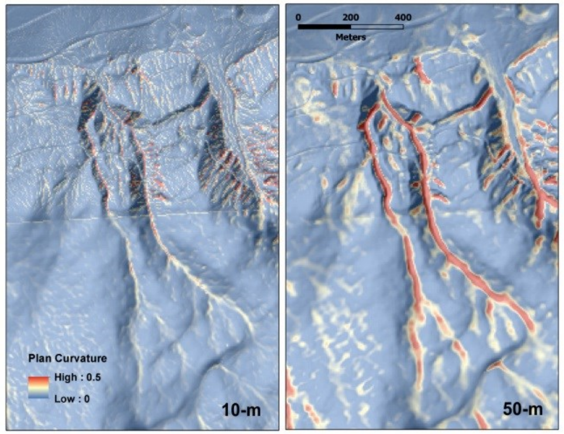
Salmonidae Incognito: How Can You Protect Salmon When You Don’t Know Where They Are?

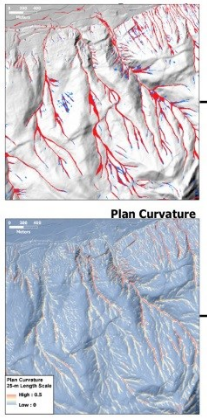
A Potential Crowdfunding Solution

Mapping Potential Salmon Habitats using Digital Topographic Data

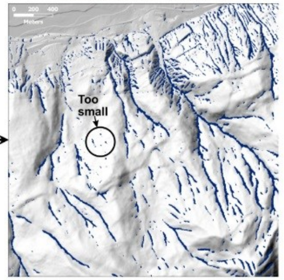
Start with Plan curvature



Add Contributing area * S^2

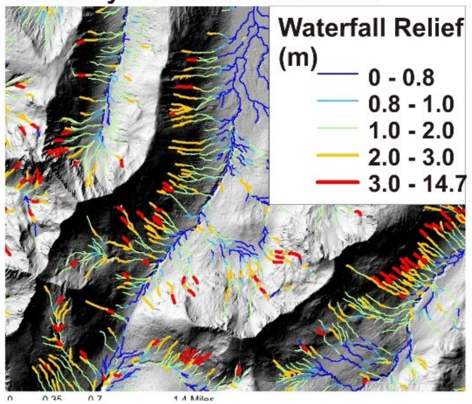


Identify Candidate Channel initiation



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.

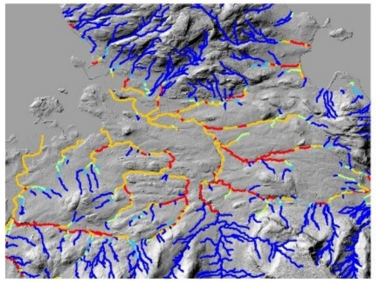
Create Synthetic River Network



Identify waterfall barriers (LiDAR)

Use Alaskan Anadromous Gradient Barriers

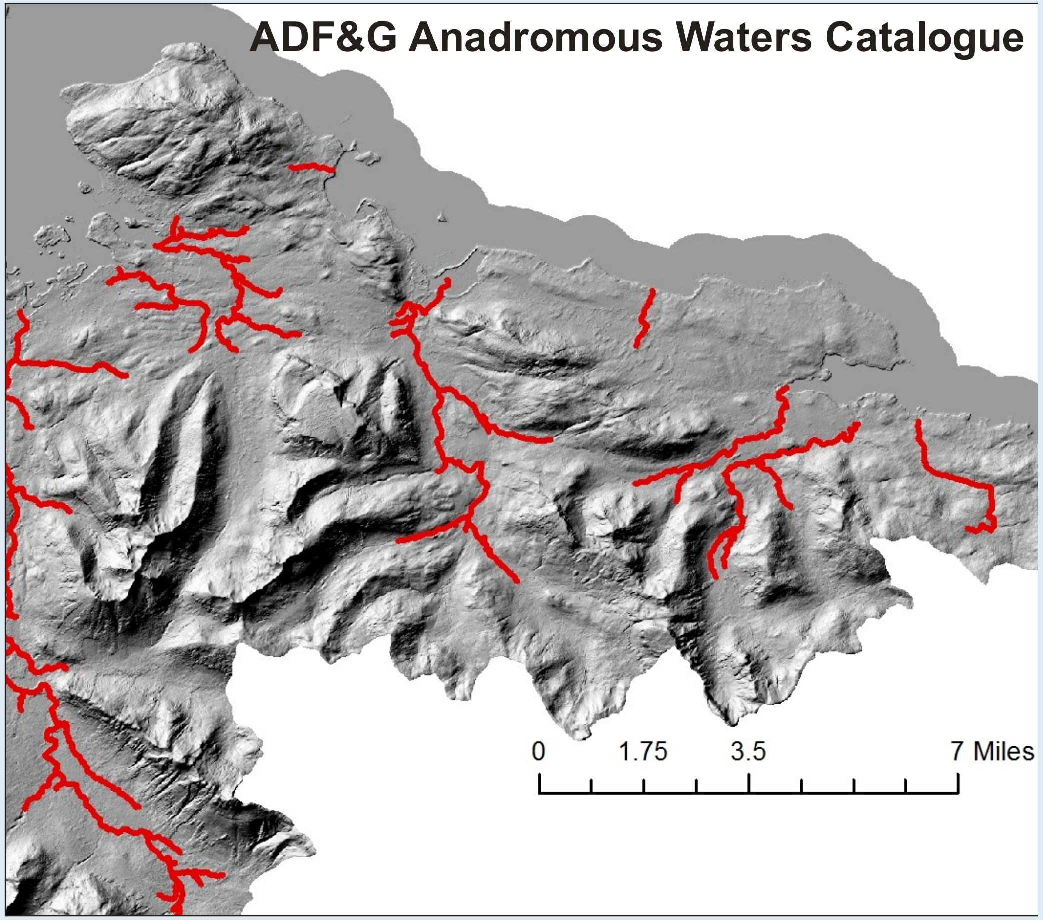
Criterion	Coho	Steelhead	Sockeye	Chinook
Steep channel	>=225 ft @ 12%	→		
Fall height (m)	11 ft	13 ft	10 ft	11 ft



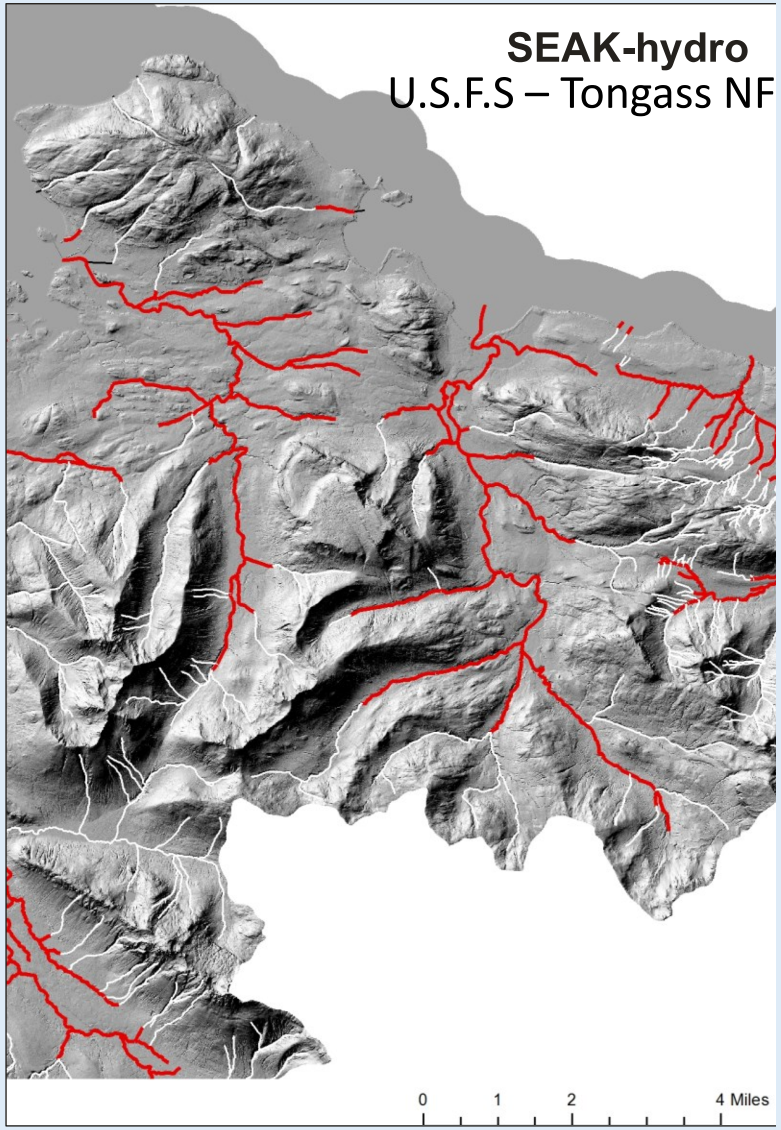
Apply Intrinsic Habitat Potential Models using flow, gradient and confinement thresholds (Burnett et al. 2007)

Project Pilot Area, approximately 1,000 km2 with 1 m LiDAR digital elevation model (DEM)

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

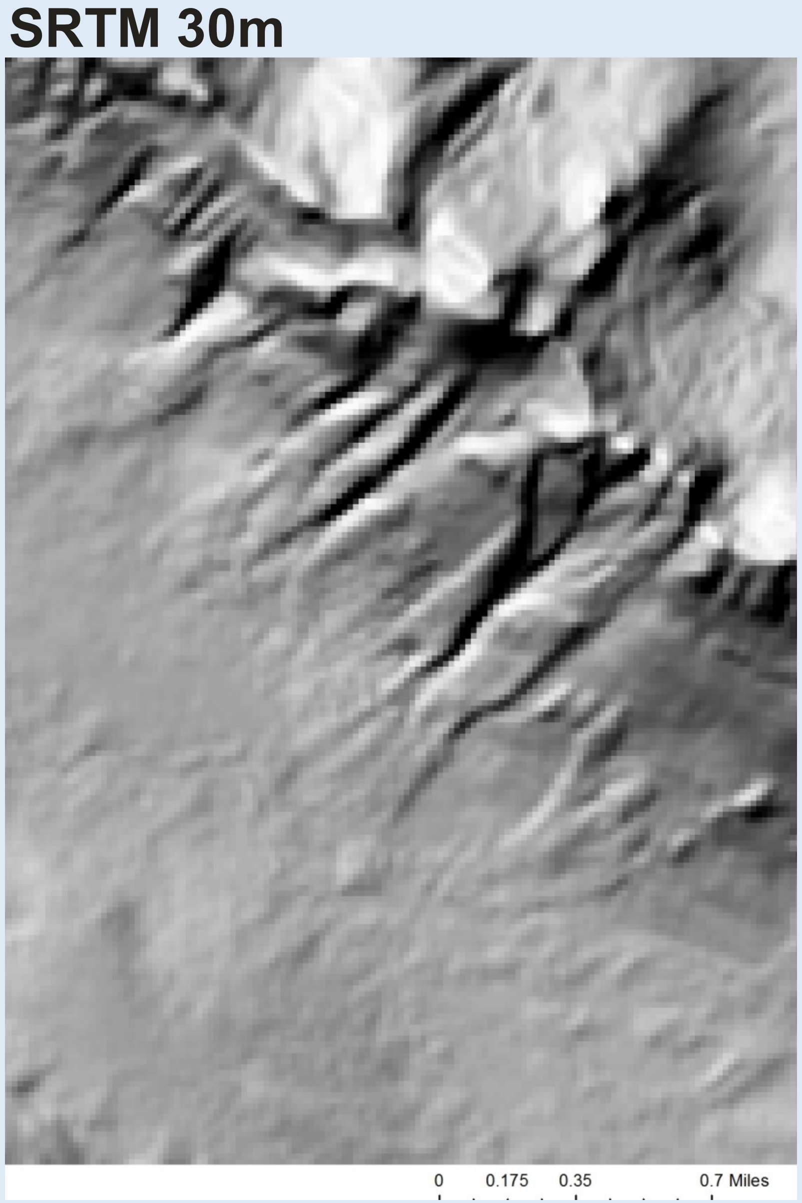


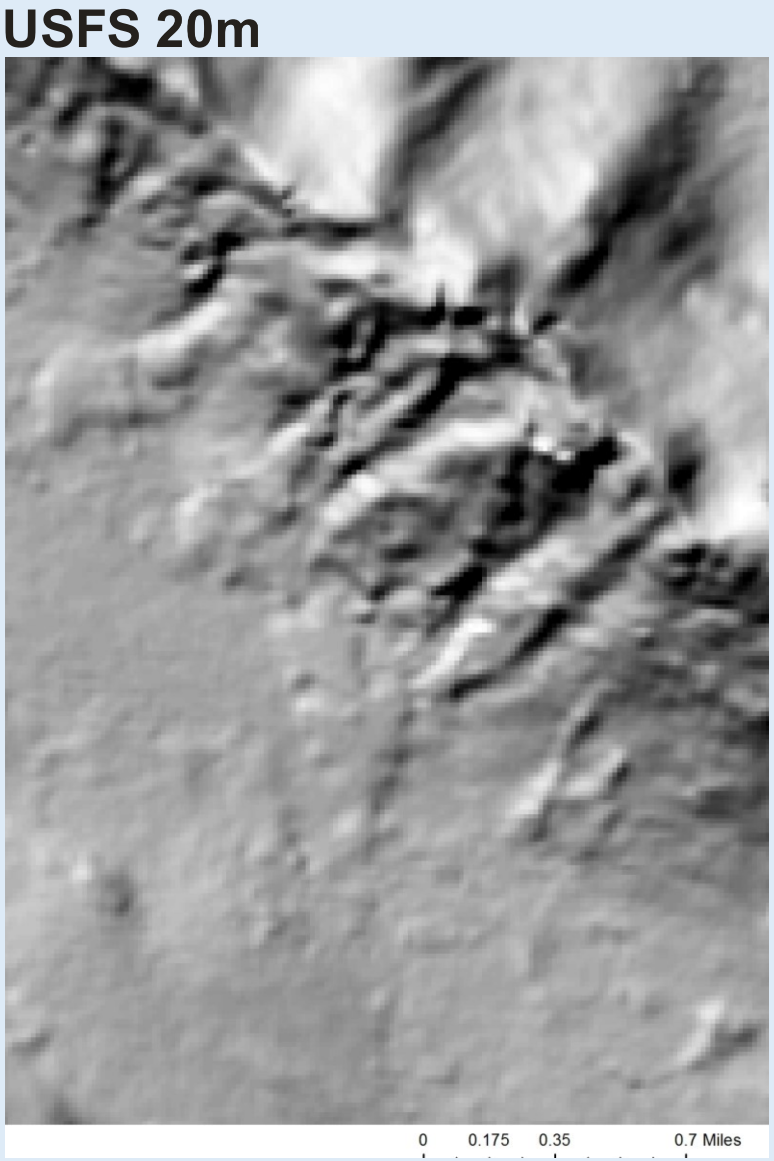
Drainage density salmon streams: 0.26 km km $^{-2}$



Drainage density all streams: 1.39 km km $^{-2}$
Salmon streams: 0.44 km km $^{-2}$

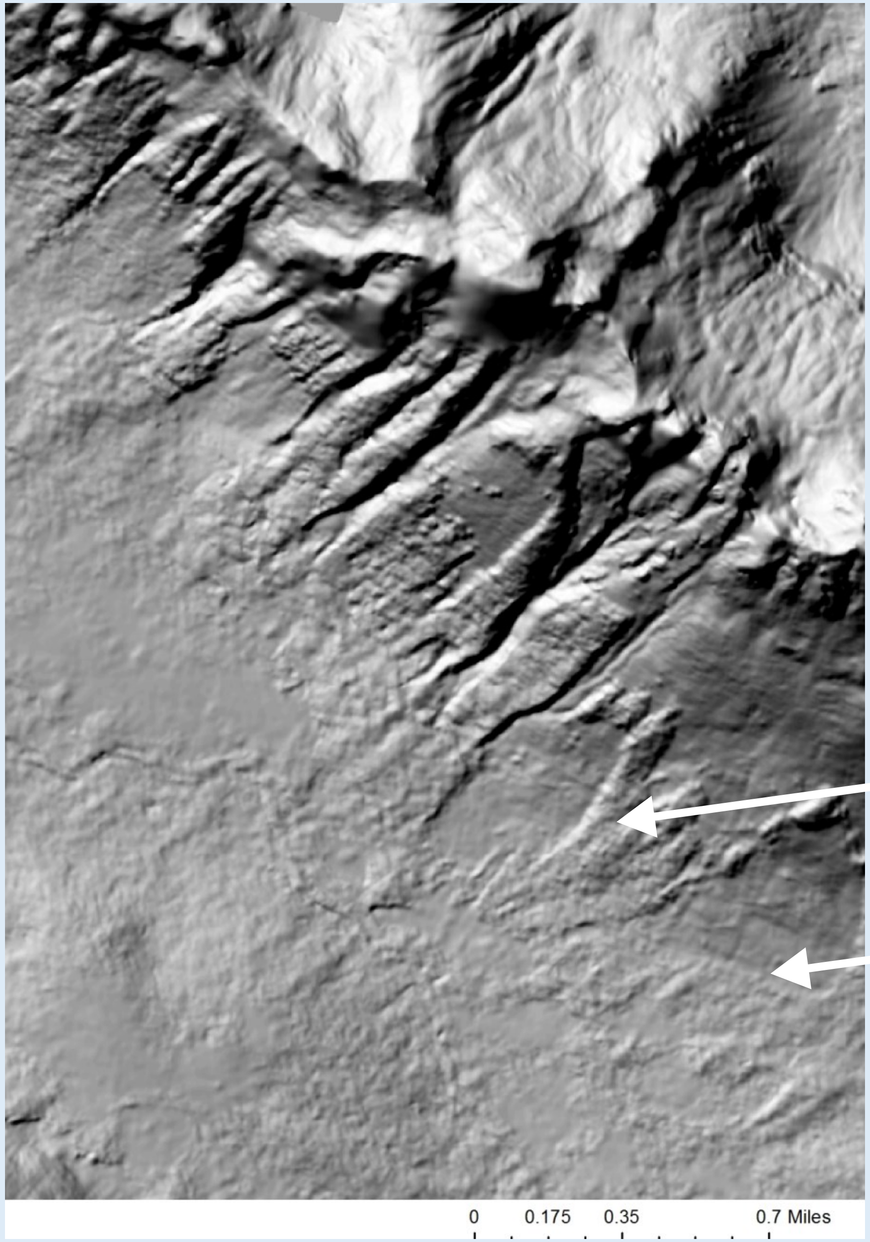
Next, we can derive entire river networks and salmon habitats using available DEMs in Southeast Alaska and B.C.





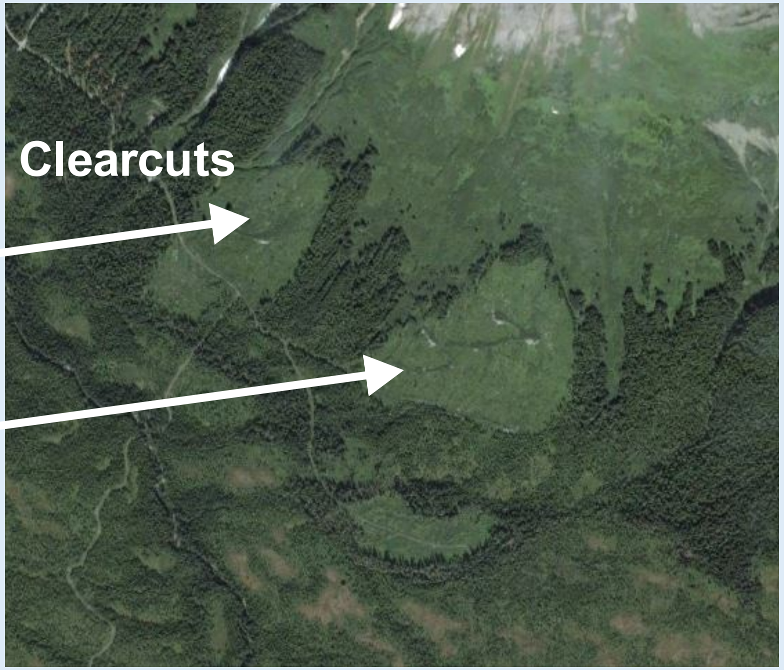
Equivalent to B.C. 25m DEM

IfSAR 5m

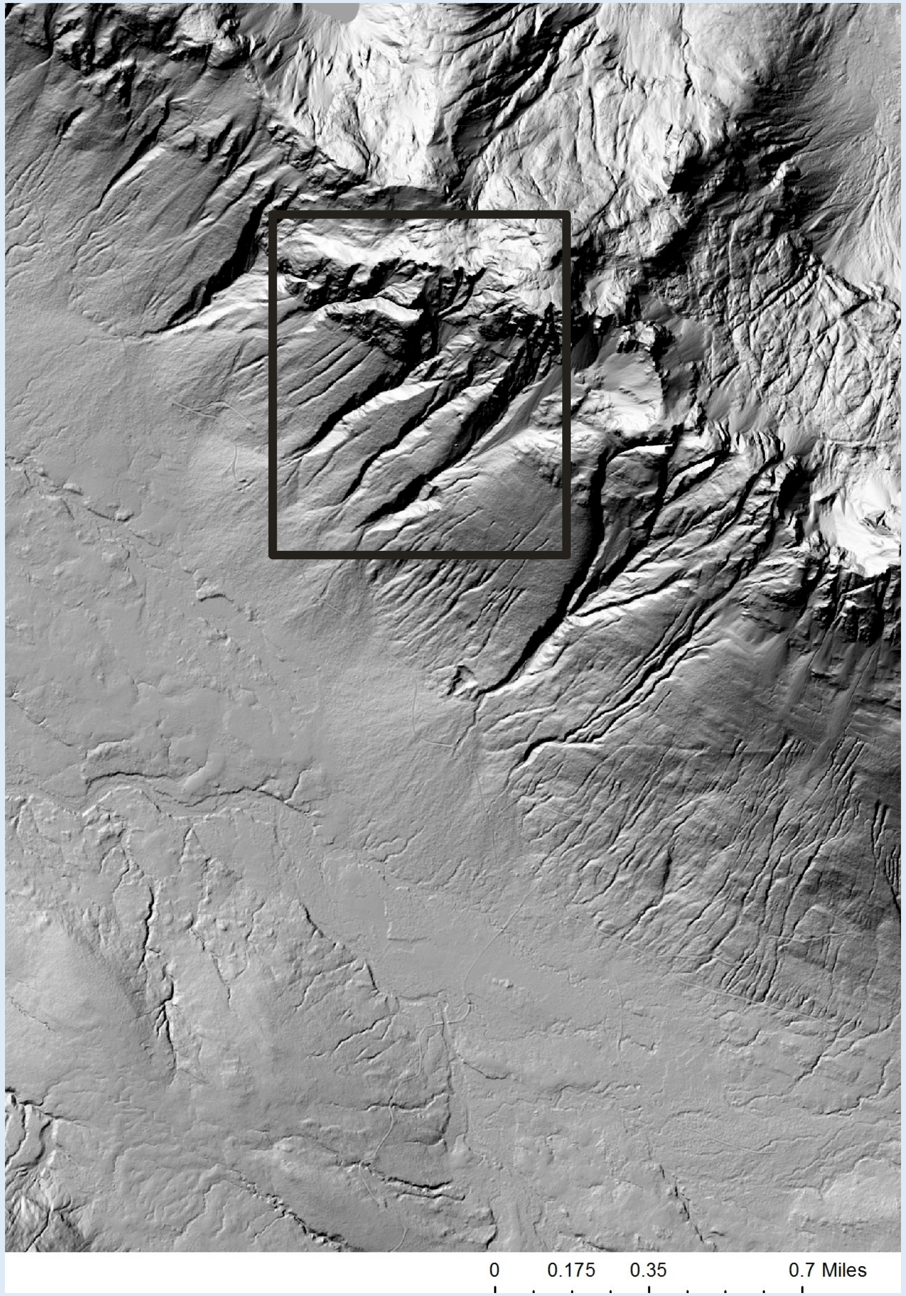


Southeast Alaska also have newly available 5m DEMs called IfSAR provided by the U.S.G.S., because LiDAR DEMs are considered too expensive and unaffordable in Alaska;

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)



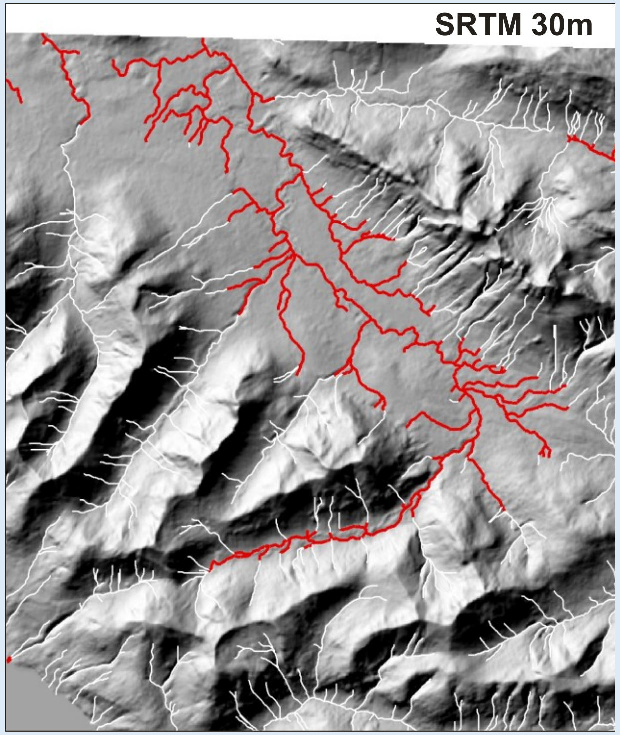
LiDAR 1-2m



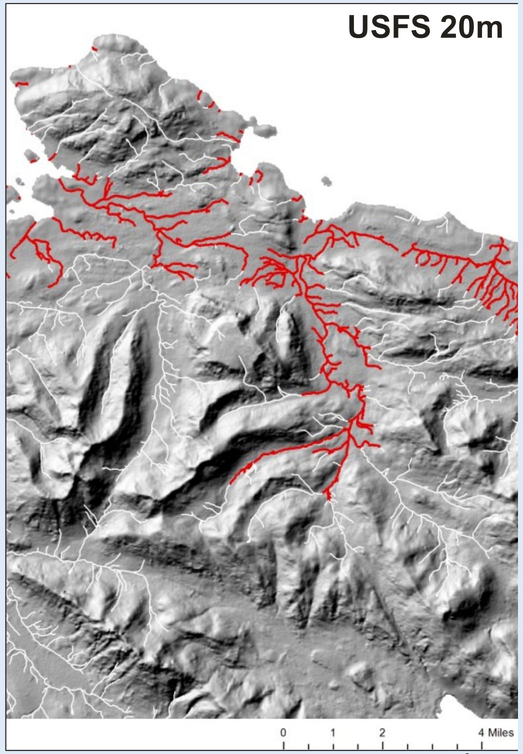
LiDAR (1m DEM) is the gold standard and can see under vegetation (using the latest sensors) as can be seen in this shaded relief imagery.

All channels can be seen and thus accurate river networks can be derived from it.

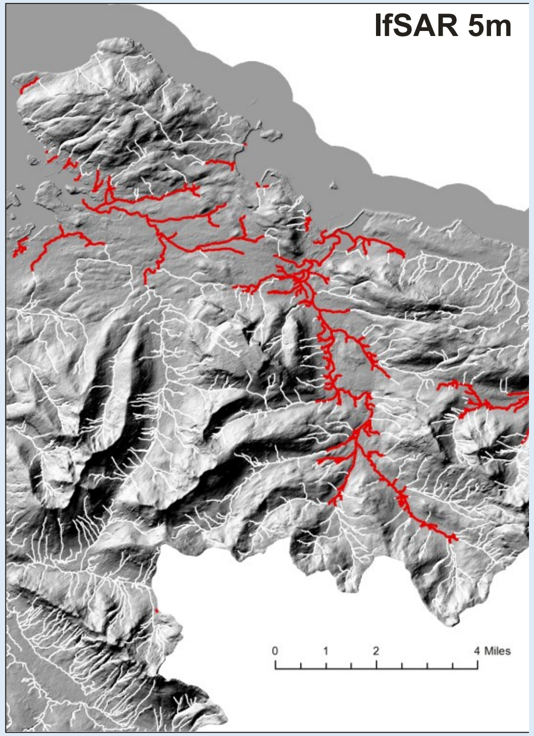
Imagery from the pilot analysis area in northern Chichigof Island, southeast Alaska (Hoonah Community Forest Project).



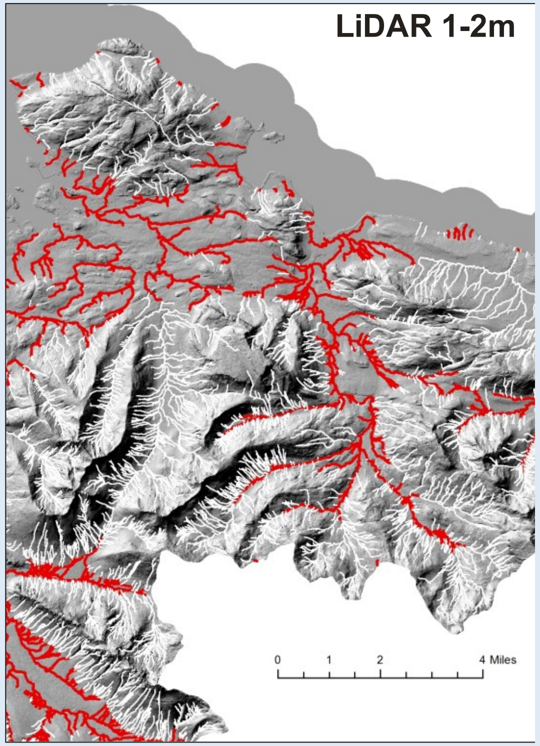
Drainage density all streams: 1.94 km km $^{-2}$
Salmon streams: 0.39 km km $^{-2}$



Drainage density all streams: 1.55 km km $^{-2}$
Salmon streams: 0.36 km km $^{-2}$



Drainage density all streams: 2.64km km $^{-2}$
Salmon streams: 0.35 km km $^{-2}$

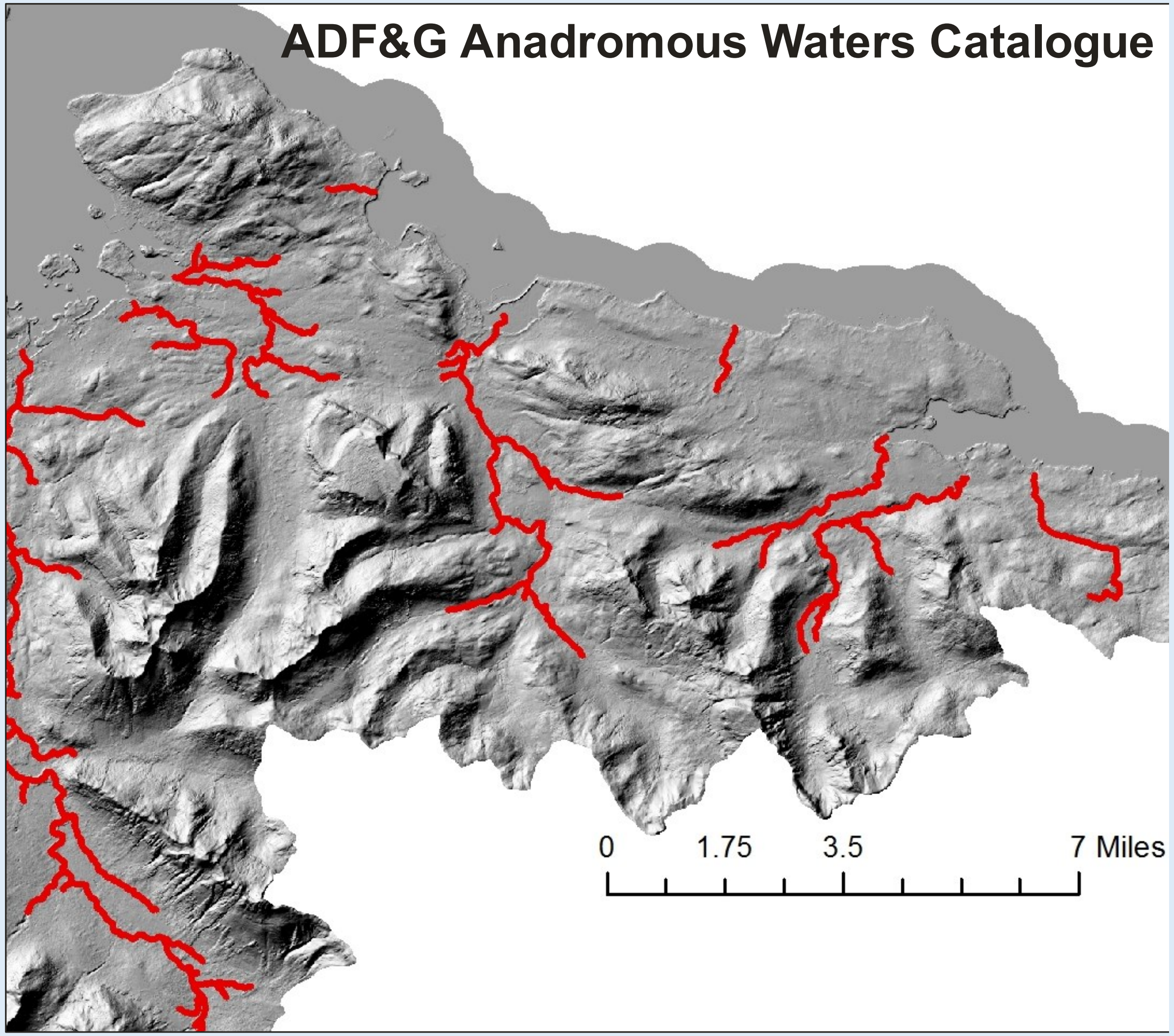


Drainage density all streams: 4.92 km km $^{-2}$
Salmon streams: 1.18 km km $^{-2}$

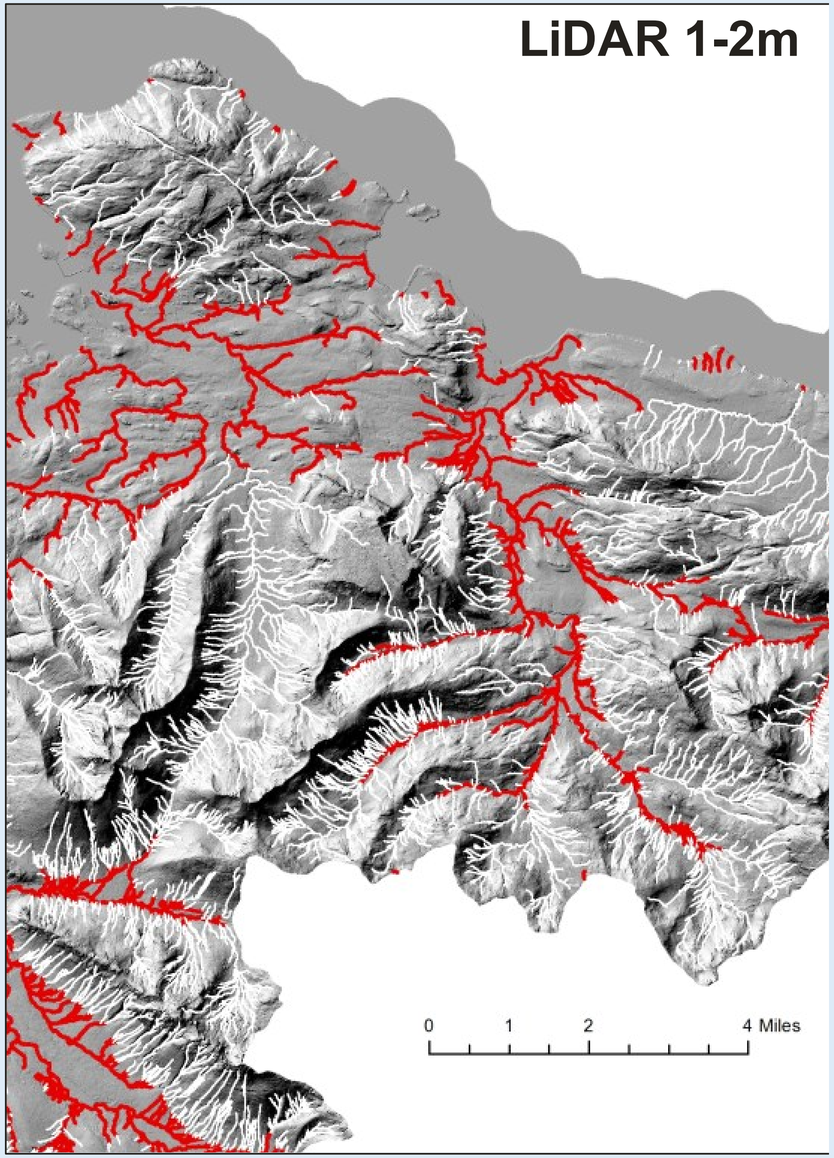
Salmon streams

This 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.

Compare the ADF&G AWC salmon extent with that predicted using the LIDAR DEM: AWC has 400% fewer salmon streams (based on length)



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

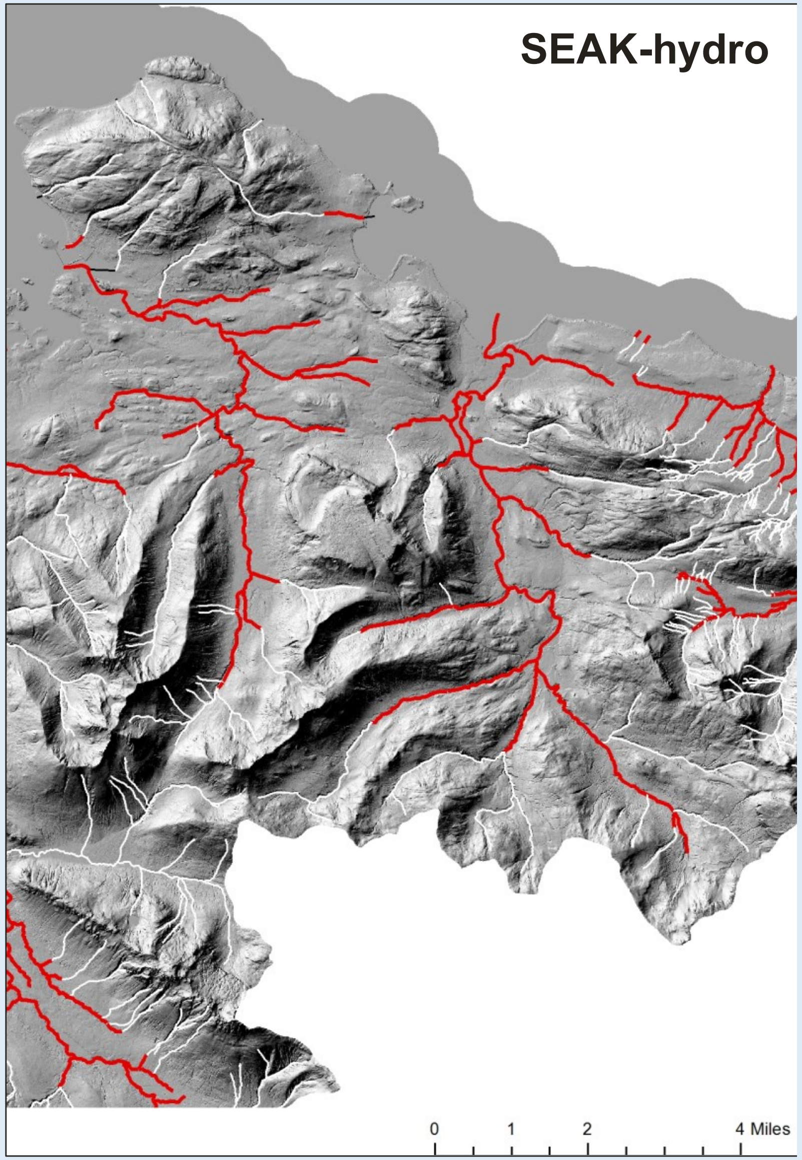


Salmon streams

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

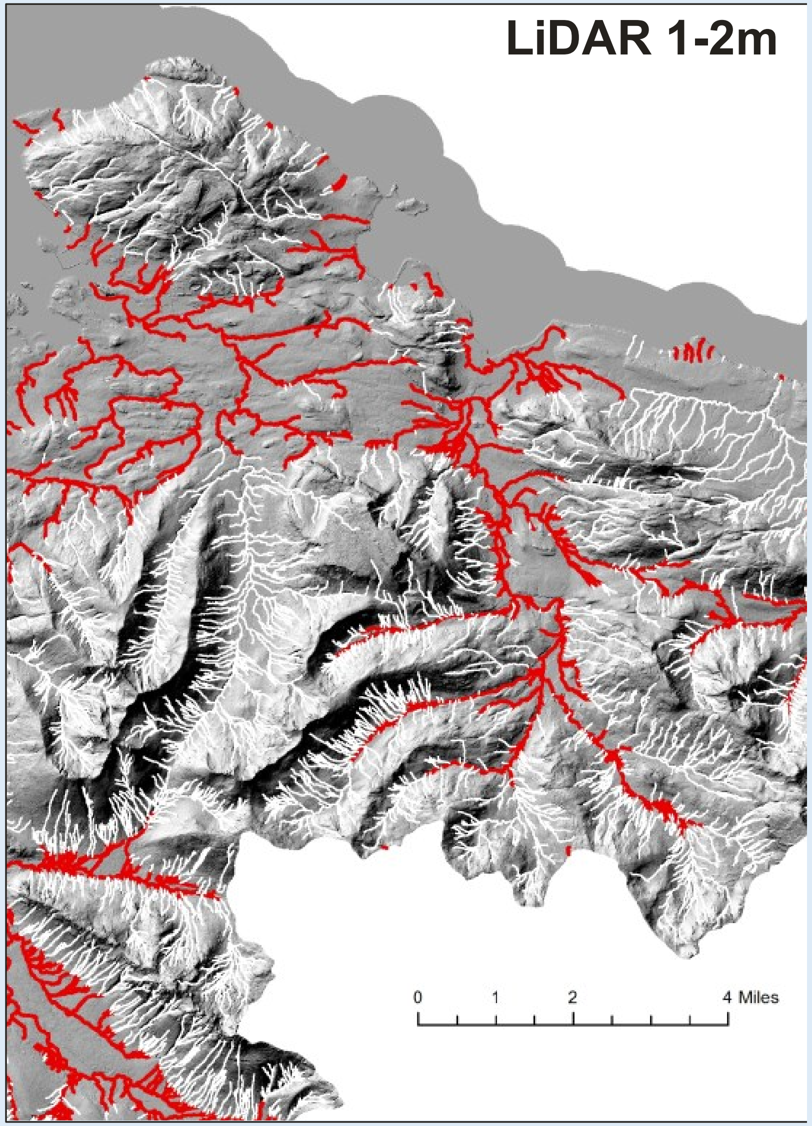
Salmon streams: 1.18 km km $^{-2}$

Compare the SEAK-hydro (Tongass NF) salmon extent with that predicted using the LIDAR DEM: SEAK has 200% fewer salmon streams (based on length)



Drainage density all streams: 1.39 km km $^{-2}$

Salmon streams: 0.44 km km $^{-2}$

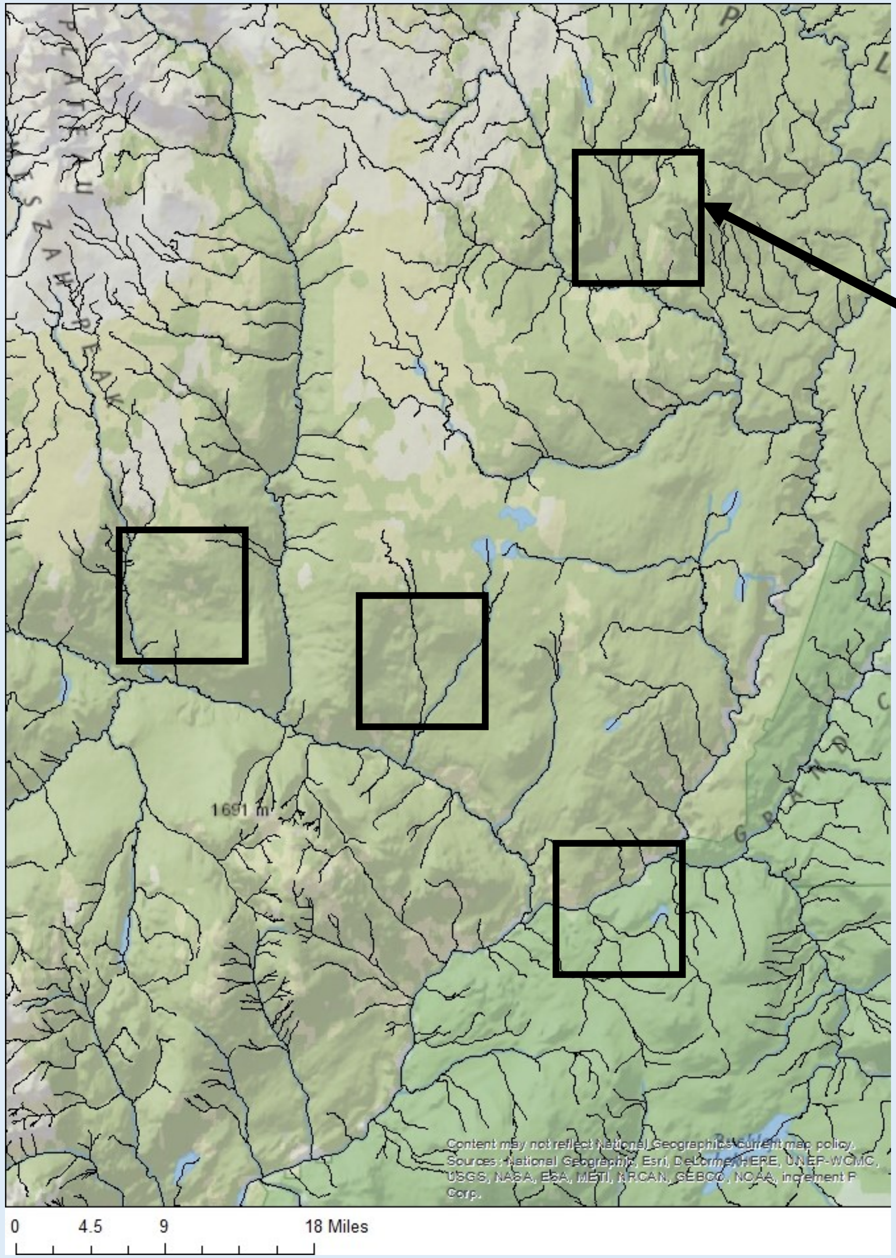


Drainage density all streams: 4.92 km km $^{-2}$

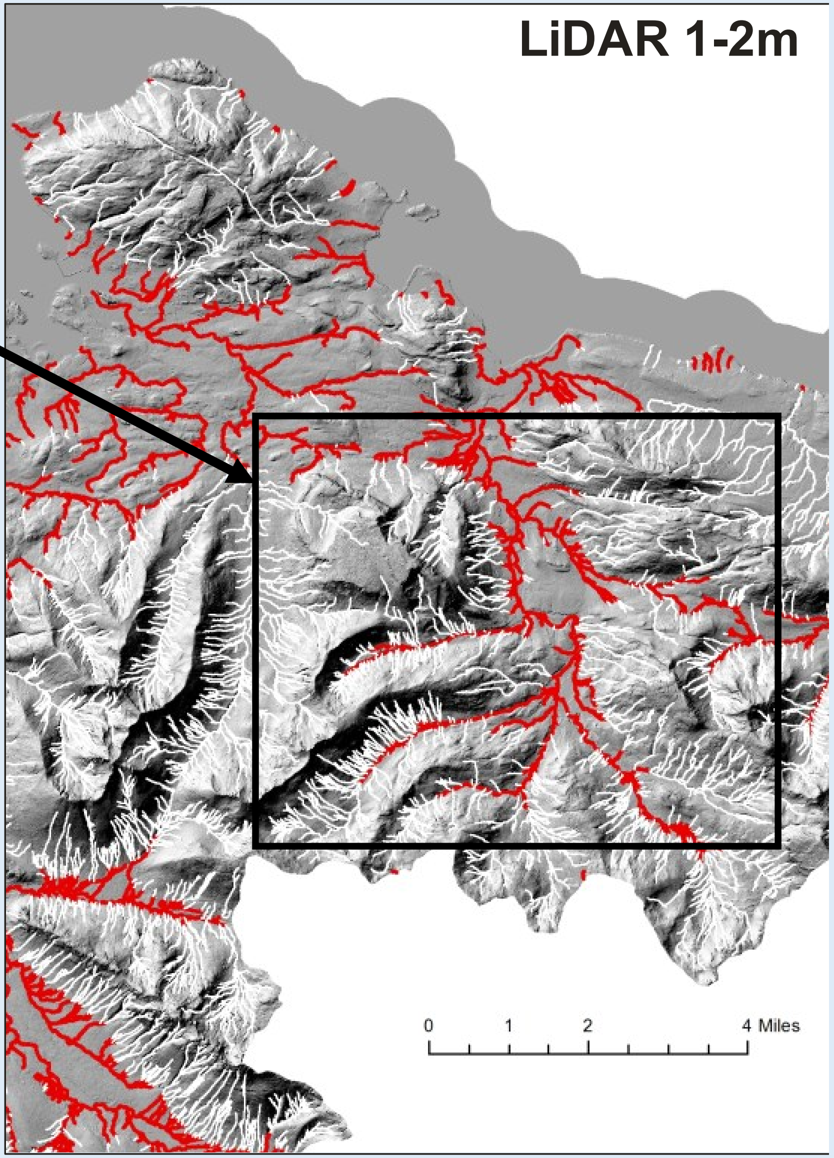
Salmon streams: 1.18 km km $^{-2}$

Salmon streams

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



Drainage density all streams: 1.37 km km^{-2}

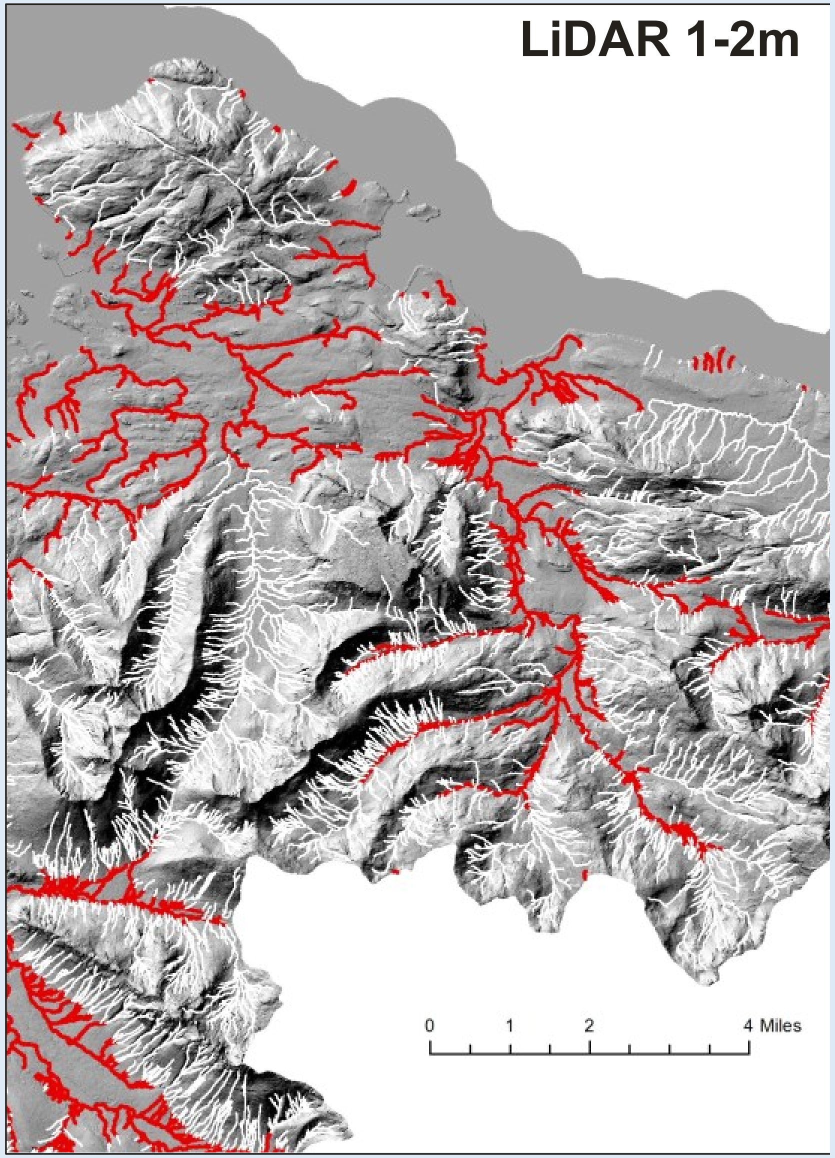


Drainage density all streams: 4.92 km km^{-2}
Salmon streams: 1.18 km km^{-2}

Note that the boxes in the two images are of the same scale; the streams in the box on the right indicates how many streams are missing in the B.C. trans-boundary area; the B.C. streams (Provincial hydrography) have about 350% less stream length compared to the LiDAR).

B.C. Fish Streams

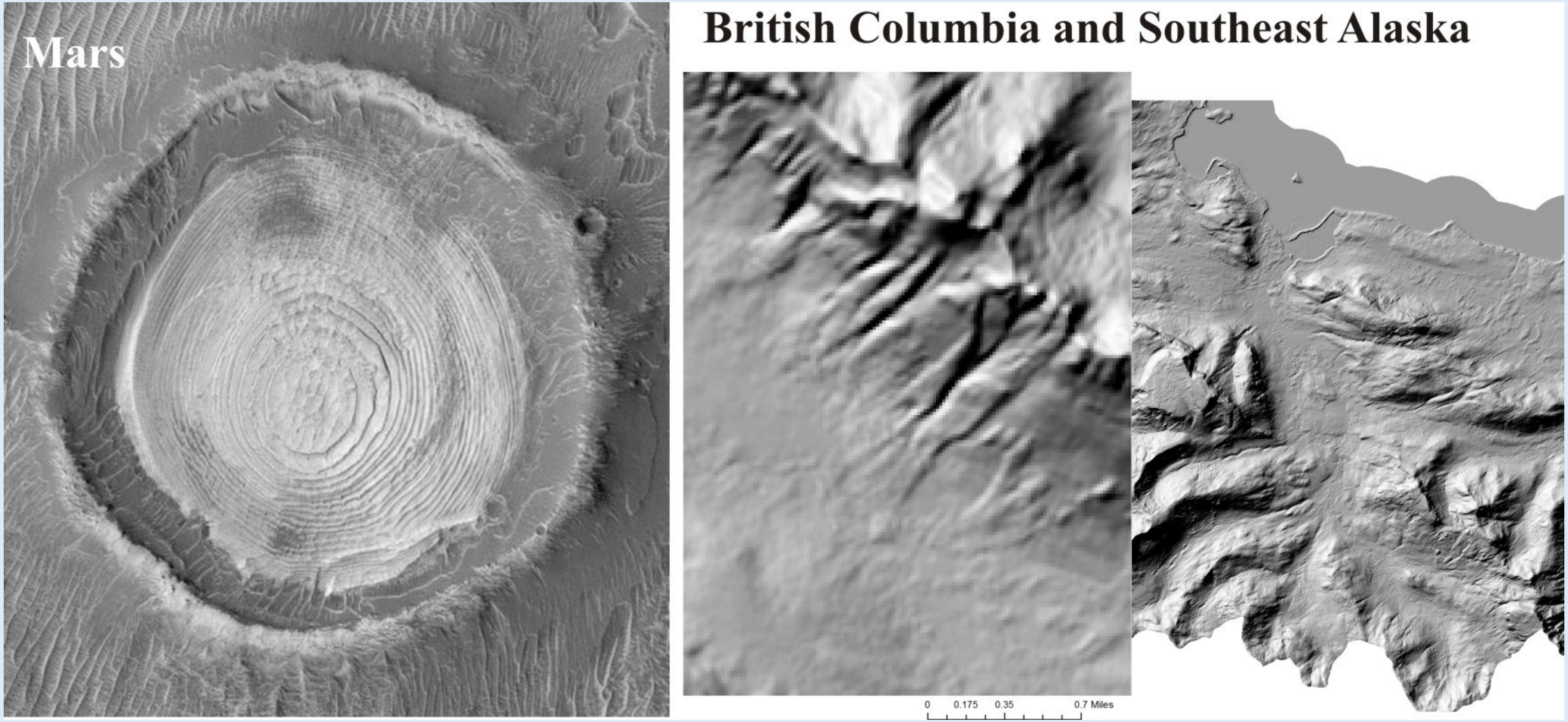
Drainage density all streams: 1.37 km km^{-2}
Salmon streams: 0.22 km km^{-2}



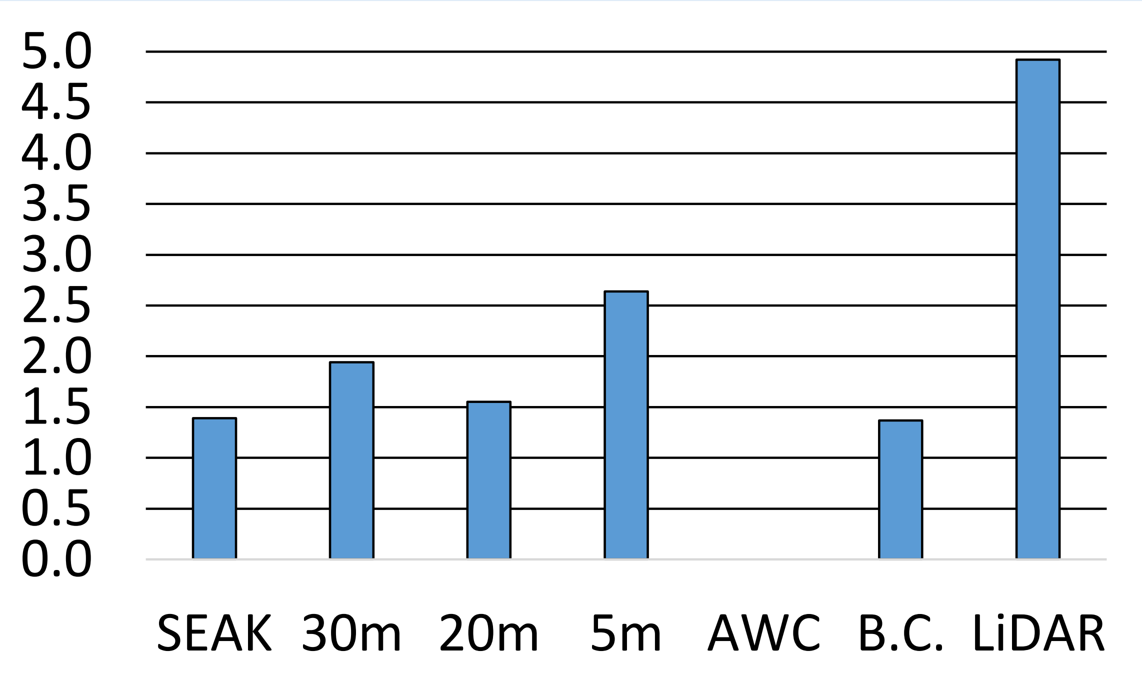
Drainage density all streams: 4.92 km km^{-2}
Salmon streams: 1.18 km km^{-2}

Note that the B.C. fish (includes salmon) streams on the left has a density of 0.22 km km-2, compared to the potential salmon stream density using LiDAR; this indicates that salmon streams in B.C. might be underestimated (in length) by as much as 500%!

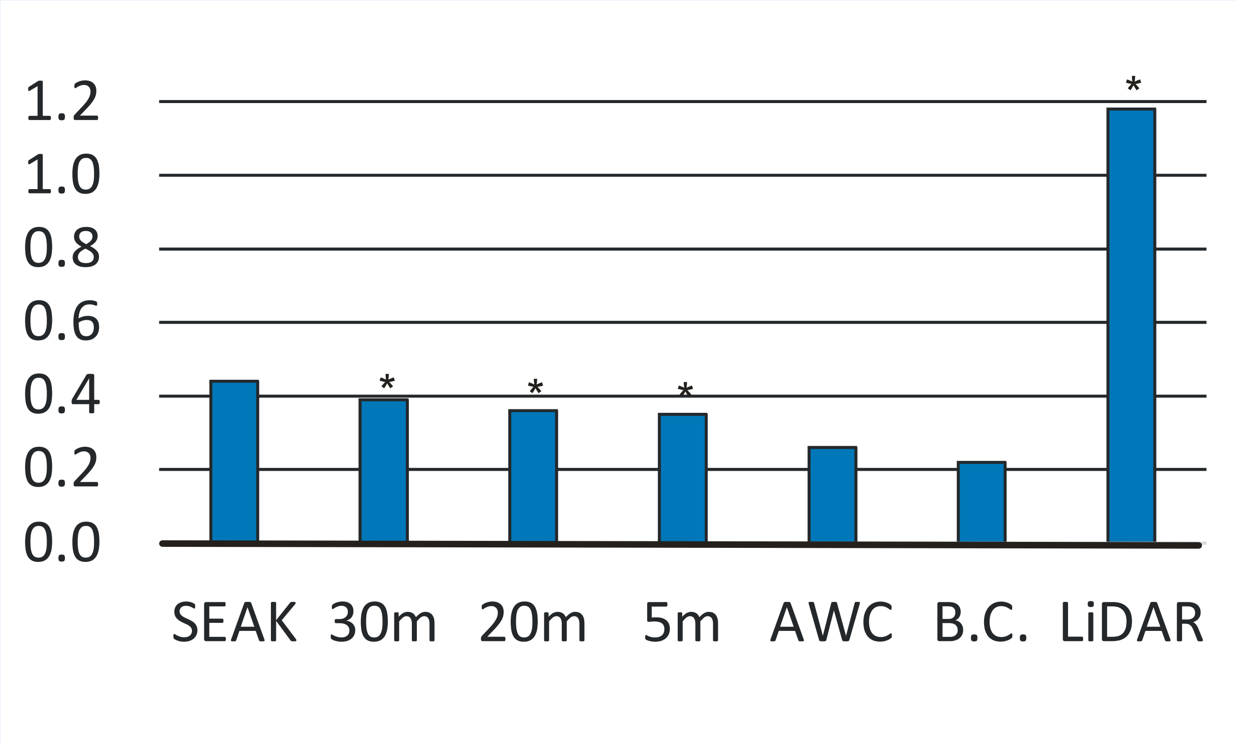
Why does Mars have better digital elevation models and maps than the U.S. – Canadian Trans Boundary Region?



Abundance of all streams by density (km km^{-2})



Salmon stream abundance by density (km km^{-2})



Histograms showing the relative differences in mapped streams (all) and salmon habitats only

* Potential salmon streams, predicted using synthetic river networks derived from DEMs and by gradient barriers and models

B.C. = British Columbia (Stikine, Taku, & Unuk Rivers)

Bottom Line:

LiDAR salmon (potential) maps are:
400% greater than AWC,
200% greater than SEAK-hydro,
300% - 400% greater than 5m, 20m and 30m salmon maps
400% to 500% greater than mapped B.C. fish streams

Bottom Line:

In the trans-boundary region, the predicted length of all missing streams is estimated at 250,000 miles (distance to the moon is 240,000 miles)!

The predicted length of missing salmon streams could be as high as 60,000 miles (2 ½ times around the world)!

-U.S.G.S. considers LiDAR acquisition in Alaska unfordable (thus the IfSAR 5m radar product)

-Digital terrain models on Mars better than trans-boundary

-There is a compelling story about the undetected, unmapped and unprotected salmon streams

-There is the ongoing international controversy over the B.C. open pit and underground mines. How can one evaluate potential impacts when you do not know where the majority of streams are?

-Crowdfunding might a home grown solution to acquire LiDAR and create accurate stream maps including salmon habitats over the 70,000 mi^2 area

-U.S.G.S. has the 3DEP program that might match 1:1 LiDAR funding

A journal paper is currently in development that described the analysis, results and interpretations. It will be submitted to Plos One by end of May 2016.

The Challenge of Mapping Complete River Networks and Potential Salmon Habitats in Southeast Alaska and in Adjoining Canadian Trans-Boundary Watersheds. Benda et al. in prep.

Abstract

The Southeast Alaska region, inclusive of the Alexander Archipelago and the large rivers that extend into British Columbia (Stikine, Taku and Unuk watersheds), constitutes one of the last environmental strongholds of five species of wild Pacific Salmon. To manage resource development and to protect salmon in this trans-boundary region, federal, state and provincial agencies need to know the locations and abundance of salmon habitats accurately. We investigated the feasibility of identifying and mapping complete stream networks, including locations and abundance of salmon habitats in southeast Alaska and northern British Columbia (180,000 km^2). We delineated complete river networks using a range of digital elevation models (DEMs) including 1m LiDAR available in a 1,000 km^2 pilot area in southeast Alaska, the newly available 5m IfSAR DEM across southeast Alaska and a 20m DEM available in British Columbia. We applied thresholds of channel steepness, including waterfalls, and salmon habitat models to identify potential salmon habitats in the virtual watersheds. The predicted density ($km\ km^{-2}$) of all streams, and of potential salmon streams, were compared to those within existing map products including the Alaska Department of Fish and Game Anadromous Salmon stream catalogue, the U.S. Forest Service's (Tongass National Forest) 1:100,000 stream layer, and British Columbia's 1:50,000 hydrography, including its mapped salmon streams. In the U.S., the predicted LiDAR-derived salmon stream extent is 400% greater than the State of Alaska's salmon stream catalogue, 200% greater than the Tongass National Forest salmon distribution, and 350% greater than the derived salmon streams using the newly available IfSAR 5m river networks. In B.C., we infer that LiDAR derived stream networks, and salmon streams specifically, would be respectively 350% and 550% greater in length compared to what is contained within existing B.C. map products. In addition, predicted salmon streams that are delineated using B.C.'s 20m DEM would be 350% less than LiDAR derived salmon stream extent. Based on this analysis we estimate that as much as 400,000 km of all streams, and 100,000 km of salmon streams, remain unidentified and unmapped across the north Pacific trans-boundary ecosystem. How can salmon habitats be protected, including within watersheds exposed to proposed timber harvest, road building, hydro-development and mining projects if agencies do not know the locations of the majority of salmon habitats? We conclude that delineation of complete river networks

A Crowdfunding campaign is a solution to acquire LiDAR across the U.S. – Canada Trans Boundary ecosystem; refer to the crowdfunding poster (link) for additional information.

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