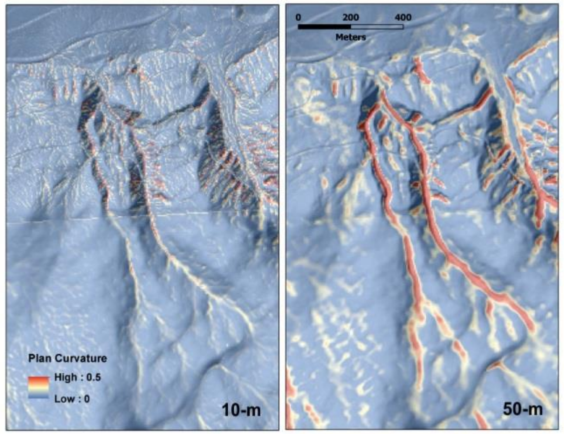
Salmonidae Geographica: How Can You Protect Salmon If You Don’t Know Where They Are?

A Potential Crowdfunding Solution

Terrain Works

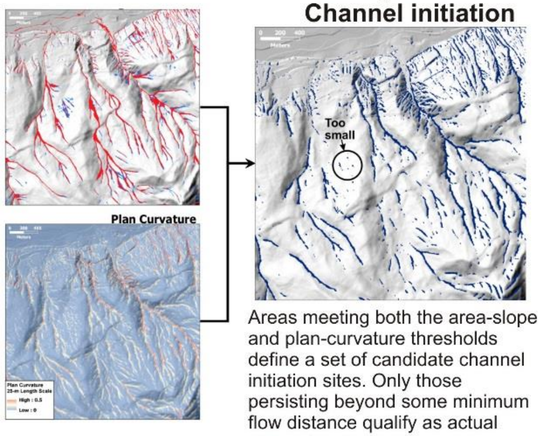
Mapping Potential Salmon Habitats using Digital Topographic Data

Start with Plan curvature



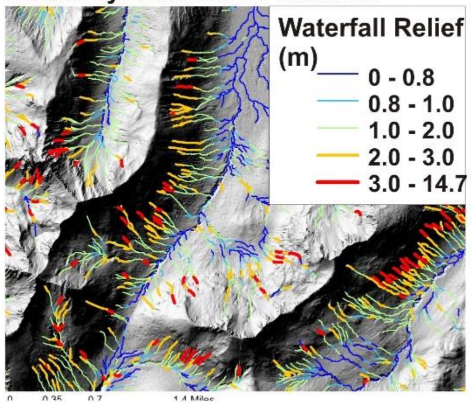
Add Contributing area * S^2

Identify Candidate Channel initiation



Areas meeting both the area-slope and plan-curvature thresholds define a set of candidate channel initiation sites. Only those persisting beyond some minimum flow distance qualify as actual channels.

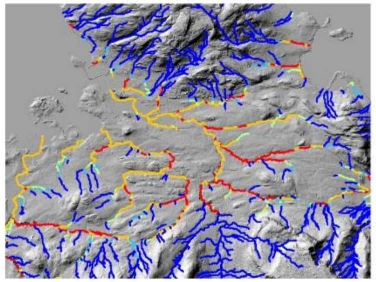
Create Synthetic River Network



Identify waterfall barriers (LiDAR)

Use Alaskan Anadromous Gradient Barriers

Criterion	Coho	Steelhead	Sockeye	Chinook
Steep channel	>=225 ft @ 12%	→		
Fall height (m)	11 ft	13 ft	10 ft	11 ft



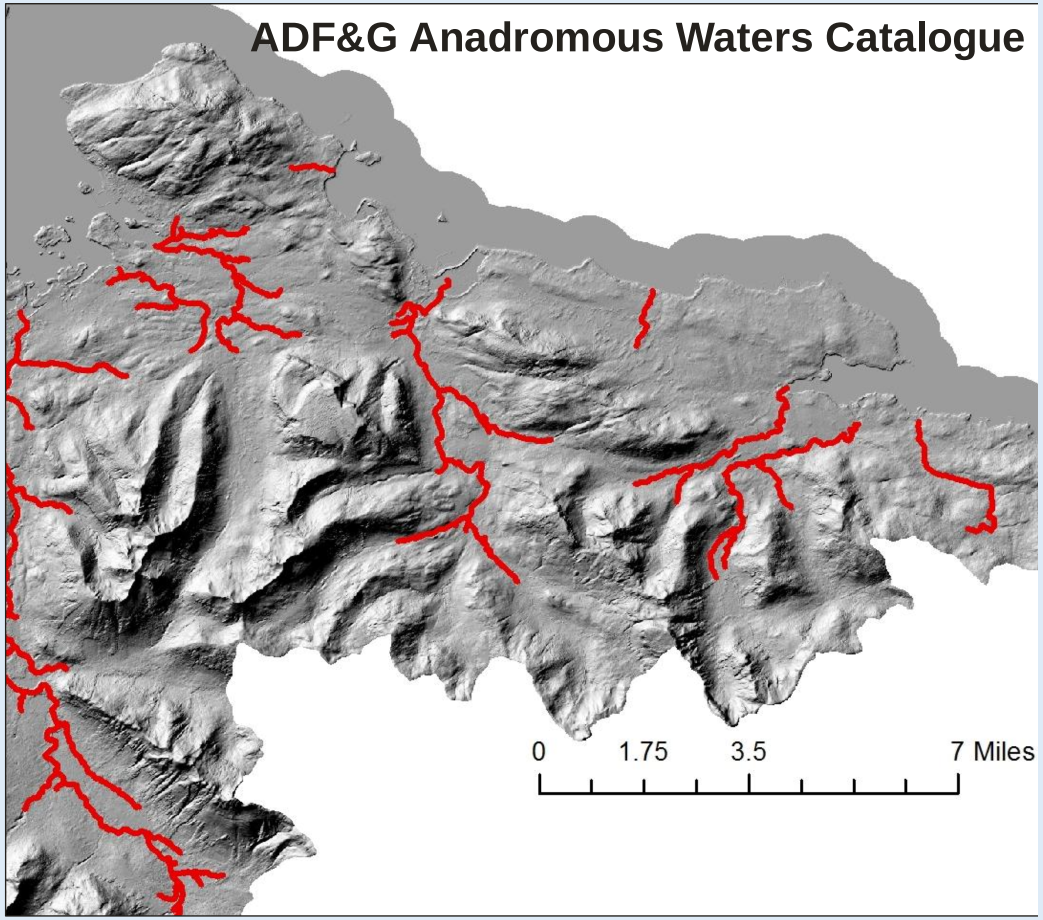
Apply Intrinsic Habitat Potential Models using flow, gradient and confinement thresholds (Burnett et al. 2007)

Project Pilot Area, approximately 1,000 km^2 with 1 m LiDAR digital elevation model (DEM)

We can map salmon habitats using digital elevation models (DEMs) by identifying channel gradient thresholds and by applying salmon models. The extent and accuracy of predicting salmon habitats are strongly influenced by the resolution of DEMs.

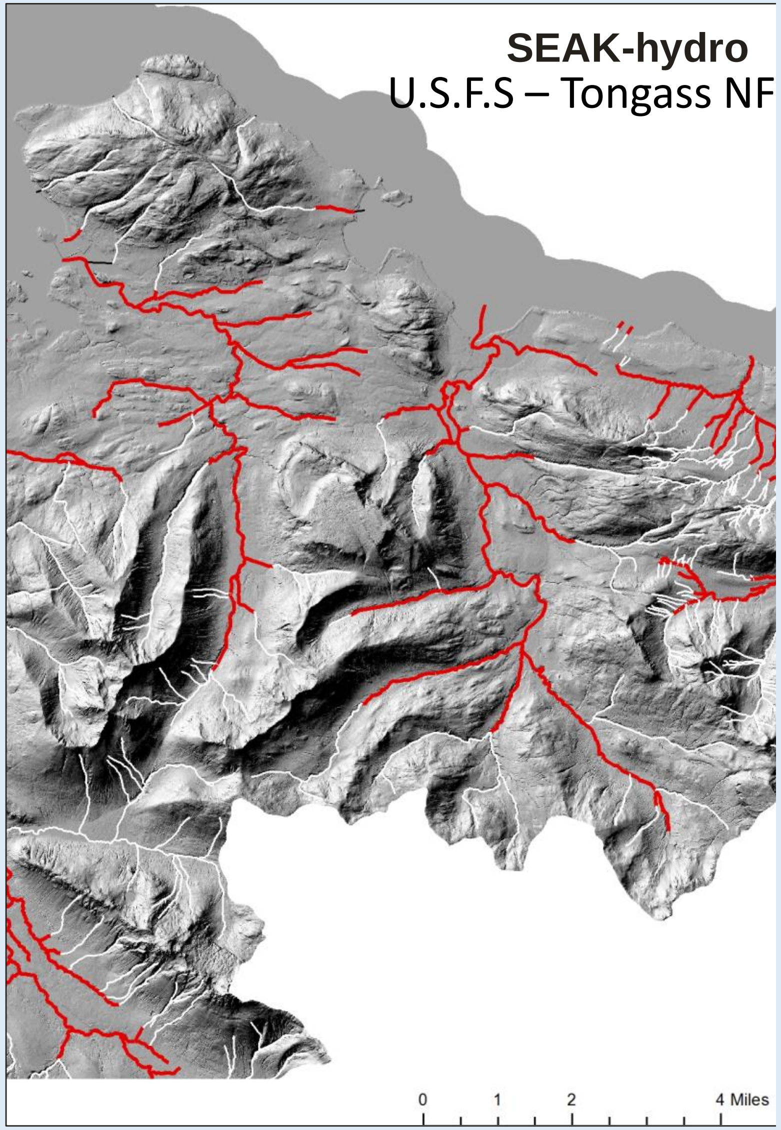
Here we examine the ability of four DEM resolutions: in southeast Alaska (20m, IfSAR 5m and 1m LiDAR) and in British Columbia (17m). We compare those salmon maps to salmon extent in existing cartographic map products including SEAK-Hydro, ADF&G Anadromous Waters Catalog and B.C. Provincial stream layer.

We can start with available maps that show where salmon habitats are located



Drainage density salmon streams: 0.26 km km $^{-2}$

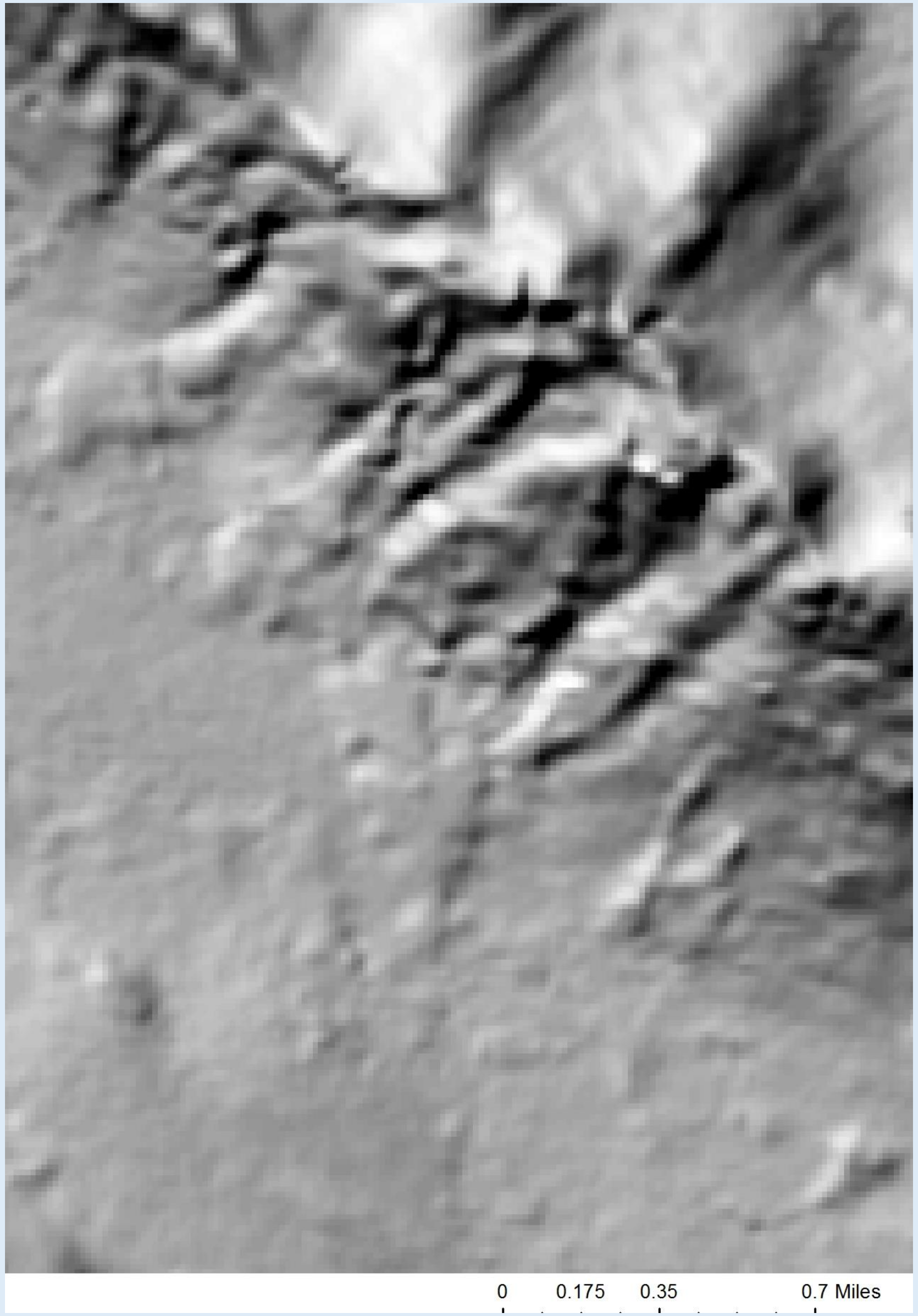
Note the use of densities (km km^{-2}) that allow us to compare stream networks and salmon stream length across the different data products



Drainage density all streams: 1.6 km km^{-2}
Salmon streams: 0.36 km km^{-2}

USFS 20m

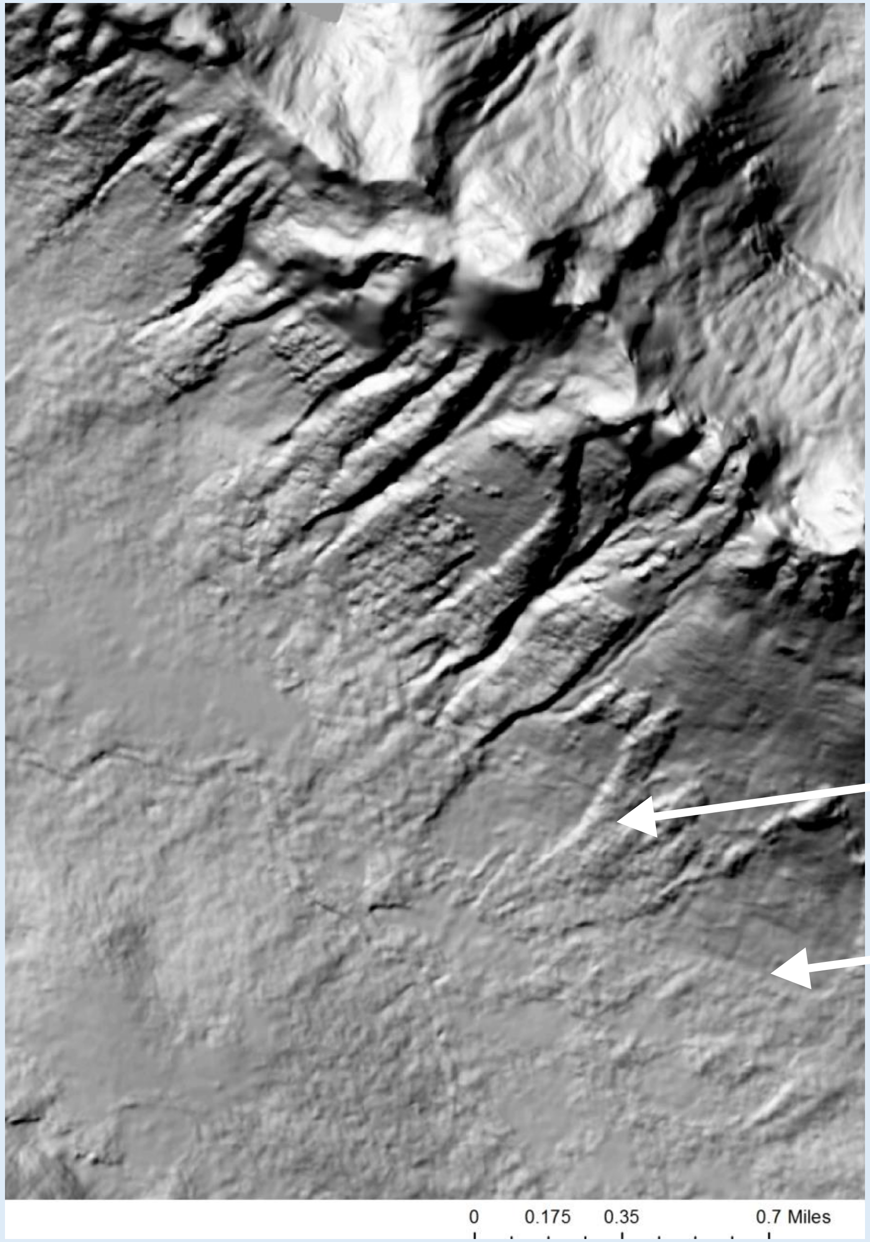
Next, we can derive entire river networks and salmon habitats using the highest resolution DEMs available in Southeast Alaska and B.C.

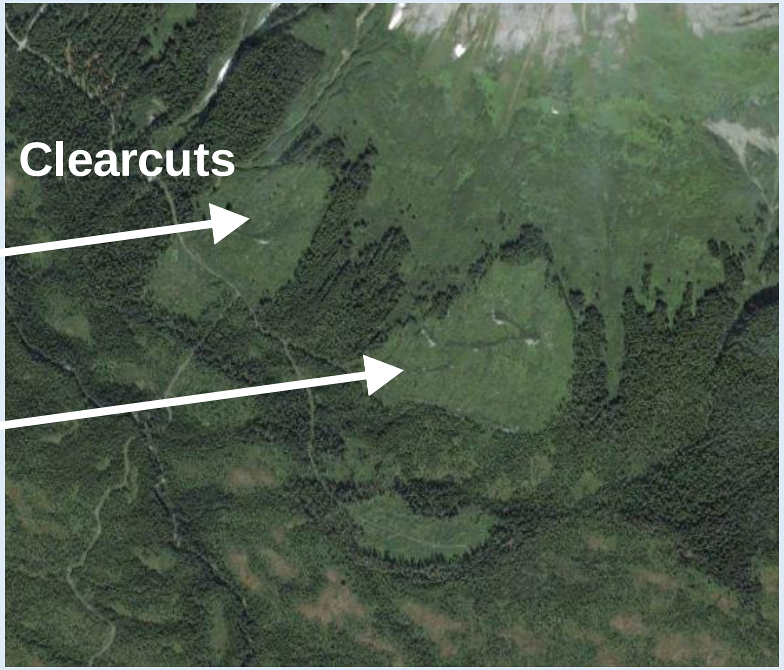


IfSAR 5m

Southeast Alaska also has newly available 5m DEMs called IfSAR provided by the U.S.G.S., because LiDAR DEMs are considered too expensive and unaffordable in Alaska;

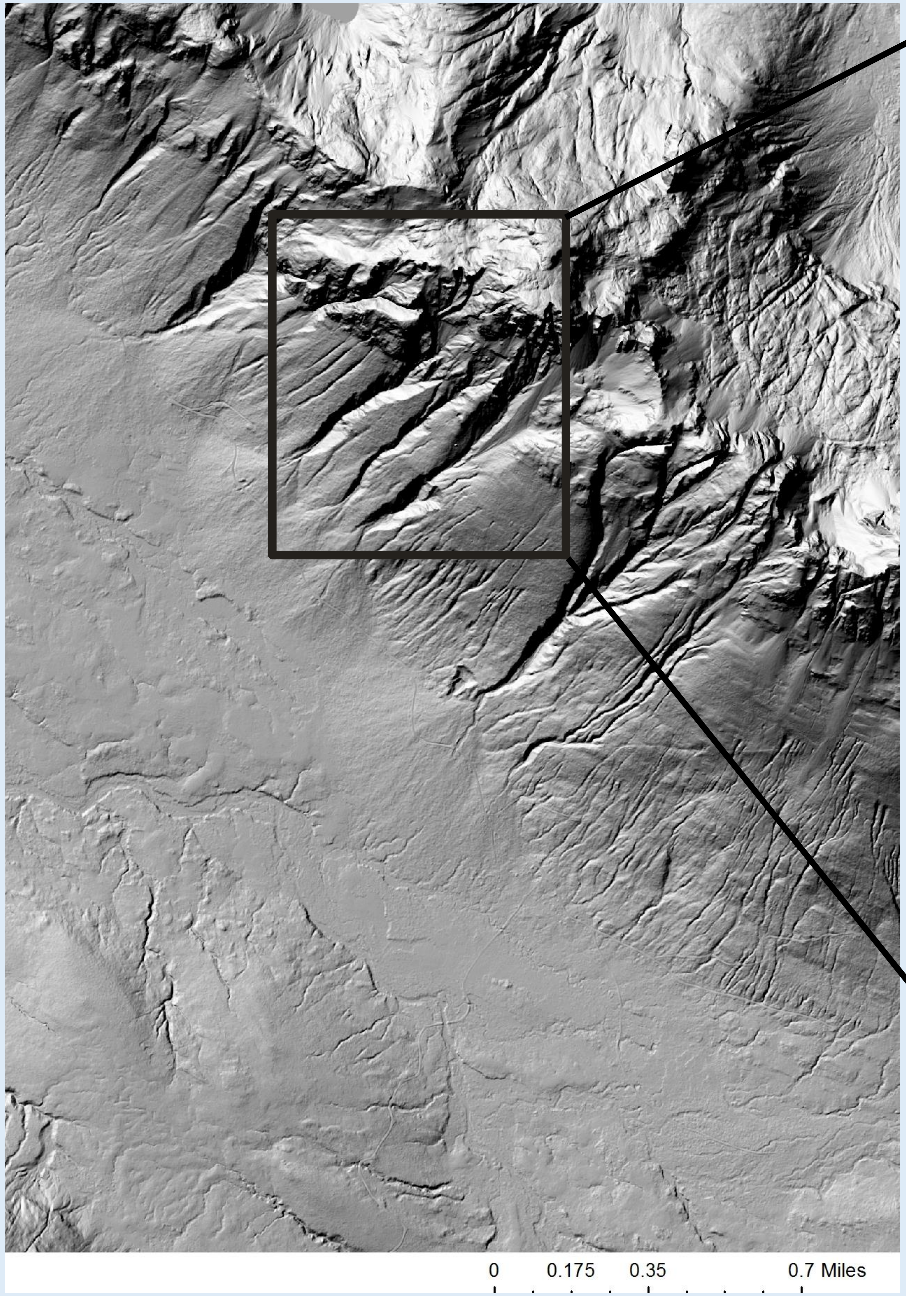
However, in southeast Alaska, the new IfSAR 5 m, that is a surface radar product (as compared to laser altimetry [LiDAR] that uses lasers to “see” under forest canopy), cannot be used to derive accurate stream networks and salmon habitats (DEM is too noisy because of variable vegetation heights); the IfSAR product might be better in northern regions where there is less vegetation.





The IfSAR 5m DEM is effected by variation in vegetation heights

LiDAR 1-2m

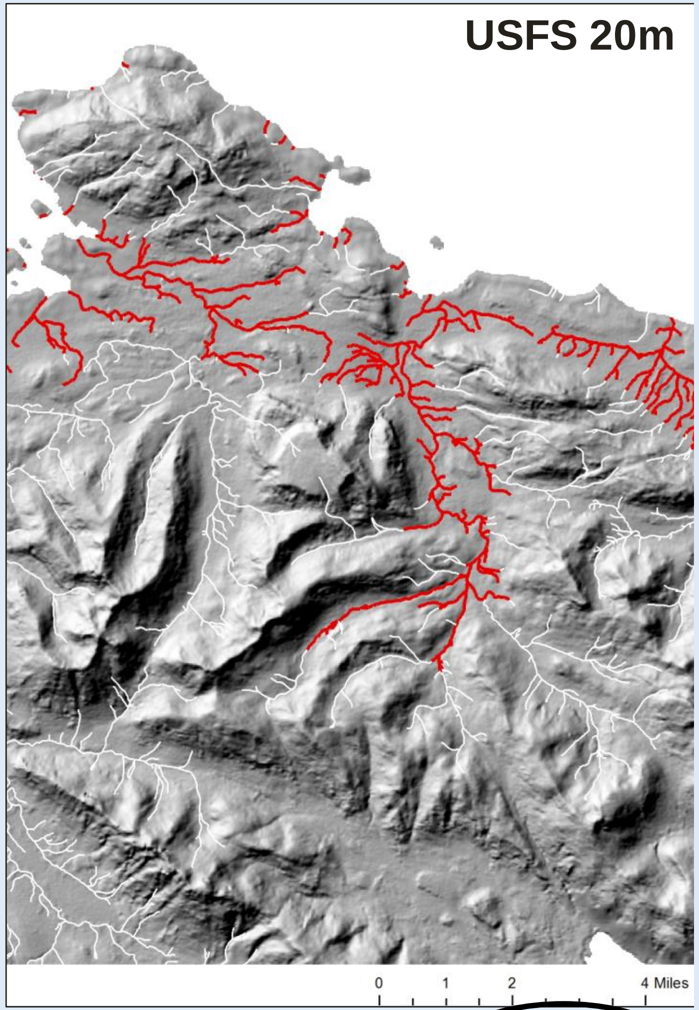


North Chichigof Island
Southeast Alaska

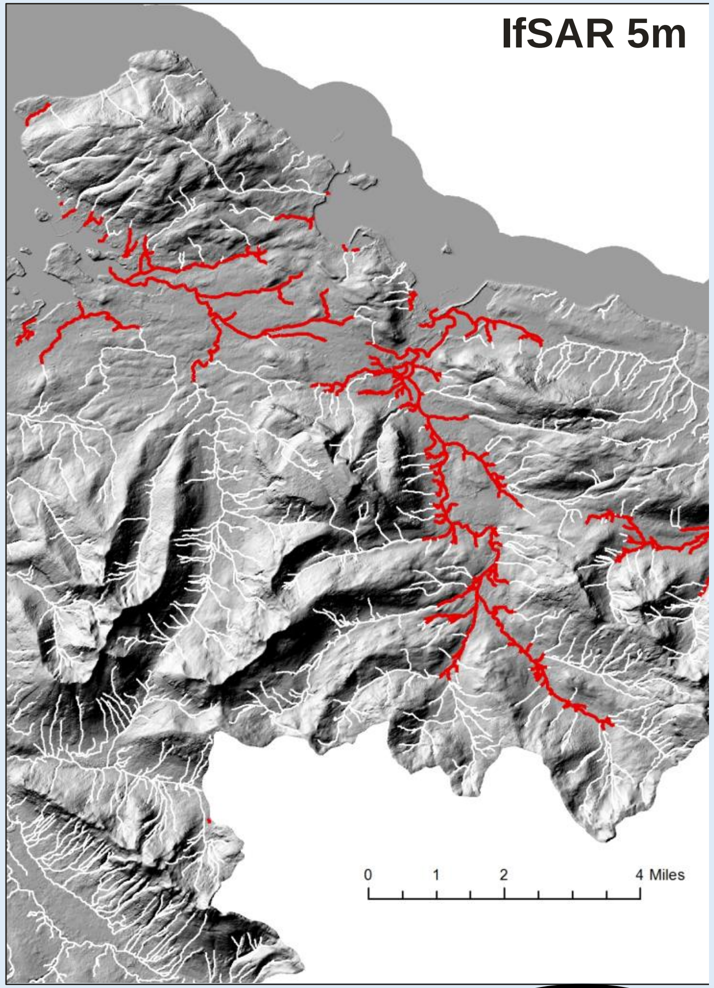
LiDAR (1m DEM) is the gold standard and can "see" under vegetation (using the latest sensors) as viewed in this shaded relief imagery.

All channels can be seen and thus accurate river networks can be derived from the LiDAR DEM (from headwaters to mainstems, and valley side channels).

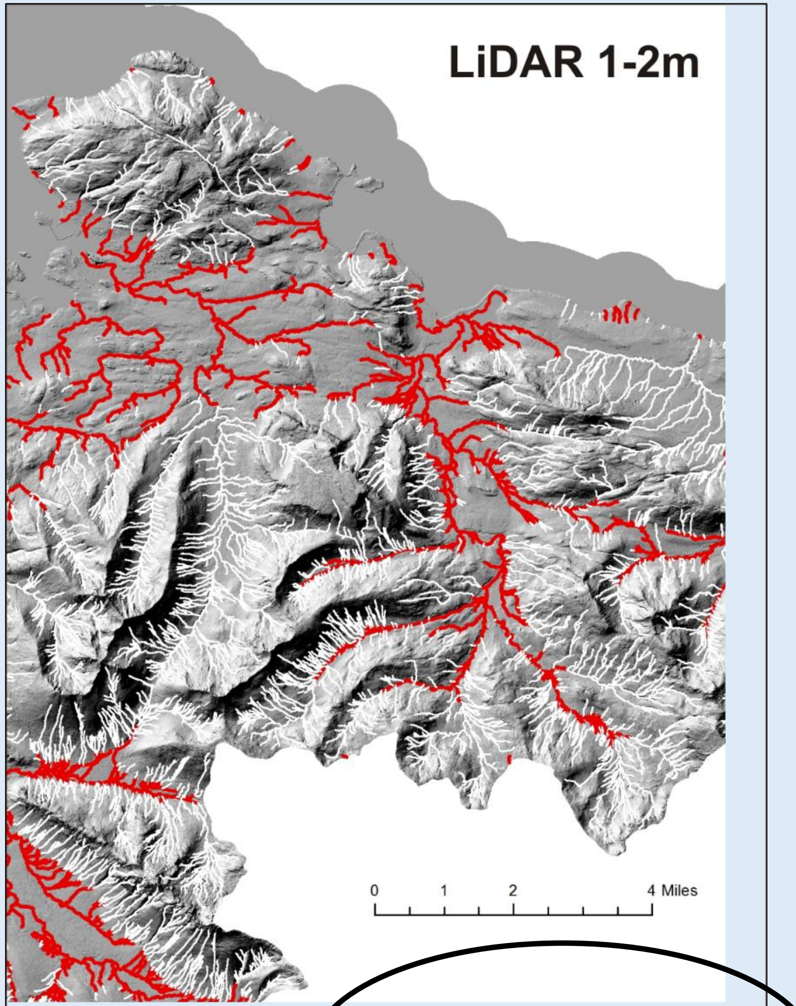
Imagery is from the pilot analysis area in northern Chichigof Island, southeast Alaska (Hoonah Community Forest Project).



Drainage density all streams: 1.4 km km^{-2}
Salmon streams: 0.4 km km^{-2}



Drainage density all streams: 2.7 km km^{-2}
Salmon streams: 0.14 km km^{-2}



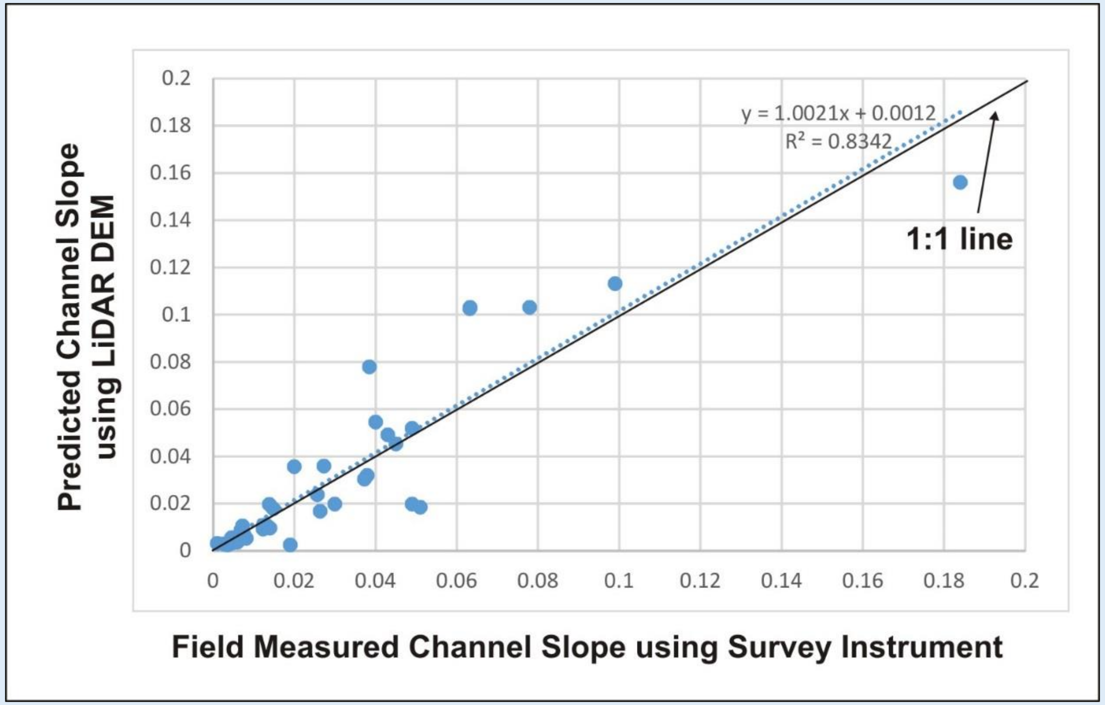
Drainage density all streams: 5.0 km km^{-2}
Salmon streams: 0.76 km km^{-2}

Salmon streams

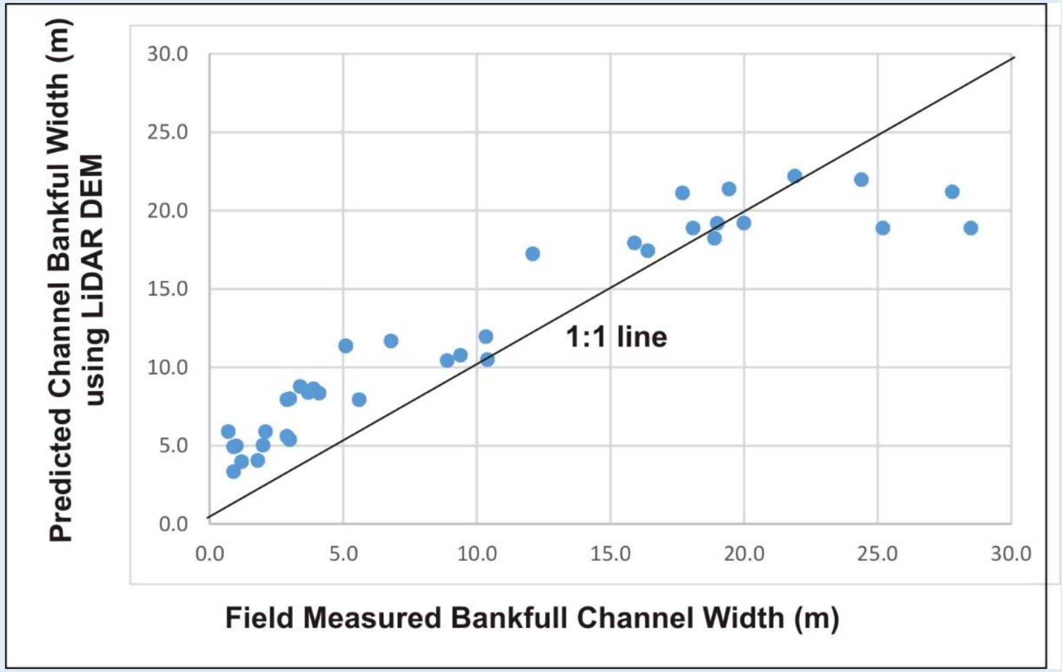
This image shows how the various DEM resolutions support, or not, the delineation of stream and river networks and salmon habitats. Note the differences in the densities of all streams and salmon streams; LiDAR produces the best river networks with the highest densities, including for potential salmon streams.

How Accurate is LiDAR for Predicting Channel Attributes Relevant to Gradient Barriers and Salmon Habitat Modeling?

Field data were collected in the Hoonah study area (at 43 sites) including channel length, channel slope, channel bankfull width, bankfull depth and floodplain width.



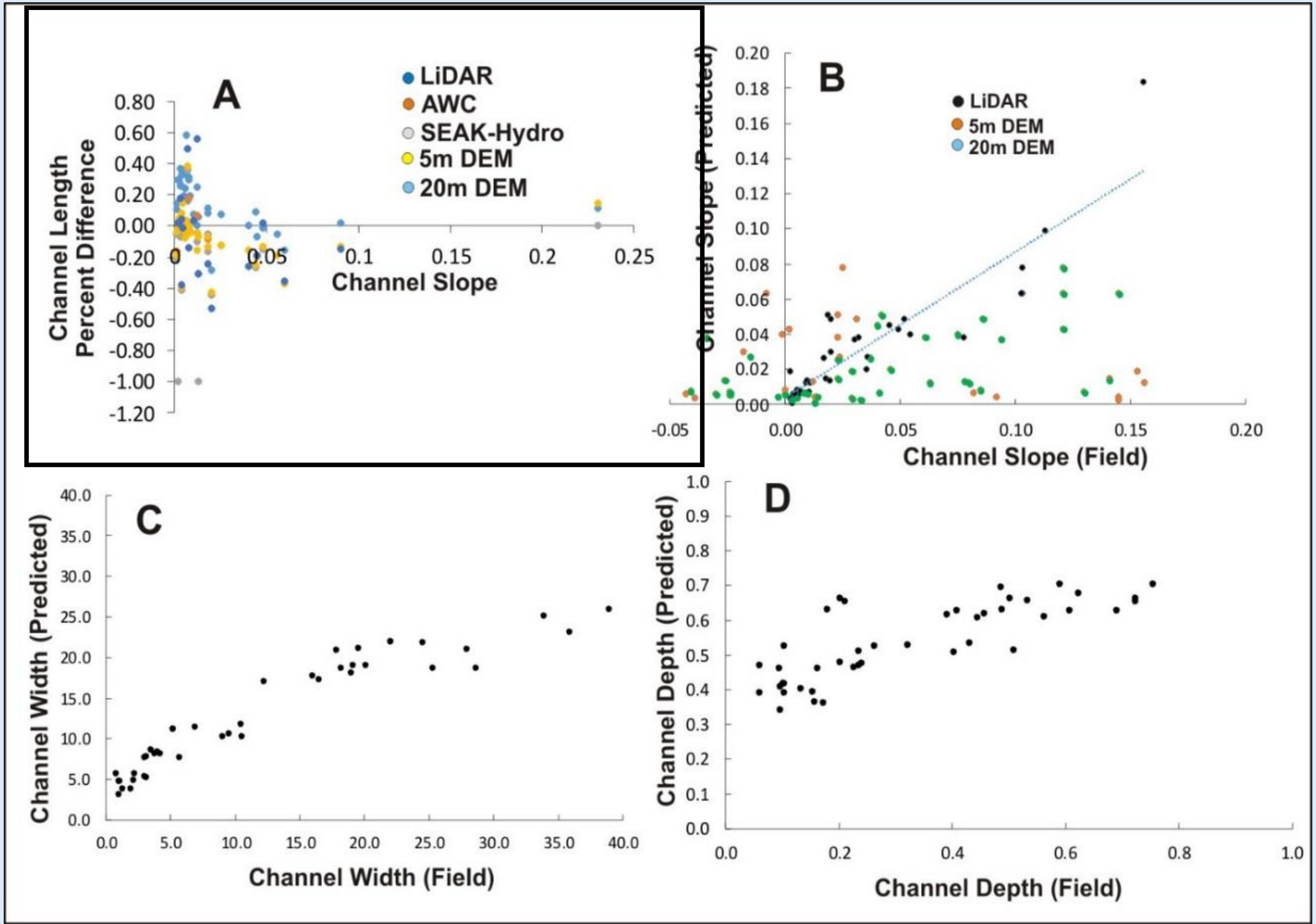
Channel gradient, the principle variable in predicting salmon gradient barriers and in salmon intrinsic habitat potential modeling, was very accurately predicted using LiDAR.



Bankfull channel width is an important component of salmon habitat models and it is used in calculating channel confinement, as floodplain width divided by channel width. Channel width is predicted using a regression equation based on 1,000 data points across SE AK. The model preformed very well.

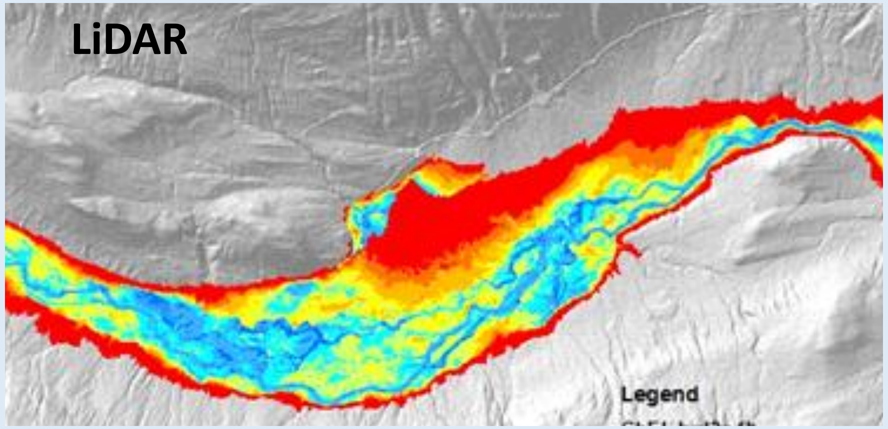
How Accurate is LiDAR for Predicting Channel Attributes Relevant to Gradient Barriers and Salmon Habitat Modeling?

Field data on channel lengths are used to correct the over prediction (LiDAR) and under prediction of all measured and predicted all stream lengths and salmon stream lengths

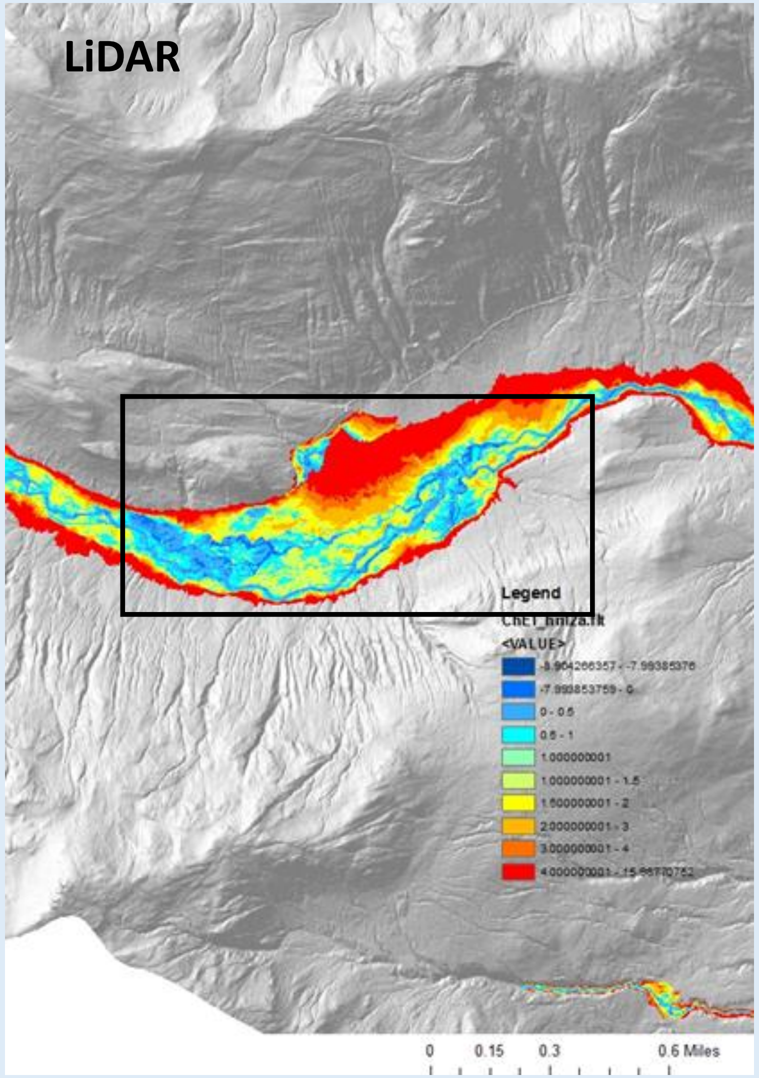


How Accurate is LiDAR for Predicting Channel Attributes Relevant to Gradient Barriers and Salmon Habitat Modeling?

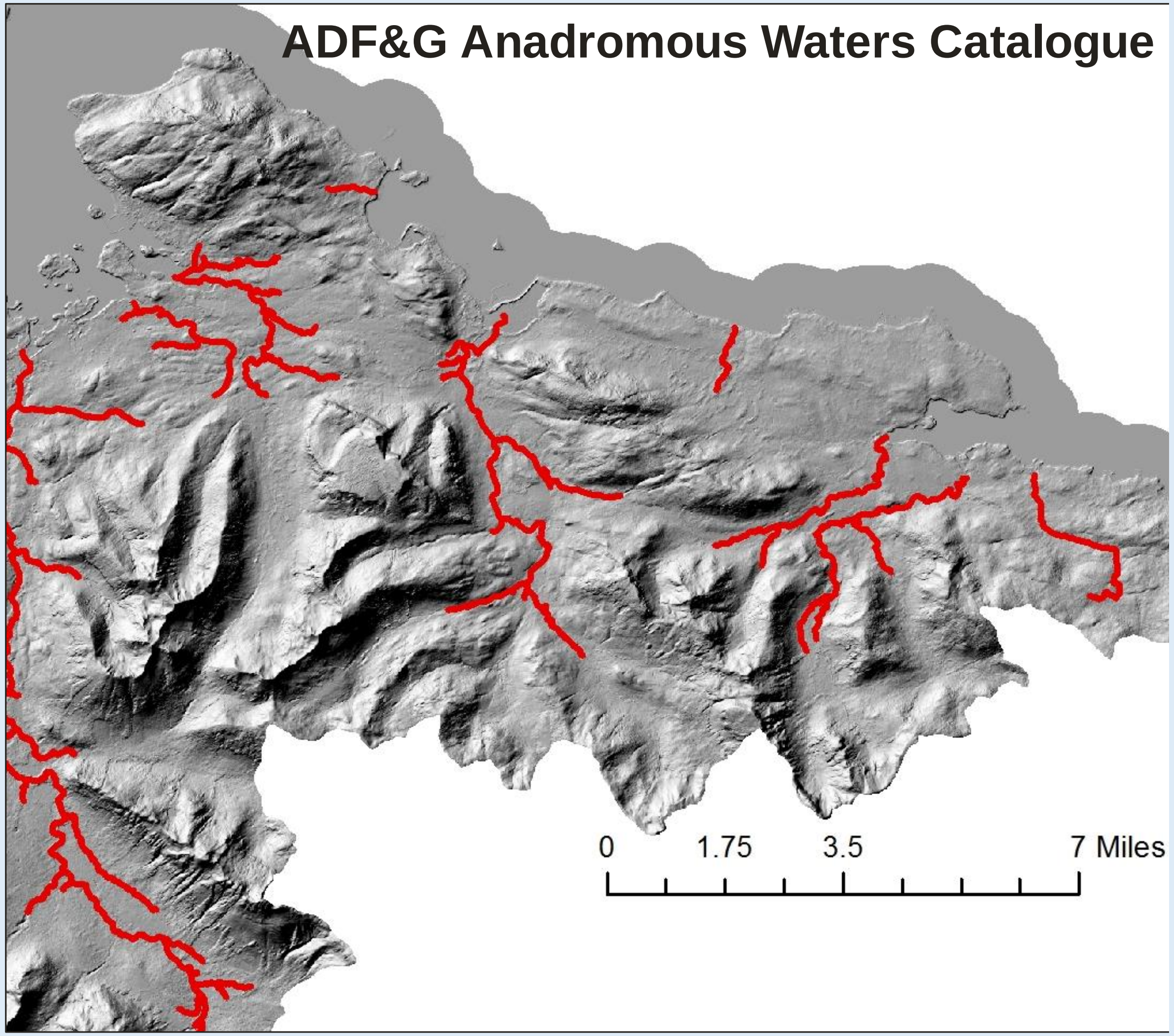
Field data were collected in the Hoonah study area (at 43 sites) including channel gradient (using a survey station), channel bankfull width, bankfull depth and floodplain width.



Mapping valley floor elevations and floodplains using LiDAR is highly accurate, thus predictions of channel confinement (valley width/channel width) in the salmon models is also considered accurate.

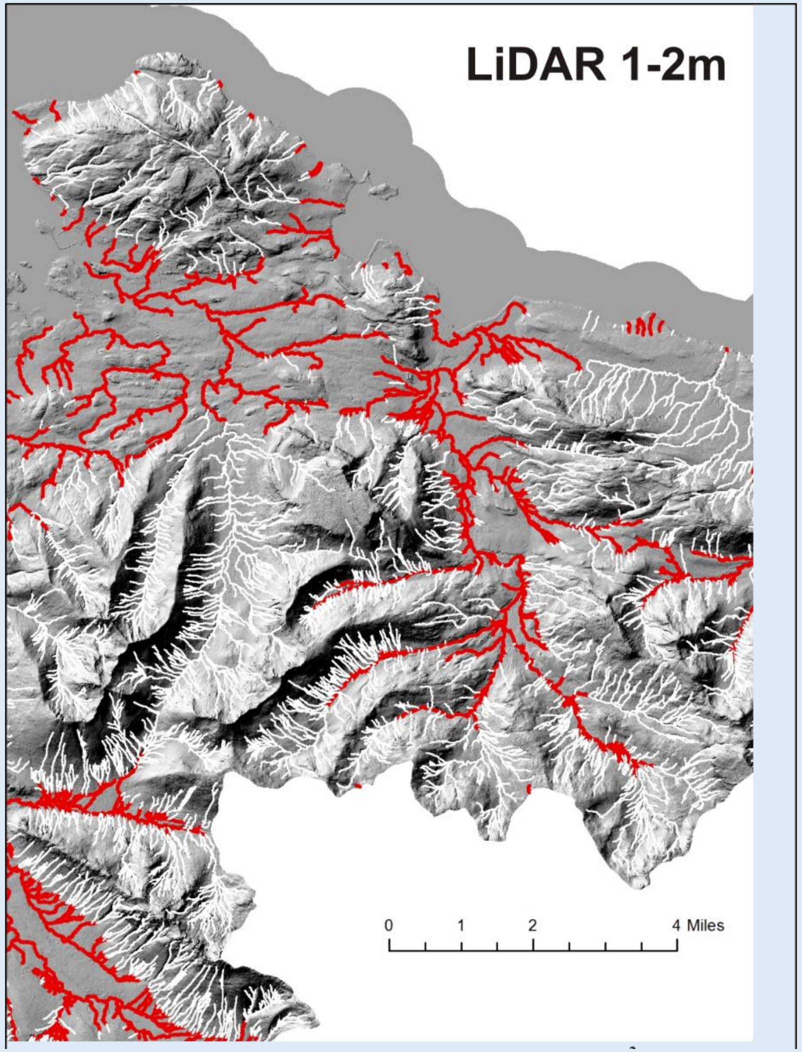


Compare the ADF&G AWC salmon extent with that predicted using the LIDAR DEM: AWC may be missing up to 60% of potential salmon streams (based on length)



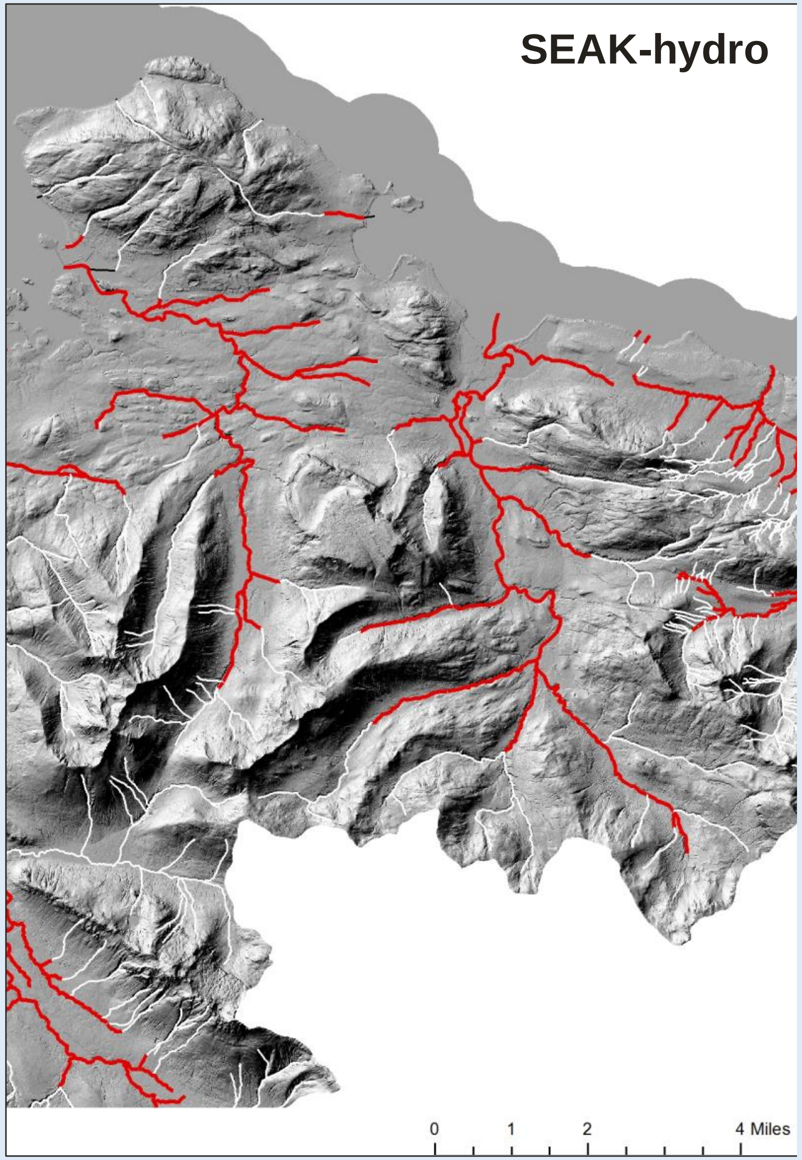
Drainage density all streams: na
Salmon streams: 0.28 km km^{-2}

Salmon streams

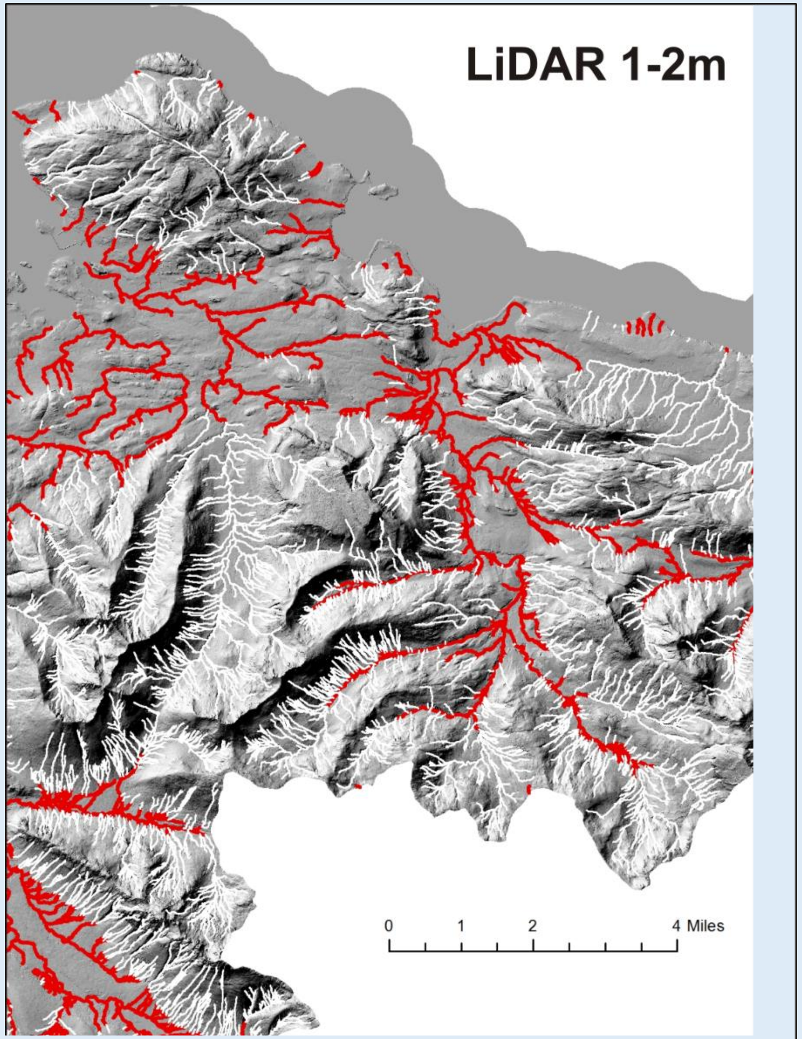


Drainage density all streams: 5.0 km km^{-2}
Salmon streams: 0.76 km km^{-2}

Compare the SEAK-hydro (Tongass NF) salmon extent with that predicted using the LIDAR DEM: SEAK-Hydro may be missing up to 50% of salmon streams (based on length).



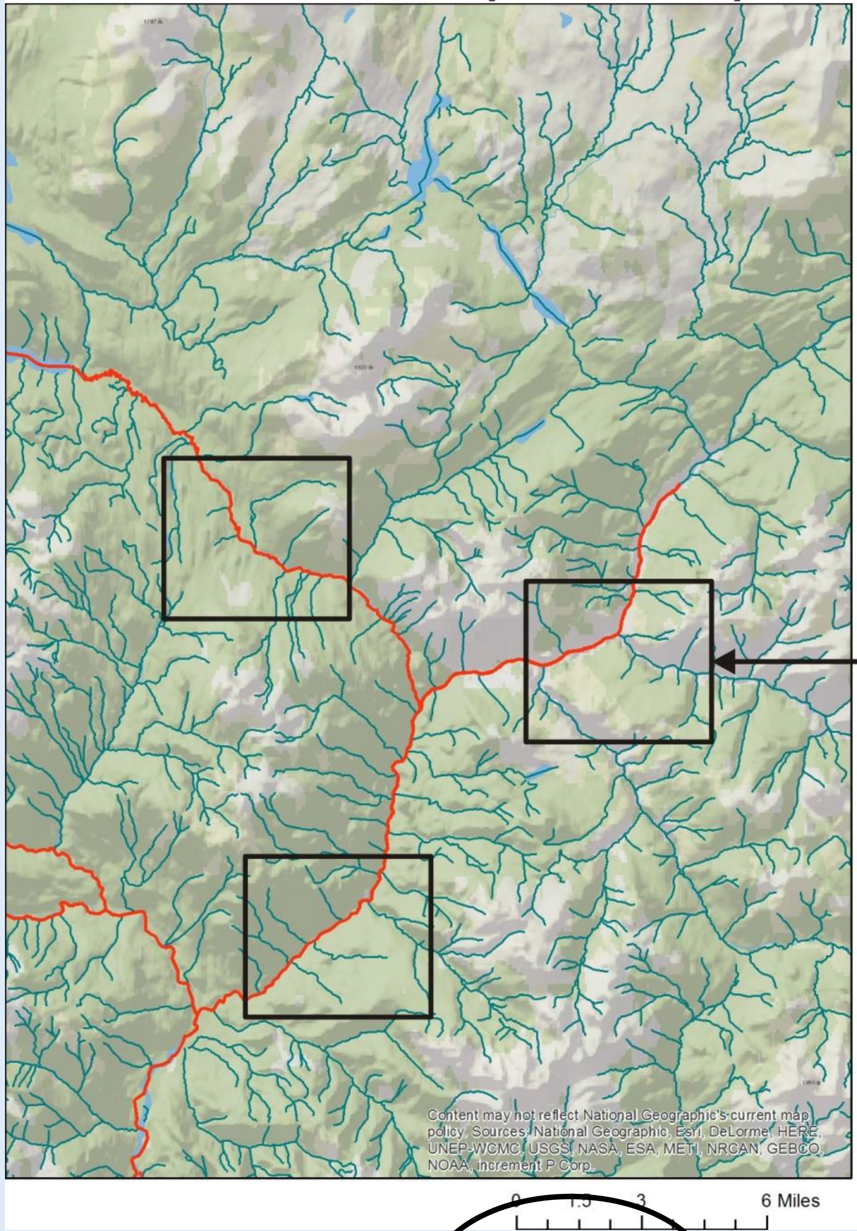
Drainage density all streams: 1.6 km km^{-2}
Salmon streams: 0.36 km km^{-2}

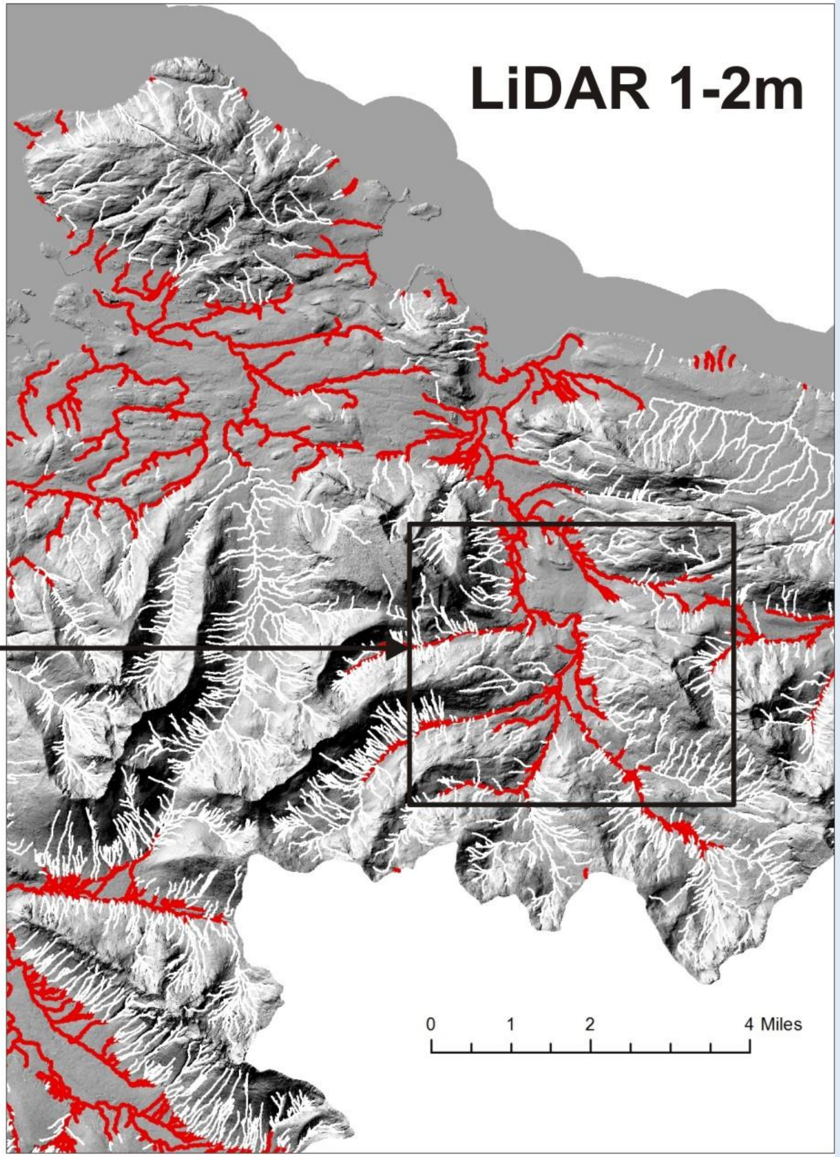


Drainage density all streams: 5.0 km km^{-2}
Salmon streams: 0.76 km km^{-2}

Salmon streams

B.C. All streams (1:50,000)



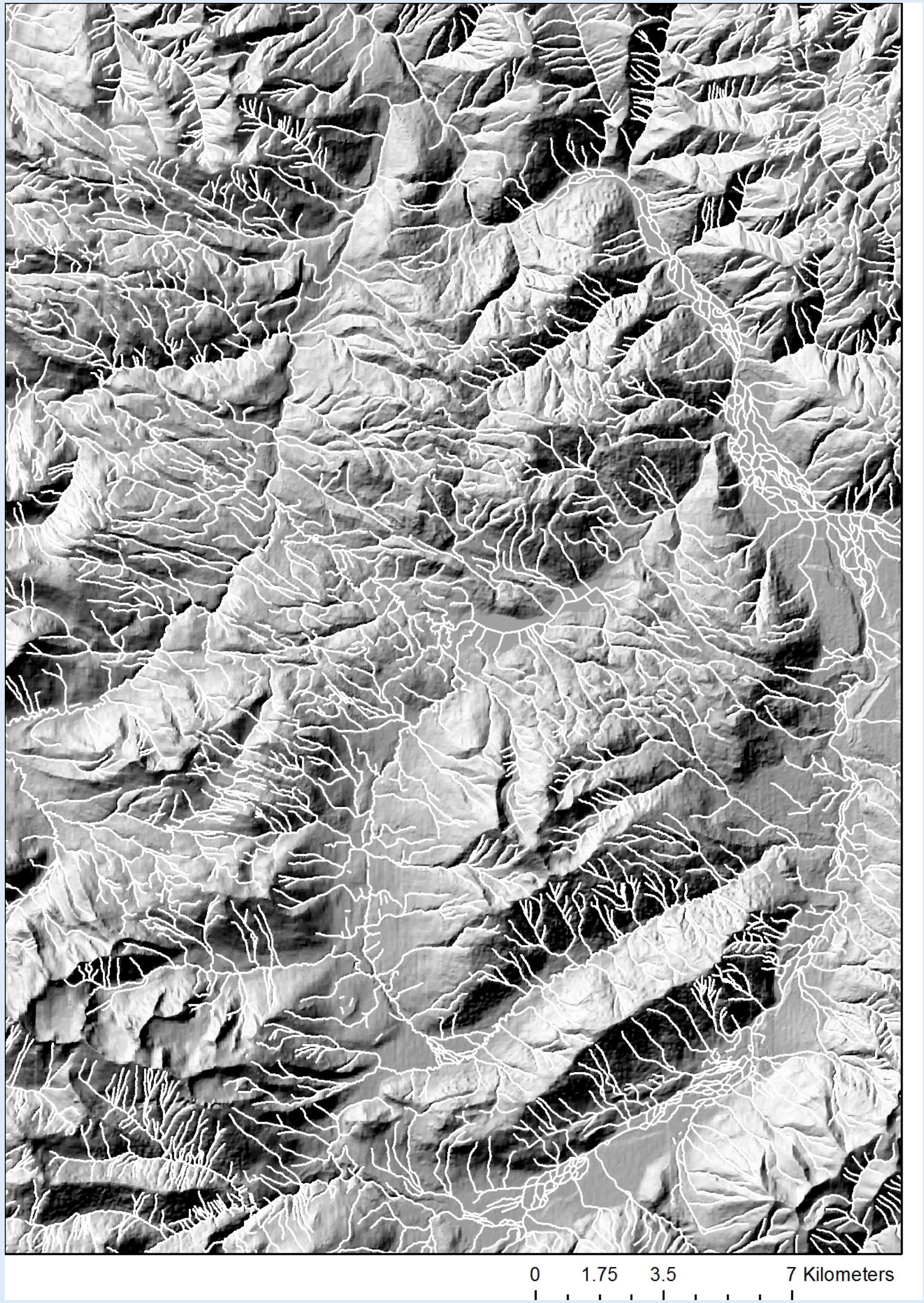


Let's check out what is available in B. C. coastal watersheds.

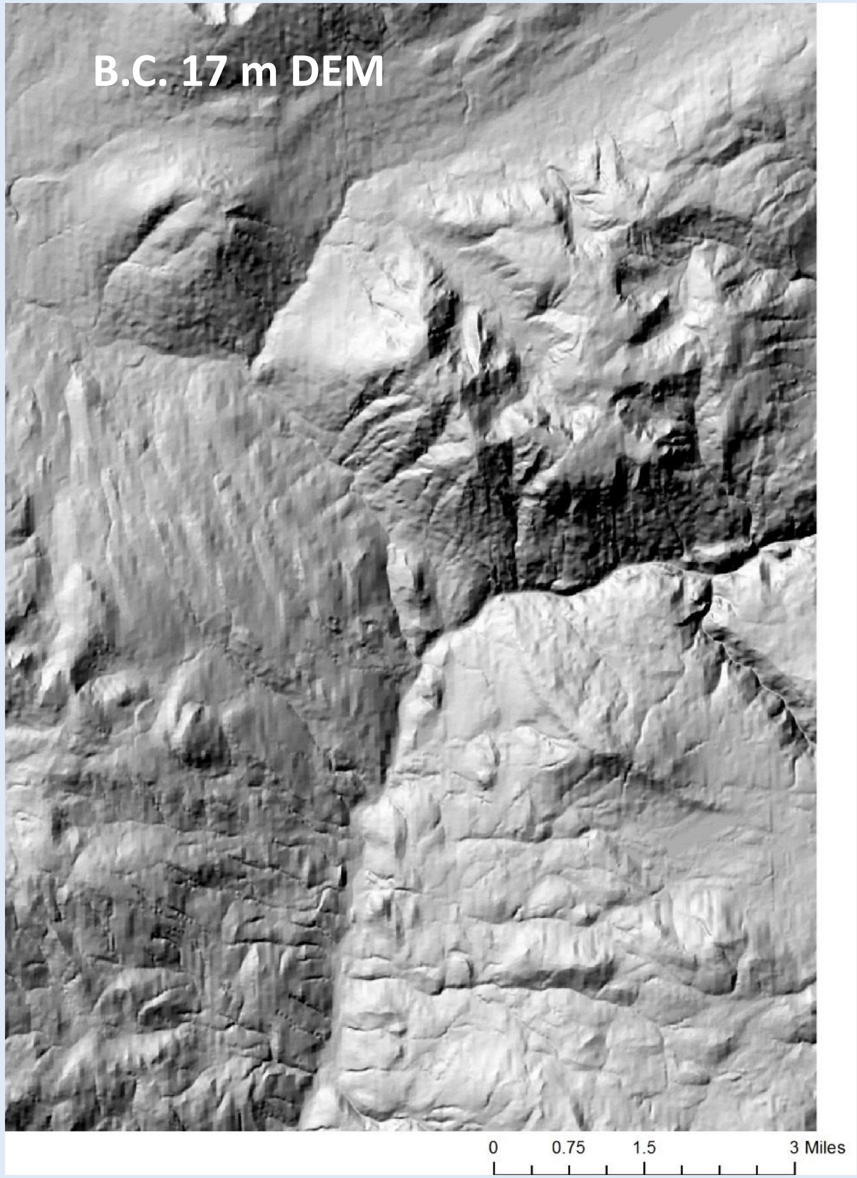
Drainage density all streams: 0.95 km km^{-2}
salmon streams: 0.03 km km^{-2}

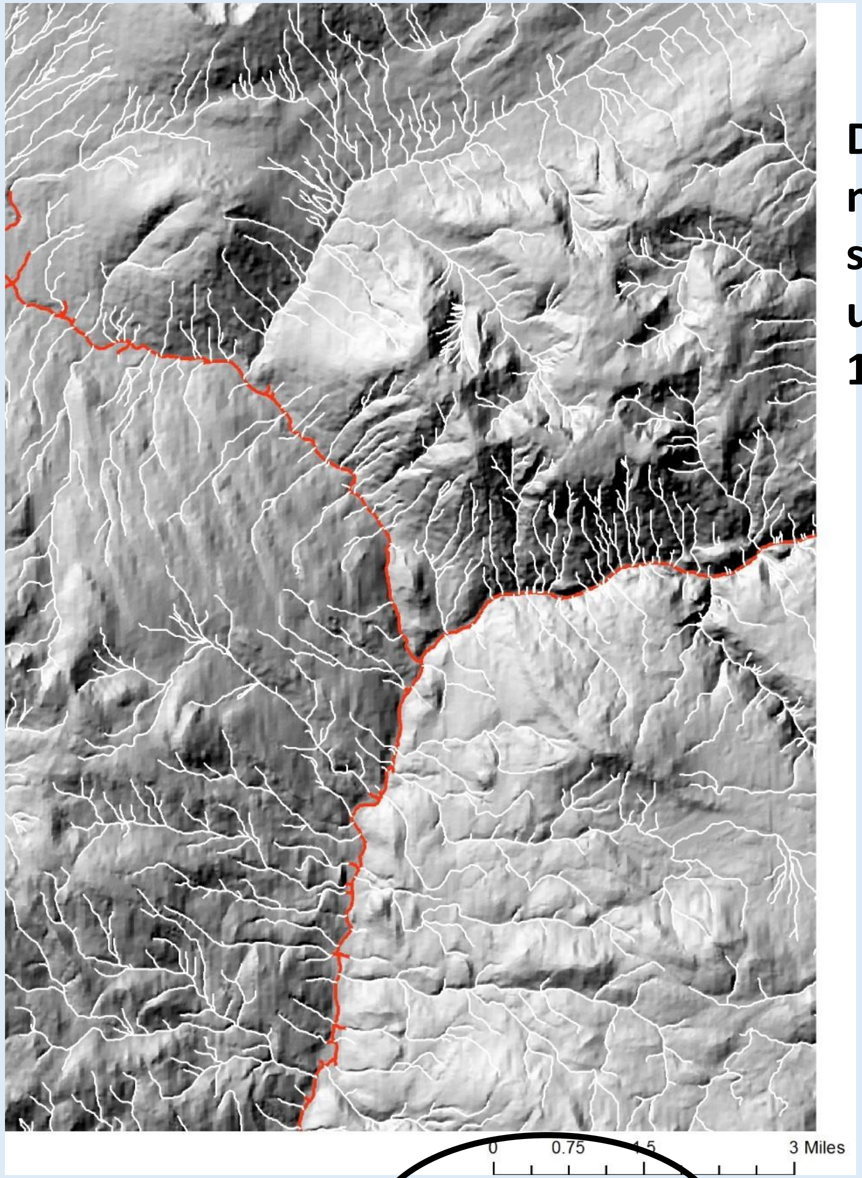
Drainage density all streams: 4.92 km km^{-2}
Fish streams: 0.76 km km^{-2}

BC also maintains a 1:20,000 hydrography with a higher all stream density (2.8 km km^{-2}); no fish or salmon streams are delineated.



Can we delineates more complete stream networks and salmon habitat in B.C. using the available 17m DEM across the coastal watersheds?





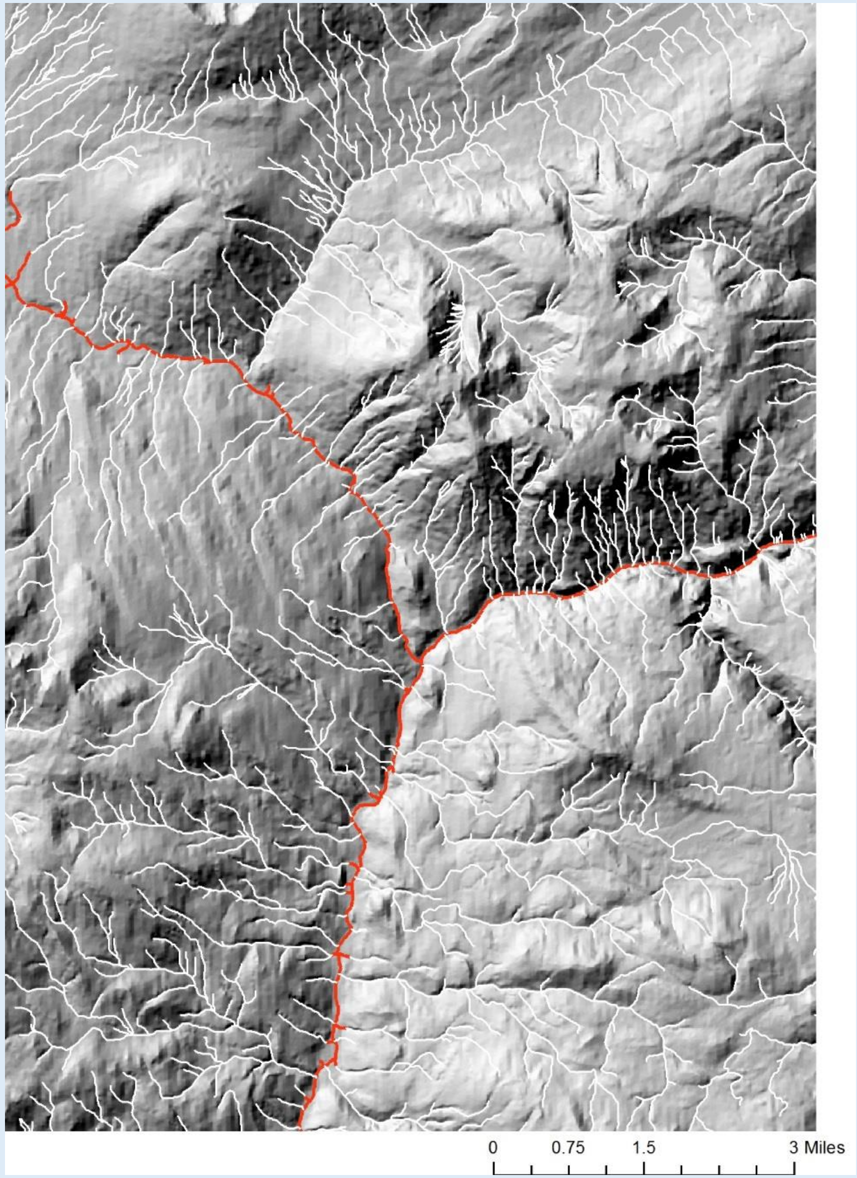
Derived stream network and salmon streams using the B.C. 17m DEM

Salmon streams

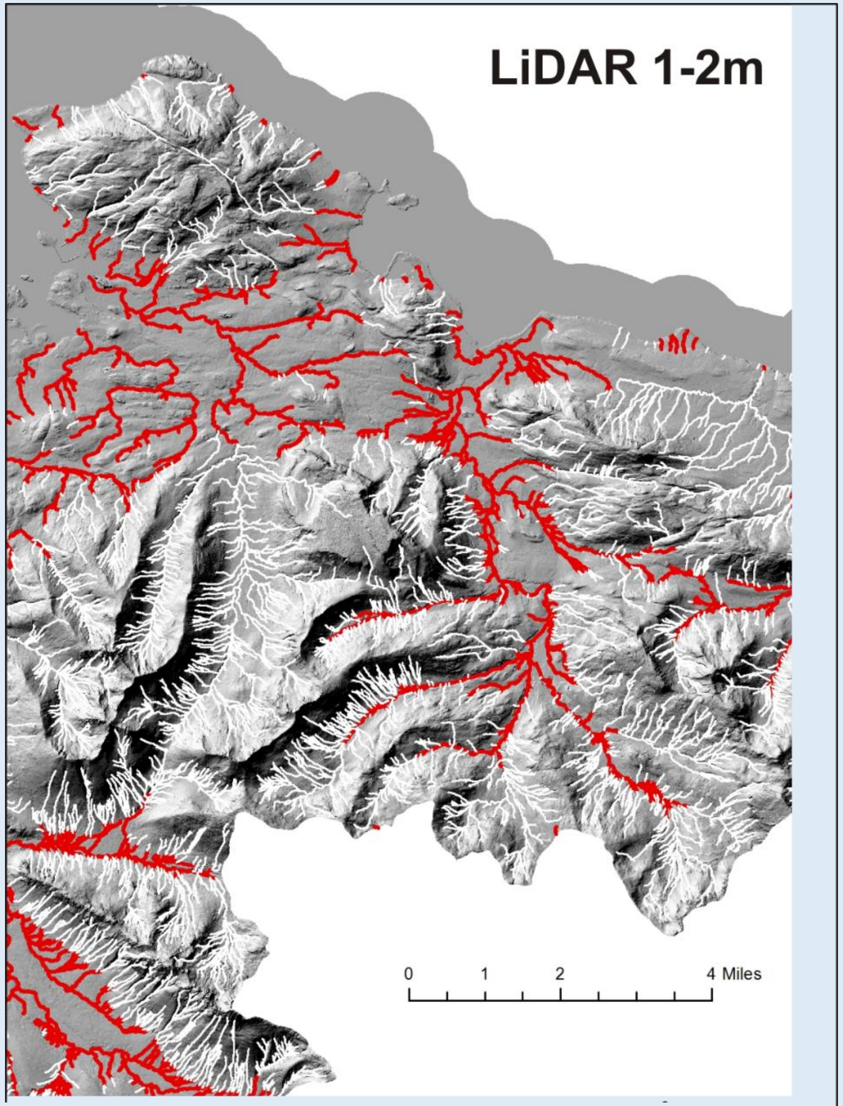
Drainage density all streams: 2.4 km km^{-2}

Fish streams: 0.45 km km^{-2}

Compare the derived stream network using B.C. 17m DEM with streams using a 1-2m LiDAR DEM



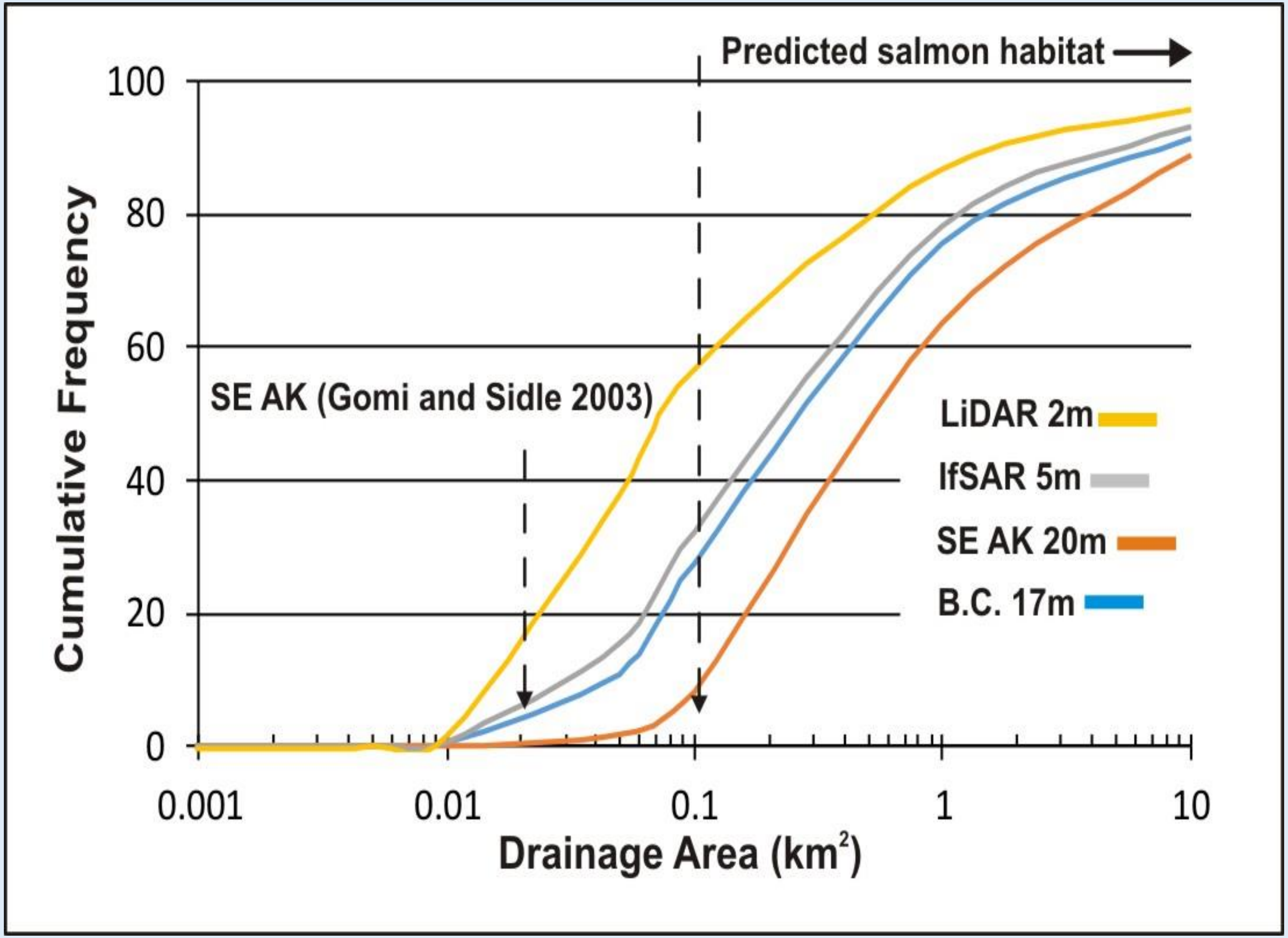
Drainage density all streams: 2.85 km km^{-2}
Fish streams: 0.45 km km^{-2}



Drainage density all streams: 5.0 km km^{-2}
Salmon streams: 0.76 km km^{-2}

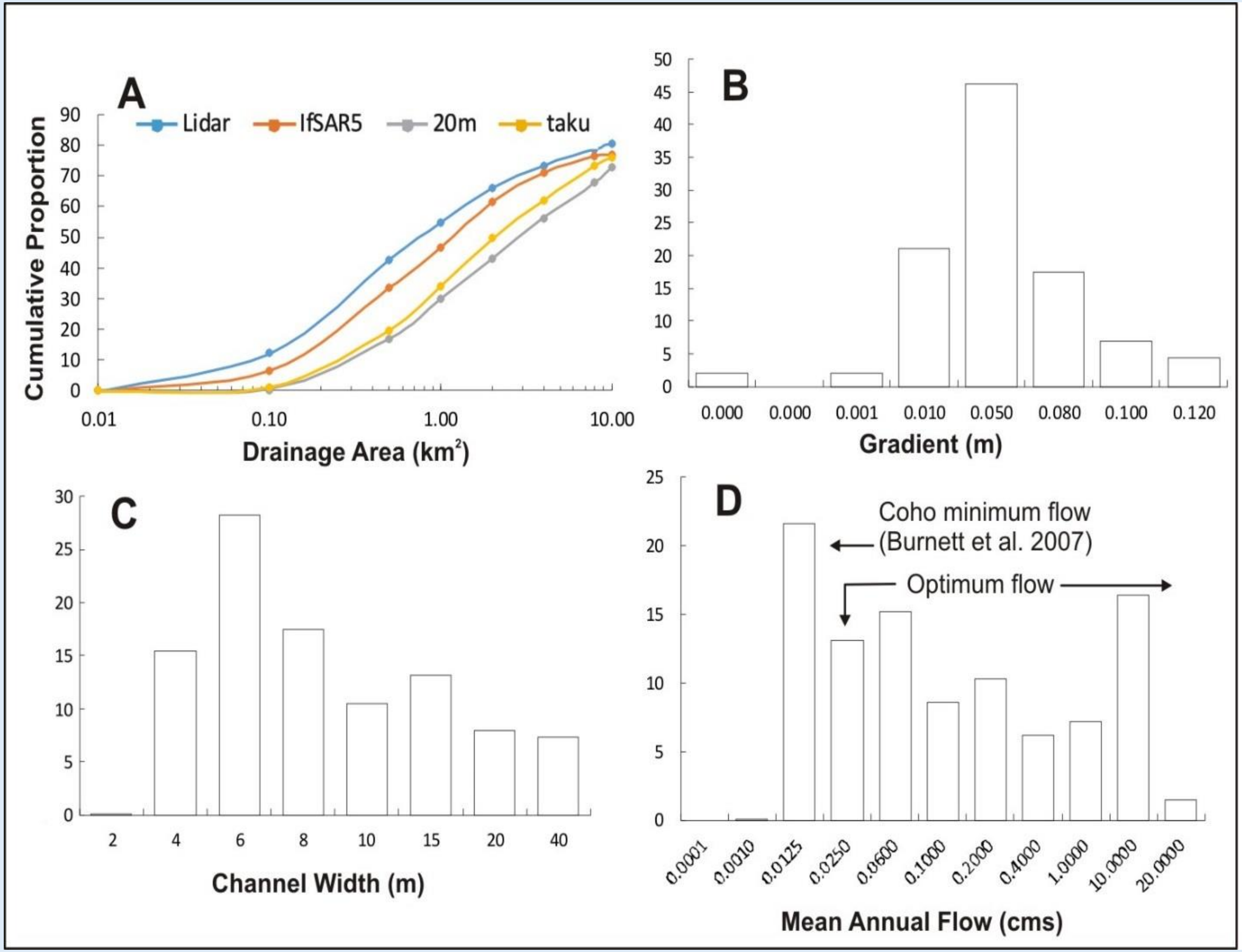
Salmon streams

Cumulative distributions of channel drainage areas of four synthetic river networks and the headwater drainage area thresholds in SE AK (Gomi and Sidle 2003). The plot indicates the likely omission of large portions of the smallest headwater streams in the IfSAR 5m, SE AK 20m and BC 17m derived synthetic networks.

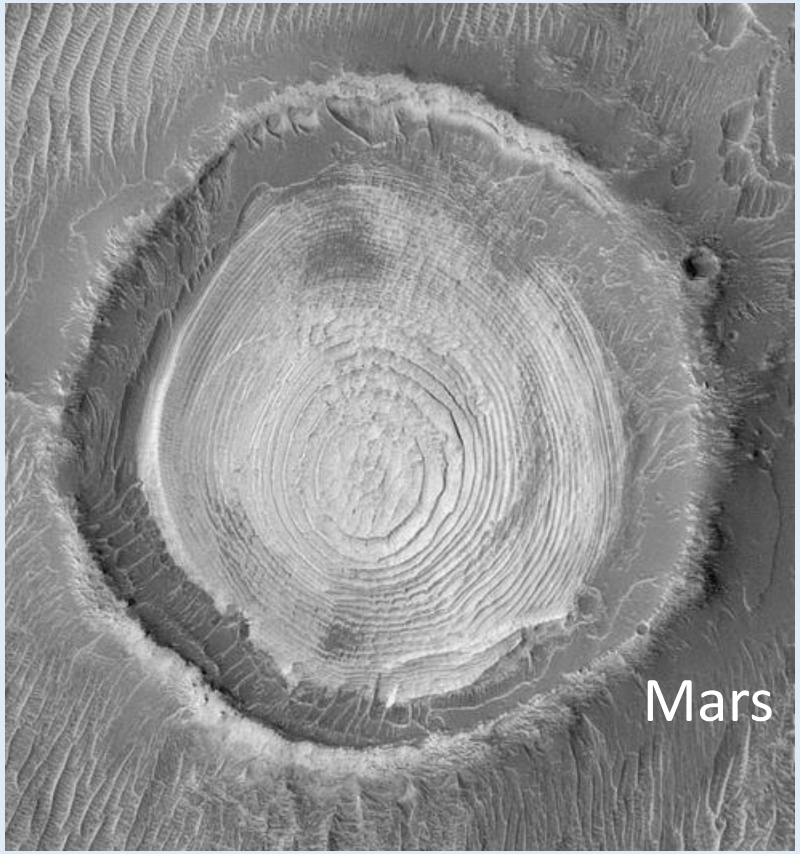


(A) Cumulative distributions of predicted potential salmon habitats of all synthetic networks derived from DEMs, truncated at 10 km². (B-D) Histograms of channel slopes, channel width and mean annual flow of predicted salmon potential streams delineated from the LiDAR DEM in north Chichigof Island.

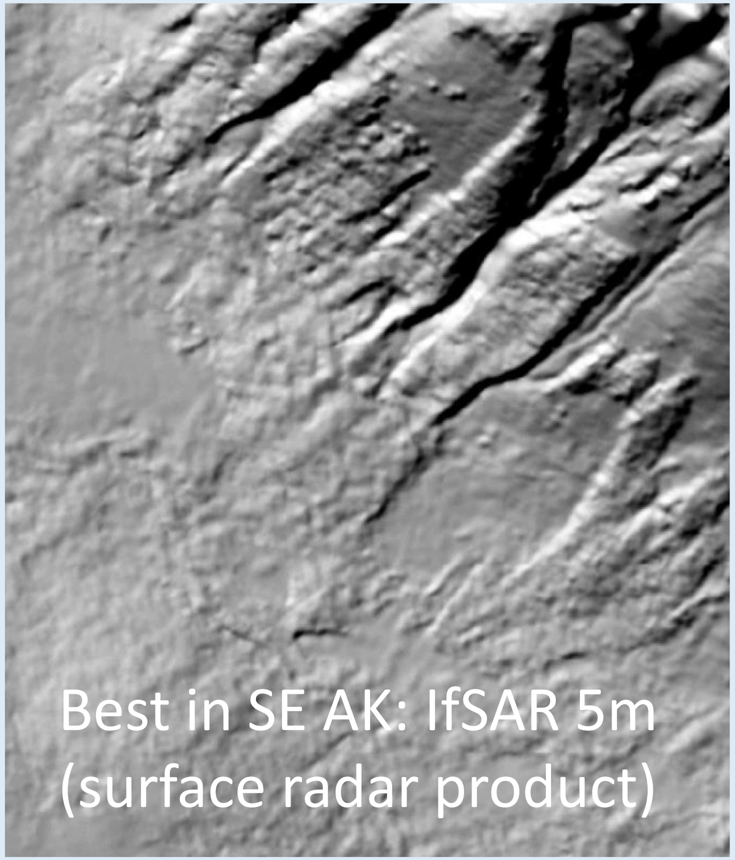
This indicates that the majority of salmon habitats occur in the lower, low gradient portion of headwater streams. It also shows the partial omission of these channels in DEM products, with the exception of LiDAR.

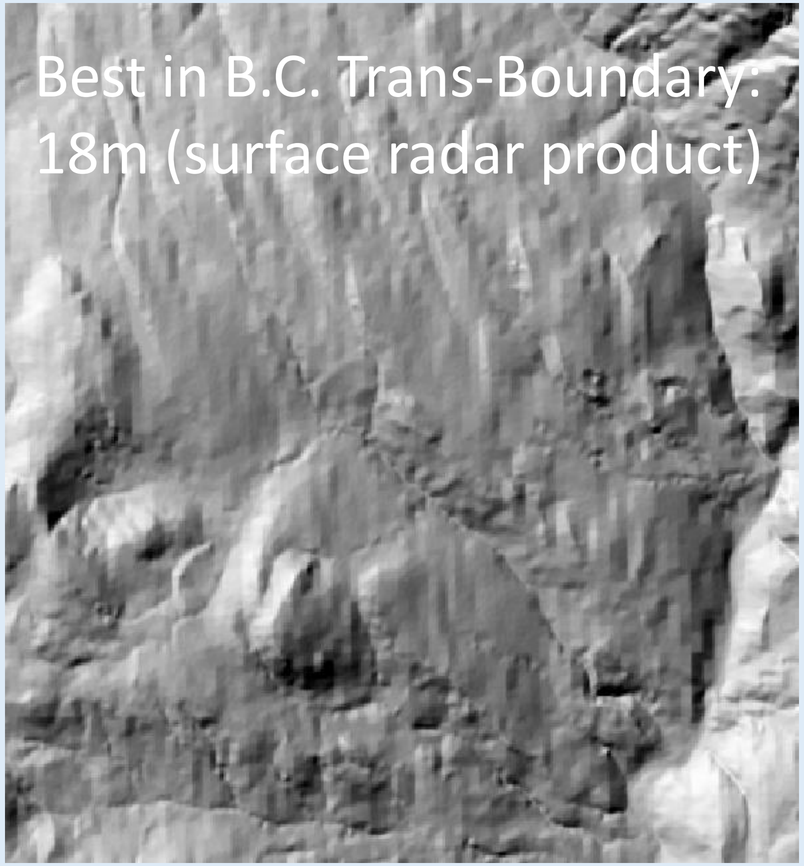


Why does Mars have better digital elevation models and maps than the U.S.–Canadian Trans Boundary Region?

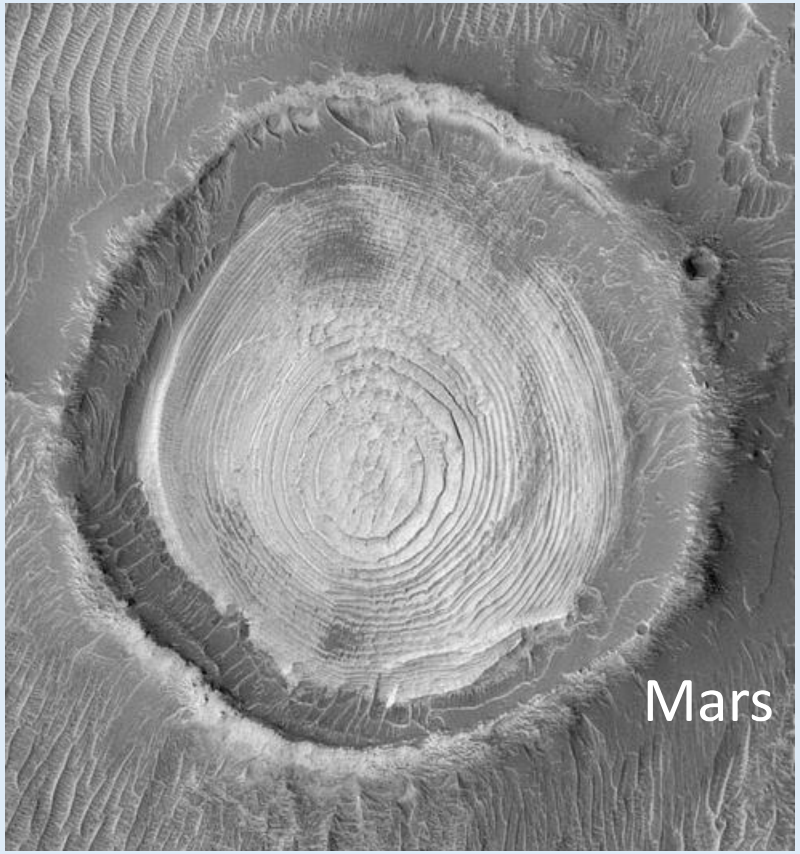


Remember the "Schiaparelli Crater" in "The Martian"





Answer: Because the U.S. and Canadian Governments consider LiDAR in remote areas like Alaska and northern British Columbia too expensive and thus unaffordable.



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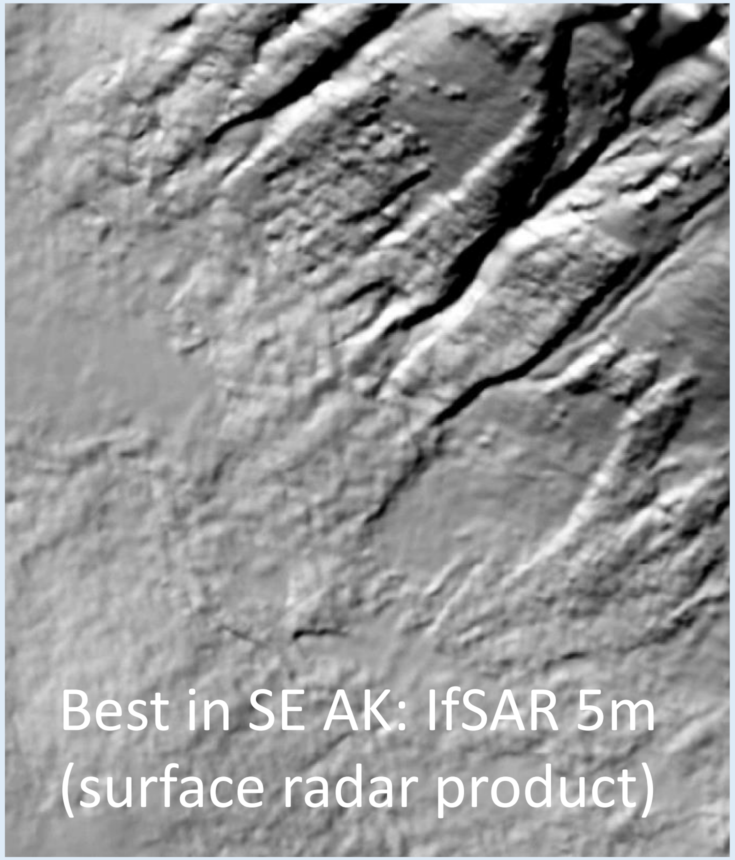
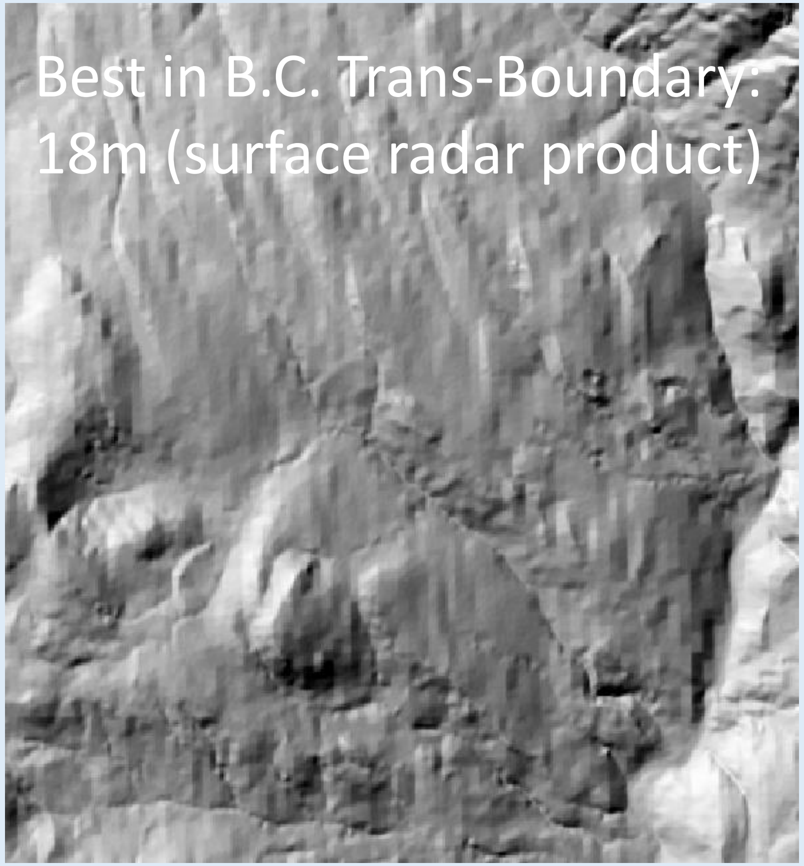
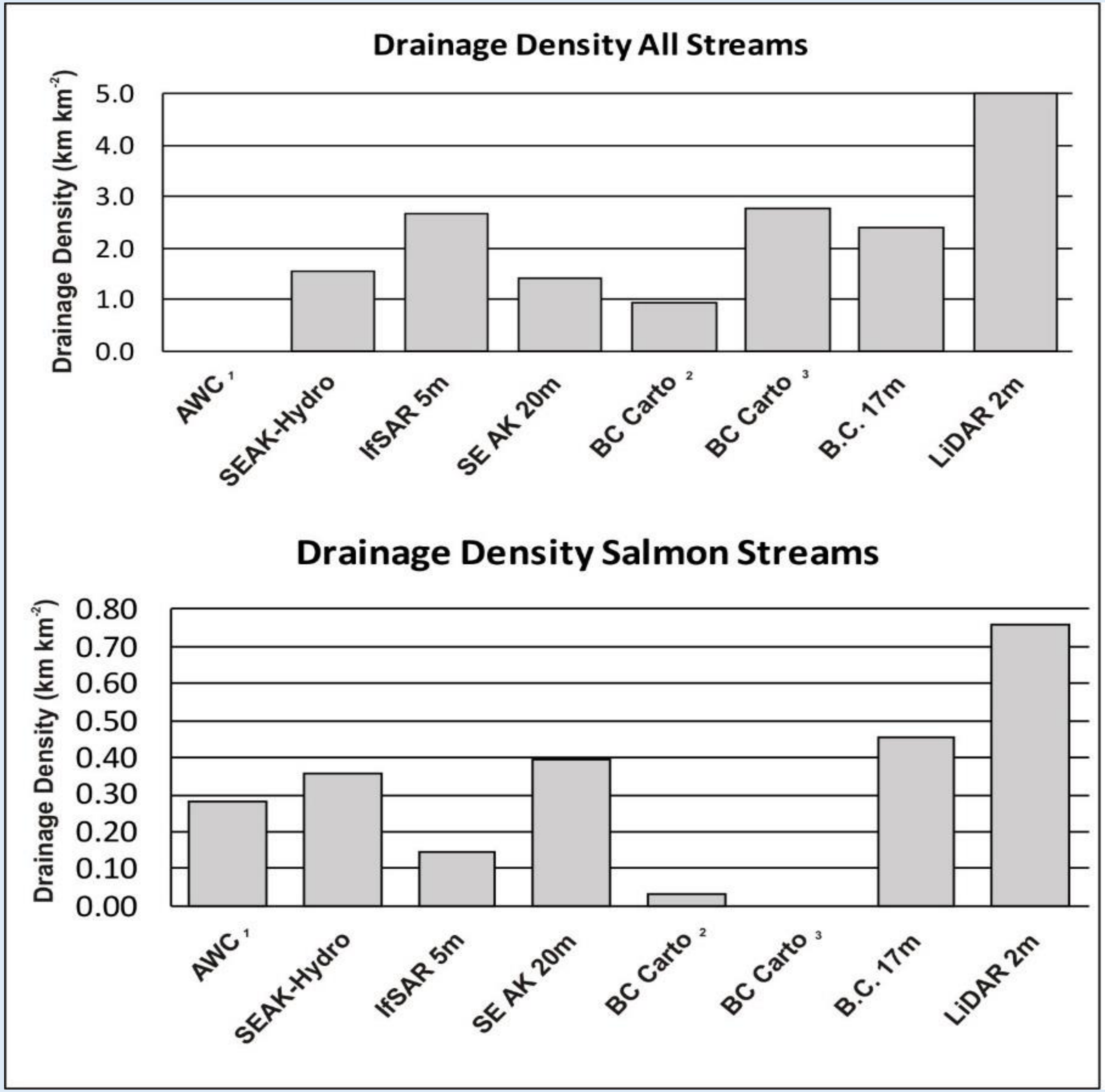




Data Analysis: Contrast the abundance of all streams and salmon streams only across existing data products and DEMs



In the trans-boundary region, the predicted length of all missing streams could be as high as 220,000 miles (distance to the moon is 240,000 miles).

The predicted length of missing salmon streams could be as high as 50,000 miles (about 2 times around the world).

Implications

How can federal, state and provincial agencies, Alaska Natives, BC First Nations, fishing and conservation organization evaluate potential environmental impacts associated open pit mining, road building, logging and hydro projects if they don't even know the accurate locations and abundances of salmon habitats, or river networks in general.

Up to half or more of salmon habitats may be undetected, unmapped and thus unprotected in much of the Trans-Boundary area.

This represents the most basic limitation on science, resource management and conservation.

The delineation of complete river networks and accurate salmon habitat identification will not be achieved in the U.S.-Trans Boundary region until LiDAR DEMs become available.