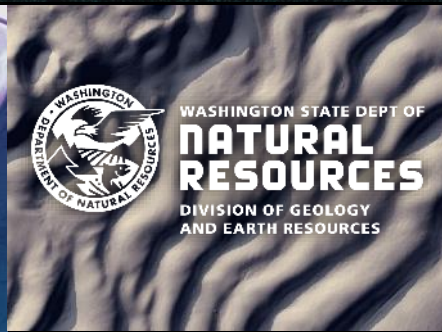
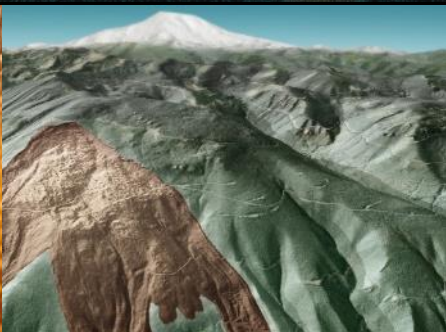


REVEALING WASHINGTON'S HIDDEN LANDFORMS WITH LIDAR (AND OTHER ELEVATION DATA)

DANIEL COE, WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES

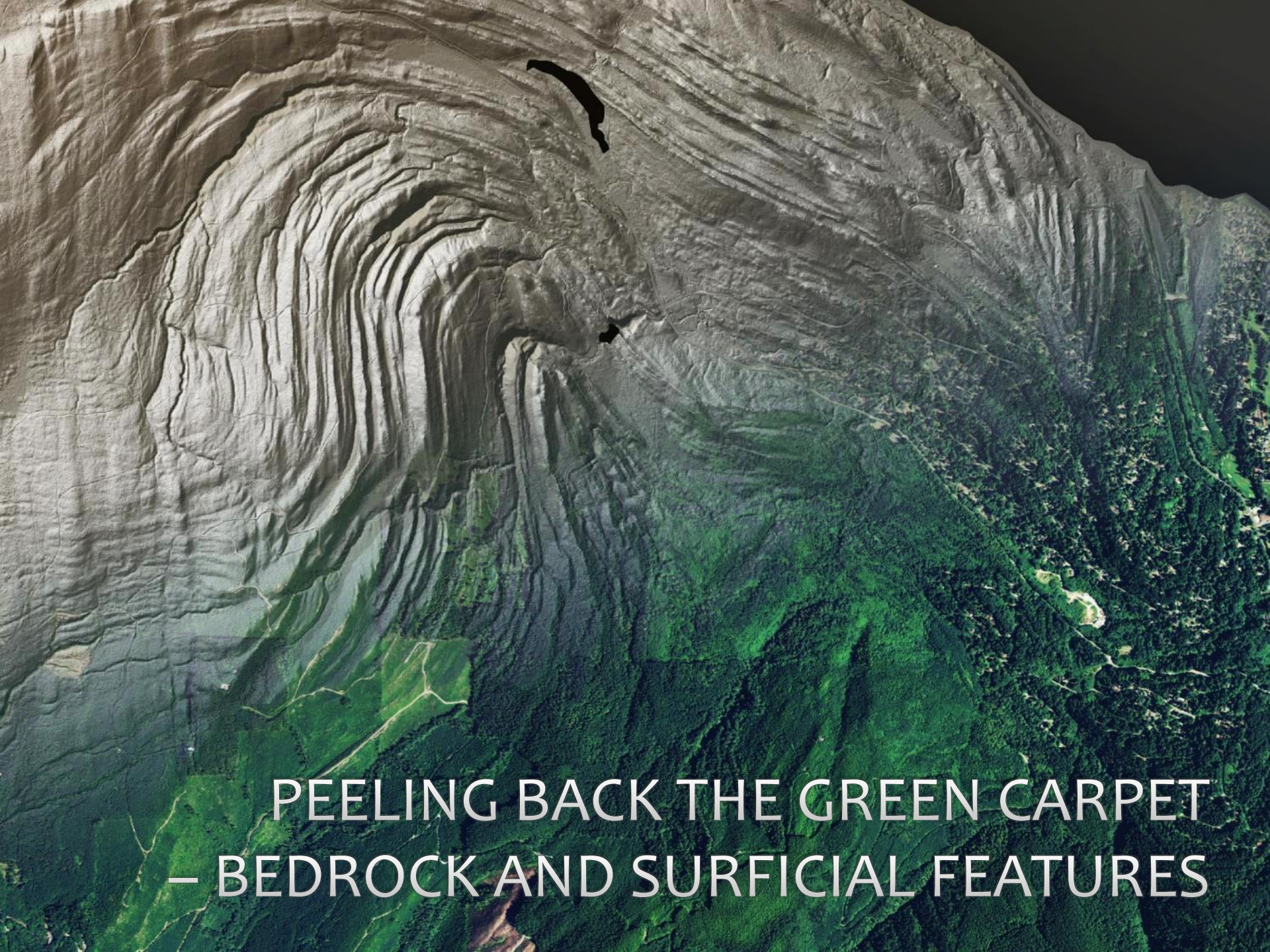


CARTOGRAPHY AND LIDAR

- LIDAR = LIDAR-DERIVED ELEVATION MODELS (MOSTLY BARE EARTH)
- CARTOGRAPHER'S GOAL - TO CREATE SIMPLIFIED VERSIONS OF REALITY
- WITH LIDAR, DETAILS ARE ESSENTIAL
- SIMPLIFICATION WHILE RETAINING GREAT DETAIL IS CHALLENGING
- FOCUS ON ONE OR TWO VARIABLES – ELEVATION, TOPOGRAPHY
- CONTRAST IS KEY



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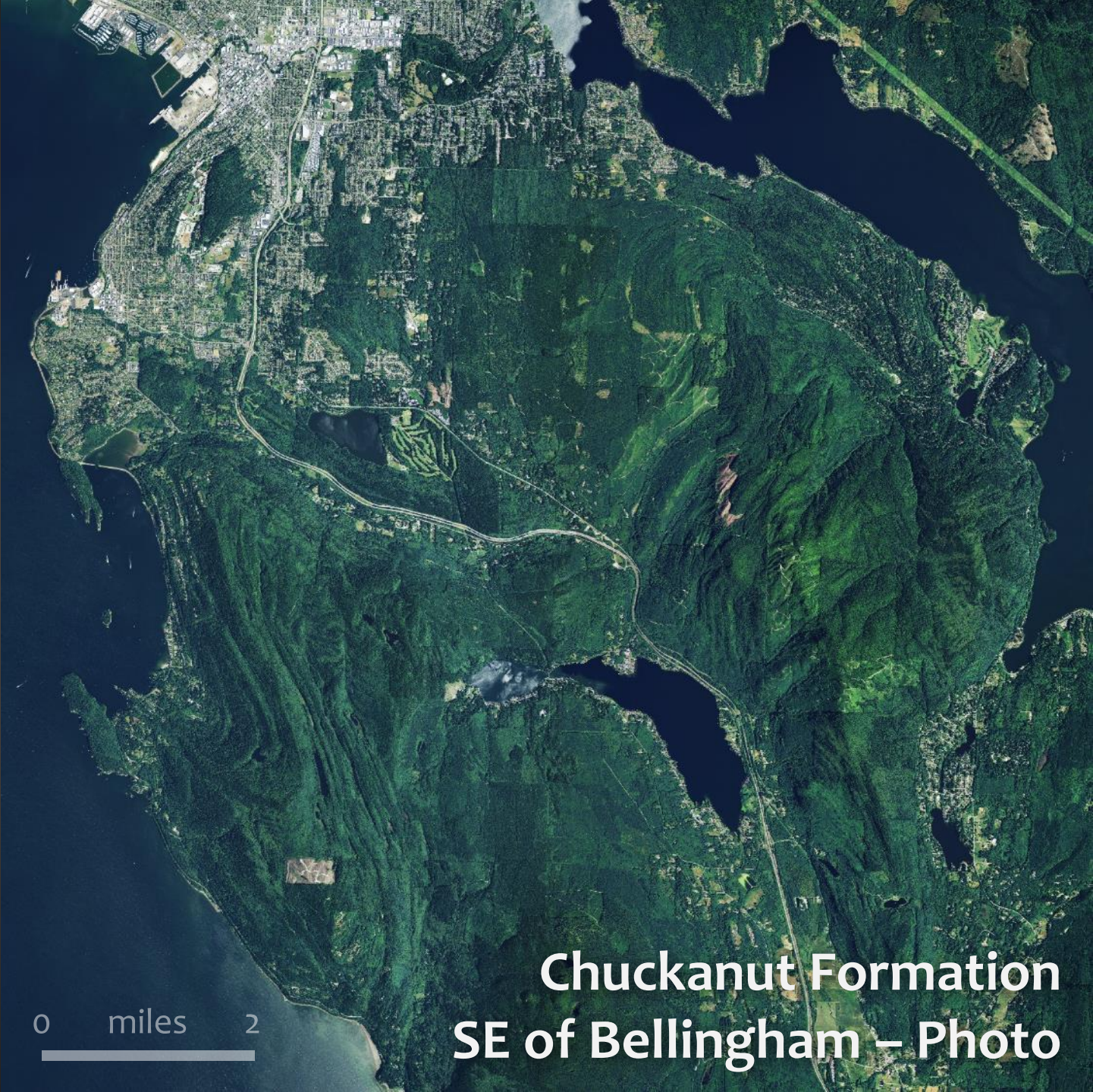
PEELING BACK THE GREEN CARPET
- BEDROCK AND SURFICIAL FEATURES

BEDROCK AND SURFICIAL FEATURES

- GEOLOGIC MAPPING
- FAULTS AND FOLDS
- GLACIAL FEATURES

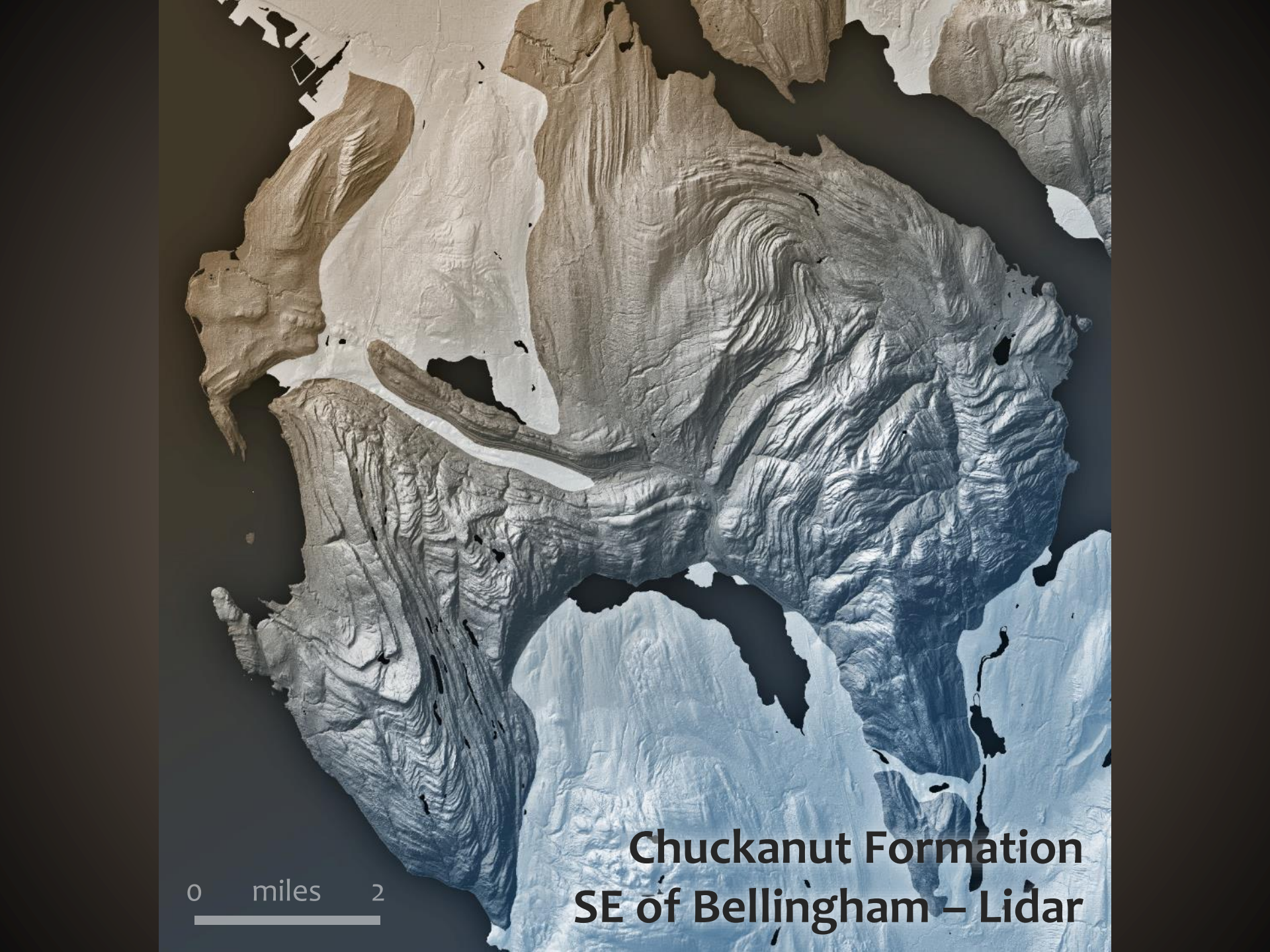


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0 miles 2

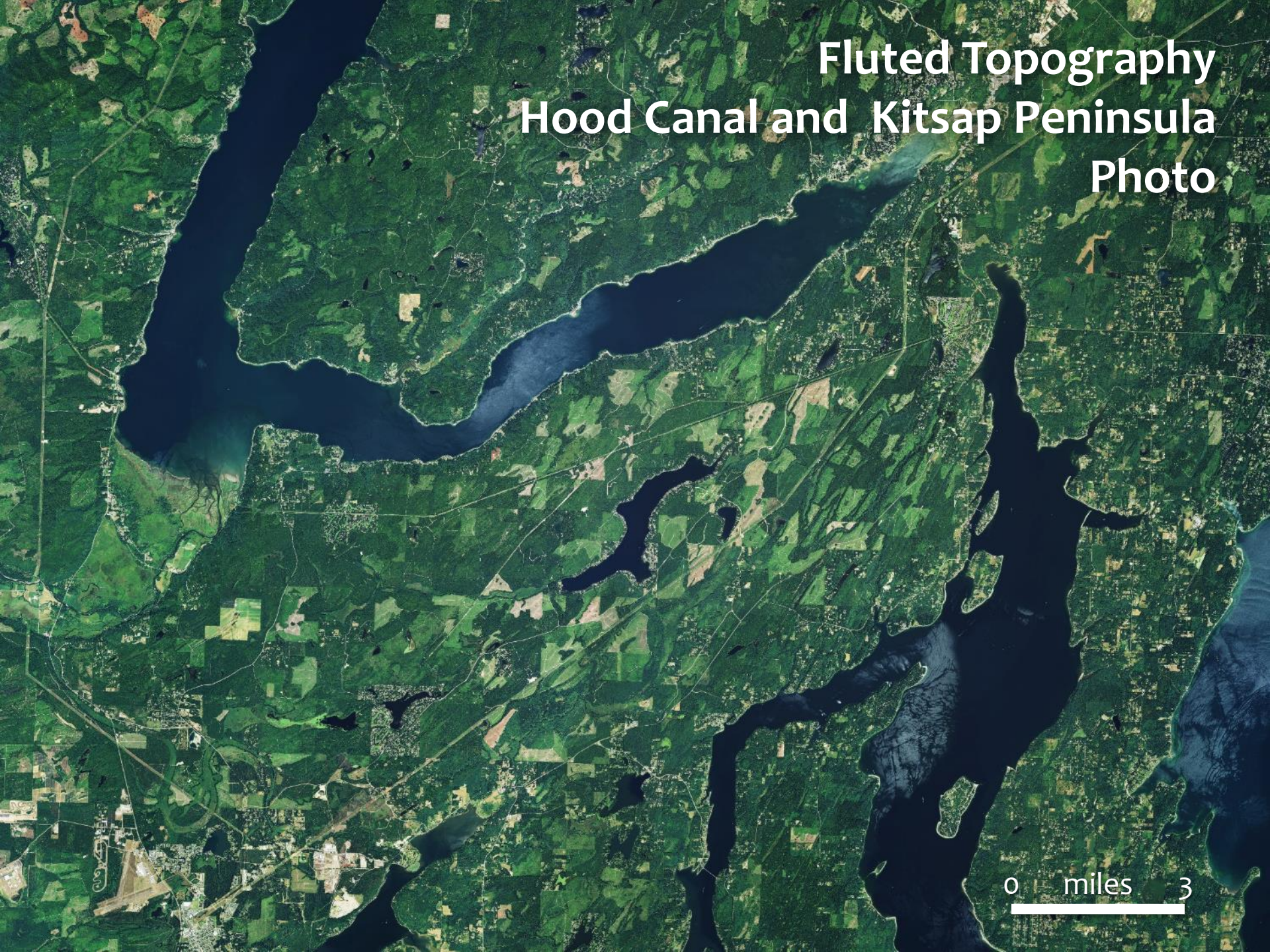
**Chuckanut Formation
SE of Bellingham – Photo**



0 miles 2

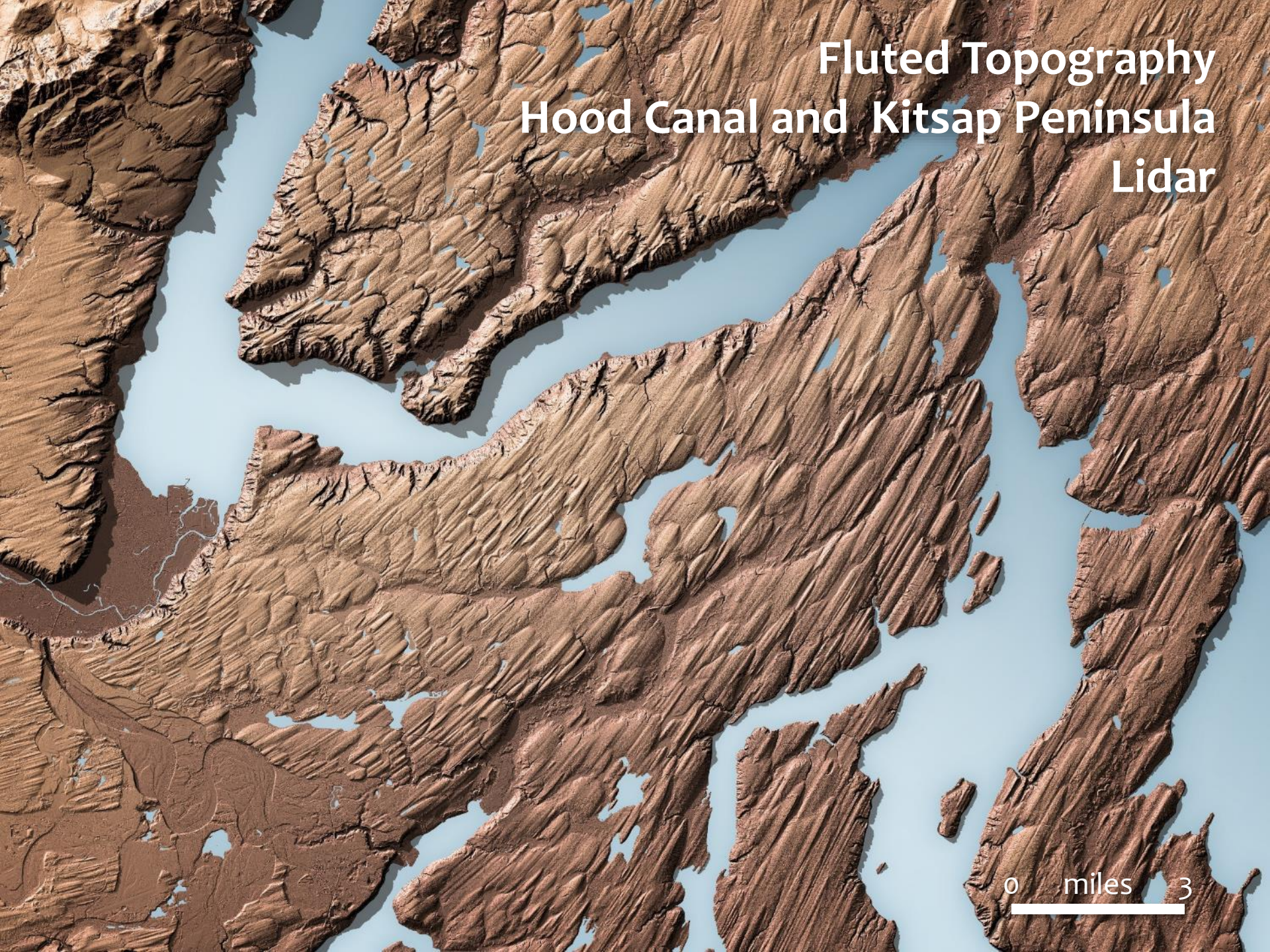
**Chuckanut Formation
SE of Bellingham – Lidar**

Fluted Topography Hood Canal and Kitsap Peninsula Photo



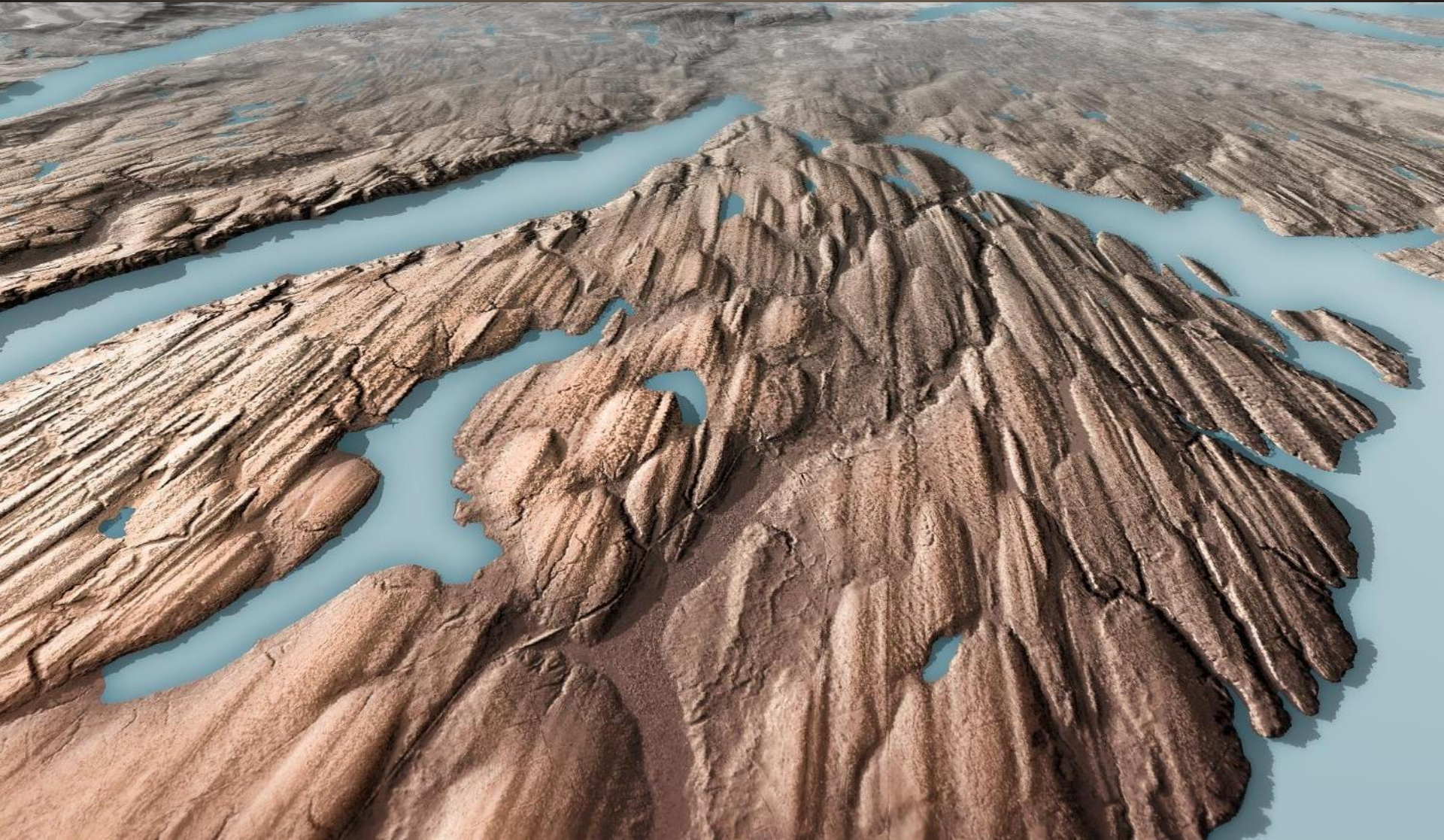
0 miles 3

Fluted Topography Hood Canal and Kitsap Peninsula Lidar



0 miles 3

Fluted Topography Hood Canal and Kitsap Peninsula – Lidar



A 3D topographic map of a mountainous region. The terrain is color-coded by elevation, with higher elevations in shades of brown and orange, and lower elevations in shades of green and grey. A prominent blue river winds through the lower elevations. In the background, a large, snow-capped mountain peak rises against a clear blue sky. A semi-transparent dark grey rectangular box is overlaid on the upper portion of the map, containing white text.

GRAVITY IS DANGEROUS
– VISUALIZING LANDSLIDES

VISUALIZING LANDSLIDES

- GOODBYE TREES
- VAST IMPROVEMENT FROM 10 METER DEM
- LIDAR ALLOWS FOR FASTER AND MORE ACCURATE MAPPING



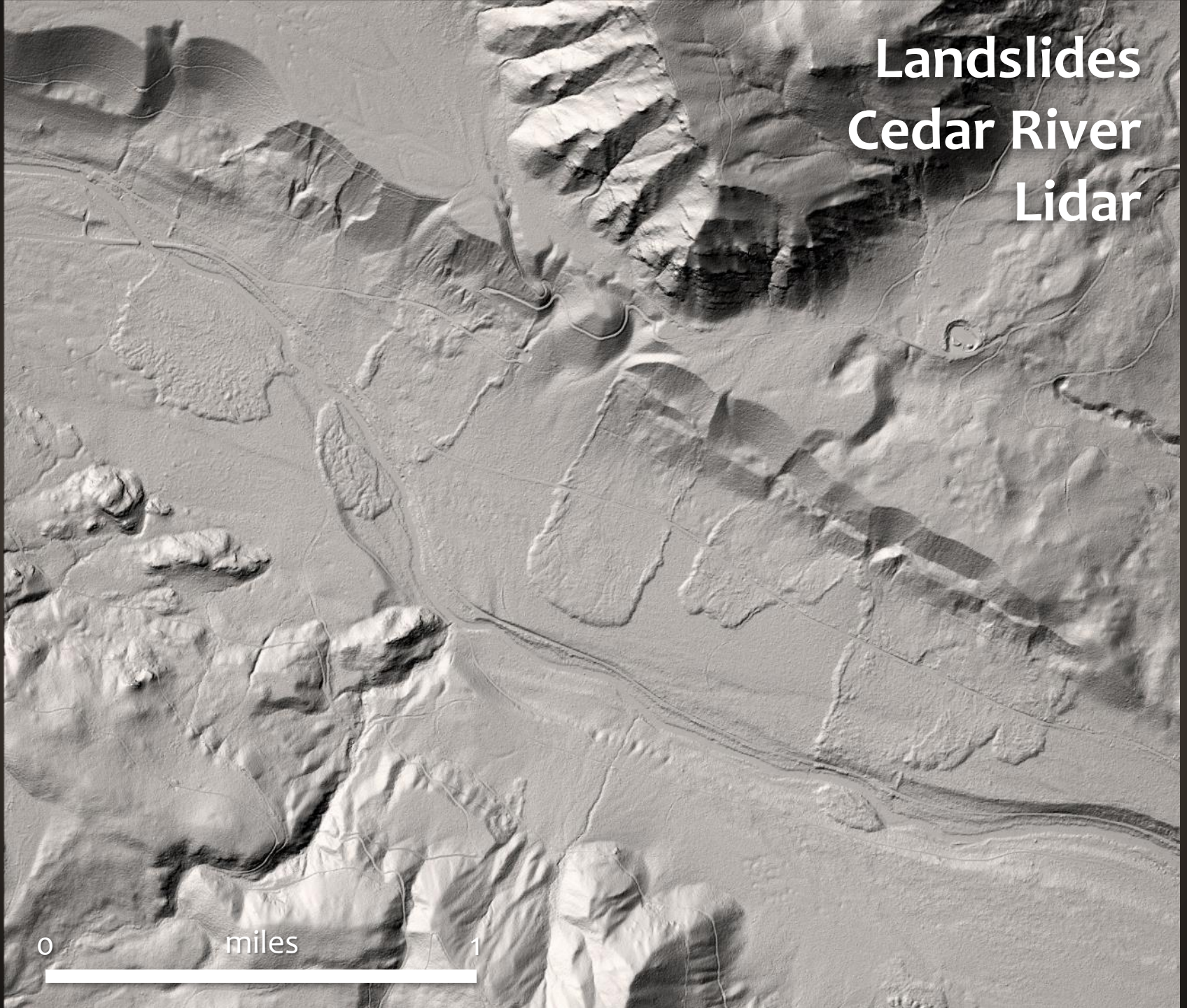
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**Landslides
Cedar River
Photo**



0 miles 1

**Landslides
Cedar River
Lidar**



0 miles 1

Landslides Cedar River Lidar



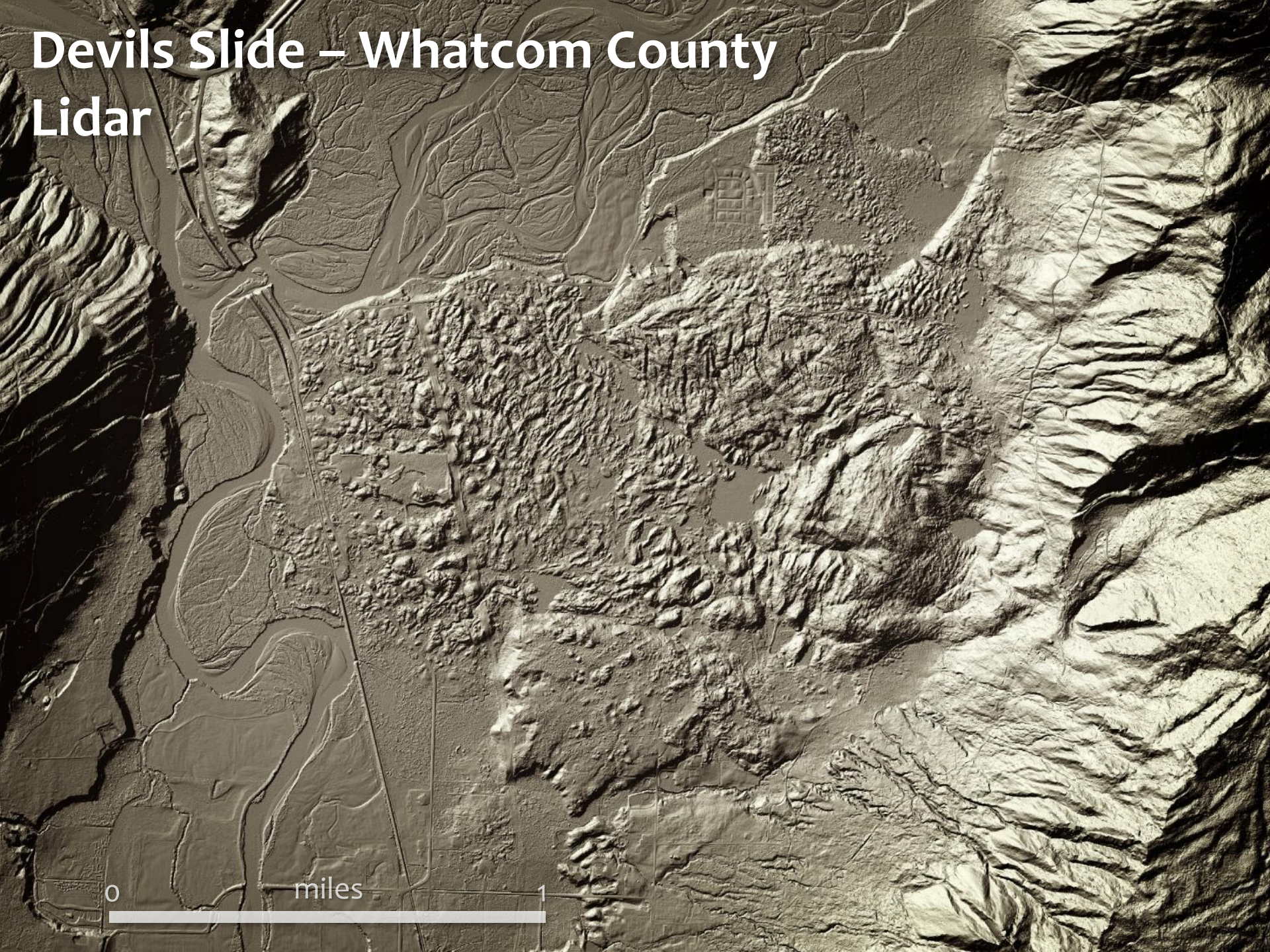
Devils Slide – Whatcom County

10m Shaded Relief

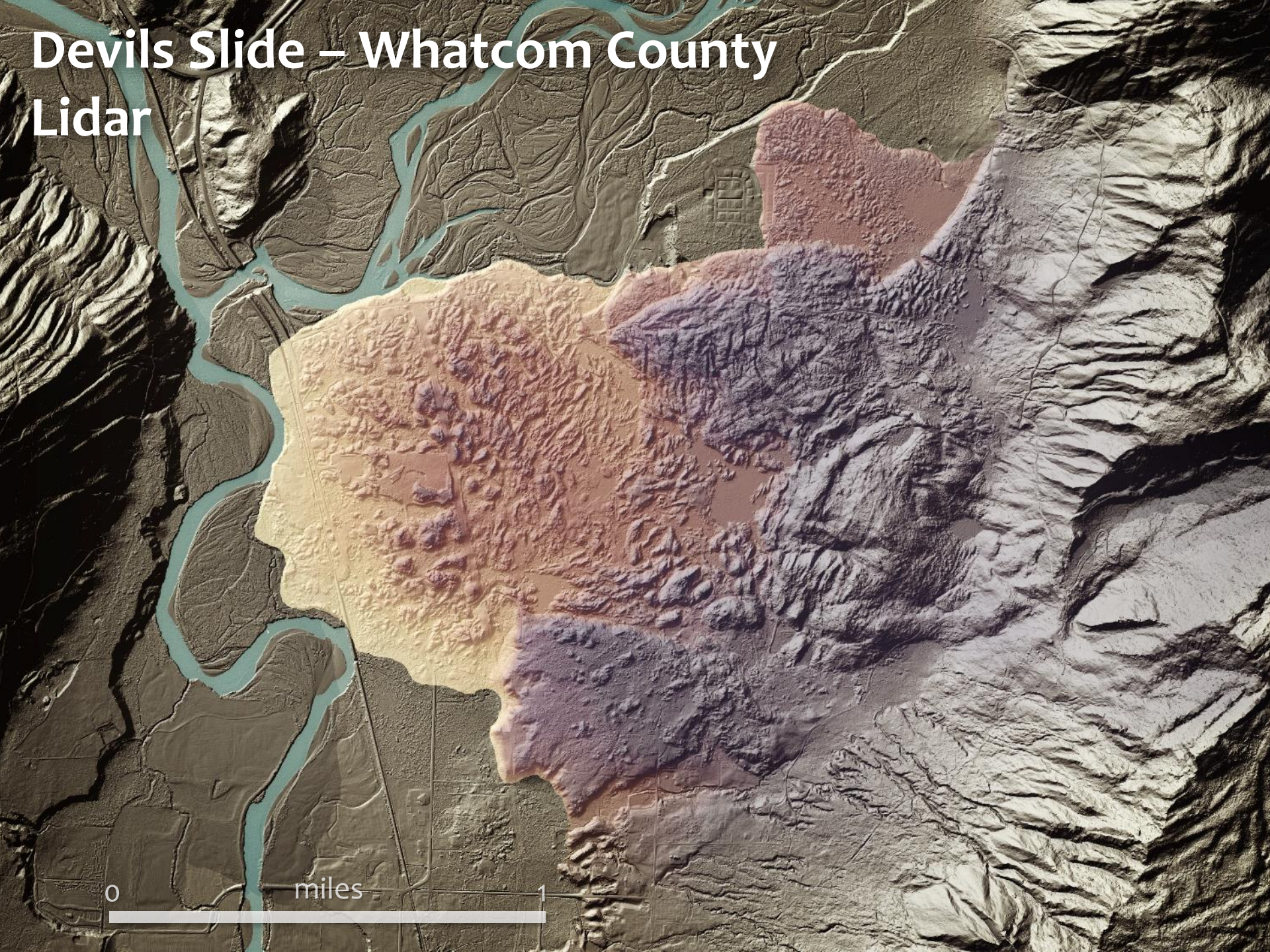


0 miles 1

Devils Slide – Whatcom County Lidar



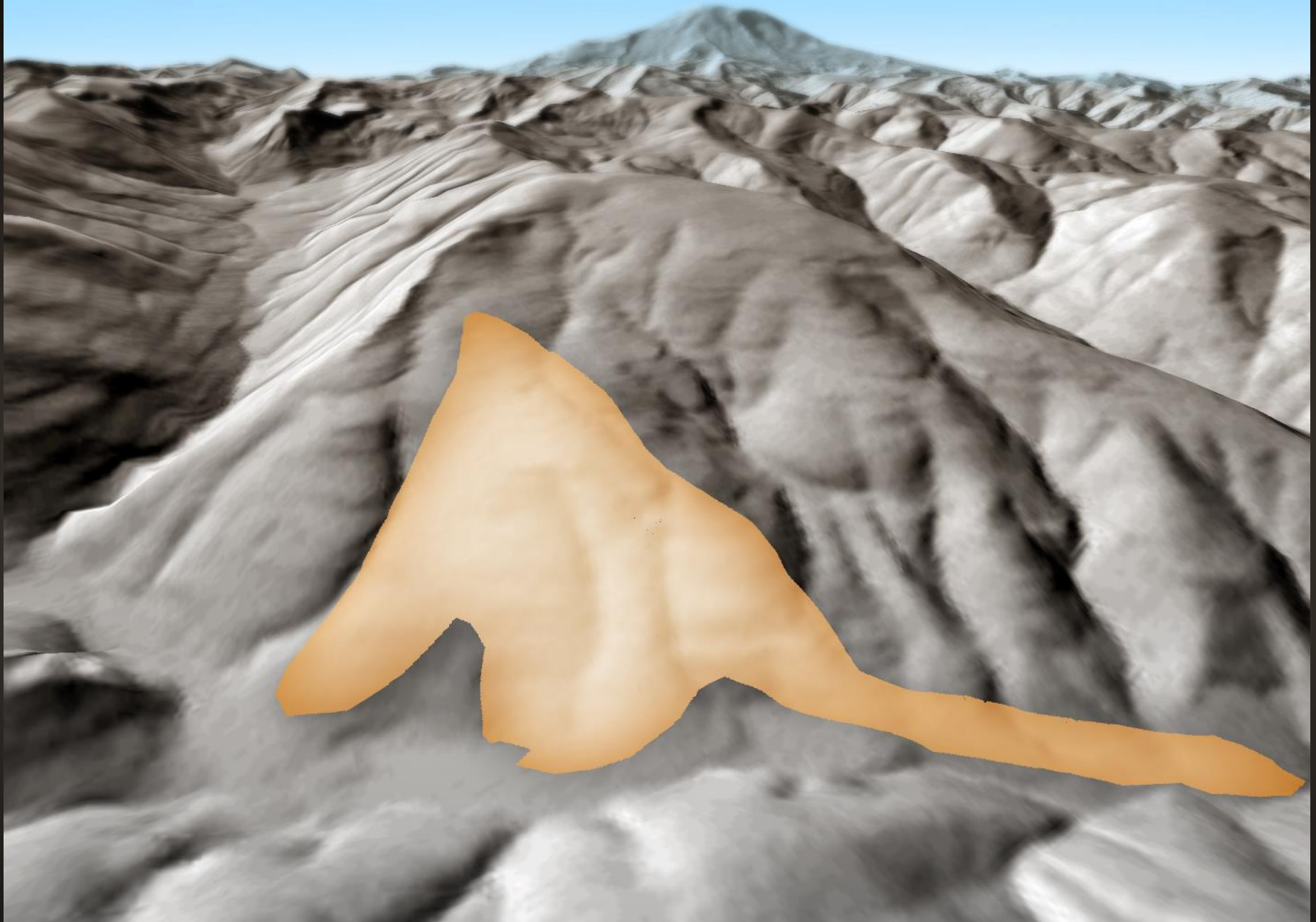
Devils Slide – Whatcom County Lidar



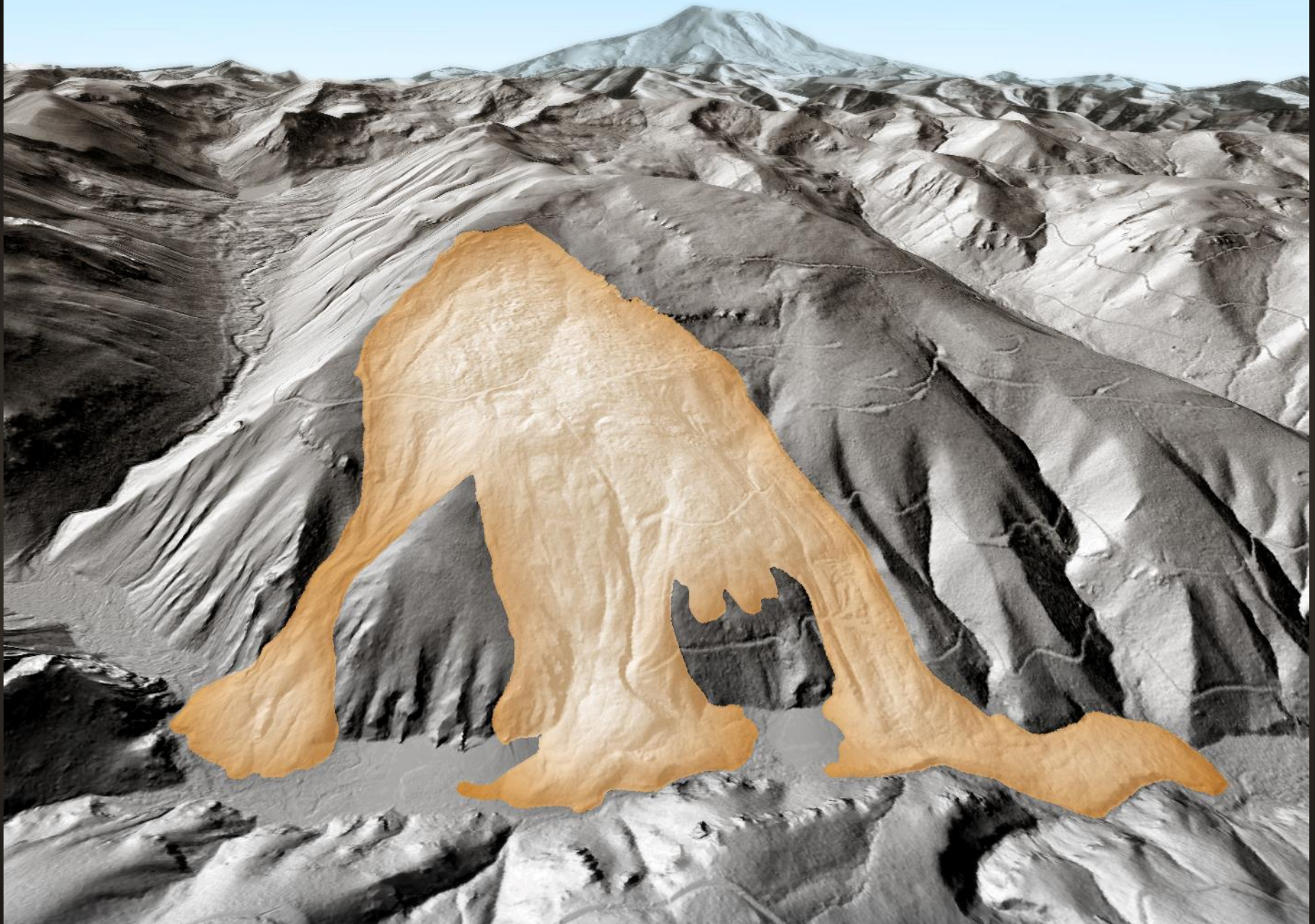
0 miles 1



Greenwater Lakes landslide, NE Pierce County – Photo



Greenwater Lakes landslide, 1:100,000-scale geologic unit



Greenwater Lakes landslide, NE Pierce County – new mapping

Greenwater Lakes landslide
NE Pierce County
Lidar

1.2 miles





LIQUID SCULPTURE
– RIVERS AND TIDES

RIVERS AND TIDES

- DEMs VS RELATIVE ELEVATION MODELS (REMs)
- HISTORICAL CHANNELS
- CHANNEL MIGRATION
- ROADS/LEVEES/INFRASTRUCTURE
- HABITAT



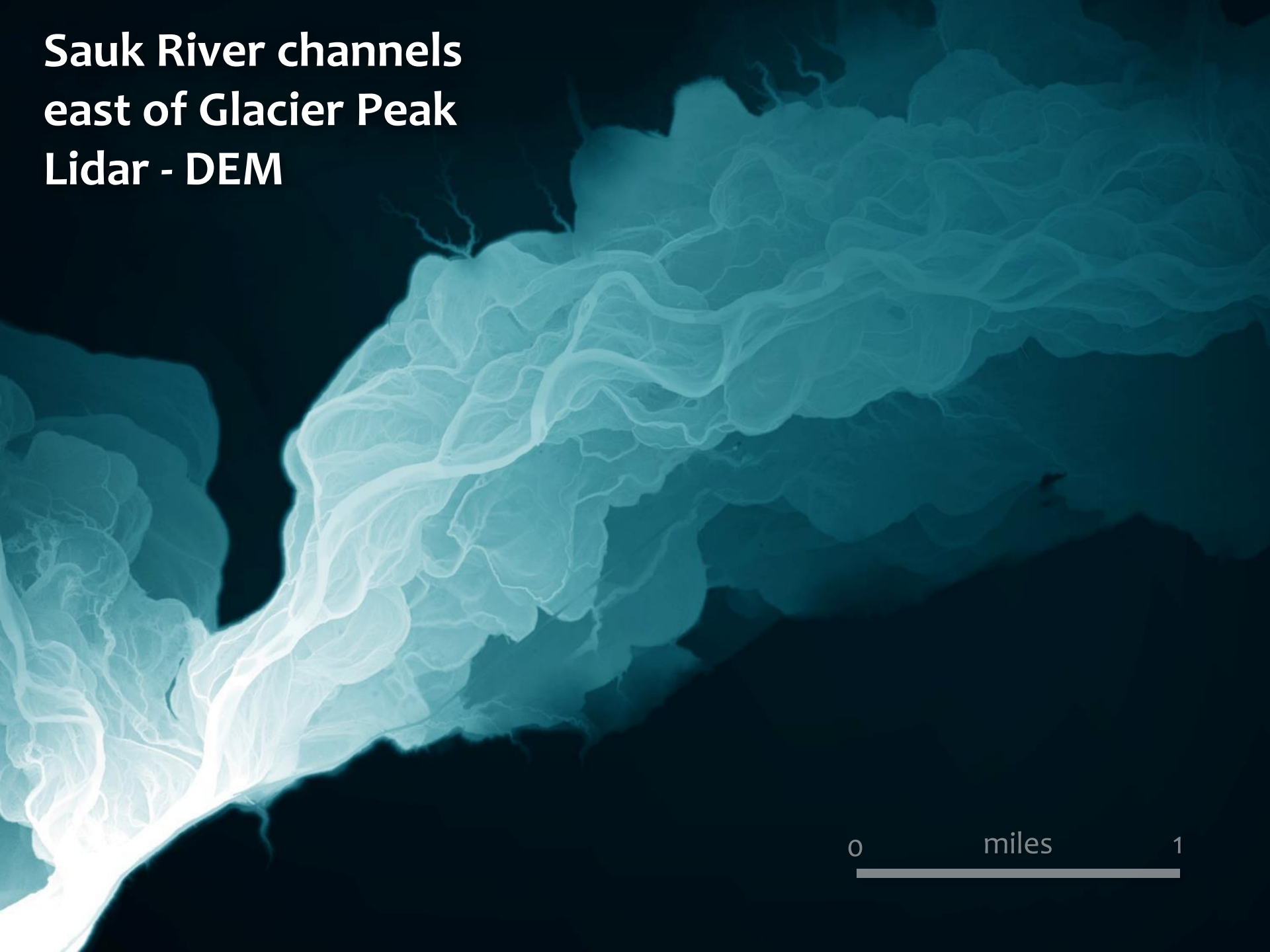
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Sauk River channels east of Glacier Peak Photo



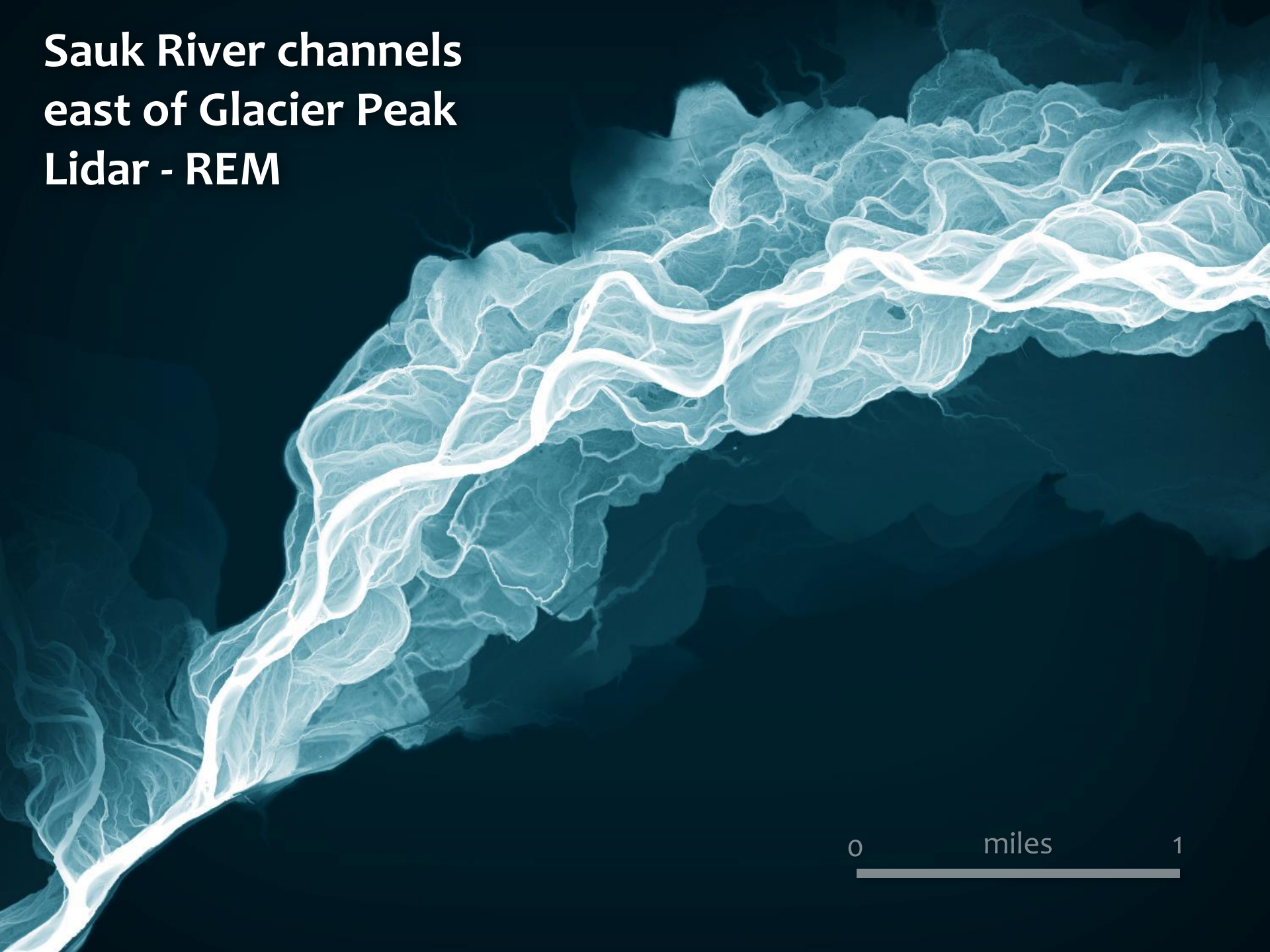
0 miles 1

**Sauk River channels
east of Glacier Peak
Lidar - DEM**



0 miles 1

**Sauk River channels
east of Glacier Peak
Lidar - REM**

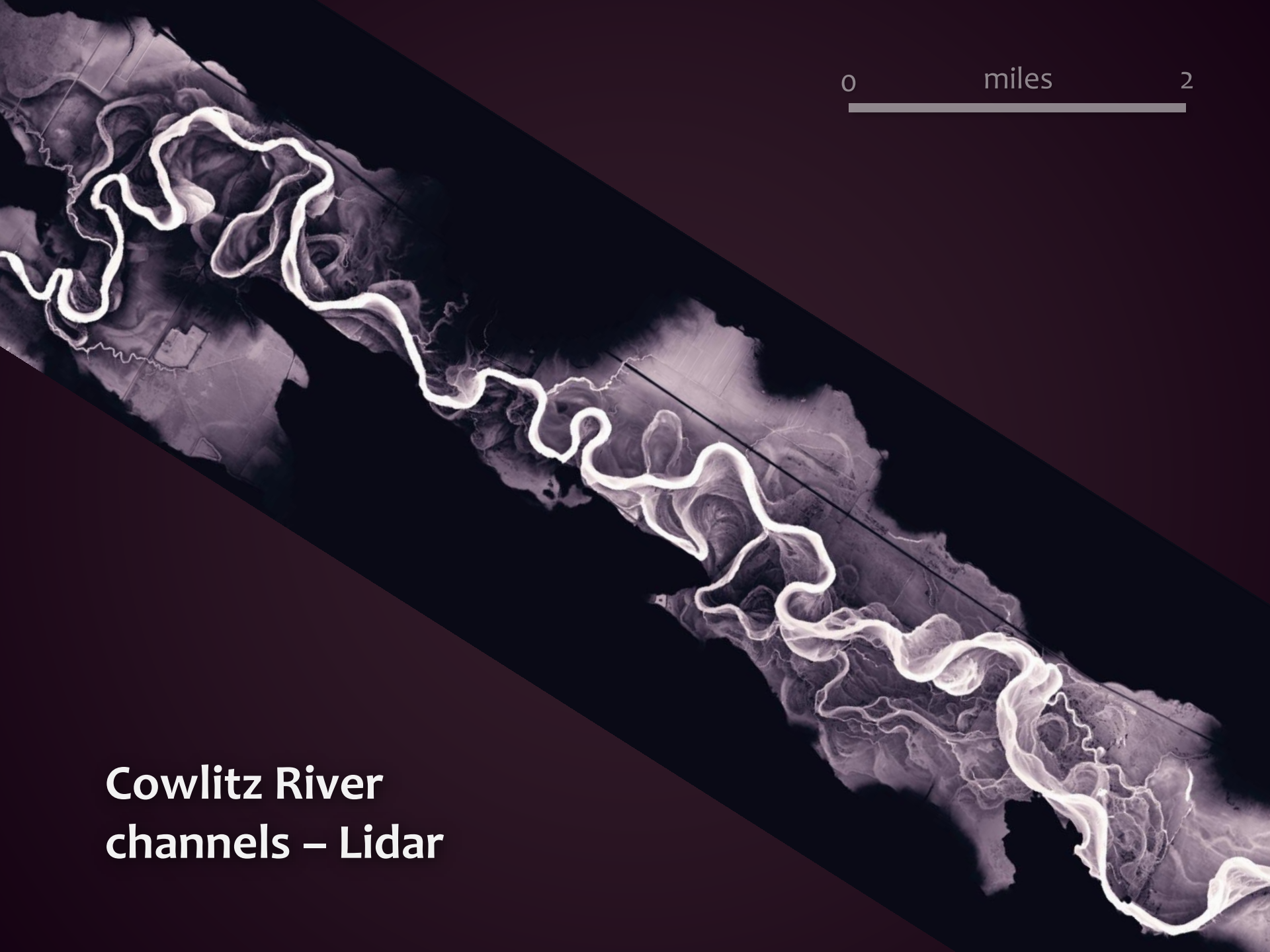


0 miles 1



0 miles 2

**Cowlitz River
channels – Photo**



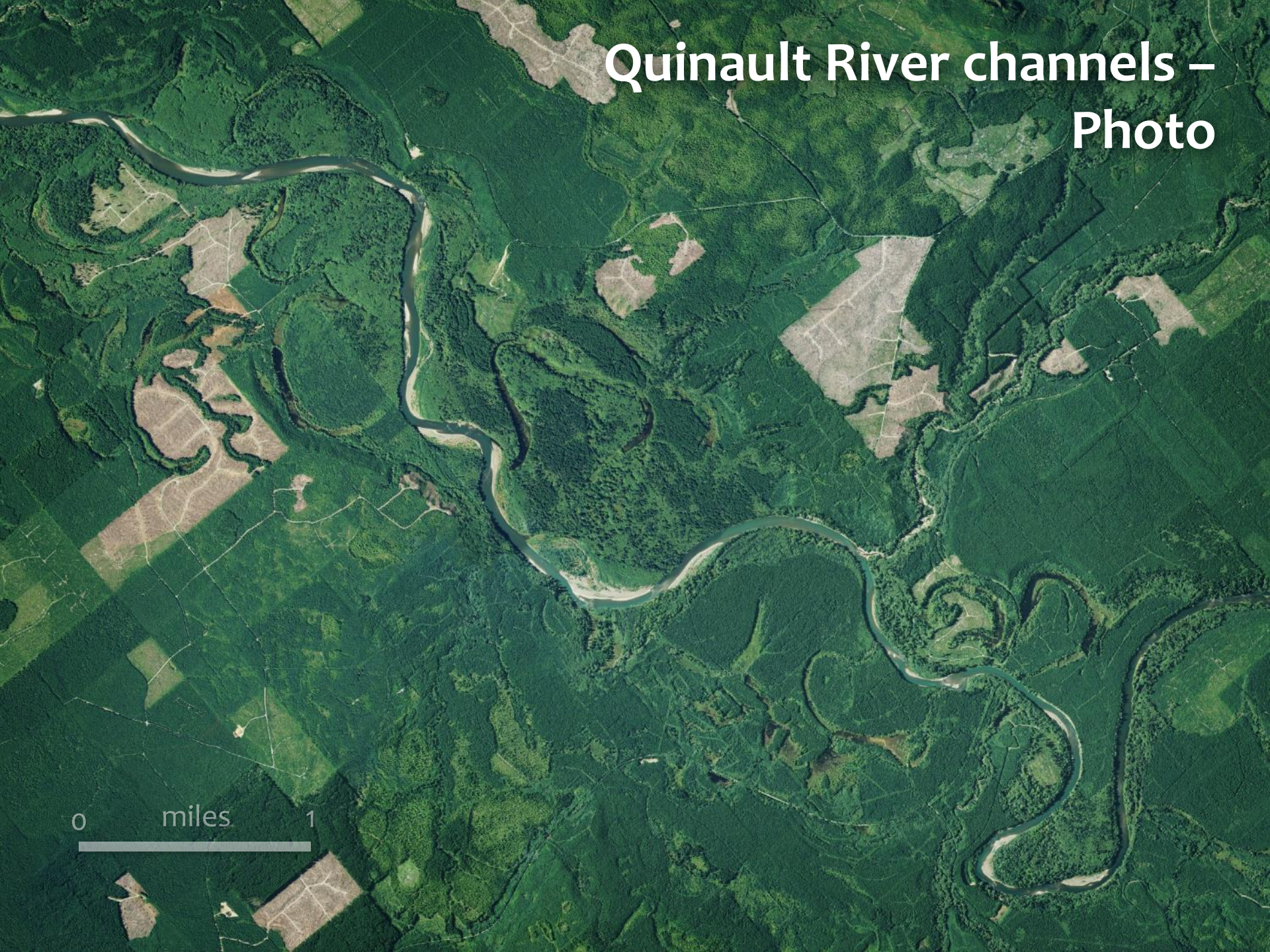
**Cowlitz River
channels – Lidar**



0 miles 2

**Cowlitz River
channels – Photo/Lidar**

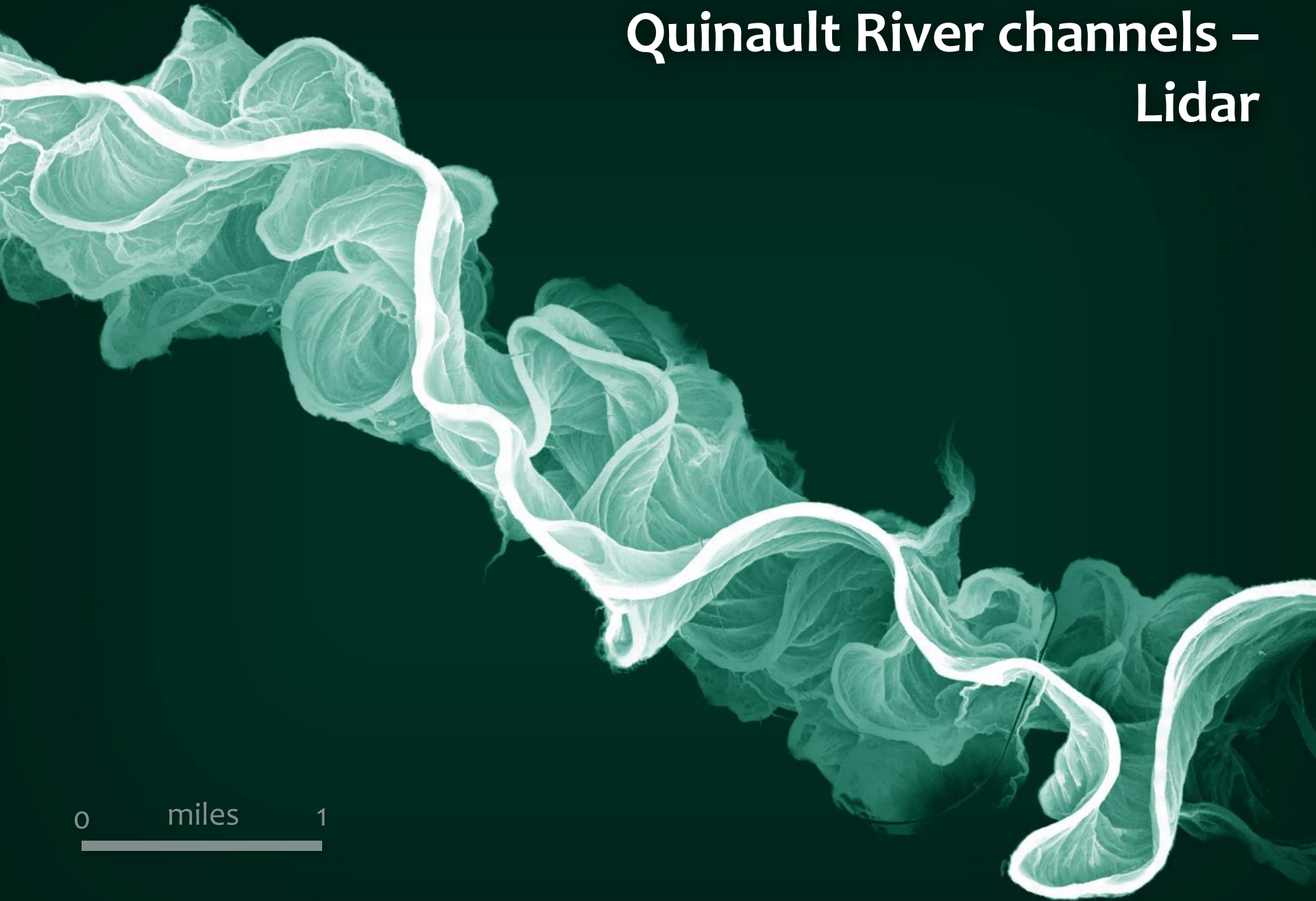
Quinault River channels – Photo



0 miles 1



Quinault River channels – Lidar



0 miles 1



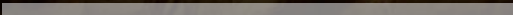
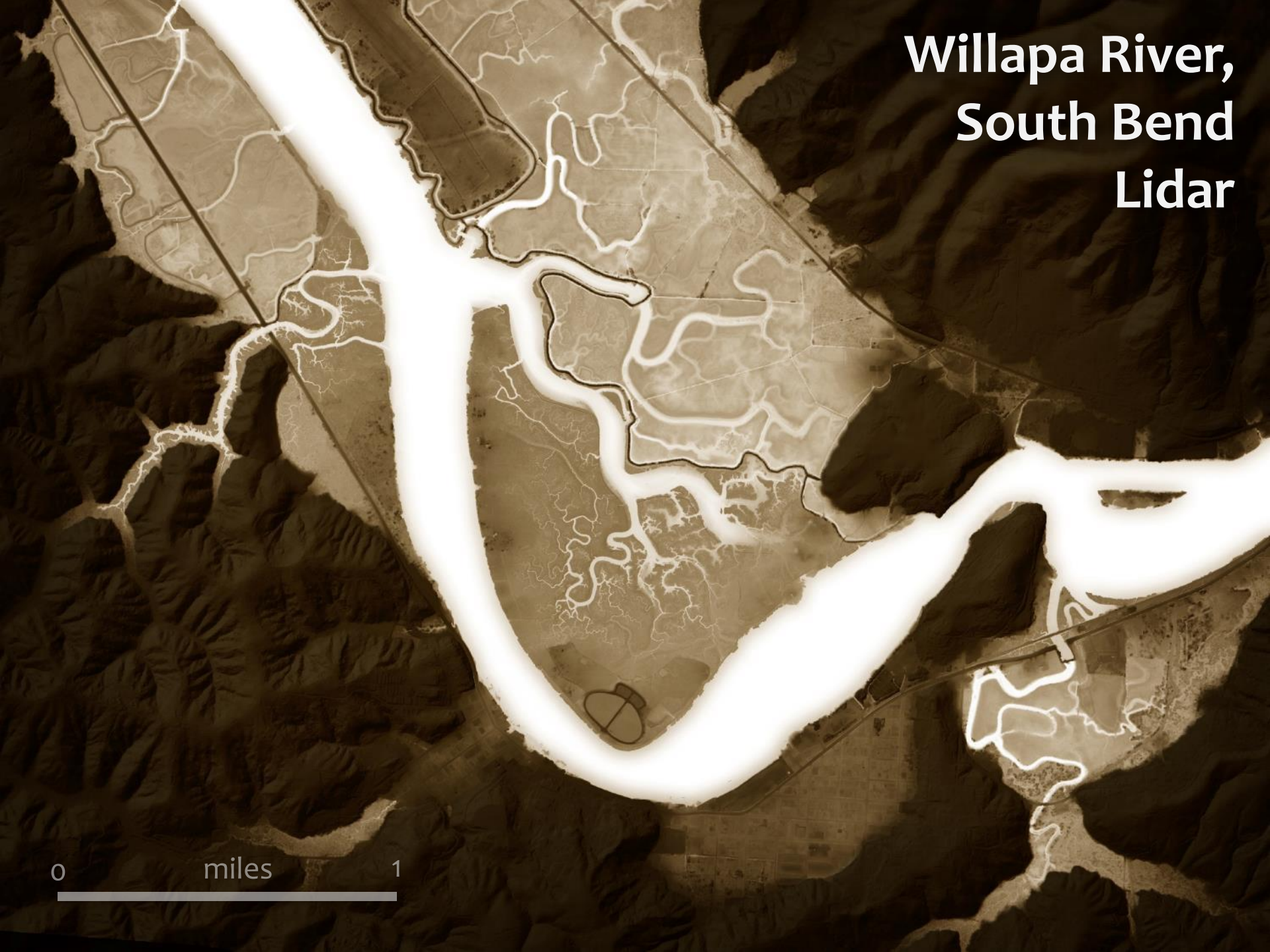
Willapa River, South Bend Photo



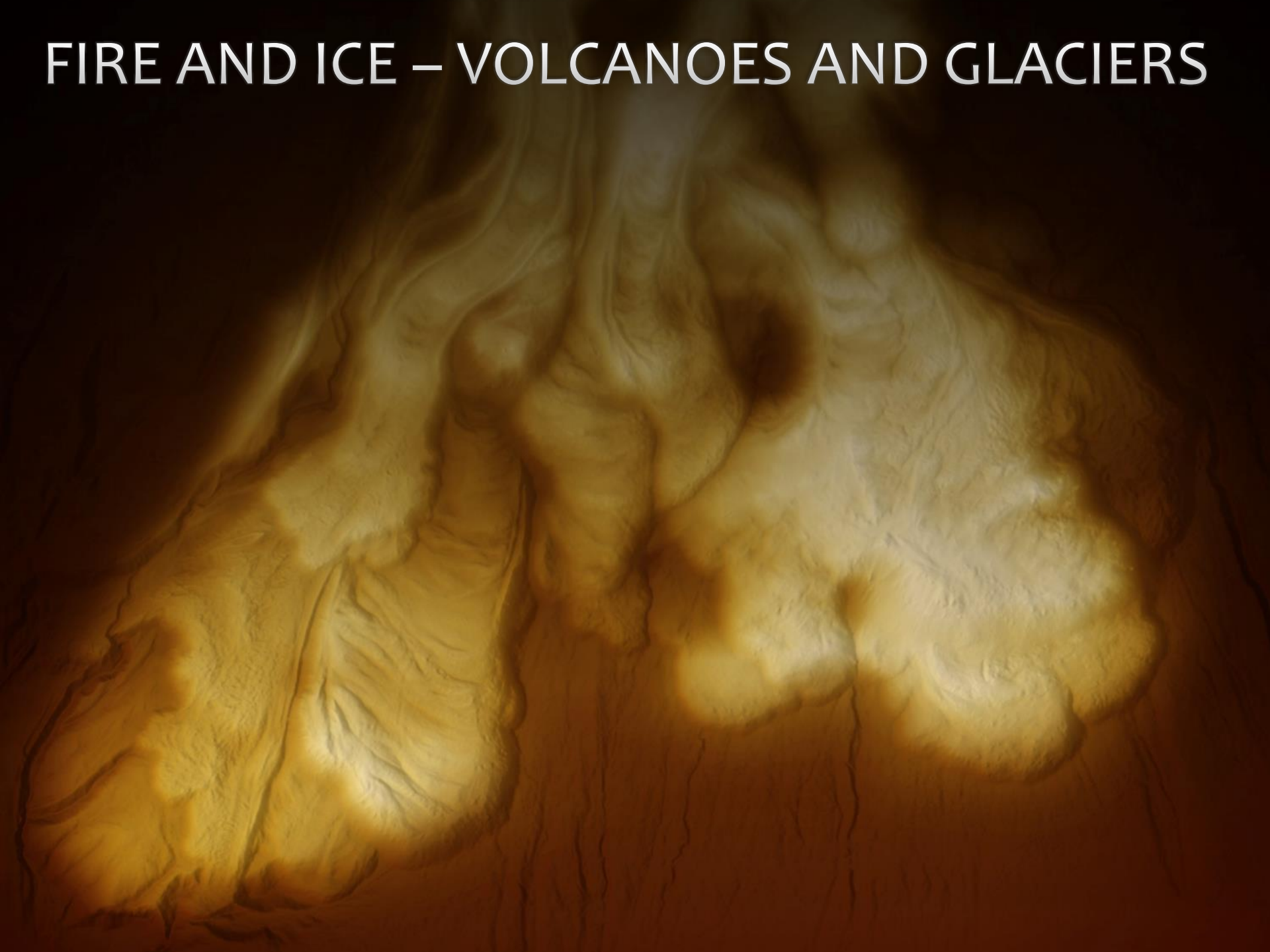
0 miles 1

**Willapa River,
South Bend
Lidar**

0 miles 1

A horizontal white scale bar is located at the bottom left of the image, spanning from the '0' to the '1'.

FIRE AND ICE – VOLCANOES AND GLACIERS

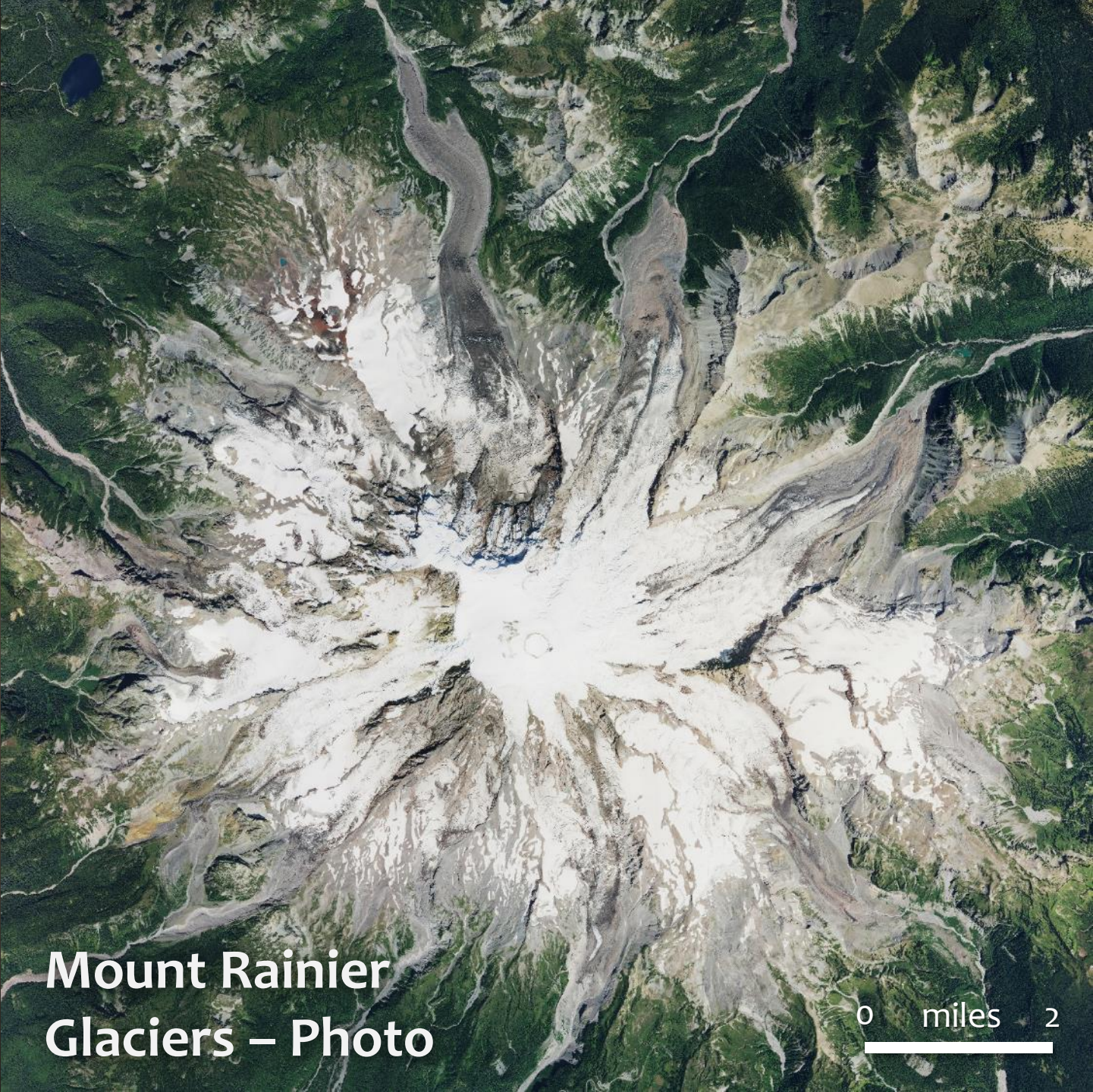


VOLCANOES AND GLACIERS

- LAVA FLOWS
- GLACIAL ICE AND SNOWFIELDS



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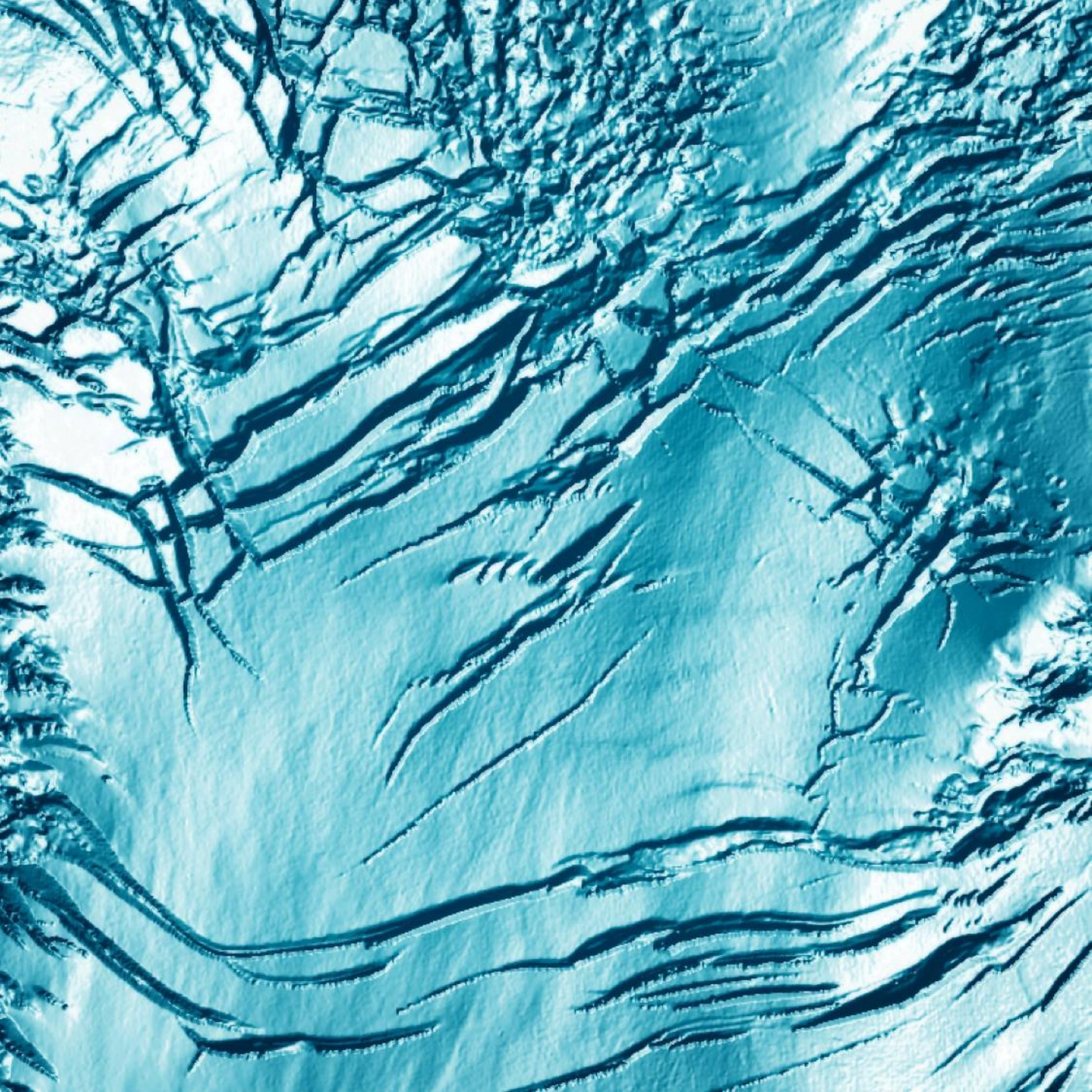
**Mount Rainier
Glaciers – Photo**

0 miles 2



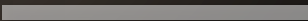
**Mount Rainier
Glaciers – Lidar**

0 miles 2



**Mount
Rainier
Glaciers
Lidar**

0 feet 500



**West Crater lava flow
Skamania County
Photo**

0 - miles 0.5

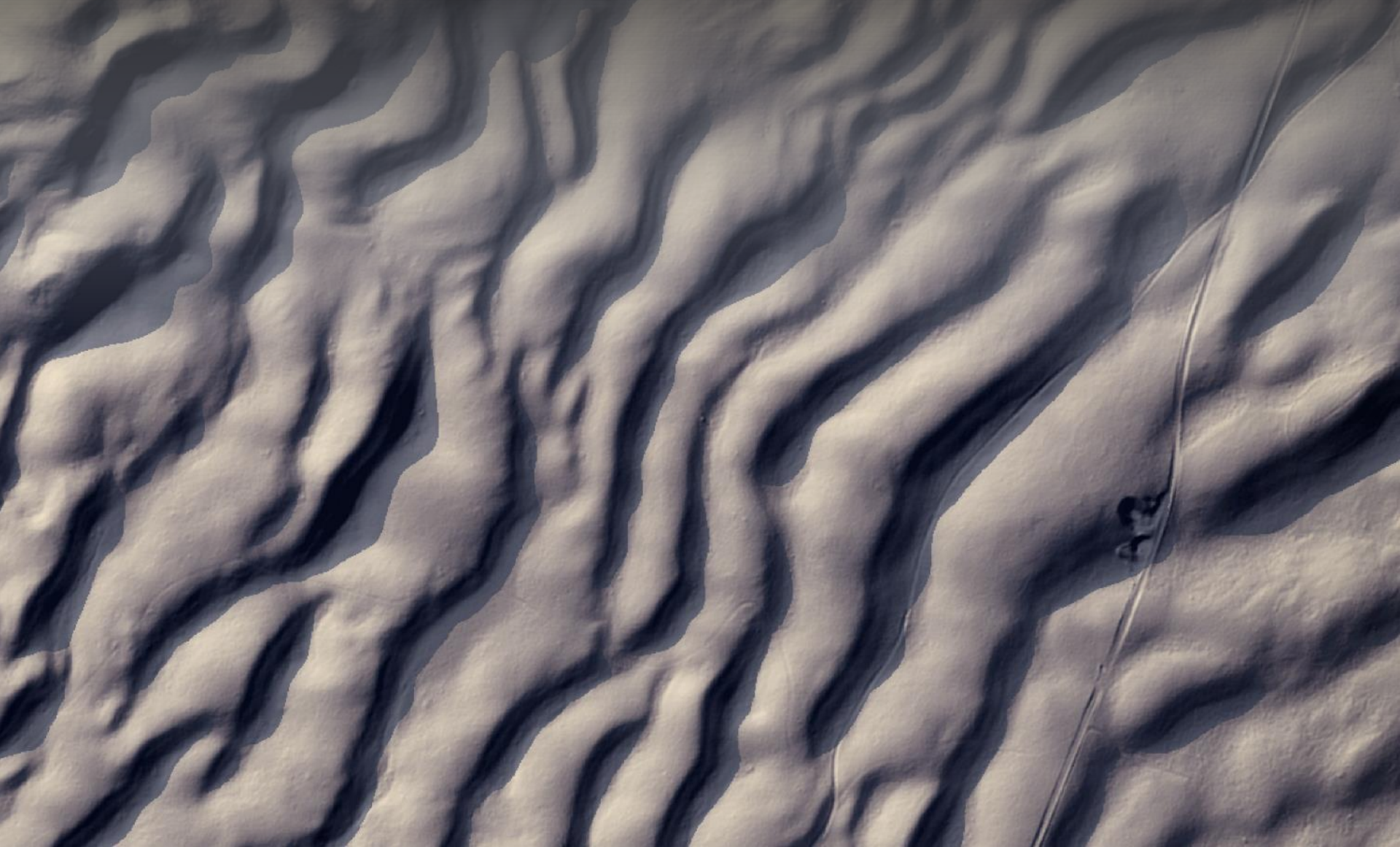


**West Crater lava flow
Skamania County
Lidar**



0 miles 0.5

GEOLOGIC CURIOSITIES – MYSTERIOUS MOUNDS AND ICE-AGE FLOODS



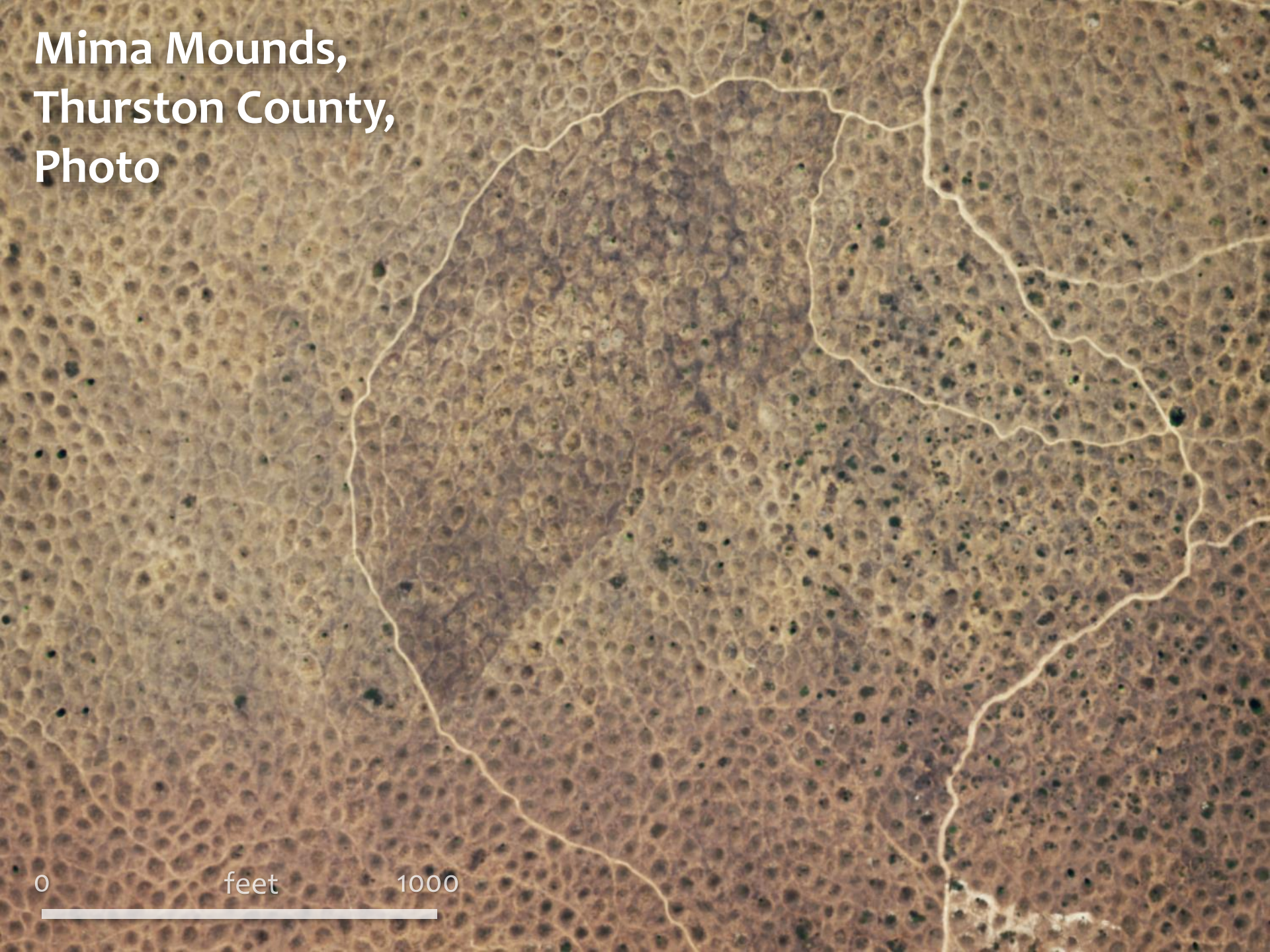
MYSTERIOUS MOUNDS AND ICE-AGE FLOODS

- MIMA MOUNDS
- GLACIAL OUTURST FLOODS

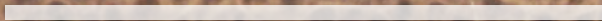


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**Mima Mounds,
Thurston County,
Photo**

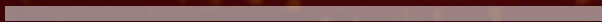


0 feet 1000



Mima Mounds,
Thurston County,
Lidar

0 feet 1000

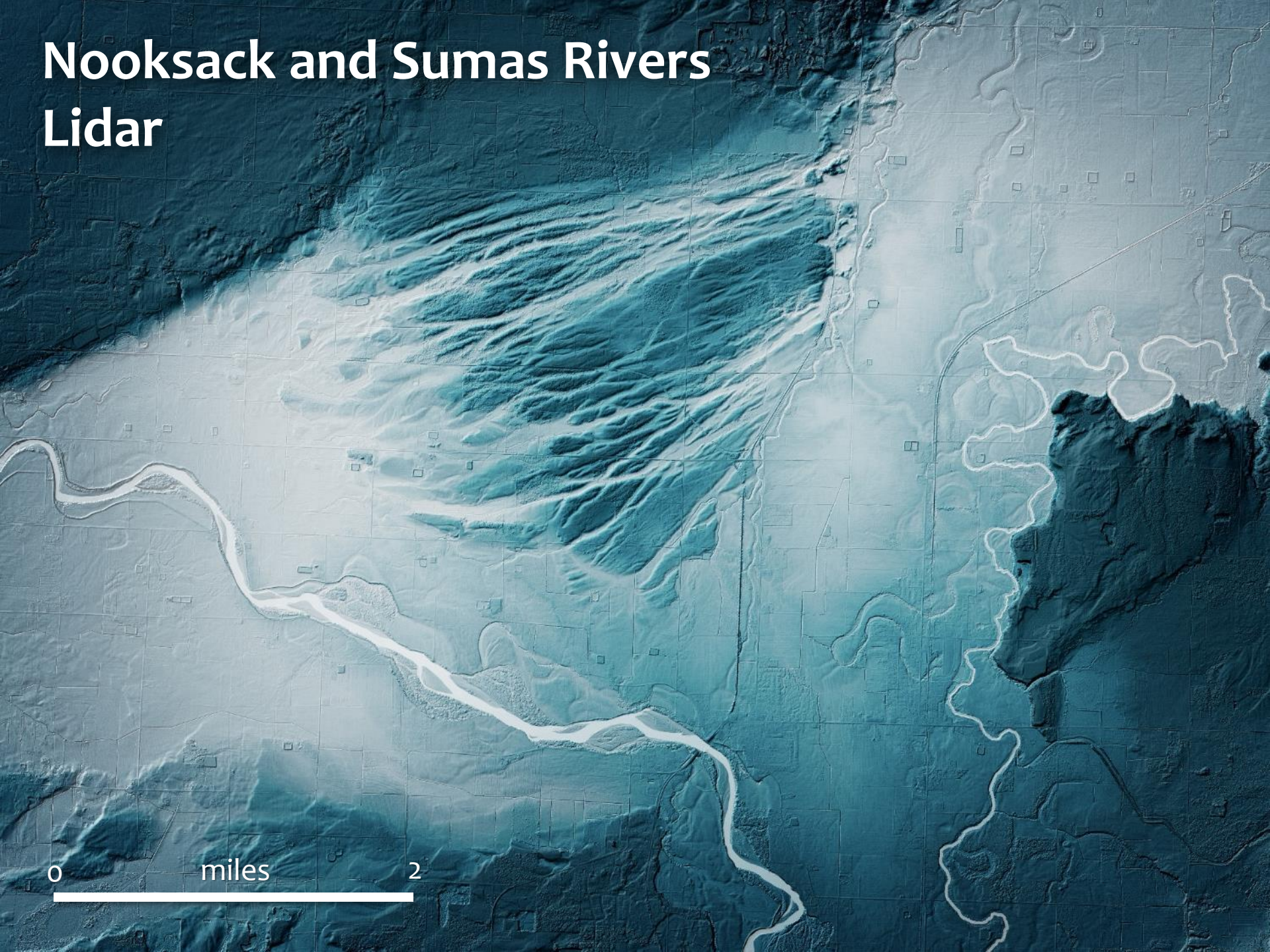


Nooksack and Sumas Rivers Photo

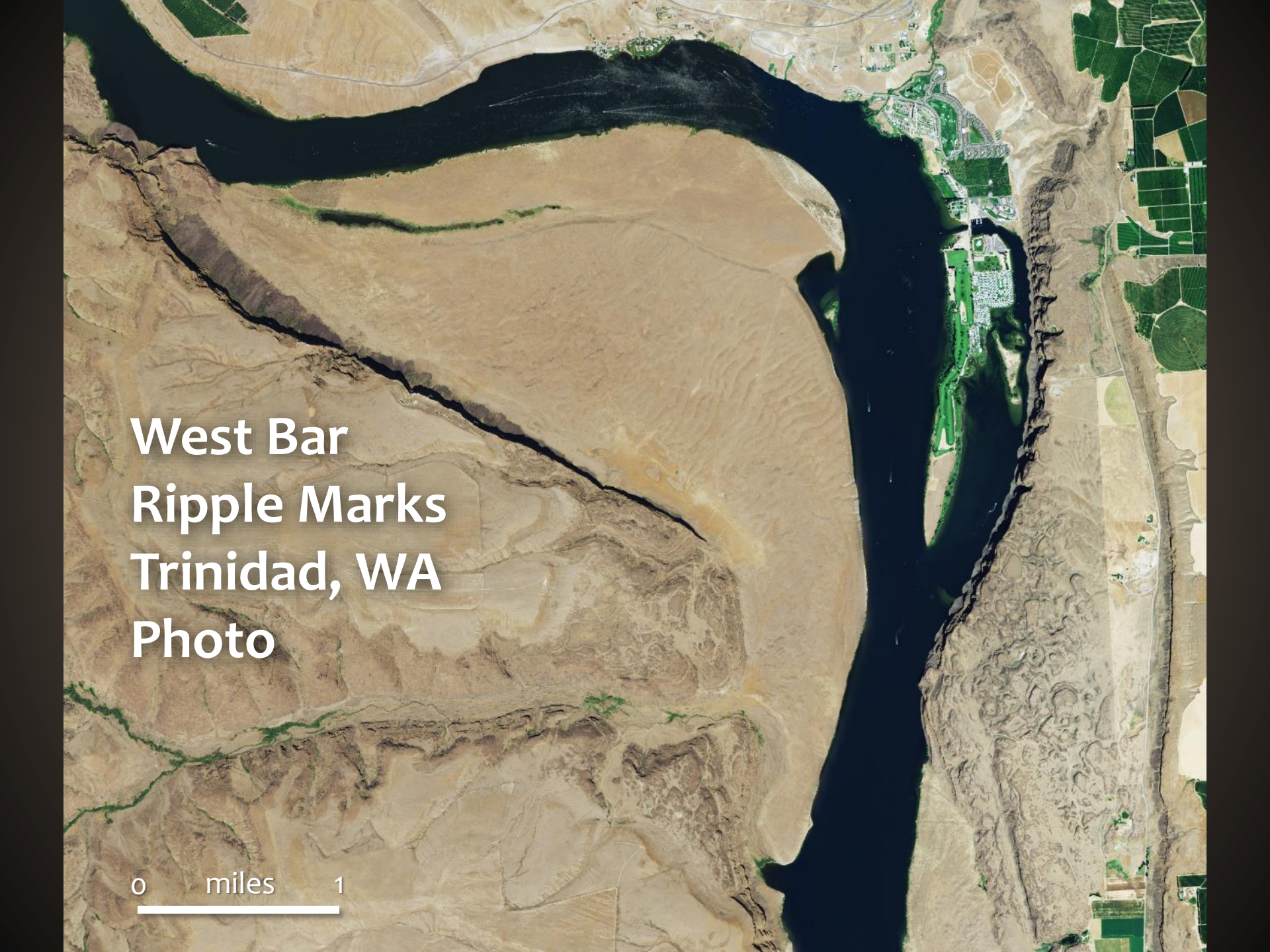


0 miles 2

Nooksack and Sumas Rivers Lidar

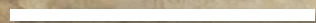


0 miles 2

An aerial photograph showing a wide river channel on the right side, flowing from the top towards the bottom. The river is dark, contrasting with the light brown, sandy terrain. On the left side of the river, there is a large, flat area of land with distinct, concentric, ripple-like patterns in the soil, which are the 'ripple marks' mentioned in the caption. The terrain is mostly light brown and tan, with some green patches of vegetation. In the upper right corner, there is a small cluster of buildings and a road, indicating a nearby settlement. The overall scene is a natural landscape with a prominent geological feature.

**West Bar
Ripple Marks
Trinidad, WA
Photo**

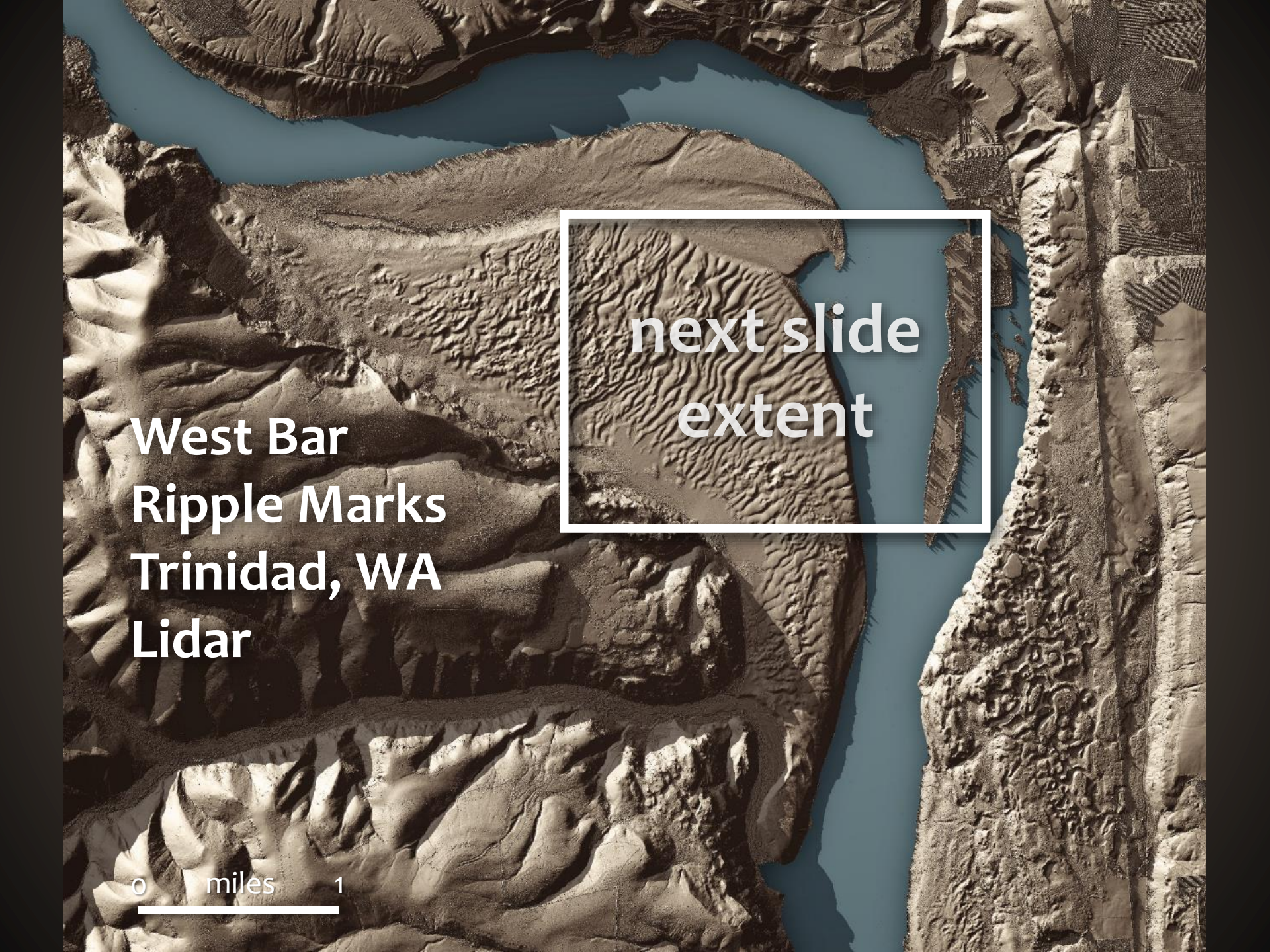
0 miles 1



**West Bar
Ripple Marks
Trinidad, WA
Lidar**

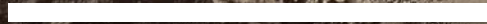
**next slide
extent**

0 miles 1



**West Bar
Ripple
Marks
Trinidad, WA
Lidar**

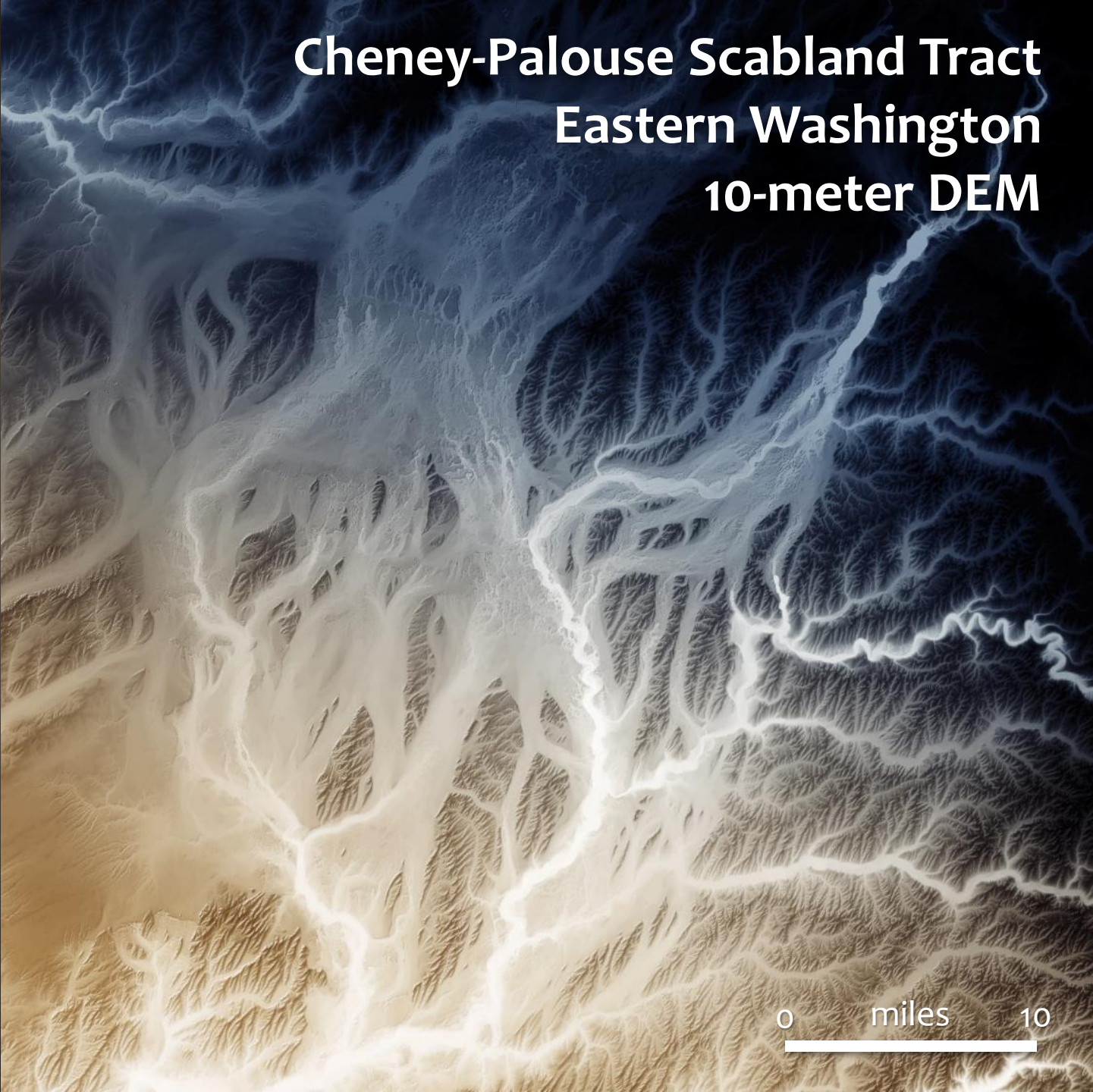
0 miles 0.5



Cheney-Palouse Scabland Tract Eastern Washington Photo



**Cheney-Palouse Scabland Tract
Eastern Washington
10-meter DEM**





TECHNIQUES

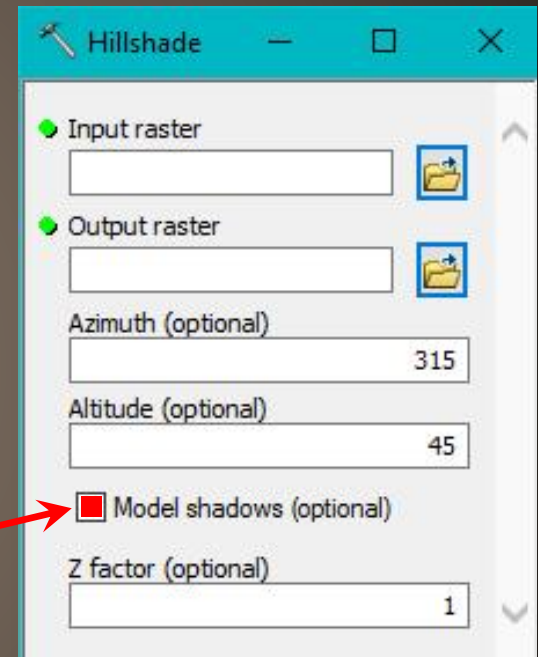
- ESRI HILLSHADE TOOL / ROTATE DATA FRAME
- RELATIVE ELEVATION MODELS AND ADJUSTING ELEVATION VALUES
- BLENDING IMAGES

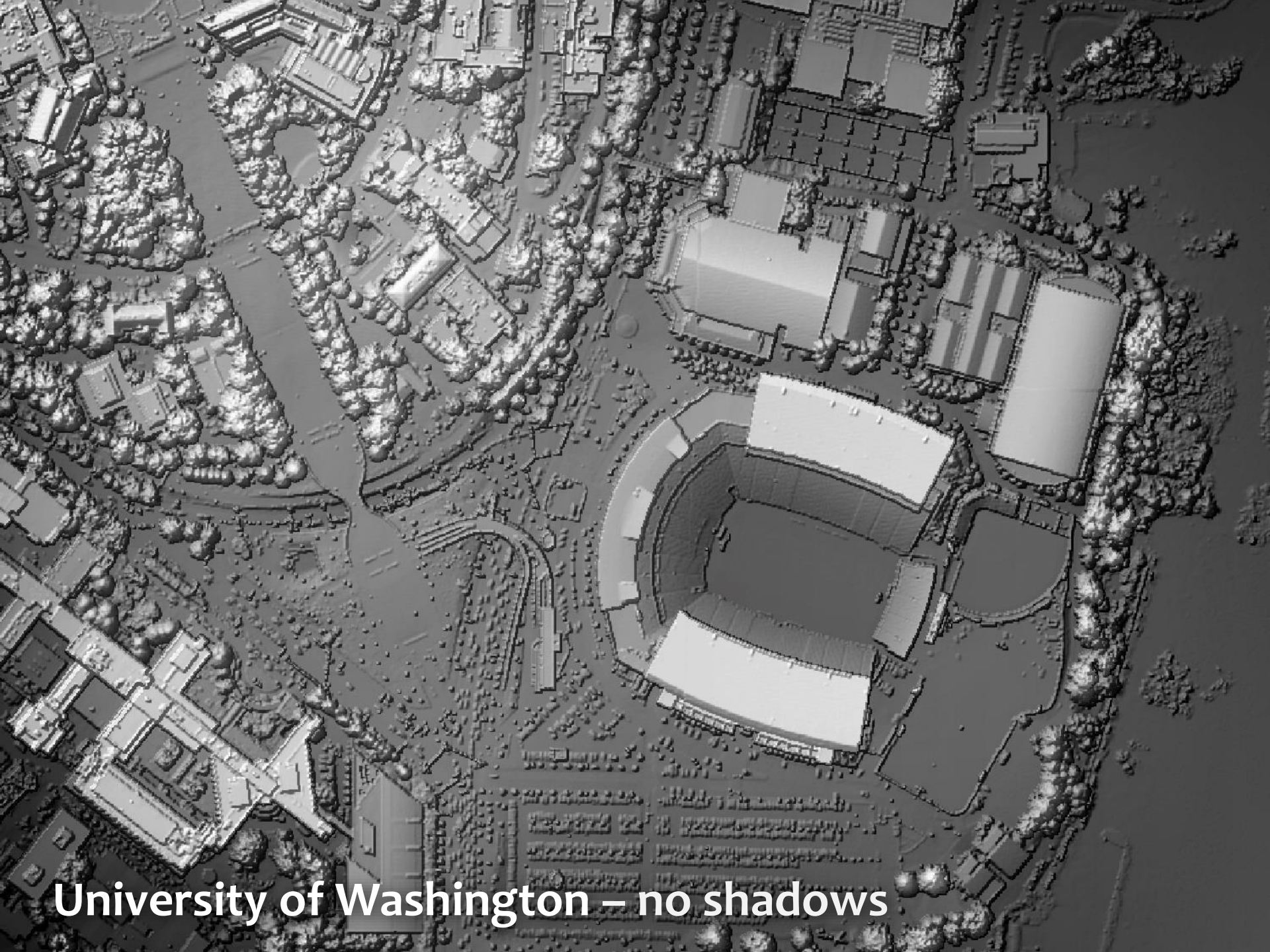


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HILLSHADE TOOL / ROTATE DATA FRAME

- ROTATE DATA FRAME  TO AESTHETICALLY FRAME YOUR PROJECT – ADJUST SHADED RELIEF TO MATCH
- HILLSHADE TOOL - DON'T JUST USE THE DEFAULTS!
- VERTICAL EXAGGERATION (Z FACTOR), AZIMUTH, ALTITUDE
- SHADOW CHECK BOX 
- LAYER MULTIPLE HILLSHADES— A GOOD COMBINATION FOR TERRAIN:
LAYER 1 – 3 X VERTICAL WITH SHADOWS AT 75% TRANSPARENT
LAYER 2 – DEFAULT HILLSHADE





University of Washington – no shadows



University of Washington – with shadows

RELATIVE ELEVATION MODELS (REM)

- “DETRENDS” A RIVER SURFACE
- CONVERTS RIVER SURFACE TO “0” ELEVATION
- ELEVATIONS OF ADJACENT LAND = HEIGHT ABOVE RIVER
- MULTIPLE METHODS - USE POINT OR LINE DATA THAT POSSESS ELEVATIONS CORRESPONDING TO THE RIVER’S SURFACE.
- DATA ARE INTERPOLATED TO CREATE A NEW RASTER AND THEN SUBTRACTED FROM THE ORIGINAL DEM TO CREATE THE REM.



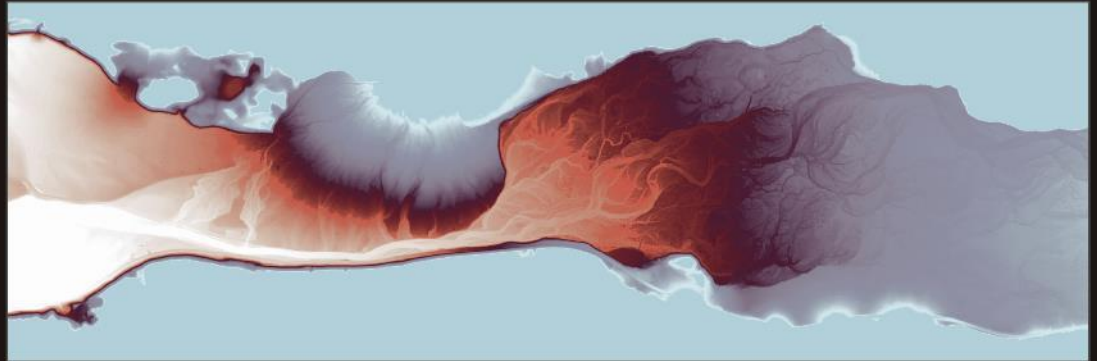
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RELATIVE ELEVATION MODELS (REM)

DEM compared
to REM

Both have
elevation color
range of 100
vertical feet

DEM



lower
elevation ←

→ higher
elevation

REM

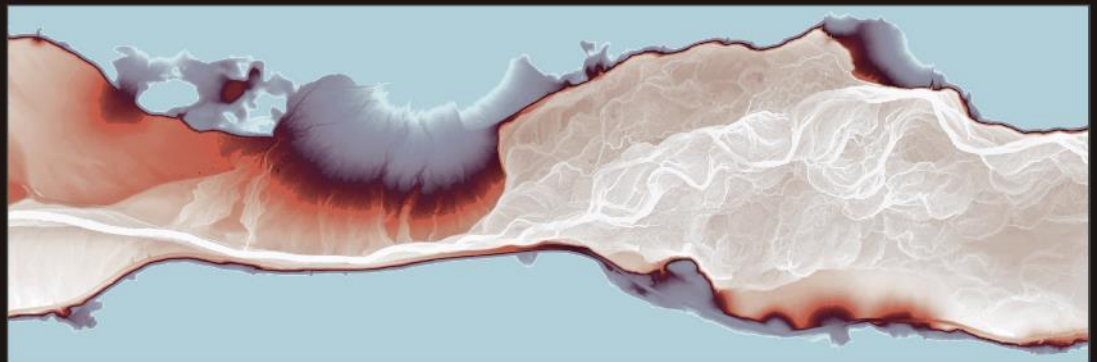
higher
elevation



lower elevation



higher
elevation



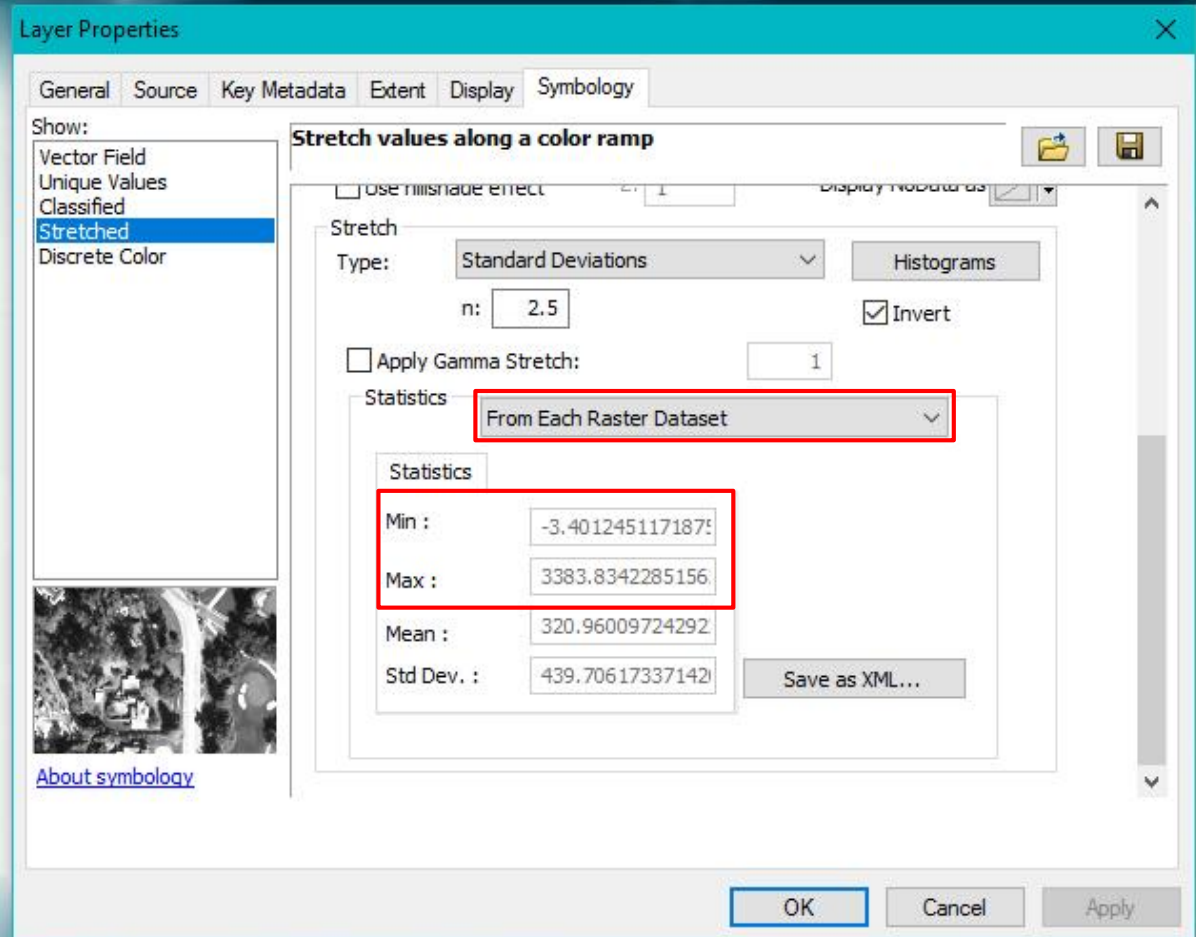
REM RESOURCES AND METHODS:

- OLSON, P. L., LEGG, N. T., ABBE, T. B., REINHART, M. A., RADLOFF, J. K., 2014, A METHODOLOGY FOR DELINEATING PLANNING-LEVEL CHANNEL MIGRATION ZONES: WASHINGTON STATE DEPARTMENT OF ECOLOGY PUBLICATION NO. 14-06-025, 83P.
<https://fortress.wa.gov/ecy/publications/documents/1406025.pdf>
- POSTER - FLOODPLAIN VISUALIZATION USING LIDAR-DERIVED RELATIVE ELEVATION MODELS
http://file.dnr.wa.gov/publications/ger_presentations_dmt_2016_coe.pdf



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SYMBOLOLOGY ELEVATION SETTINGS



SYMBOLOLOGY ELEVATION SETTINGS

Layer Properties

General Source Key Metadata Extent Display Symbology

Show:
Vector Field
Unique Values
Classified
Stretched
Discrete Color

Stretch values along a color ramp

Use hillshade effect

Stretch Type: Standard Deviations

n: 2.5

Apply Gamma Stretch: 1

Statistics: From Custom Settings (below)

Statistics

Min :	0	Import...
Max :	20	Load XML...
Mean :	320.96009724292	From Graphics
Std Dev. :	439.70617337142	Save as XML...

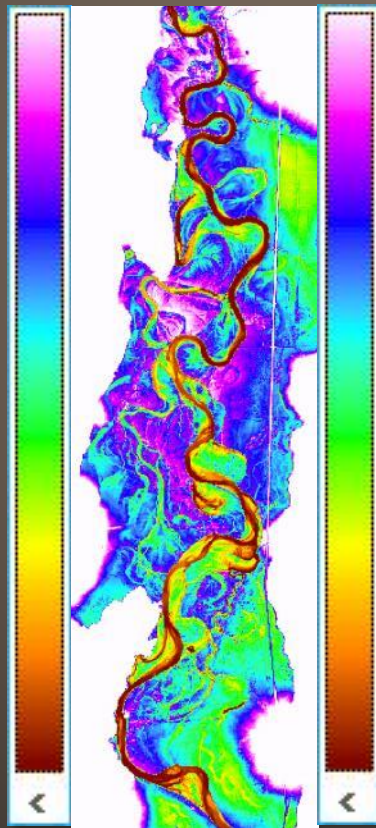
[About symbology](#)

OK Cancel Apply

SYMBOLGY ELEVATION SETTINGS

- FOR RIVER VISUALIZATIONS – MONOCHROMATIC COLOR RAMP WITH HIGH CONTRAST, IE. DARK COLOR FADING TO WHITE

great for analysis >
not so great
for cartography



< more aesthetically
pleasing
easier to visually
interpret

BLENDING IMAGES

- CAN BE ACHIEVED IN ARCGIS –
 - LAYERING WITH TRANSPARENCY
 - IMAGE ANALYSIS FUNCTIONS
- PHOTOSHOP MORE EFFICIENT, DYNAMIC, AND FUN
 - LAYER MASKS AND BLENDING MODES
- GEOGRAPHIC IMAGER



FUTURE

- POINT CLOUD VISUALIZATION
- MORE PERSPECTIVE VIEW
- ANIMATIONS



Image credit: DOGAMI

THANKS!

DNR lidar page – <http://www.dnr.wa.gov/lidar>

email– Daniel Coe – daniel.coe@dnr.wa.gov



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