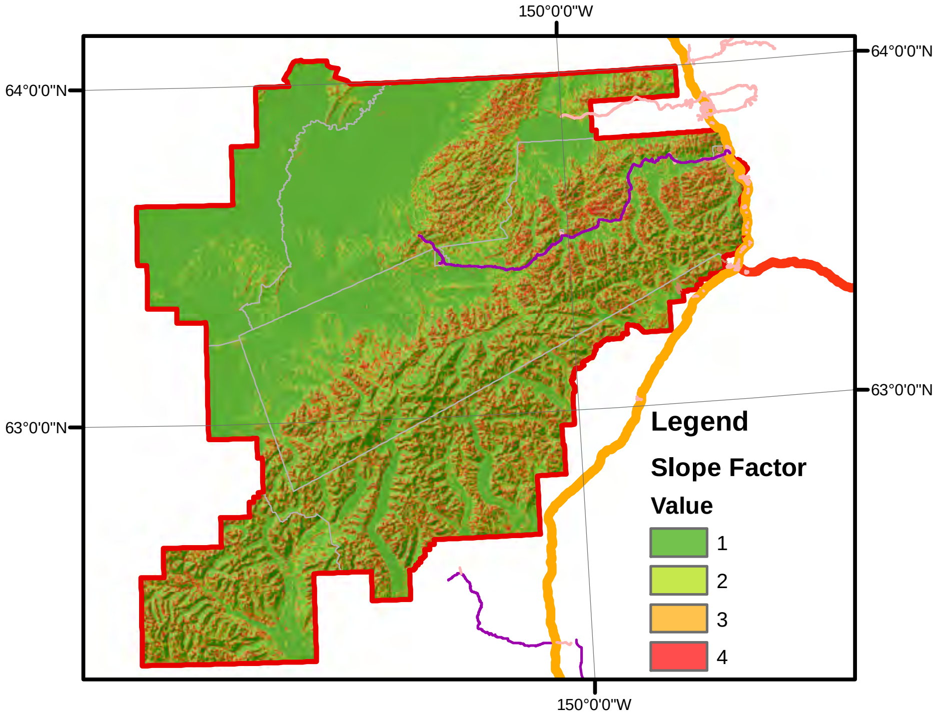
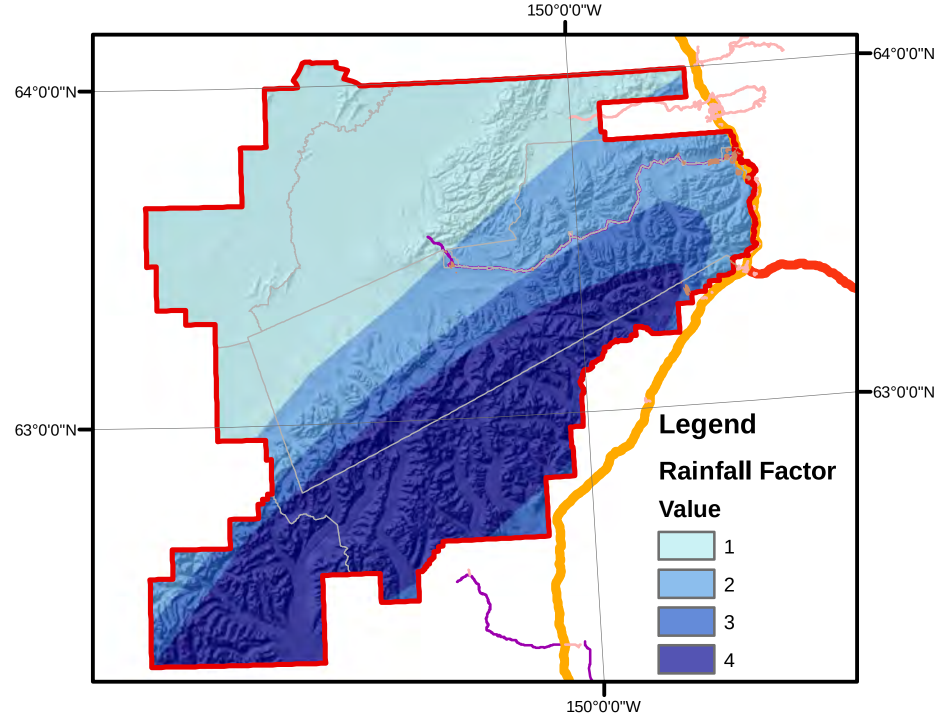
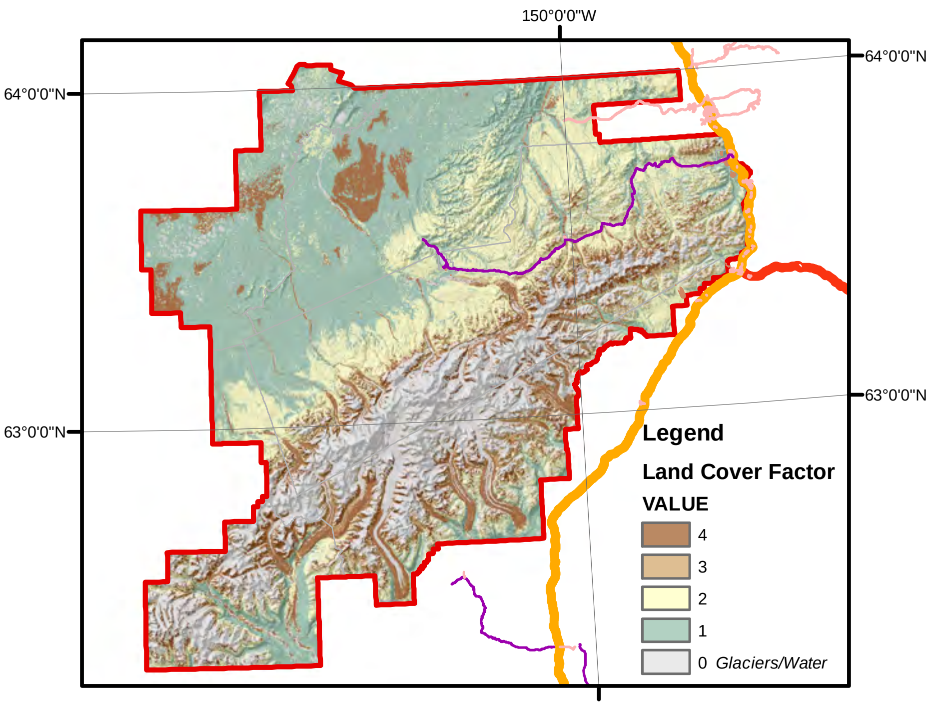


Figure 13: Relative Erosion Susceptibility Map of Denali National Park

Key Factors Affecting Runoff and Erosion in Denali National Park, Alaska, USA







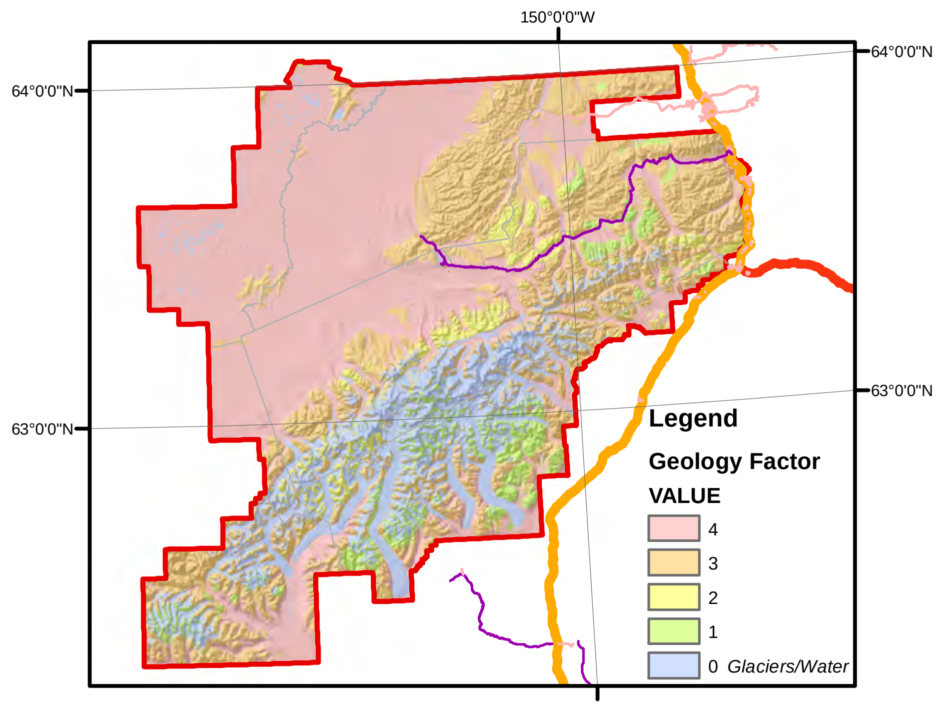


Figure 14: Erosion Risk Factors within Denali National Park

Sam Robbins
Spring 2018, 327G Final Project
May 3, 2018

Conclusions

The final Erosion Susceptibility Maps (Figures 12-14) show us several things. First, the primary controls on erosion susceptibility (considering only the risk factors presented above) are slope and land cover. The areas of highest erosional susceptibility are on the slope of the glaciers running northeast-southwest across the map.

Second, a majority of the area of Denali National Park has a low to moderately low erosion susceptibility. This is likely because, ignoring the glaciers, most of Denali is a relatively flat lying forest where soils are more consolidated and less prone to landslides.

This project aimed to determine which areas of Denali National Park are most prone to landslides. From an analysis of the erosion susceptibility maps it can be seen that the area's most likely to experience landslides are on the flanks of the glaciers where there are large slopes, minimal vegetative cover, and heavy rainfall.