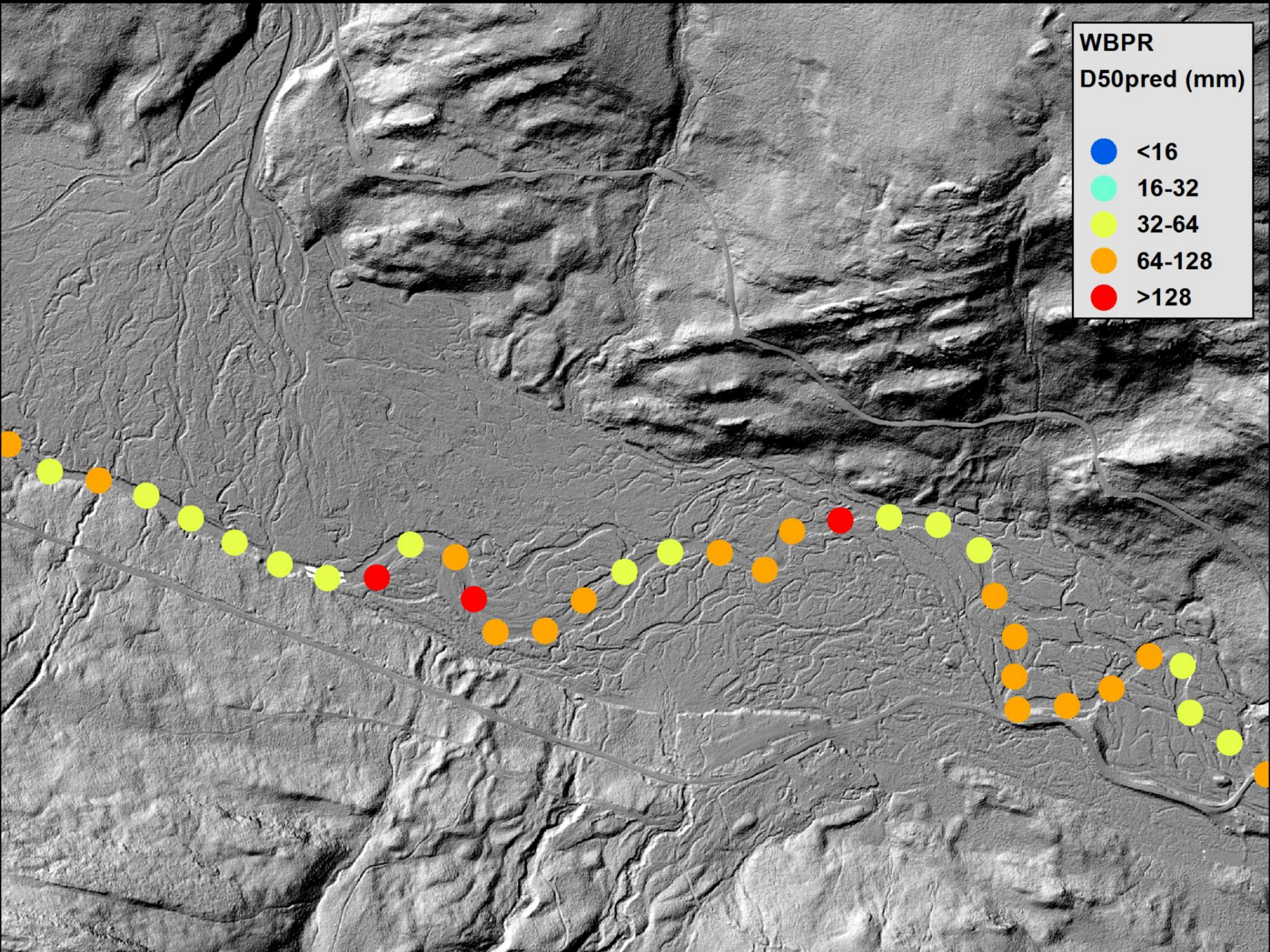
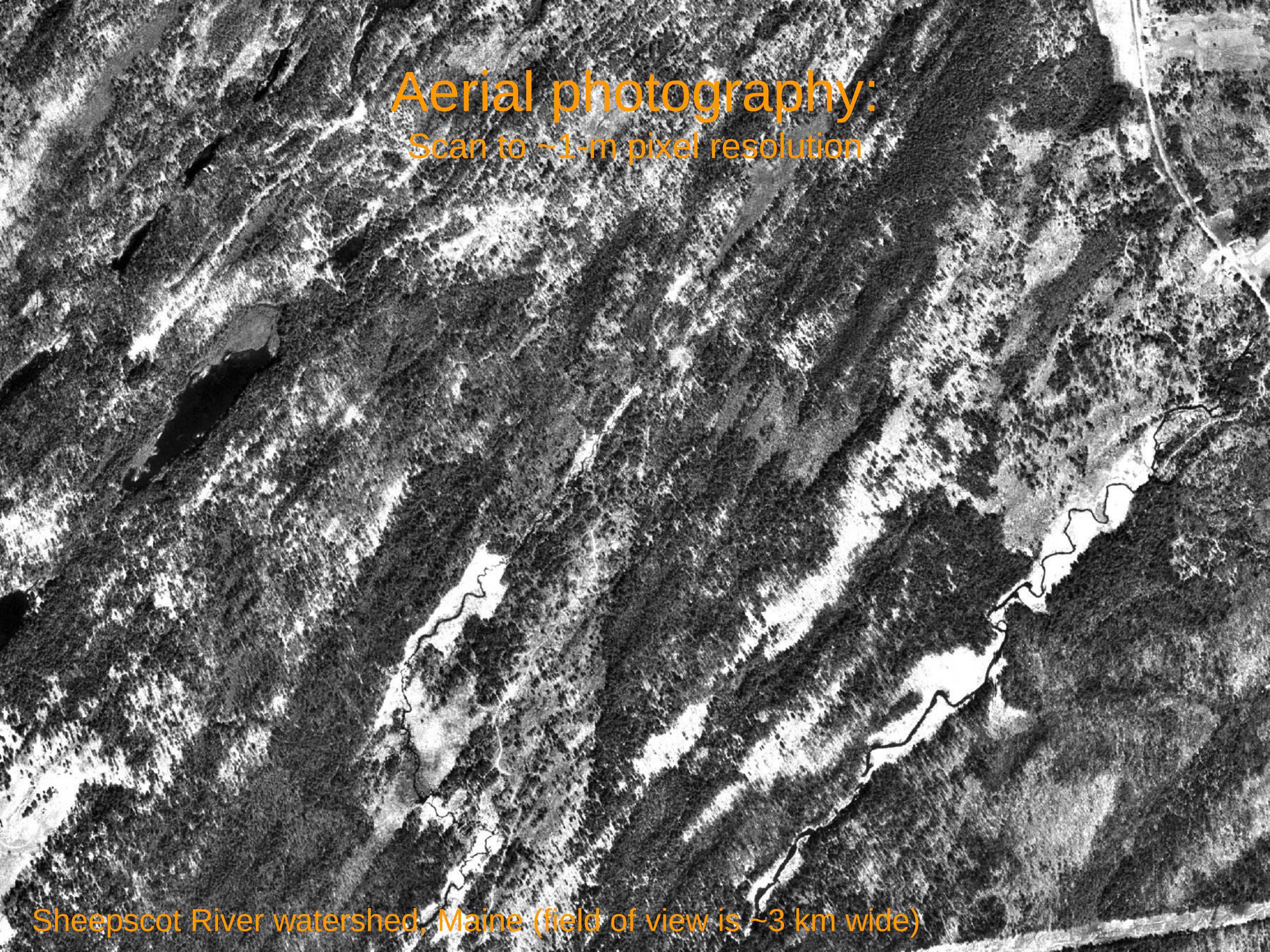
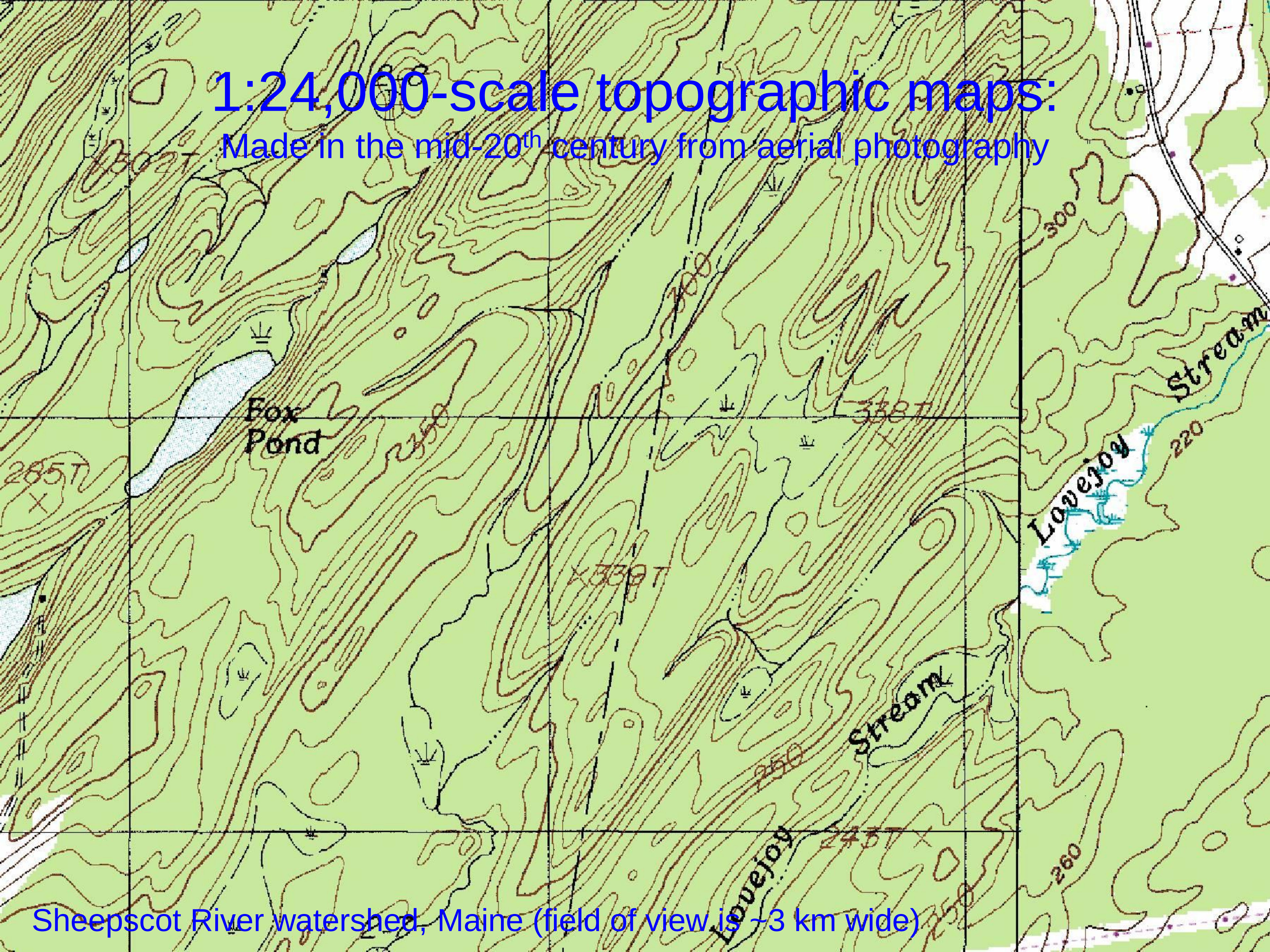

WBPR
D50pred (mm)
<16
16-32
32-64
64-128
>128


Aerial photography:
Scan to ~1-m pixel resolution
Sheepscot River watershed, Maine (field of view is ~3 km wide)

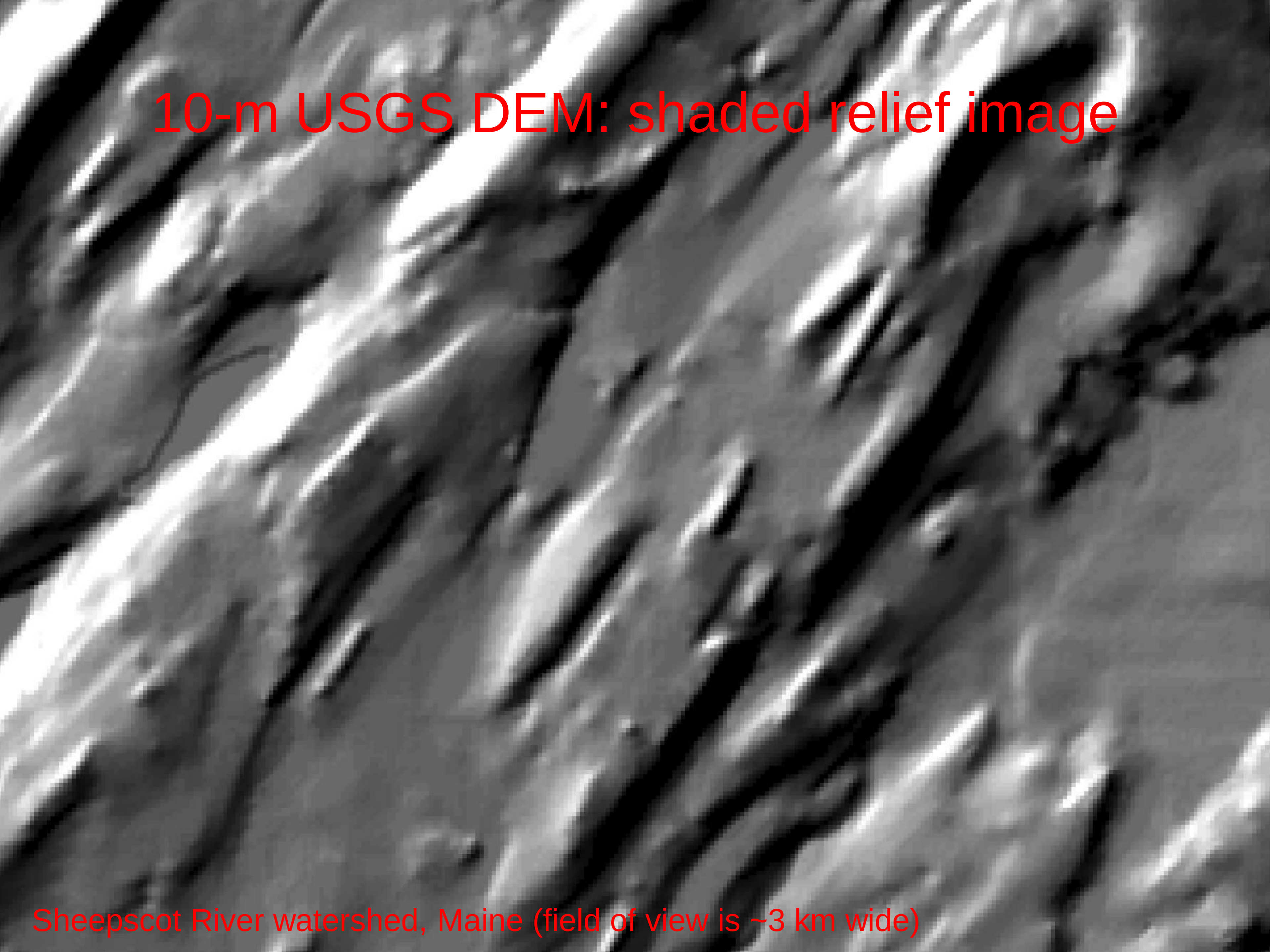
1:24,000-scale topographic maps:

Made in the mid-20th century from aerial photography

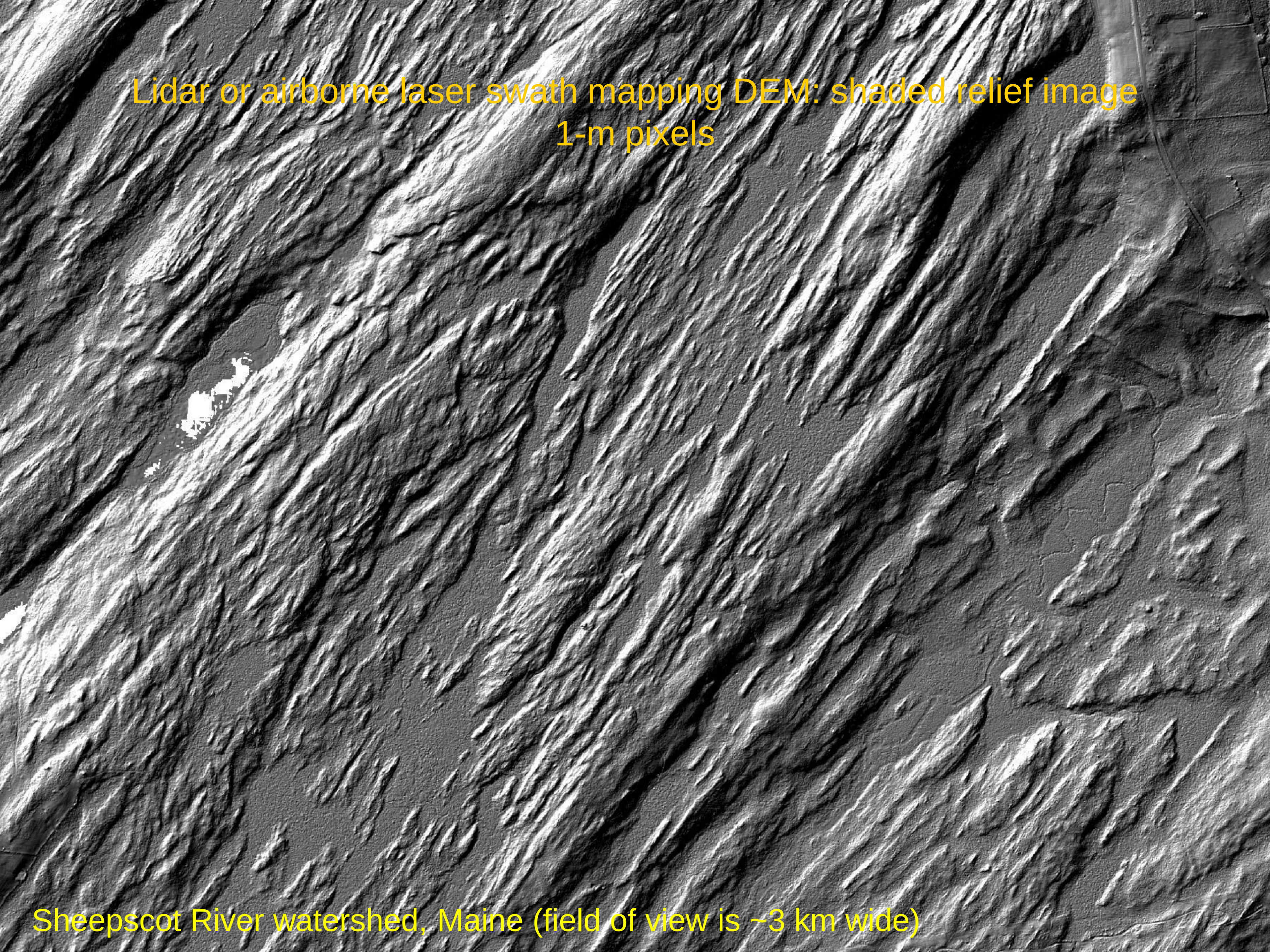


Sheepscot River watershed, Maine (field of view is ~3 km wide)

10-m USGS DEM: shaded relief image



Sheepscot River watershed, Maine (field of view is ~3 km wide)


Lidar or airborne laser swath mapping DEM: shaded relief image
1-m pixels
Sheepscot River watershed, Maine (field of view is ~3 km wide)

Narraguagus River, downeast Maine (August 2005)

Textbook view of self-formed rivers

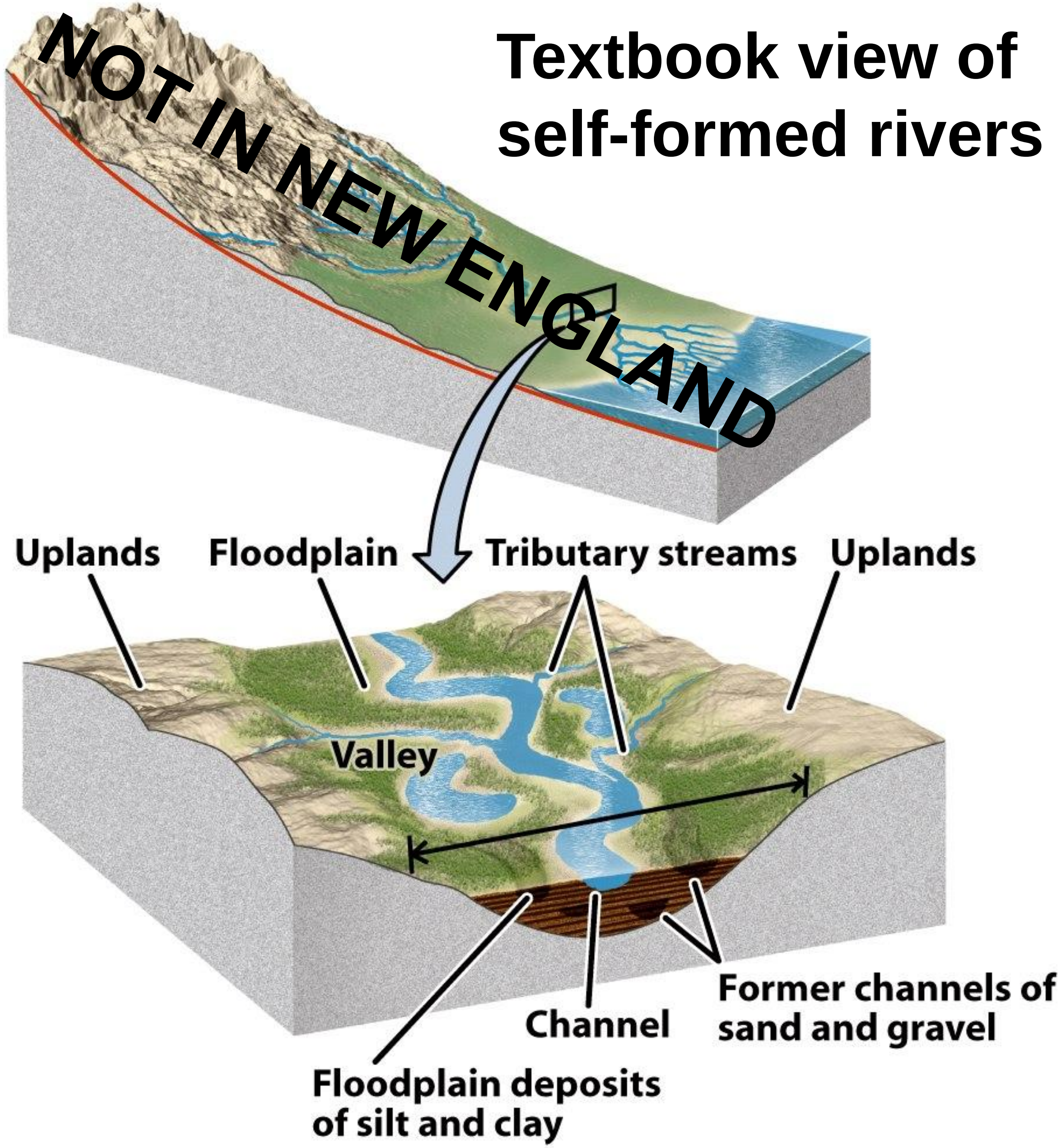
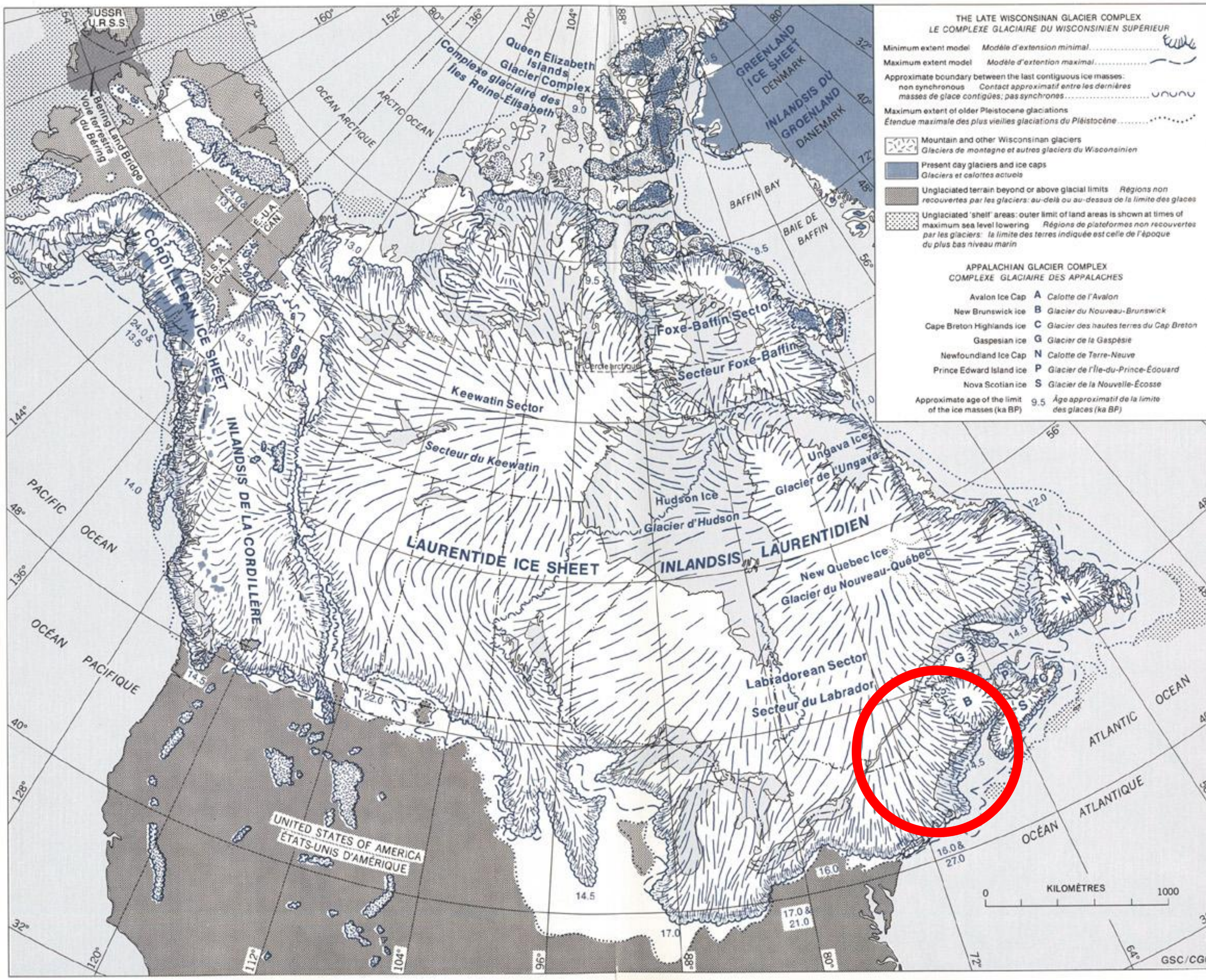


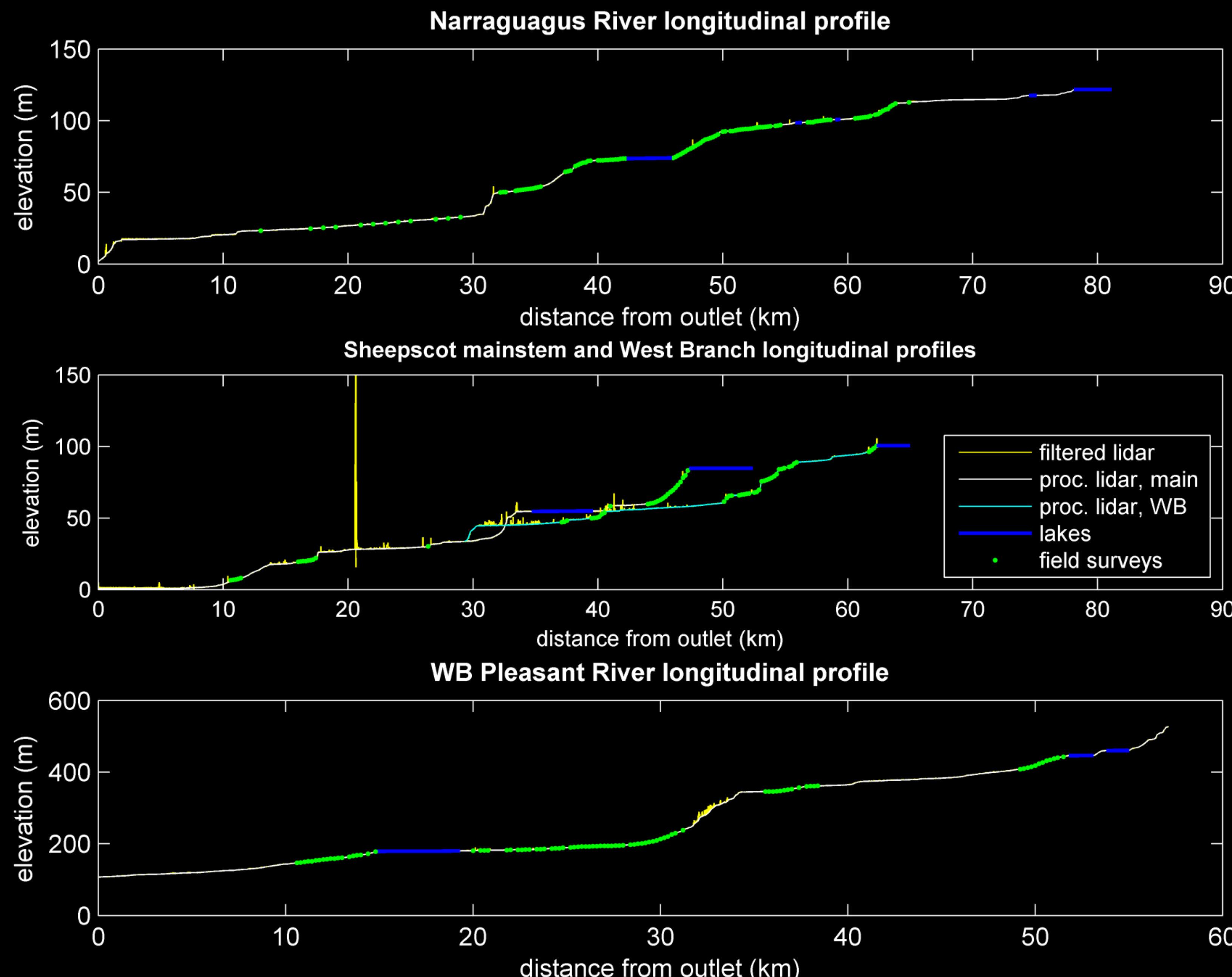
Figure 18-1
Understanding Earth, Fifth Edition



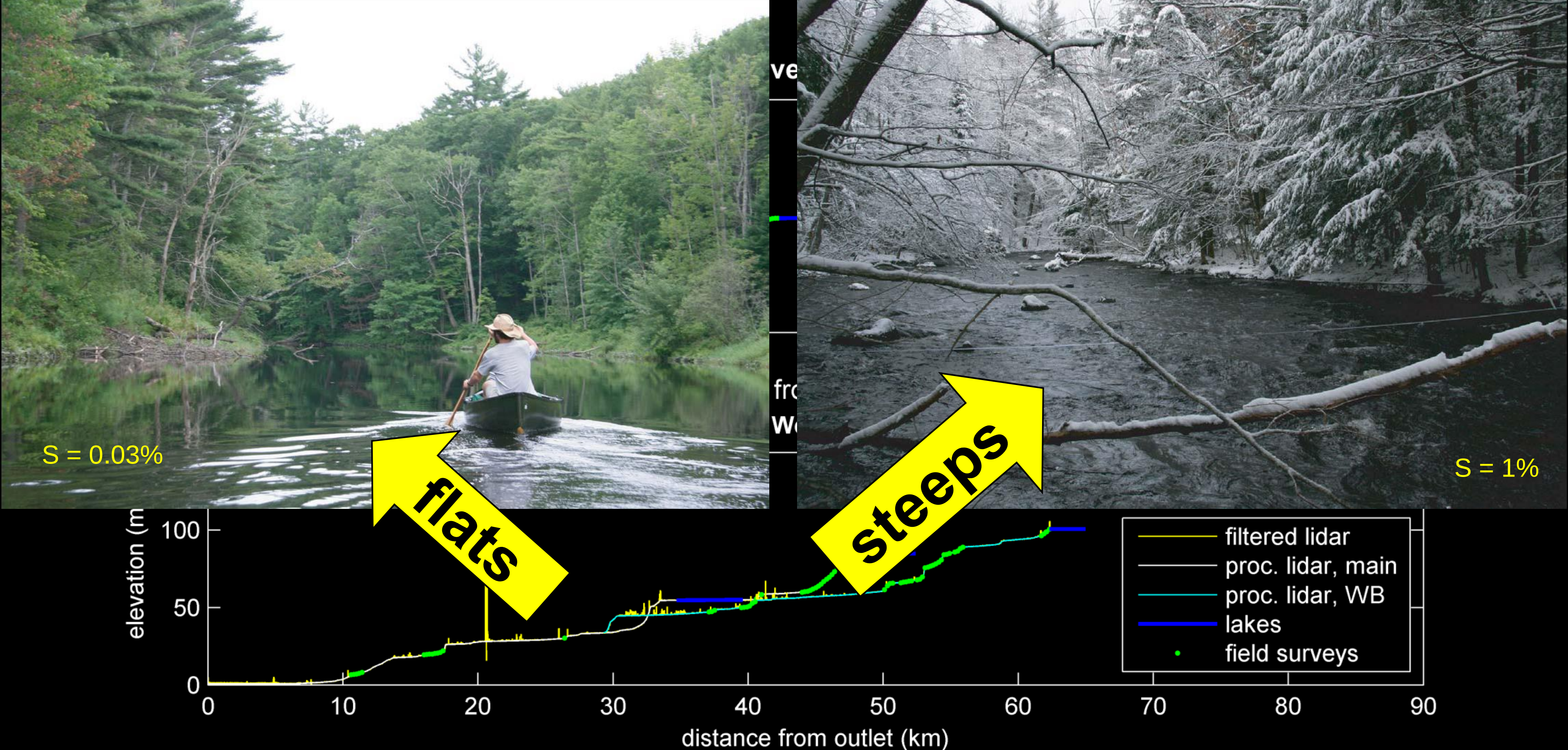
(a)

FIGURE 22.39

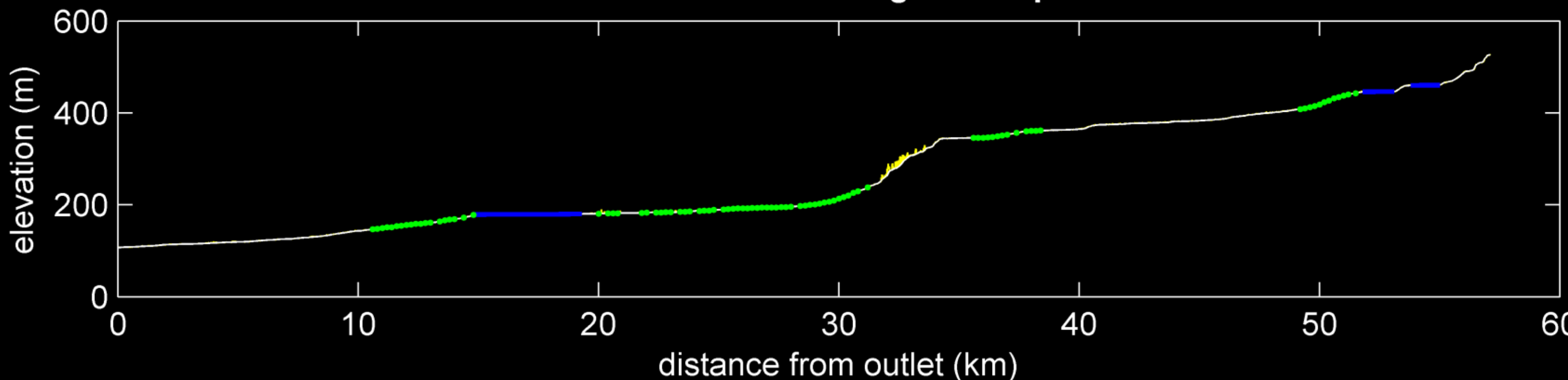
Earth: Portrait of a Planet, 2nd Edition



Narraguagus River longitudinal profile
elevation (m)
distance from outlet (km)
Sheepscot mainstem and West Branch longitudinal profiles
elevation (m)
distance from outlet (km)
filtered lidar
proc. lidar, main
proc. lidar, WB
lakes
field surveys
WB Pleasant River longitudinal profile
elevation (m)
distance from outlet (km)



WB Pleasant River longitudinal profile

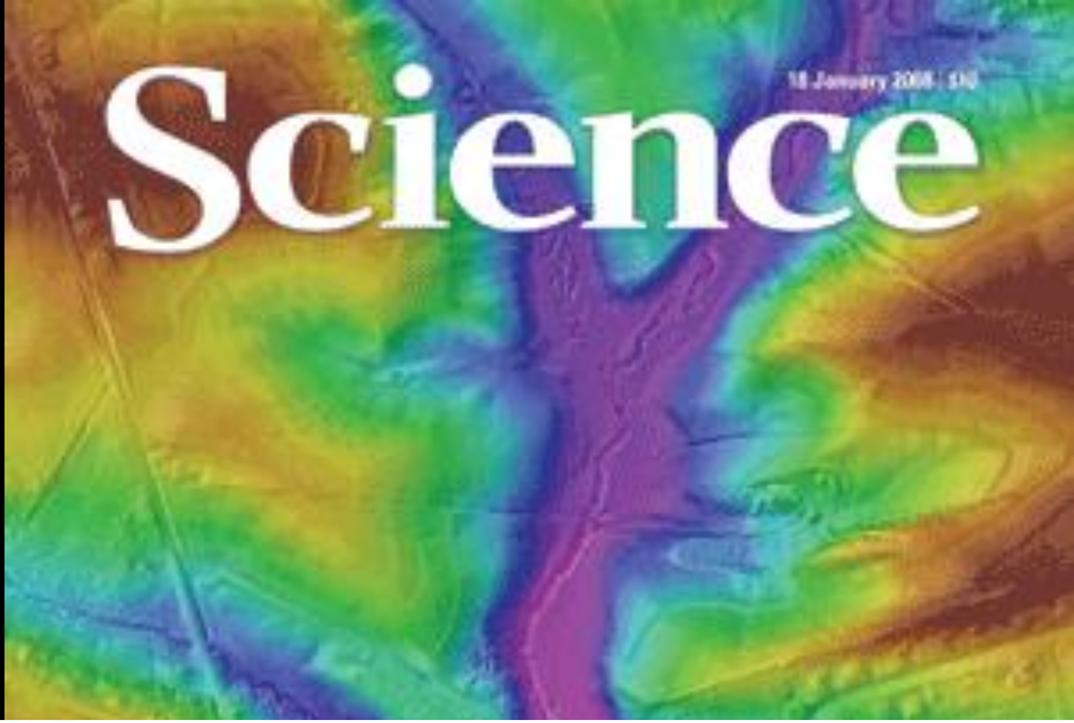


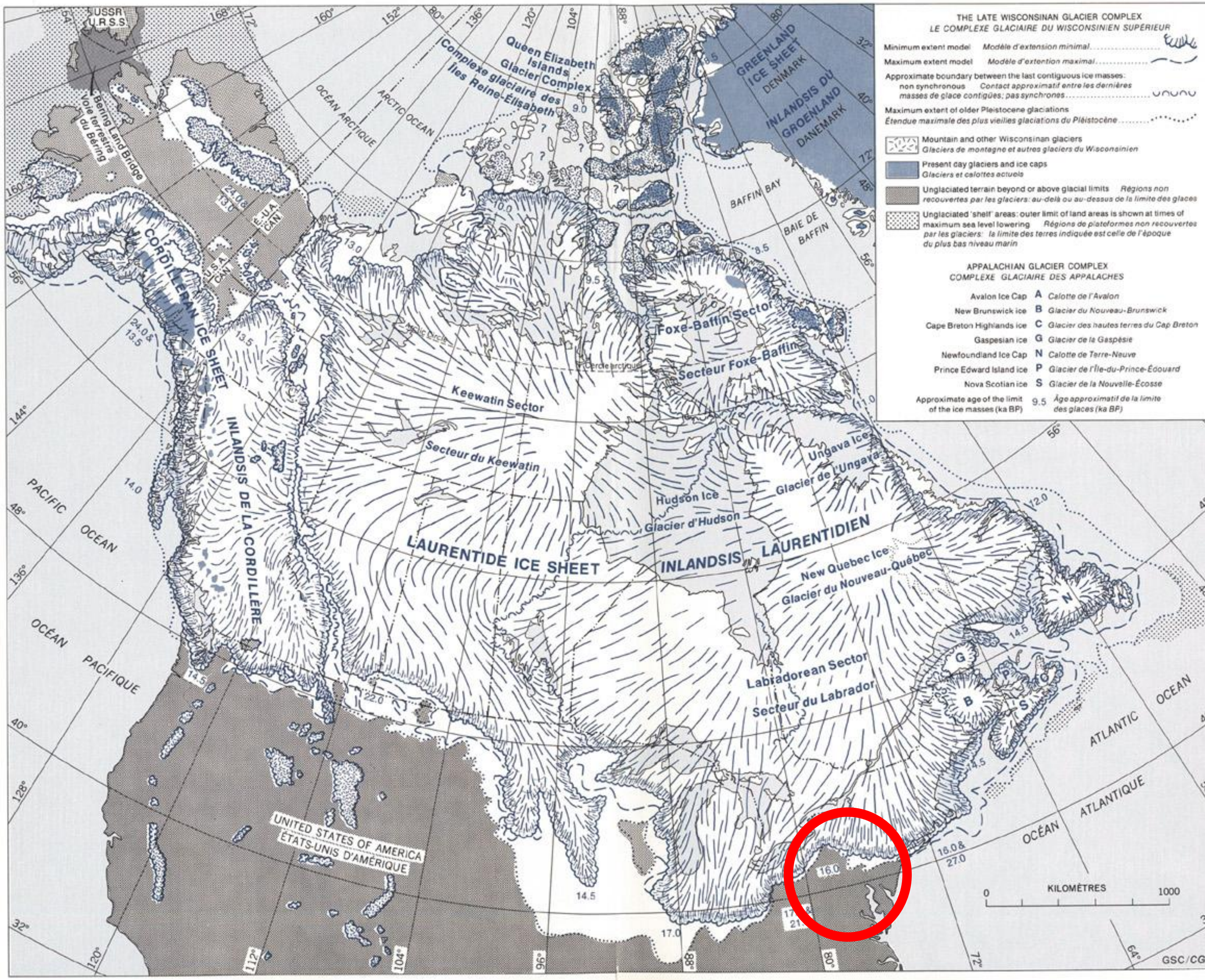

1379 m
Image © 2013 GeoEye
Google earth
Imagery Date: 5/10/2010
44°49'04.34" N 68°02'44.03" W elev 74 m
Eye alt 6.21 km


Eroding glacial deposits
Sheepscot River at Palermo (Aug. 2006)

Merrimack Village Dam, Souhegan River, NH (August 6, 2008)

Walter and Merritts (2008): Legacy sediment storage in Colonial-era millponds in U.S. Mid-Atlantic Piedmont.

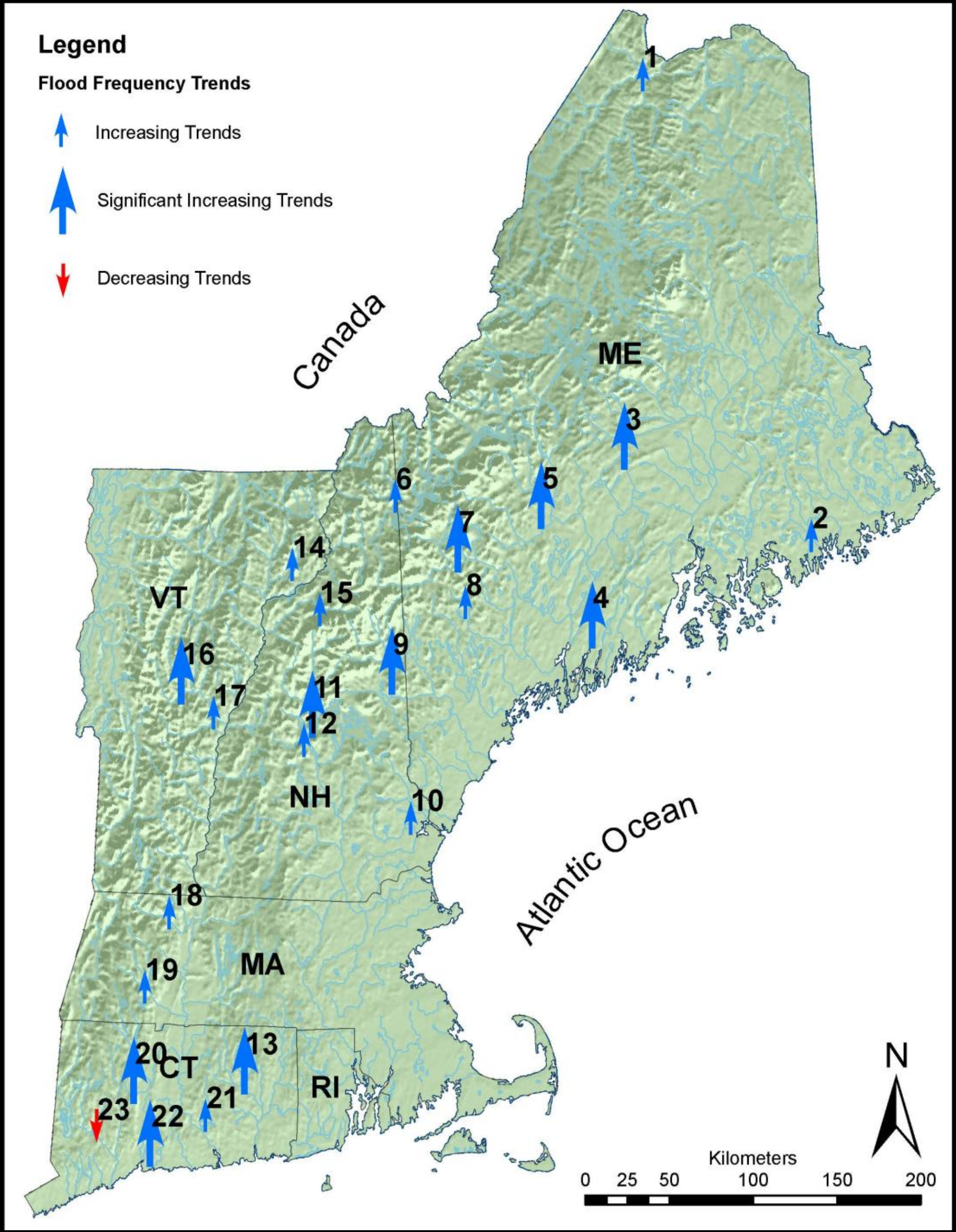




(a)

FIGURE 22.39

Earth: Portrait of a Planet, 2nd Edition

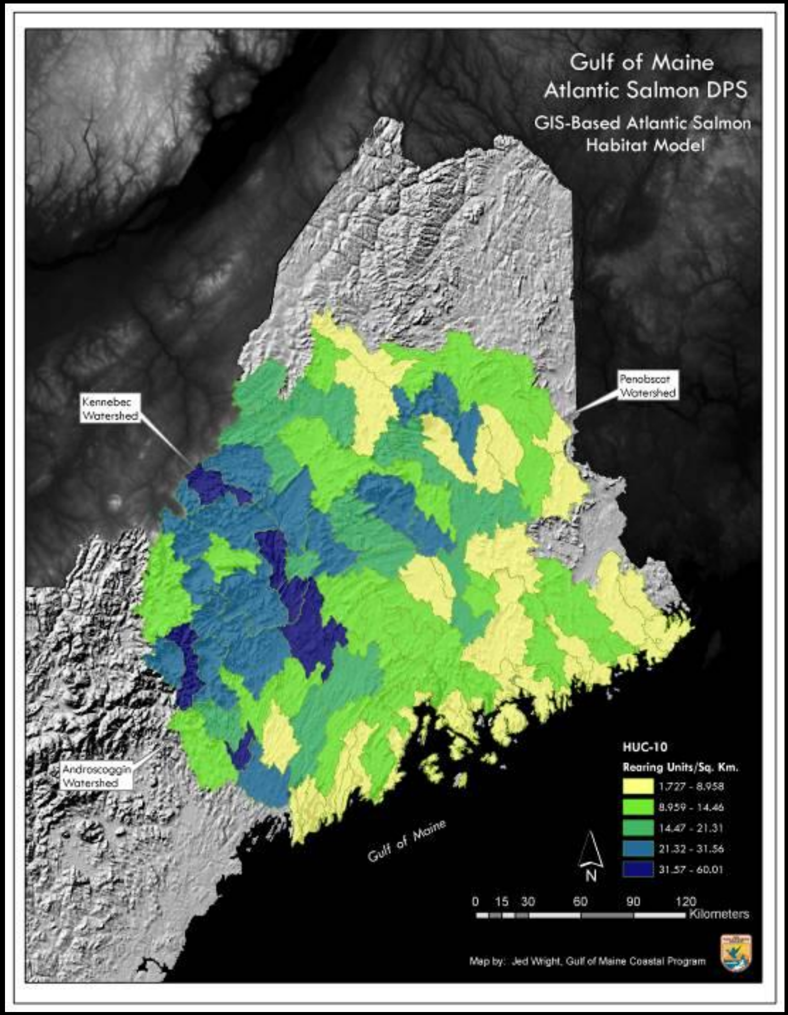


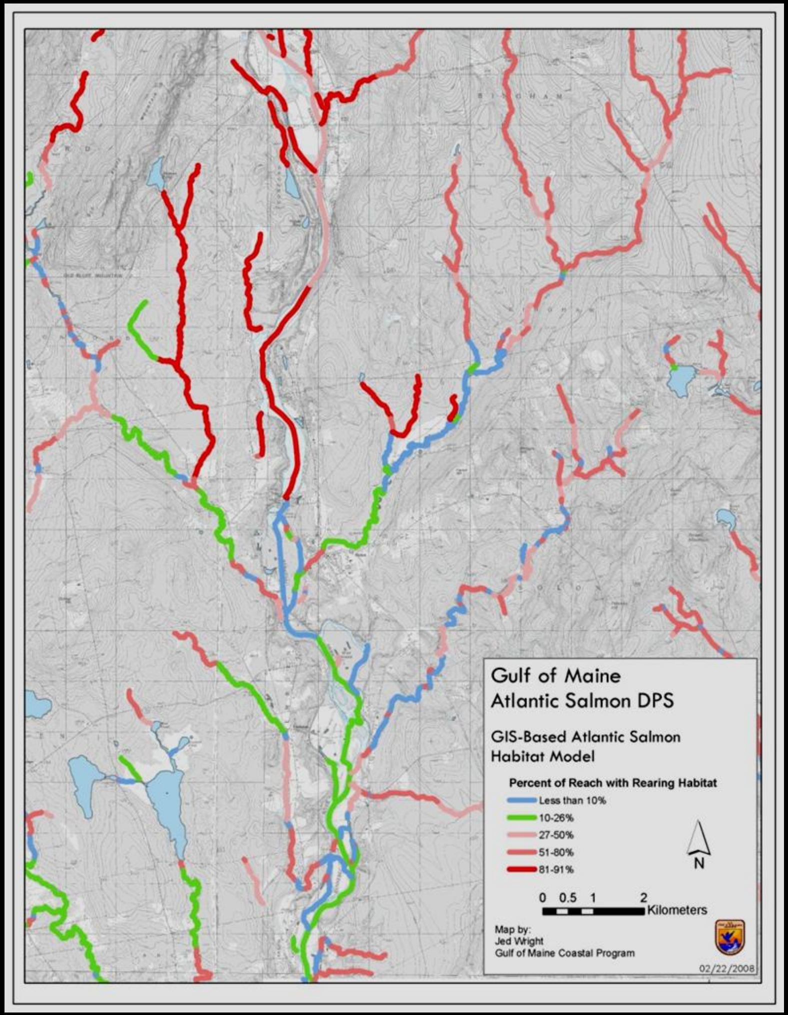
Collins 2009; Armstrong et al., 2012, *JAWRA*): Analysis of flood series

- 22 of 23 gages show ↑ annual flood counts (number of floods per year)
- 10 (45%) significant at $p<0.1$


SENSITIVE
HABITAT
BE A GOOD SPORT
Set the Young Salmon Free
SALMON PARR
SALMON SMOLT
BROOK TROUT

GIS Based Atlantic Salmon Habitat Model (Wright et al., 2008)





Process-based models to predict the location of habitat

Atlantic salmon need:

- mobile gravel bed (D = 16-32 mm for spawning; coarser for rearing)
  - not embedded (must be <10% sand and finer)
  - not armored (too coarse)
- pool and riffle morphology
  - overhead over (large woody debris, LWD)
  - deep, cool pools

(Hendry & Cragg-Hine, 2003)

Threshold single-thread, gravel-bed rivers

River channel in which the limit of competence for bed material transport is characteristically exceeded by only a modest amount (Church, 2006, *Annual Reviews*).

Models to predict bed grain size

- **Inputs:** For our shear-stress-based model we measure slope (**S**) and channel width (**w**) from lidar DEMs; drainage area (**A**) from DEMs; use $Q_{RI=2yr}$ from USGS (Hodgkins, 1999); assume constants for roughness and Shields stress
  - test two similar models:
    - Buffington et al. (2004): based on Shields stress
    - Gorman et al. (2011): based on stream power
- **Compare** to field-measured bed grain size
  - metric for success: $\mathbf{D_{pred}}$ within ±2x of $\mathbf{D_{50}}$
- **Explore** geomorphic controls on model success

Buffington et al., 2004, *Canadian Journal of Fisheries and Aquatic Science*

Basin-scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness in mountain catchments

John M. Buffington, David R. Montgomery, and Harvey M. Greenberg

Fig. 7. Maps showing the predicted extent and distribution of salmonid spawning gravels for (*a*) Scenario 1, (*b*) Scenario 2, and (*c*) Scenario 3 in the Finney Creek basin. PR, pool–riffle, PB, plane-bed; wfPR, wood-forced pool–riffle; SP, step–pool; CA, cascade.

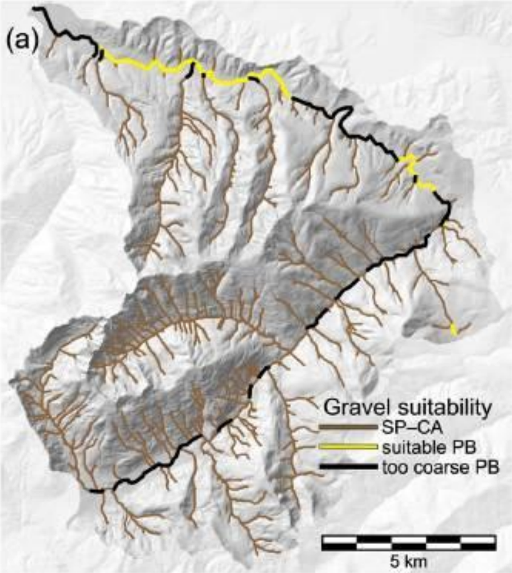
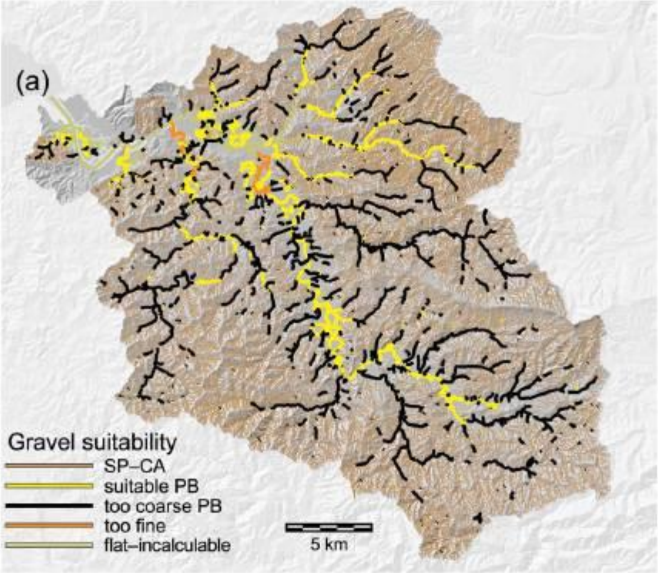


Fig. 8. Maps showing the predicted extent and distribution of salmonid spawning gravels for (*a*) Scenario 1, (*b*) Scenario 2, and (*c*) Scenario 3 in the Willapa River basin. PR, pool–riffle, PB, plane-bed; wfPR, wood-forced pool–riffle; SP, step–pool; CA, cascade.



Journal of Great Lakes Research 37 (2011) 725–731

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journal homepage: www.elsevier.com/locate/jglr

Channel substrate prediction from GIS for habitat estimation in Lake Erie tributaries

Ann Marie Gorman [a,*], Peter J. Whiting [b], Thomas M. Neeson [a,2], Joseph F. Koonce [a,1]

[a] Case Western Reserve University, Department of Biology, 308 Clapp Hall, Cleveland, OH 44106, USA
[b] Case Western Reserve University, Department of Geological Sciences, 112 A.W. Smith Building, 10900 Euclid Avenue, Cleveland, OH 44106, USA

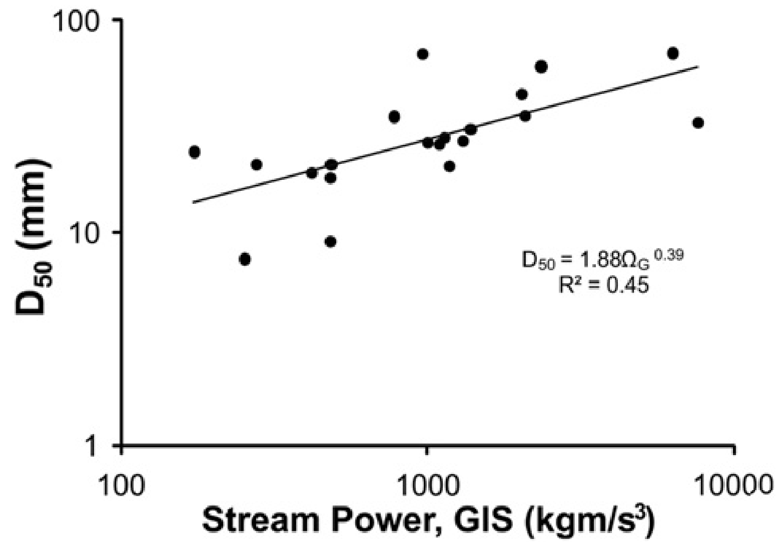
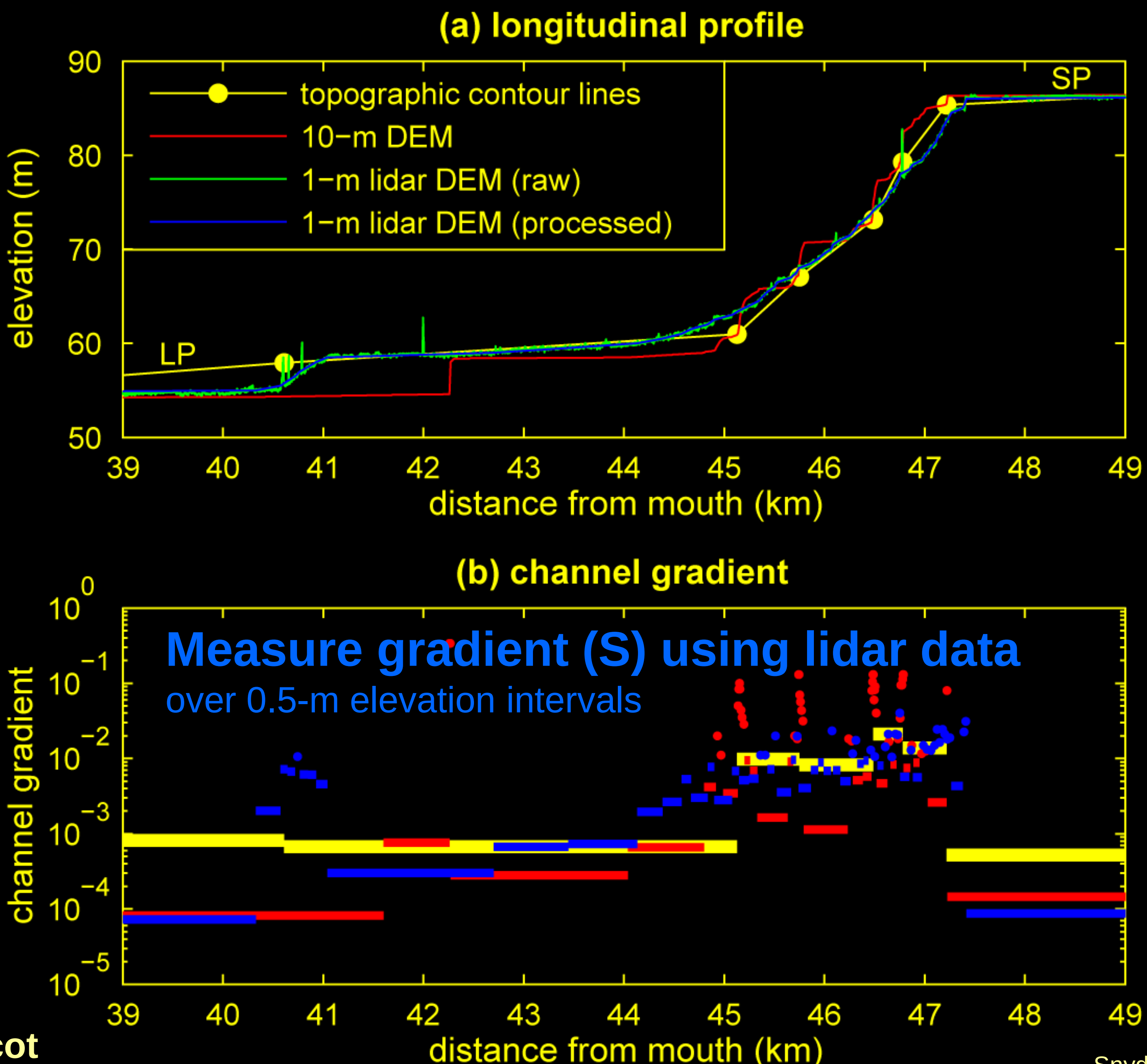
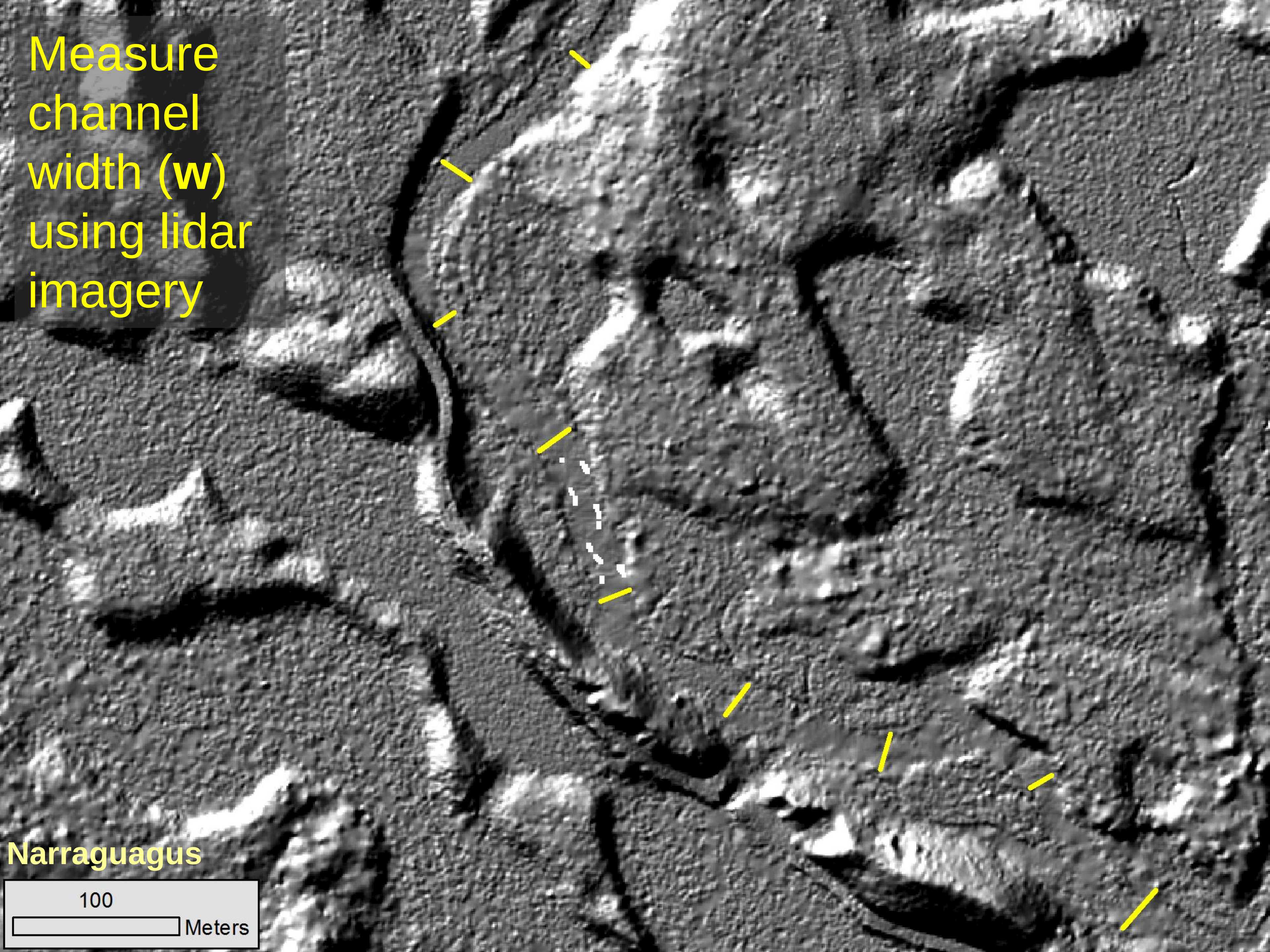


Fig. 4. GIS stream power (Ω_G (kg m/s^3)), a function of stream slope and drainage area both quantified in a GIS, can be used to predict median particle size (D_{50}) in stream reaches ($p = 0.0013$).



Sheepscot

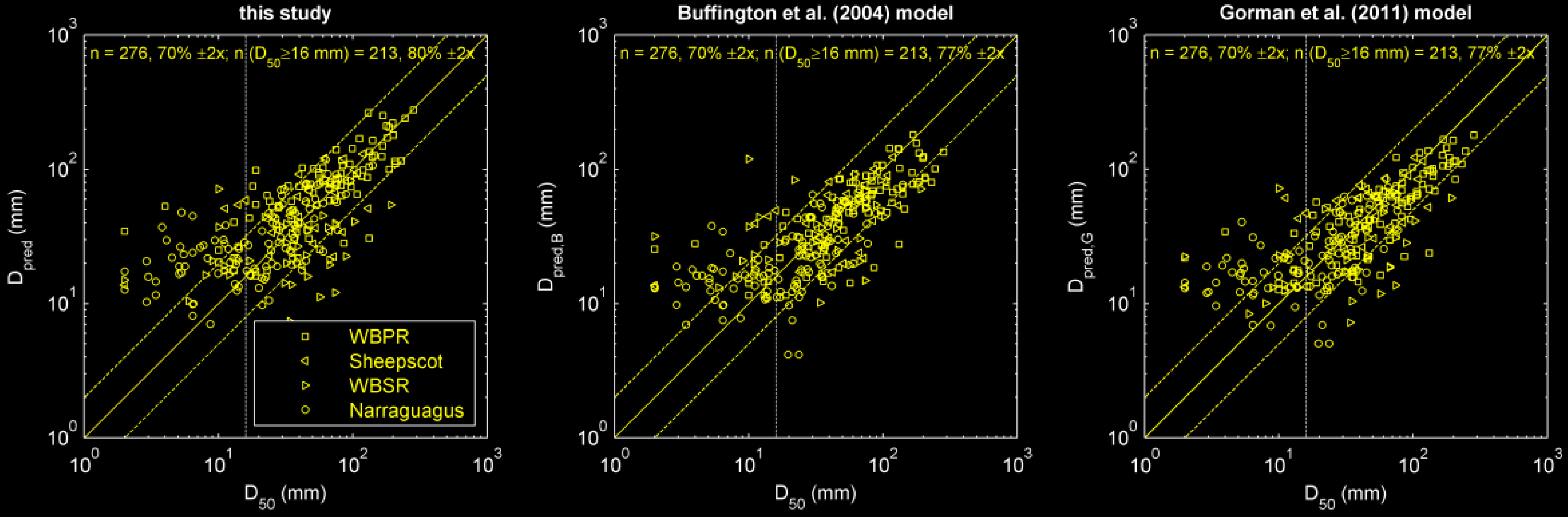
Snyder, 2009, *Eos*


Measure channel width (w) using lidar imagery
Narraguagus
100
Meters

Field measurements of bed grain size ($\mathbf{D_{50}}$)

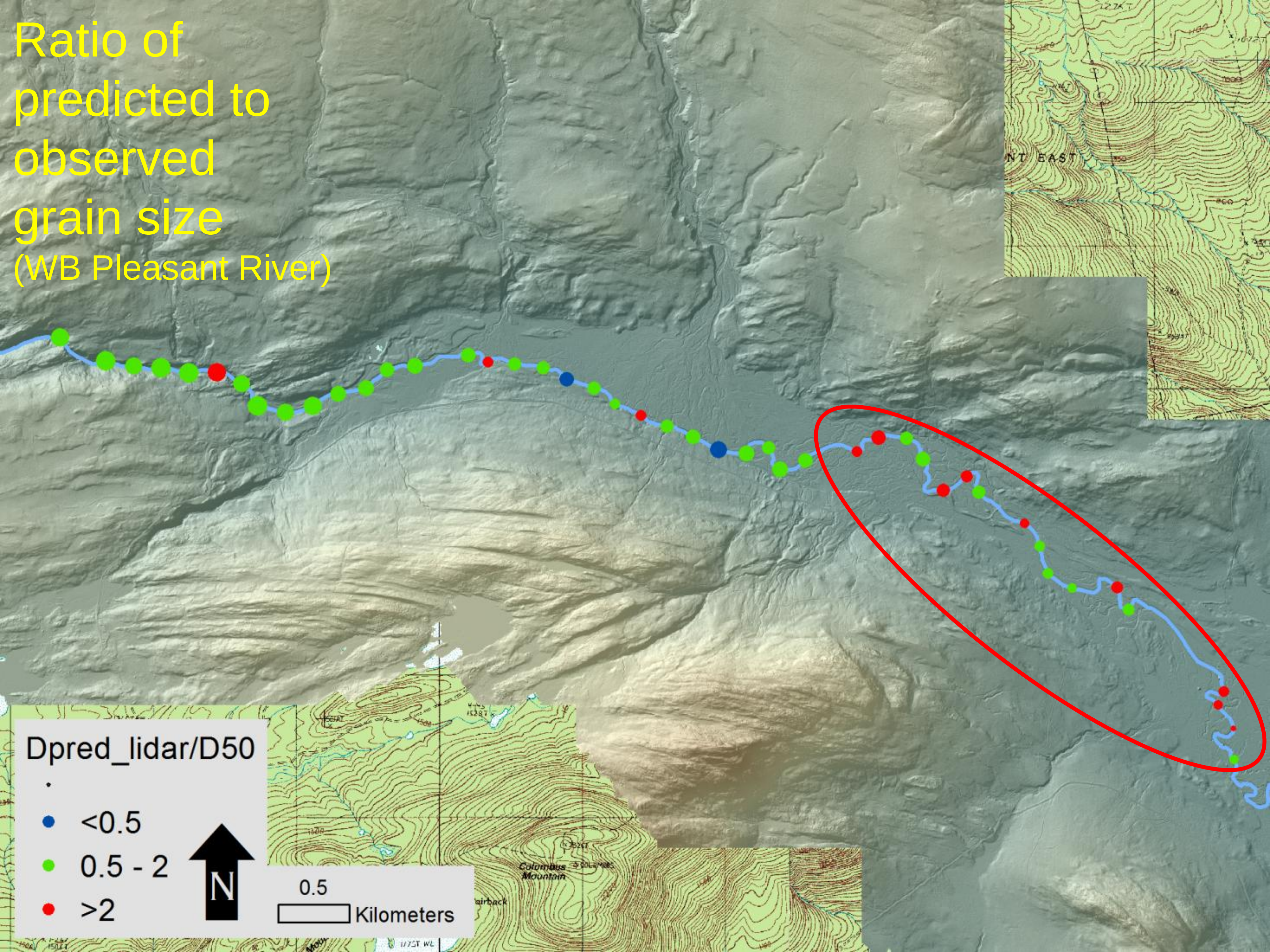
Wolman pebble counts, Narraguagus River, Maine (June 2007)

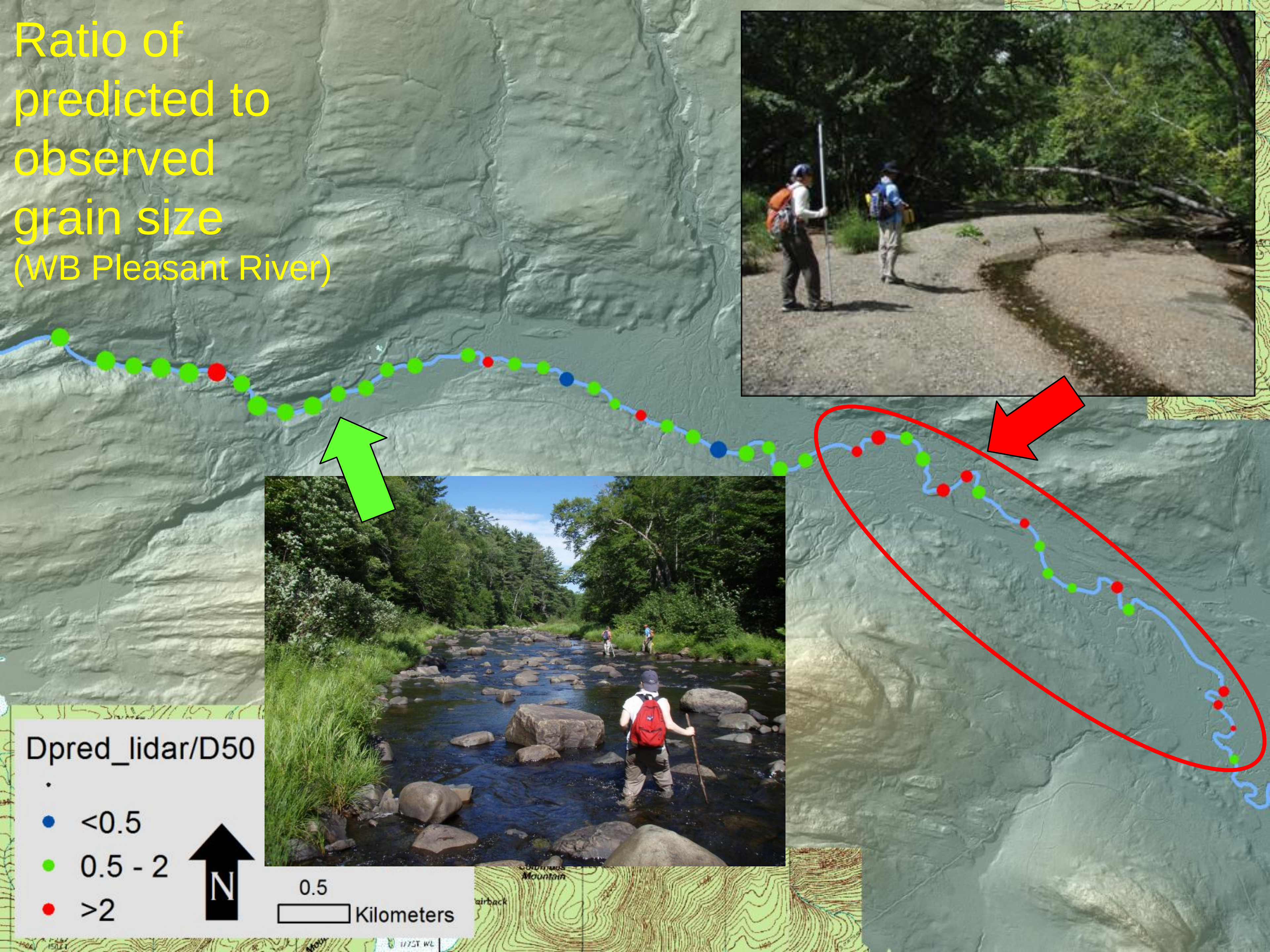
Results: all three models have similar predictive ability (70-80%)

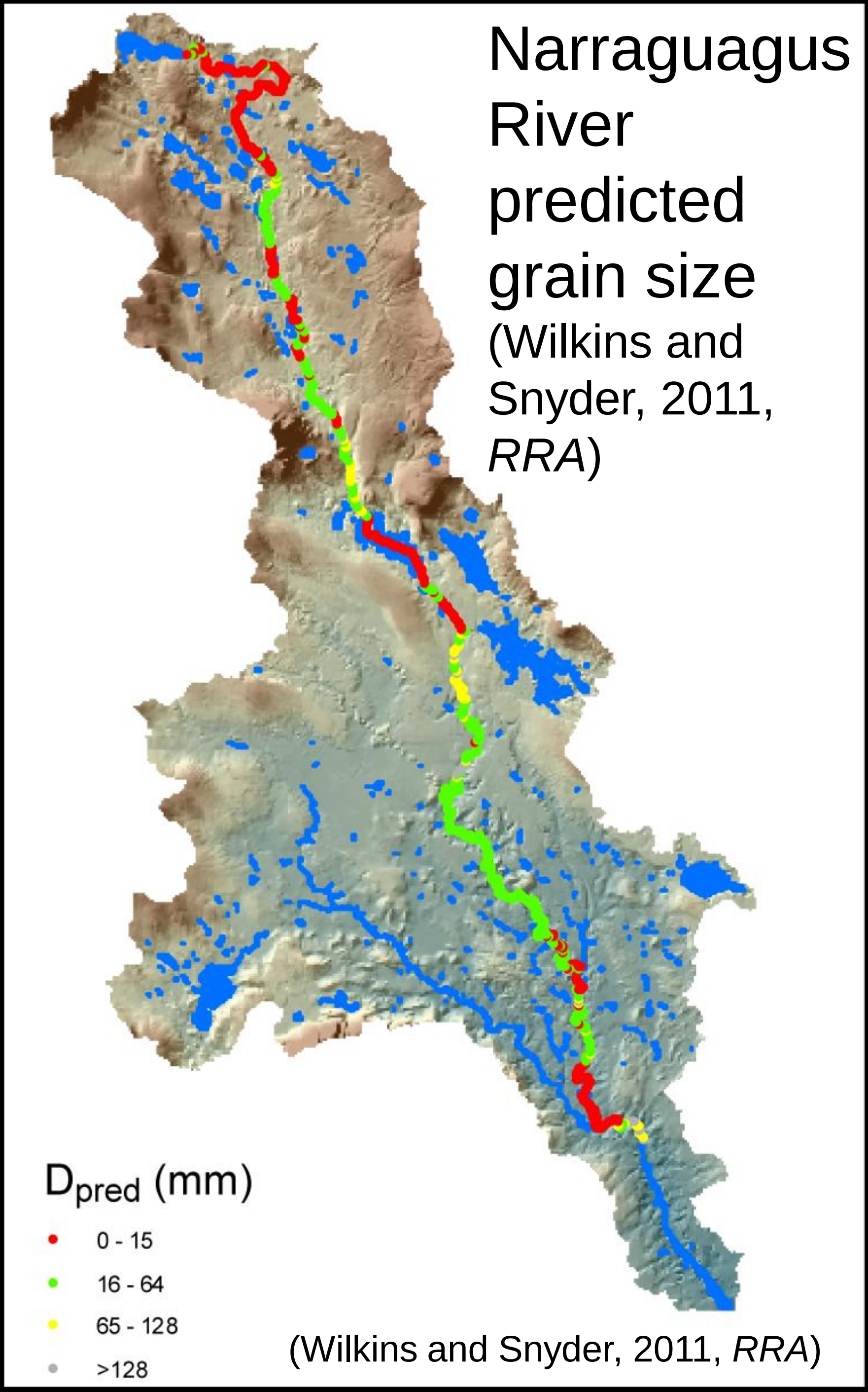


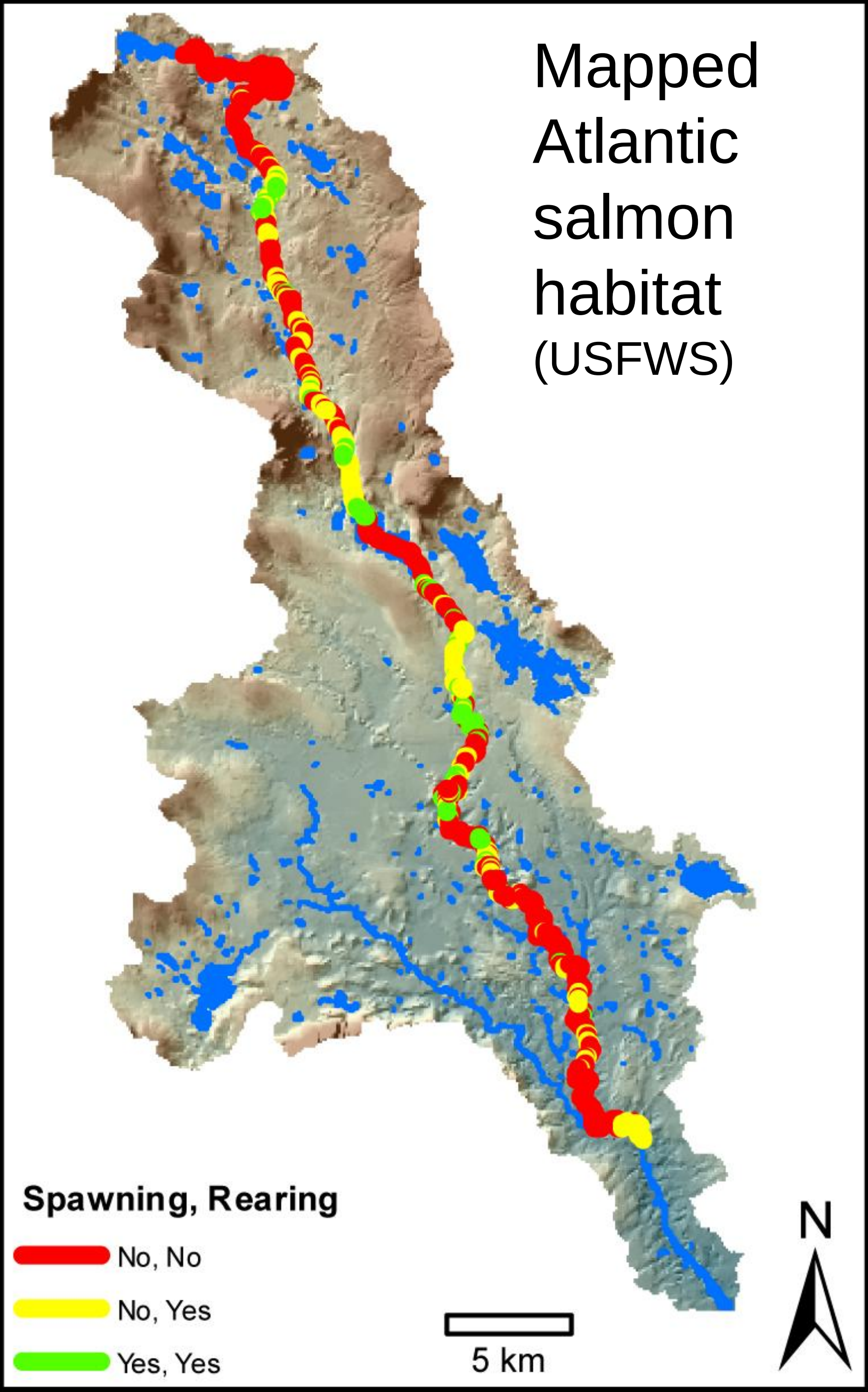
(Snyder et al., 2013, *GSA Bulletin*)

Ratio of predicted to observed grain size
(WB Pleasant River)




Ratio of predicted to observed grain size
(WB Pleasant River)
Dpred_lidar/D50
<0.5
0.5 - 2
>2
N
0.5
Kilometers


Narraguagus River predicted grain size
(Wilkins and Snyder, 2011, *RRA*)
Dpred (mm)
0 - 15
16 - 64
65 - 128
>128
(Wilkins and Snyder, 2011, *RRA*)


Mapped Atlantic salmon habitat
(USFWS)
Spawning, Rearing
No, No
No, Yes
Yes, Yes
5 km
N

Ecology of Freshwater Fish 2011: 20: 144–156
Printed in Malaysia ·

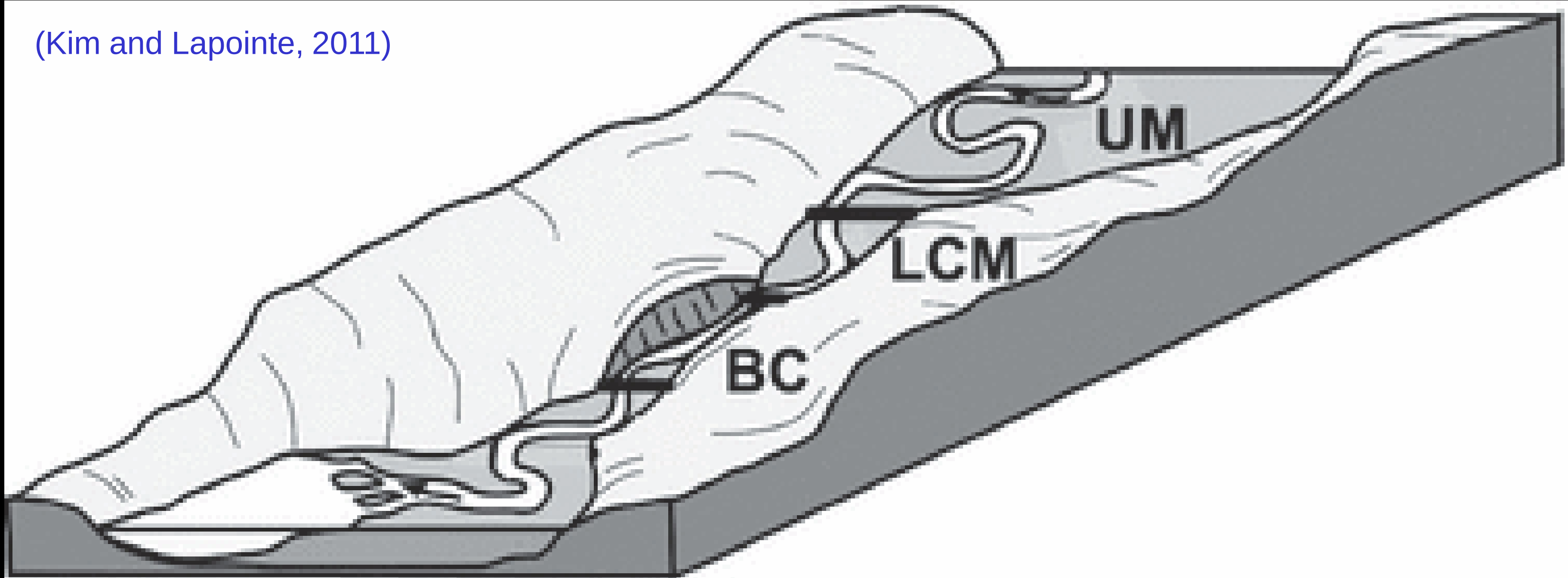
ECOLOGY OF
FRESHWATER FISH

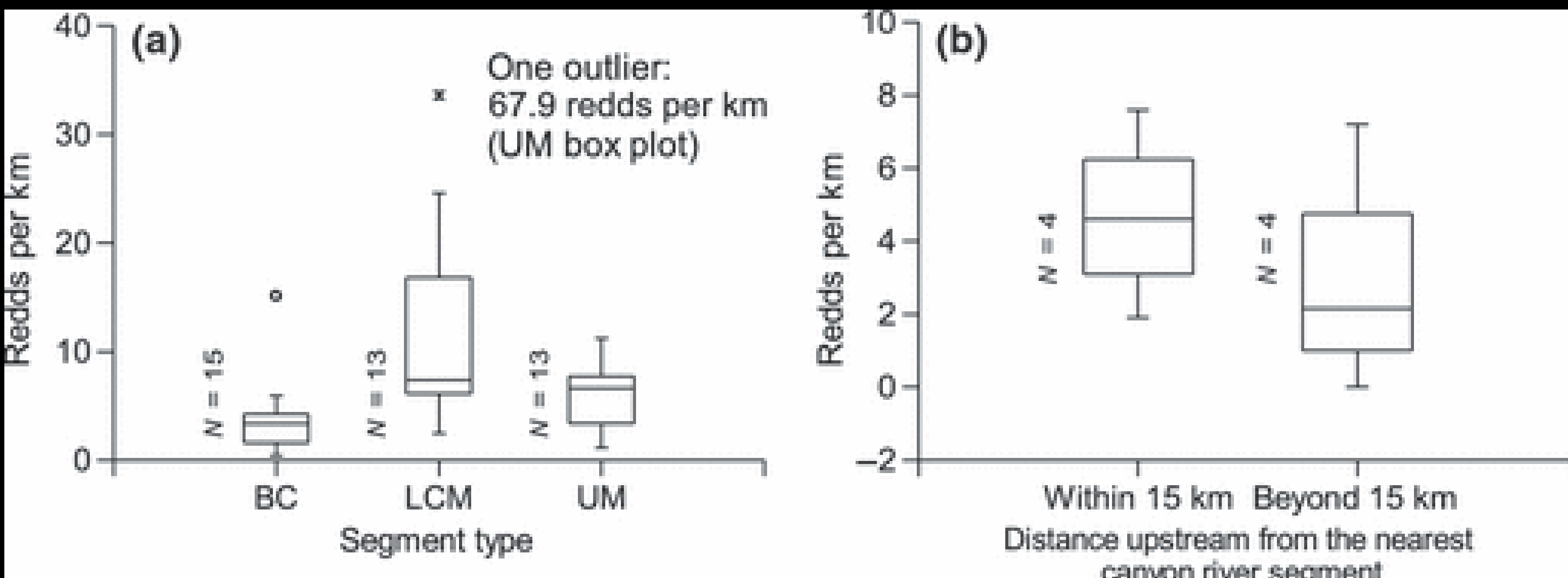
Regional variability in Atlantic salmon (*Salmo salar*) riverscapes: a simple landscape ecology model explaining the large variability in size of salmon runs across Gaspé watersheds, Canada

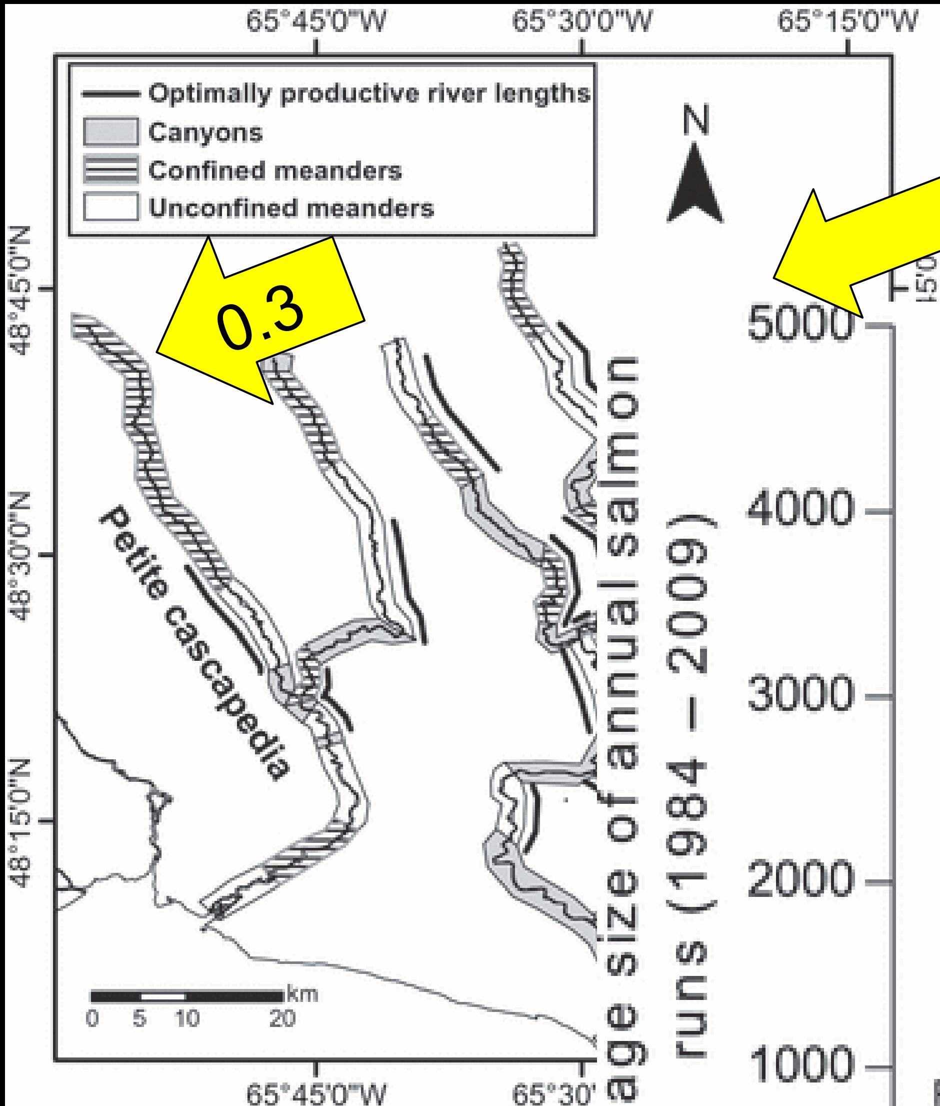
Kim M, Lapointe M. Regional variability in Atlantic salmon (*Salmo salar*) riverscapes: a simple landscape ecology model explaining the large variability in size of salmon runs across Gaspé watersheds, Canada. Ecology of Freshwater Fish 2011: 20: 144–156. © 2010 John Wiley & Sons A/S

M. Kim, M. Lapointe
Department of Geography, McGill University, Montreal, QC, Canada

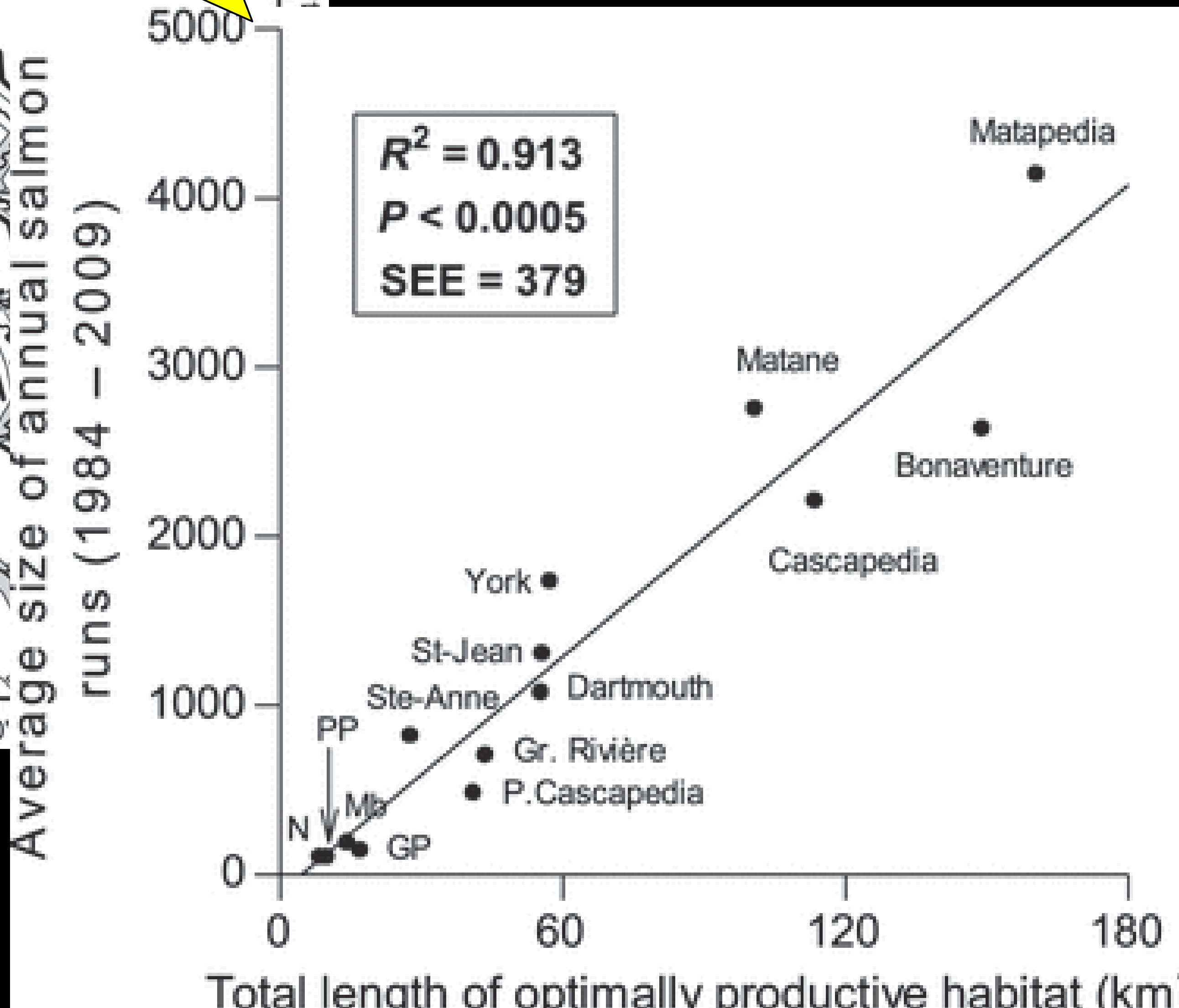
(Kim and Lapointe, 2011)



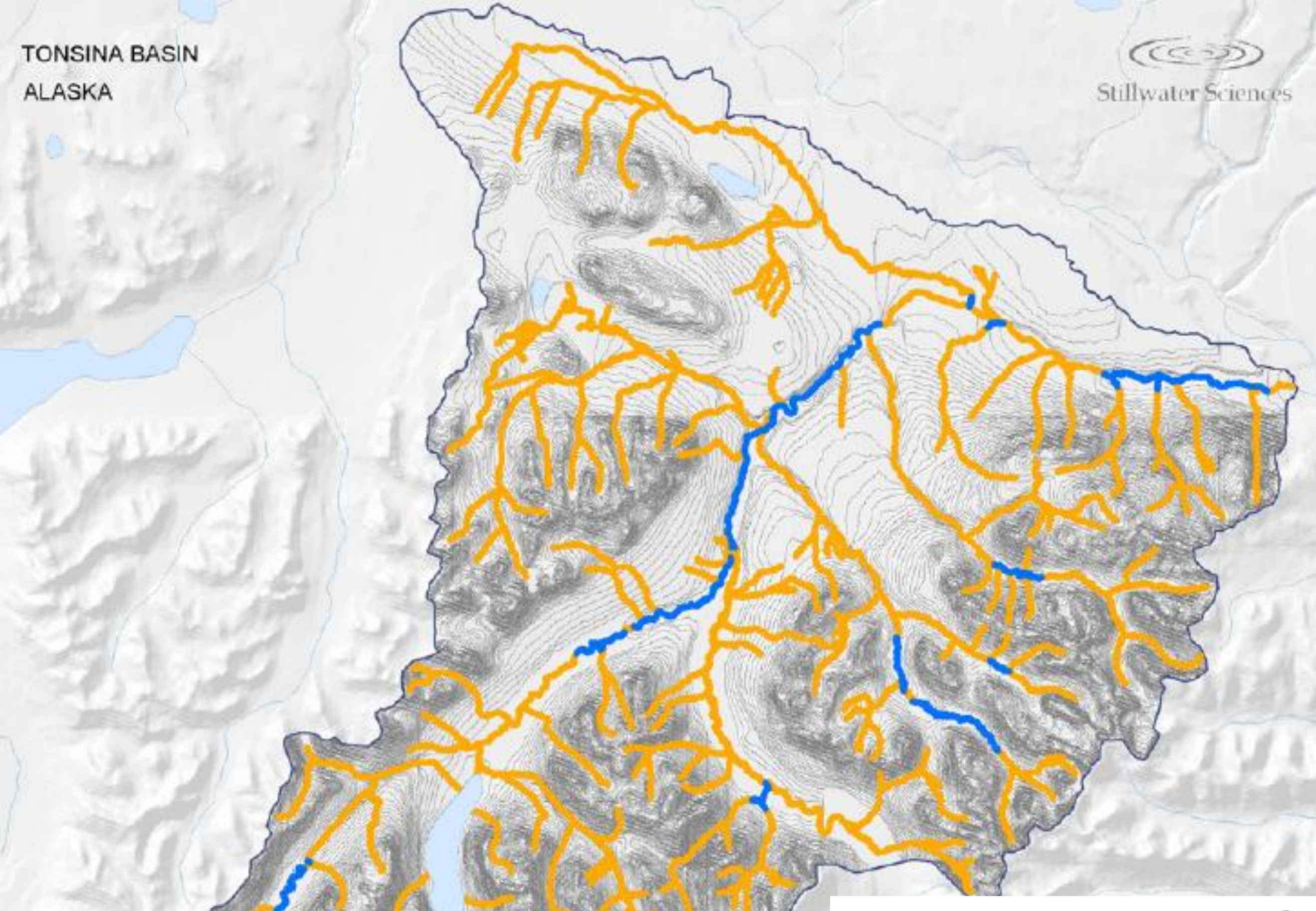




1.1 adult salmon per unit area



(Kim and Lapointe, 2011)



RIPPLE is a powerful, analytical tool to help inform habitat restoration and salmon recovery planning. RIPPLE uses an ecological process-based approach to model the distribution of fish habitat conditions in the watershed and simulate lifestage-specific population dynamics.

Summary

- GIS data can predict geomorphology at the reach scale reasonably well
  - Empirical or process-based approaches
- This can be correlated to habitat mapping
- New studies link GIS-based measures of fluvial geomorphology with fish habitat usage data

Questions

- We can do OK for salmon and lamprey, but are there key geomorphic characteristics of habitat for other diadromous fish that can be used for predictions?
- How do we use “top-down” GIS approaches to measure dynamics and responses?

Watershed processes and salmon habitat