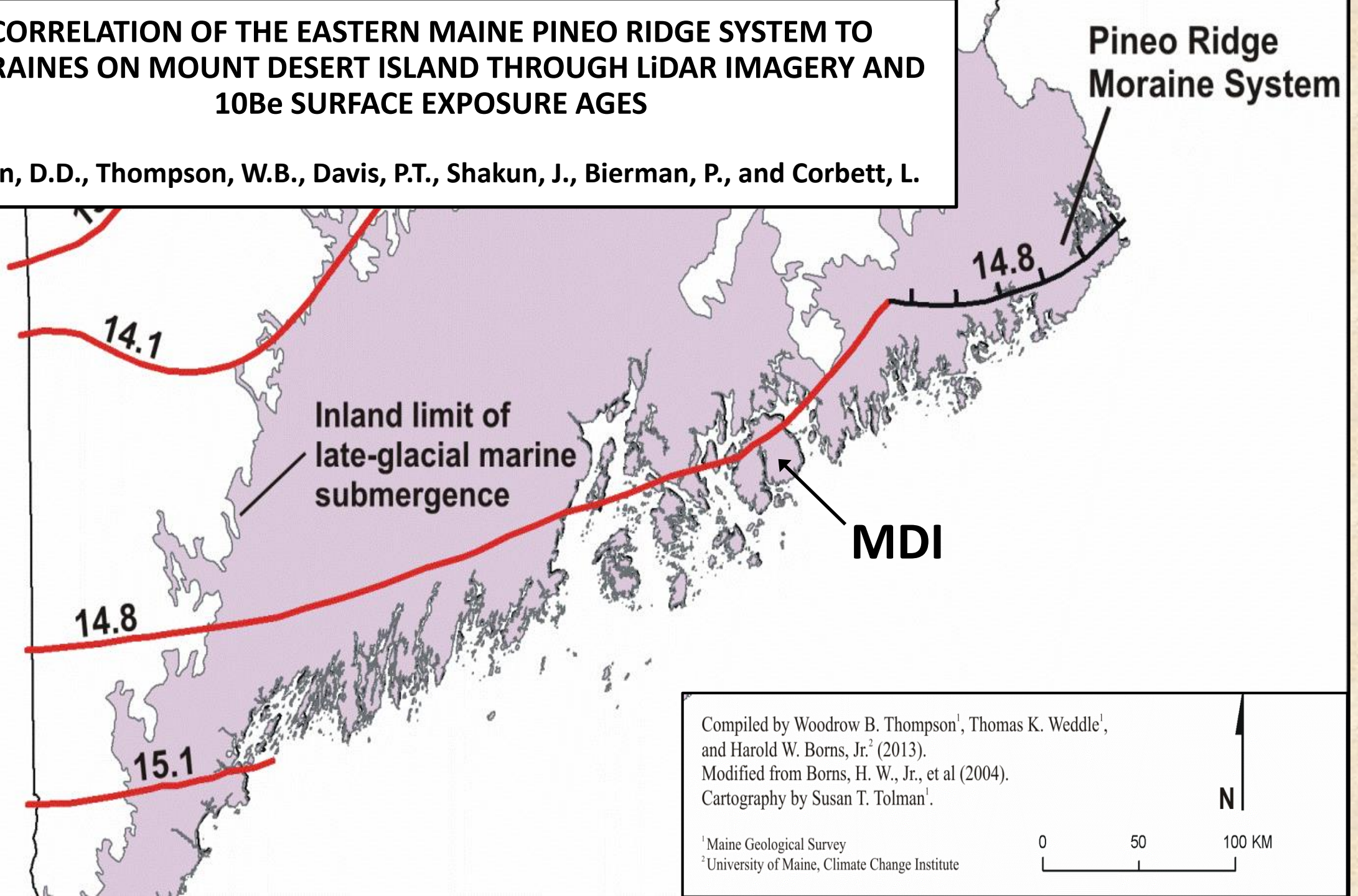


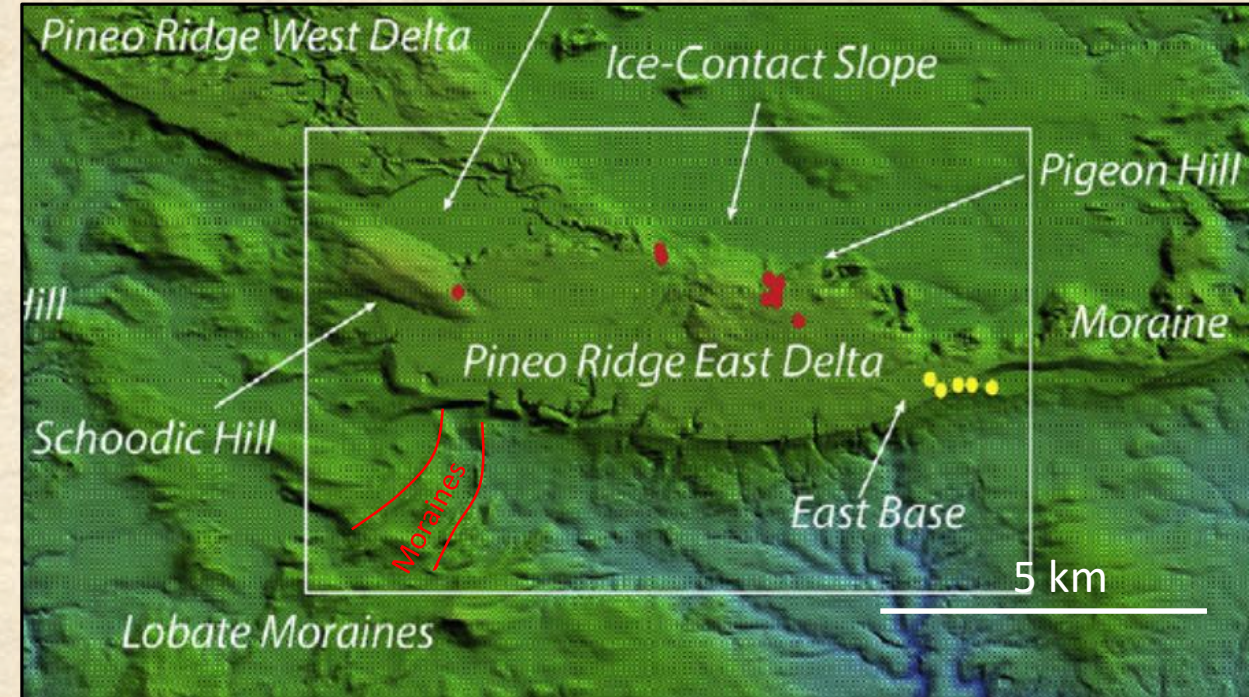
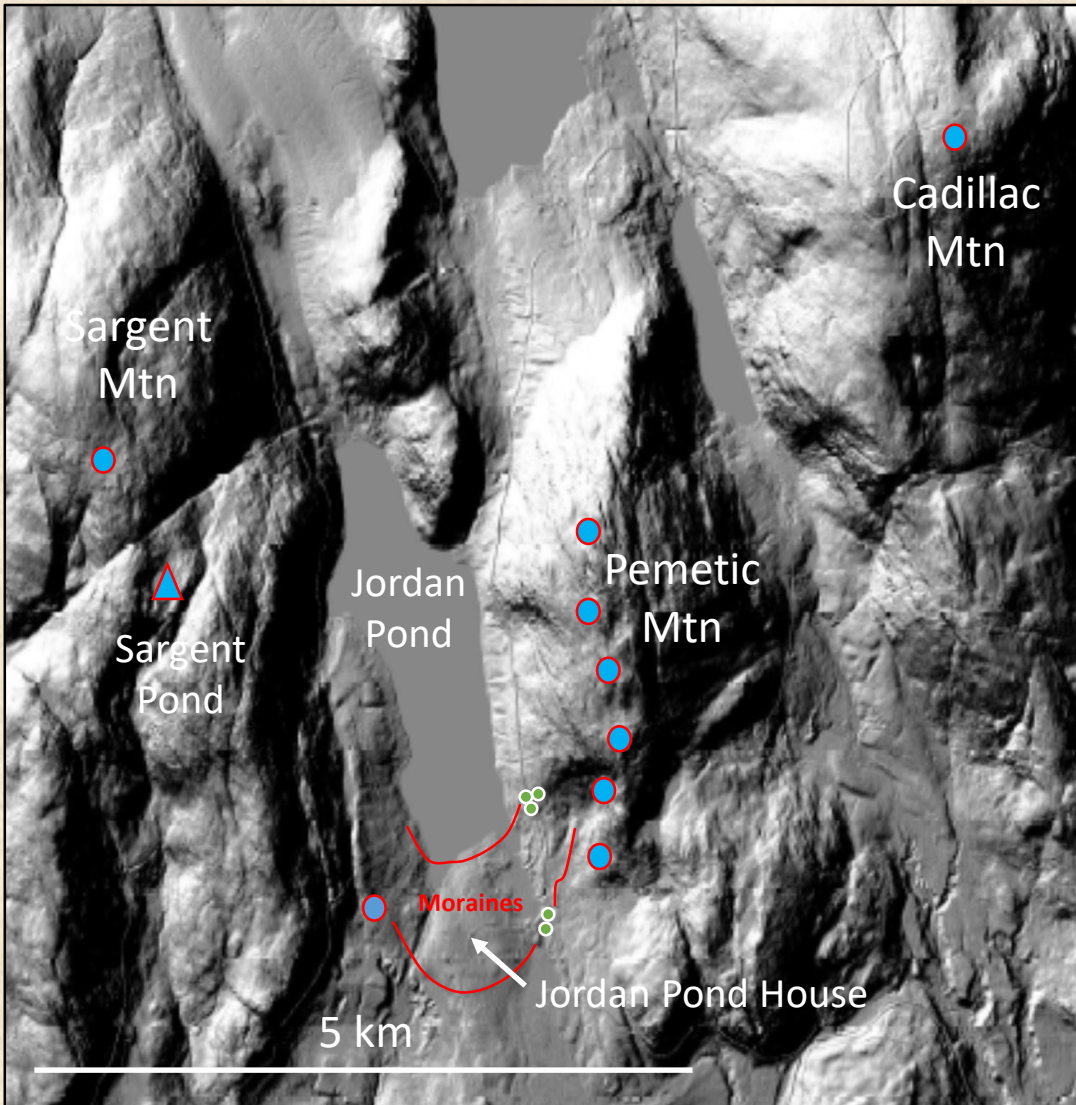
# CORRELATION OF THE EASTERN MAINE PINEO RIDGE SYSTEM TO MORAINES ON MOUNT DESERT ISLAND THROUGH LIDAR IMAGERY AND $^{10}\text{Be}$ SURFACE EXPOSURE AGES

Braun, D.D., Thompson, W.B., Davis, P.T., Shakun, J., Bierman, P., and Corbett, L.





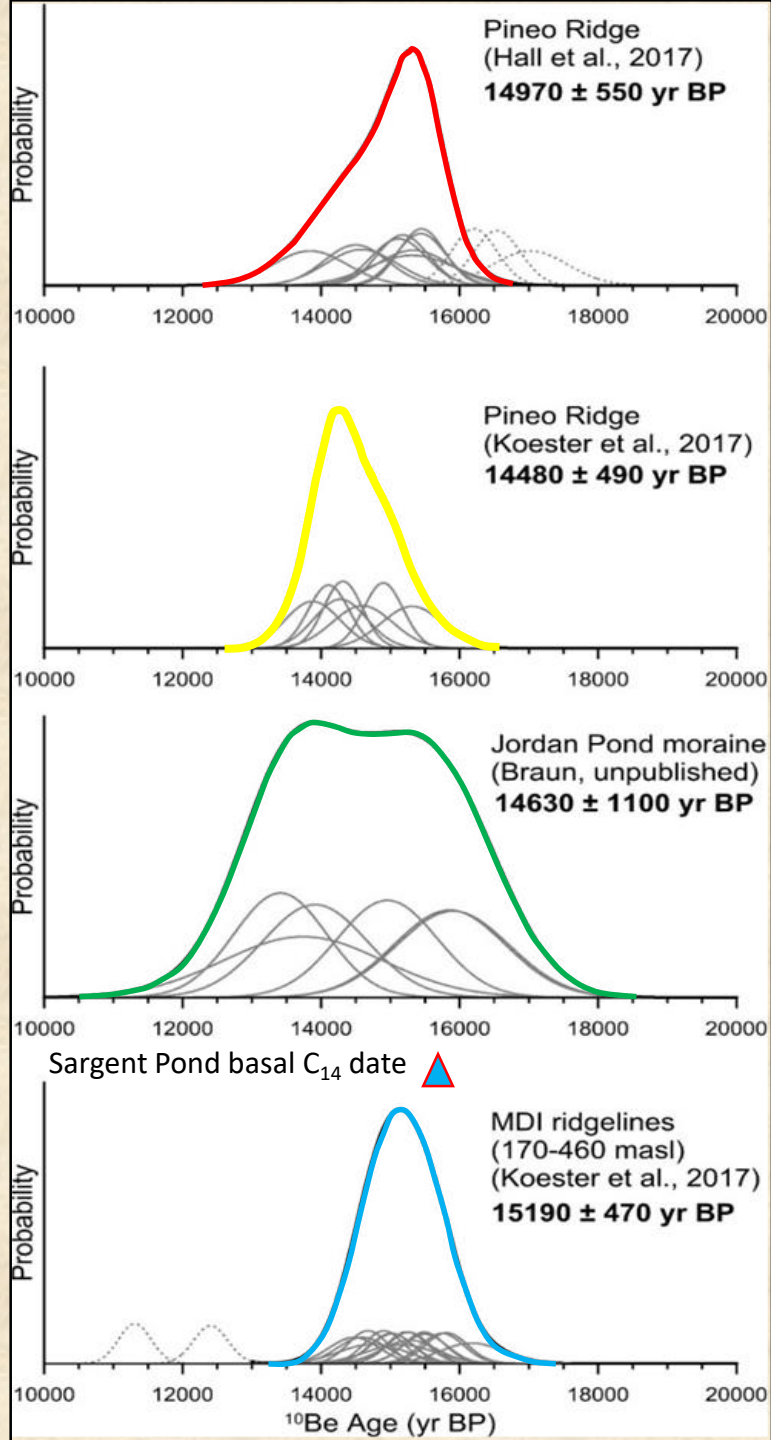
**PRS – MDI 10Be Surface exposure ages  
– 28 sites so far - enough is enough?**



Digital elevation map of the Pineo Ridge System 10Be exposure ages sample sites. Yellow dots are samples sites from Koester et al. (2017). Red dots are sample sites from Hall et al. (2017). (Part of Figure 3, page 346, Hall et al. 2017)

LiDAR hillshade of Mount Desert Island showing 10Be exposure ages sample sites. Blue dots are samples sites from Koester et al. (2017). Green dots are sample sites from Braun et al. (2018). The site with the triangle is Sargent Mountain Pond where there is a calibrated near basal radiocarbon age of  $15,718 \pm 363$  yrs (Norton et al., 2011).





## PRS & MDI surface exposure ages are essentially the same age

**Average of 3 moraine averages = 14,693 !??**  
**We will see the 14.7 ka again later on.**

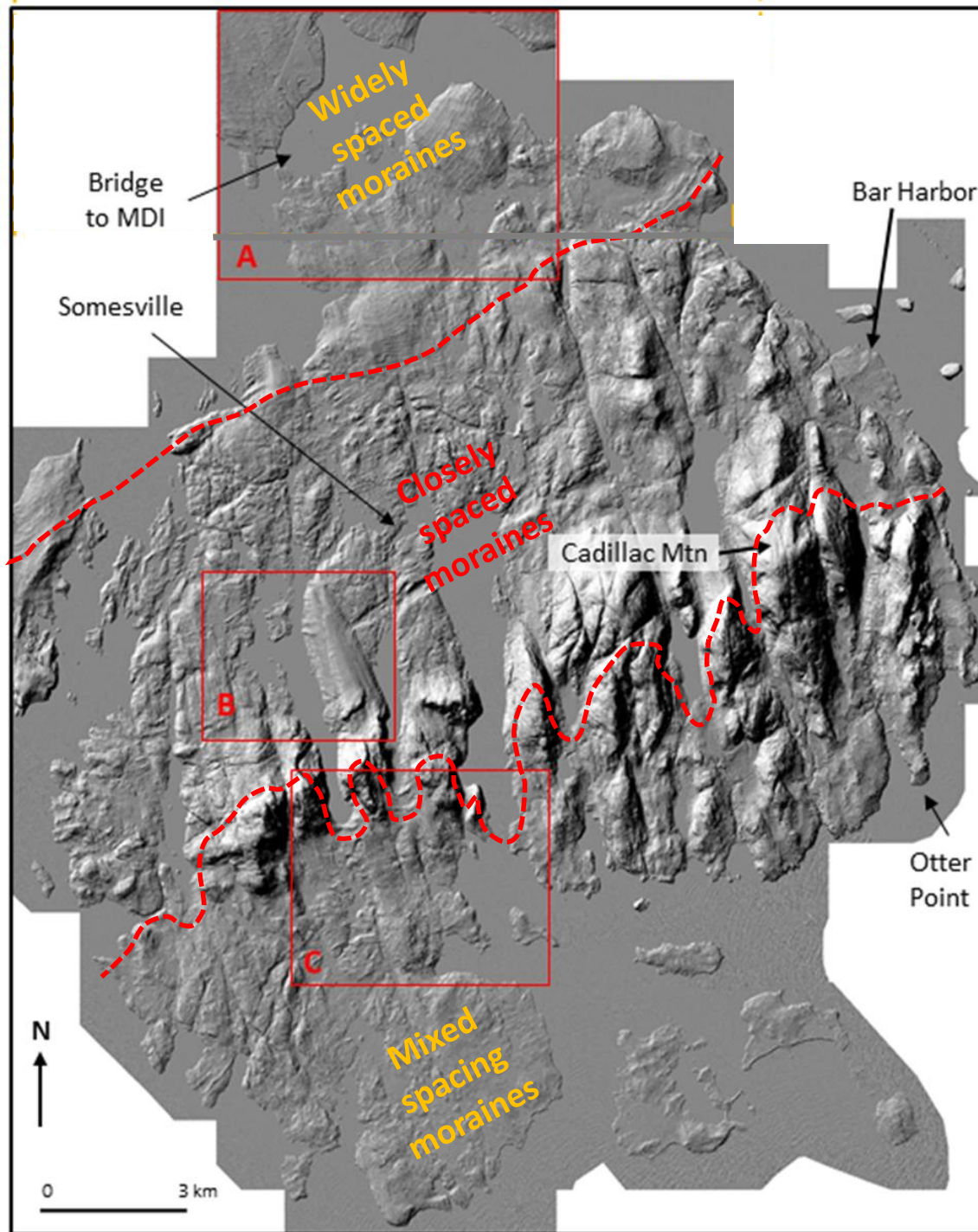
Probability distribution functions (camel plots) of  $^{10}\text{Be}$  surface exposure ages from Pineo Ridge and Mount Desert Island, Maine. Mean  $^{10}\text{Be}$  surface exposure ages for each grouping labeled in bold, and all four mean ages are indistinguishable at one standard deviation.

From Braun, D., 2018, Moraines on MDI and their relation to Pineo Ridge, fig. 33.FOP 2018 guidebook p. 30

## Moraine spacing on MDI

LiDAR hillshade image of MDI; even at this scale some of the push moraines are visible. Red rectangles A – C are enlarged same-scale images shown next for comparison of moraine spacing.

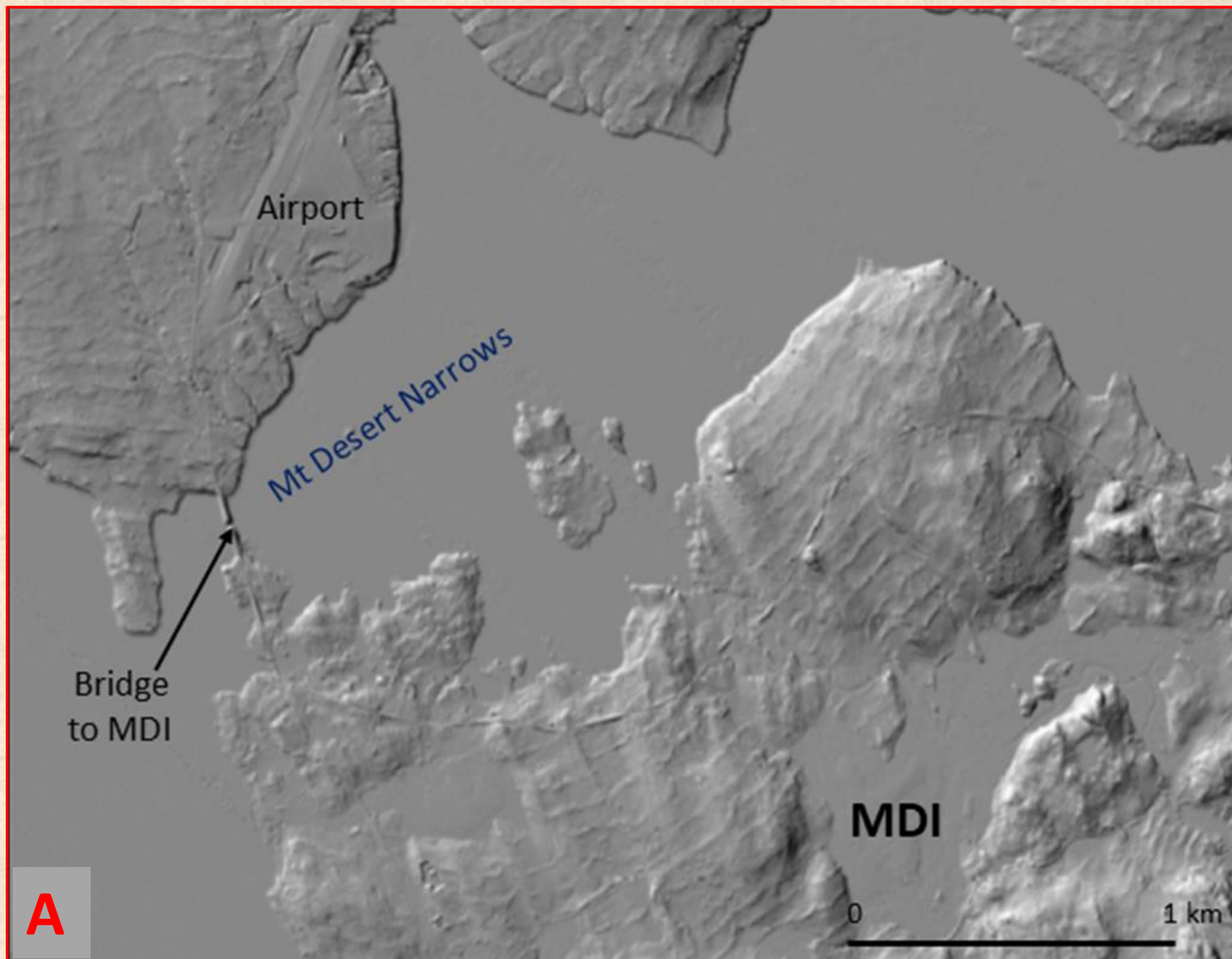
LiDAR from COA GIS laboratory

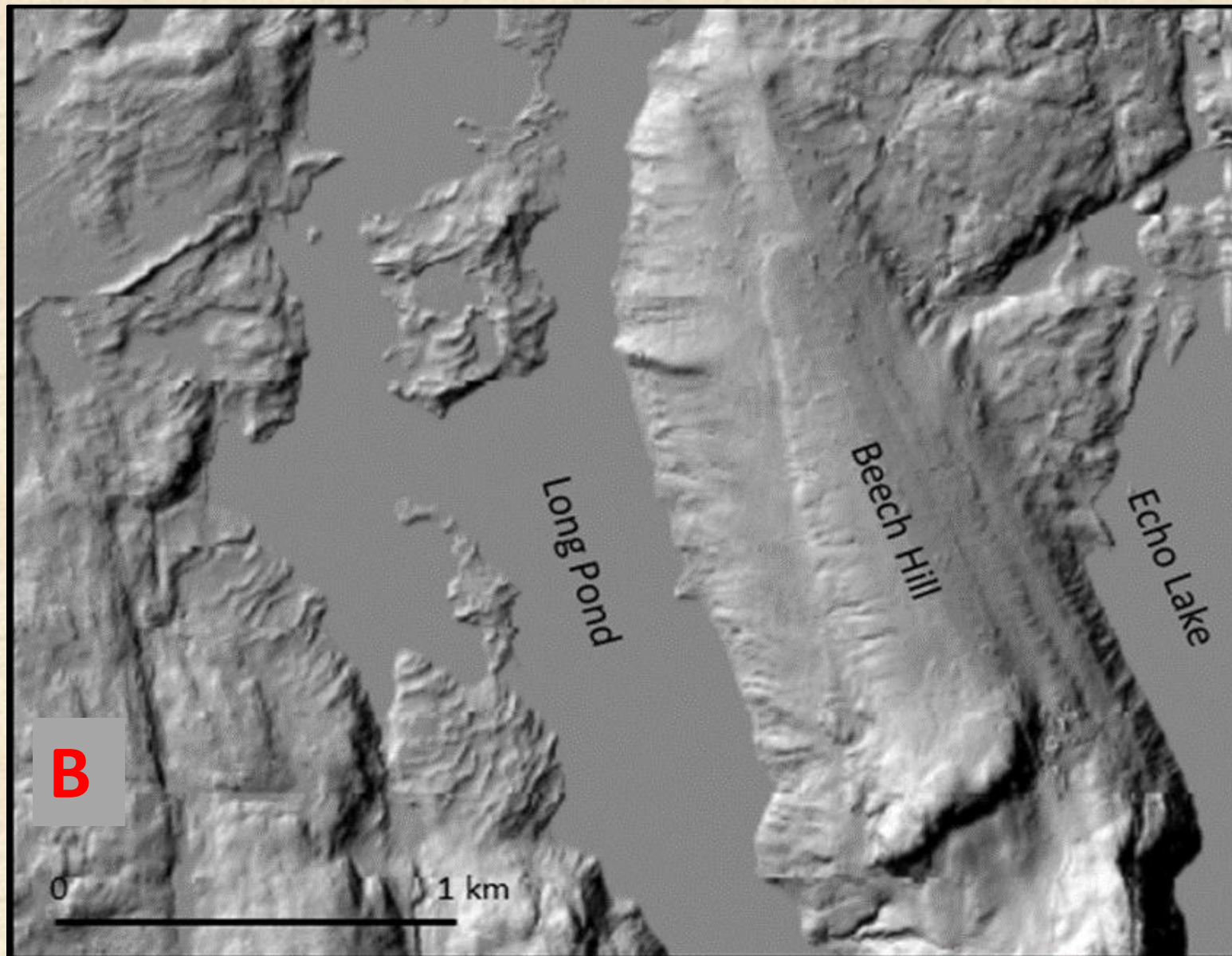




## Northern MDI and farther north

LiDAR close-up of the **widely spaced moraines**, 100-150 m (330–500 ft) between successive ridges, on the northern part of MDI and on the mainland north of MDI. Same scale as B and C that follow.

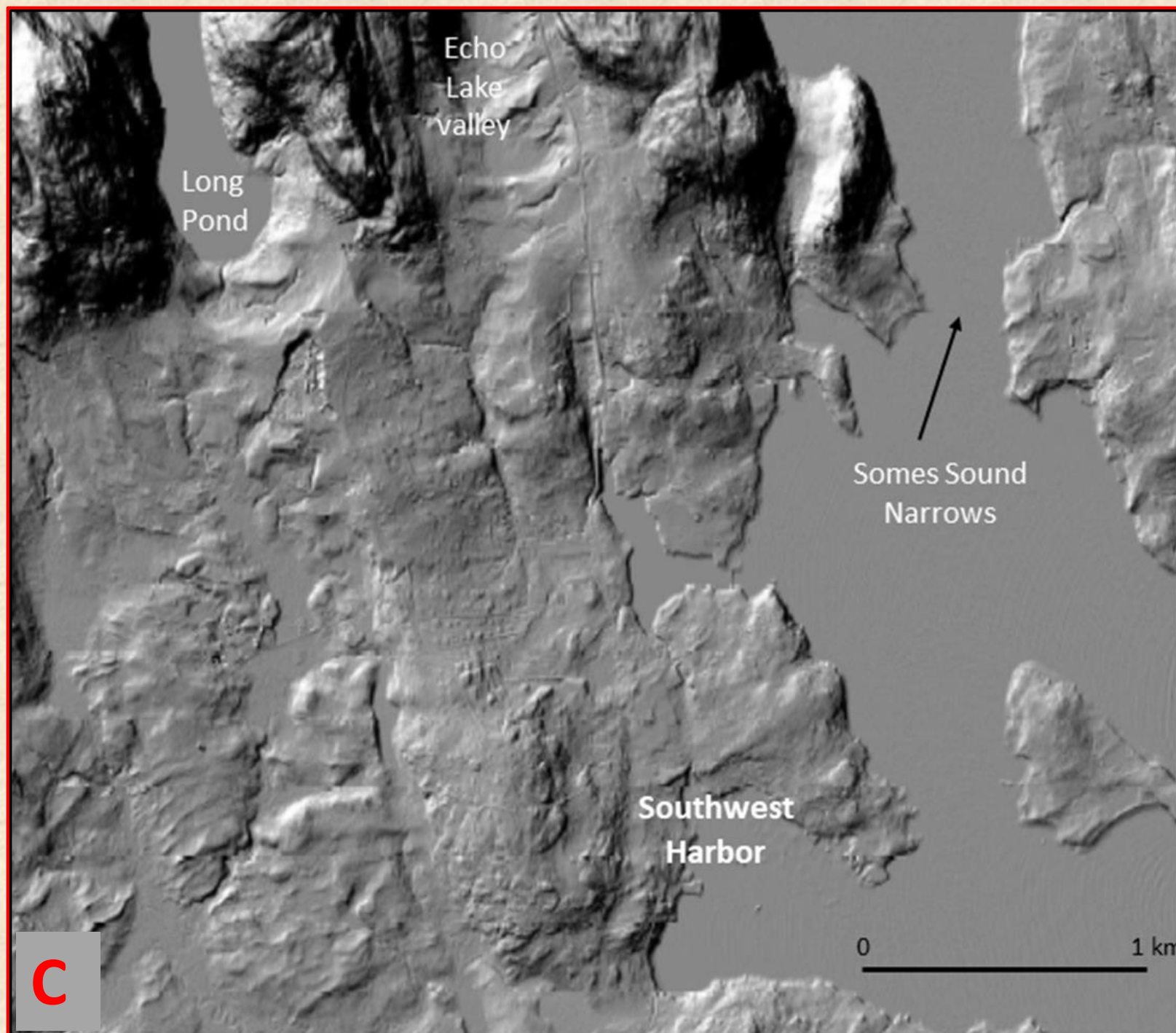




## Central MDI just north of the NE – SW mountain range crest

LiDAR close-up of the **closely spaced moraines** 20-50 m (60-165 ft) between successive ridges) on the middle part of MDI. The crests of the northeast – southwest trending mountain range on MDI are just south of this image and are at the top of the next image C

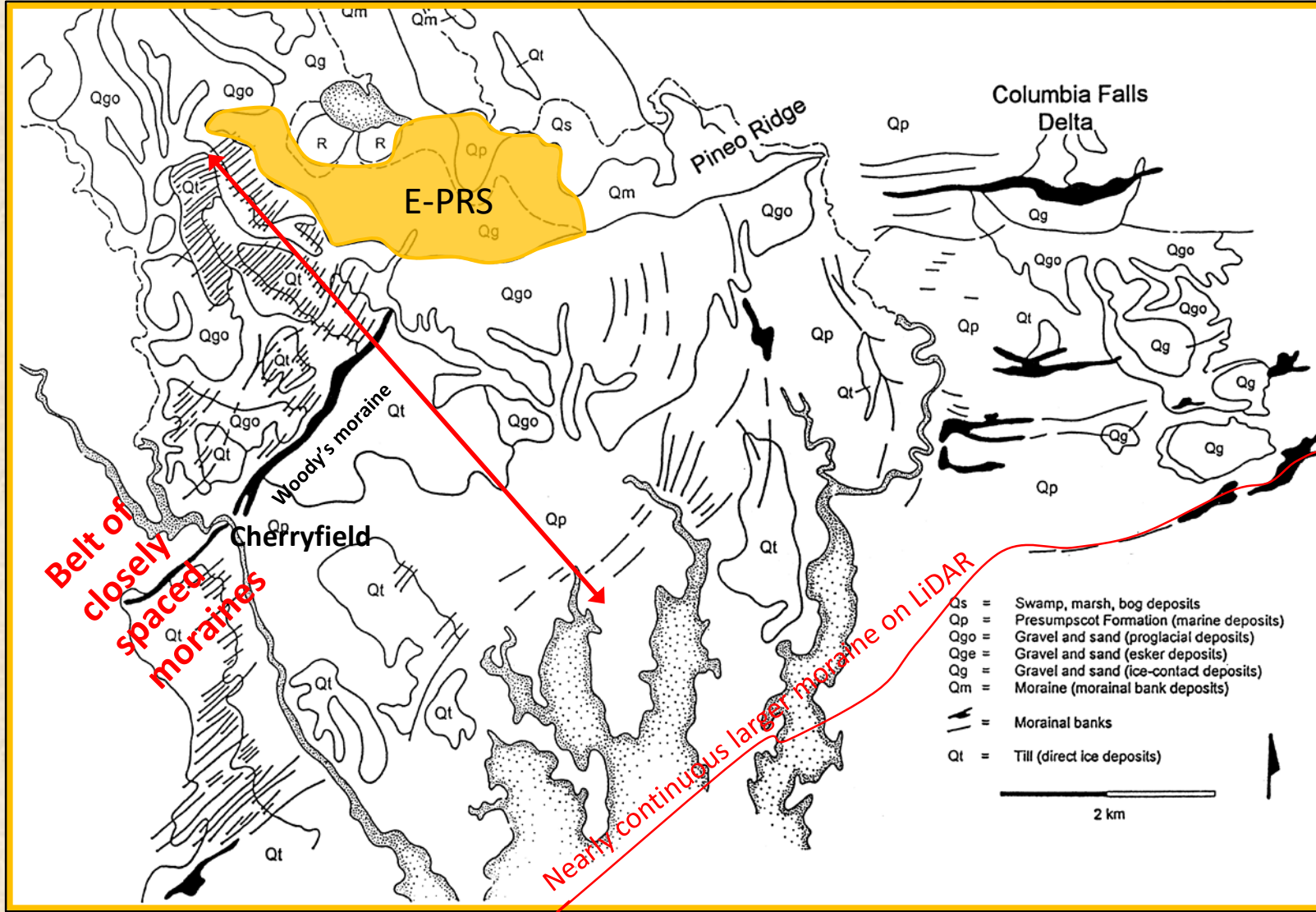




## MDI at and south of the mountain crests

LiDAR close-up of the south ends of the glacial troughs with several much larger moraines. South of there the moraines have a **somewhat variable spacing** of 30–100 m (100–330 ft).

## Identification of a zone of closely spaced moraines southwest of PRS prior to advent of LiDAR imagery

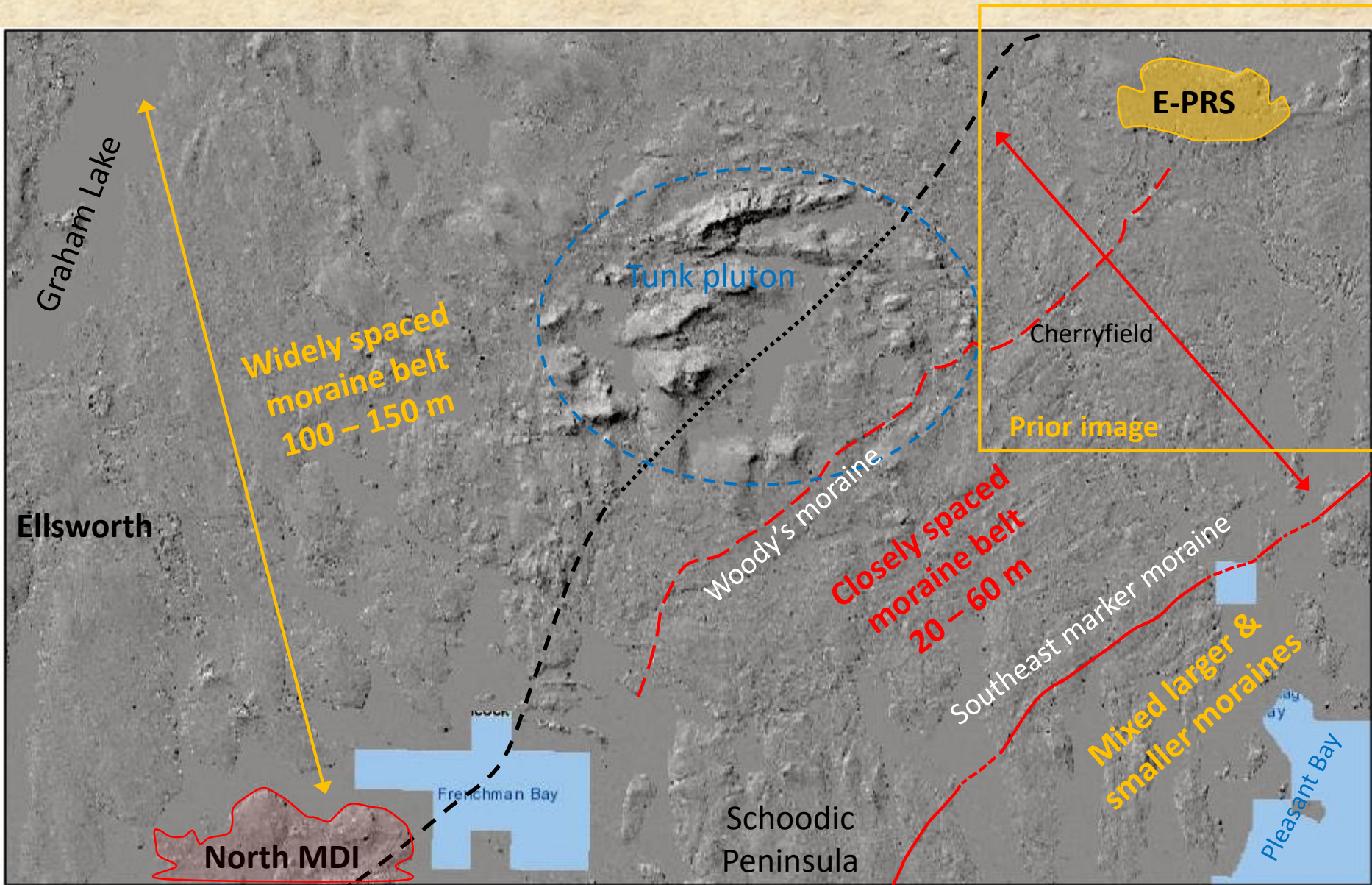


Surficial geology of portion of Cherryfield and Columbia Falls 7.5-minute quadrangles, Maine, showing location of Pineo Ridge (morainal bank) and Columbia Falls delta relative to the closely spaced moraine belt.

Quadrangle maps (Borns, 1975; Borns and Andersen, 1982). From Hunter & Smith, 2001, Morainal banks and the deglaciation of coastal Maine, fig. 6



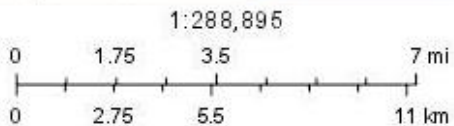
Closely spaced moraines in eastern Maine from the Pineo Ridge System (PRS) to MDI with the advent of LiDAR



The closely spaced moraine zone extends southwesterly from Pineo Ridge to MDI. Black dashed line marks the northwestern border of the zone while the continuous red line, a larger moraine, marks the southeastern border of the zone. The dashed red line is a prominent larger moraine within the zone that was traced southeast from PRS by Woody Thompson in 2010 - 2011.

Blue areas are where there is no LiDAR coverage.

LiDAR from Maine Geologic Survey



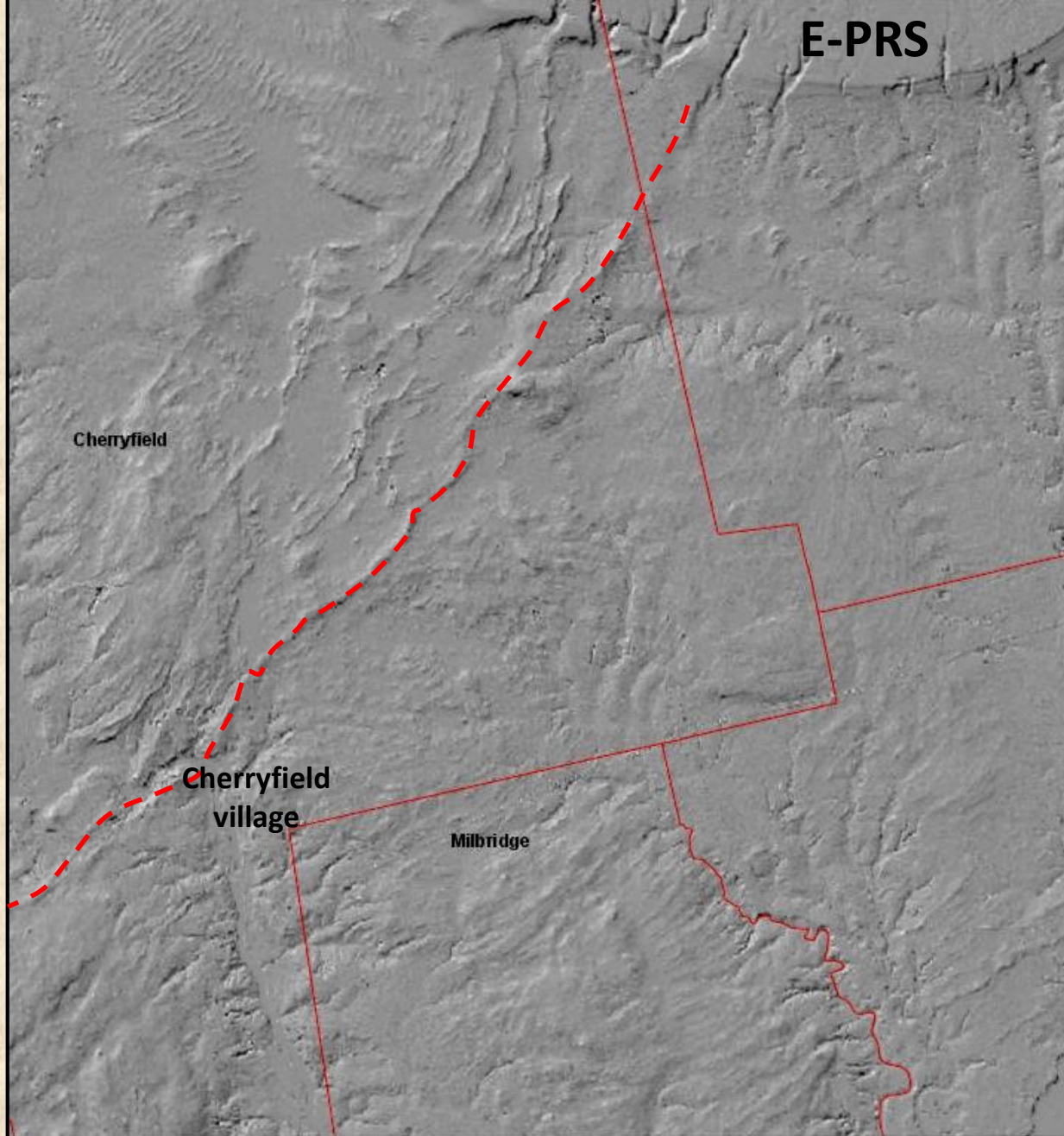


E-PRS

Tracing the larger distinct moraine  
(Woody's moraine) from PRS  
southwest towards MDI

**Thicker dashed red line** is  
the crest of the moraine

Town boundaries are  
thin **red lines**, some  
towns are named.

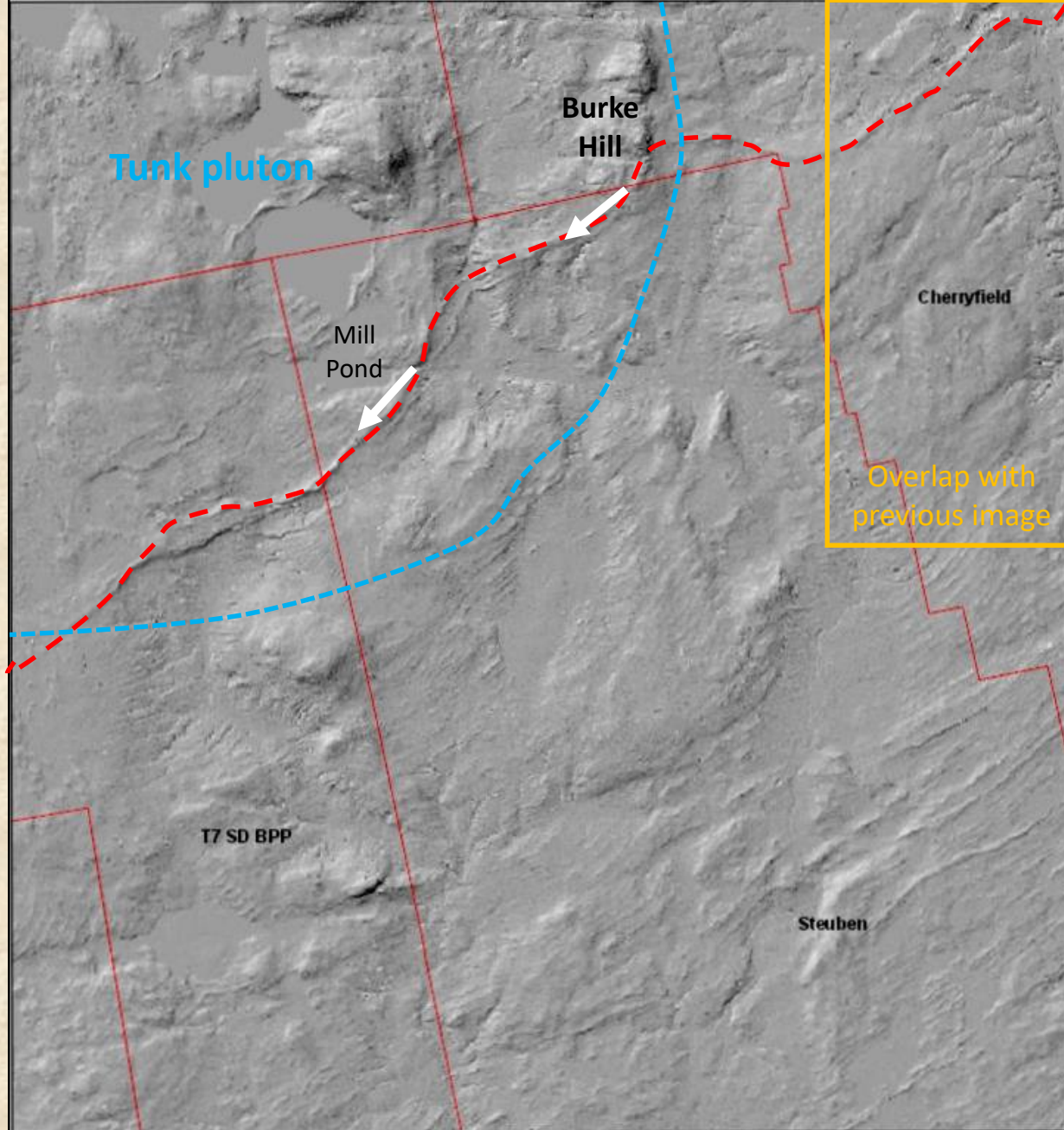


2/19/2019, 4:08:51 PM

Maine Towns

0 0.42 0.85 1.7 mi  
0 0.5 1 2 km





Tracing the larger distinct moraine  
(Woody's moraine) from PRS  
southwest towards MDI

**Thicker dashed red line** is  
the crest of the moraine

**White arrows** – next images  
- photos of the moraine in  
blueberry fields

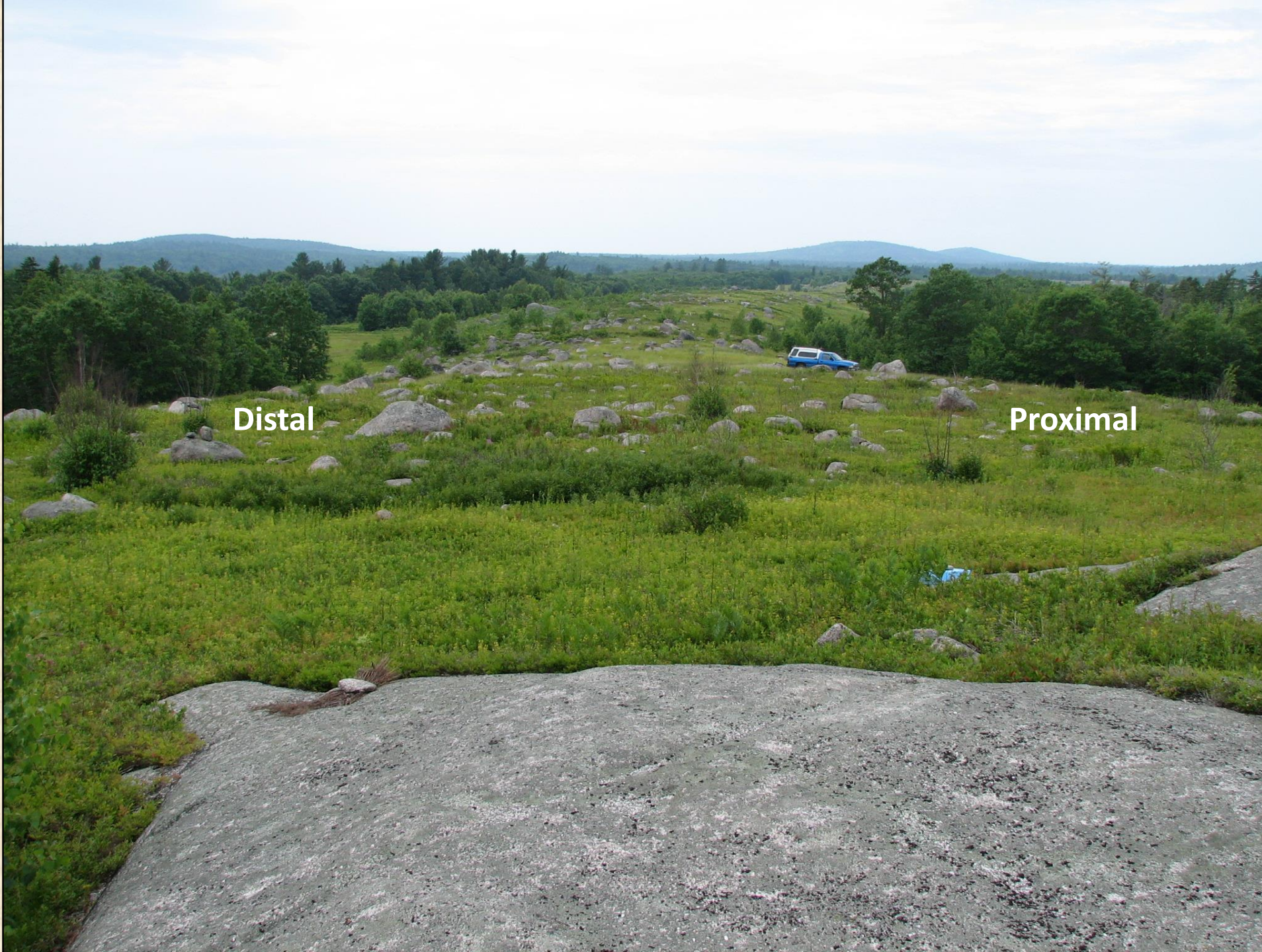
Town boundaries are  
thin **red lines**, some  
towns are named.

2/19/2019, 4:14:58 PM

Maine Towns

1:72,224  
0 0.42 0.85 1.7 mi  
0 0.5 1 2 km





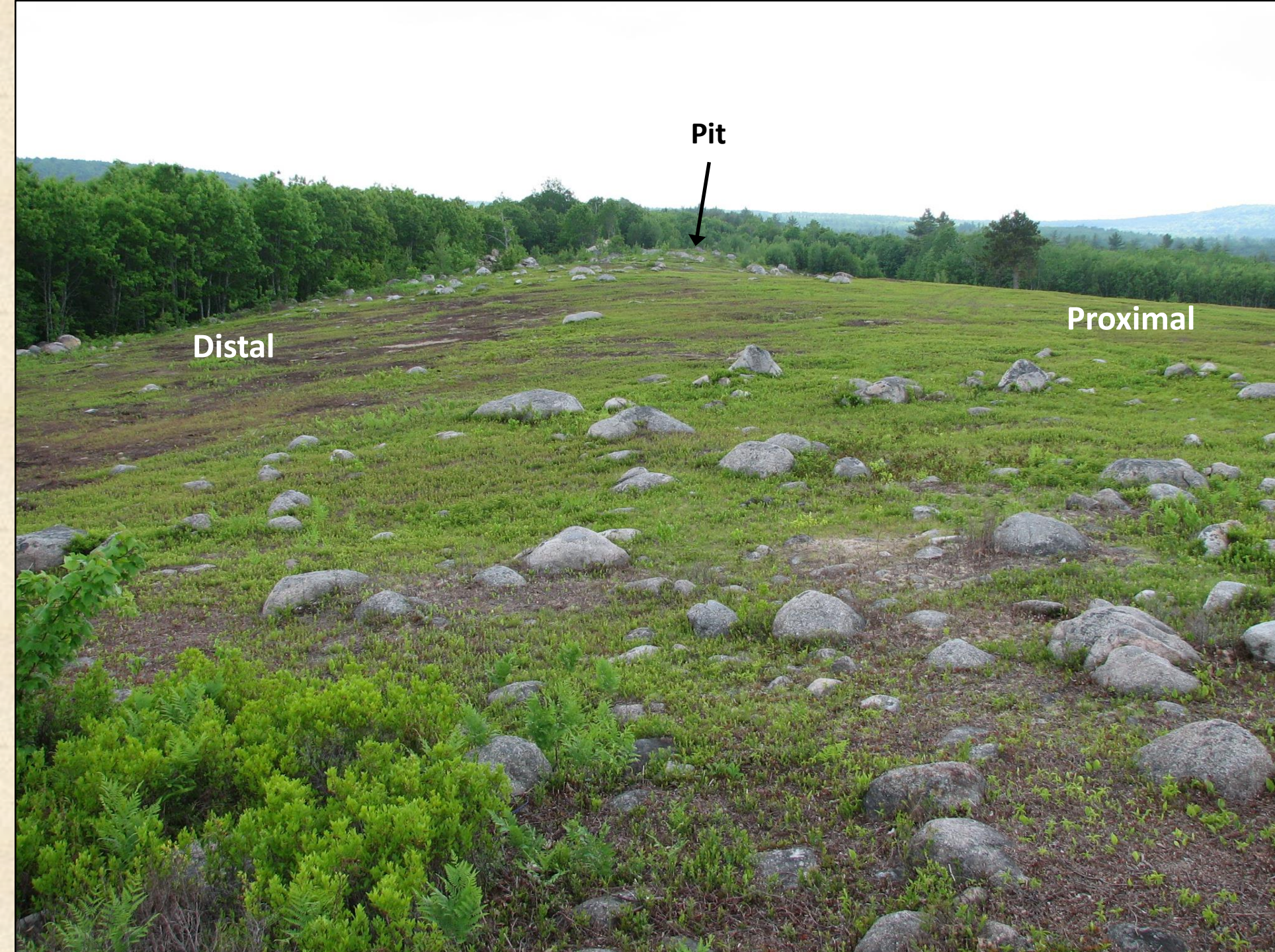
**Distal**

**Proximal**

**View looking to  
southwest along  
Woody's moraine from  
the south end of  
Burkes Hill – moraine is  
pinned to the bedrock  
in the foreground**

Ledge in foregrounds is at  
an elevation of about 73  
m (240 ft), highest stand  
of sea level is at about 82  
m (270 ft) in this area





**View to the southwest  
along the moraine crest**

Site is south of Mill Pond  
at an elevation of about  
73 m (240 ft), highest  
stand of sea level is at  
about 82 m (270 ft) in  
this area

Next image of a pit in  
the moraine is just  
southwest of this image





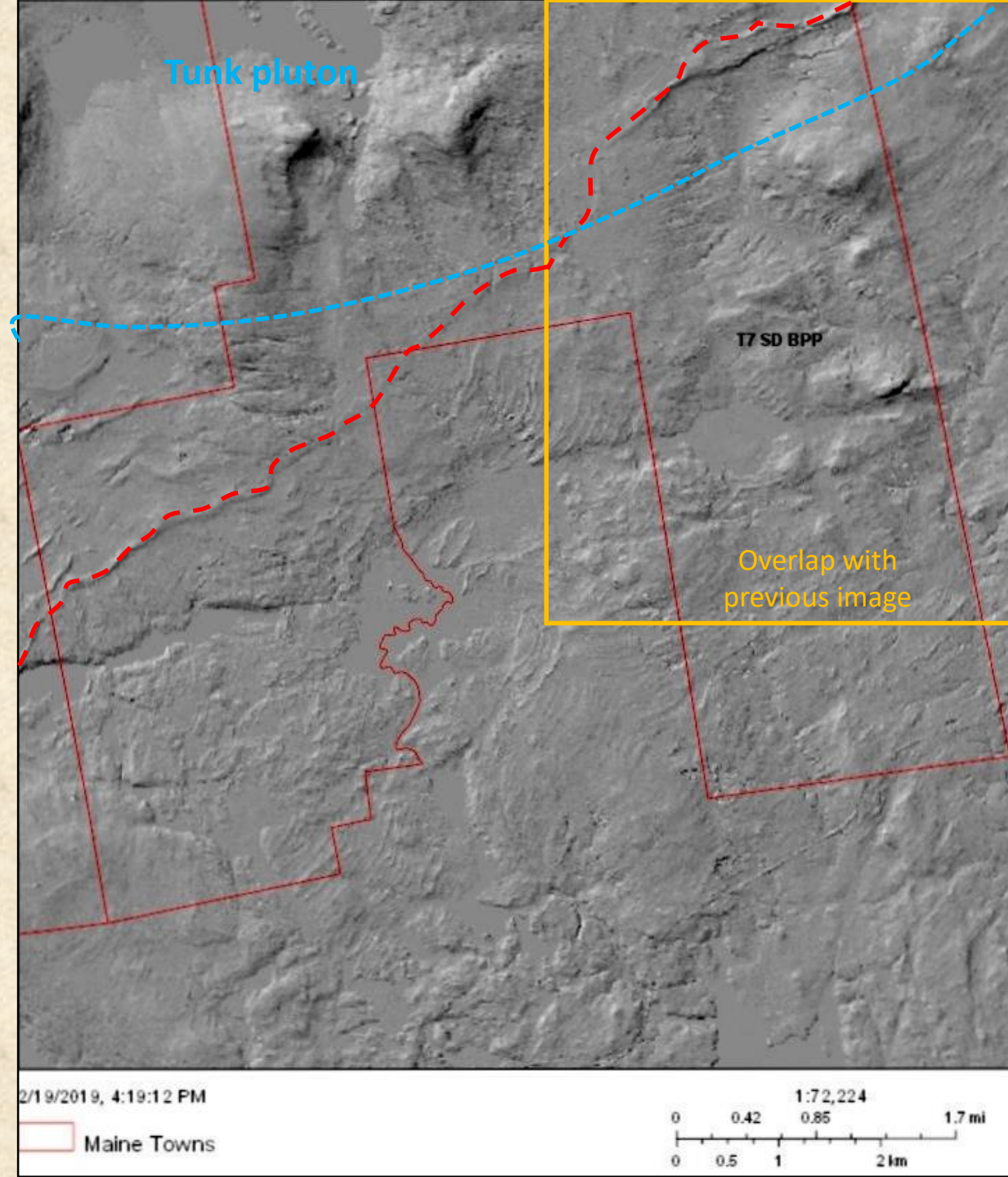
**Proximal**

**Distal**

**Exposure in the  
moraine showing  
bouldery till**

**Boulder concentration  
at the surface suggests  
some wave erosion.  
Subtle layering visible  
on the left**

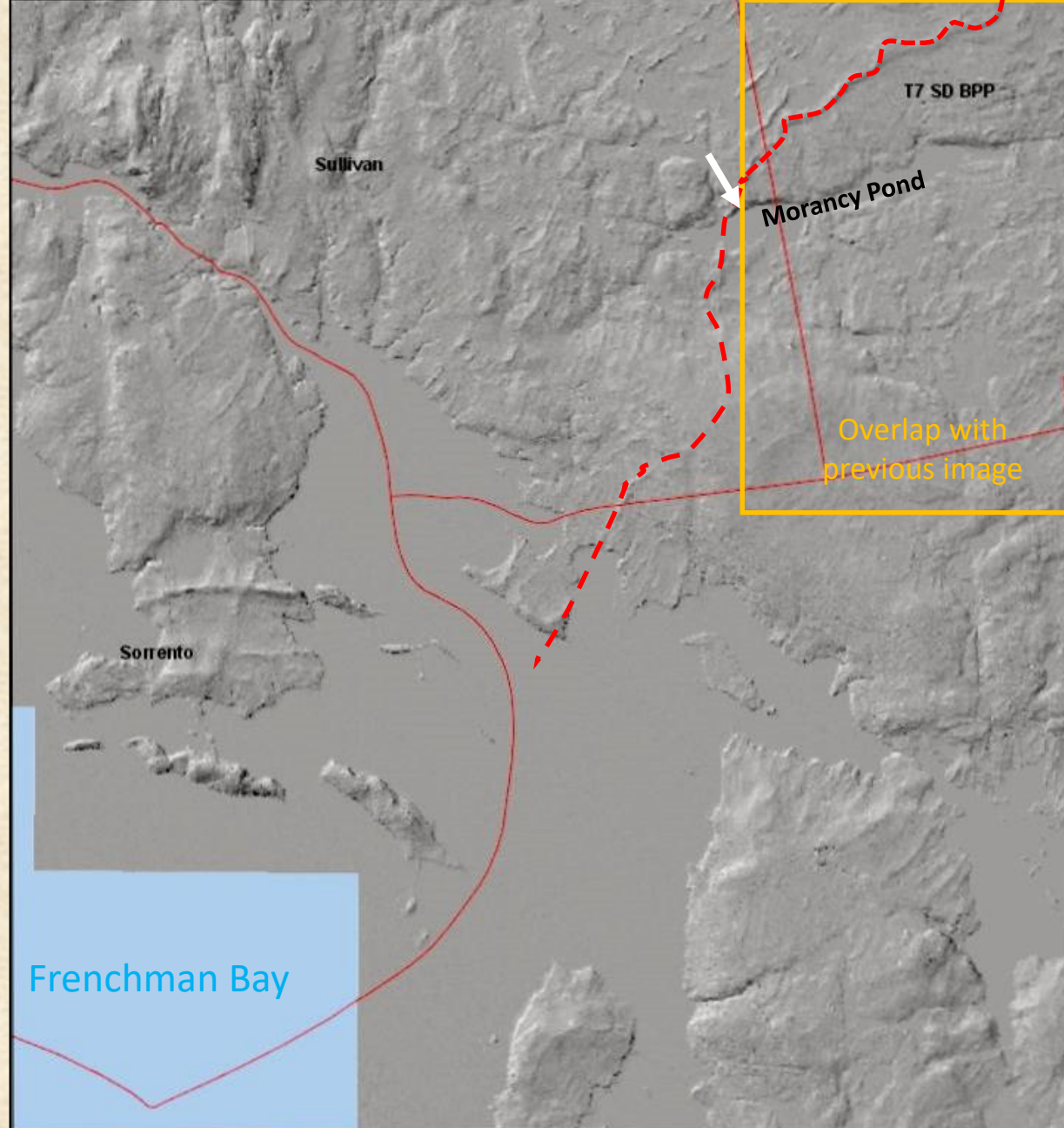




Tracing the larger distinct moraine  
(Woody's moraine) from PRS  
southwest towards MDI

**Thicker dashed red line** is  
the crest of the moraine

Town boundaries are  
thin **red lines**, some  
towns are named.



Tracing the larger distinct moraine  
(Woody's moraine) from PRS  
southwest towards MDI

**Thicker dashed red line** is  
the crest of the moraine

**White arrow** – next image -  
photo of the moraine in a  
logged area

Town boundaries are  
thin **red lines**, some  
towns are named.

2/19/2019, 4:23:26 PM

Maine Towns

1:72,224  
0 0.42 0.85 1.7 mi  
0 0.5 1 2 km

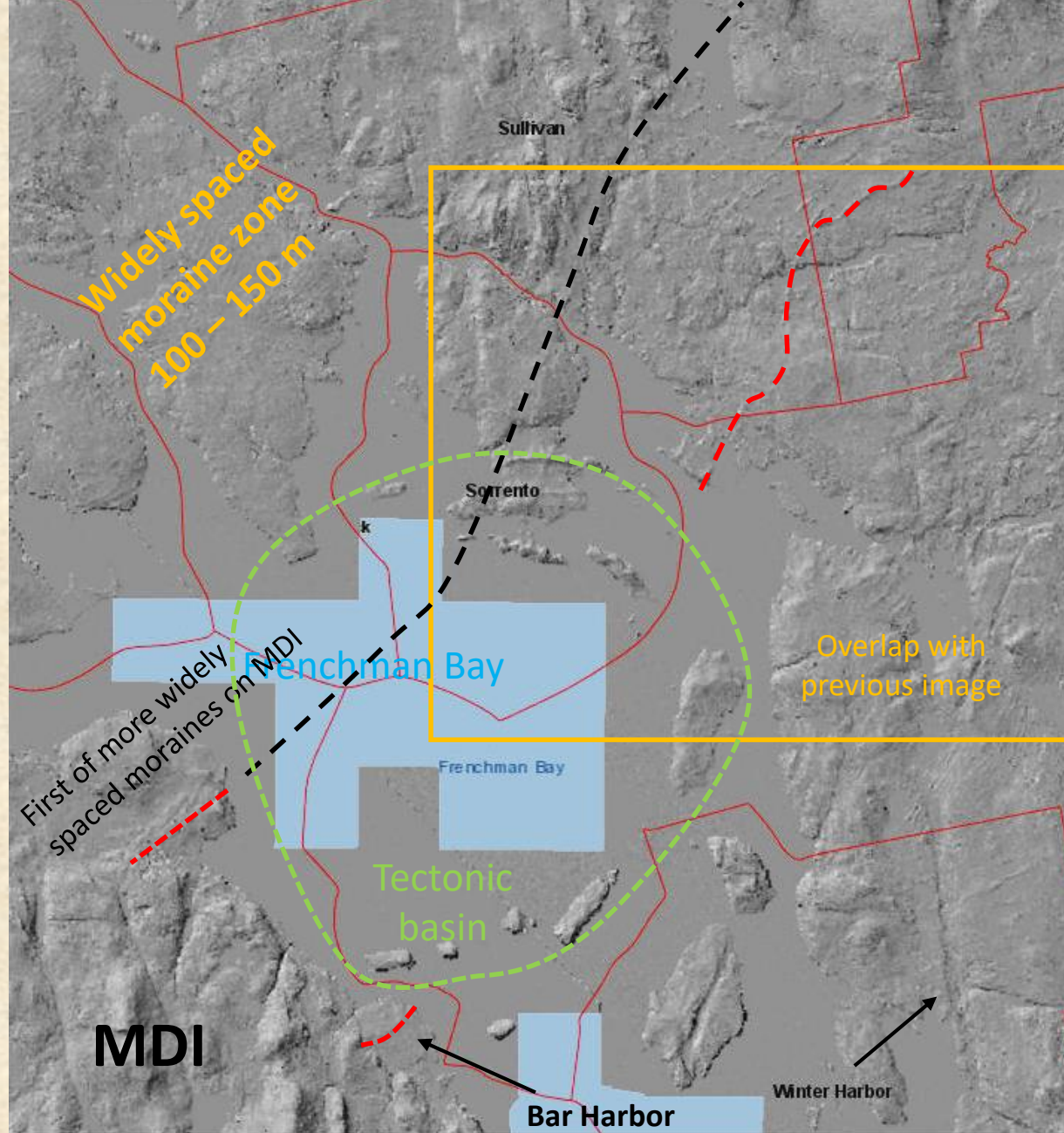




**View looking southeast  
at the proximal side of  
the moraine**

Site is near Morancy  
Pond at an elevation of  
about 55 m (180 ft),  
highest stand of sea  
level is at about 79 m  
(260 ft) in this area





Tracing the larger distinct moraine  
(Woody's moraine) from PRS  
southwest towards MDI

**Thicker dashed red line** is  
the crest of the moraine

Town boundaries are  
thin **red lines**, some  
towns are named.

This image is at a reduced smaller  
scale to reach across Frenchman Bay

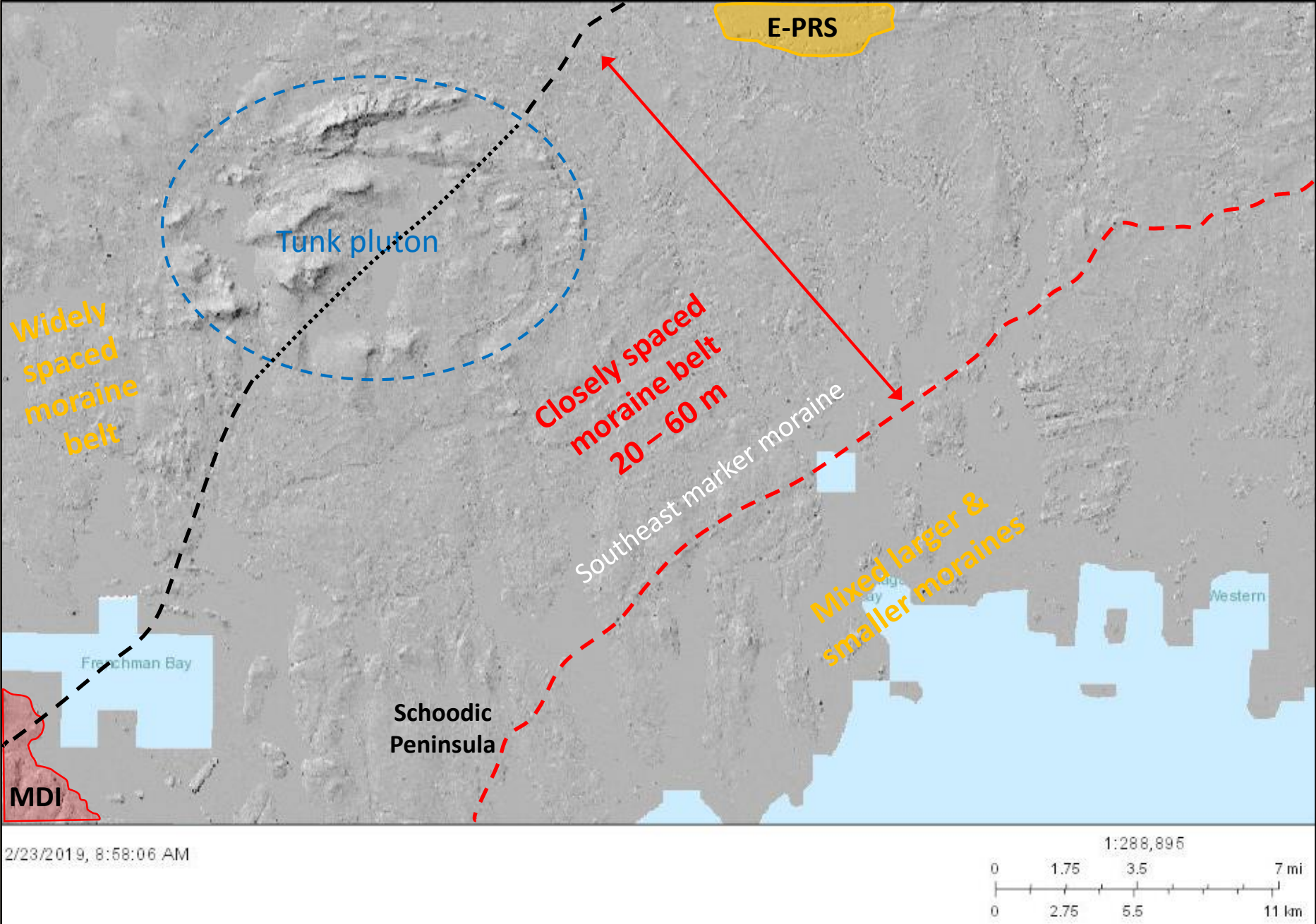
2/19/2019, 4:39:20 PM

Maine Towns

1:144,448  
0 0.75 1.5 3 mi  
0 1.25 2.5 5 km



Tracing the larger moraine that marks the southeastern edge of the closely spaced moraine belt to the southwest





East end of East PRS is  
8 km north of here

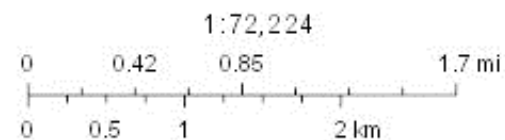
*Pleasant River*

Esker with a chain  
of fans and deltas  
extending back to  
the east end of PRS

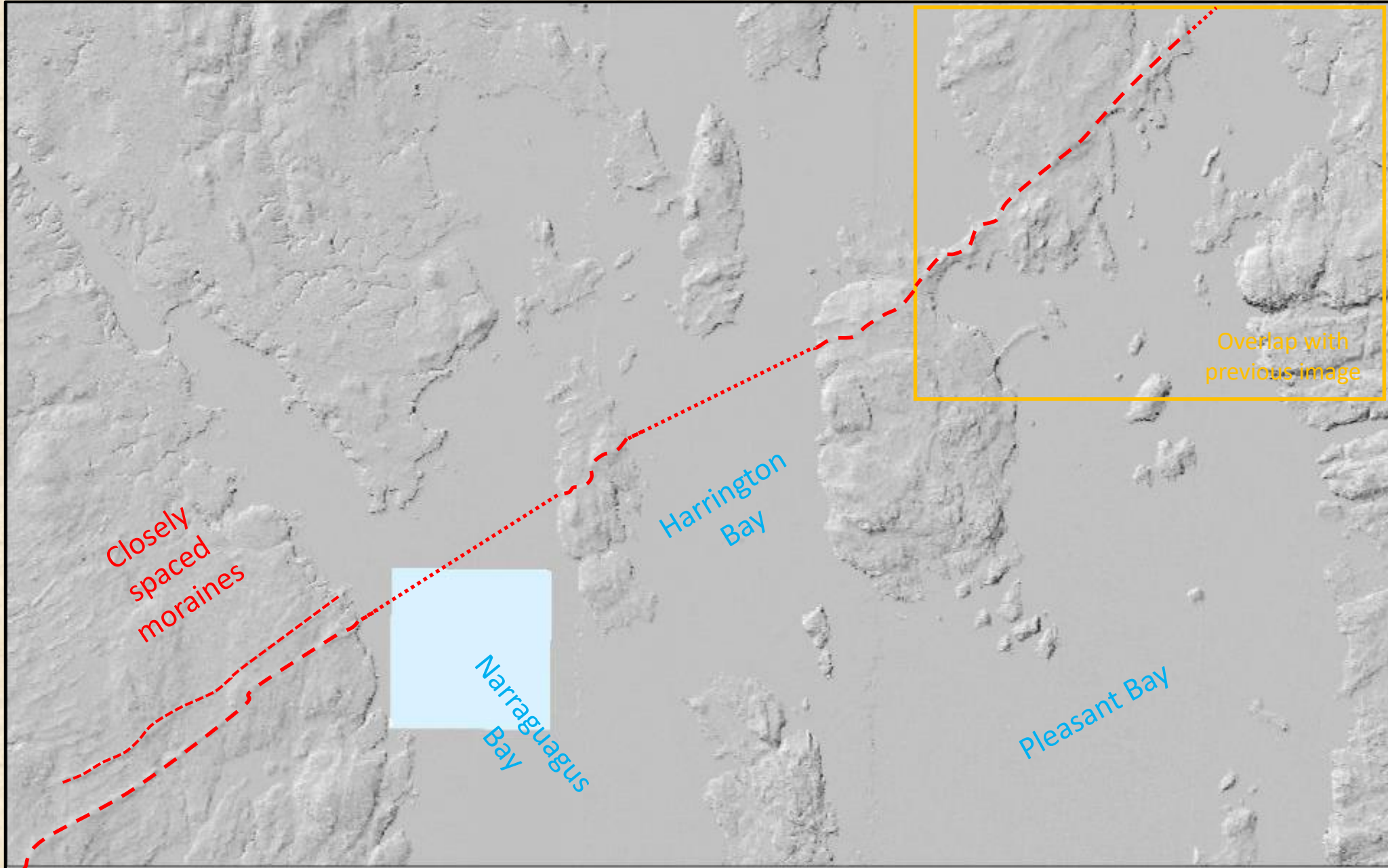
**Tracing the larger  
moraine that marks the  
southeastern edge of  
the closely spaced  
moraine belt to the  
southwest**

**Northeast most image**

2/20/2019, 9:20:29 AM

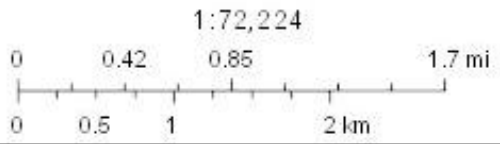




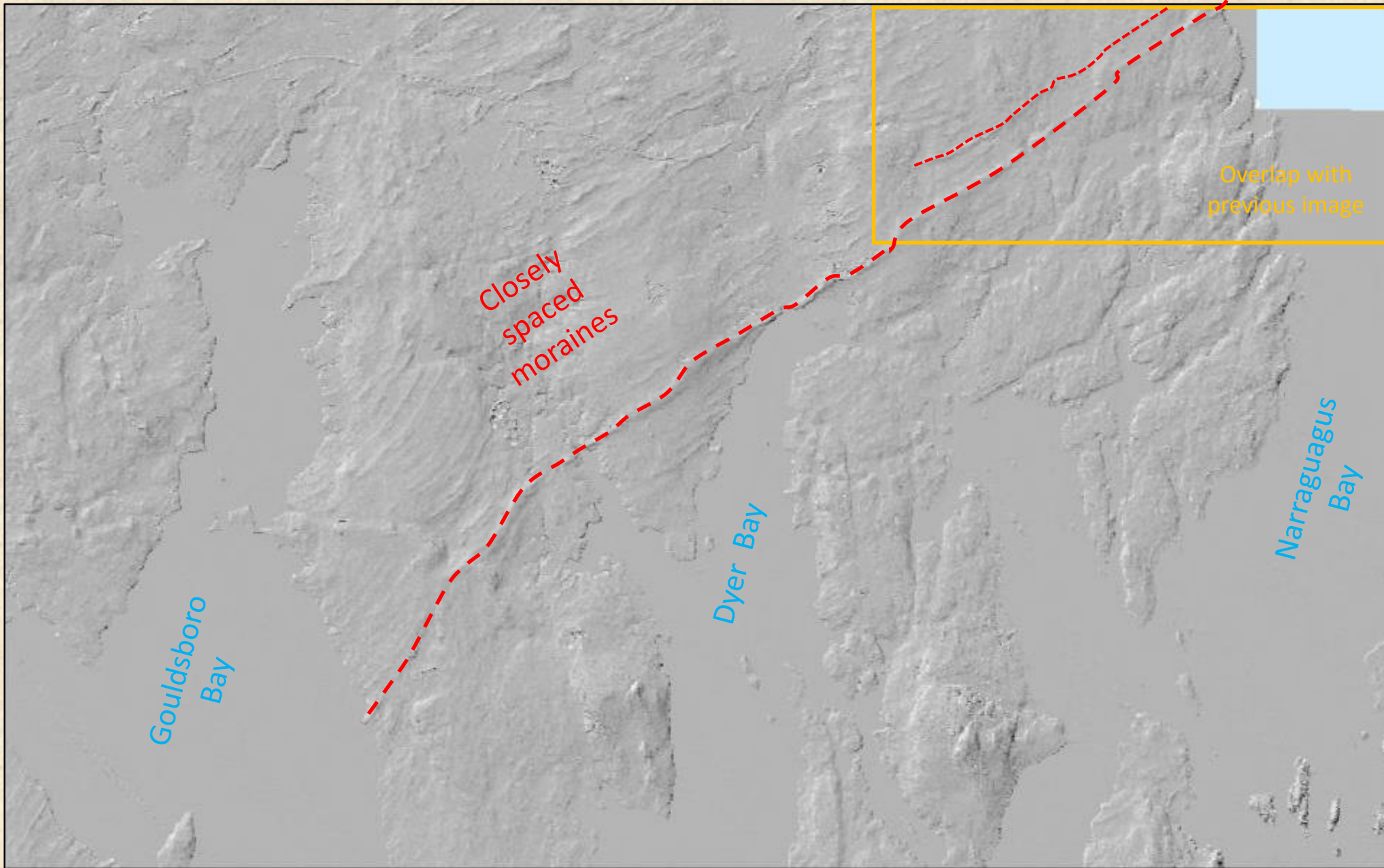


Tracing the larger moraine that marks the southeastern edge of the closely spaced moraine belt to the southwest

2/20/2019, 9:22:42 AM

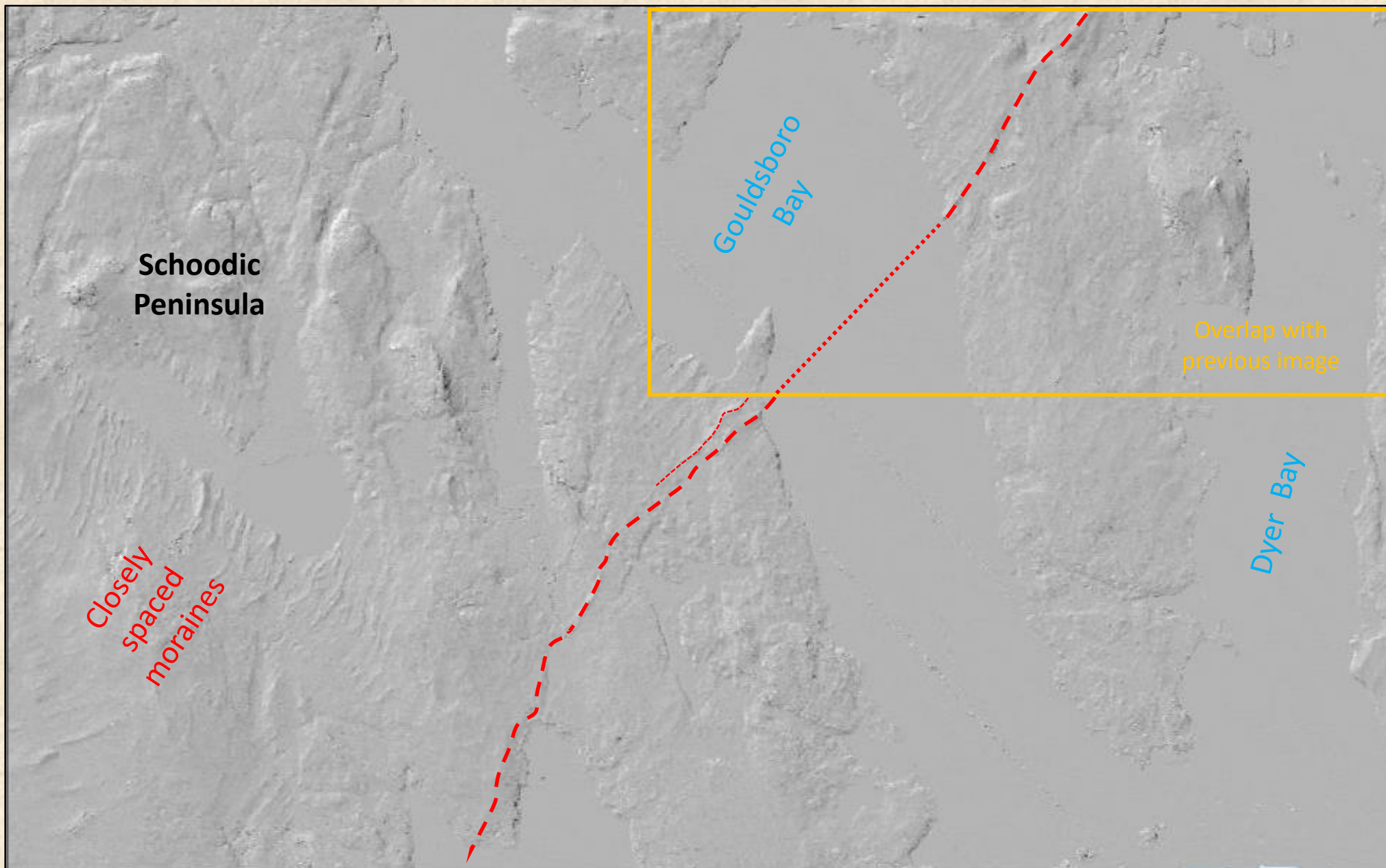






Tracing the larger moraine that marks the southeastern edge of the closely spaced moraine belt to the southwest





**Tracing the larger moraine that marks the southeastern edge of the closely spaced moraine belt to the southwest**

Overlap with previous image

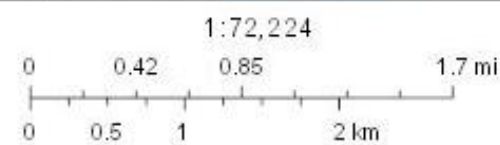
Gouldsboro Bay

Dyer Bay

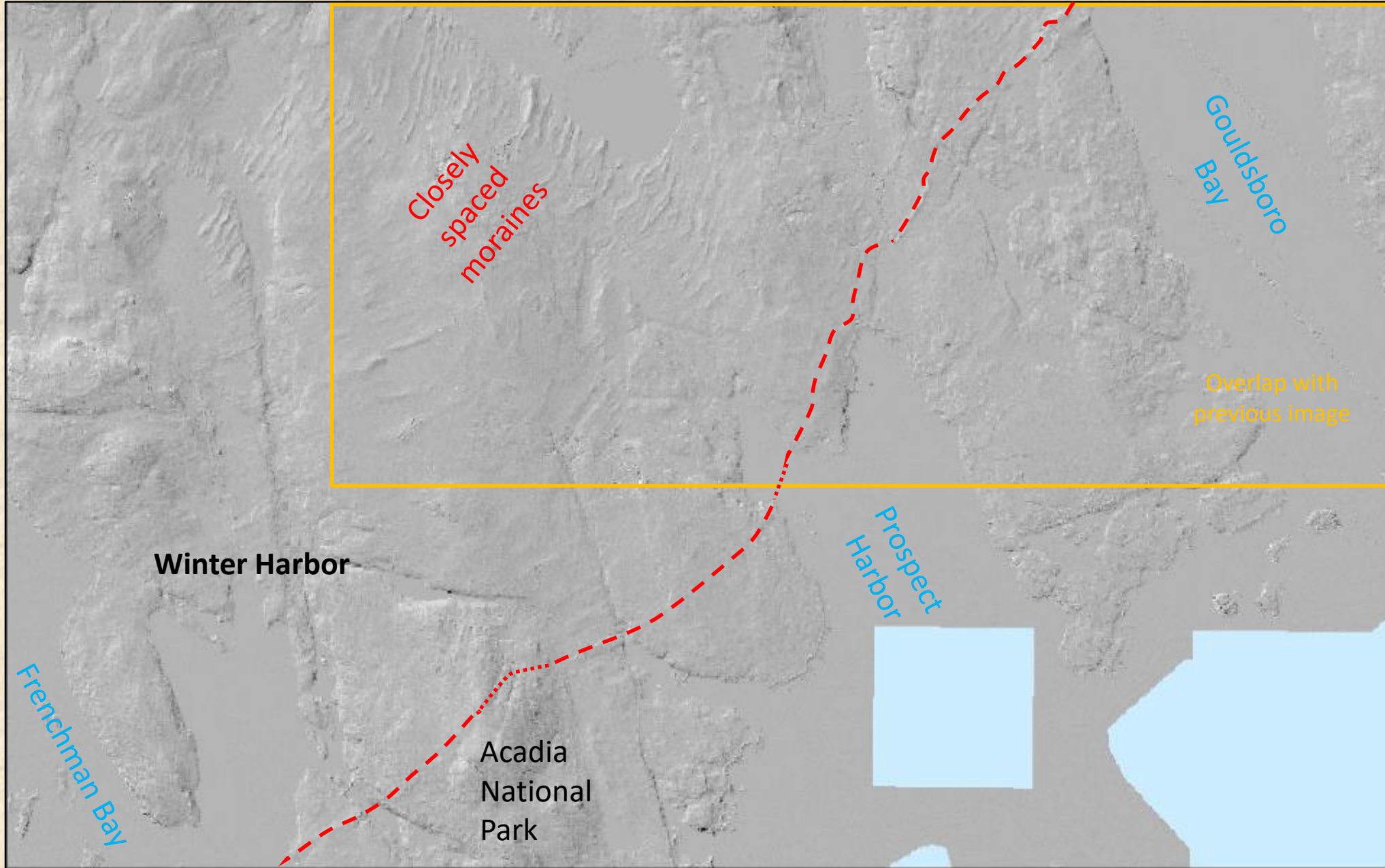
Closely spaced moraines

Schoodic Peninsula

2/20/2019, 9:26:38 AM

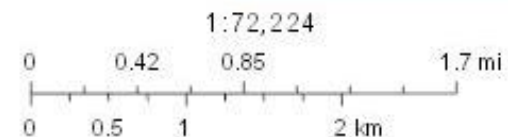




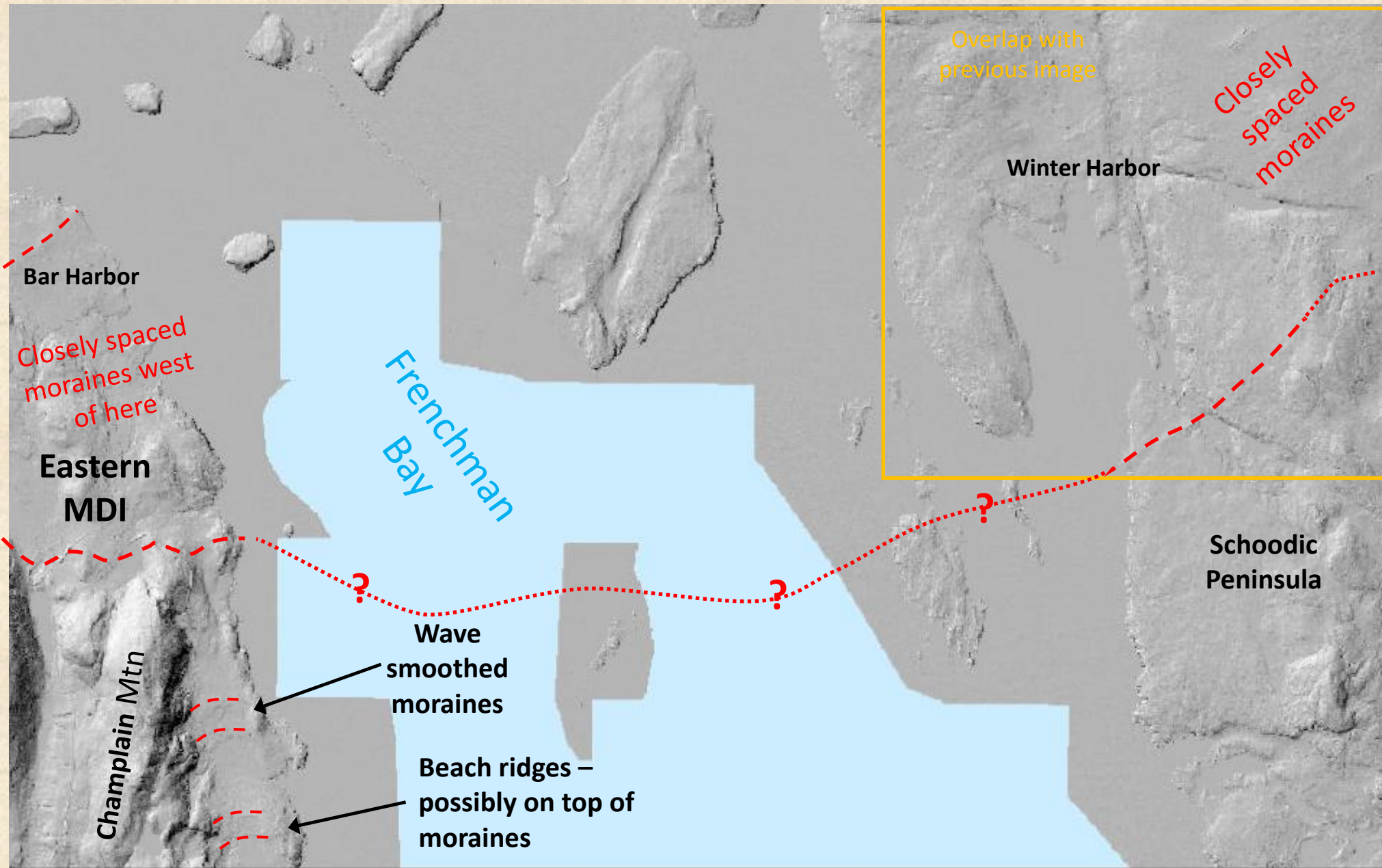


Tracing the larger moraine that marks the southeastern edge of the closely spaced moraine belt to the southwest

2/23/2019, 9:08:27 AM



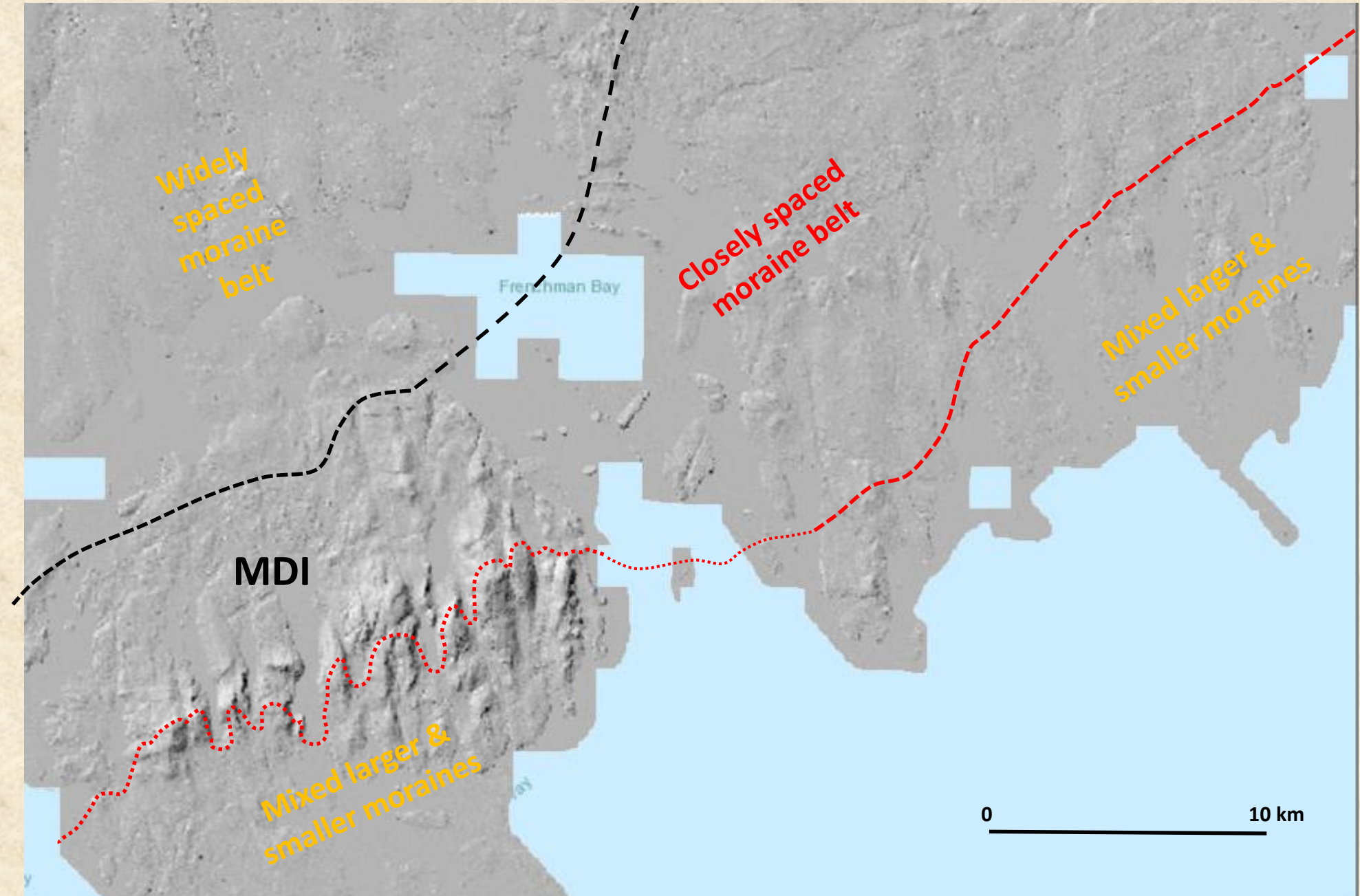




Tracing the larger moraine that marks the southeastern edge of the closely spaced moraine belt to the southwest to MDI

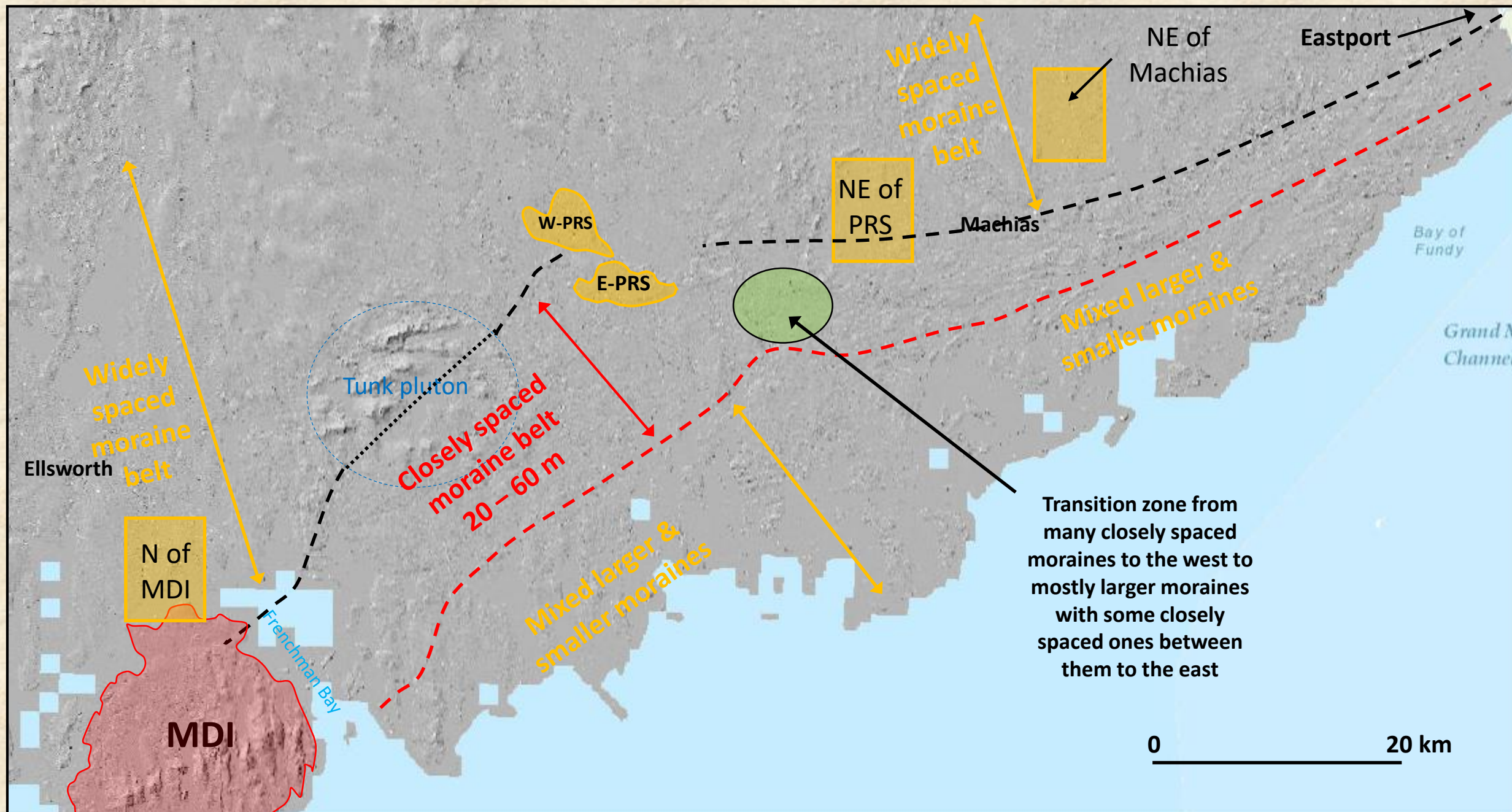


The two marker moraines from PRS can be traced towards but not directly to MDI thanks to Frenchman Bay



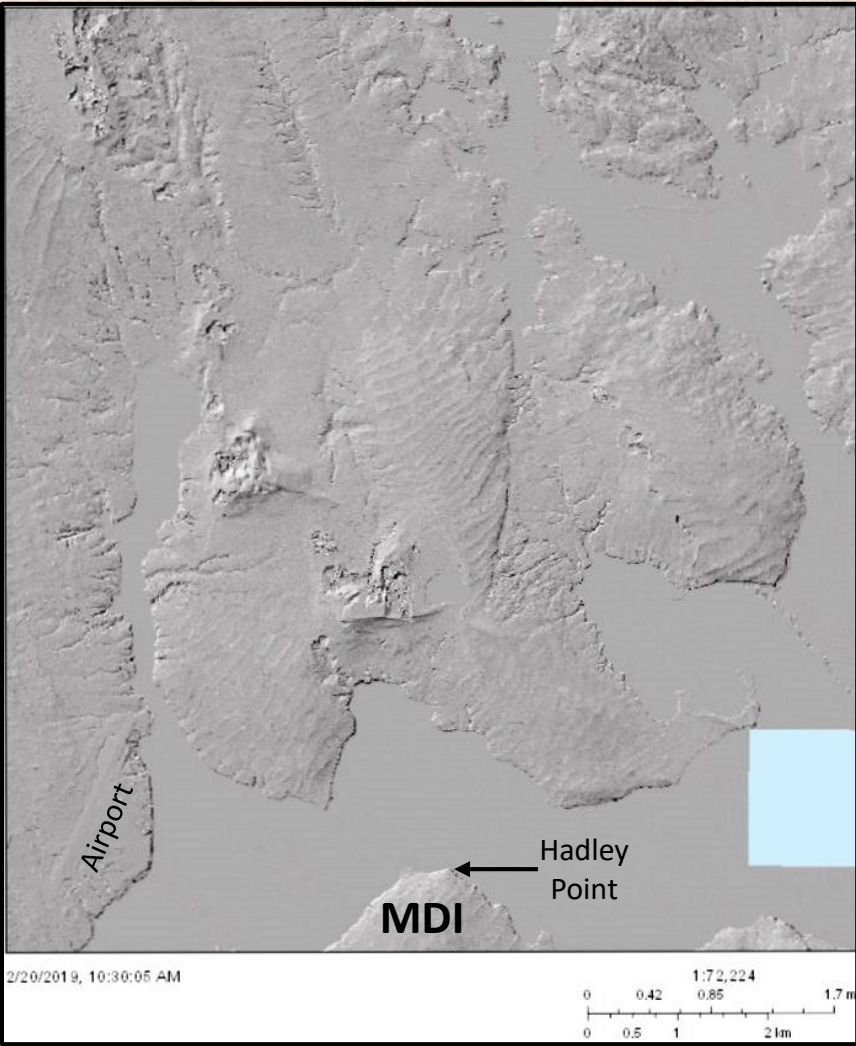


# MDI to PRS to Eastport overview showing locations of widely spaced moraine images that follow

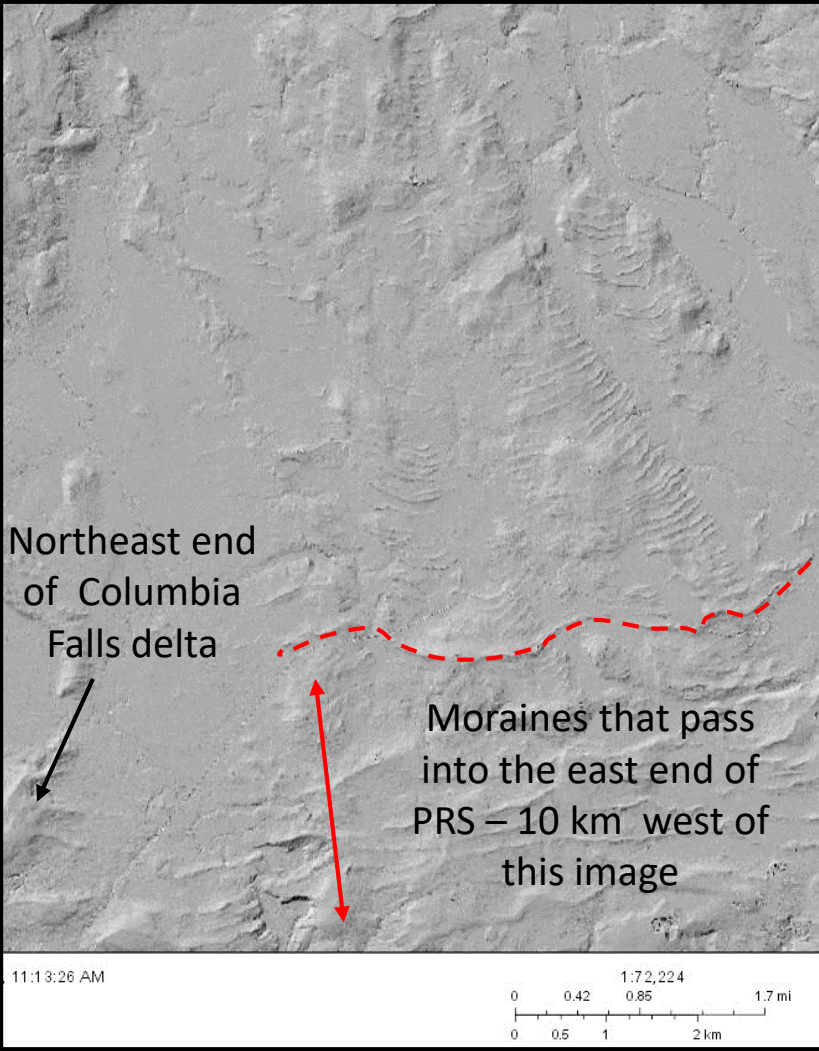




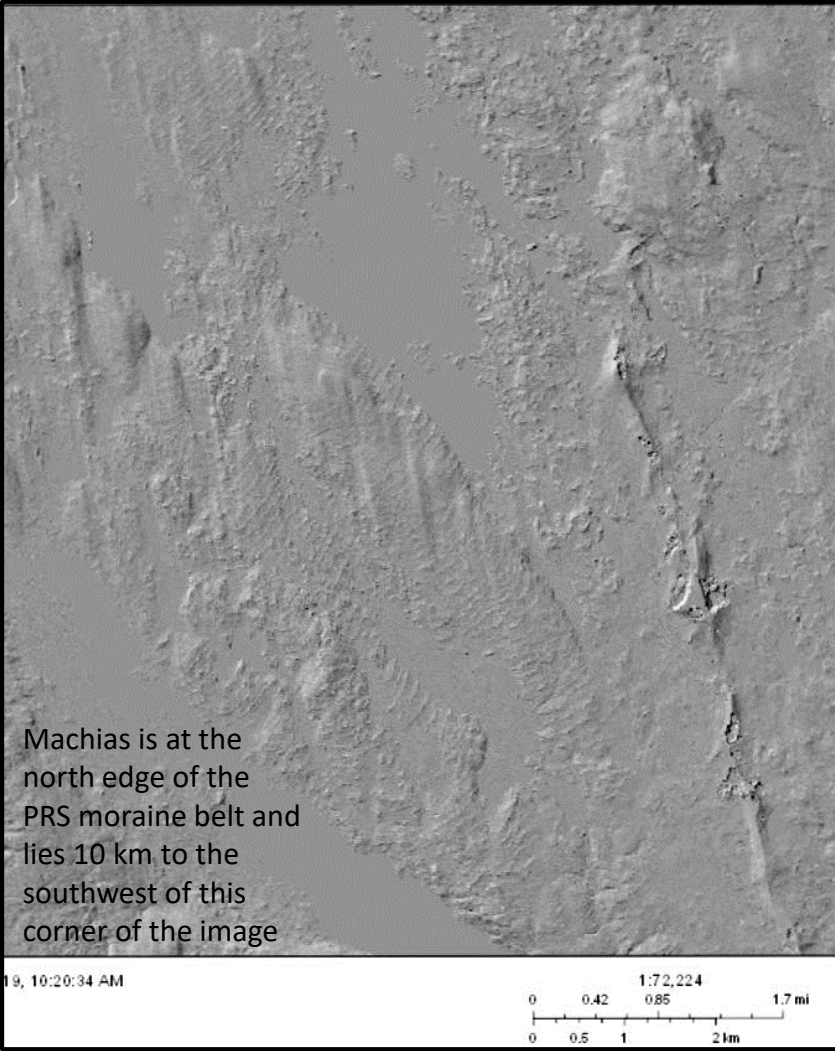
Widely spaced moraines north of MDI



Widely spaced moraines northeast of PRS and Columbia Falls delta

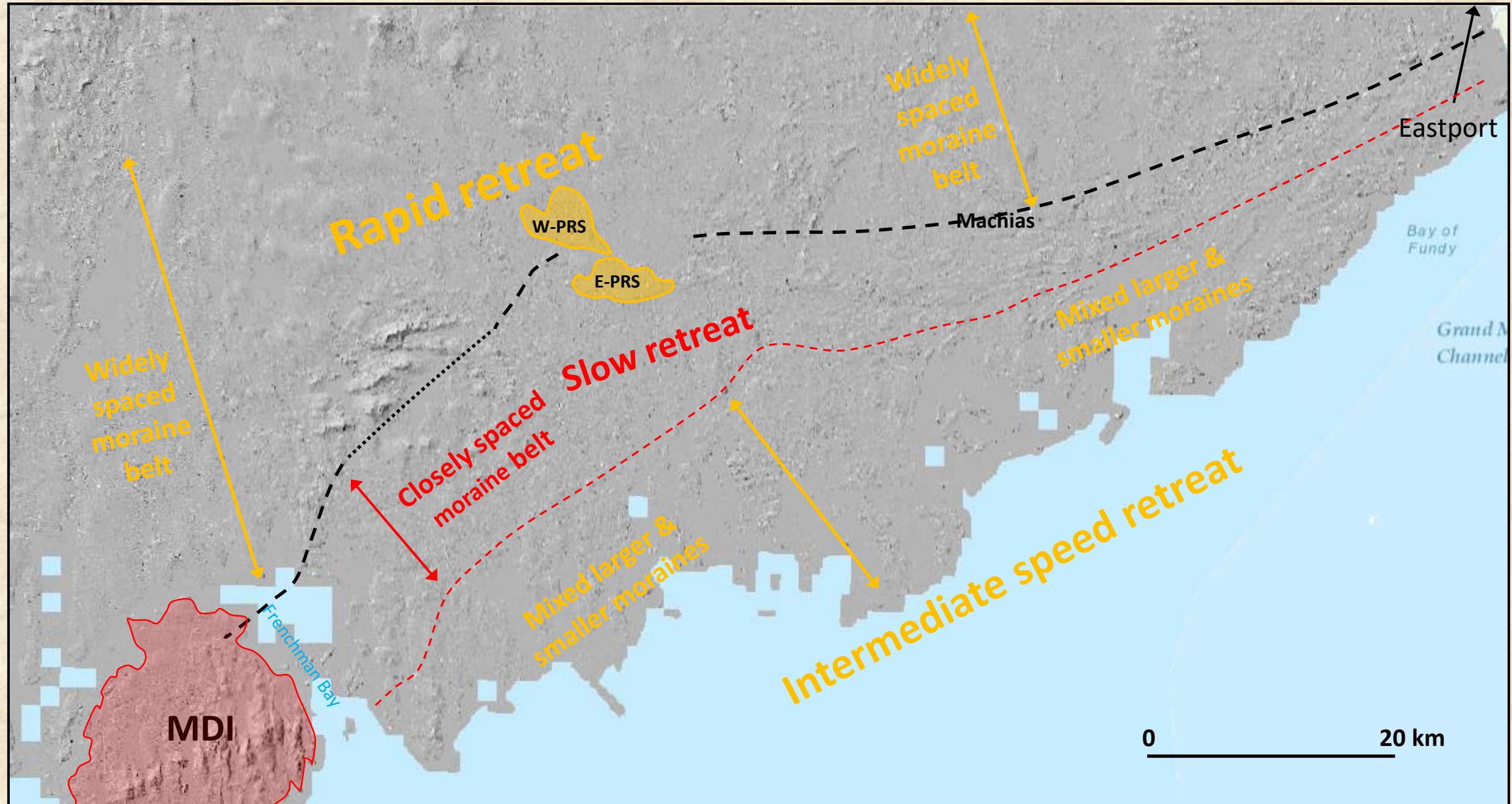


Widely spaced moraines northeast of Machias



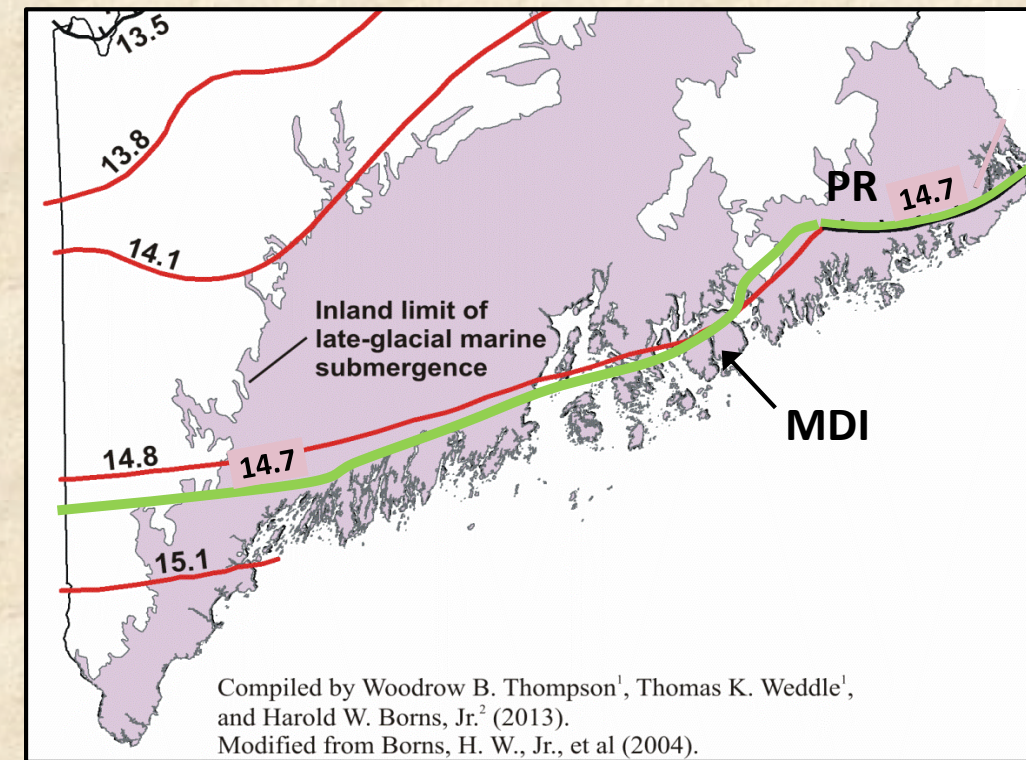
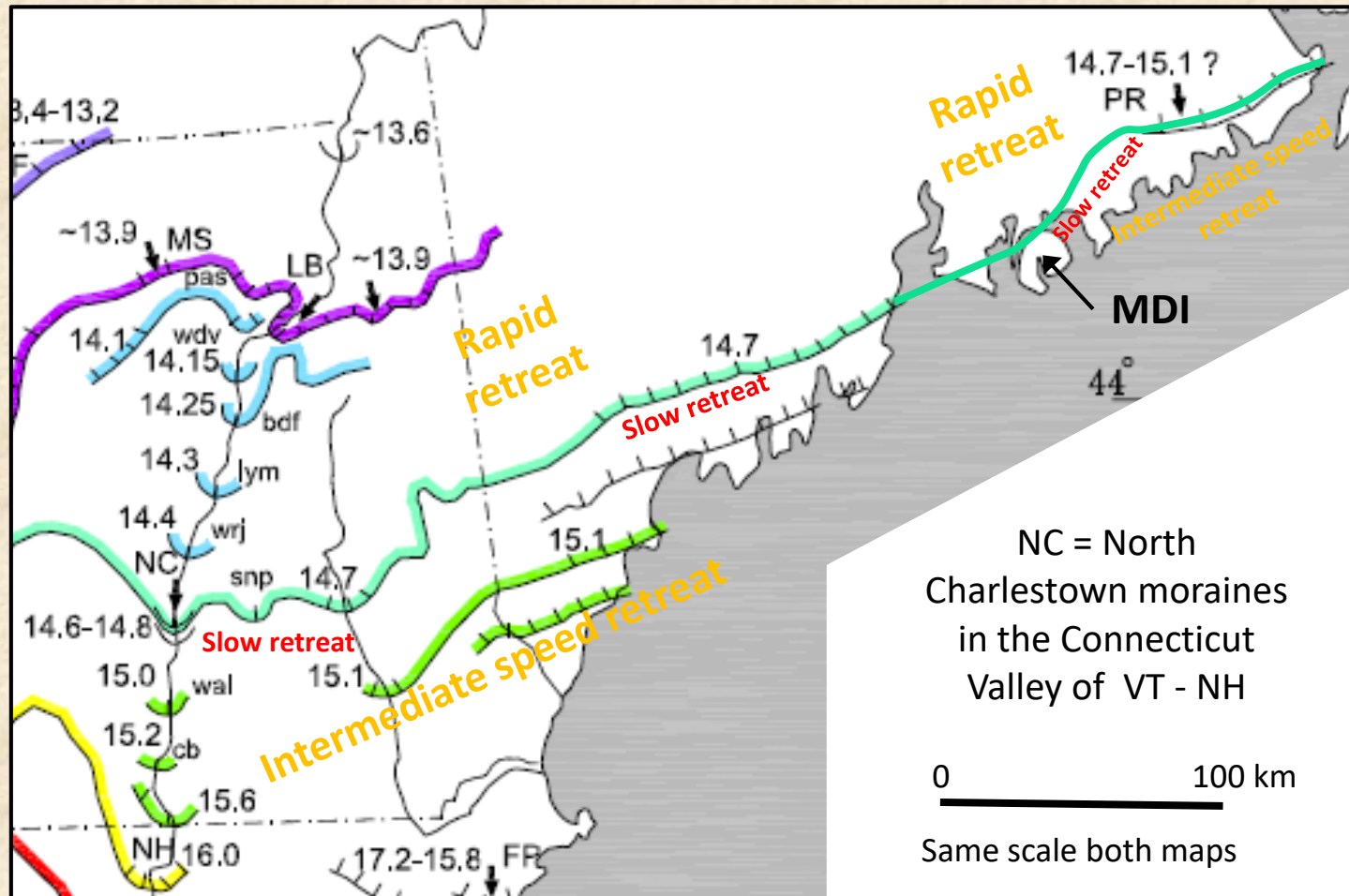


**Downeast Maine ice front retreat – intermediate speed - then a distinct slowing - then a rapid speed up for 100's of years**





# Matching the Connecticut Valley retreat record to the Downeast Maine retreat record at 14.7 ka

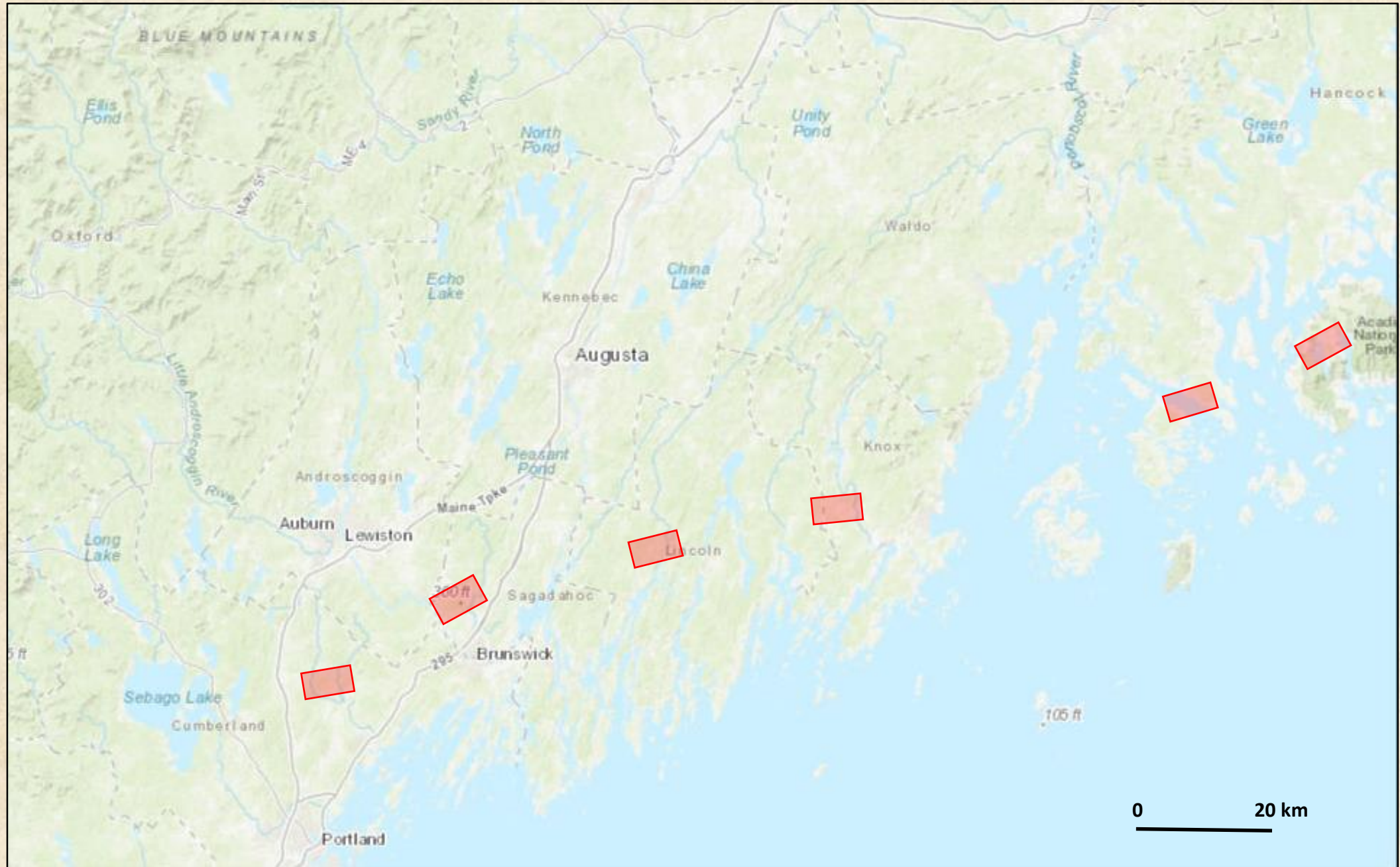


**Green line** above – Braun's present preliminary projection the MDI – PRS closely spaced moraine belt to the southwest along mid-coast Maine and into western Maine.

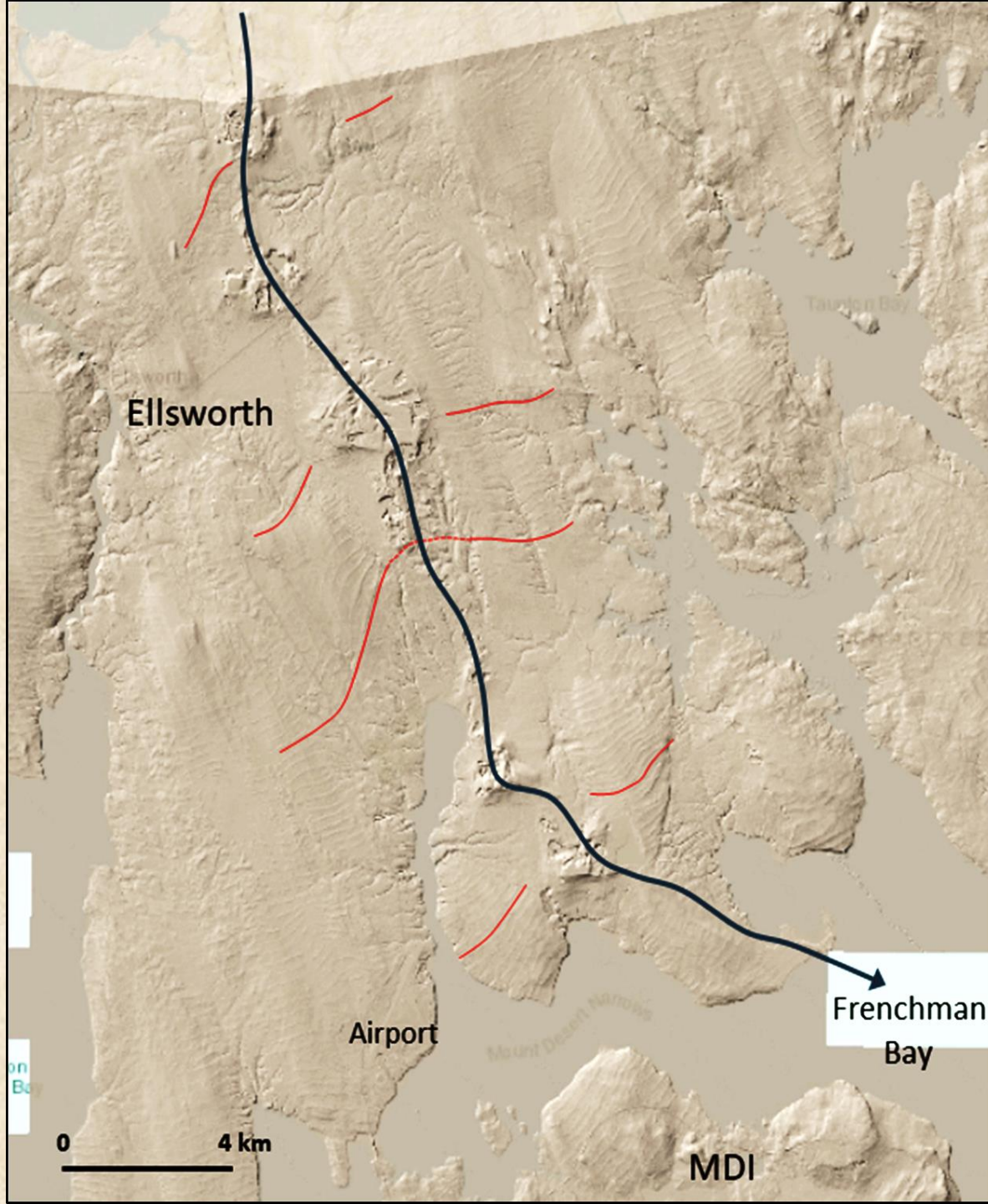
Ice margin map from Ridge (2004) as revised by Ridge 2016,  
(<http://eos.tufts.edu/varves/NAVC/navcdeglac.asp> )



## Closely spaced moraine segments southwest from MDI to Sebago Lake







LiDAR image of the small push moraines with a 100-150 m (330–500 ft) spacing from the north side of MDI to north of Ellsworth. There are approximately 200 individual moraines in the 30 km from south to north on the image.

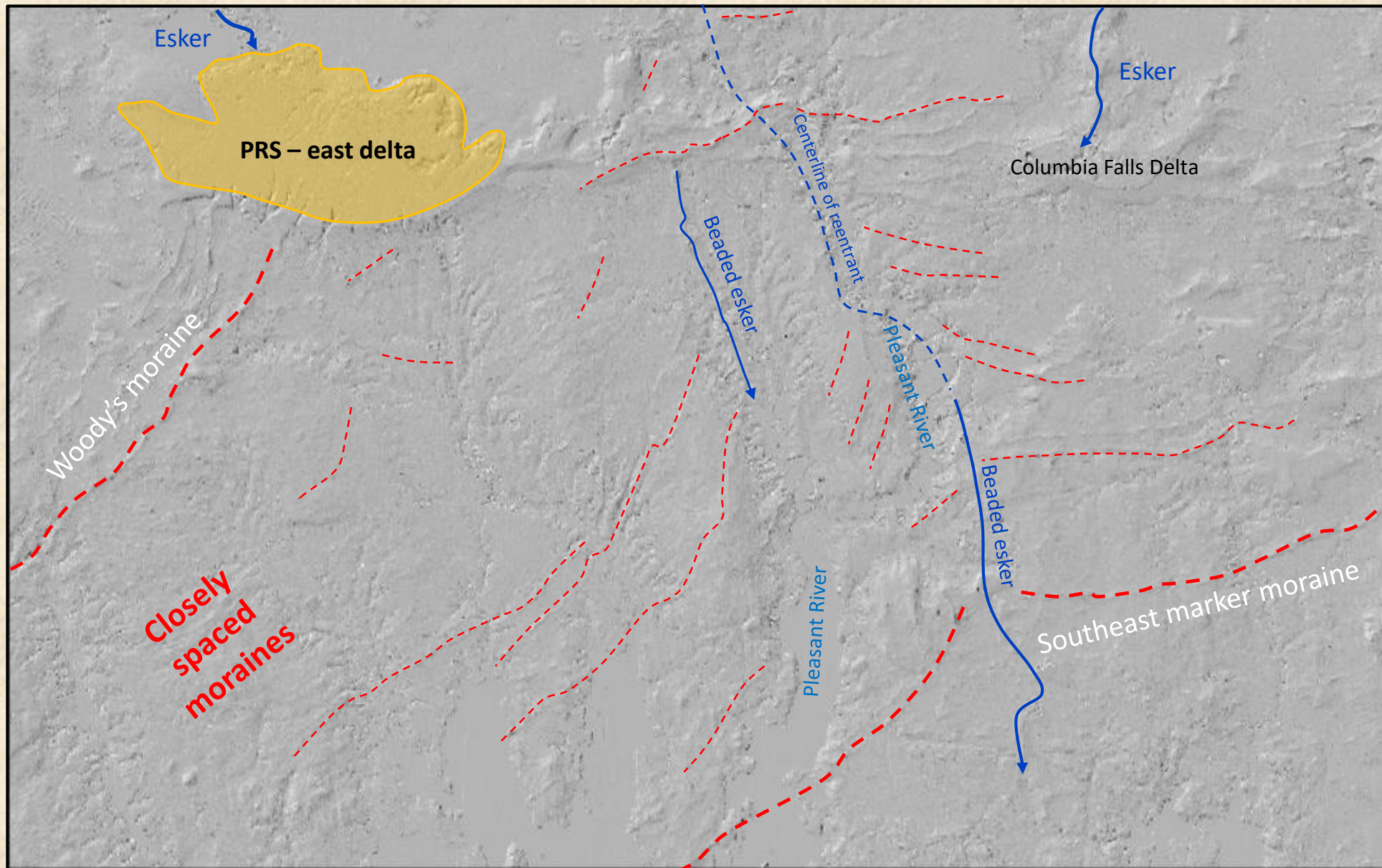
Blue arrow marks the crest of an esker that forms a reentrant in the ice front with the moraines curving northward into it.

The moraine spacing does not change to either side of the deltas indicating the deltas represent pulses of meltwater sediment rather than slowing of the ice front retreat.

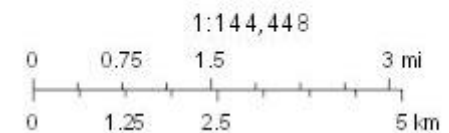
Light blue rectangles are places on the water with no LiDAR coverage.



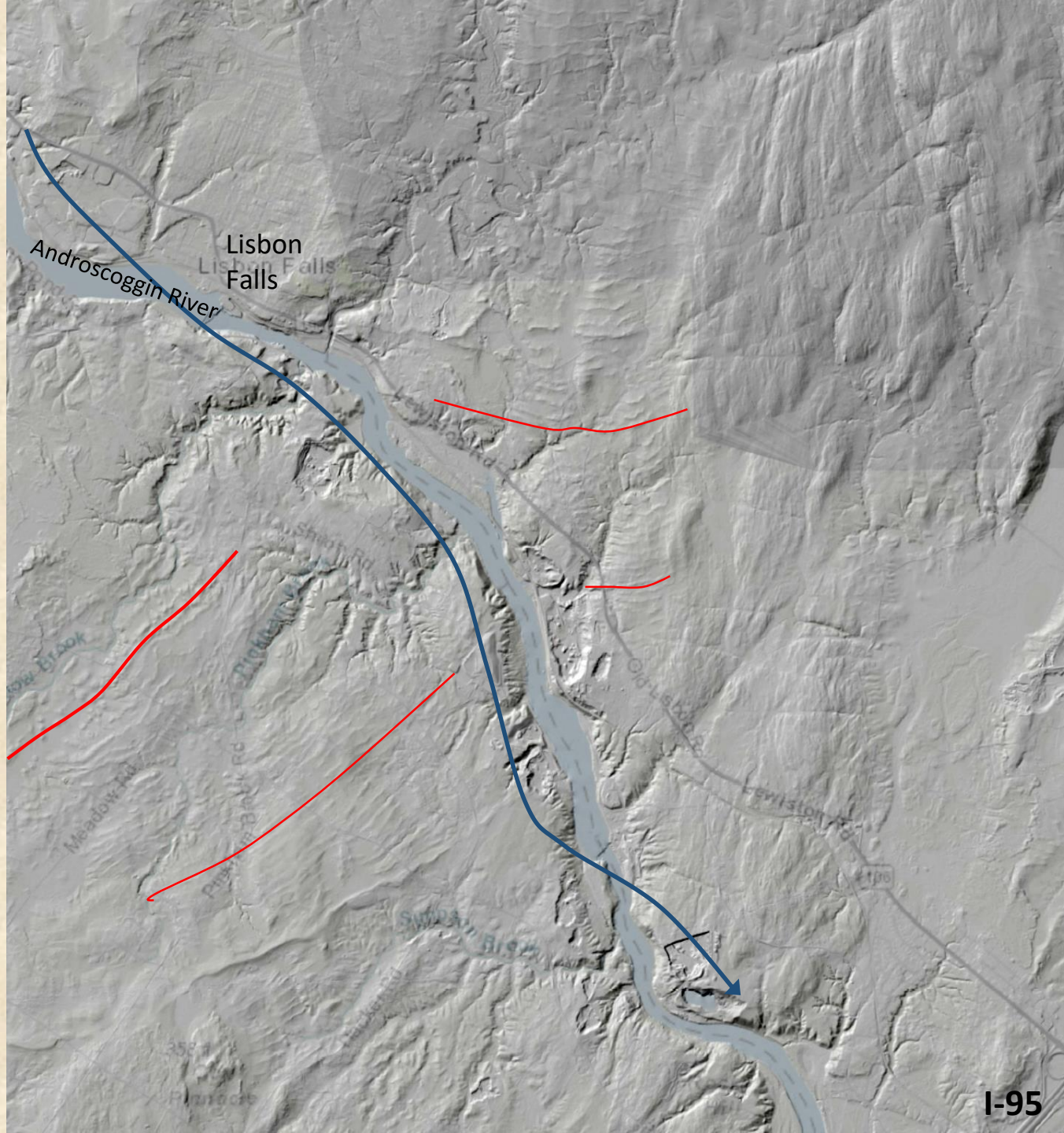
# PRS area moraine curvature



3/5/2019, 3:38:31 PM



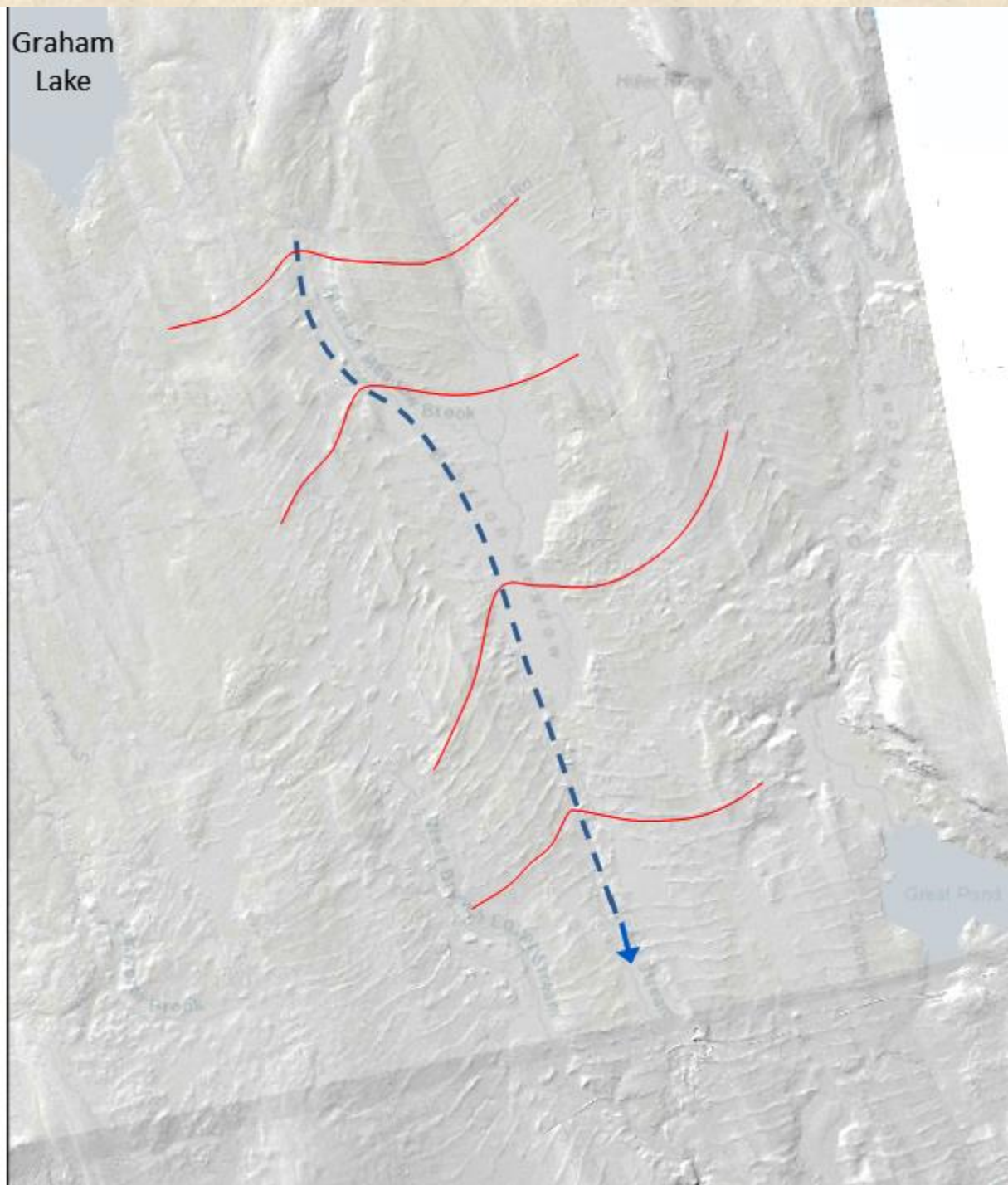




Closer view of Brunswick area  
moraines and curvature to  
north into esker channel  
around Lisbon Falls



Graham  
Lake



## Moraines northeast of Ellsworth and southeast of Graham Lake

Moraine curvature to either  
side of a shallow valley with  
no detectable esker

Valley  
Centerline

Moraine  
Ridge

0 1 2 km





## Penobscot Bay – no calving bay reentrant at head of bay

