

NOOKSACK INDIAN TRIBE **CLIMATE CHANGE STUDIES**

Oliver Grah
Water Resources Program Manager
Nooksack Indian Tribe
Deming, WA



Tribal Climate Change Webinar Series
ITEP, PNWRS, PNWTCCP, NPLCC

January 15, 2015

Objectives of Presentation:



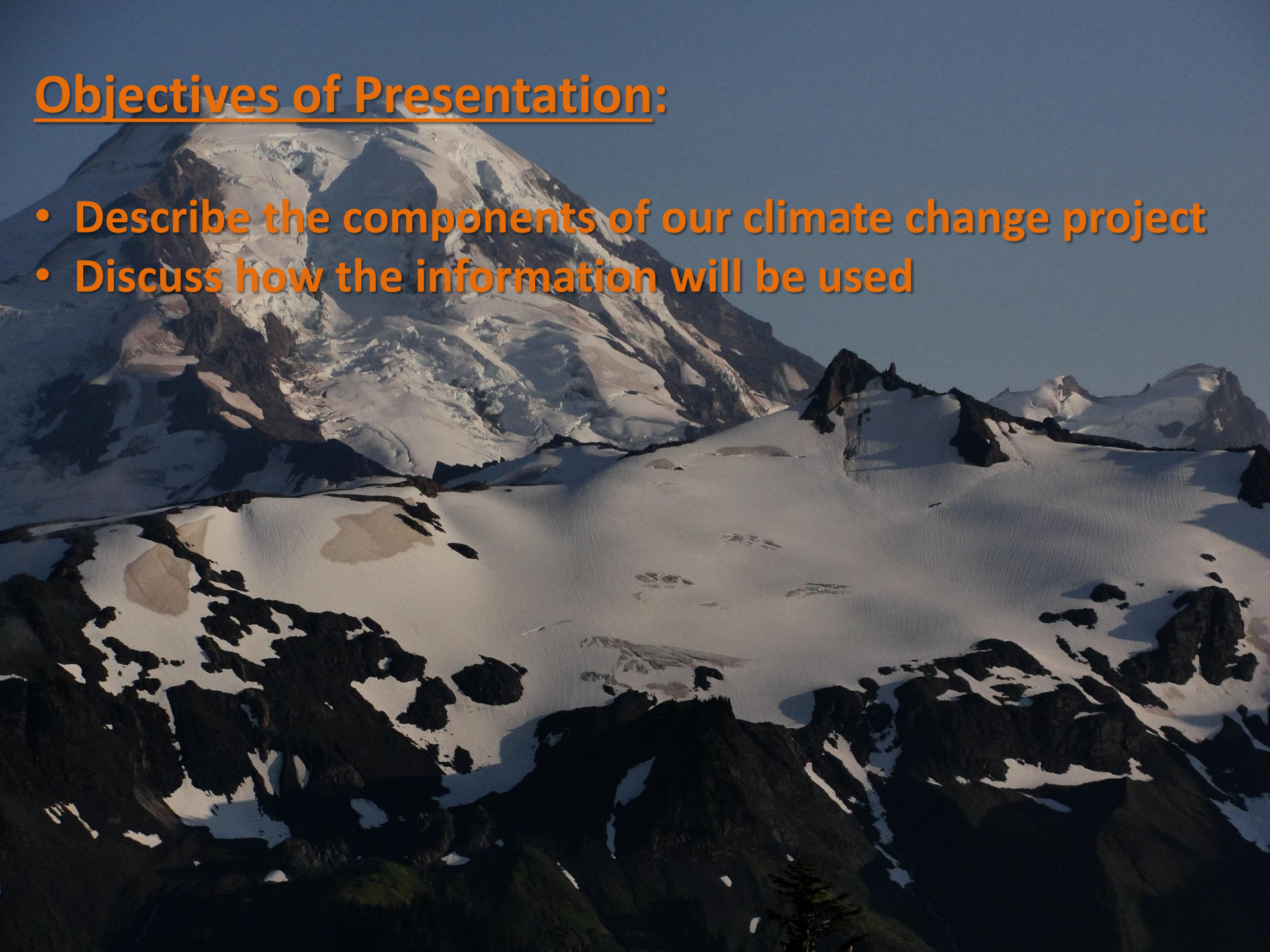
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- Describe the components of our climate change project



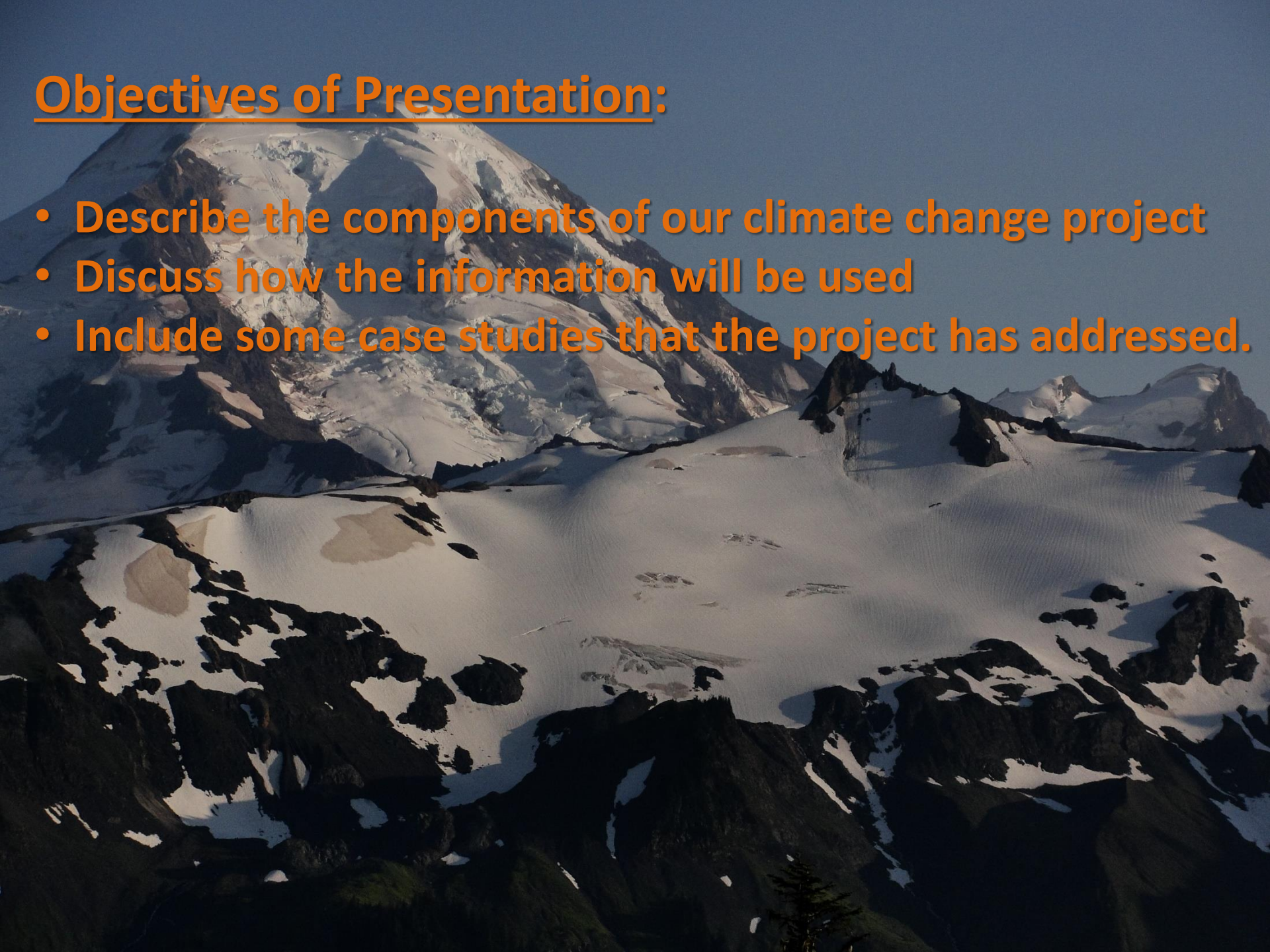
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- Discuss how the information will be used



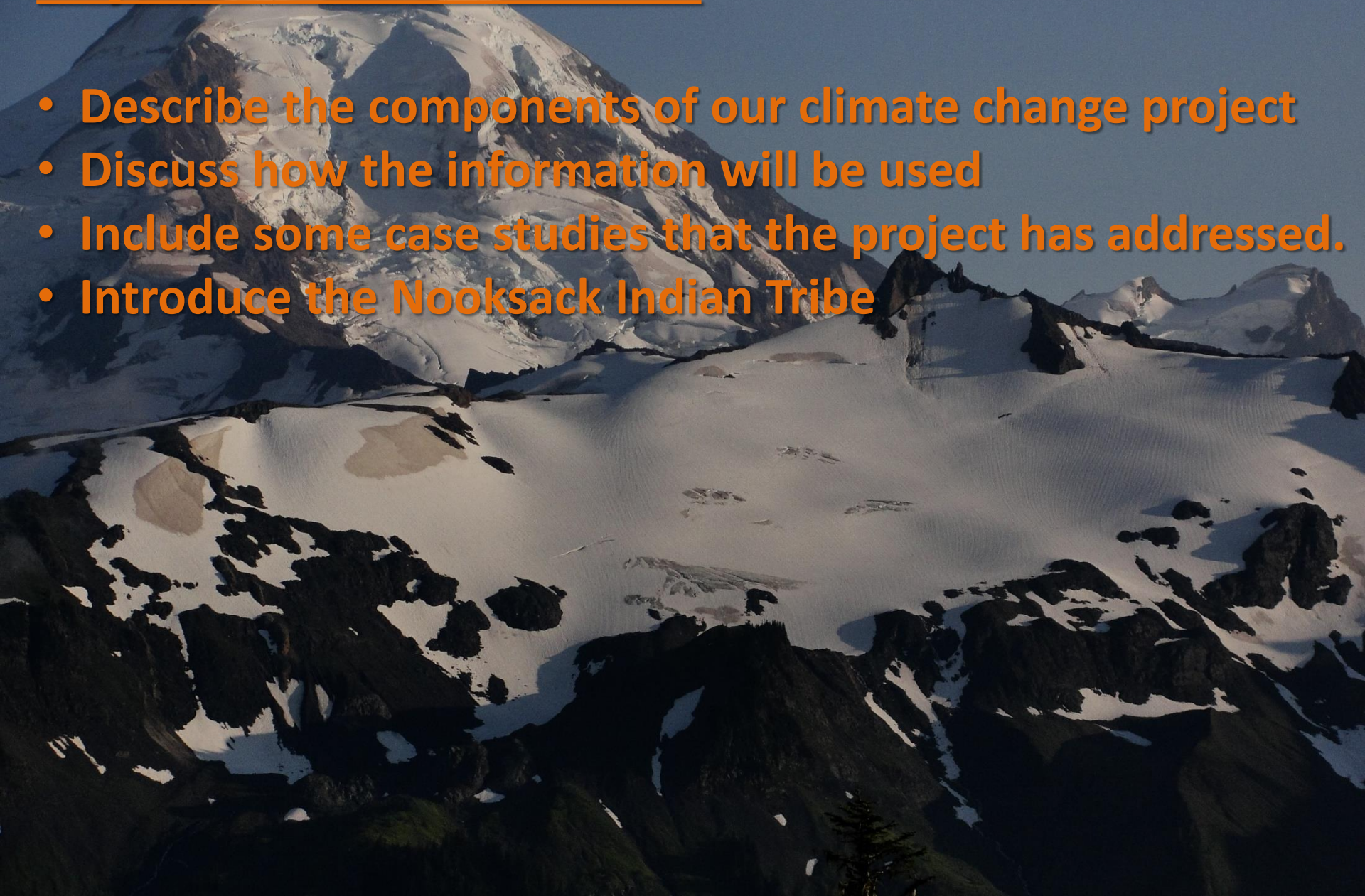
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- Discuss how the information will be used
- Include some case studies that the project has addressed.



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- Discuss how the information will be used
- Include some case studies that the project has addressed.
- Introduce the Nooksack Indian Tribe



Funding Sources:



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- EPA – PPG, NEP-CBG, Competitive CWA 319



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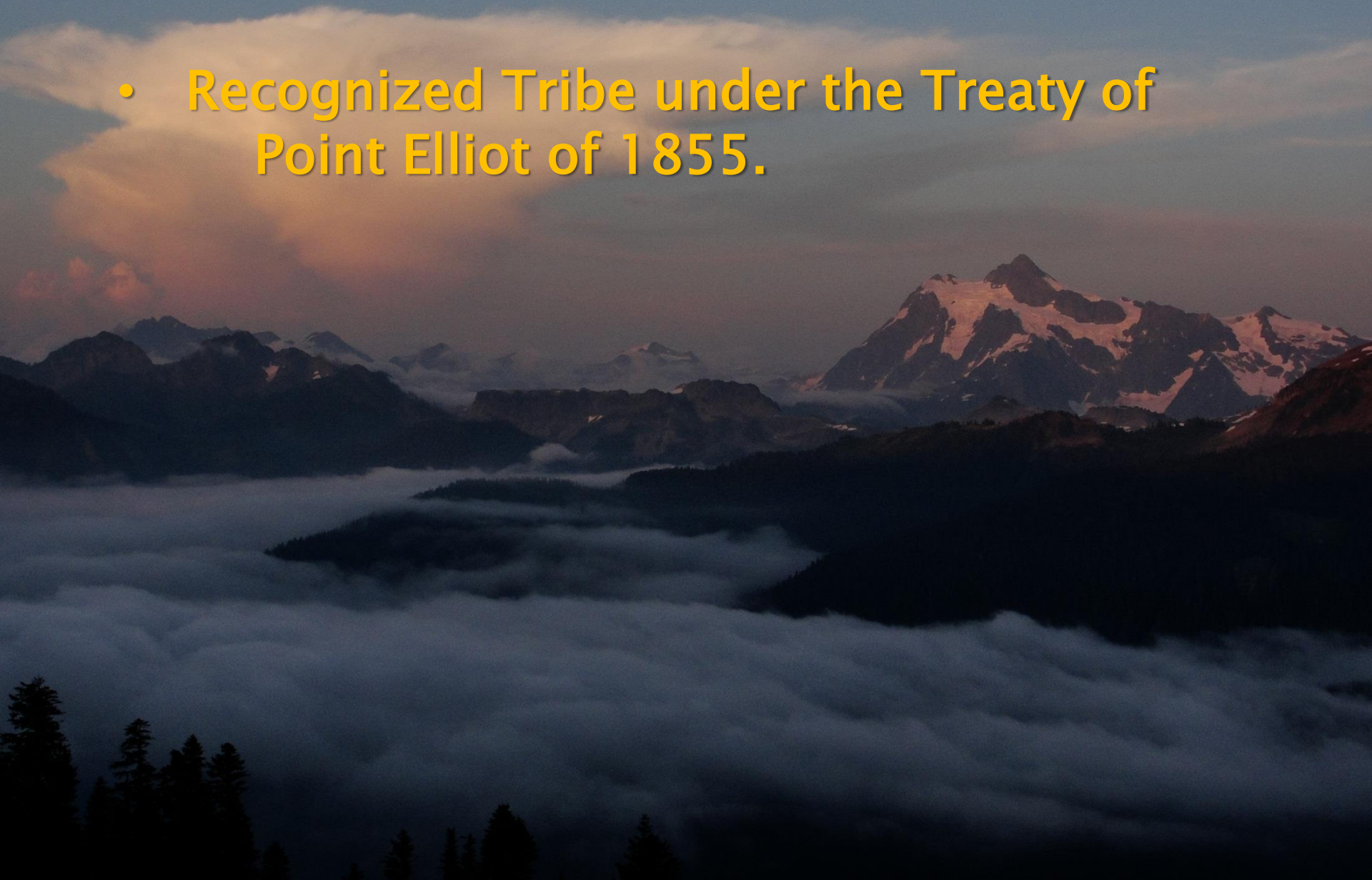


BACKGROUND – NOOKSACK INDIAN TRIBE



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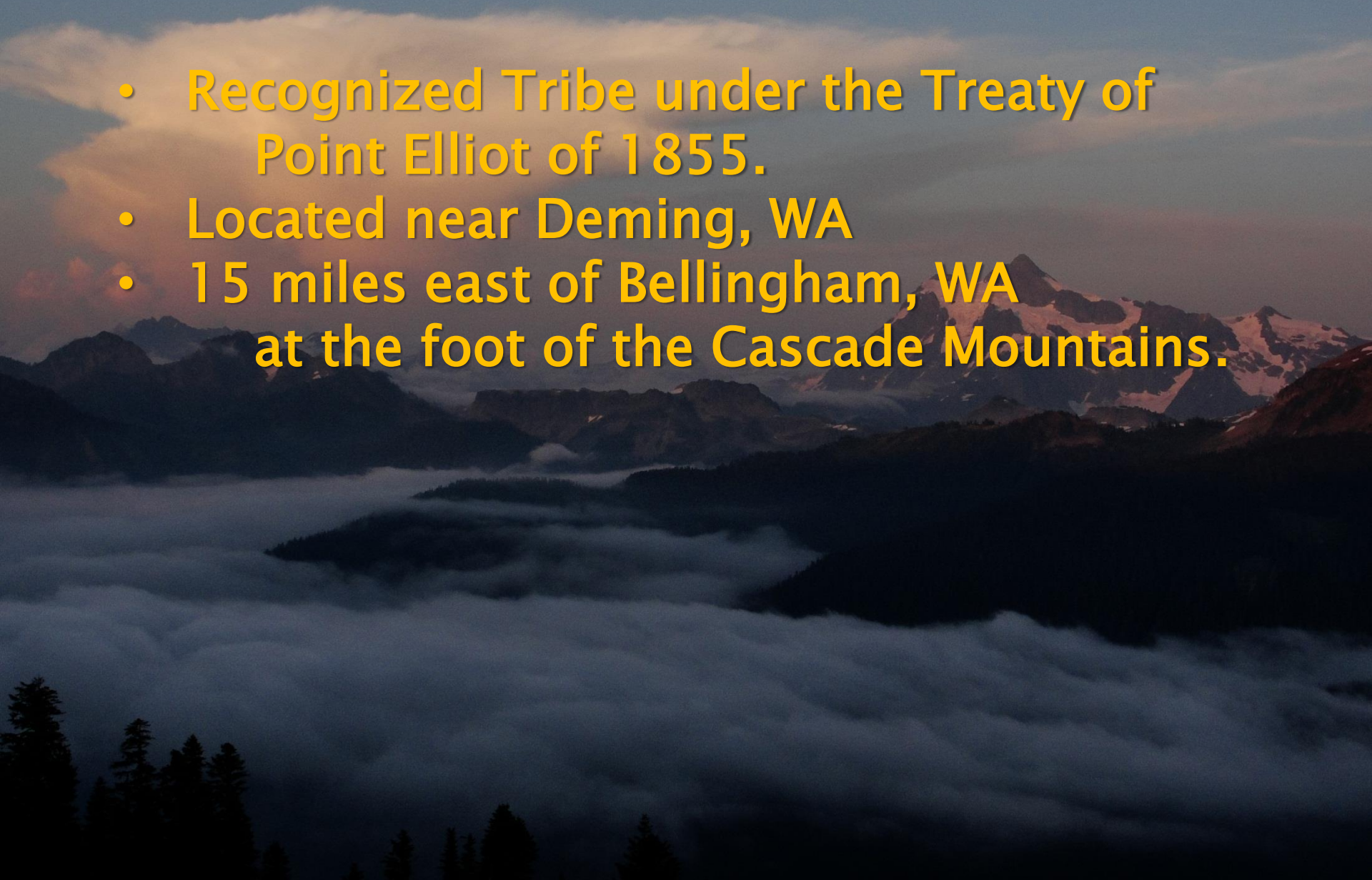
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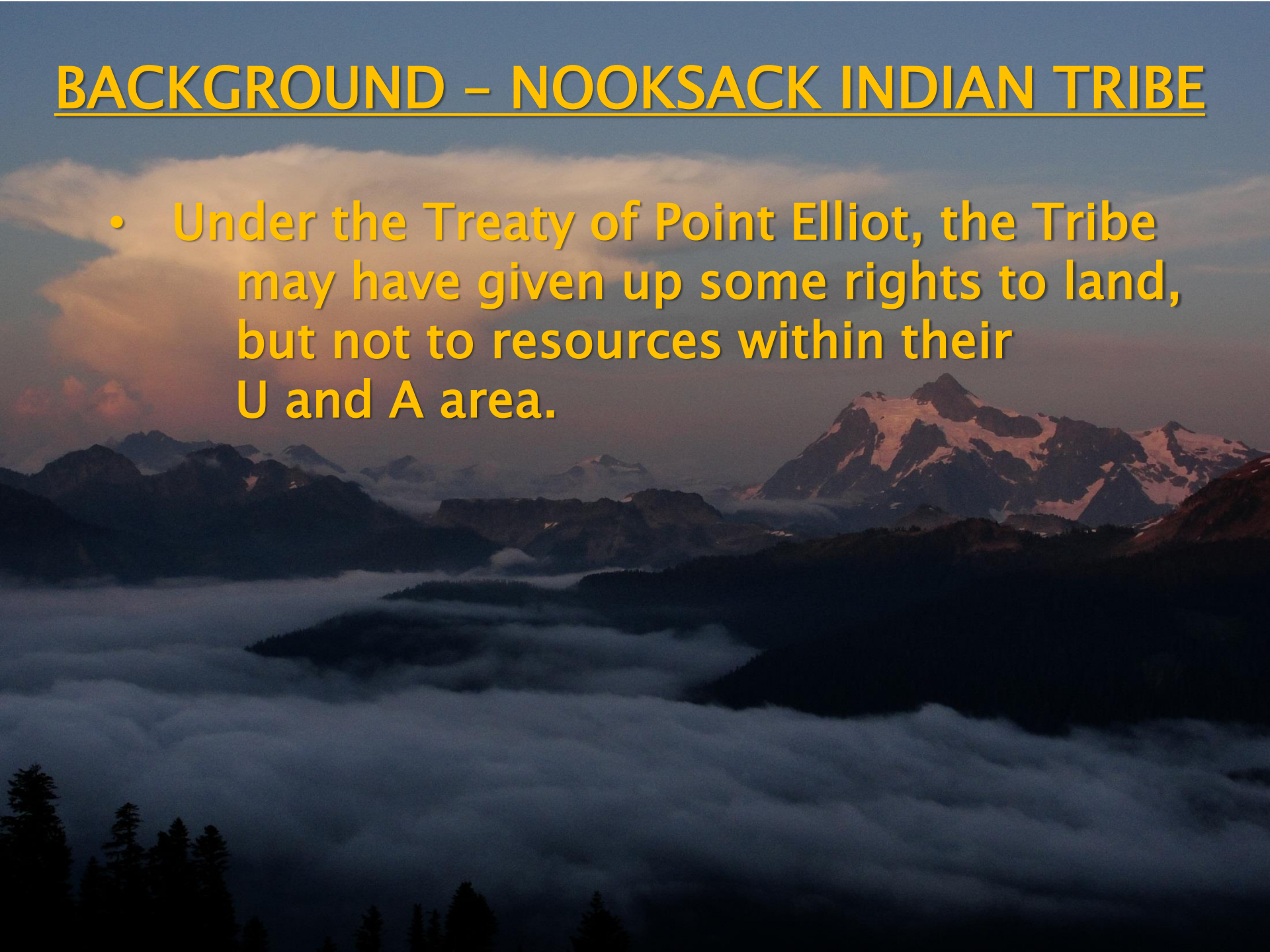
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- Small Tribe, consists of about 2,000 members.

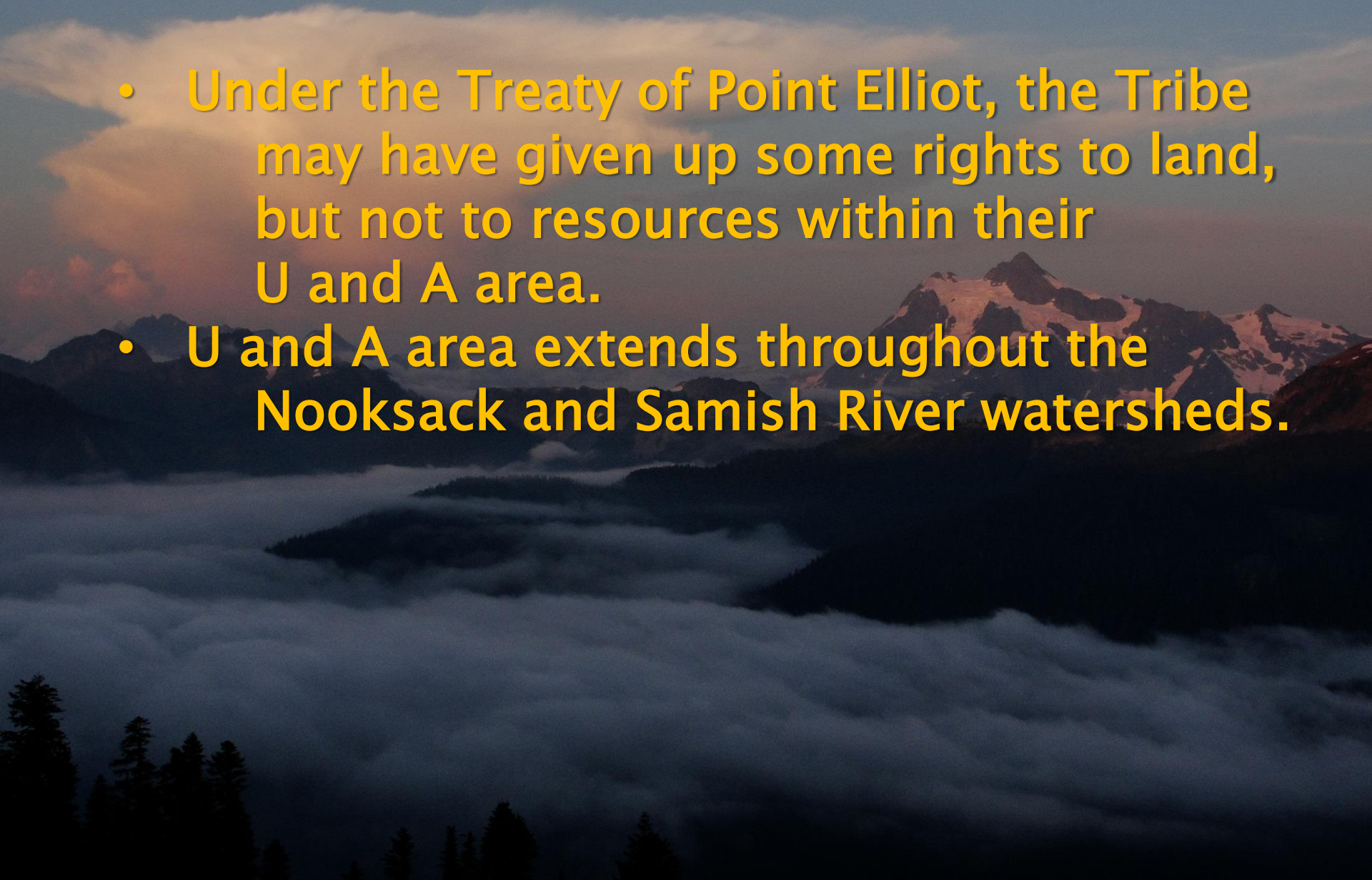
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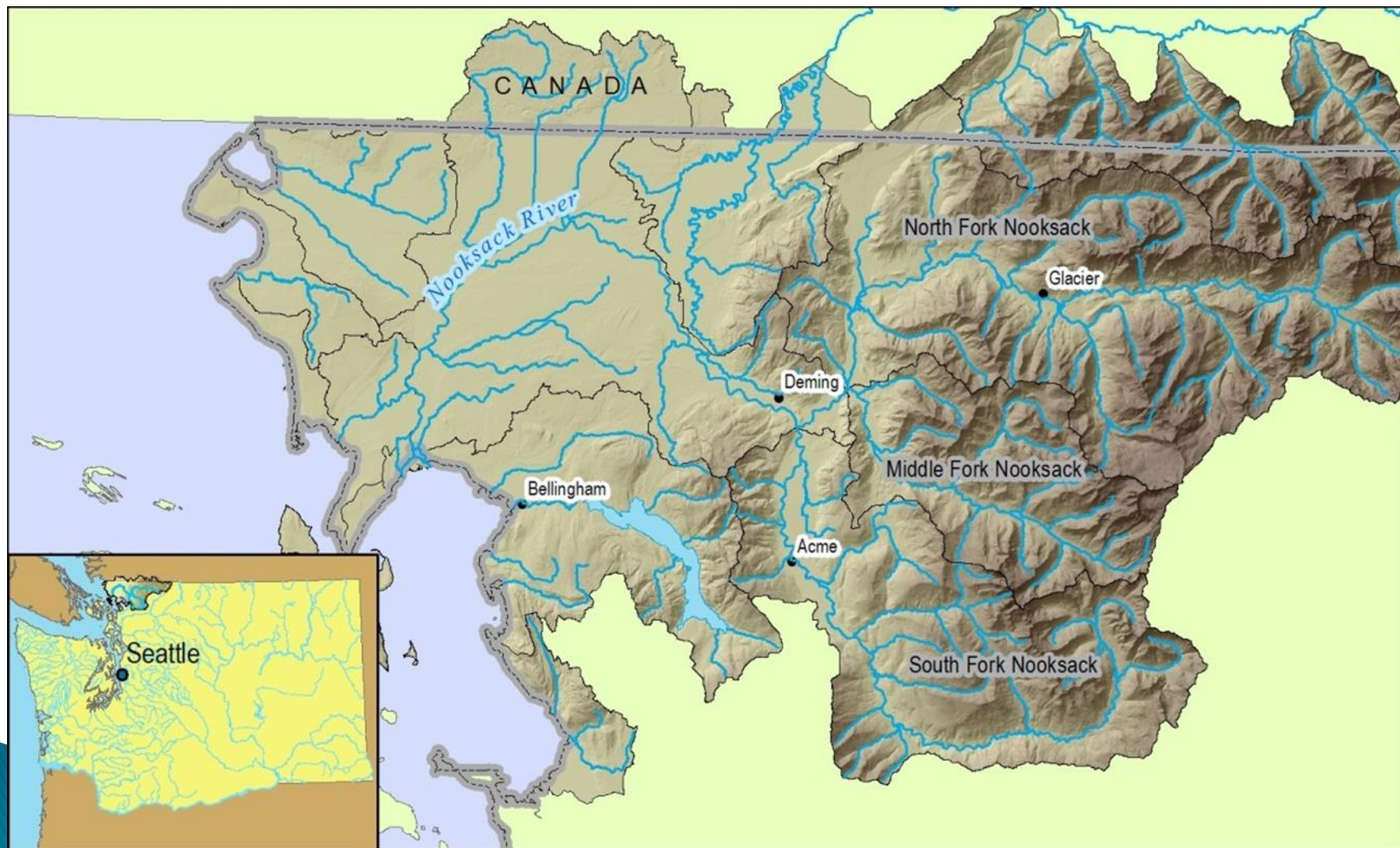
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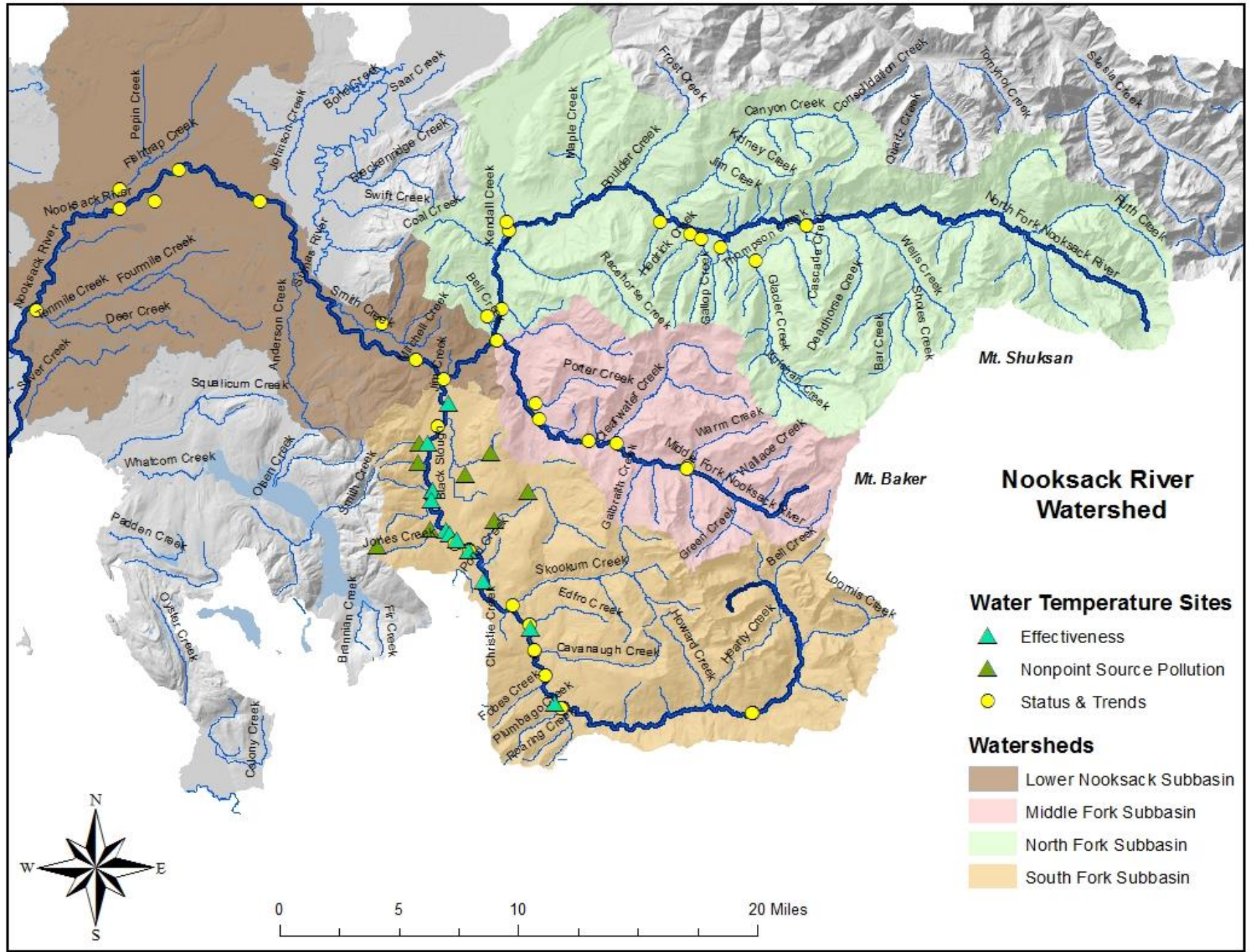
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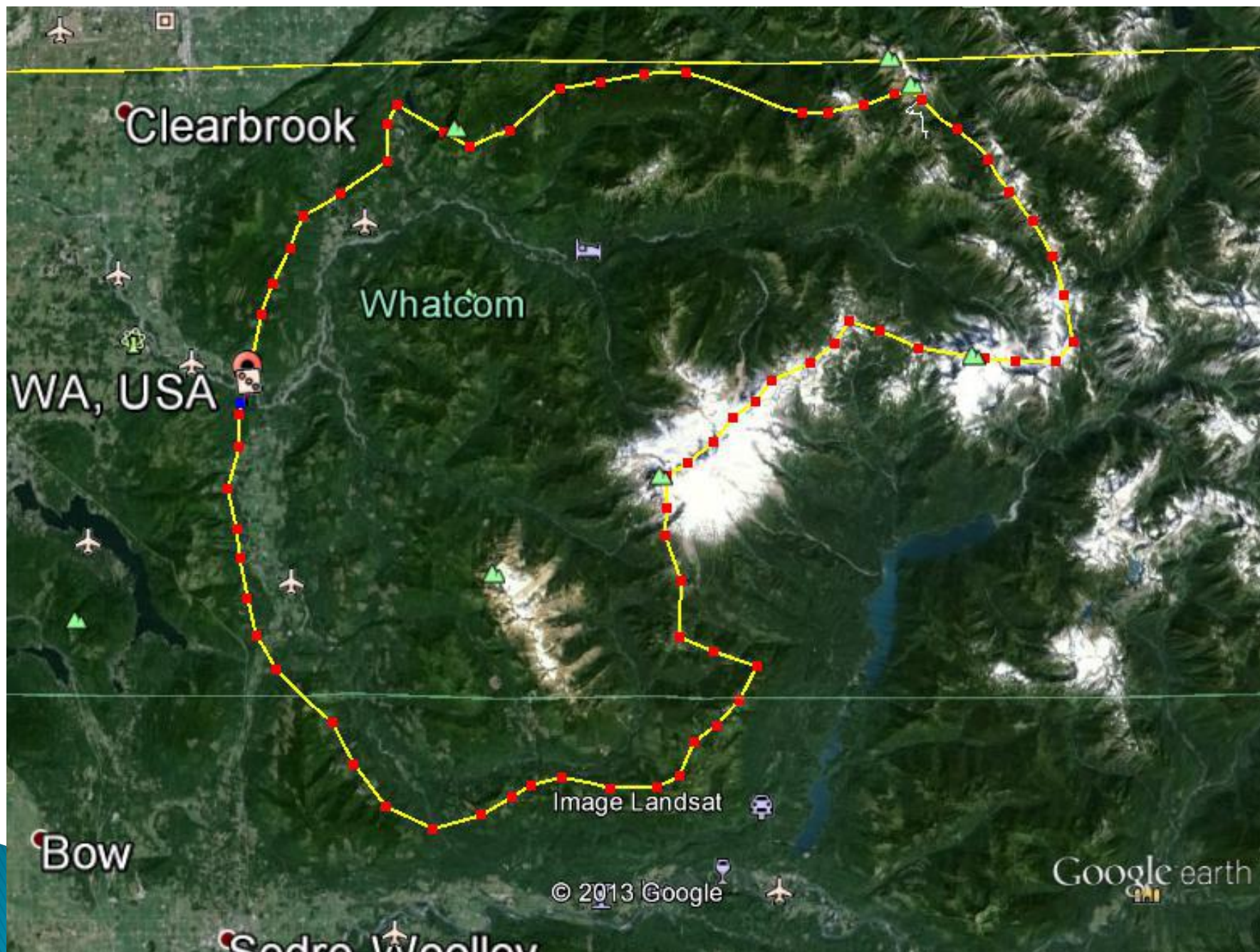
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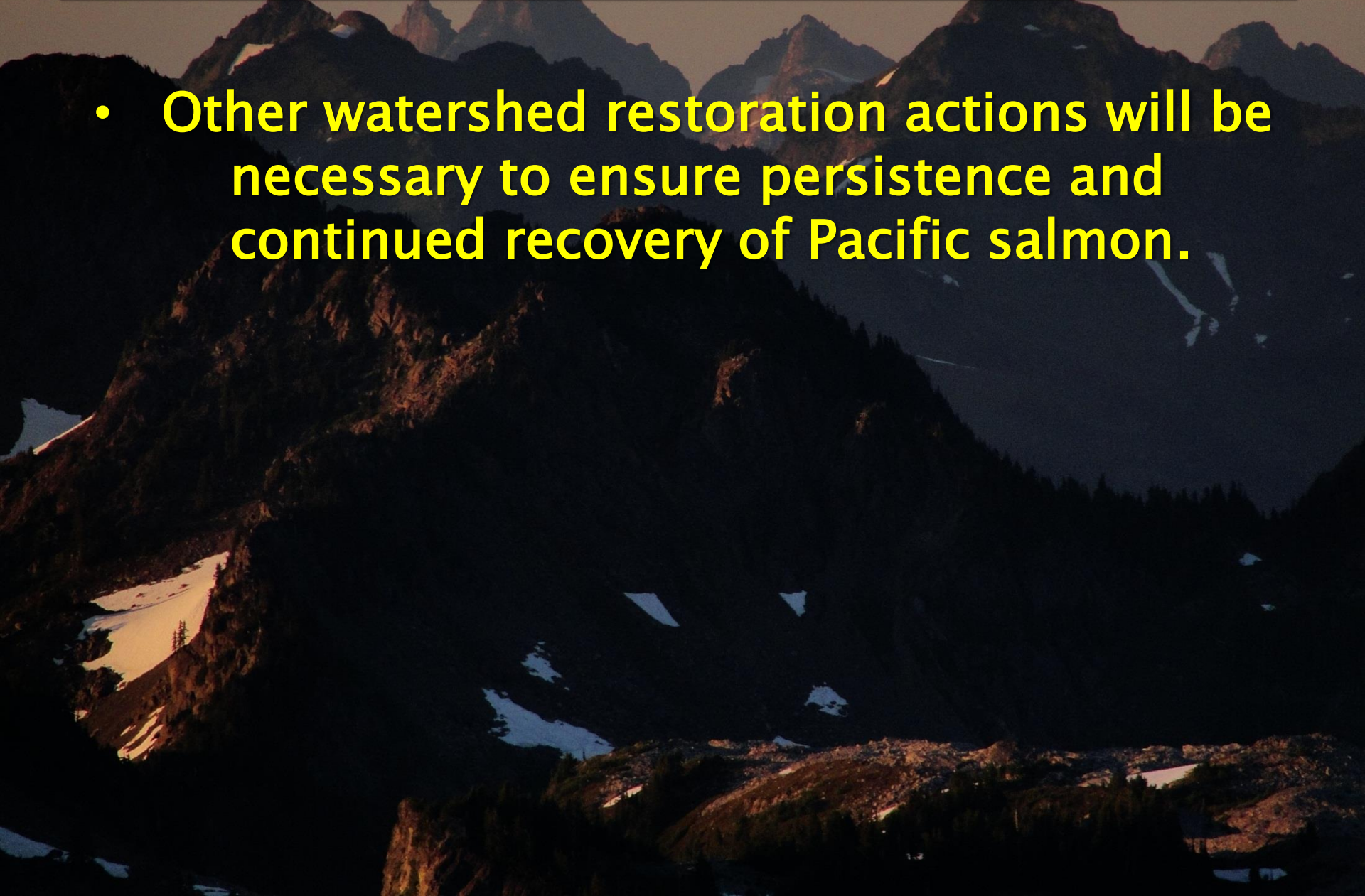
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- Salmon are currently and will continue to be stressed by legacy impacts from land use.
- Climate change impacts will cumulatively add to legacy impacts of altered stream flows and temperature.
- Huge efforts are directed towards in-stream restoration to enhance salmon recovery in response to legacy impacts.



BACKGROUND – NOOKSACK INDIAN TRIBE

- Other watershed restoration actions will be necessary to ensure persistence and continued recovery of Pacific salmon.



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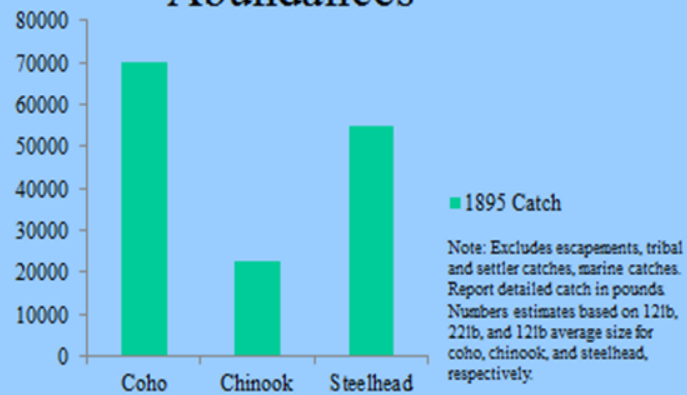
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- This information is needed to plan for effective habitat restoration measures that address the additional stresses of future climate change.

Salmon Stocks

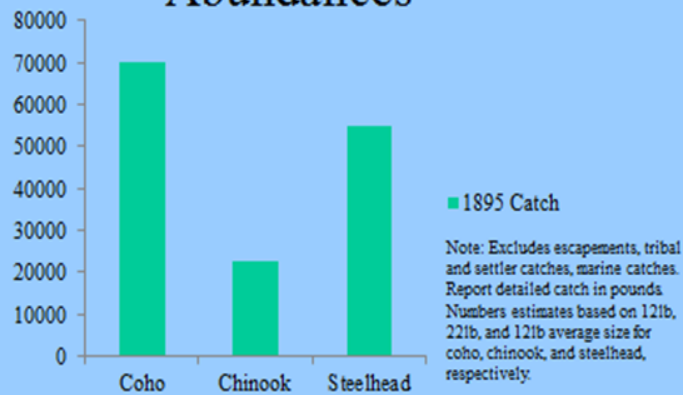
Early Nooksack Salmon Abundances



Source: Report of U.S. commissioner of Fish and Fisheries, year ending June 1896

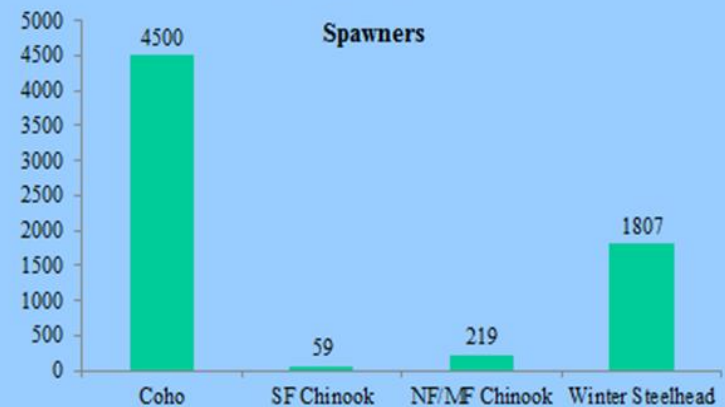
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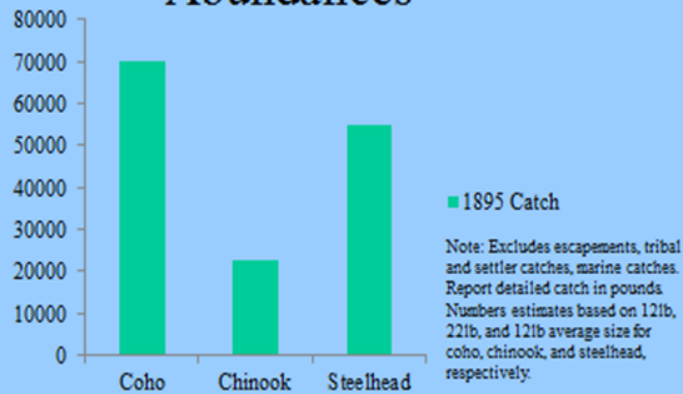
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Recent Nooksack Salmon Abundances:



Salmon Stocks

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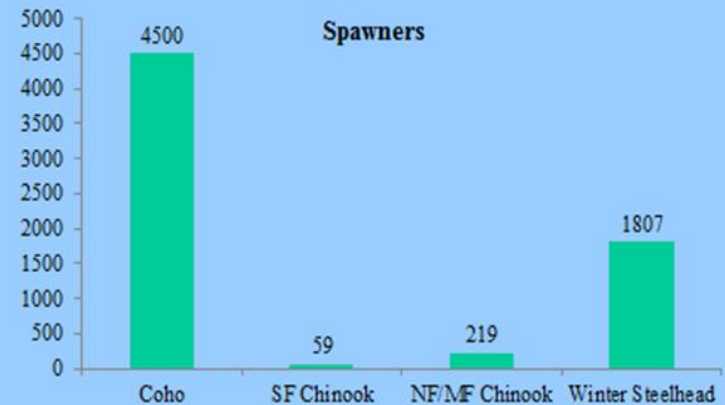


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WRIA 1 Water Symposium

36

Recent Nooksack Salmon Abundances:



WRIA 1 Water Symposium

40



Today, native salmonid runs are less than 8 % of the runs in the late 1800's.



Nooksack Indian Tribe Climate Change Project



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Original project:



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Original project:

- Small EPA-PPG work plan component in FY2010



Nooksack Indian Tribe Climate Change Project

Original project:

- Small EPA-PPG work plan component in FY2010
- Literature review on glacier ablation



Attributes of Tribe's Overall Climate Change Project:



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- **Baseline Stream Temperature or Status and Trends Monitoring.**



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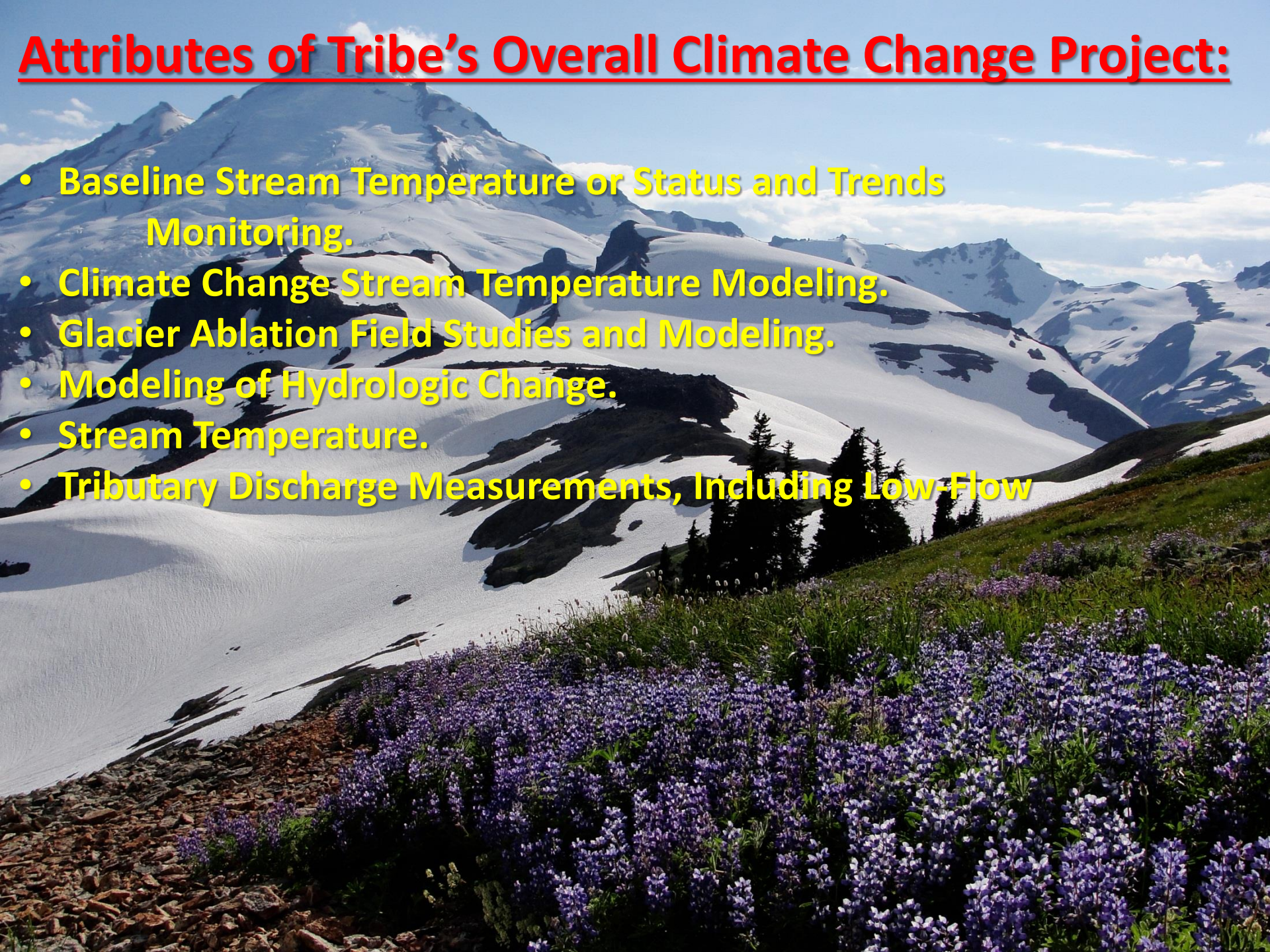
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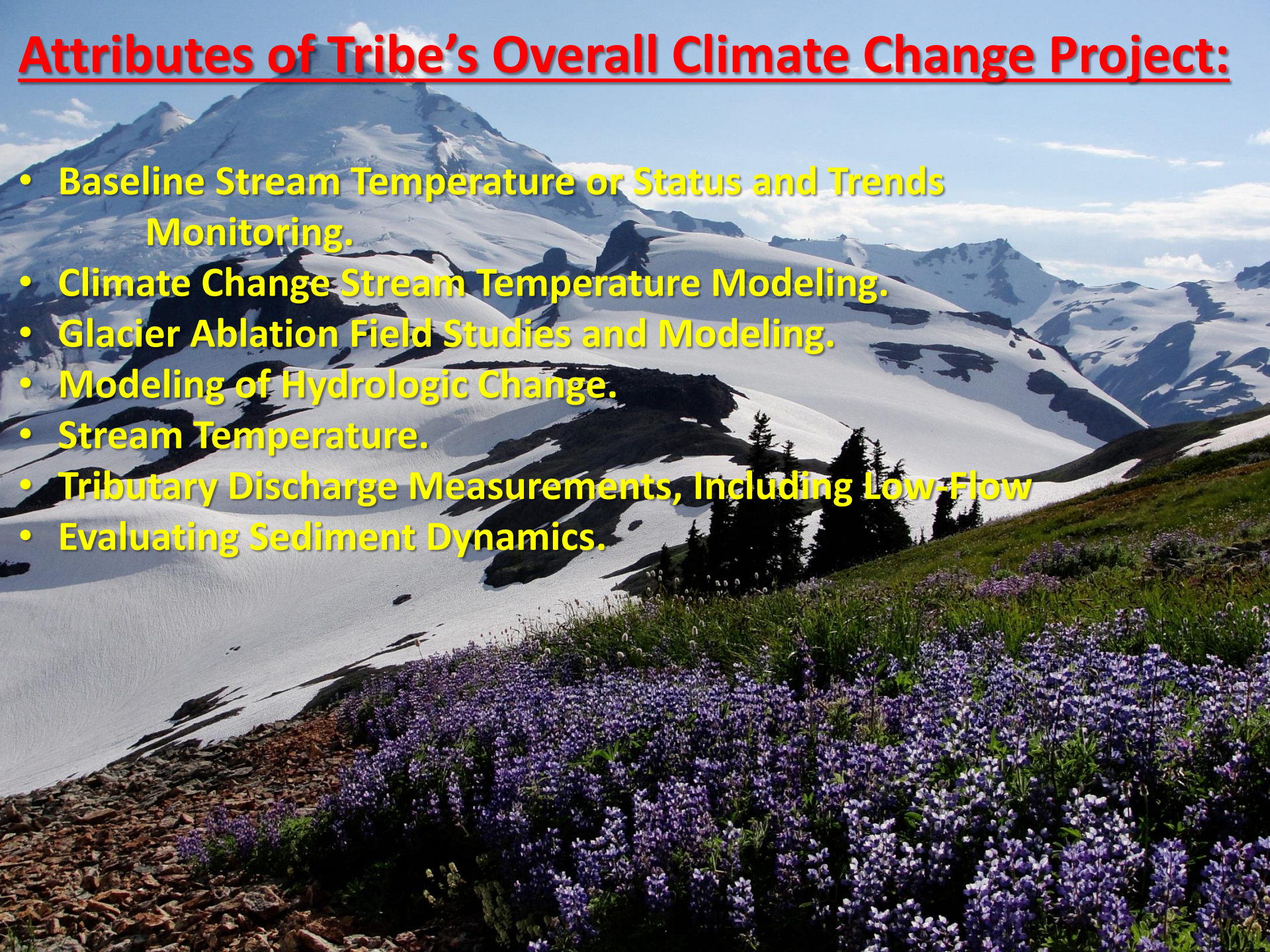
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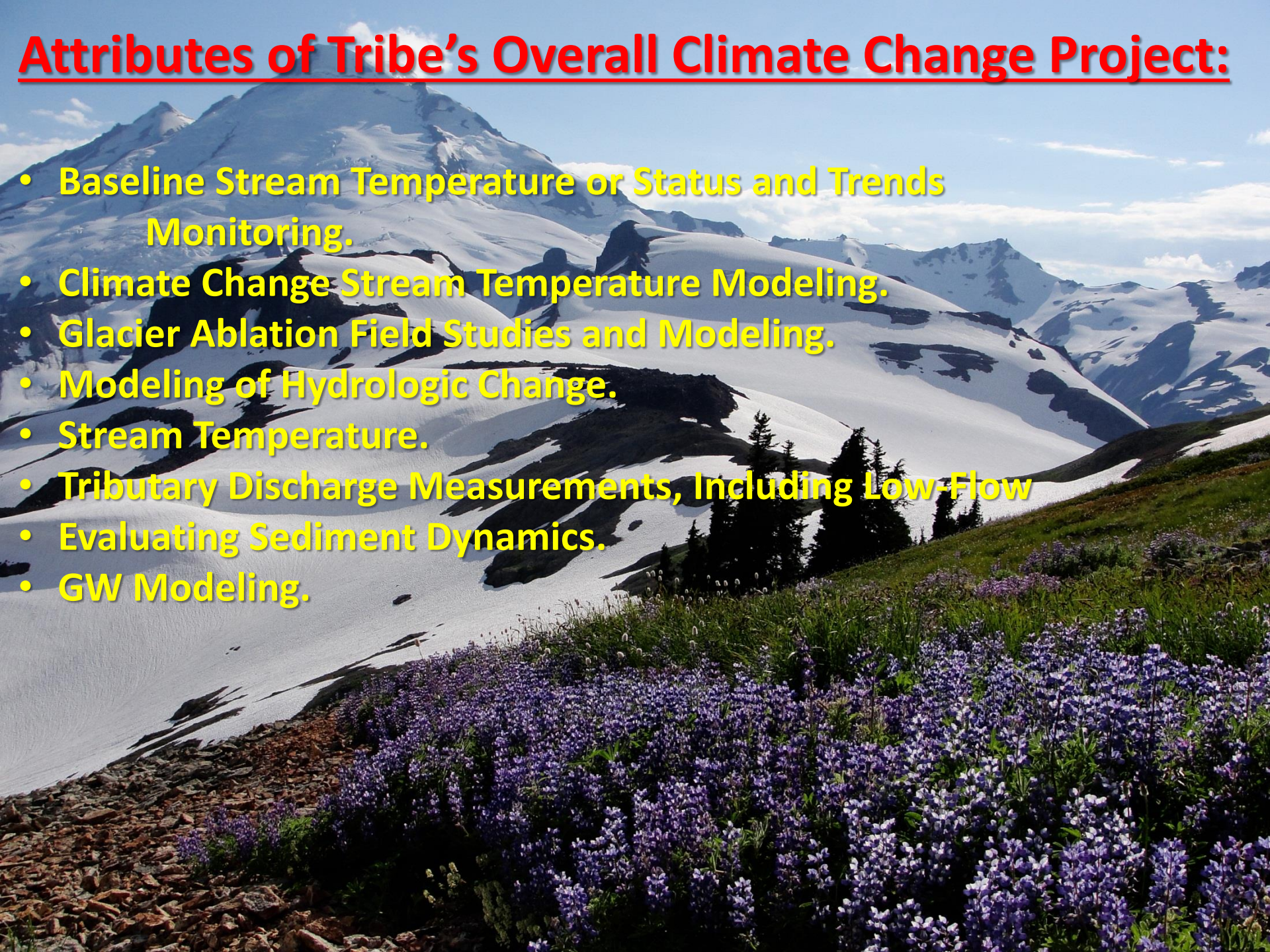
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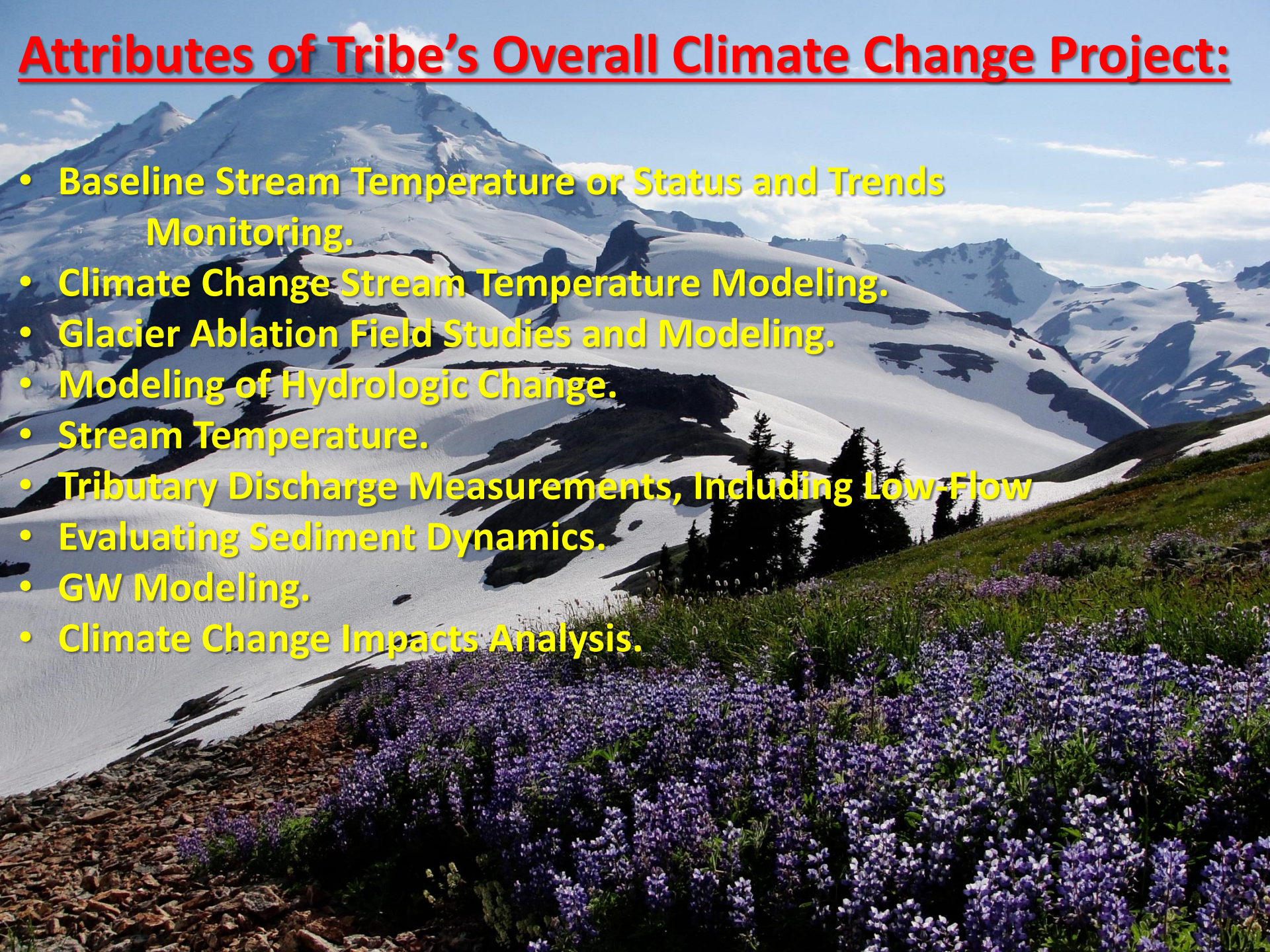
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- GW Modeling.



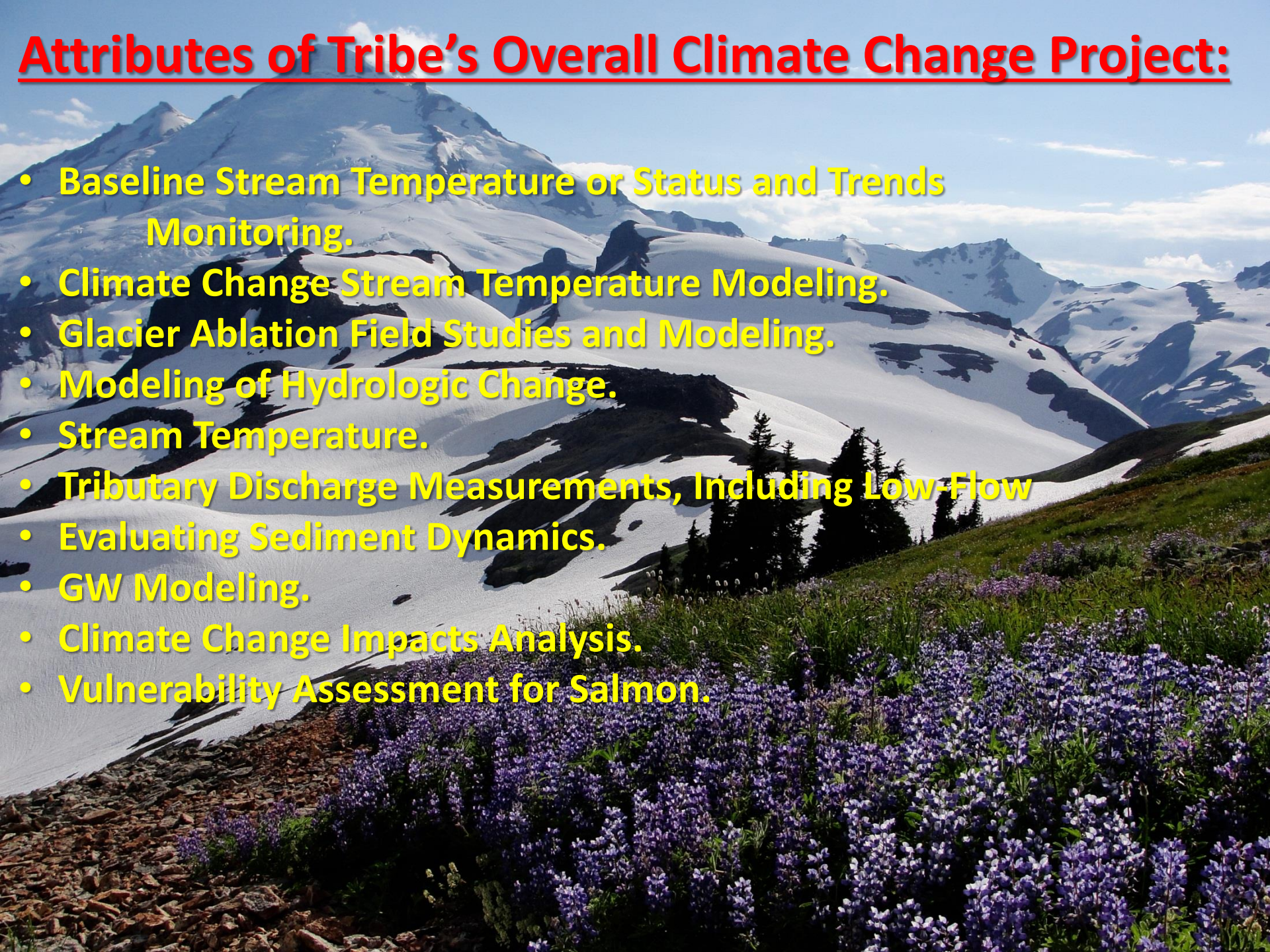
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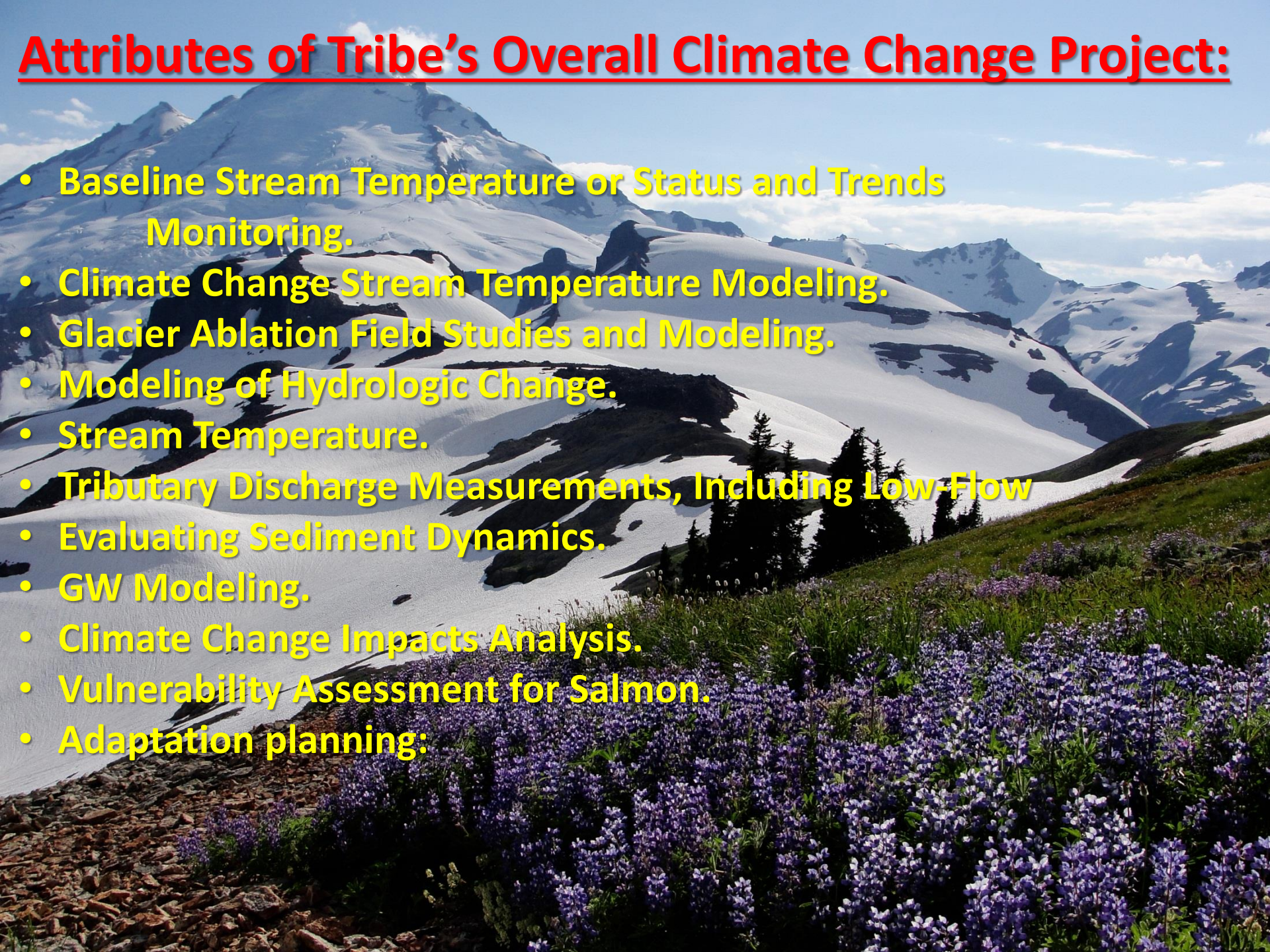
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Current project will not address:



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- Sea level rise



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- Shoreline – shellfish



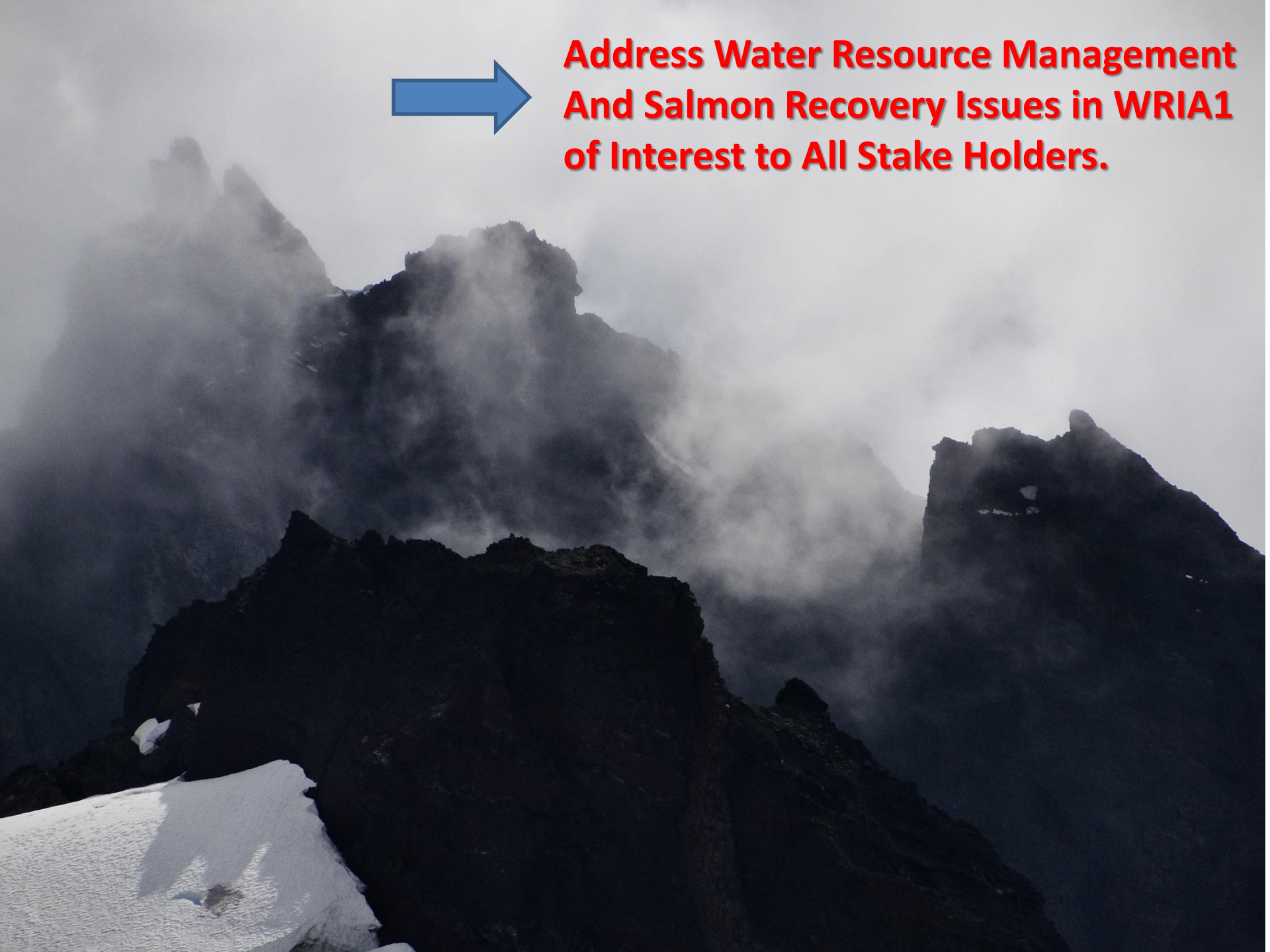
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- Upland resources





**Address Water Resource Management
And Salmon Recovery Issues in WRIA1
of Interest to All Stake Holders.**



Legacy Impacts:



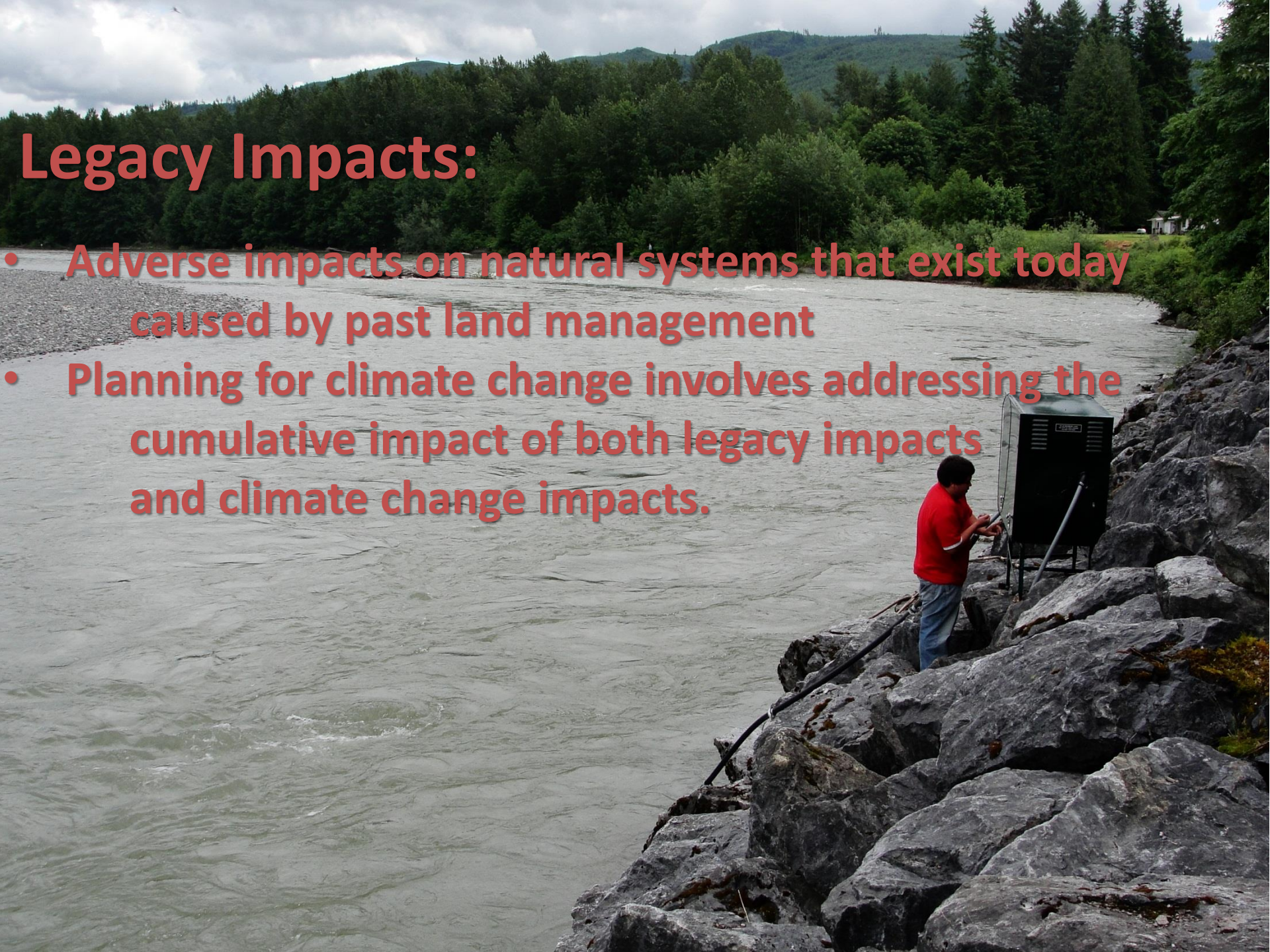
Legacy Impacts:

- Adverse impacts on natural systems that exist today caused by past land management



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- Adverse impacts on natural systems that exist today caused by past land management
- Planning for climate change involves addressing the cumulative impact of both legacy impacts and climate change impacts.





Legacy Impacts:

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- Intensive and extensive timber harvest – altered hydrology



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- Unstable forest roads – channel blockages



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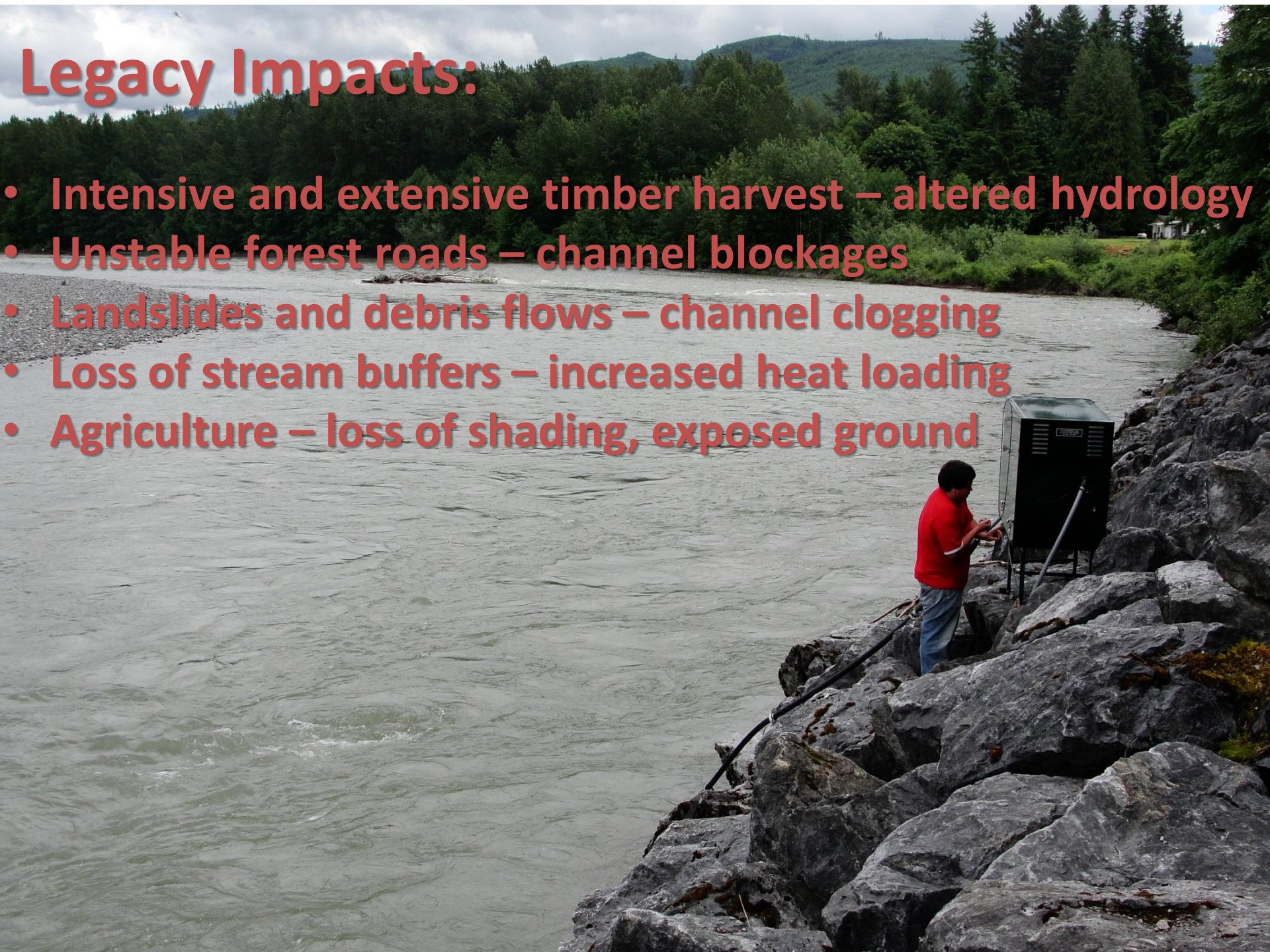
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- Transportation infrastructure – highways and railroads
- Development – impervious surfaces
- Flood control – constricts channels and separates channels from their floodplains





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Nooksack River

- Legacy Impacts:



Huge adverse
impacts on fish



CWA COMPLIANCE

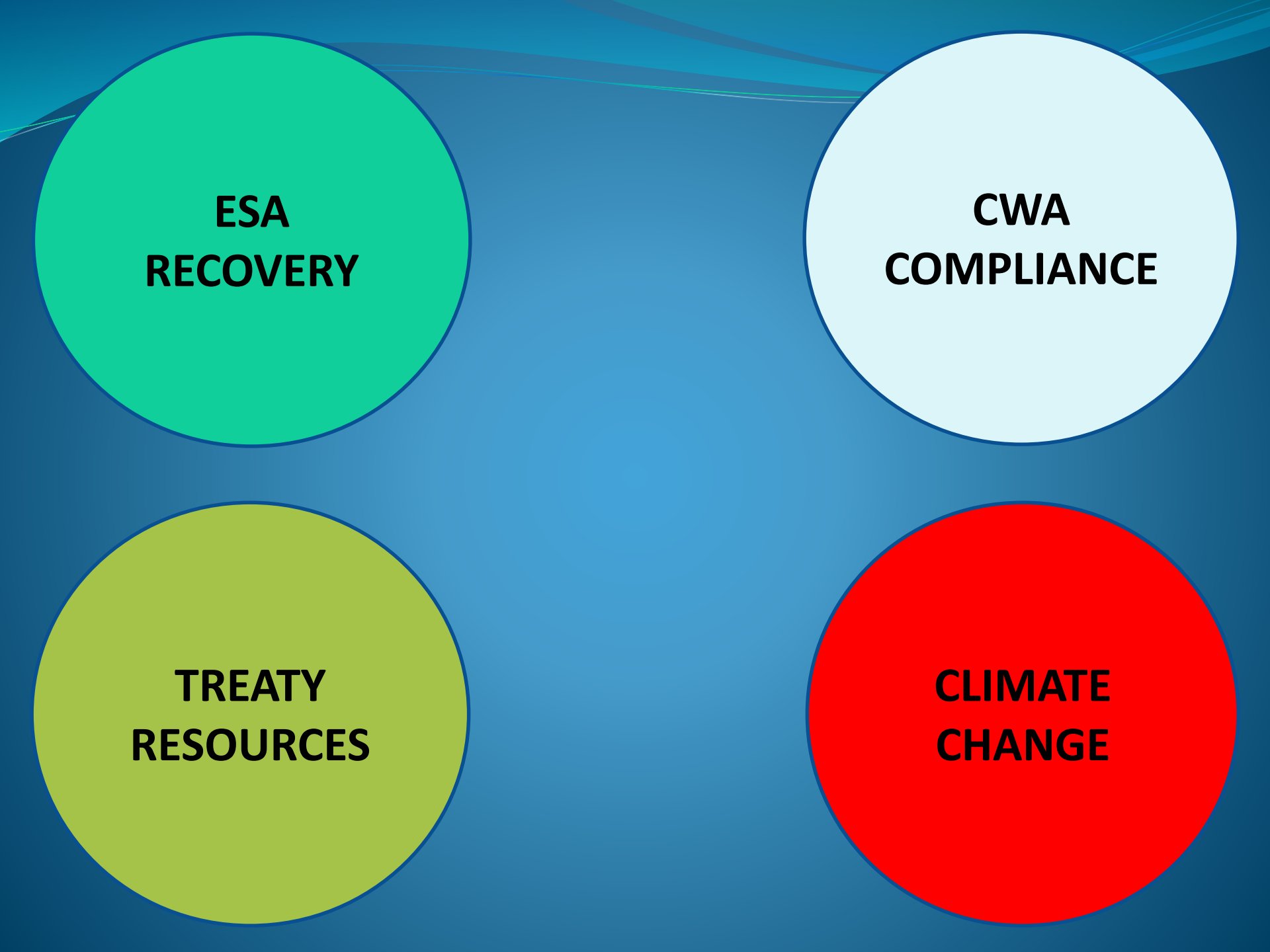
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RECOVERY**

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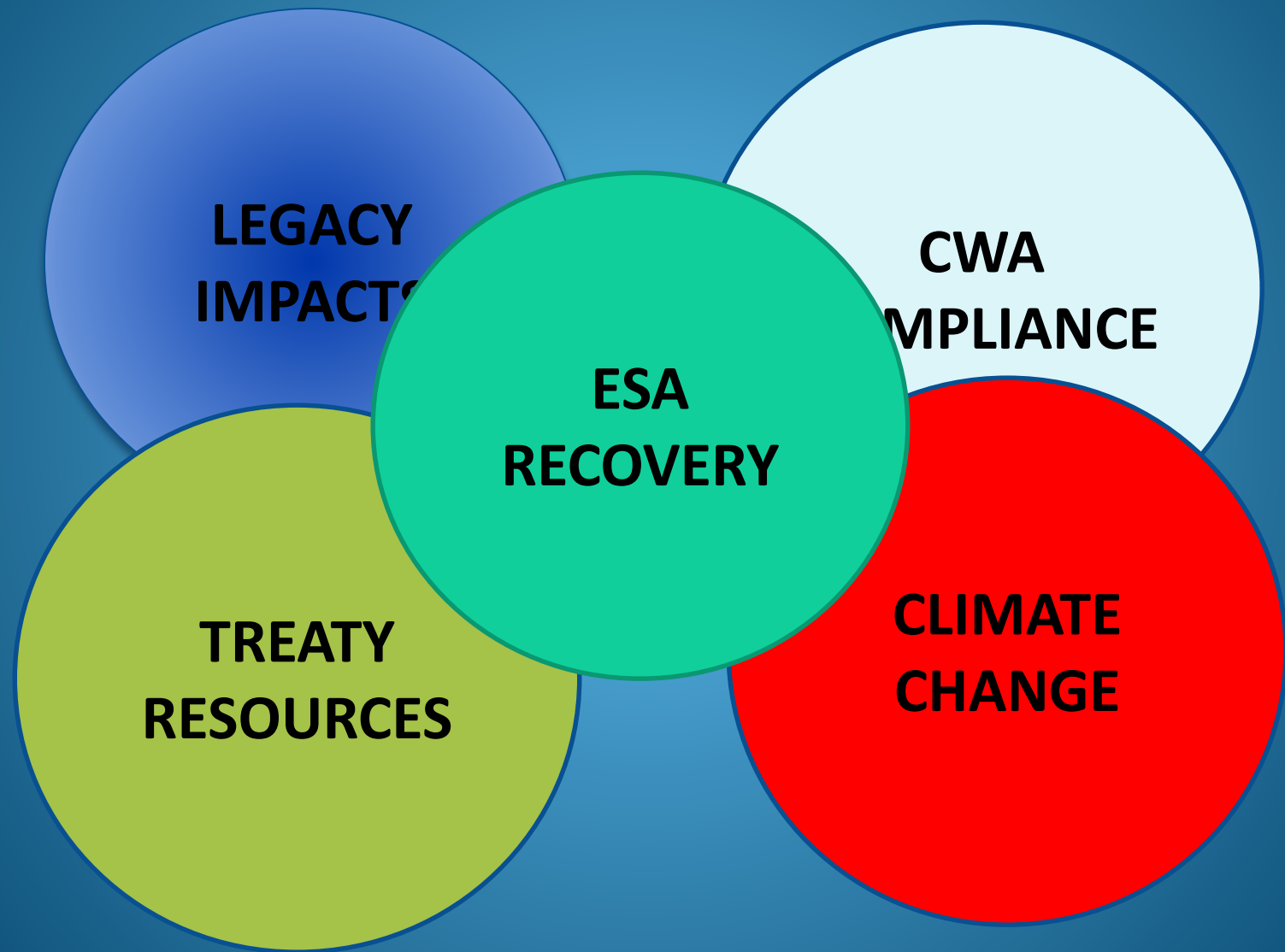
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IMPACTS:



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- Increasing air temperatures, 3-4°C



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 - Depth
 - area



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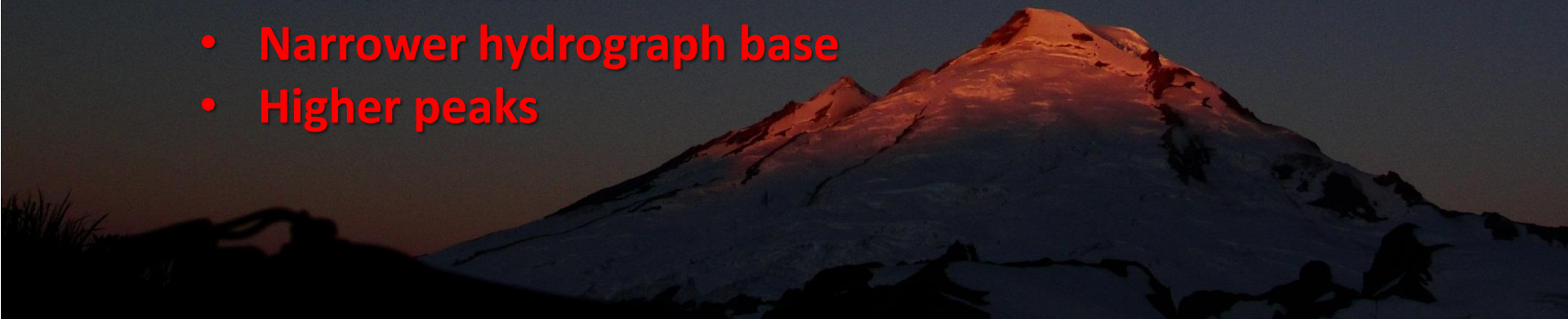
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- Altered Hydrograph:



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- Most glaciers in the North Cascade Mountains will disappear.
- Altered Hydrograph:
 - -40% in summer
 - +30% in winter
 - Narrower hydrograph base
 - Higher peaks



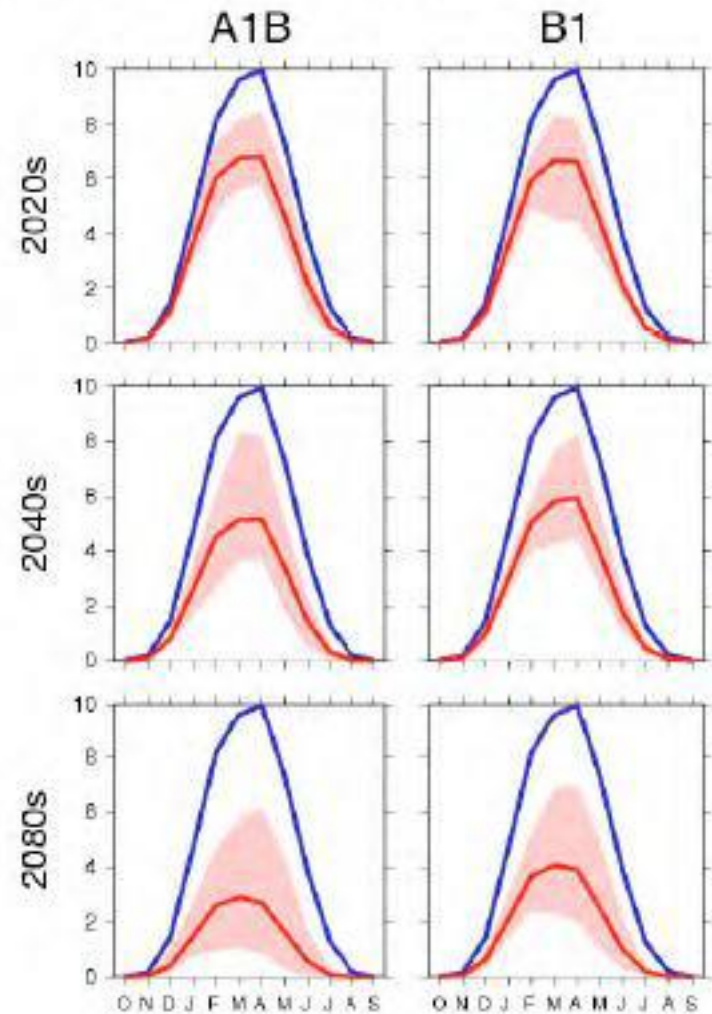
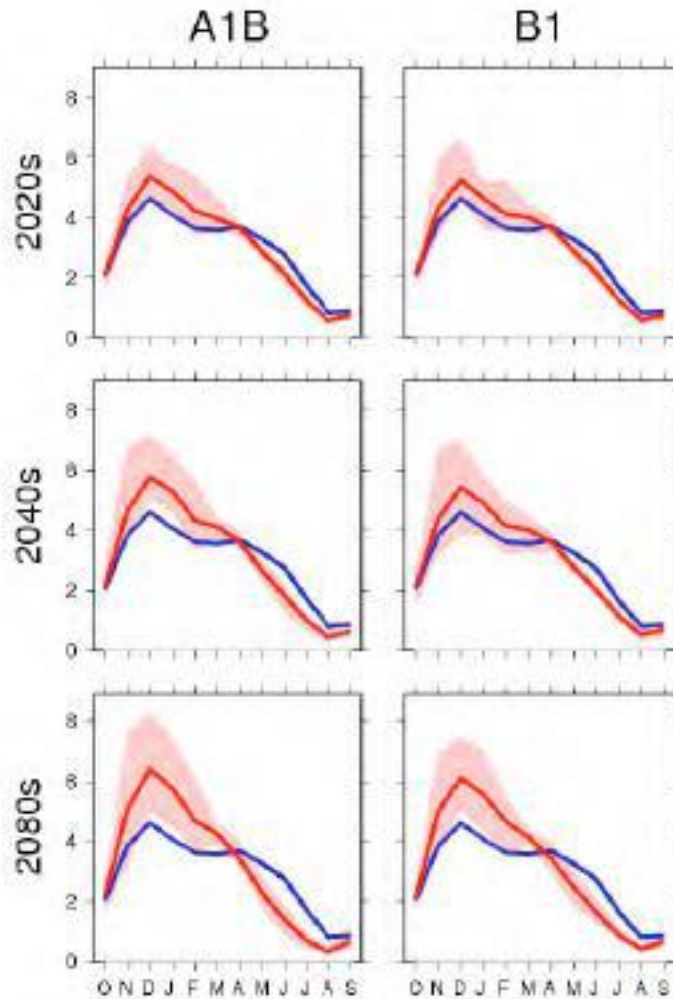
Projected Changes: Nooksack

combined flow (in):

snow water equivalent (in):

Runoff

Snow



IMPACTS:

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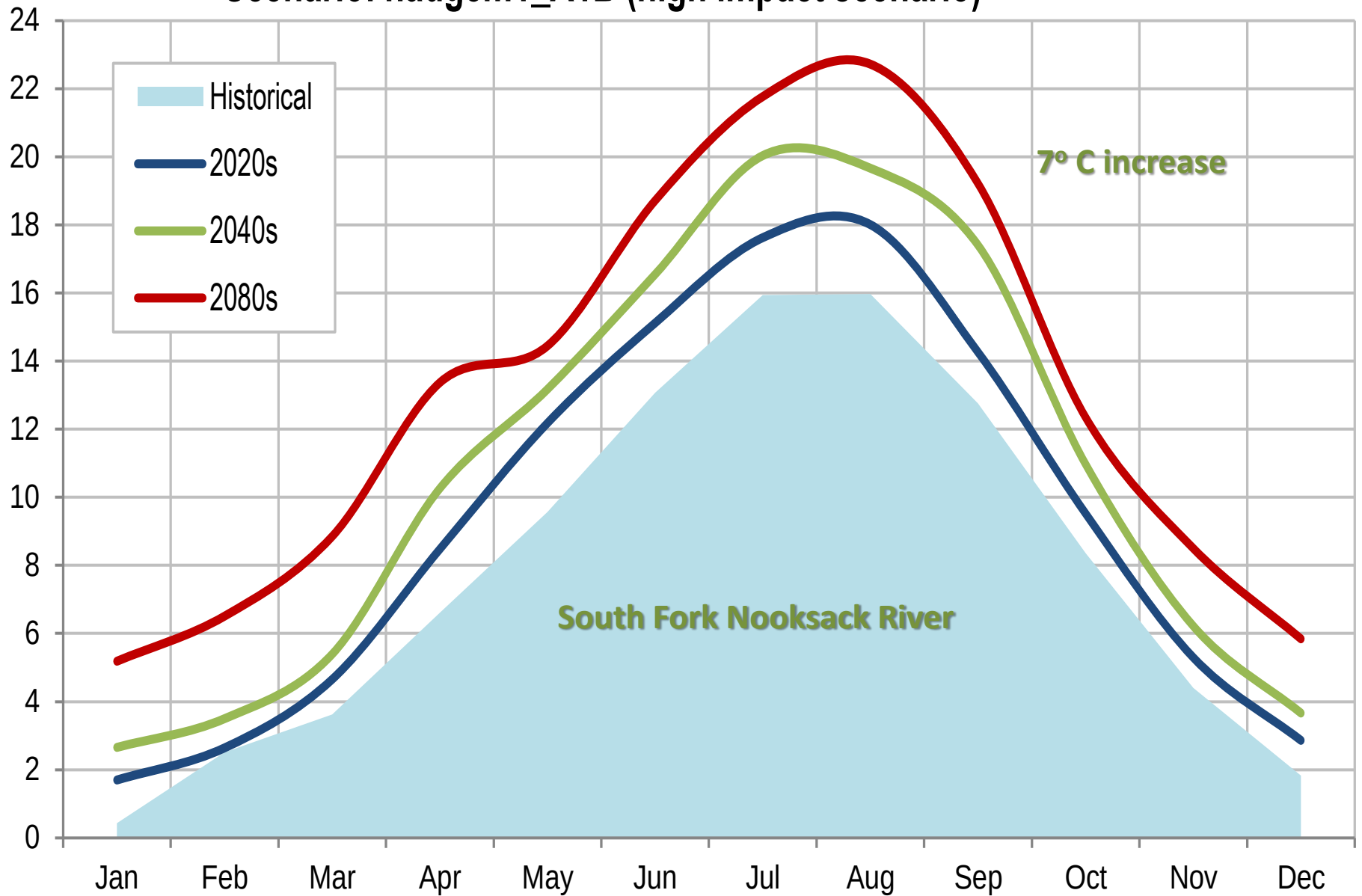
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- Increasing summer water temperatures, 2-3° C



Average Temperature (deg C)

Scenario: hadgem1_A1B (high impact scenario)



IMPACTS:

- Change in sediment loading and transport dynamics, likely an increase.
- Increasing summer water temperatures, 2-3° C
- Decreasing spring water temperatures



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- Change in sediment loading and transport dynamics, likely an increase.
- Increasing summer water temperatures, 2-3° C
- Decreasing spring water temperatures
- On top of legacy impacts, which are likely of greater magnitude than climate change impacts

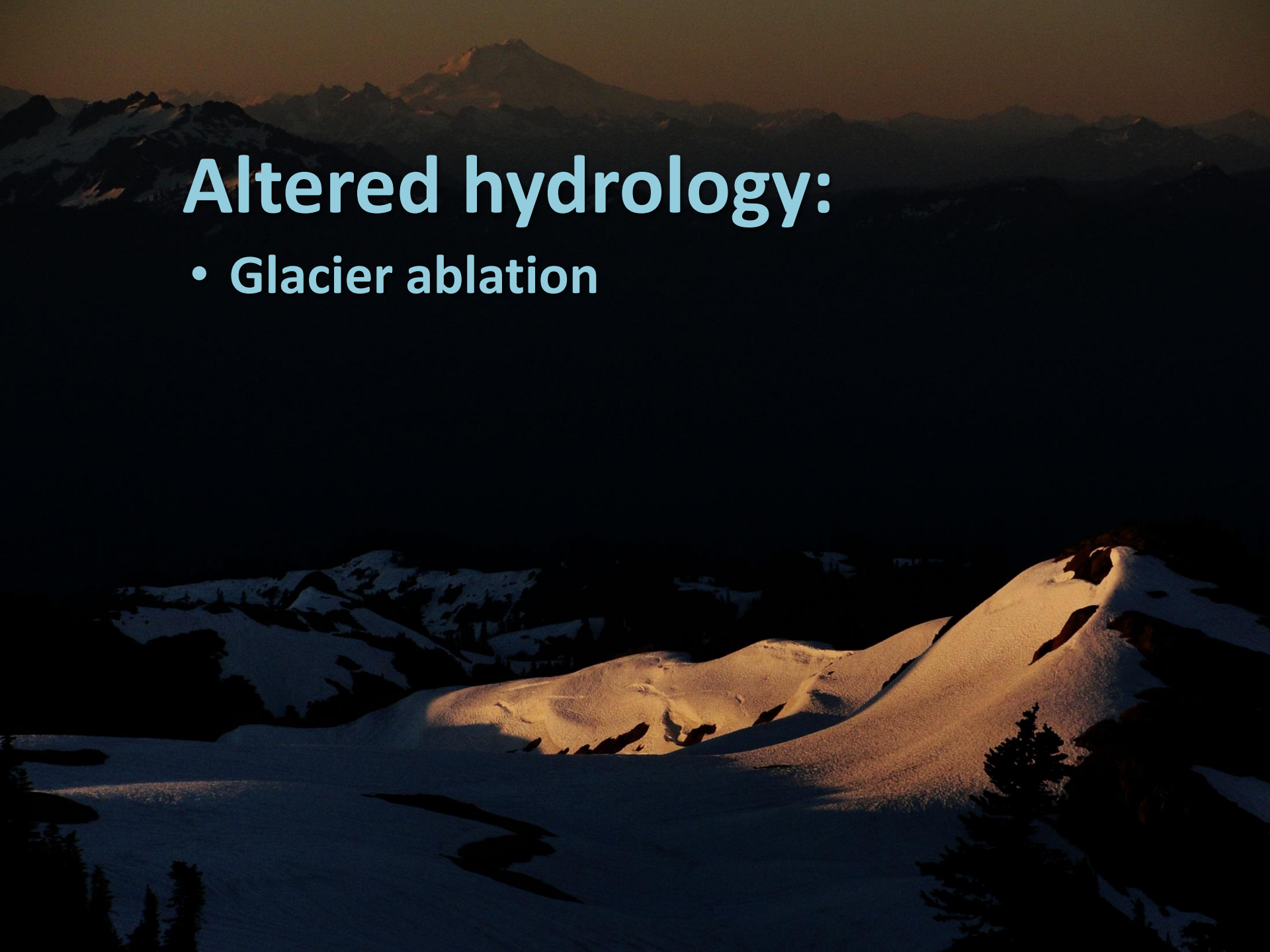


Altered hydrology:



Altered hydrology:

- Glacier ablation



Altered hydrology:

- Glacier ablation
- Altered snow accumulation/melt



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Altered hydrology:

- Glacier ablation
- Altered snow accumulation/melt
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- Altered sediment dynamics



Water availability:



Water availability:

- Municipal



Water availability:

- Municipal
- Commercial



Water availability:

- Municipal
- Commercial
- Industrial



Water availability:

- Municipal
- Commercial
- Industrial
- Agriculture



Water availability:

- Municipal
- Commercial
- Industrial
- Agriculture
- Fish



• Flood frequency and magnitude



- Flood frequency and magnitude
- Sediment dynamics

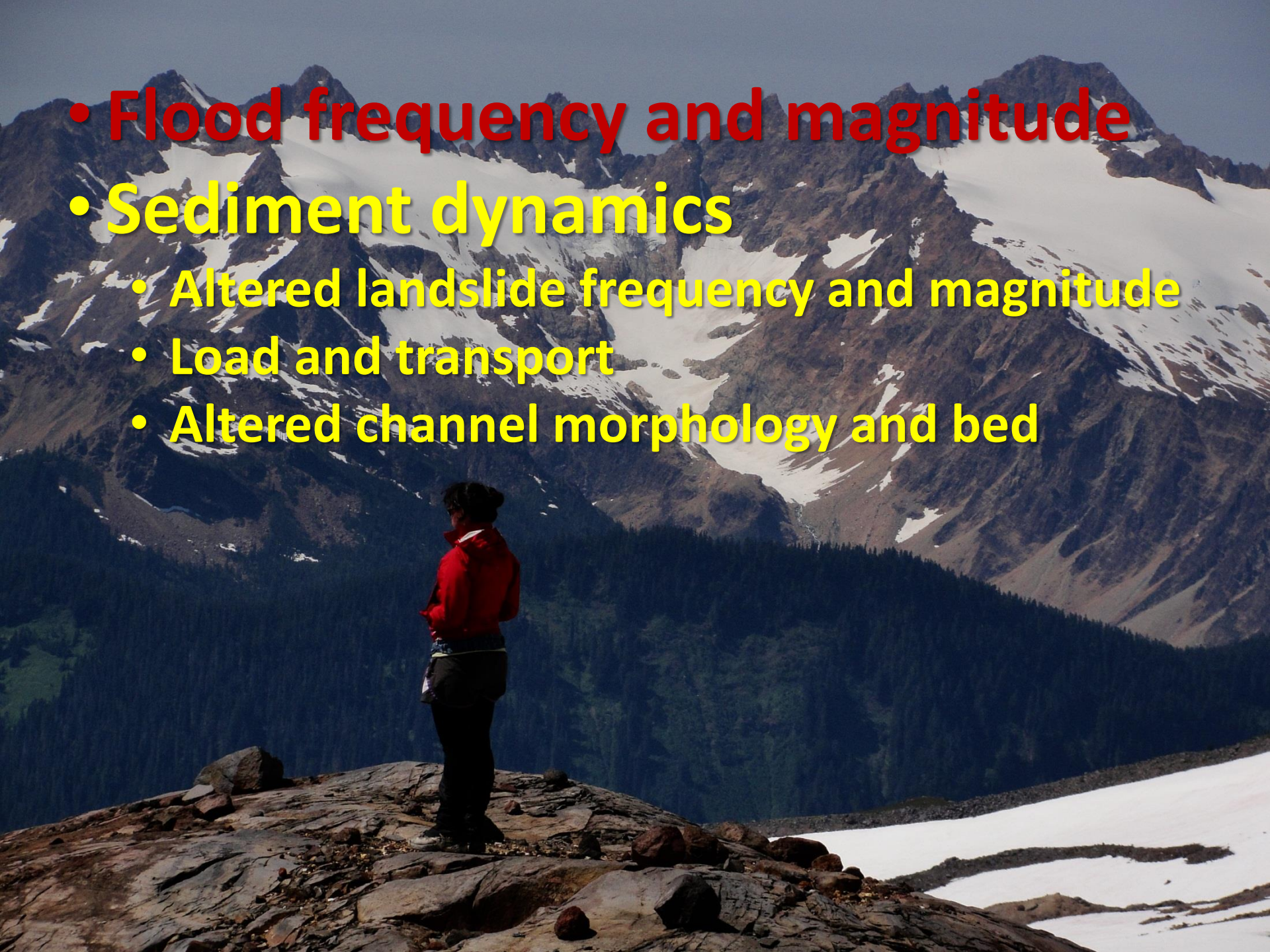


- Flood frequency and magnitude
- Sediment dynamics
 - Altered landslide frequency and magnitude



- Flood frequency and magnitude
- Sediment dynamics
 - Altered landslide frequency and magnitude
 - Load and transport



- 
- Flood frequency and magnitude
 - Sediment dynamics
 - Altered landslide frequency and magnitude
 - Load and transport
 - Altered channel morphology and bed

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- Flood frequency and magnitude
 - Sediment dynamics
 - Altered landslide frequency and magnitude
 - Load and transport
 - Altered channel morphology and bed
 - Infrastructure damage

Fish habitat and survival:



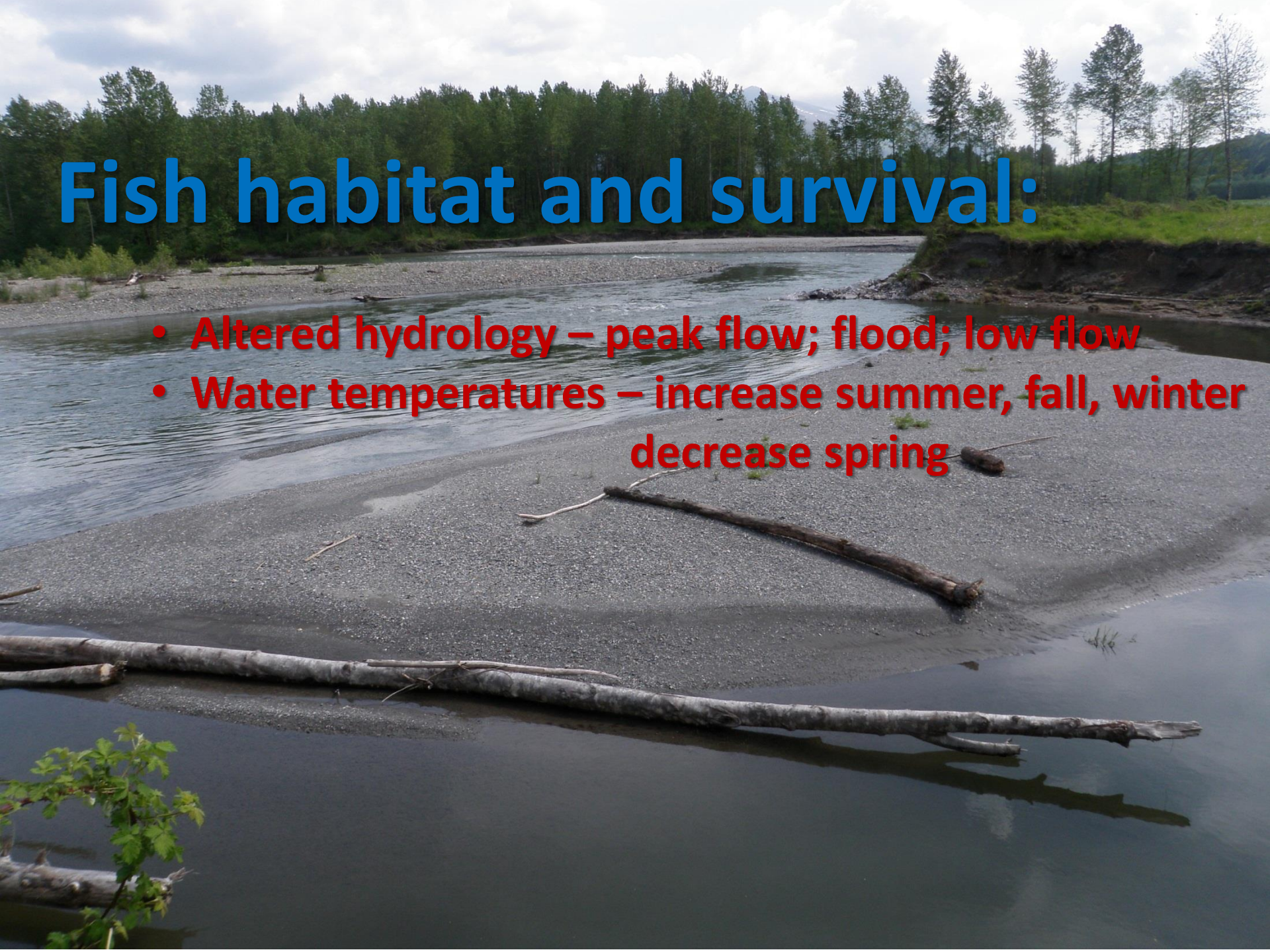
Fish habitat and survival:

- Altered hydrology – peak flow; flood; low flow



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- Altered bed material – size and clogging

Fish habitat and survival:

- Altered hydrology – peak flow; flood; low flow
- Water temperatures – increase summer, fall, winter decrease spring
- Altered bed material – size and clogging
- Reduced habitat availability and quality

Vulnerability Assessment:



Vulnerability Assessment:

- Altered flow regimes, higher peak flows, flood, lower critical season flows.



Vulnerability Assessment:

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Vulnerability Assessment:

- Temperature related physiologic stress and pathologies



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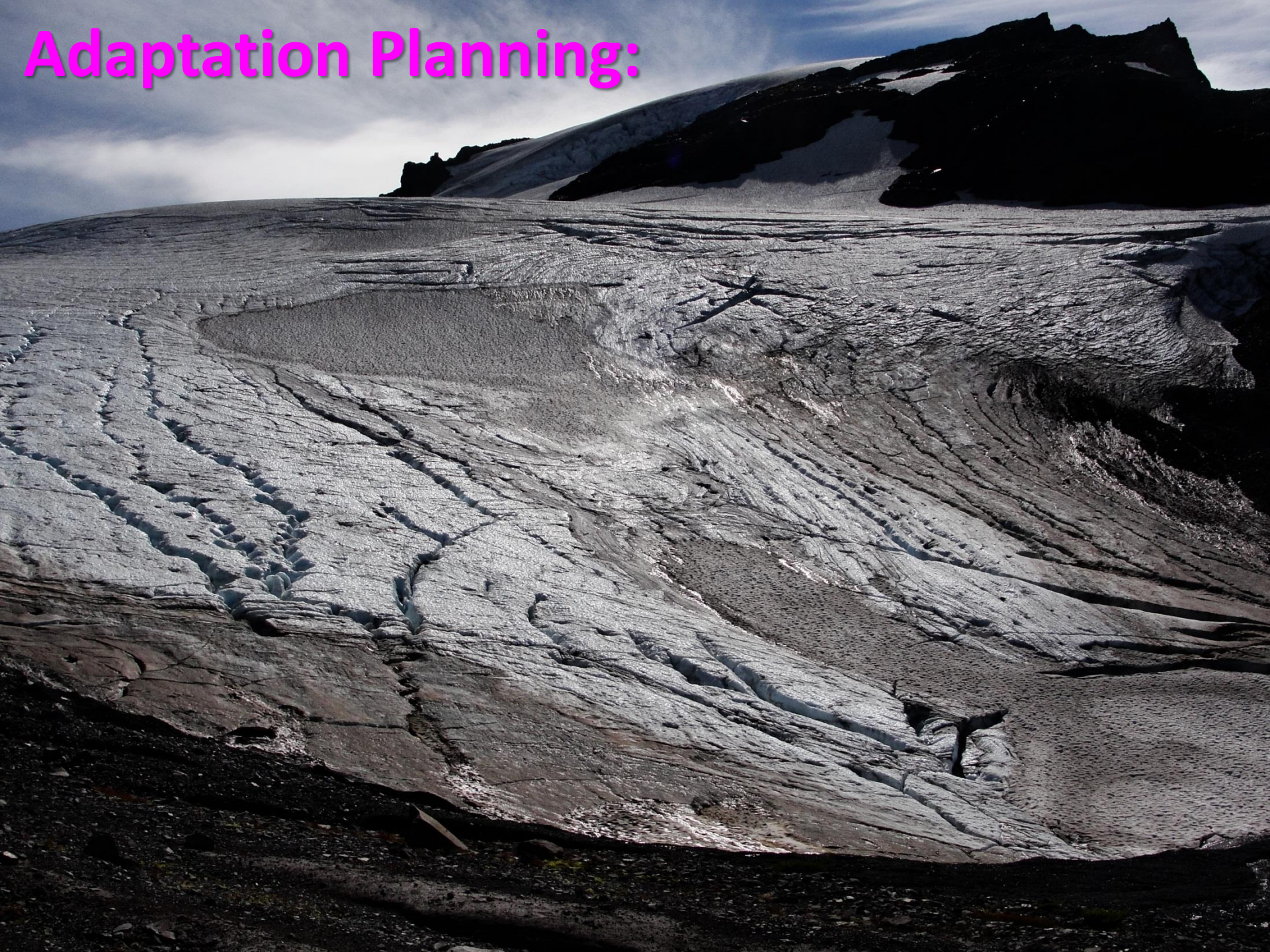
Vulnerability Assessment:

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Vulnerability Assessment:

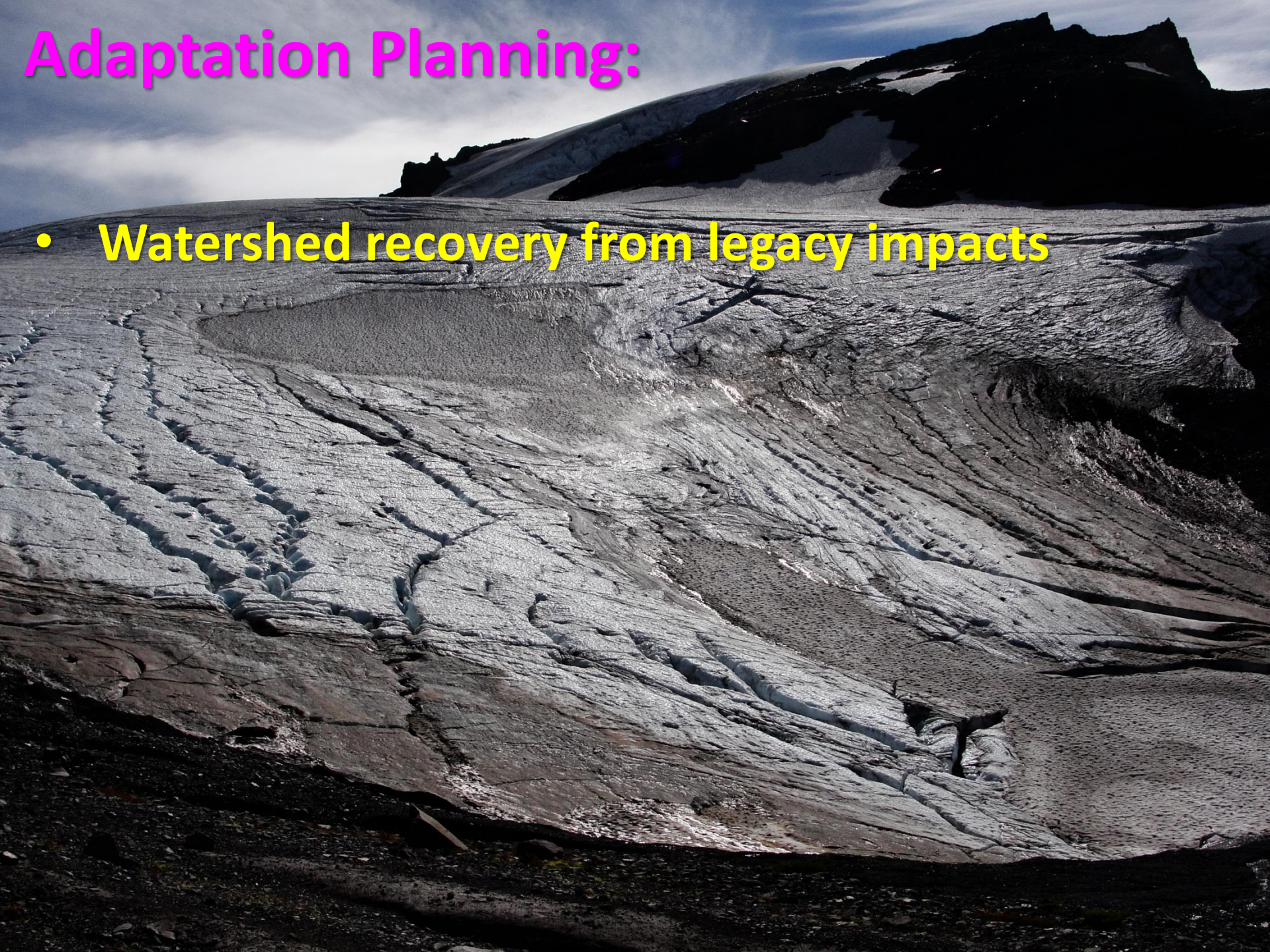
- Temperature related physiologic stress and pathologies
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- All lifestages of the nine species of Pacific salmon will be adversely impacted

Adaptation Planning:



Adaptation Planning:

- Watershed recovery from legacy impacts



Adaptation Planning:

- Watershed recovery from legacy impacts
- Adaptive management



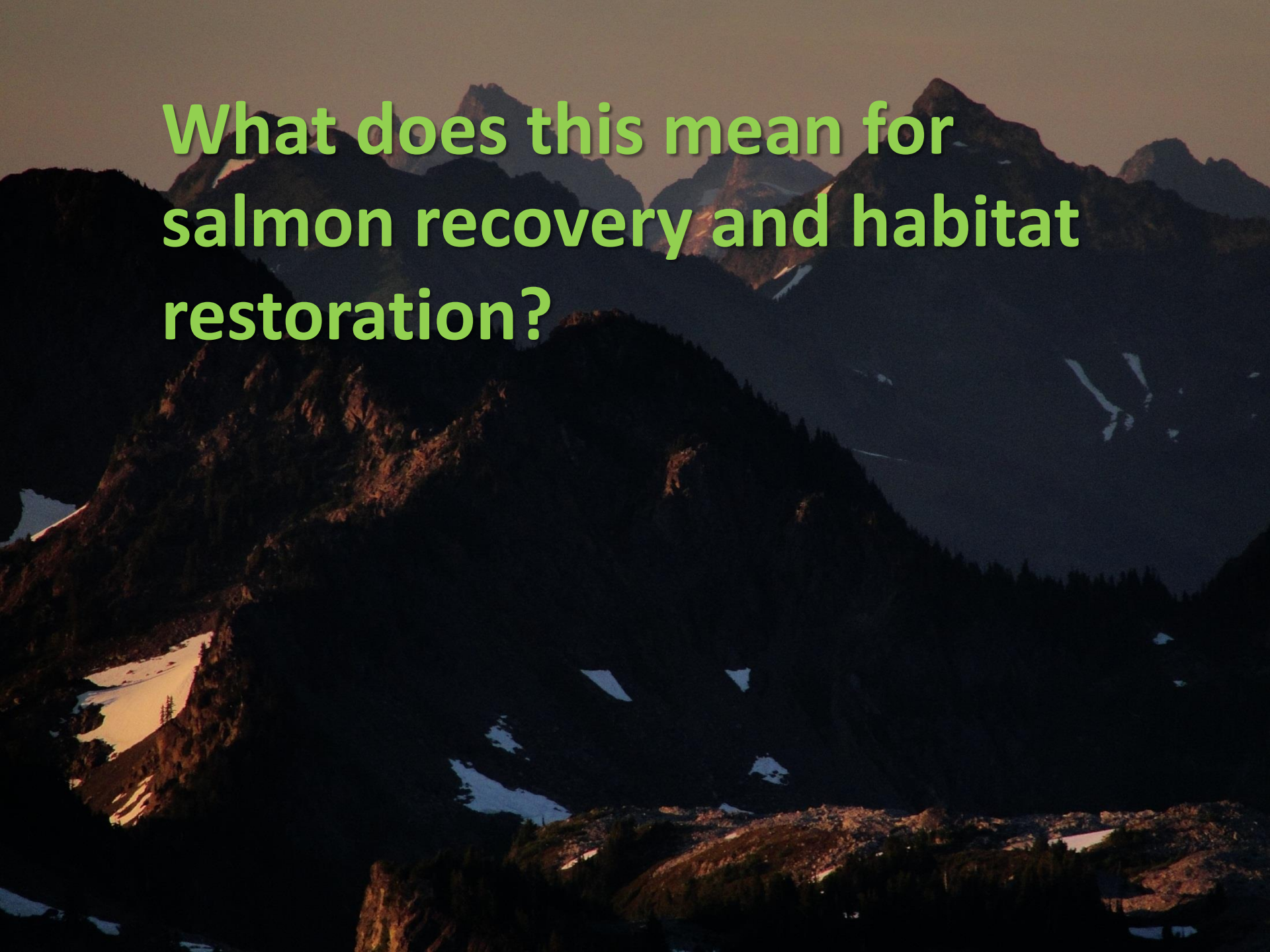
Adaptation Planning:

- Watershed recovery from legacy impacts
- Adaptive management
- Re-prioritize actions – 10-yr plan

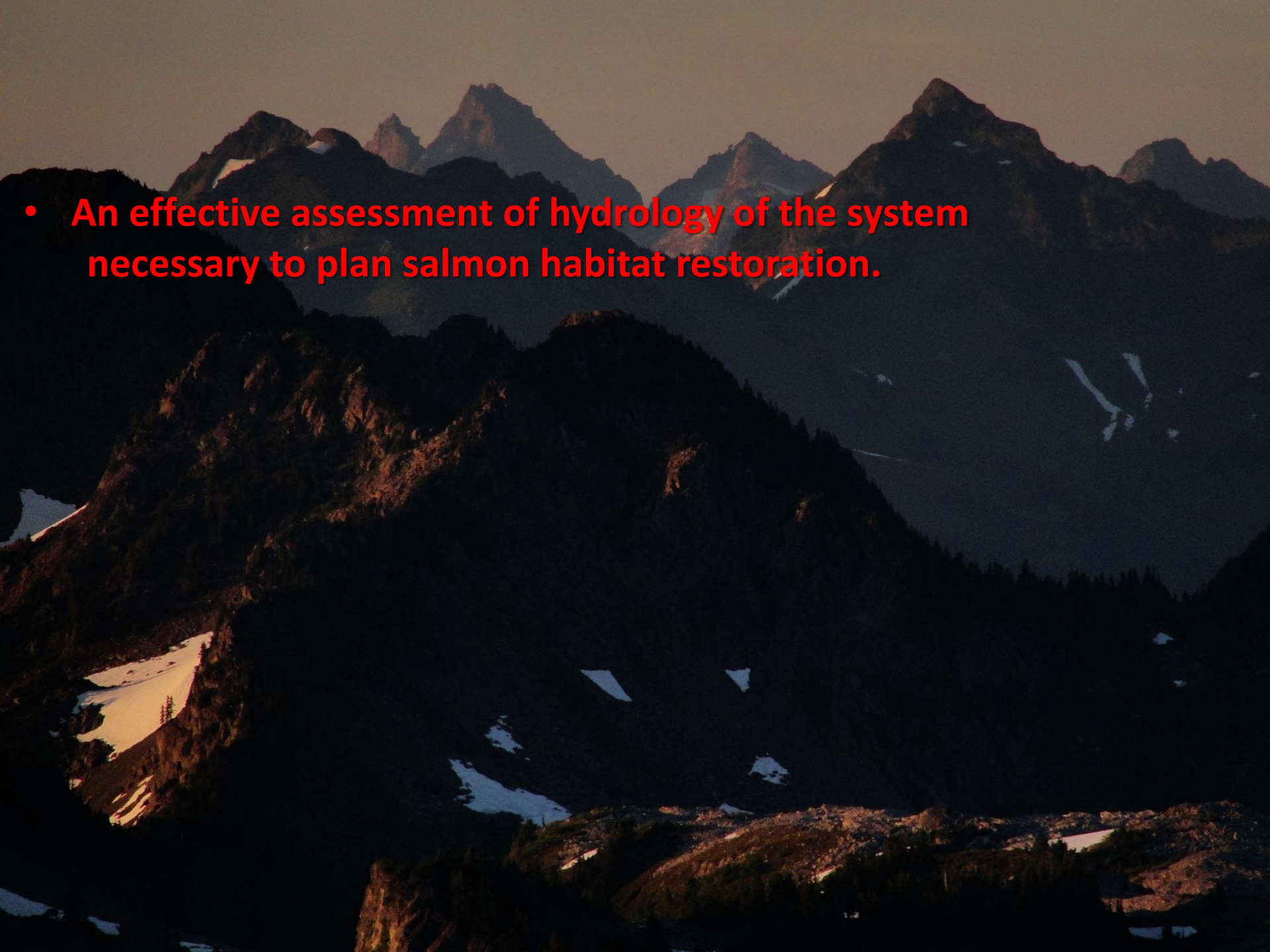


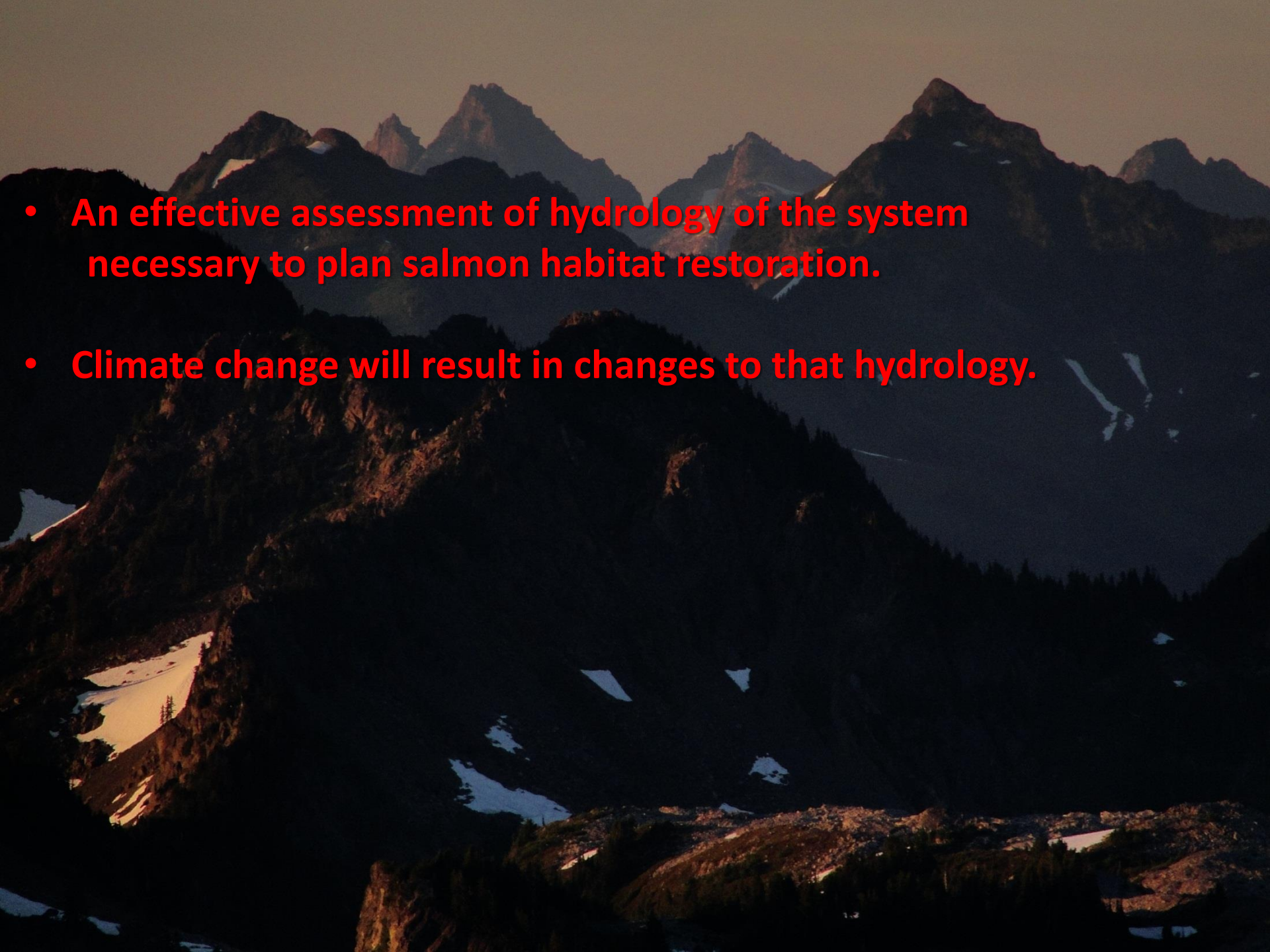


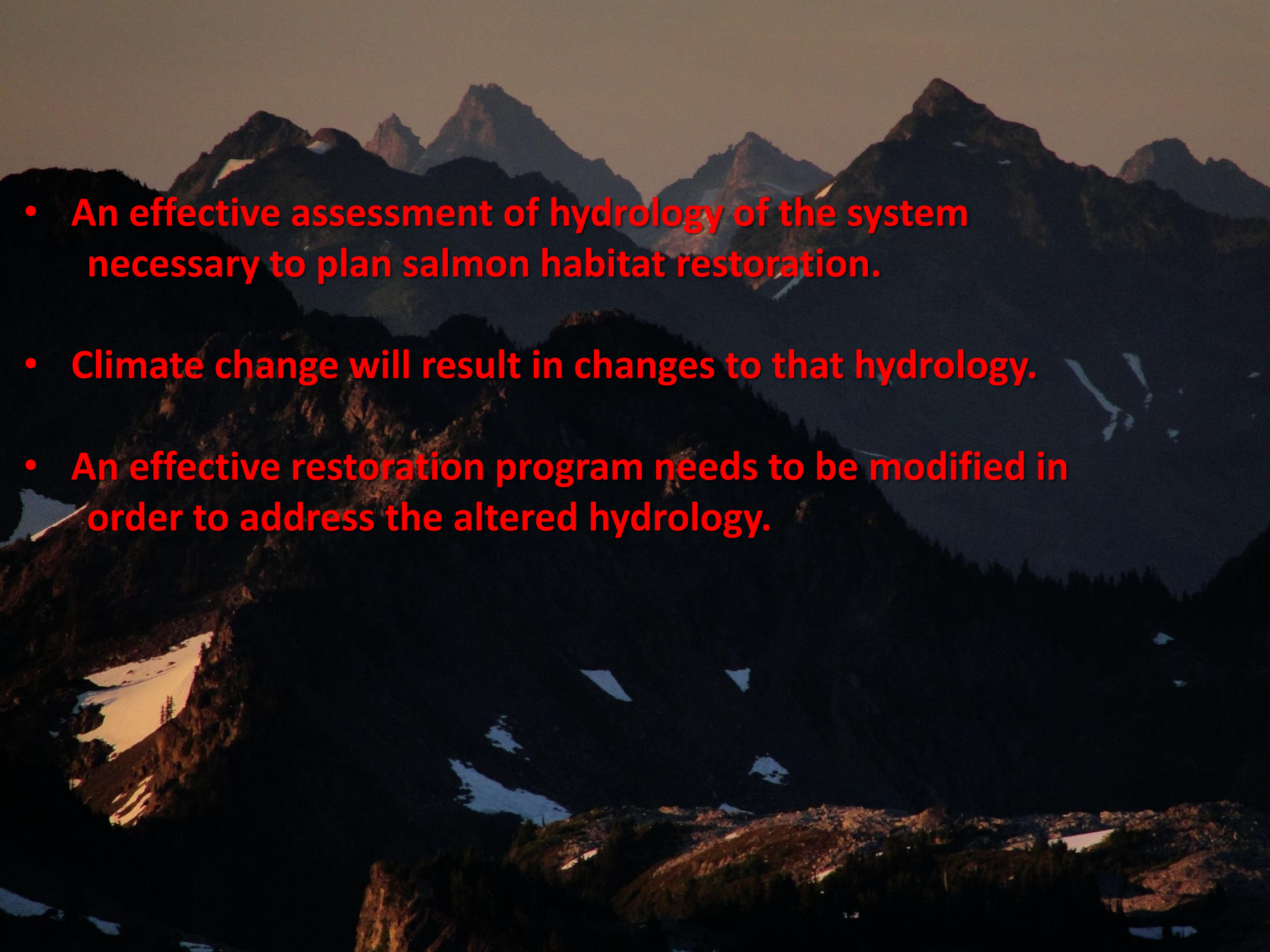
**What does this mean for
salmon recovery and habitat
restoration?**



- **An effective assessment of hydrology of the system necessary to plan salmon habitat restoration.**



- 
- A dramatic mountain landscape at dusk or dawn. The scene features several jagged, snow-capped mountain peaks in the background, with the sky transitioning from a deep orange to a dark blue. In the foreground, a steep, dark mountain slope is visible, with patches of snow and a small, rocky outcrop. The overall atmosphere is serene and majestic.
- An effective assessment of hydrology of the system necessary to plan salmon habitat restoration.
 - Climate change will result in changes to that hydrology.

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- A dramatic mountain landscape at dusk or dawn. The scene features several sharp, snow-capped mountain peaks in the background, with the sky transitioning from a deep orange near the horizon to a darker blue above. The foreground and middle ground show steep, dark slopes with patches of snow and dense evergreen forests. The overall atmosphere is serene and majestic.
- An effective assessment of hydrology of the system necessary to plan salmon habitat restoration.
 - Climate change will result in changes to that hydrology.
 - An effective restoration program needs to be modified in order to address the altered hydrology.

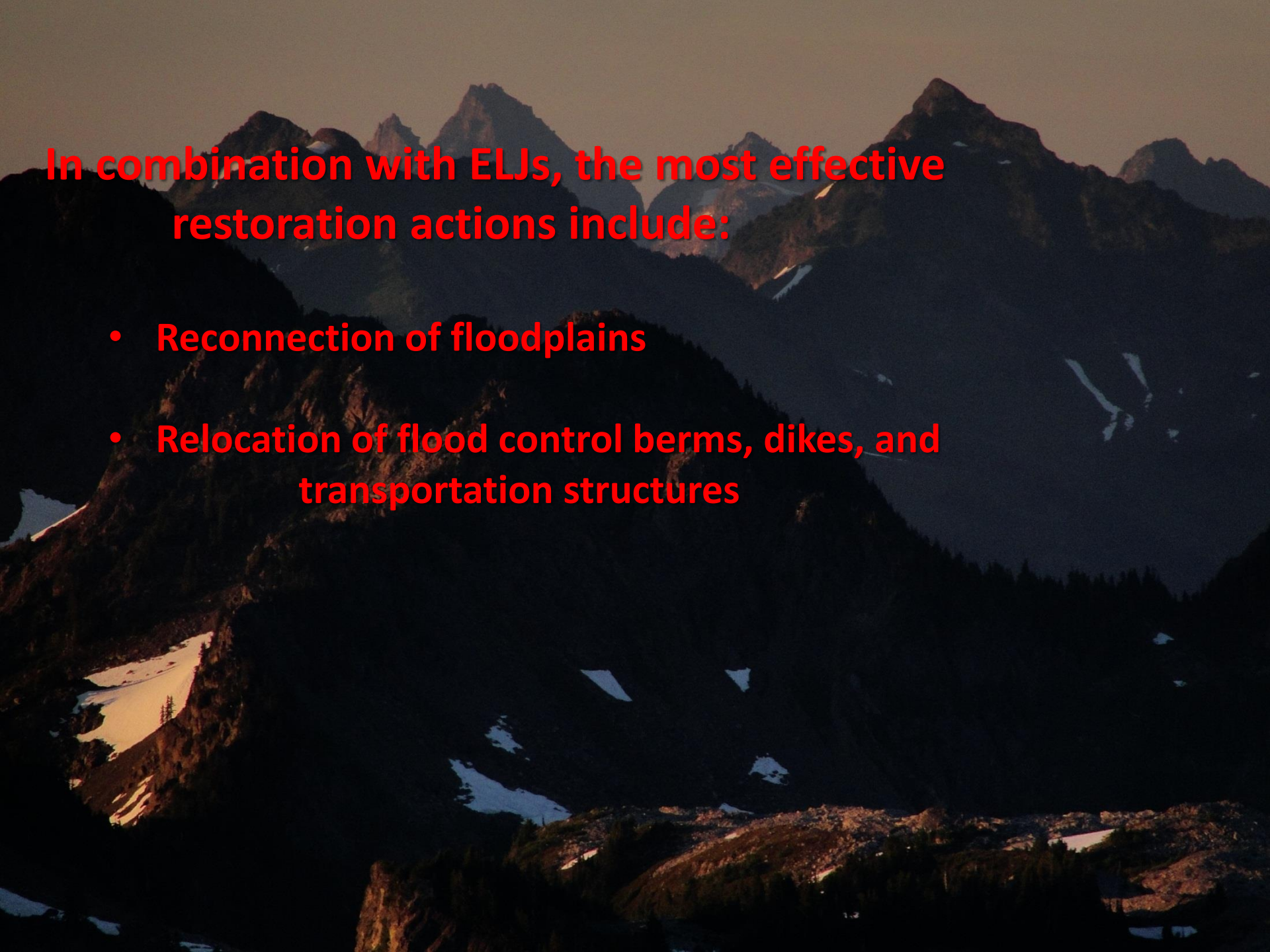
In combination with ELJs, the most effective restoration actions include:



A dramatic mountain landscape at dusk or dawn. The scene features several jagged, snow-capped mountain peaks in the background, partially shrouded in mist. The foreground and middle ground consist of steep, dark slopes covered in dense evergreen forests. Patches of snow are visible in the valleys and along the mountain ridges. The lighting is soft and warm, suggesting the low sun is either rising or setting, creating a serene and majestic atmosphere.

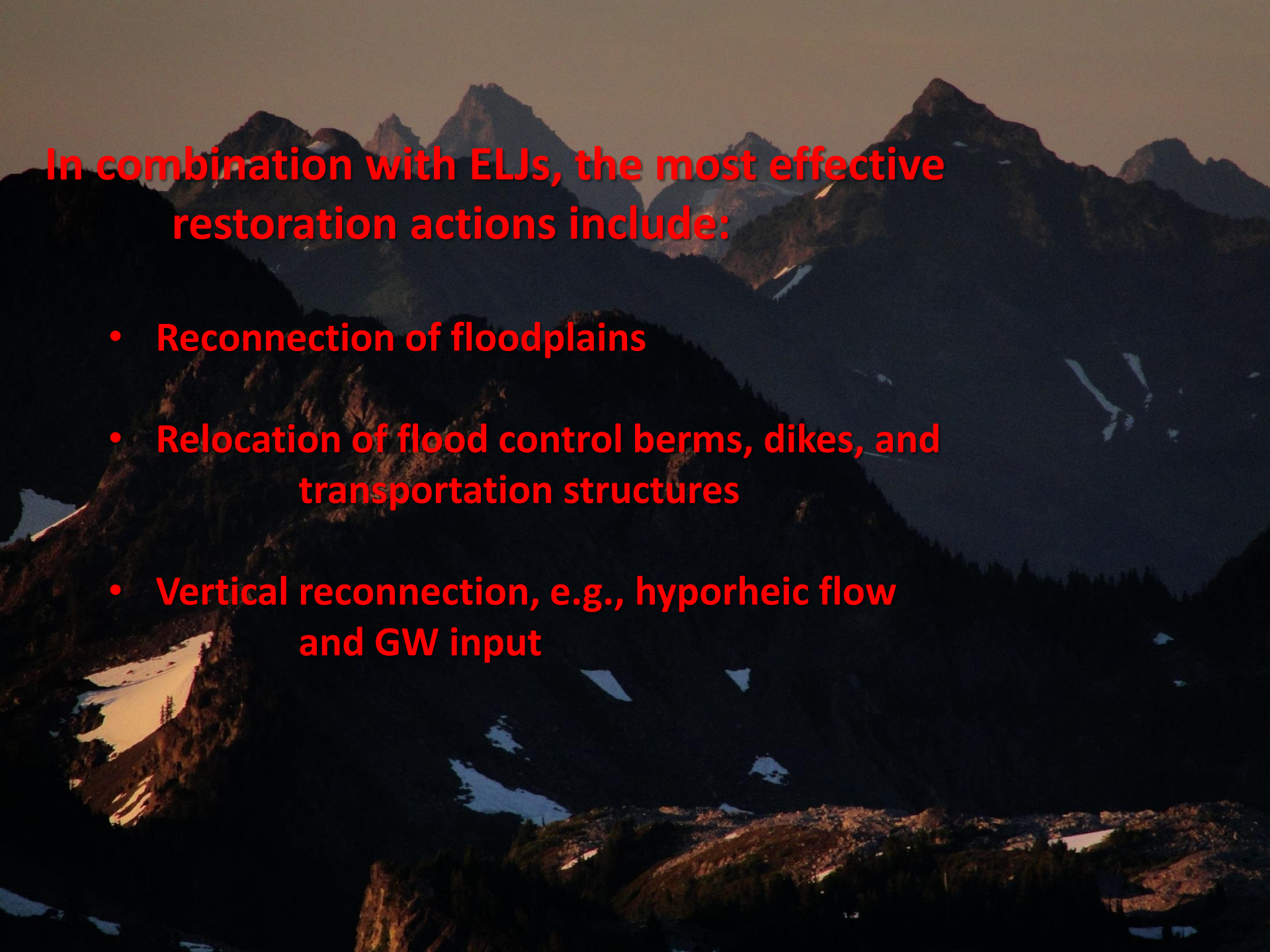
In combination with ELJs, the most effective restoration actions include:

- **Reconnection of floodplains**

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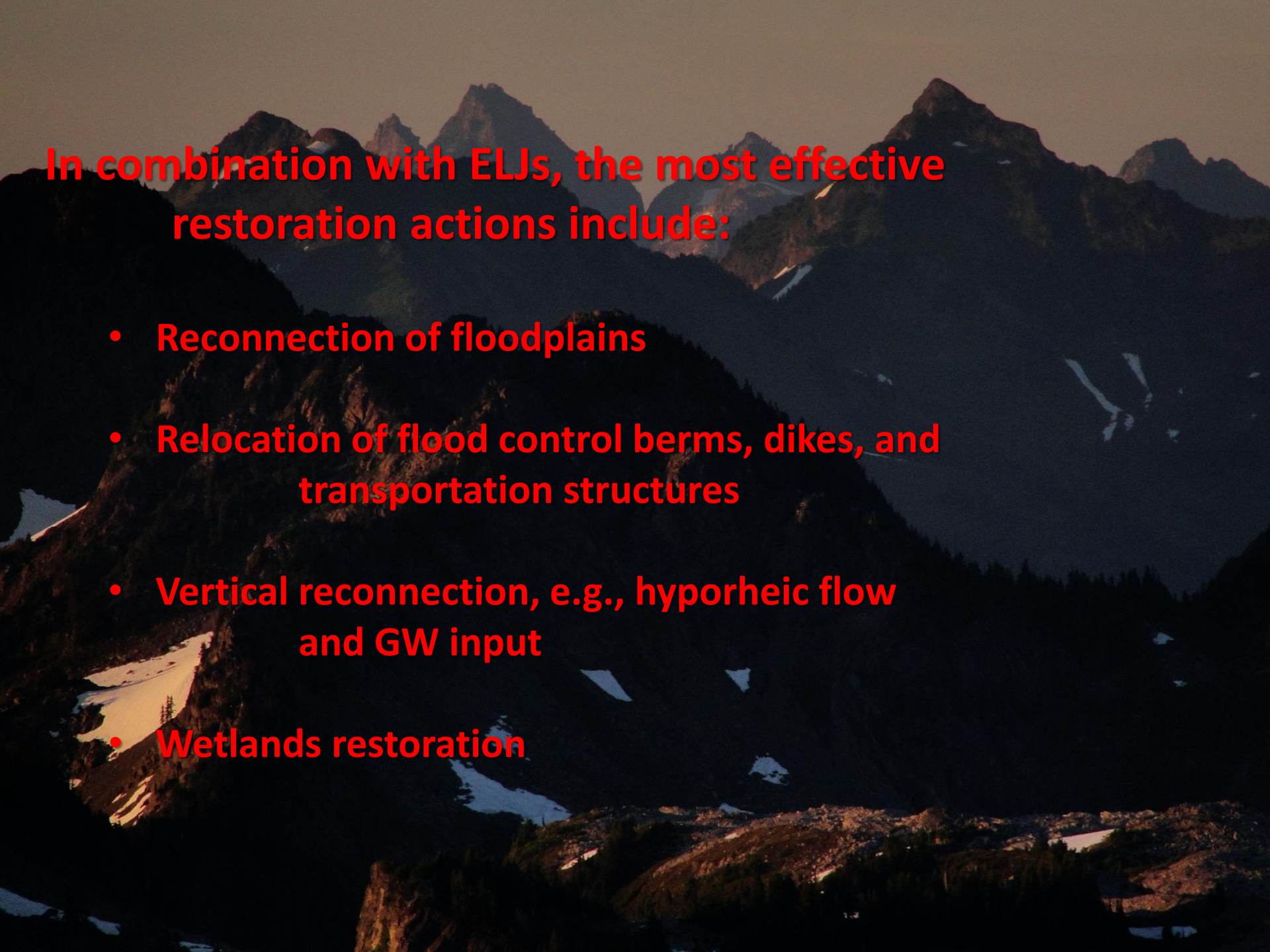
In combination with ELJs, the most effective restoration actions include:

- **Reconnection of floodplains**
- **Relocation of flood control berms, dikes, and transportation structures**

A dramatic mountain landscape at dusk or dawn. The scene features several jagged, snow-capped mountain peaks in the background, with the sky transitioning from a deep blue to a warm orange glow. In the foreground, a dark, forested valley is visible, with patches of snow on the slopes and a small body of water in the distance. The overall atmosphere is serene and majestic.

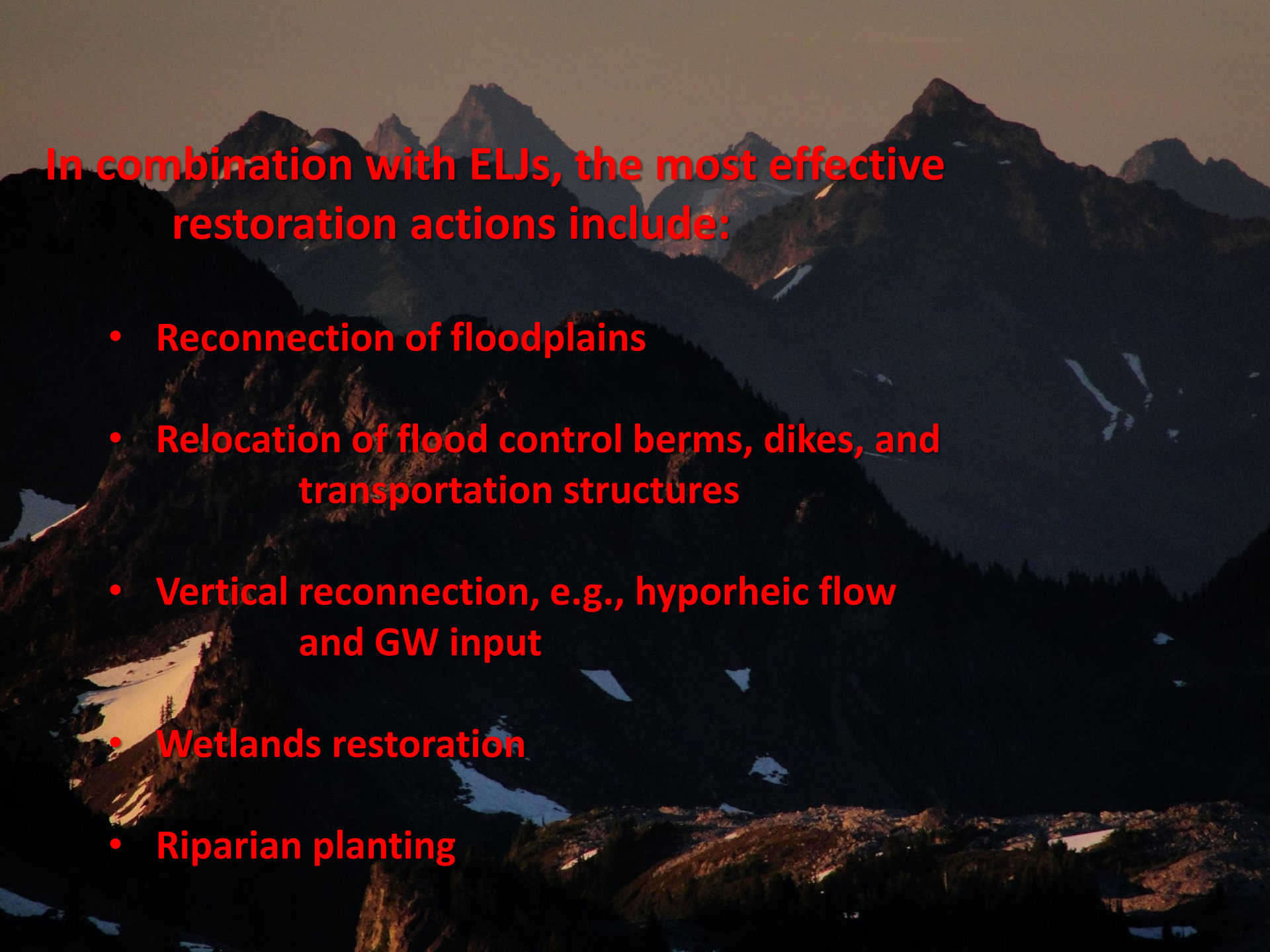
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- **Vertical reconnection, e.g., hyporheic flow and GW input**

A dramatic mountain landscape with snow-capped peaks and a valley below. The mountains are dark and rugged, with patches of snow on their slopes and in the valleys. The sky is a deep blue, suggesting dusk or dawn. The overall scene is majestic and serene.

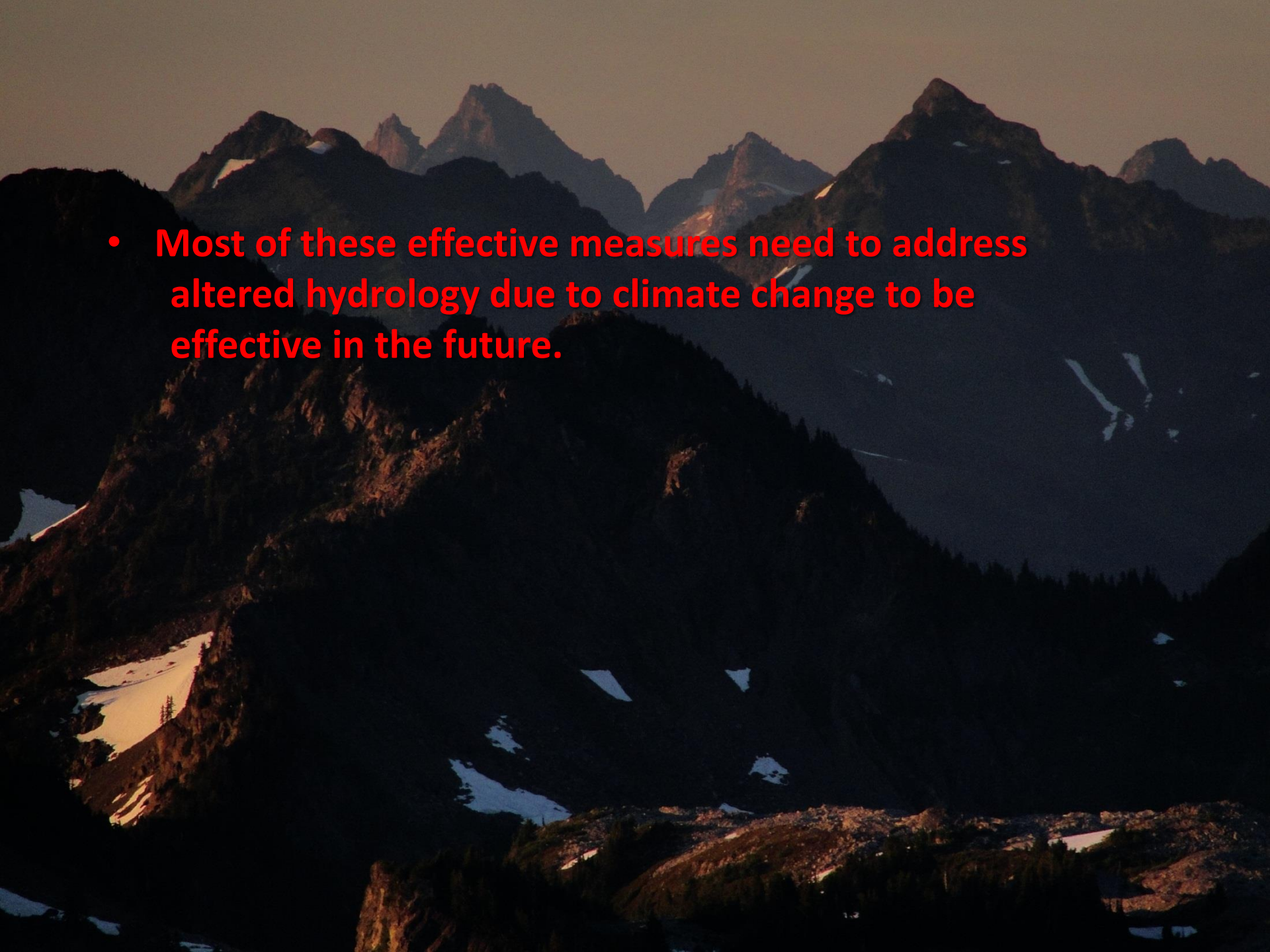
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- **Wetlands restoration**

A dramatic mountain landscape with snow-capped peaks and a valley below. The scene is captured in a cinematic style, with warm, golden light illuminating the mountain slopes and the sky. The foreground shows a steep, rocky slope with patches of snow and sparse vegetation. In the background, several jagged mountain peaks rise against a hazy, orange-tinted sky. The overall mood is majestic and serene.

In combination with ELJs, the most effective restoration actions include:

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- **Riparian planting**

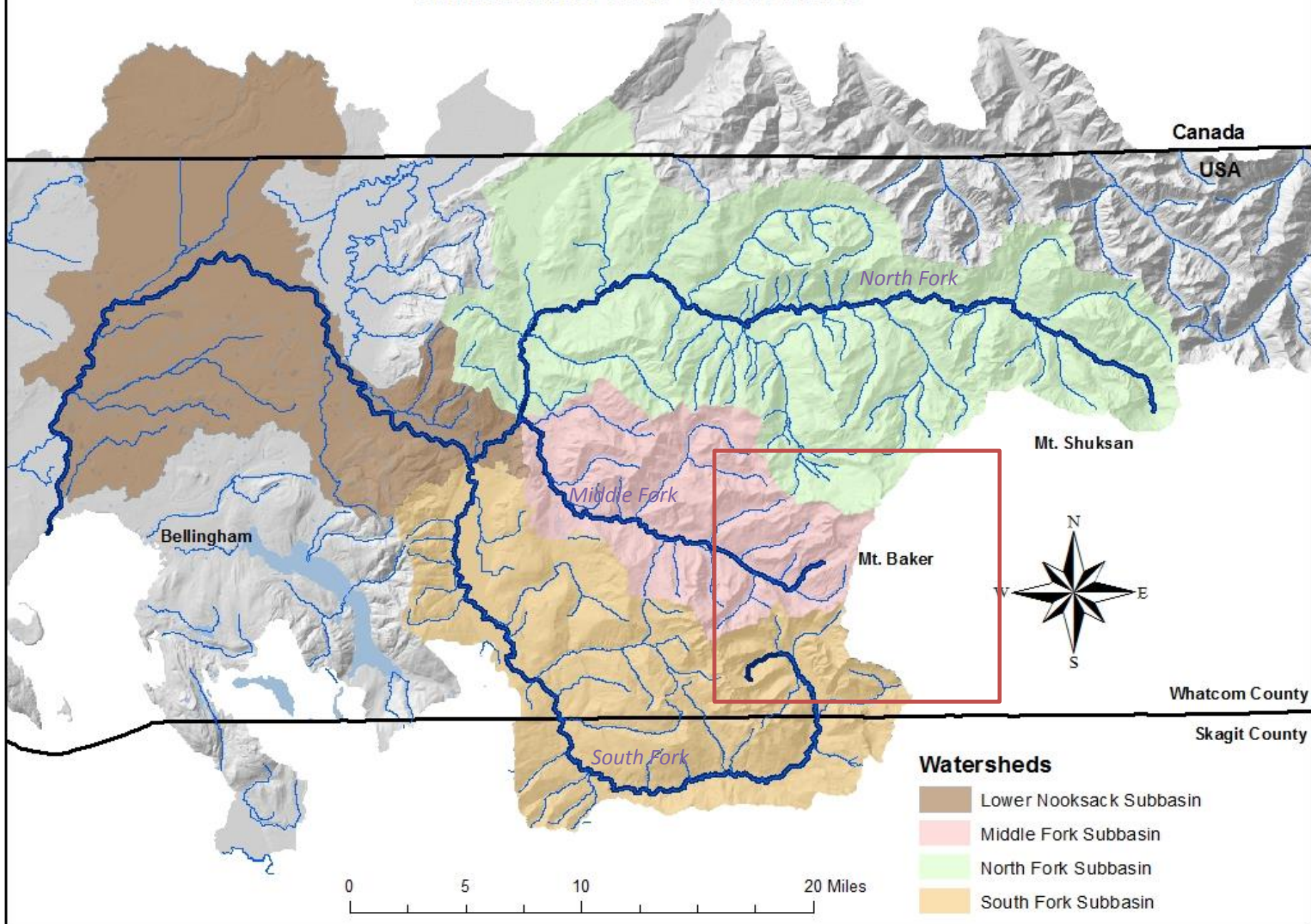
- 
- Most of these effective measures need to address altered hydrology due to climate change to be effective in the future.

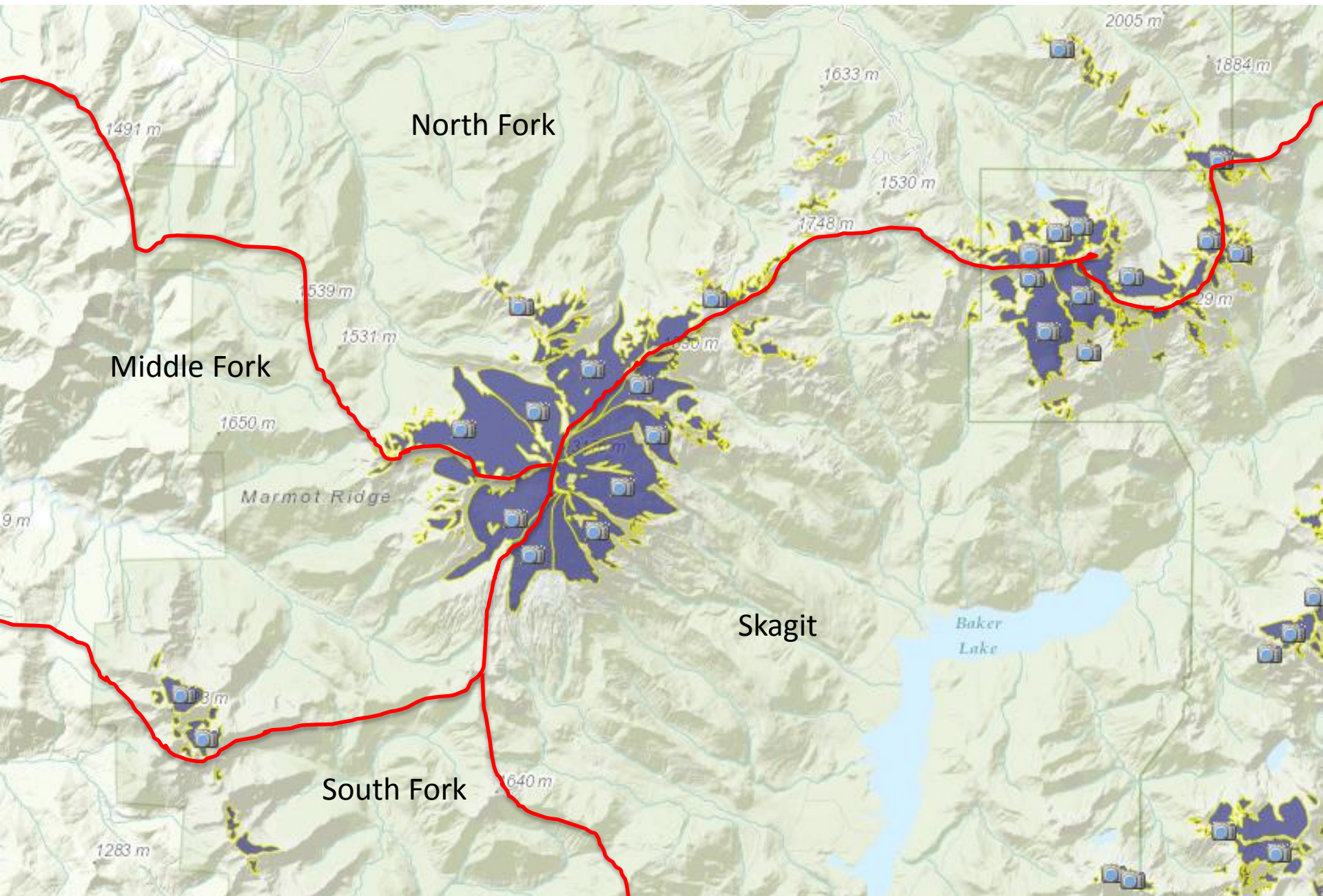




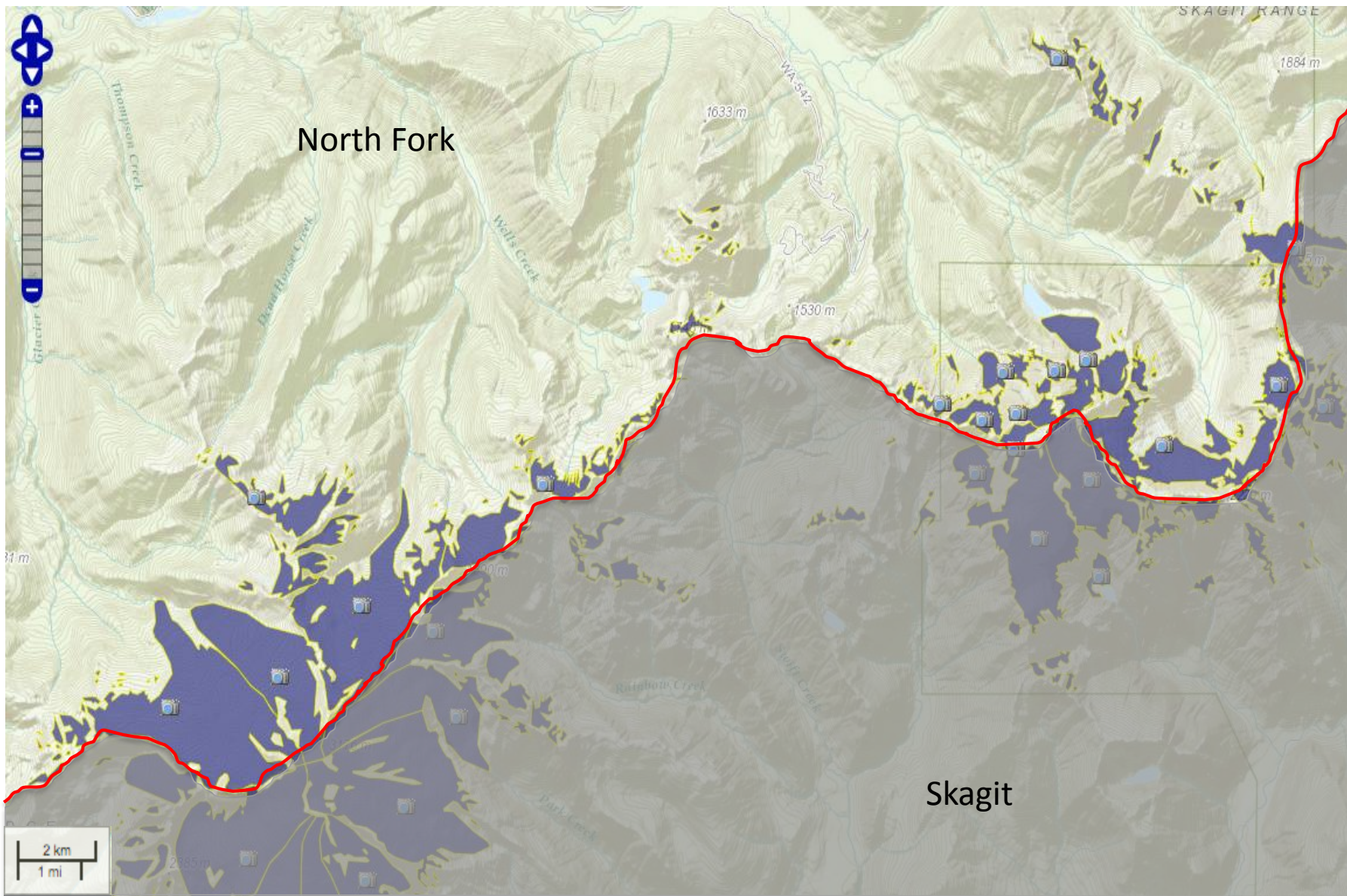
So, where are the glaciers?

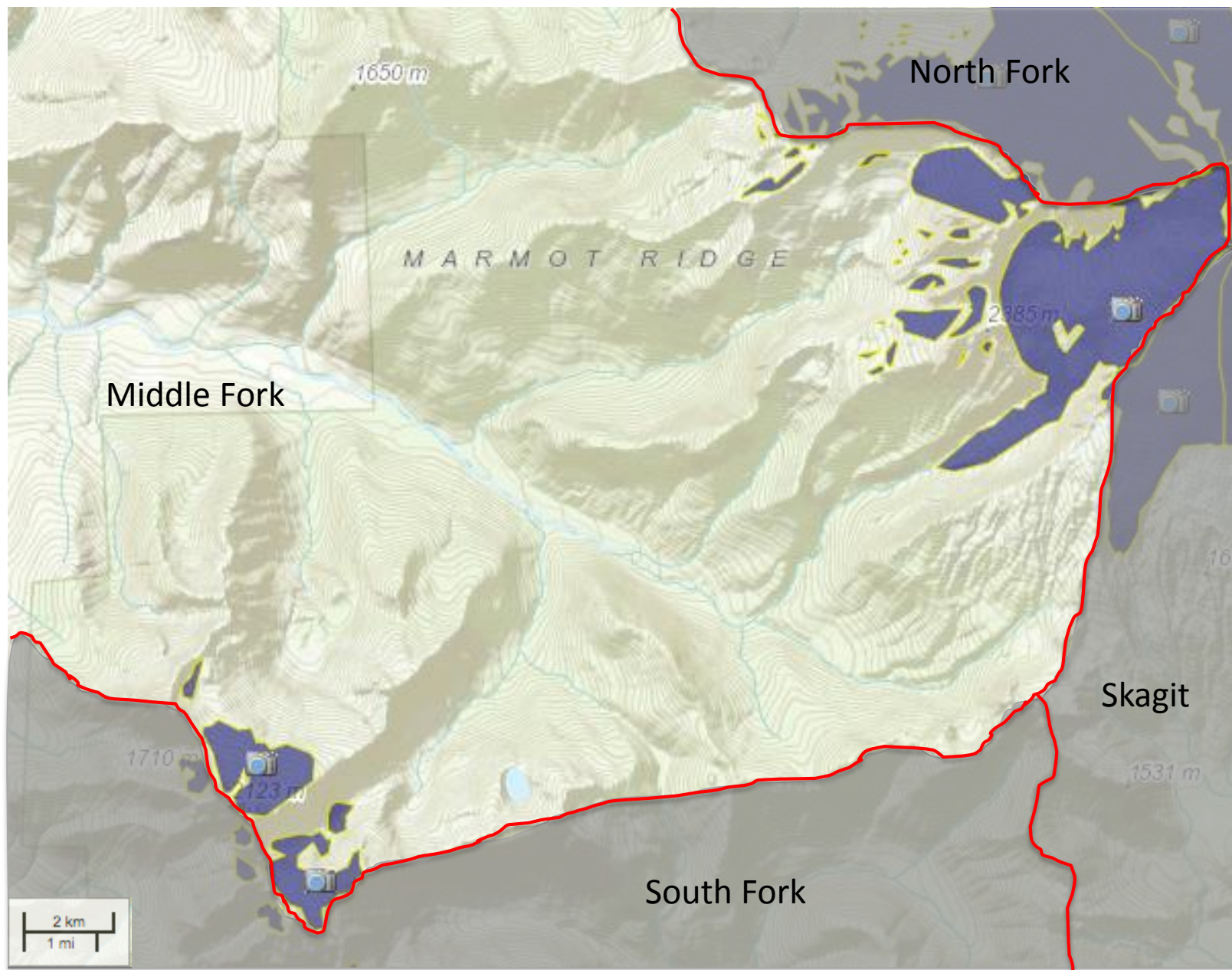
Nooksack River Watershed

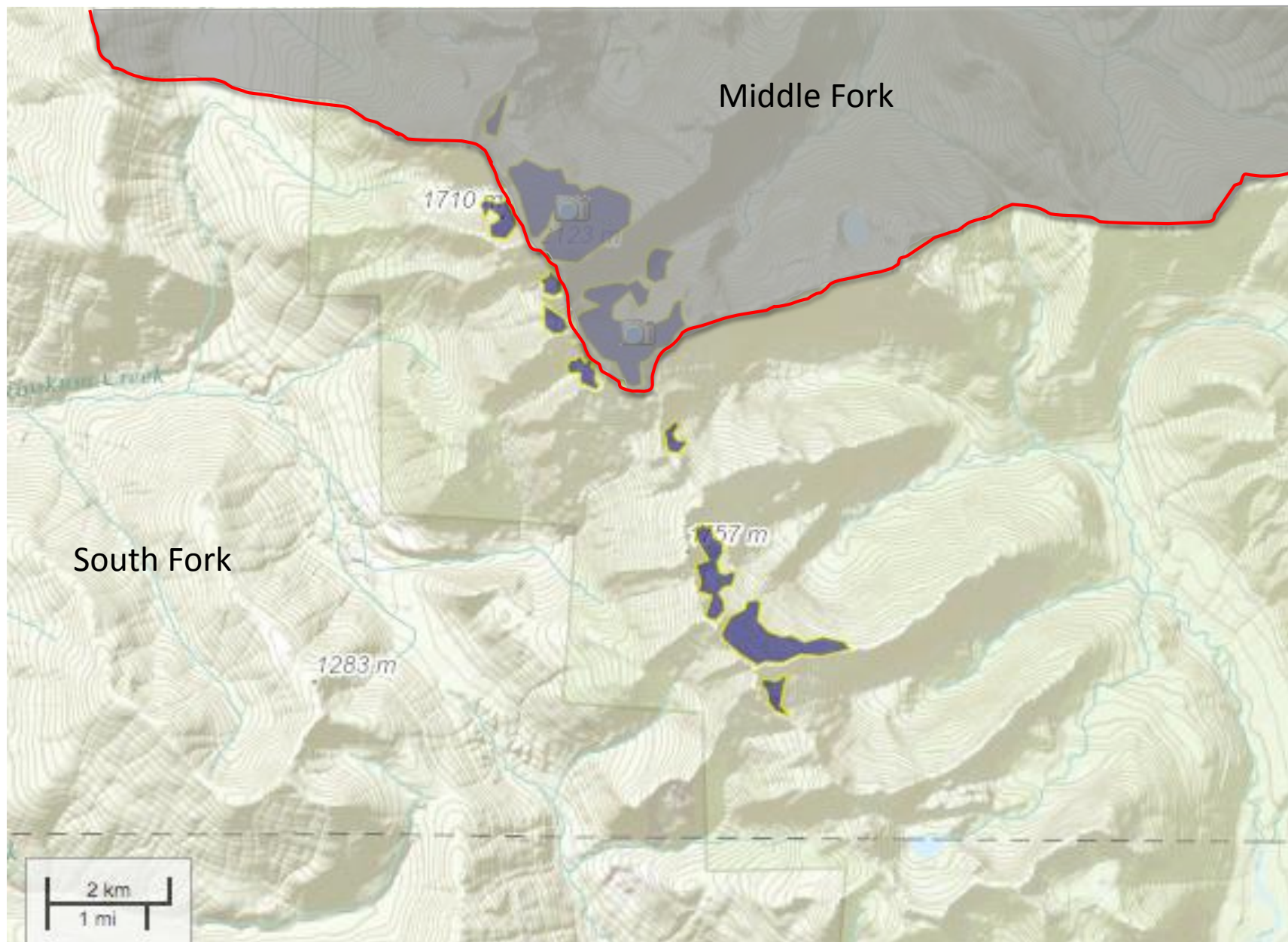




(source: <http://glaciers.geos.pdx.edu/>).



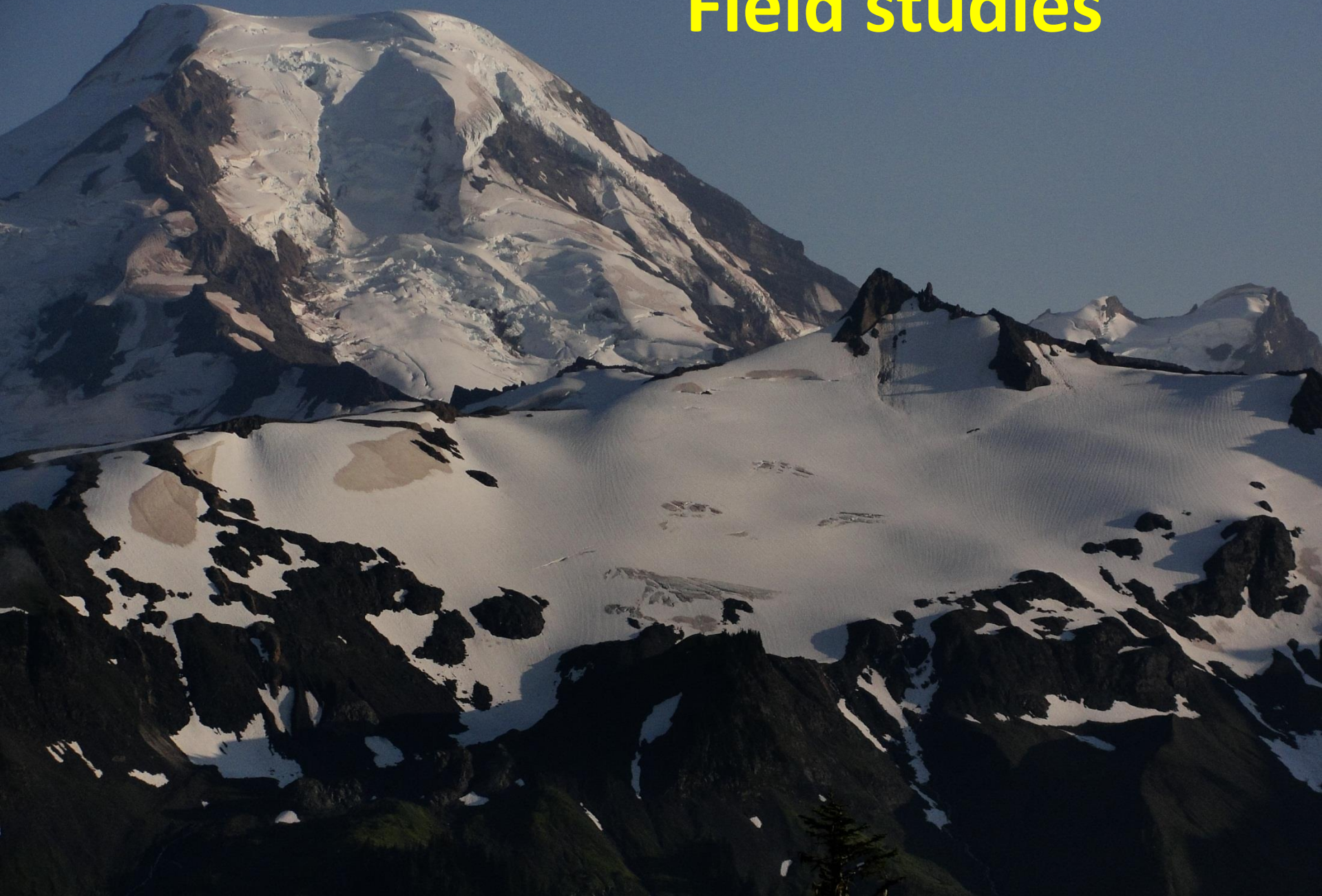




Nooksack River Basin

- **North Fork- 727 km² -glacier area 23.9 km²**
 - Substantial glacier area-Coleman, Roosevelt, Mazama, Heliotrope, Sholes, Hadley, Bastille
- **Middle Fork-190 km²-glacier area 6.7 km²**
 - Moderate glacier area- Deming, Thunder, Twin Sisters
- **South Fork –272 km² - glacier area 0.1 km²**
 - Minimal Glacier area and lower mean elevation

Field studies























Glacier and Snow Areal Extent

August 4



September 12

















Some recent observations/findings:



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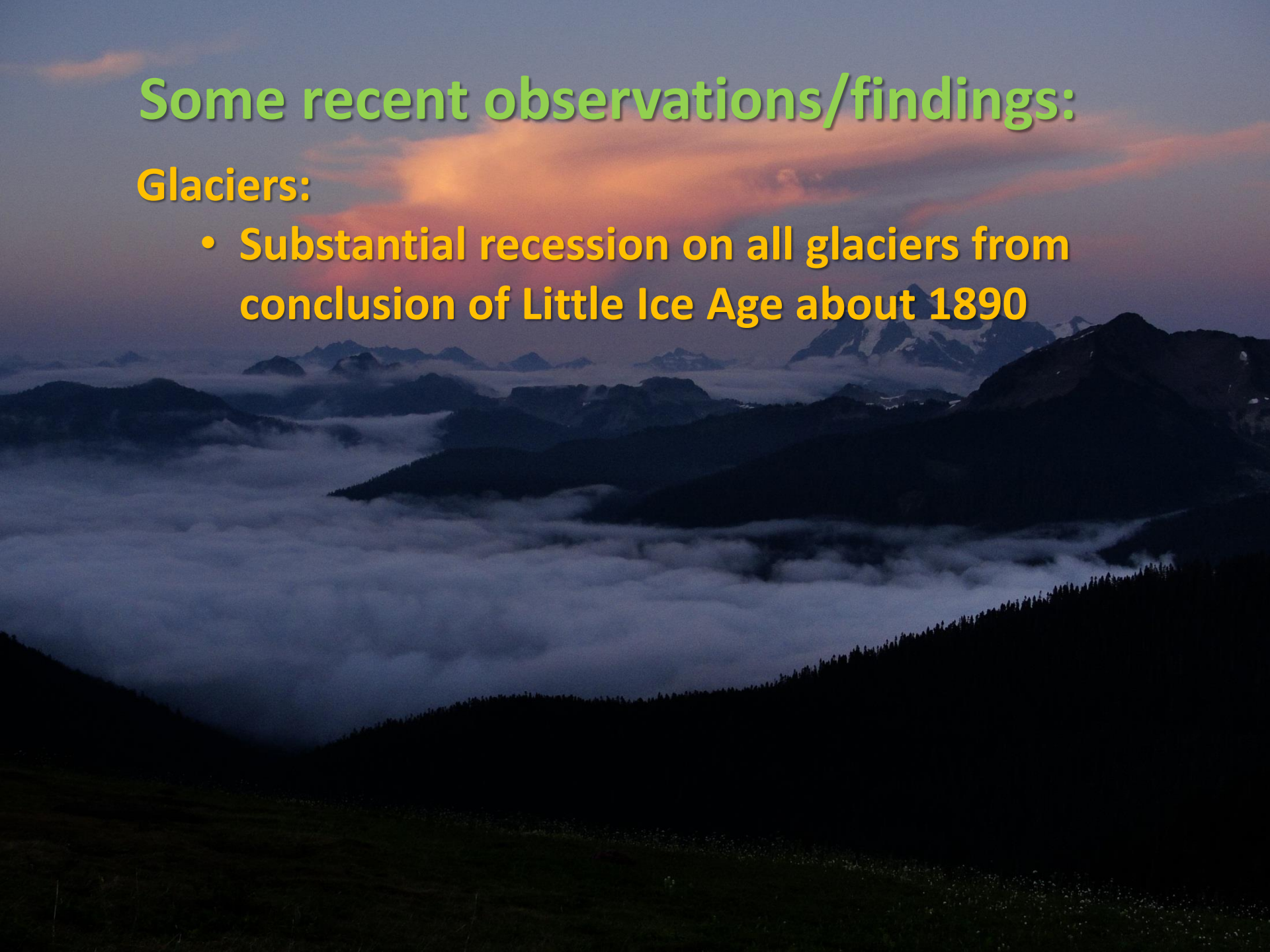
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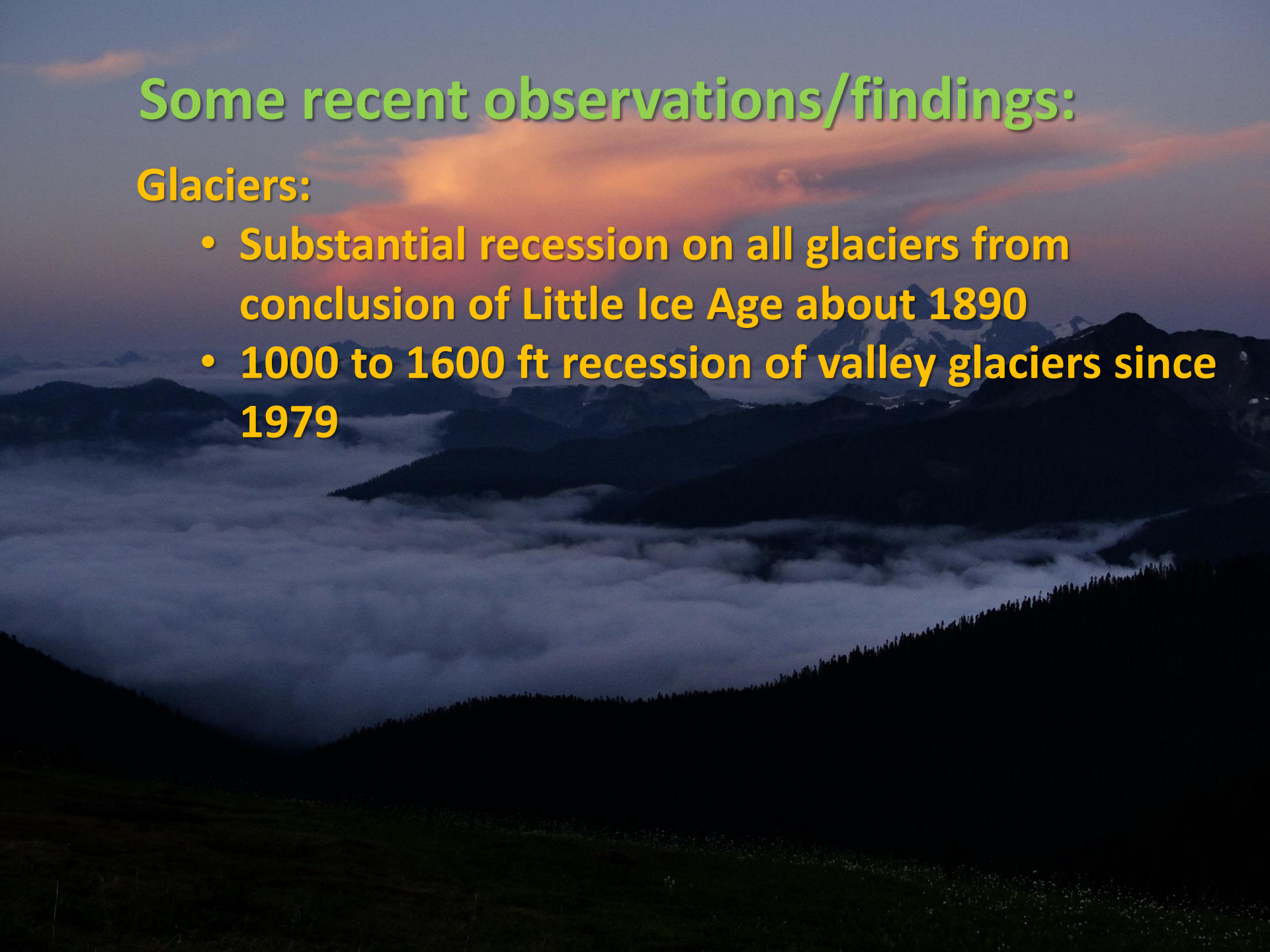
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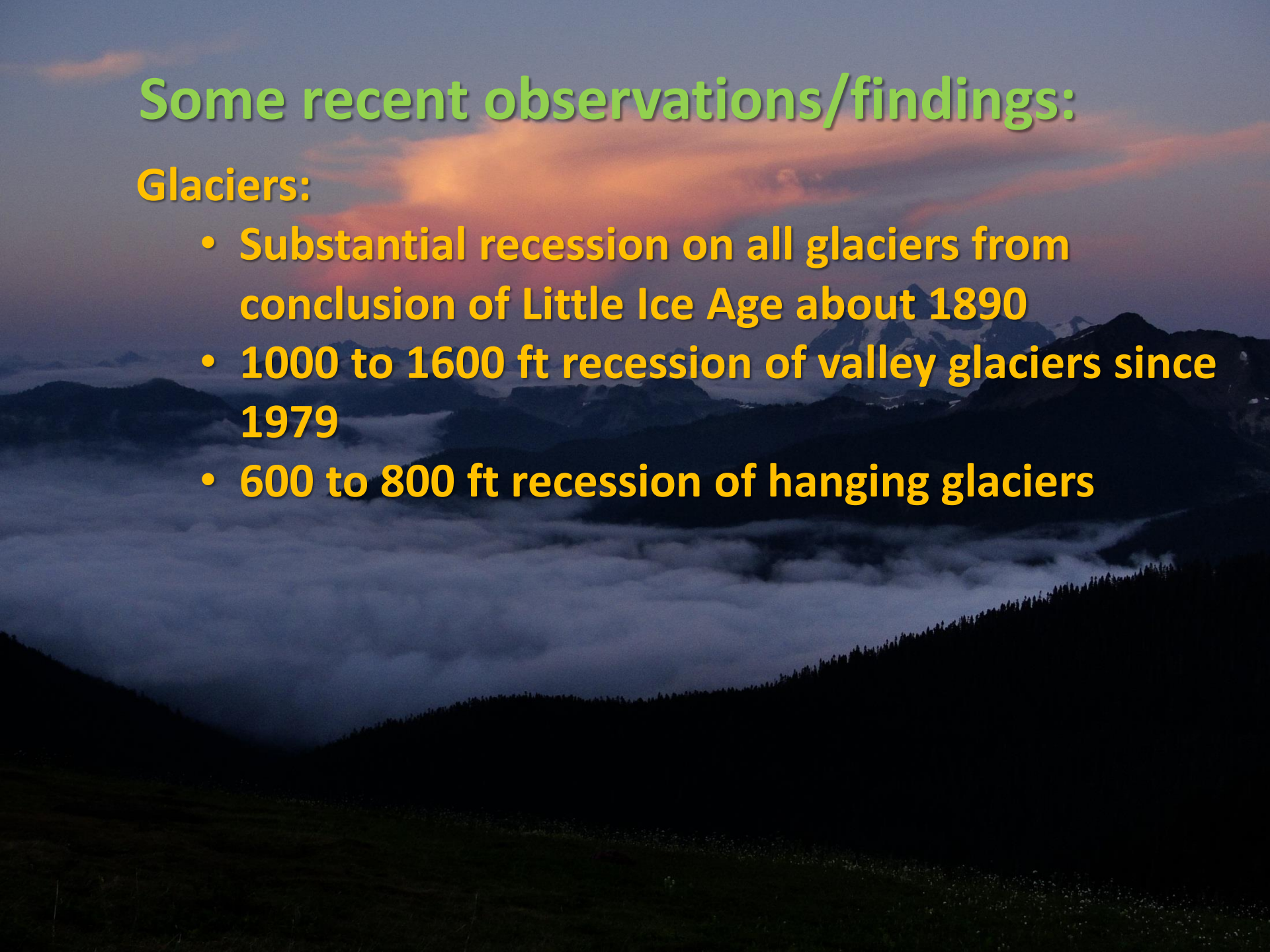
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- Trends will continue
- Most low to mid-elevation glaciers will disappear

Some recent observations/findings:

Flow:



Some recent observations/findings:

Flow:

- Glacier melt has minor diurnal fluctuation of flow



Some recent observations/findings:

Flow:

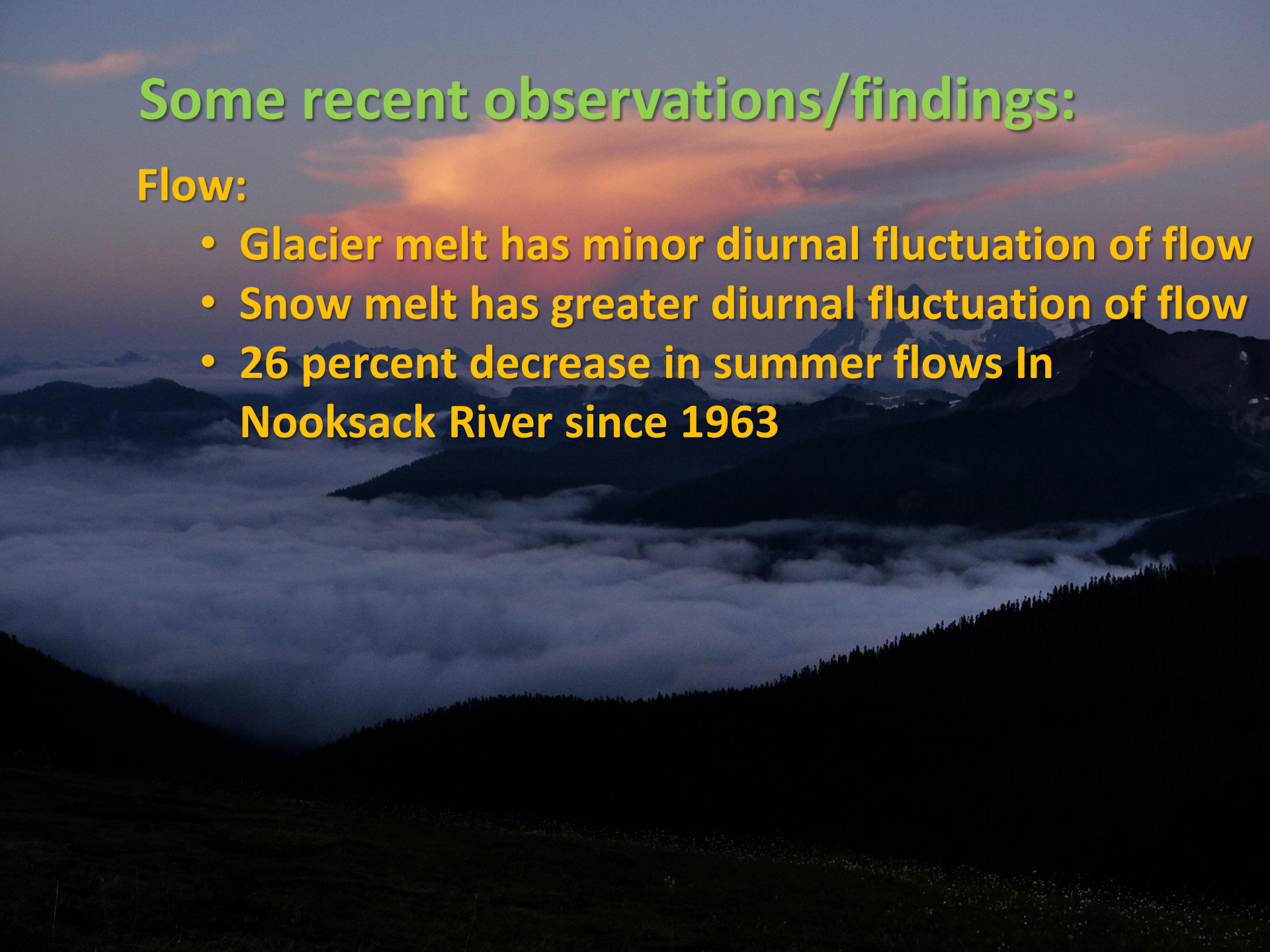
- Glacier melt has minor diurnal fluctuation of flow
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- Conditions in the North Fork and Middle Fork will be similar to those currently of the South Fork

Some recent observations/findings:

Sediment:



Some recent observations/findings:

Sediment:

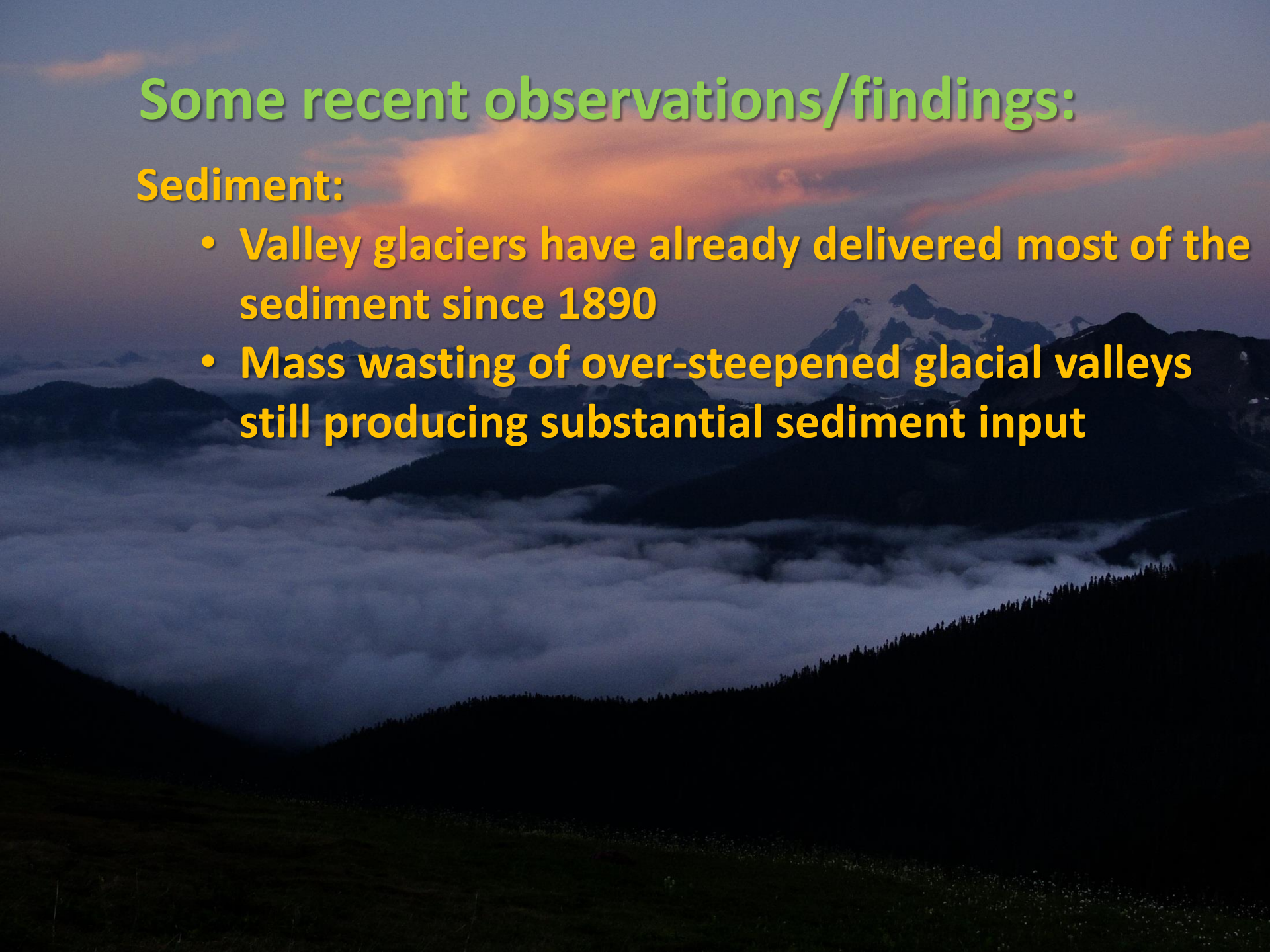
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Some recent observations/findings:

Sediment:

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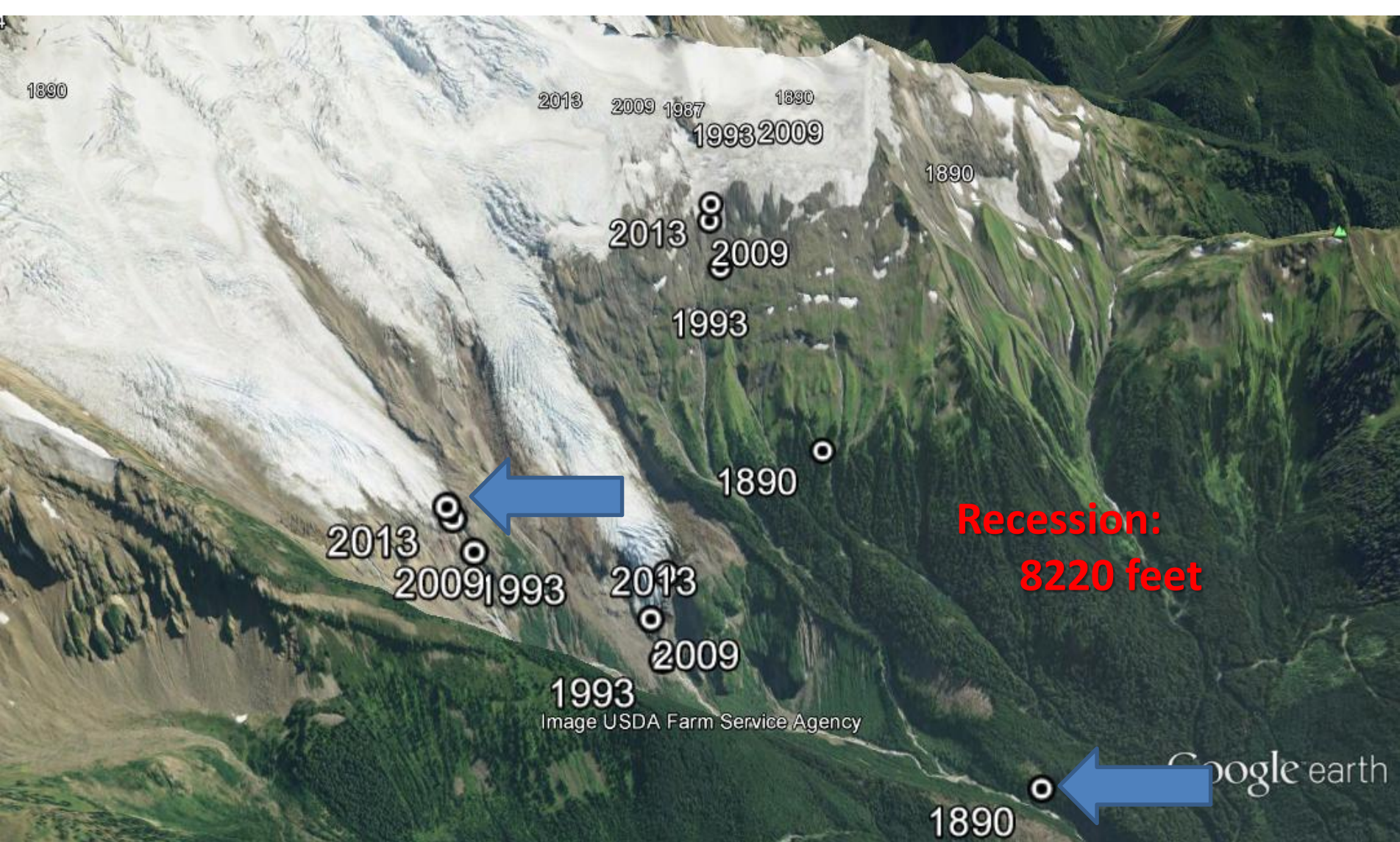
Sediment:

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- Mass wasting of over-steepened glacial valleys still producing substantial sediment input
- Most residual glaciers produce moderate amounts of suspended sediment
- Snowmelt fed streams carry minor amounts of suspended sediment

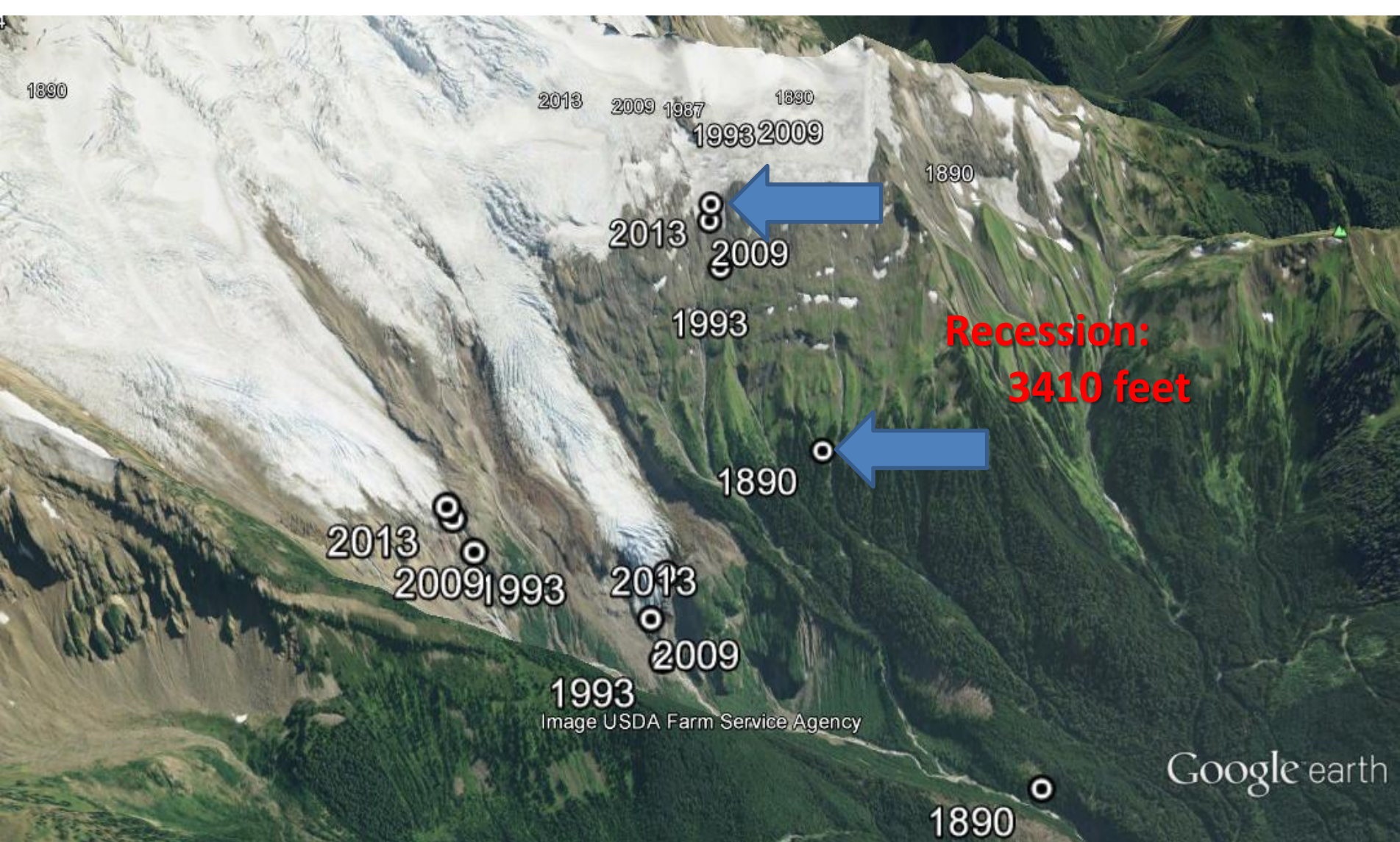








Roosevelt Glacier

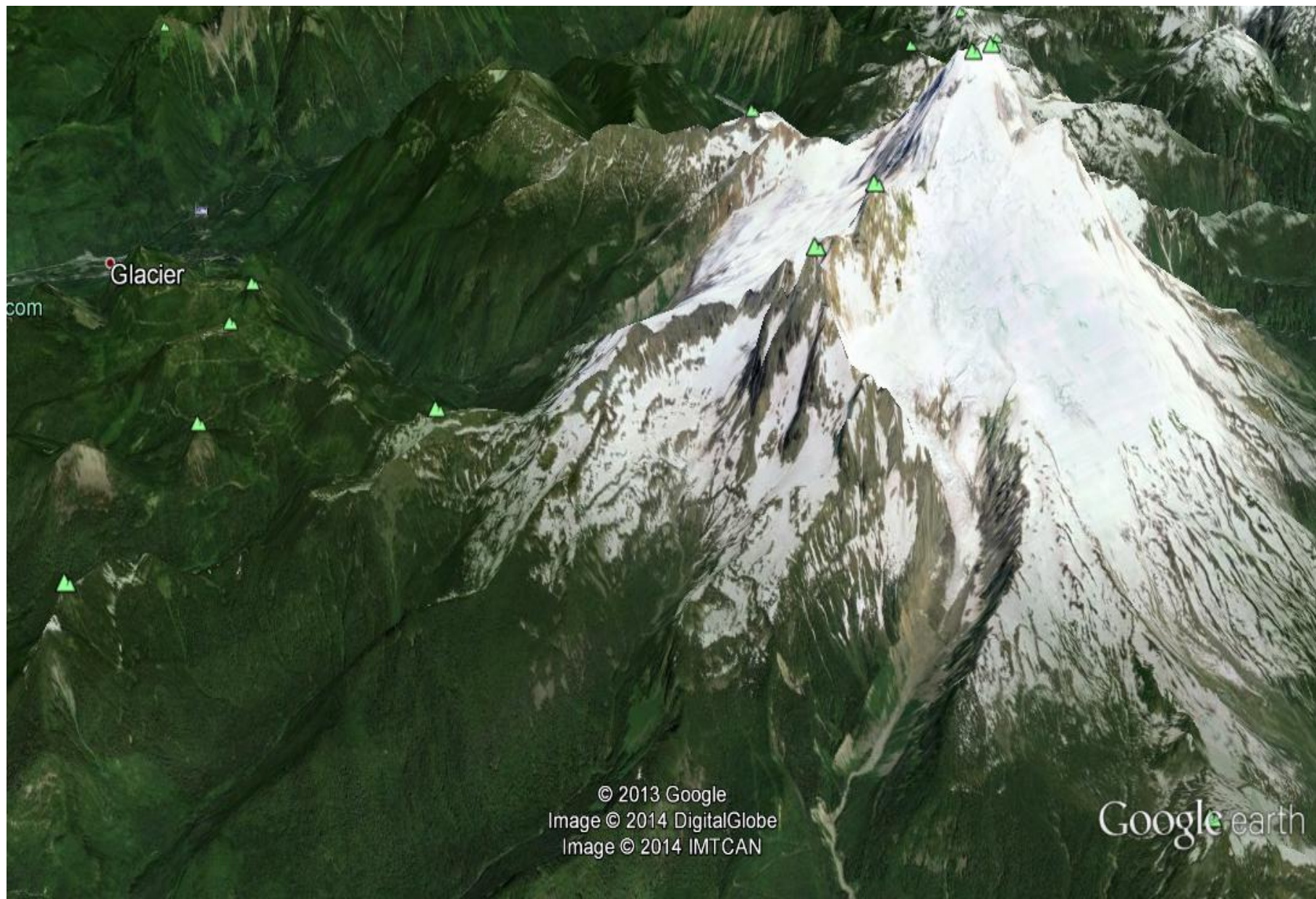


Heliotrope Glacier

Glacier Recession since the end of the Little Ice Age (feet).

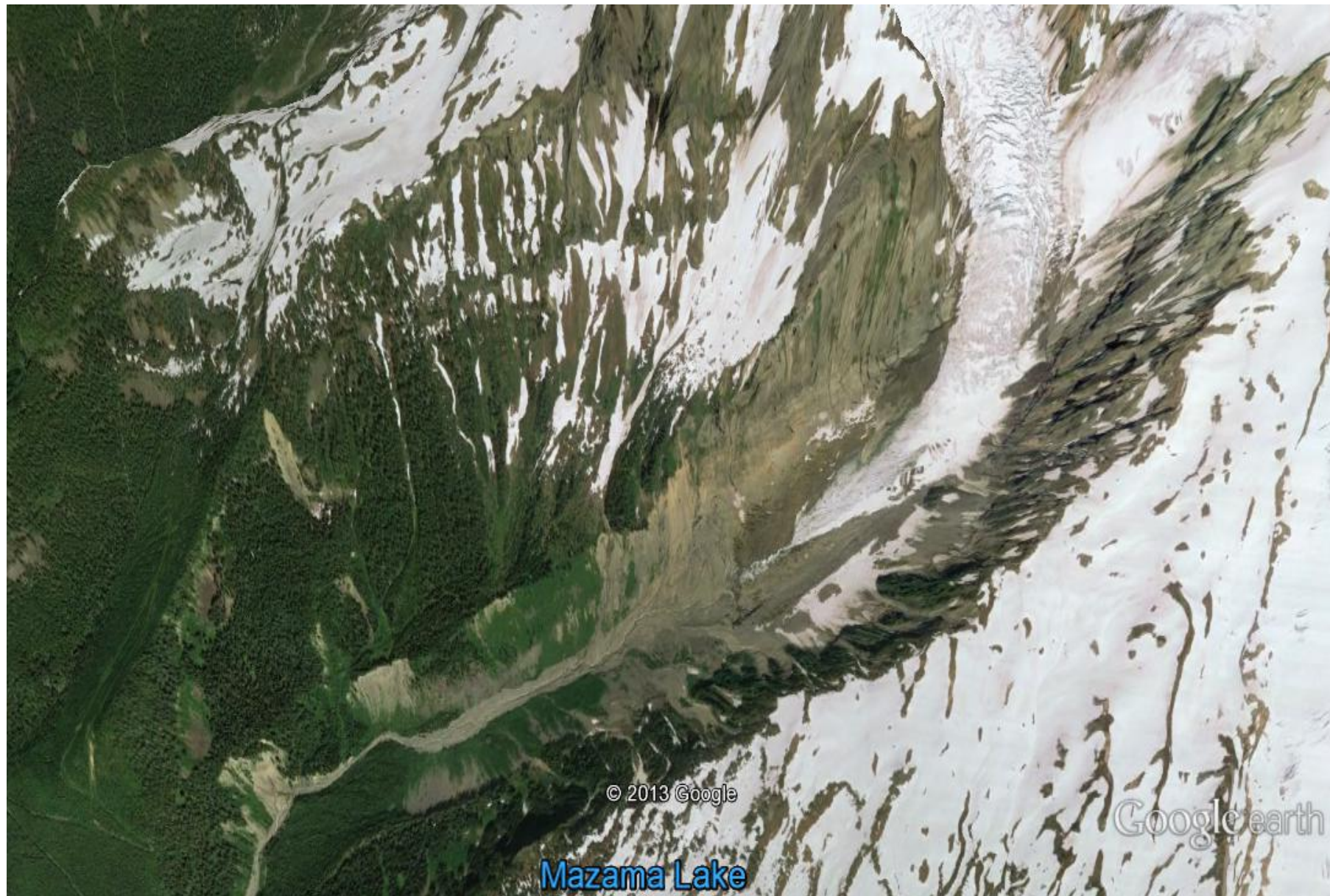
Glacier	1890-1993	2013	1993-2013	TOTAL
Roosevelt	7830	8220	390	8220
Coleman	5220	6140	920	6140
Deming	6050	7495	1445	7495
Mazama	4980	7220	2240	7220
Rainbow	10515	11830	1350	11865
Thunder	7190	7860	670	7860
<i>Sholes</i>	4060	4710	650	4710
<i>Heliotrope</i>	2460	3410	950	3410
<i>Hadley</i>	3380	3890	510	3890
Bastile	5580	6020	440	6020

Average Recession = 6683 feet



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Image © 2014 DigitalGlobe
Image © 2014 IMTCAN

Google earth



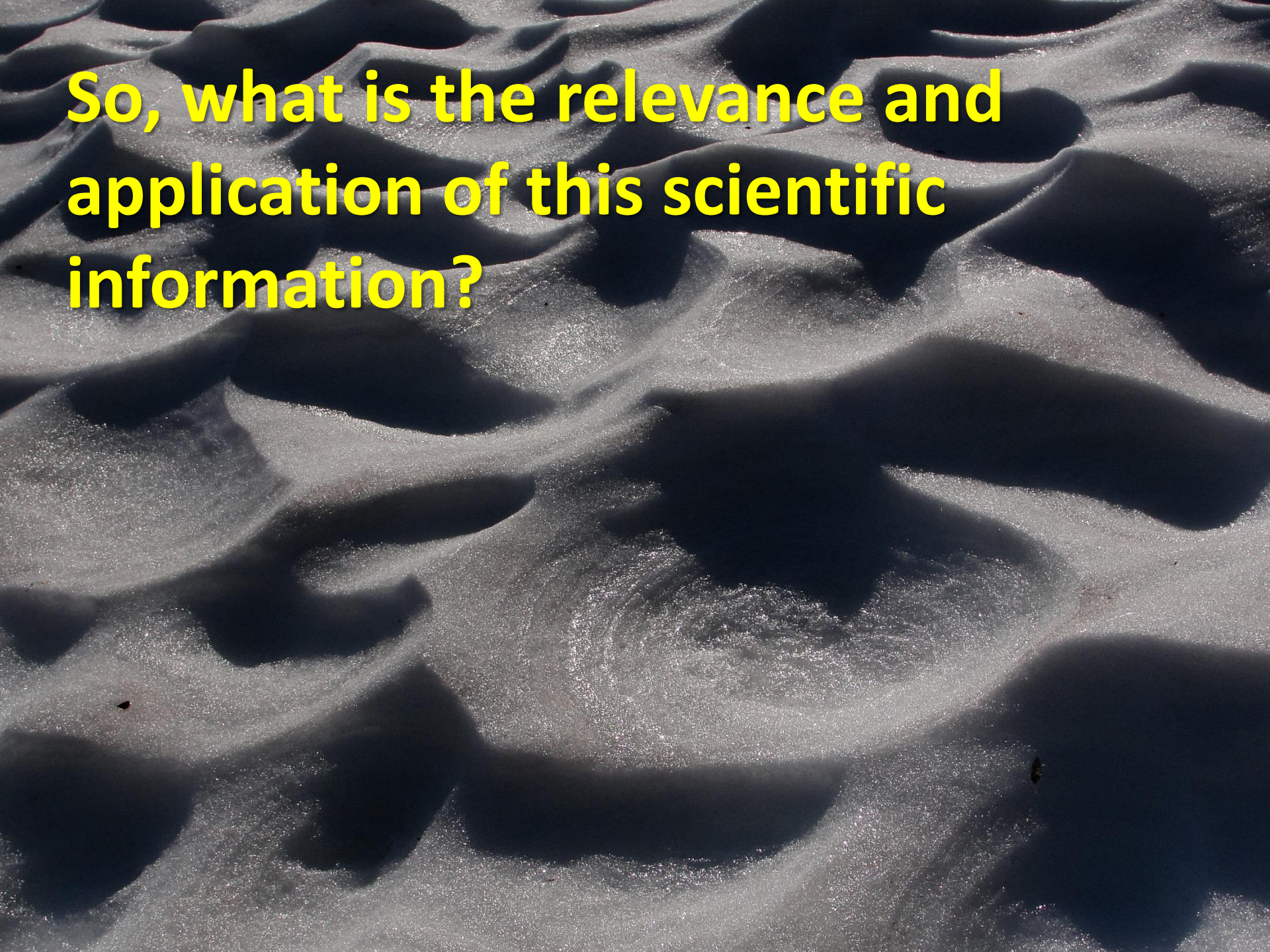
© 2013 Google

Google earth

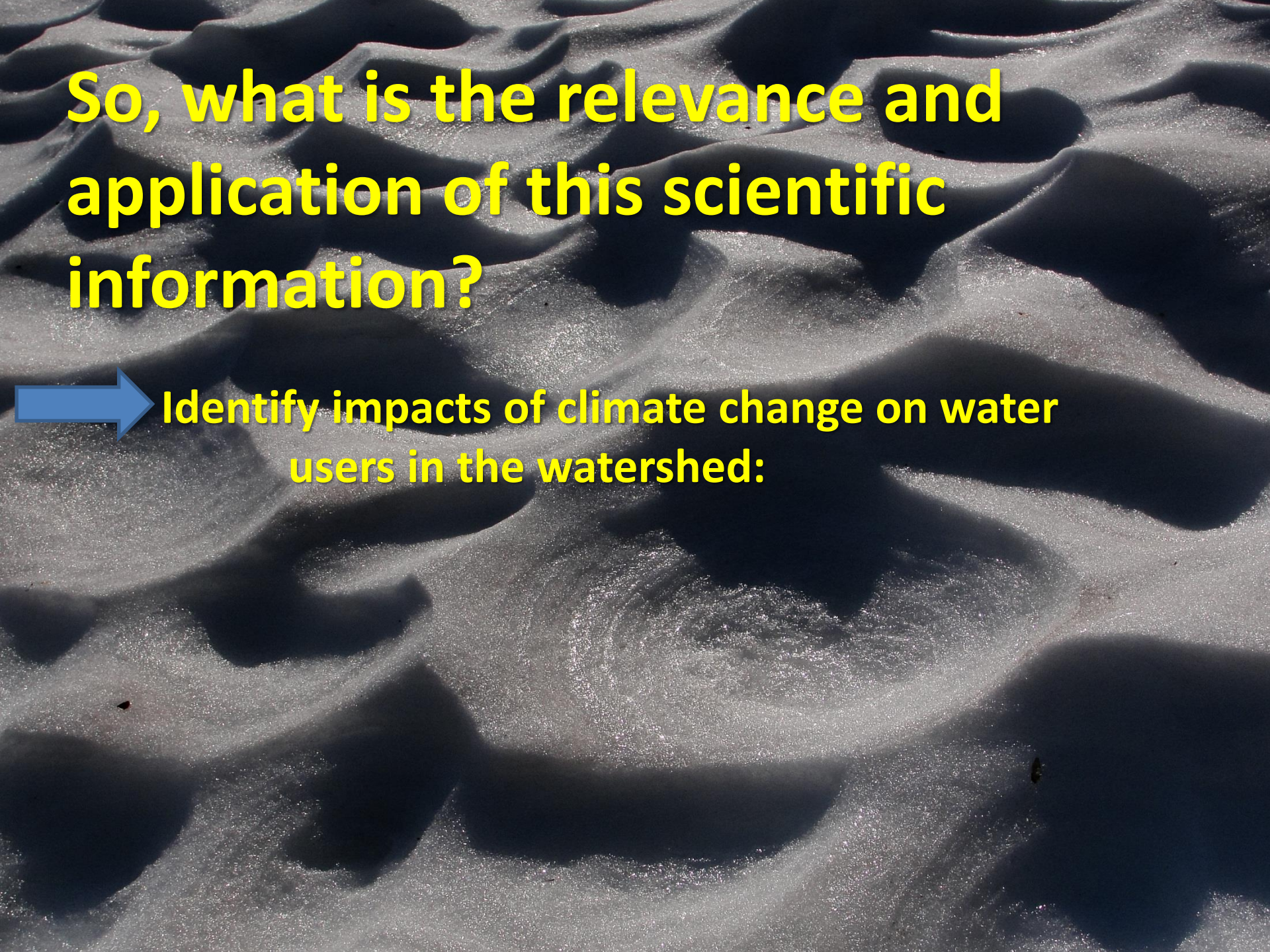
Mazama Lake







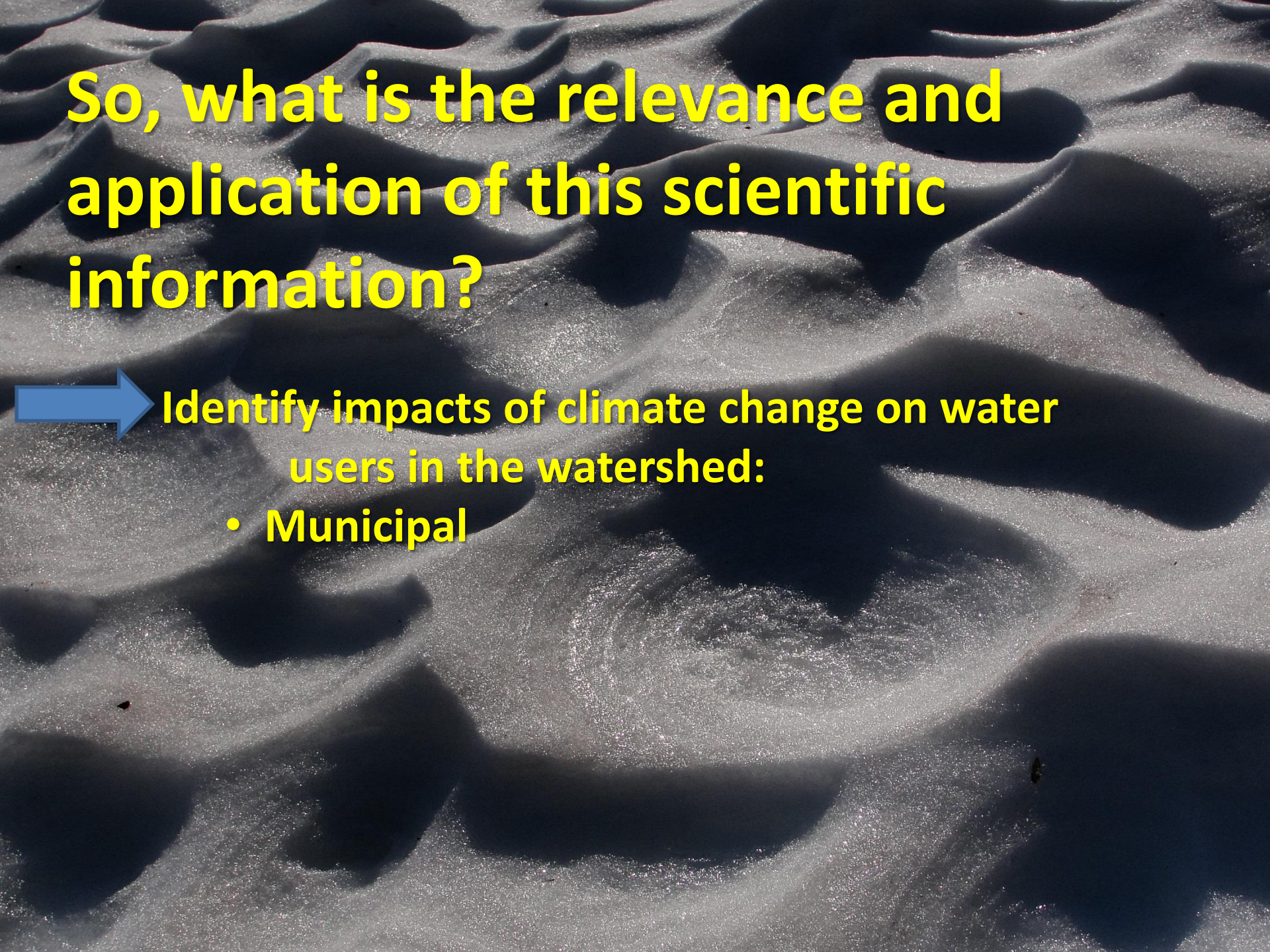
So, what is the relevance and application of this scientific information?



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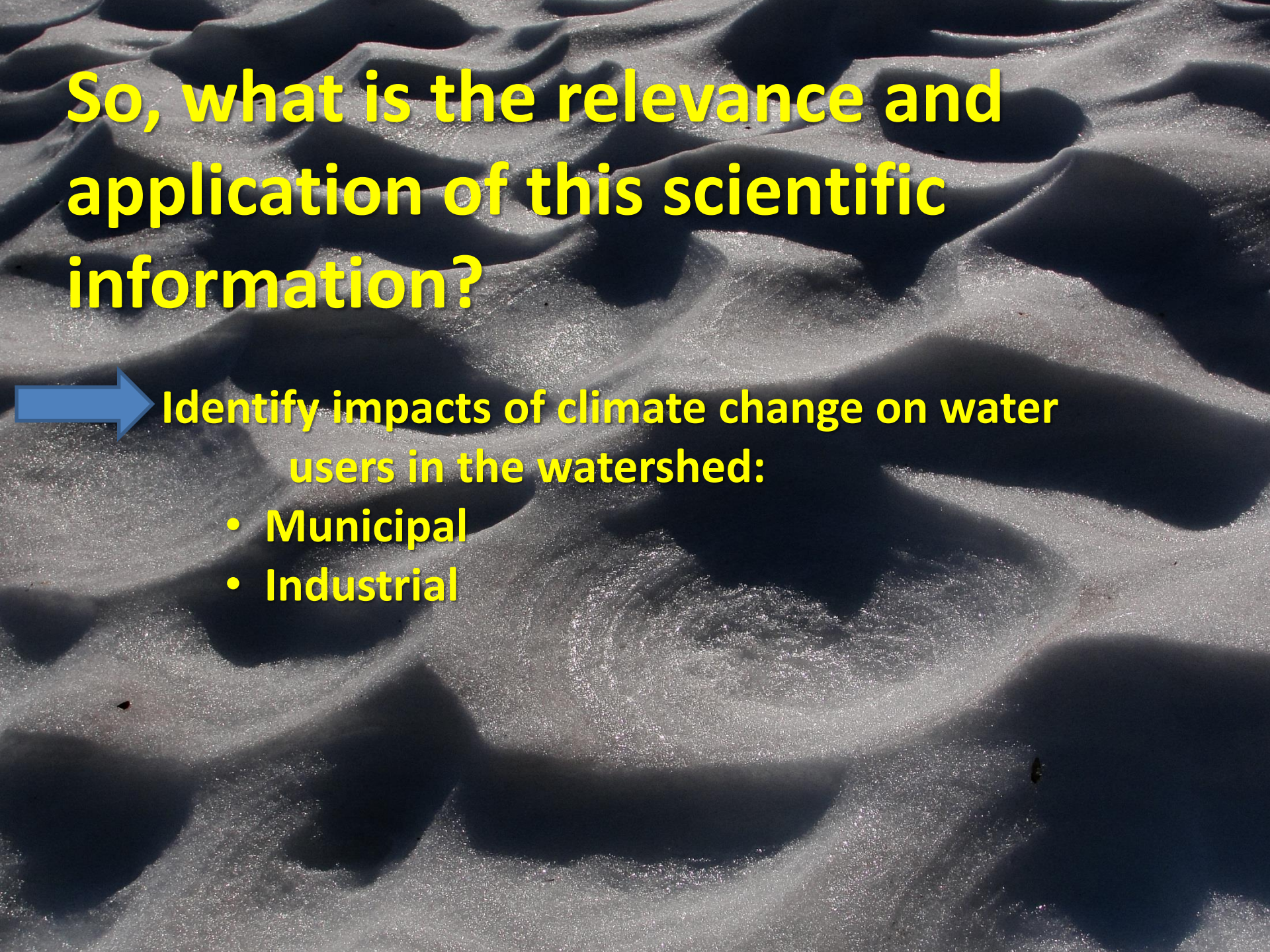
Identify impacts of climate change on water users in the watershed:



So, what is the relevance and application of this scientific information?

 **Identify impacts of climate change on water users in the watershed:**

- **Municipal**

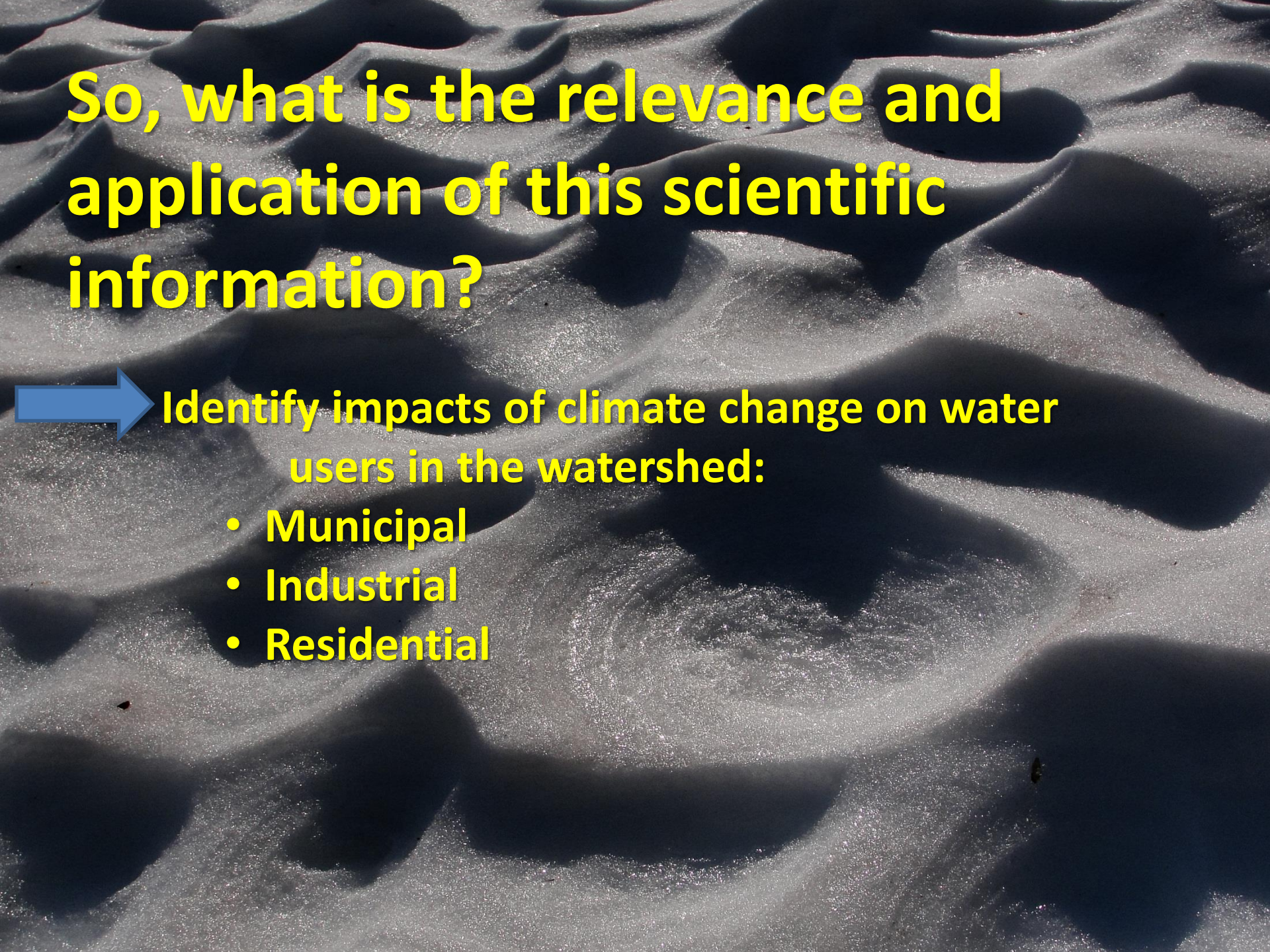


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Identify impacts of climate change on water users in the watershed:

- Municipal
- Industrial



So, what is the relevance and application of this scientific information?



Identify impacts of climate change on water users in the watershed:

- Municipal
- Industrial
- Residential

So, what is the relevance and application of this scientific information?

➡ Identify impacts of climate change on water users in the watershed:

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- Industrial
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- Agriculture

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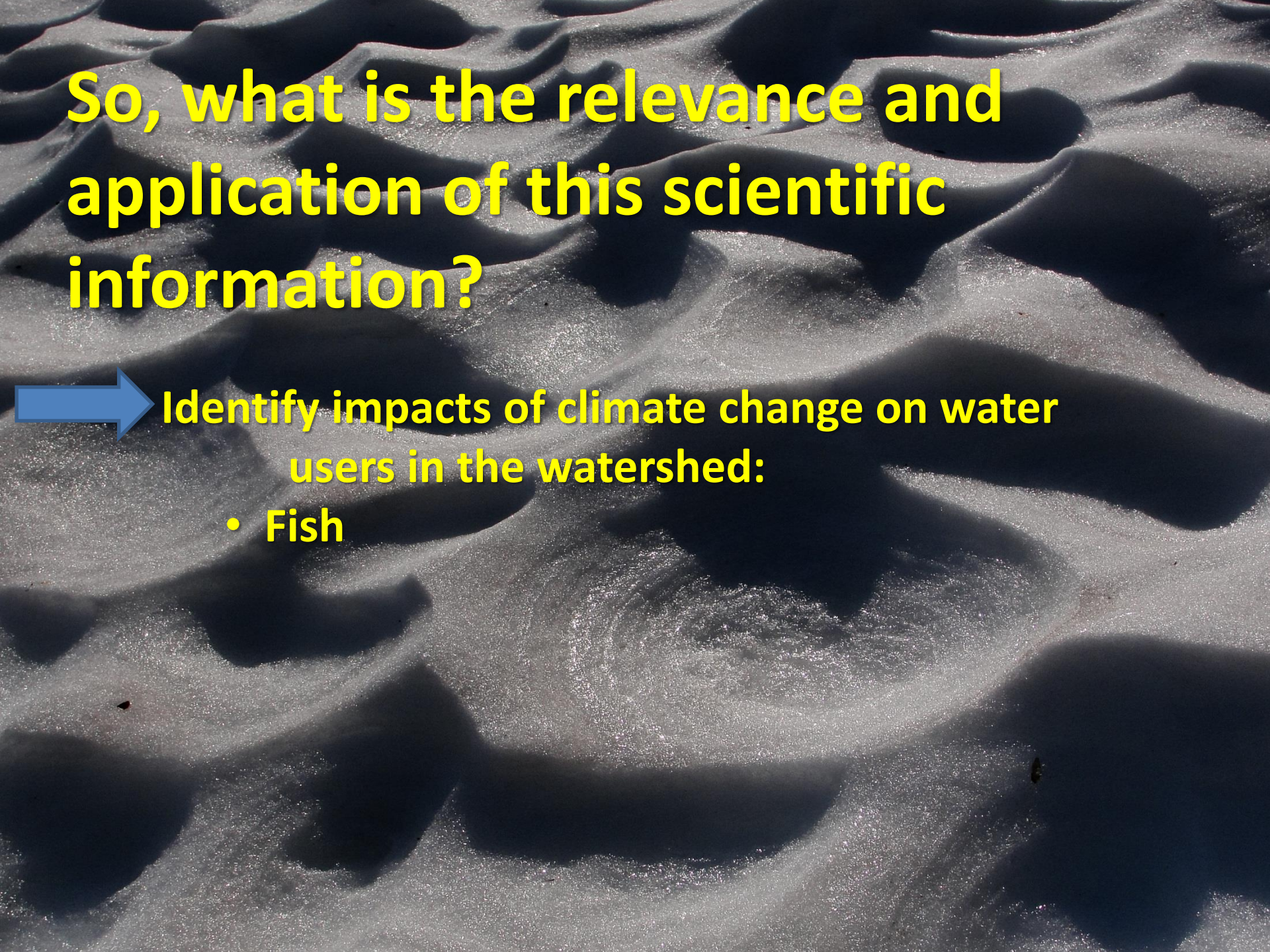
➡ Identify impacts of climate change on water users in the watershed:

- Municipal
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- Flood control

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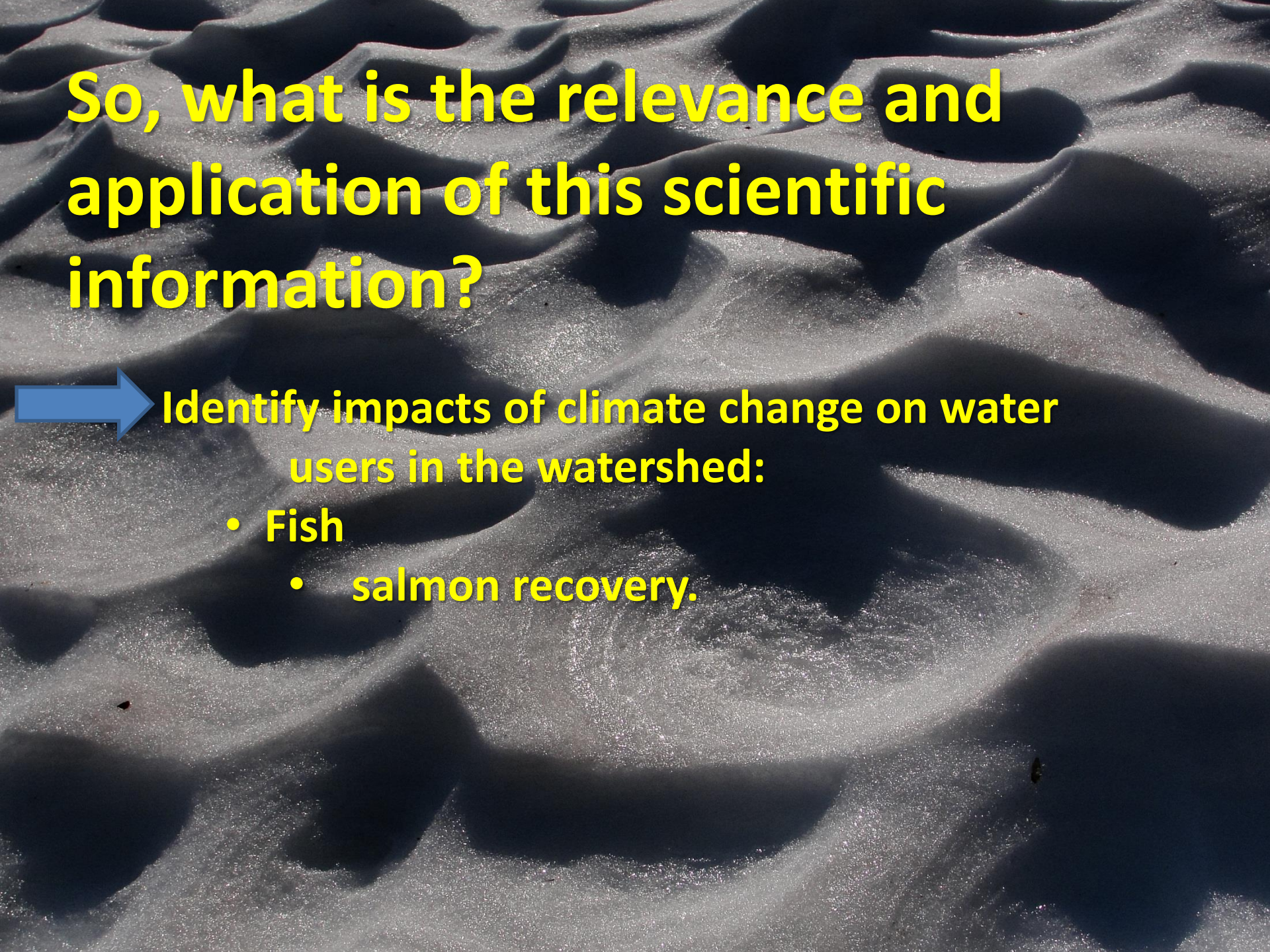
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So, what is the relevance and application of this scientific information?

 **Identify impacts of climate change on water users in the watershed:**

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So, what is the relevance and application of this scientific information?



Identify impacts of climate change on water users in the watershed:

- Fish
 - salmon recovery.

So, what is the relevance and application of this scientific information?

➡ Identify impacts of climate change on water users in the watershed:

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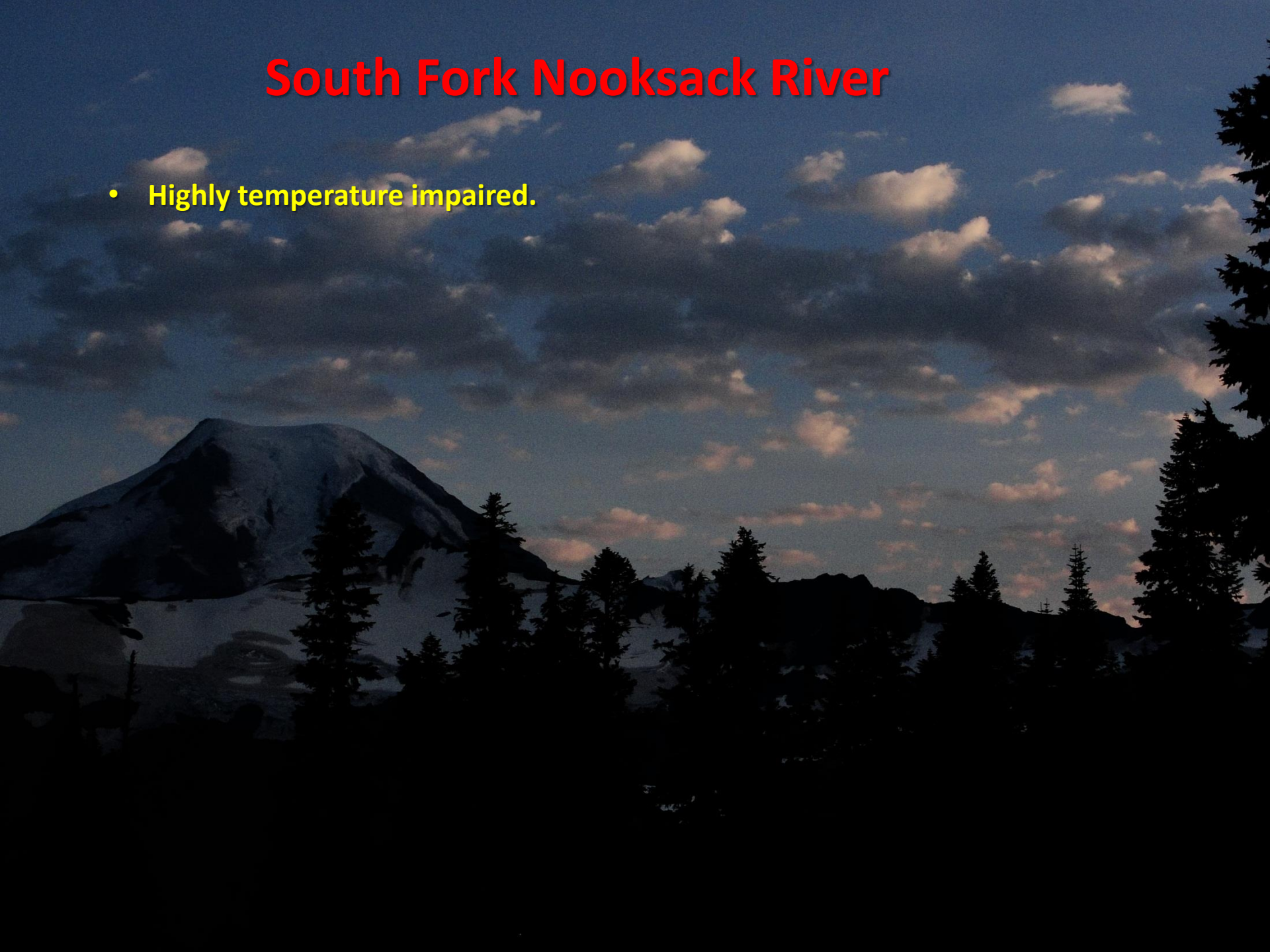
- Fish
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 - **treaty resources.**
 - restoration planning.

South Fork Nooksack River



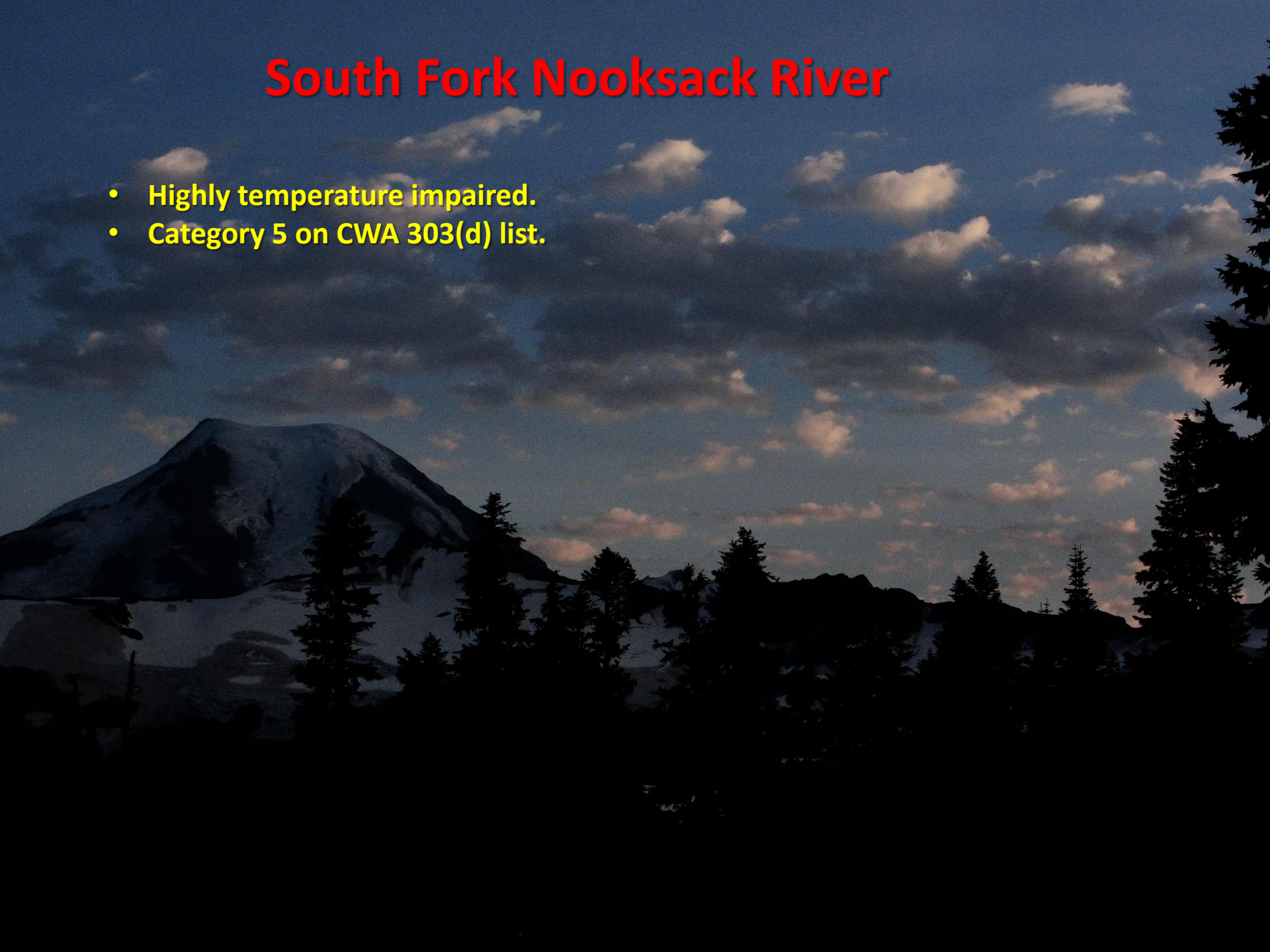
South Fork Nooksack River

- Highly temperature impaired.



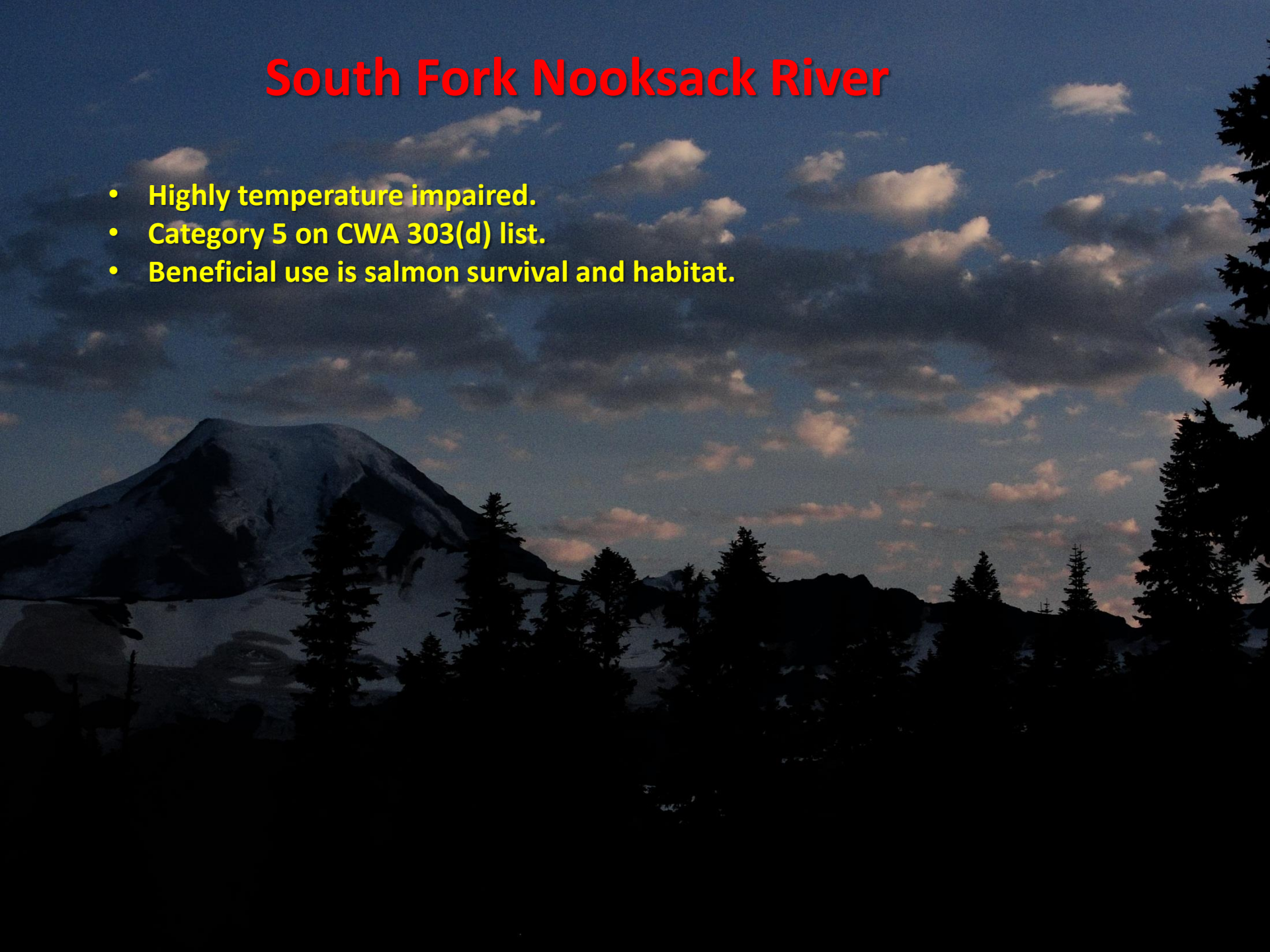
South Fork Nooksack River

- Highly temperature impaired.
- Category 5 on CWA 303(d) list.



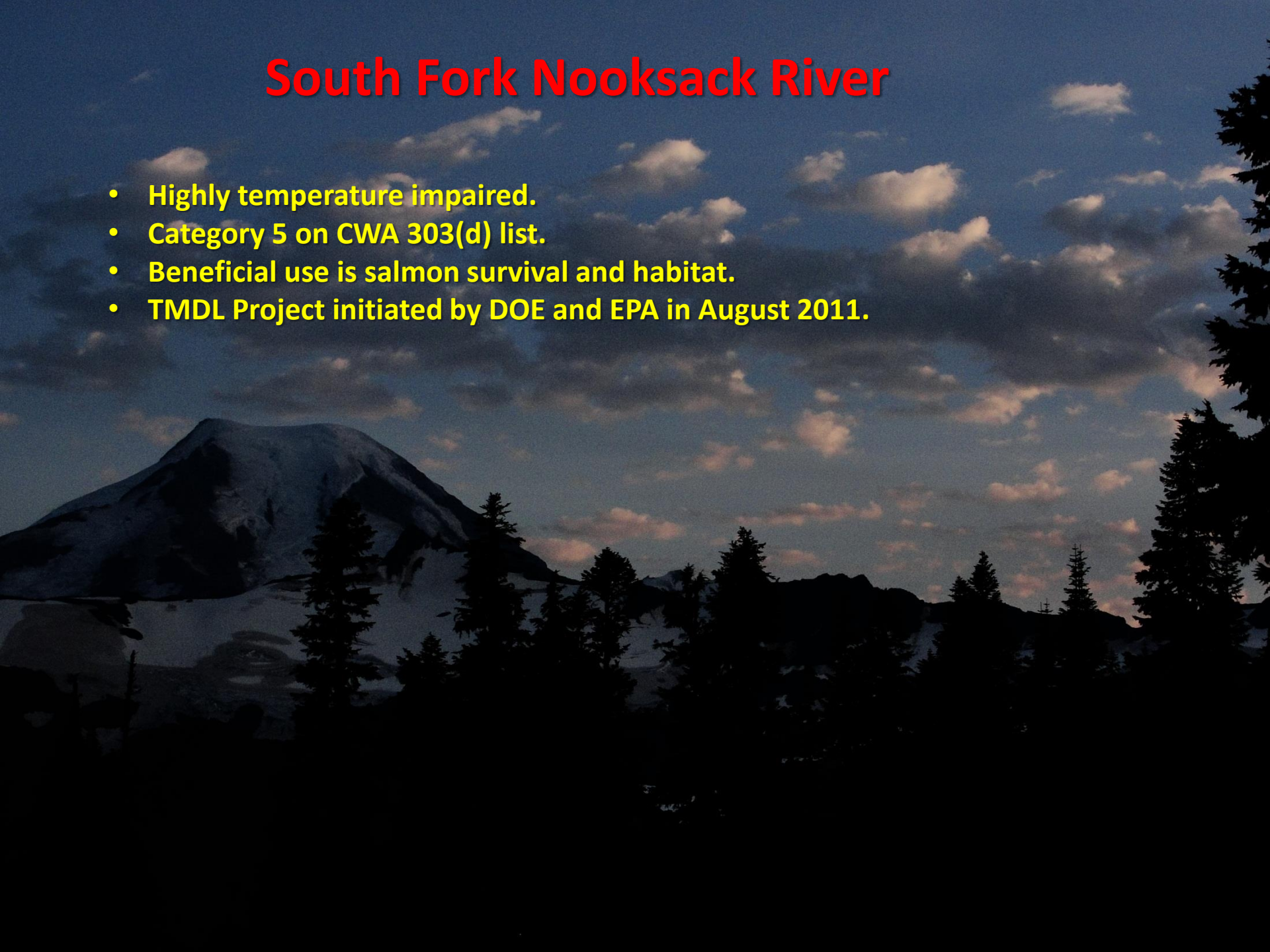
South Fork Nooksack River

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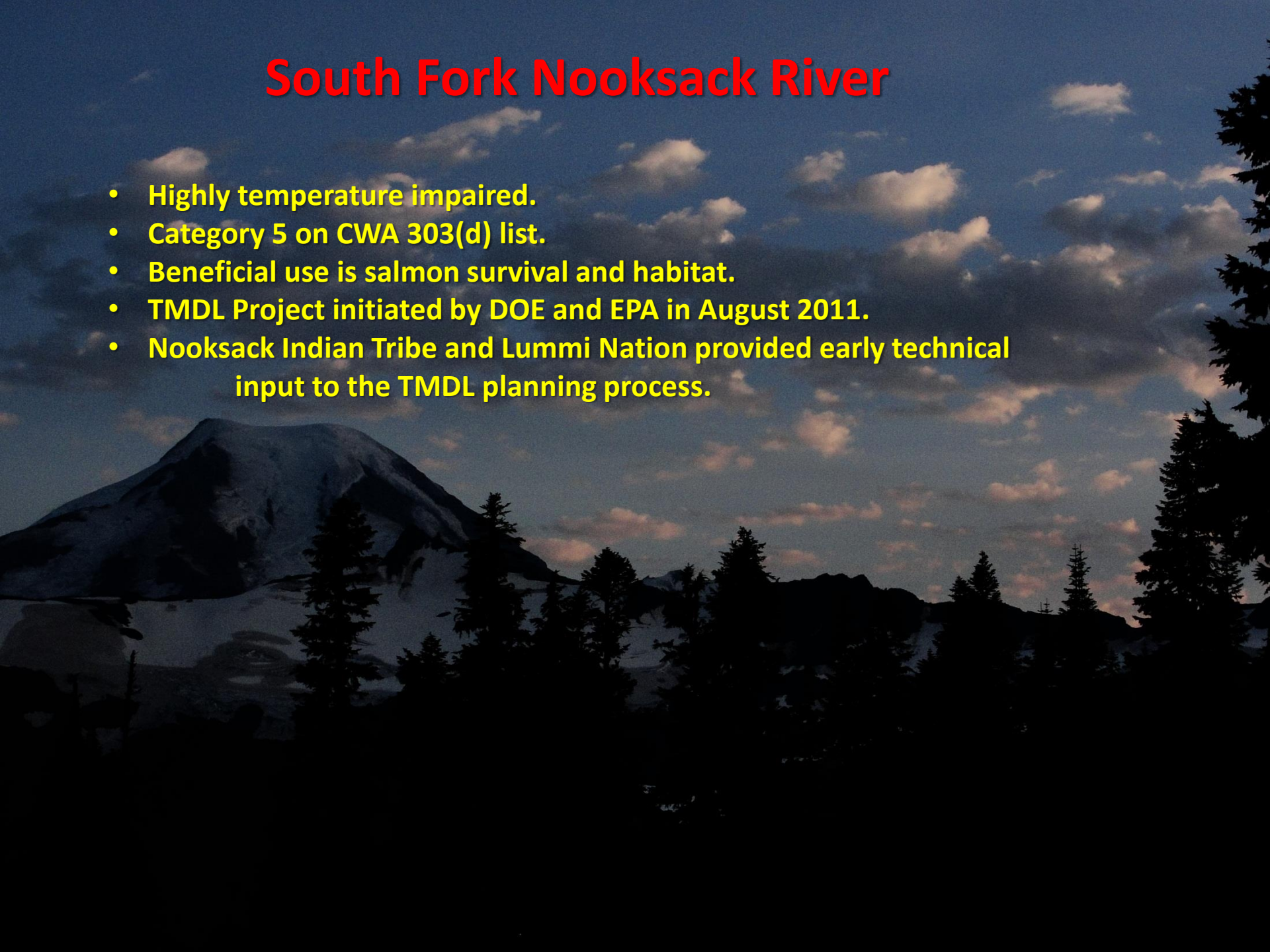
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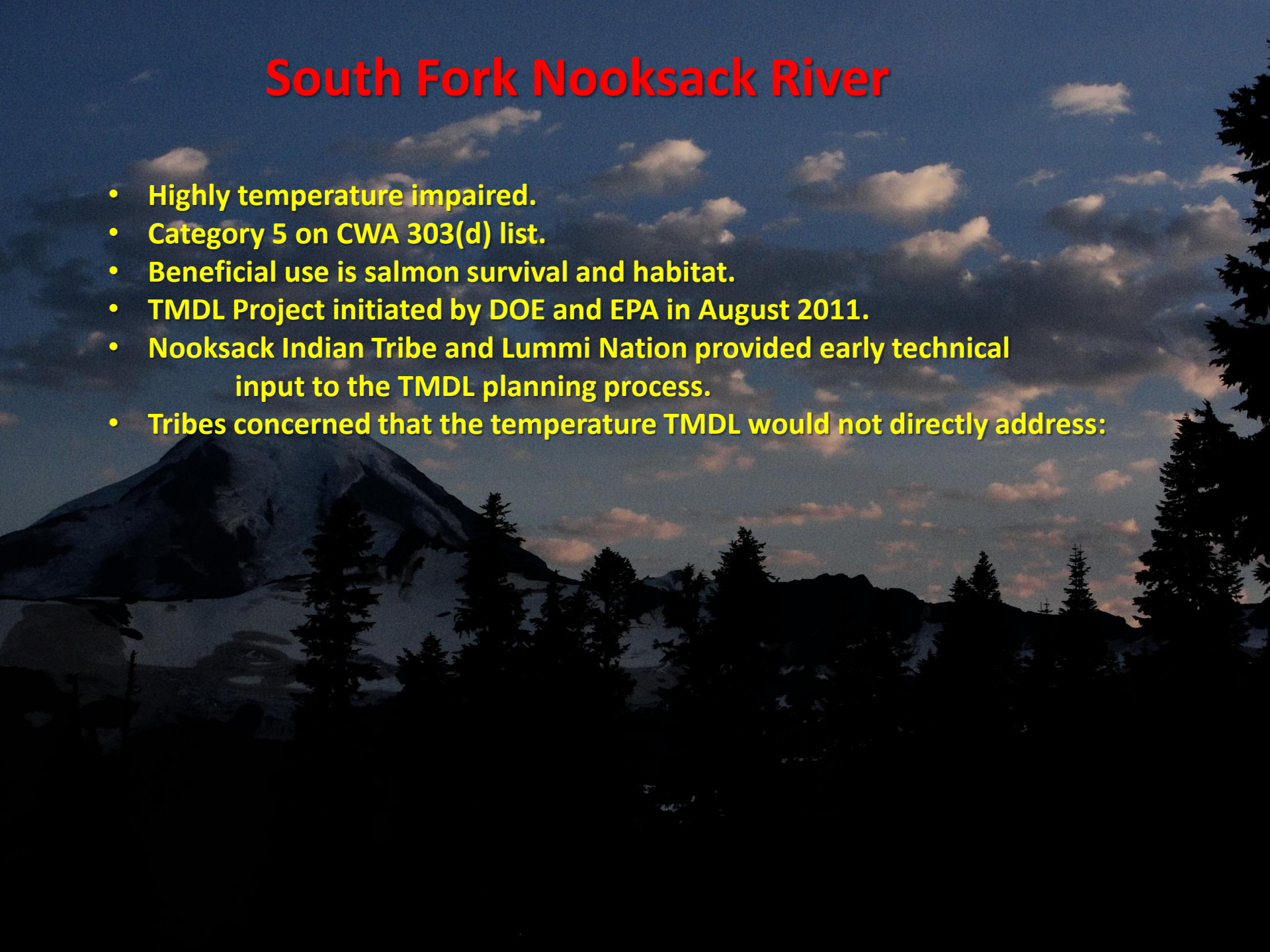
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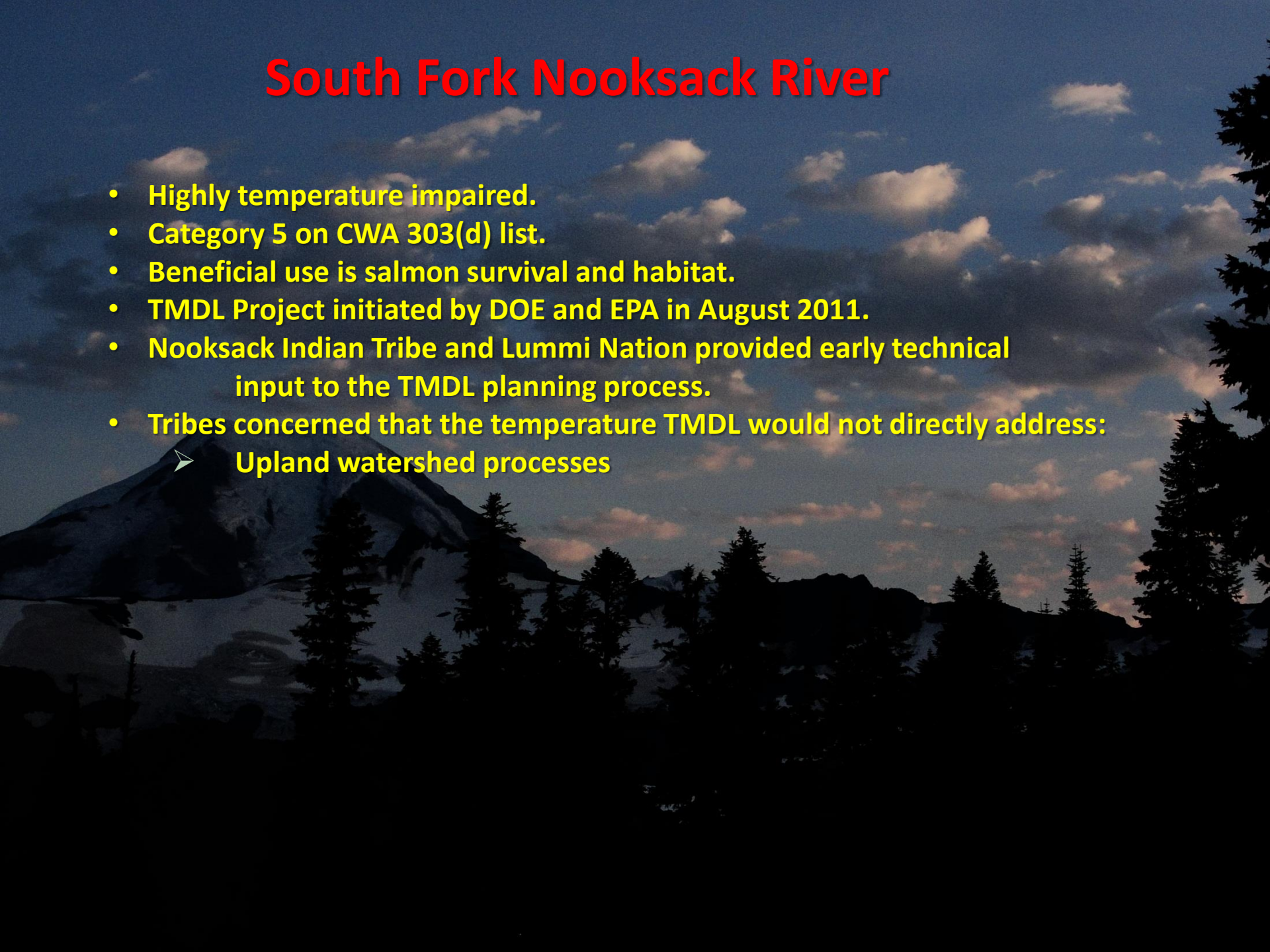
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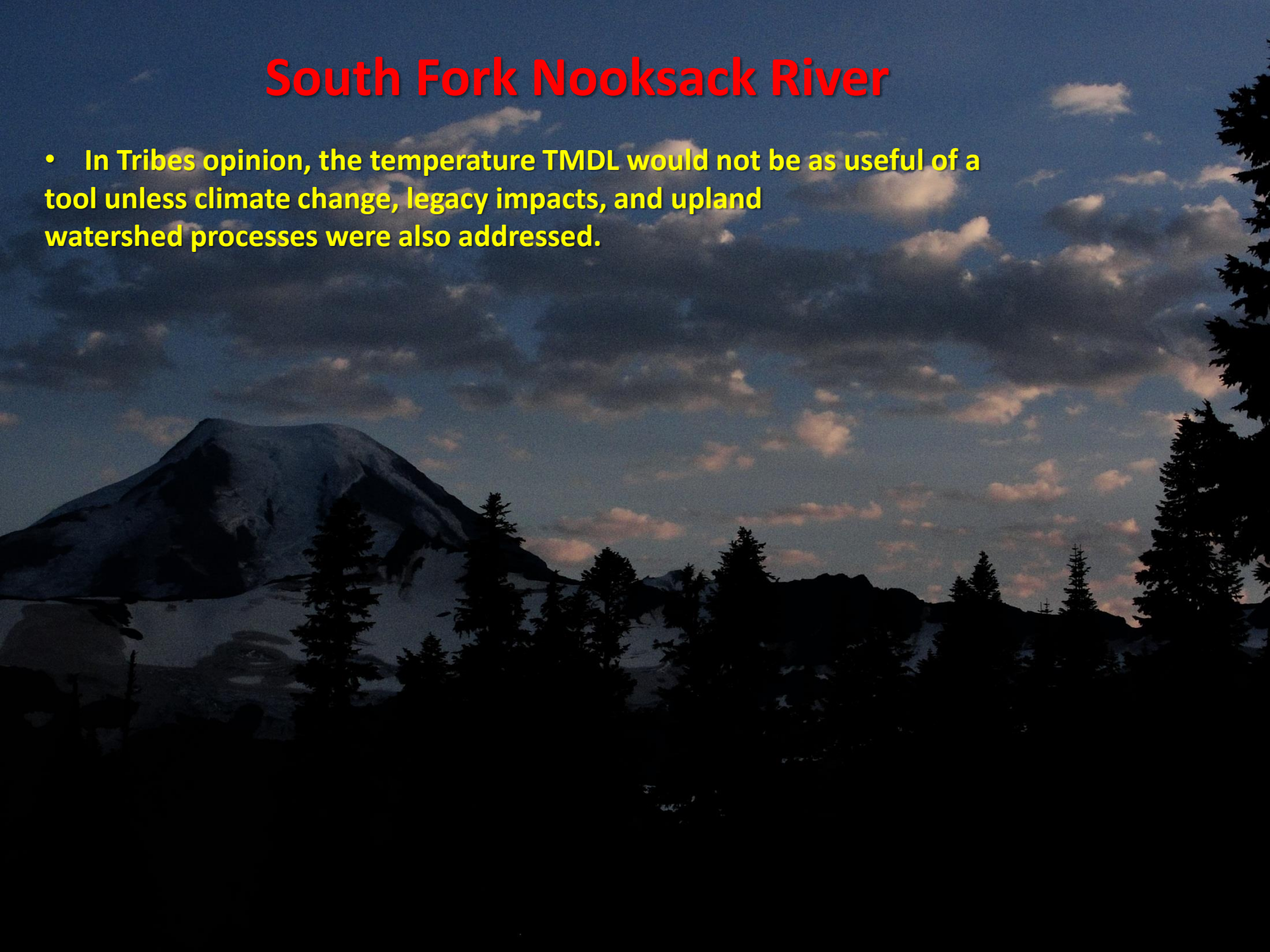
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 - Upland watershed processes
 - Legacy impacts
 - Climate change
 - Reasonable natural conditions

South Fork Nooksack River

- Highly temperature impaired.
- Category 5 on CWA 303(d) list.
- Beneficial use is salmon survival and habitat.
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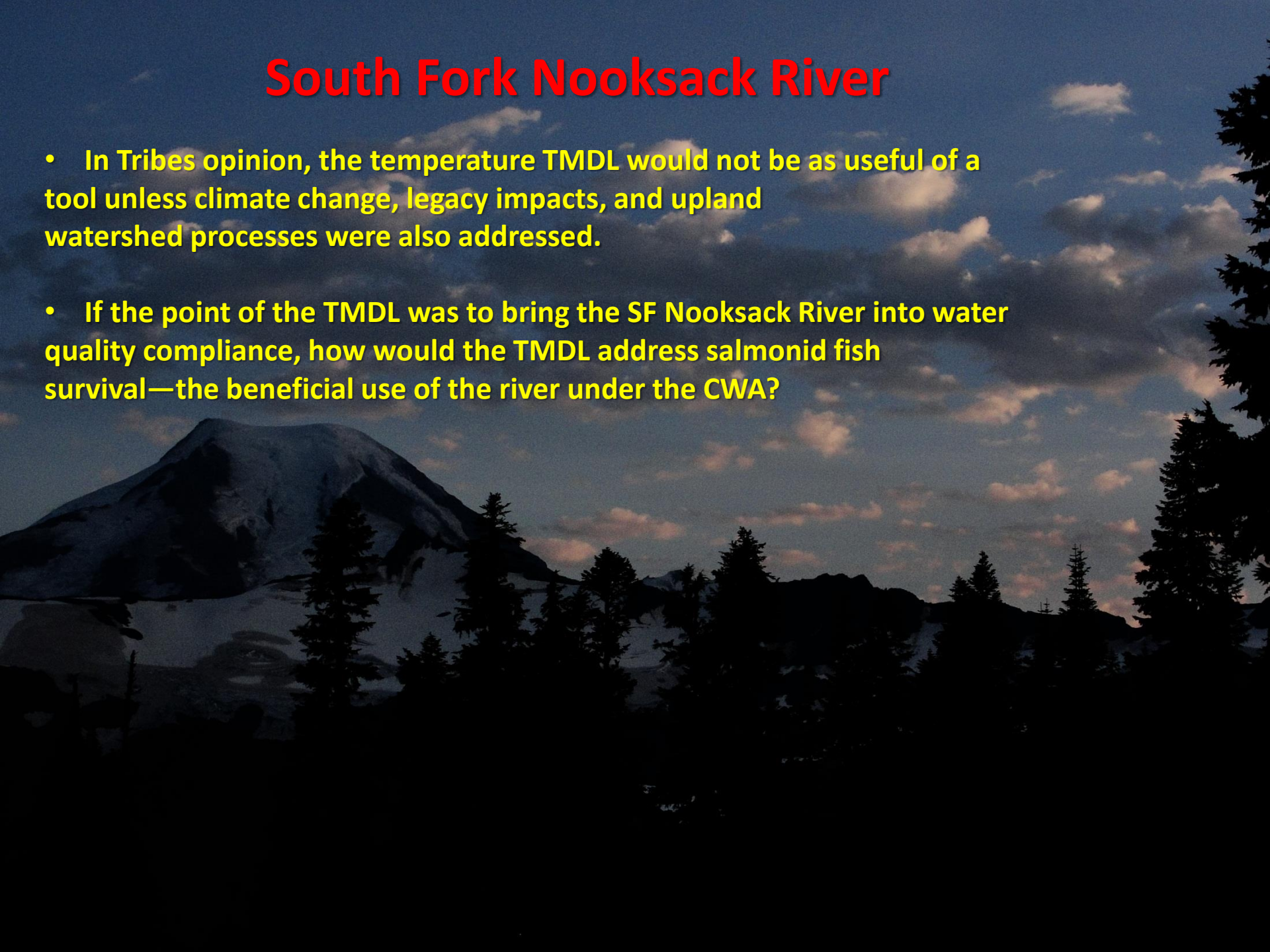
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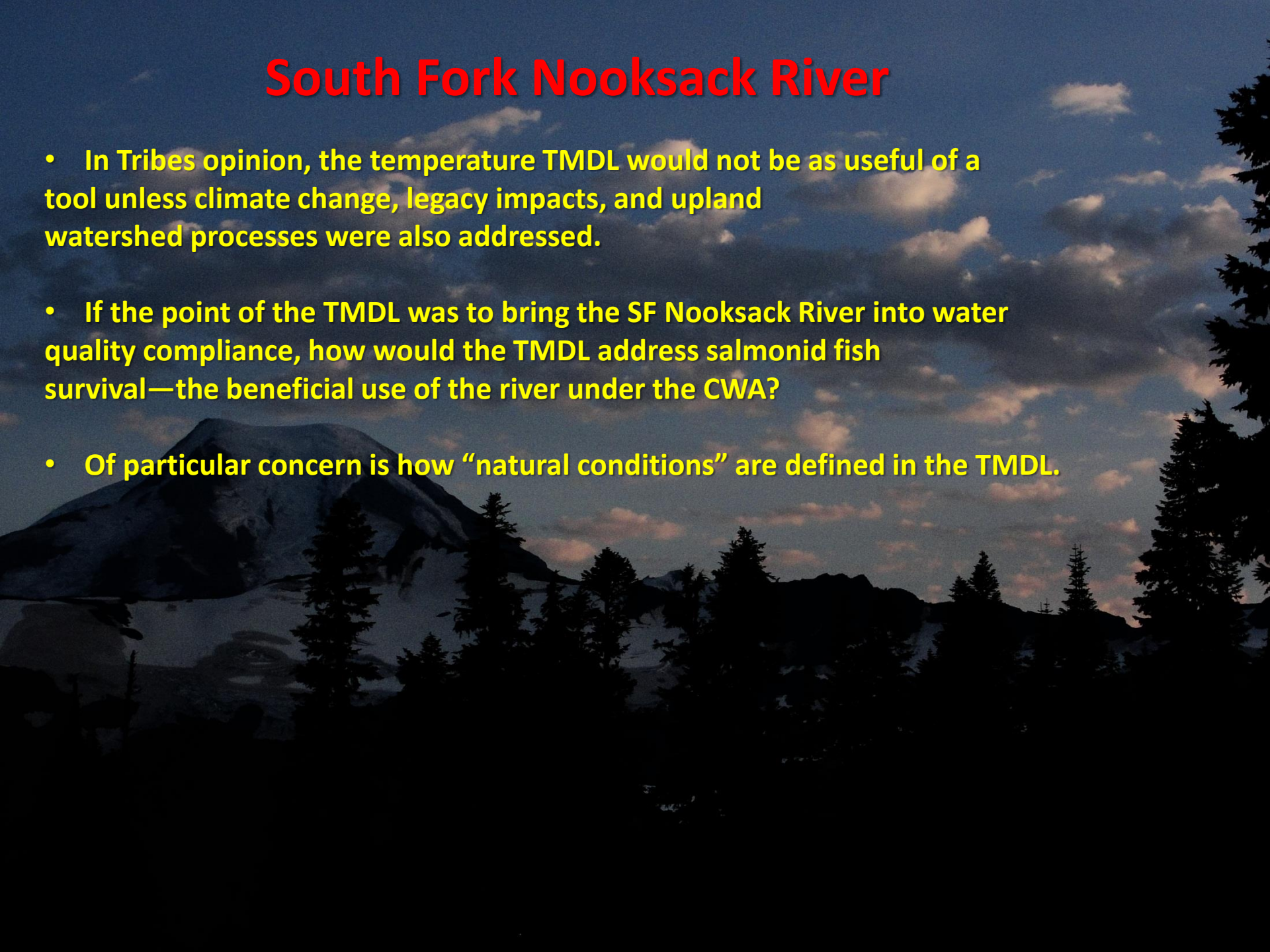
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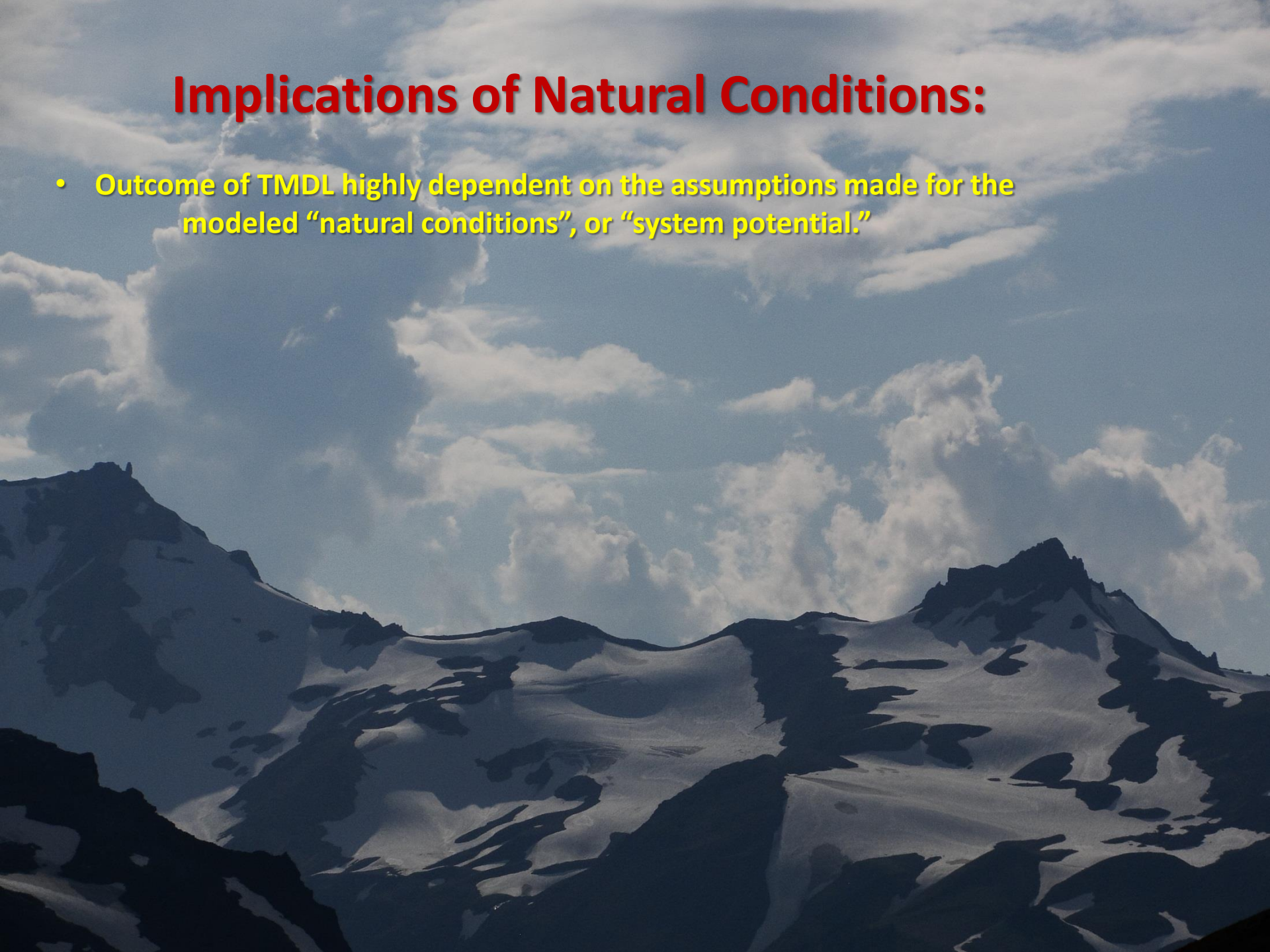
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- Complicated set of criteria based on beneficial use – species, life stage, season, location.

Implications of Natural Conditions:



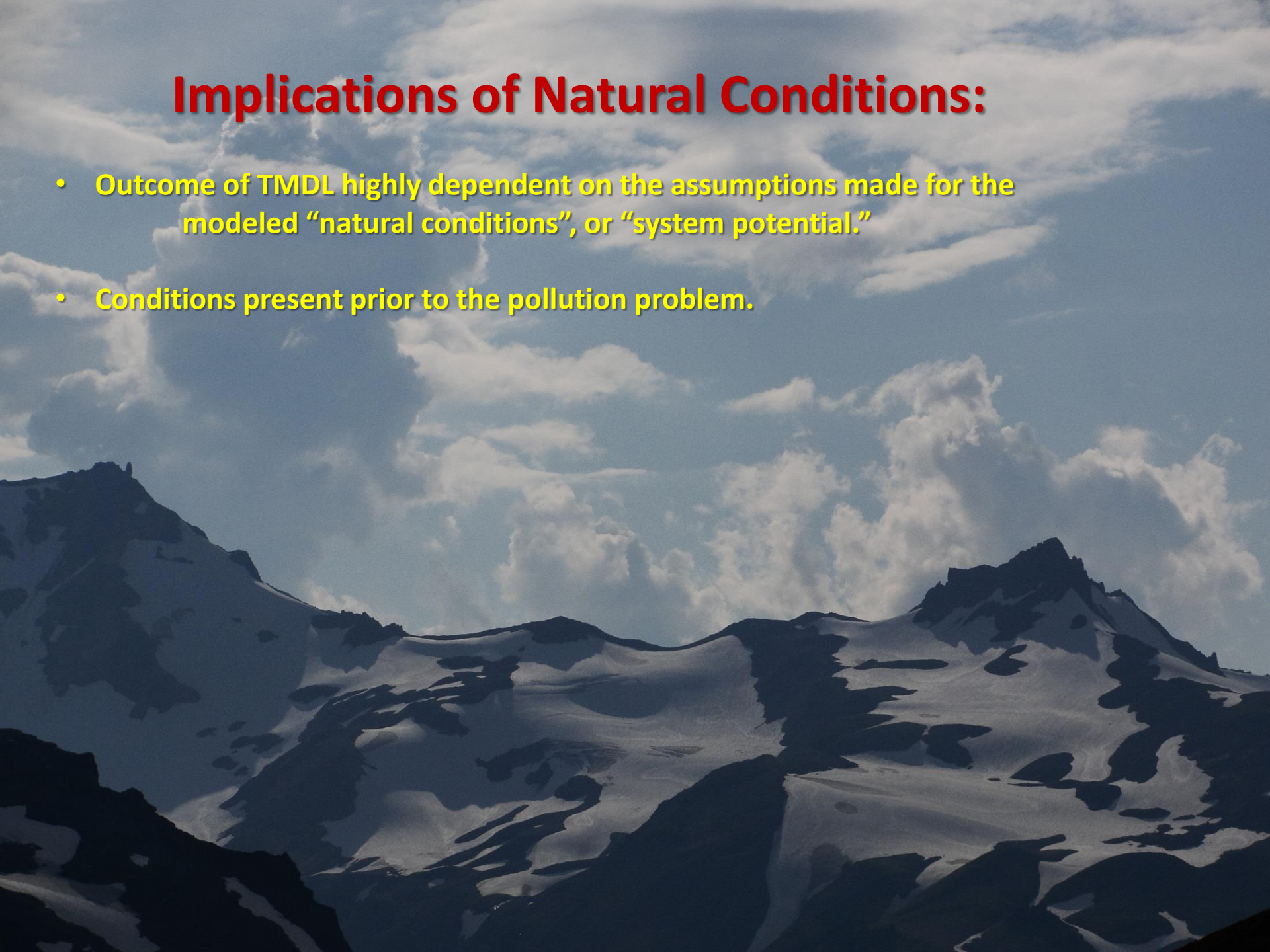
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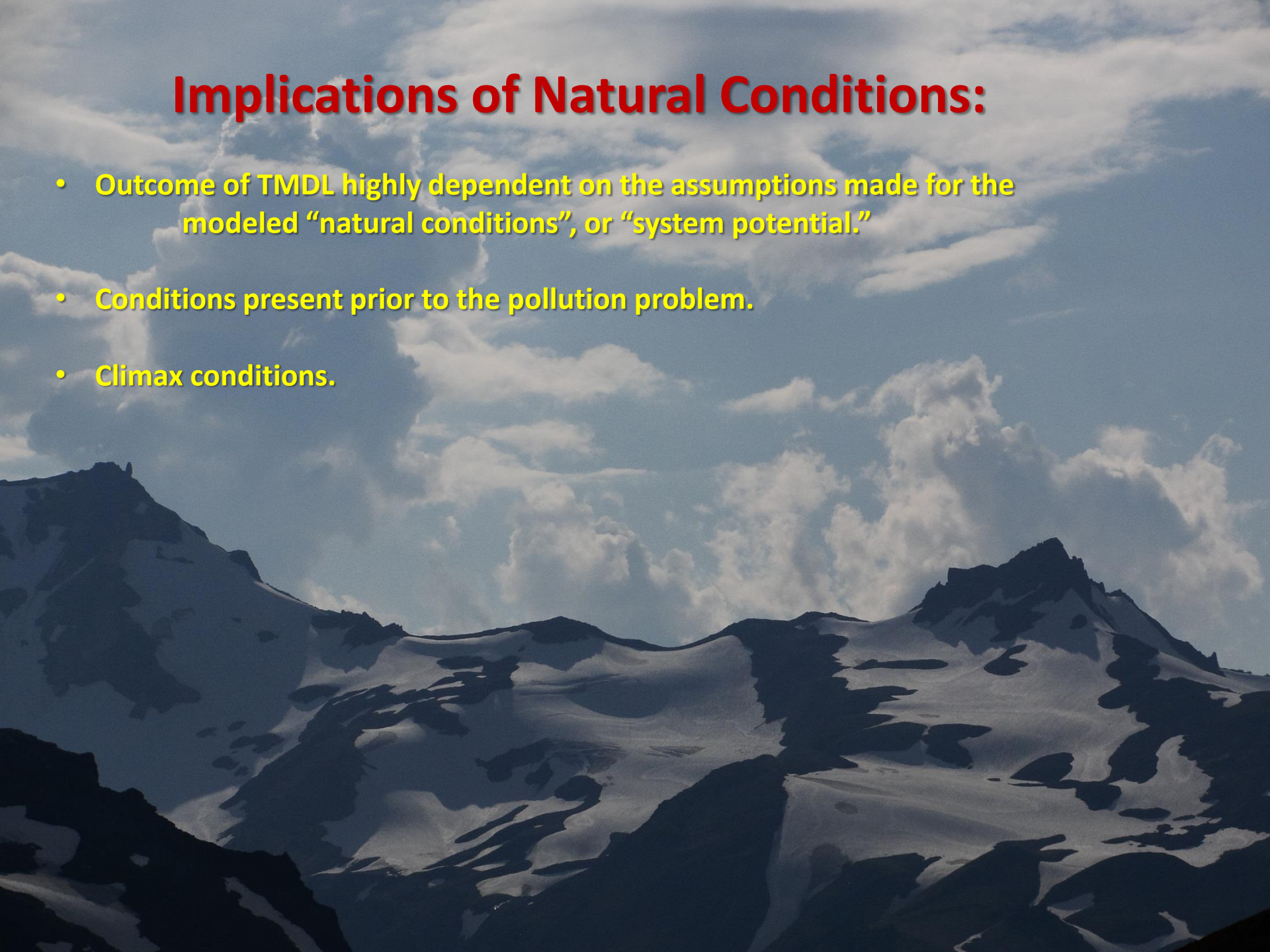
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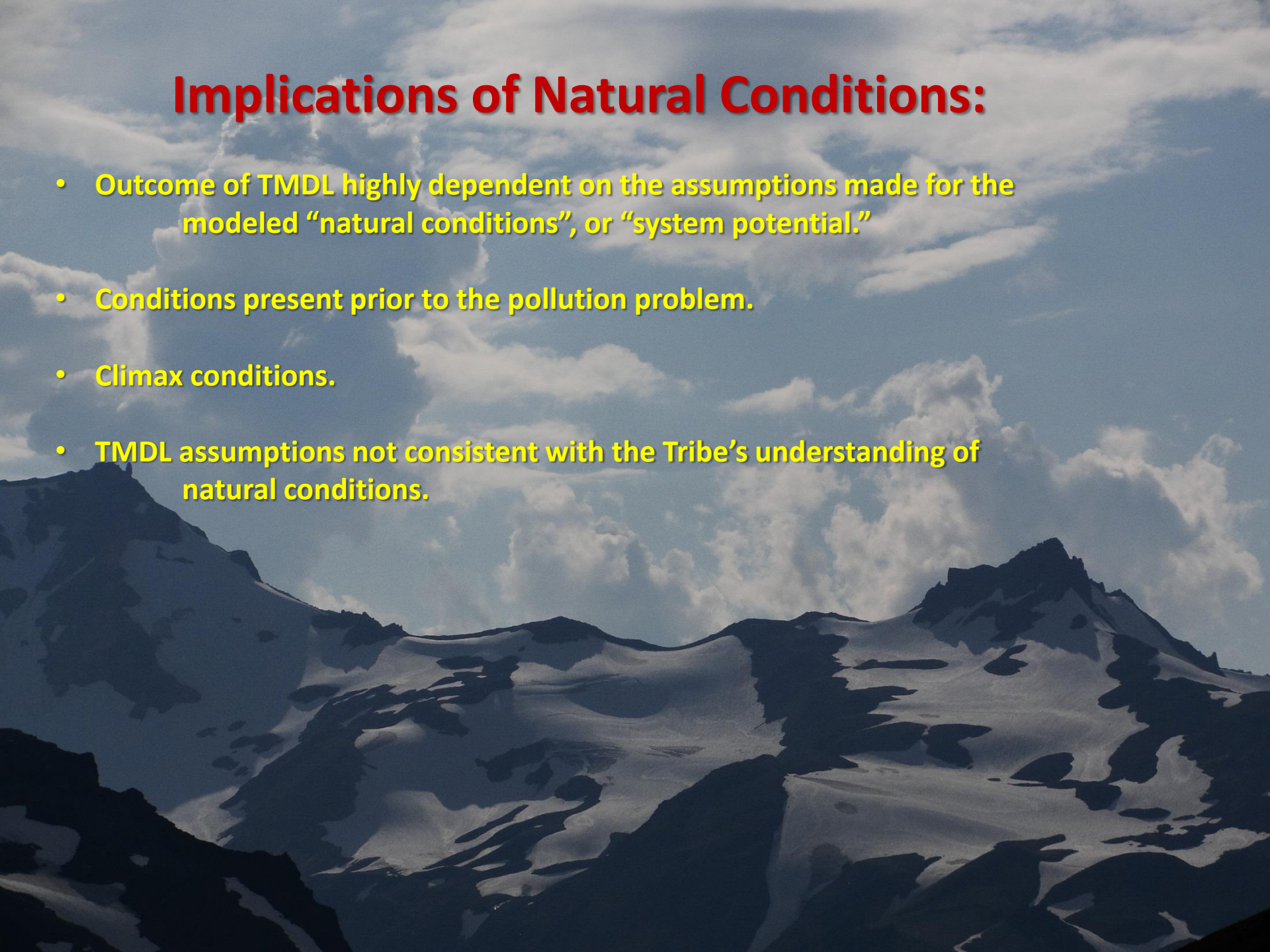
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Implications of Natural Conditions:

- A possible interpretation of this inconsistency is that there is no temperature issue.
- Has huge implications on salmon recovery and restoration planning.



Results of TMDL

Condition	Average Maximum Stream Temperature (deg C)		
	12	16	16
WQ Criteria	Headwaters to RM 28	RM 28 to Confluence	All Reaches
River Reach			
Original Prediction	17.8	19.6	18.7
Cooler Headwaters (20%)	16.9	19.0	18.0
Natural Channel Geometry	17.2	18.9	18.1
Increased Riparian Tree Height and Buffer Width	16.7	18.2	17.5
Enhanced Hyporheic Exchange	17.8	19.3	18.6
Combined Natural Parameters	15.1	16.4	15.8
Percent Change	-15.2%	-16.3%	-15.5%

Climate Change



Climate Change

- What happens with stream temperature with the confounding effects of projected climate change?



Climate Change

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- Worse?



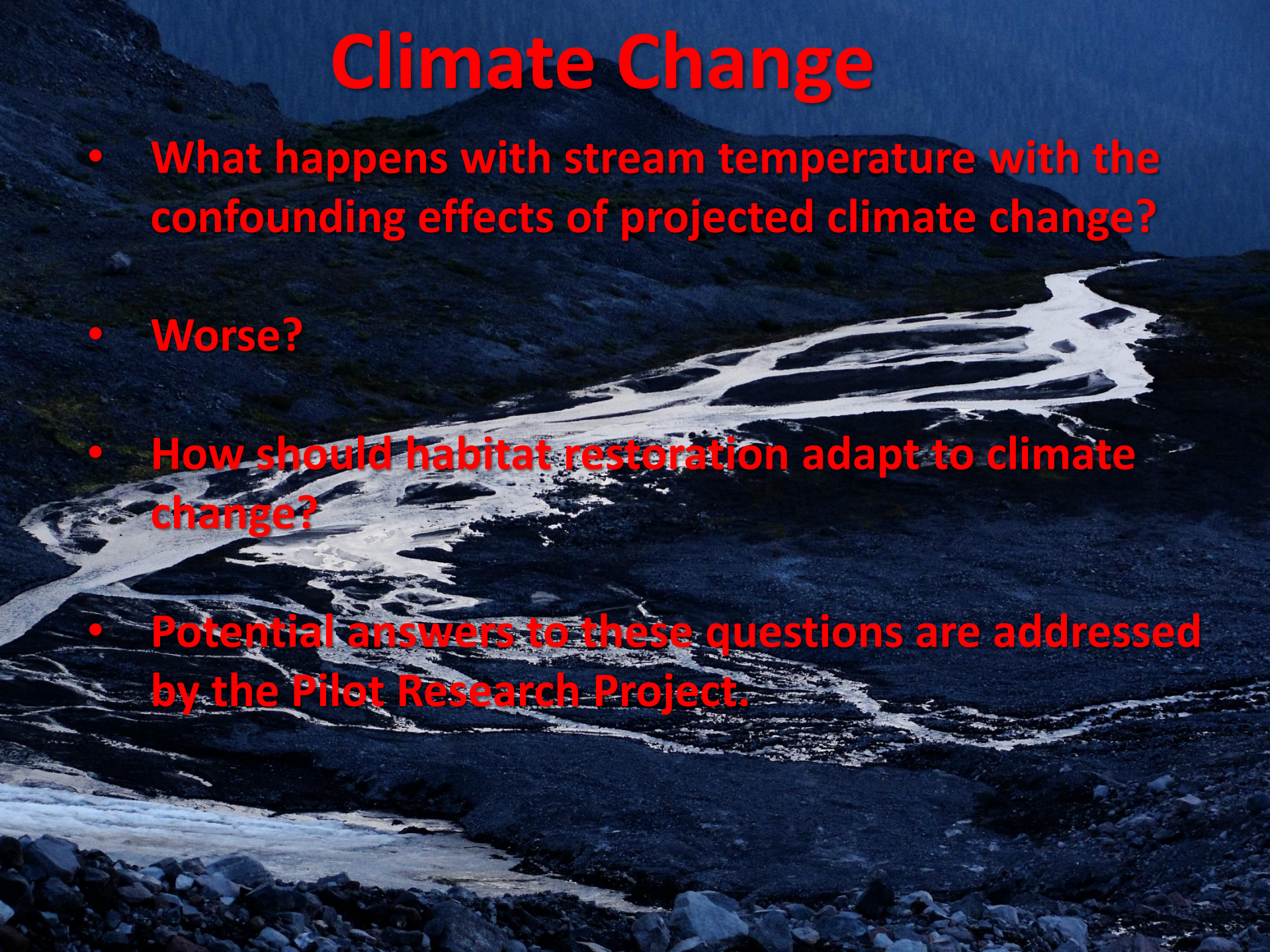
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- How should habitat restoration adapt to climate change?
- Potential answers to these questions are addressed by the Pilot Research Project.

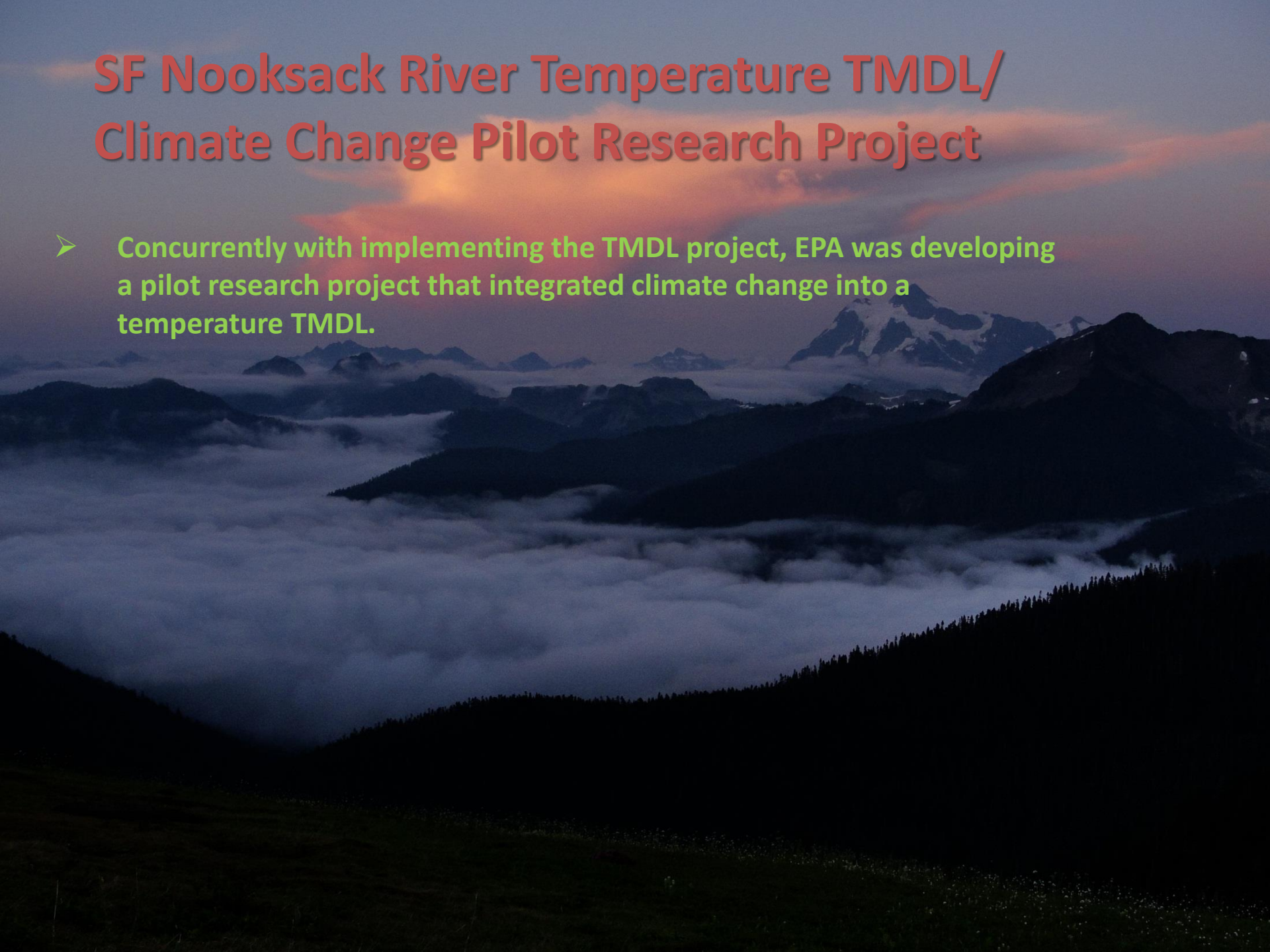


SF Nooksack River Temperature TMDL/ Climate Change Pilot Research Project



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- EPA decided to apply the pilot research project to the SF Nooksack River.
- The pilot research project is designed to support the TMDL project in reducing the impact of high temperatures on salmon.
- But more importantly, support both salmon recovery and CWA compliance by focusing on what salmon habitat restoration actions would be needed to promote salmon survival in the face of climate change at population levels that provide for harvestable surpluses.

Climate Change Pilot Research Project

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 - **Comprehensive analysis of freshwater habitat for ESA salmon restoration in the SFNR under climate change.**
 - **Will result in a prioritized list of climate change adaption strategies that supports salmon restoration in the SFNR under climate change.**

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Qualitative Assessment

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SPRING CHINOOK

River Entry

Upstream Migration/
Holding

Spawning

Intragravel
Development

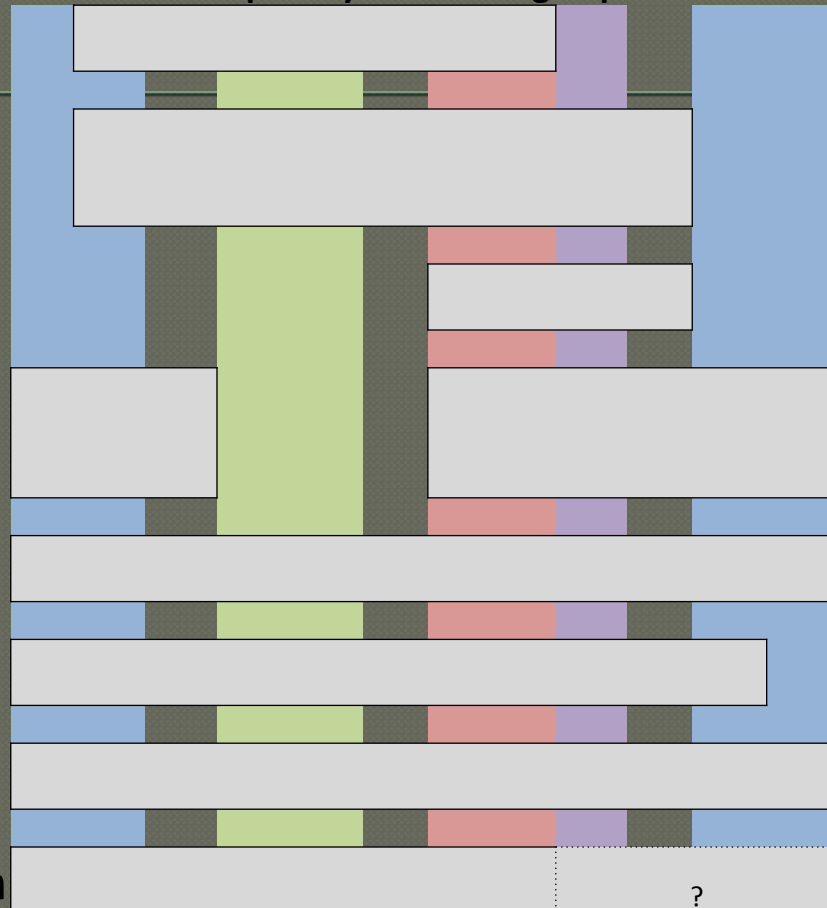
Age-0 rearing

Age-0 outmigration

Age-1+ rearing

Age-1+ outmigration

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



Legend

- Increased Winter Peak Flows
- Loss of Spring Snowmelt Reducing Discharge
- Increased Summer Temperatures
- Decreased Summer Low Flows and Increased Temperatures
- Respective Life Stage Periodicities

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- **Review existing fish habitat restoration tools and plans.**
- **Re-prioritize strategies based on tools that are the most robust in the face of climate change.**

Qualitative Assessment

- **Apply the methods of Beechie et al. (2012) to review and re-prioritize restoration actions.**

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Beechie et al. (2012)

- **“RESTORING SALMON HABITAT FOR A CHANGING CLIMATE”**
- **T. BEECHIE, H. IMAKI, J. GREENE, A. WADE, H. WU, G. PESS, P. RONI, J. KIMBALL, J. STANFORD, P. KIFFNEY AND N. MANTUA**

Do climate change predictions alter restoration plans?

- What habitat factors limit salmon recovery?
- What are local predicted climate change effects?
- Do proposed restoration actions reduce climate change effects?
- Do proposed restoration actions increase habitat diversity or ecosystem resilience?

Ability of Restoration Actions To Ameliorate Climate Change Effects

Expected climate change effect	Construct instream habitat	Reduce sediment supply	Restore riparian functions	Restore stream flow	Restore incised channel	Floodplain connectivity	Longitudinal connectivity
Increased temperature	N	N	Y	Y	Y	Y	Y
Decreased low flow	N	N	Y/N	Y	Y	N	Y
Increased peak flow	N	N	N	N	Y	Y	N
Reduced diversity	N	N	N	Y/N	Y	Y	Y

Y Positive Effect

N No Effect

Y/N Context-dependent Effect

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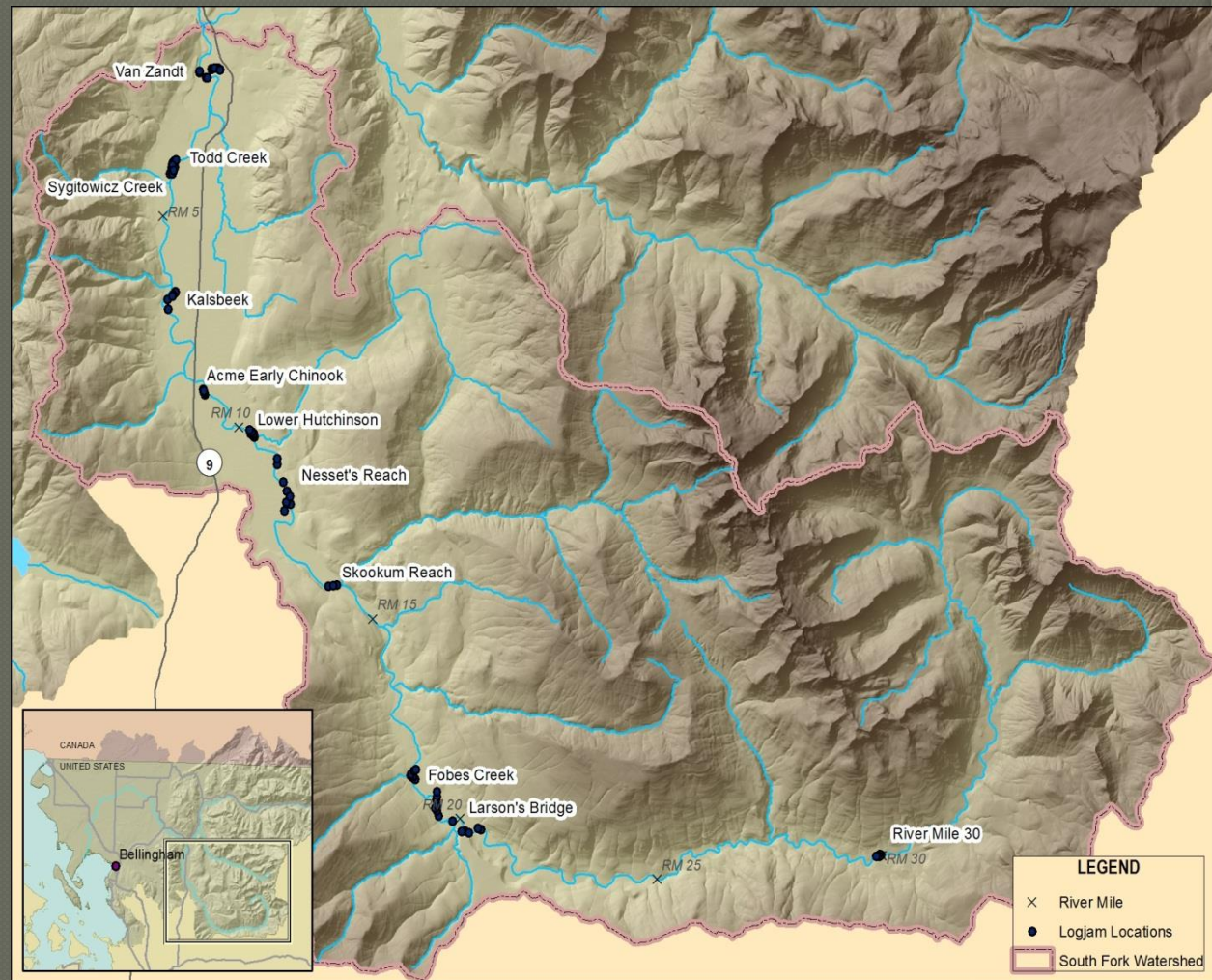
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In addition to current in-stream restoration actions such as log jams.

Logjam Projects in the South Fork Nooksack

Project Name	Structures Monitored	Year Completed
Van Zandt	15	2010
Todd Creek	8	2008
Sygitowicz Cr	7	2010
Kalsbeek	7	2007
Acme Chinook	5	2010
Low Hutchinson	6	2006
Nesset Reach	8	2008
Skookum	3	2010
Fobes Creek	14	2010
Larson's Bridge	6	2001
River Mile 30	4	2007







Fobes Cr. project

WRIA 1 Climate Change Workshop

Source: Lummi Natural Resources
Coe: Current SF Strategies

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- **Provides fish with a “bridge” to when more effective restoration strategies can be implemented.**

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- **Pilot research project implemented that addresses climate change, quantitatively and qualitatively.**
- **Quantitative analysis concludes that stream temperature will get worse for fish in the face of climate change.**

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- Get involved – you can have significant influence on how regulatory programs are implemented to protect natural resources.

THANK YOU!



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