

Airborne LiDAR for Determining Channel Morphology and Monitoring Aquatic Habitat in Pacific Northwest Rivers



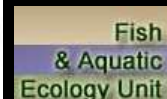
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Aquatic Monitoring in the Pacific Northwest



PACFISH/INFISH Biological Opinion (PIBO Program)

- Upper Columbia River Basin – five states

Aquatic & Riparian Effectiveness Monitoring Program

- Responsible for 57,040,261 acres - three states

“...integrity and repeatability of qualitative information is dependent on the Knowledge and experience of the field observer” (Kaufmann et al. 1999)

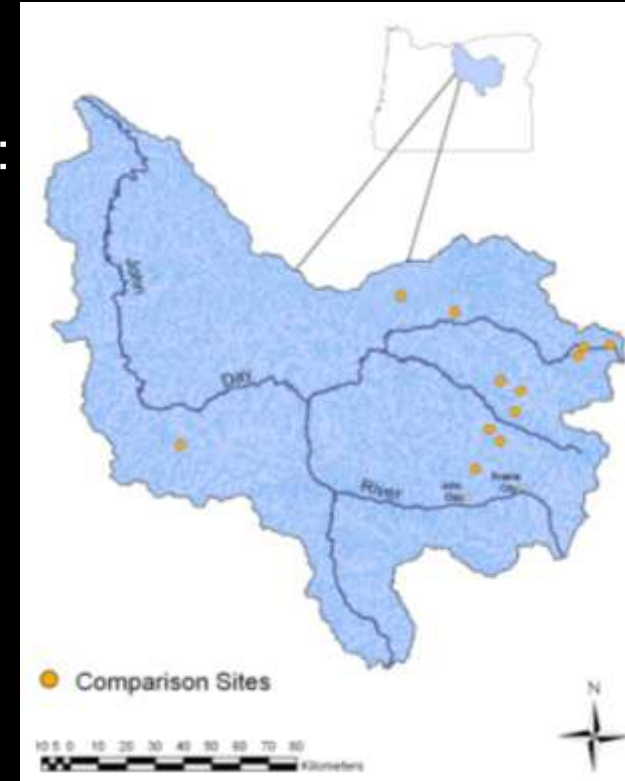
The Puget Sound LiDAR Consortium and the Oregon LiDAR Consortium have collected (*or plan to collect*) LiDAR data in areas currently covered by AREMP, PiBO and, other monitoring entities.

How can high resolution LiDAR data be applied to increase the accuracy, consistency, and spatial coverage of aquatic habitat monitoring?



Pacific Northwest Aquatic Monitoring Partnership Protocol Comparison Study

- 12 study sites in the upper John Day River basin, OR.
- 7 monitoring groups from state, federal, and tribal agencies in CA, WA, OR & ID measured physical stream attributes to compare monitoring protocols:
 - slope
 - sinuosity
 - bankfull width
 - bankfull depth
 - substrate (size, percent fines)
 - pools (number, residual depth)
 - large woody debris



- LiDAR and true color digital imagery collected on Sept. 28, 2005.

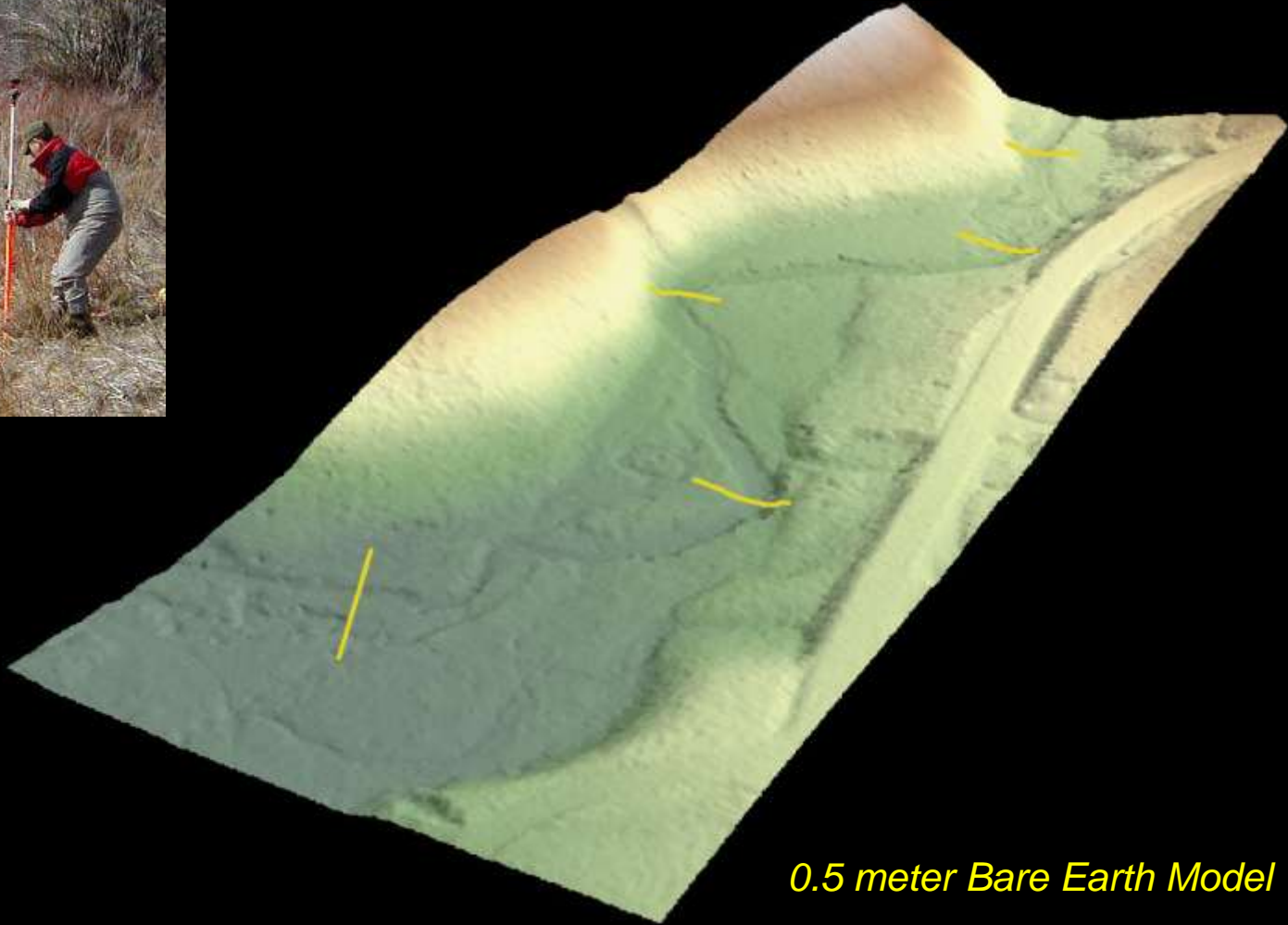
Protocol Comparison Study

John Day River Basin, OR

Stream Name (Type)	Field			LiDAR	
	Slope (%)	Bankfull Width (m)	D50 (mm)	Pulse Density Pulse/m ²	Ground Return Return/m ²
Big (PR)	1.33	3.68	9	3.14	1.26
Crane (PR)	0.94	8.01	12	3.14	1.13
Trail (PR)	1.63	9.86	53	3.08	1.09
WF Lick (PR)	3.34	3.92	39	2.89	1.23
Bridge (PB)	1.03	8.12	37	3.00	1.25
Camas (PB)	1.26	15.68	104	2.99	1.14
Potamus (PB)	2.39	8.91	67	3.10	1.19
Tinker (PB)	2.86	3.14	34	3.11	1.27
Crawfish (SP)	5.07	6.38	121	3.14	1.06
Indian (SP)	5.80	4.26	23	3.09	1.21
Myrtle (SP)	9.70	3.96	28	3.15	1.12
Whiskey (SP)	6.67	4.10	73	3.02	1.48

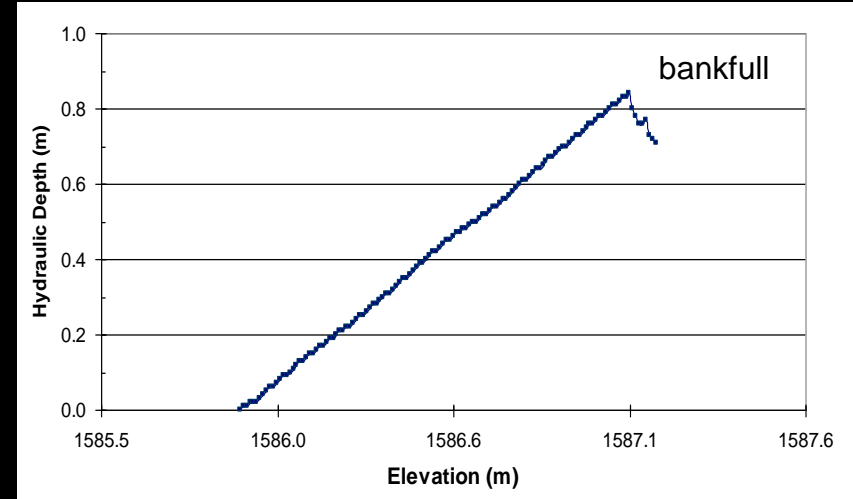
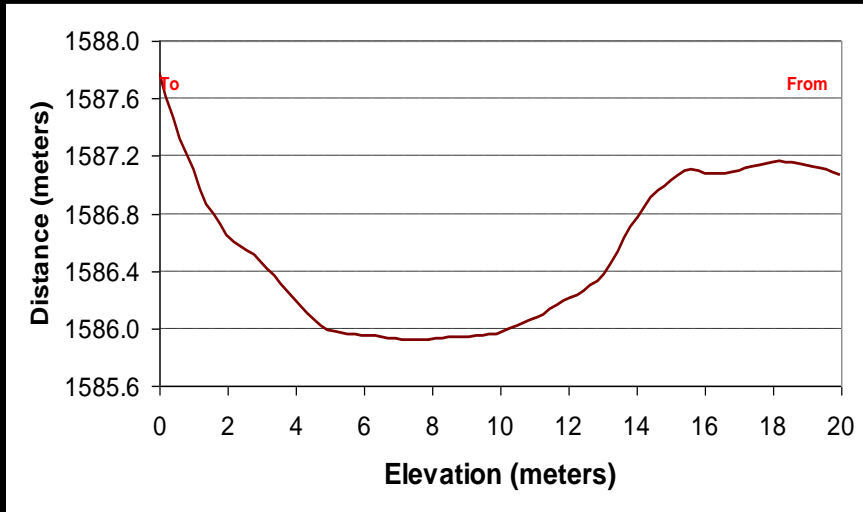
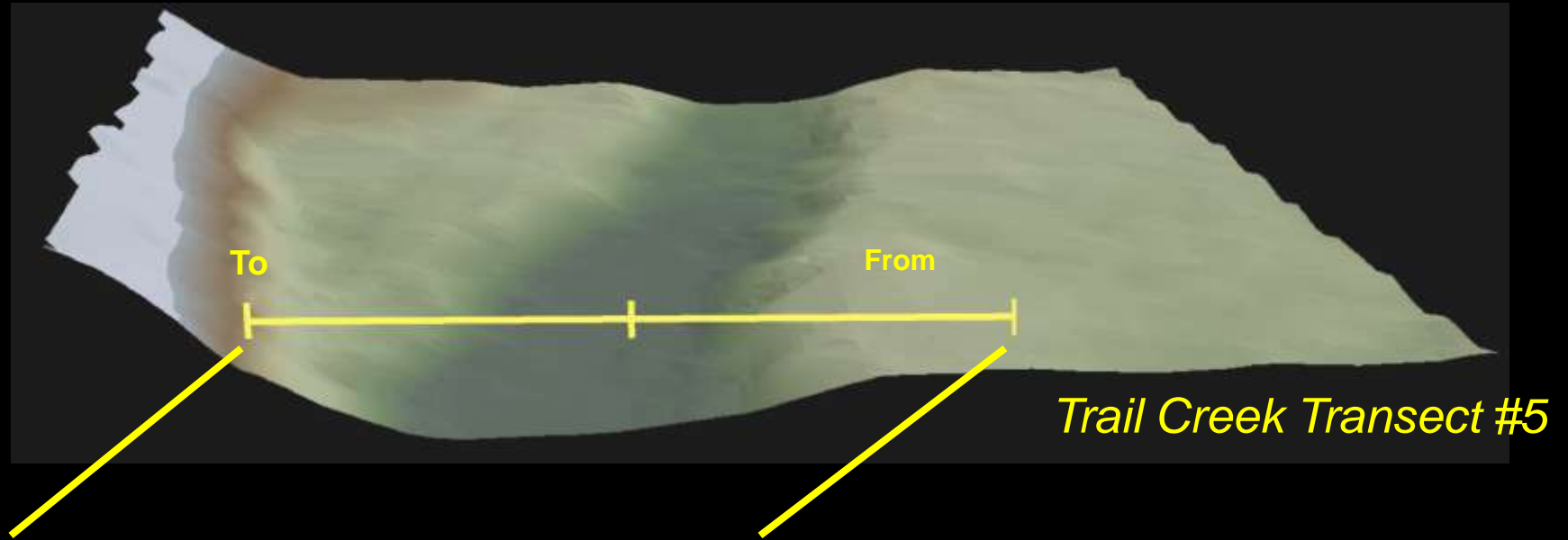


LiDAR Data for the Trail Creek Study Area

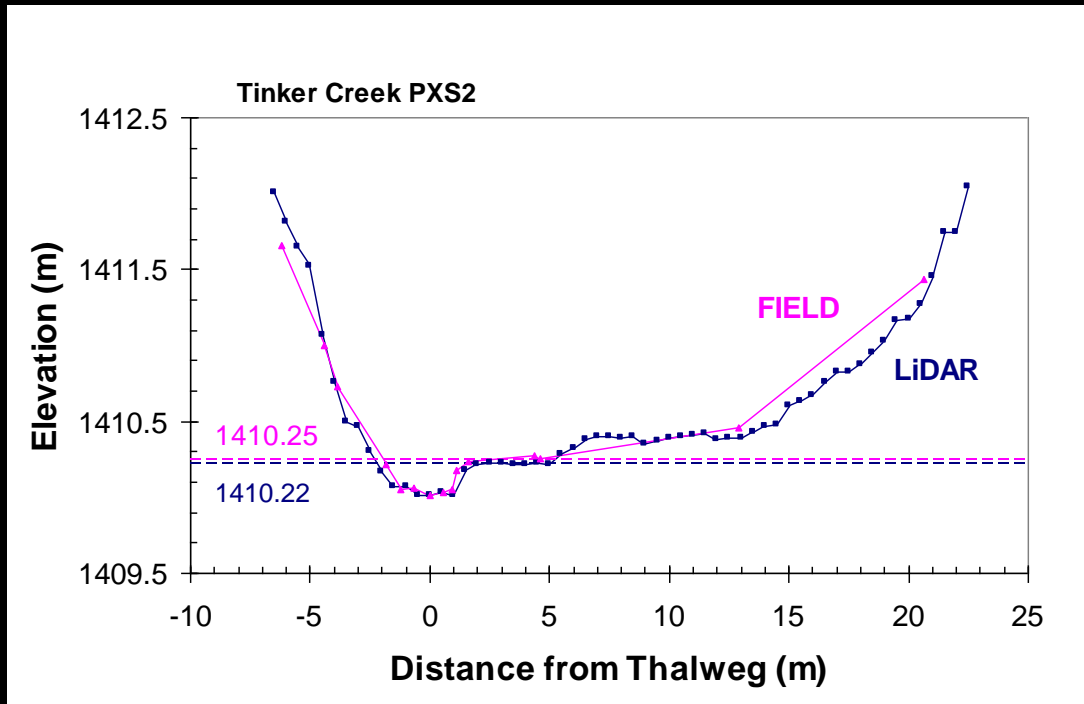


0.5 meter Bare Earth Model

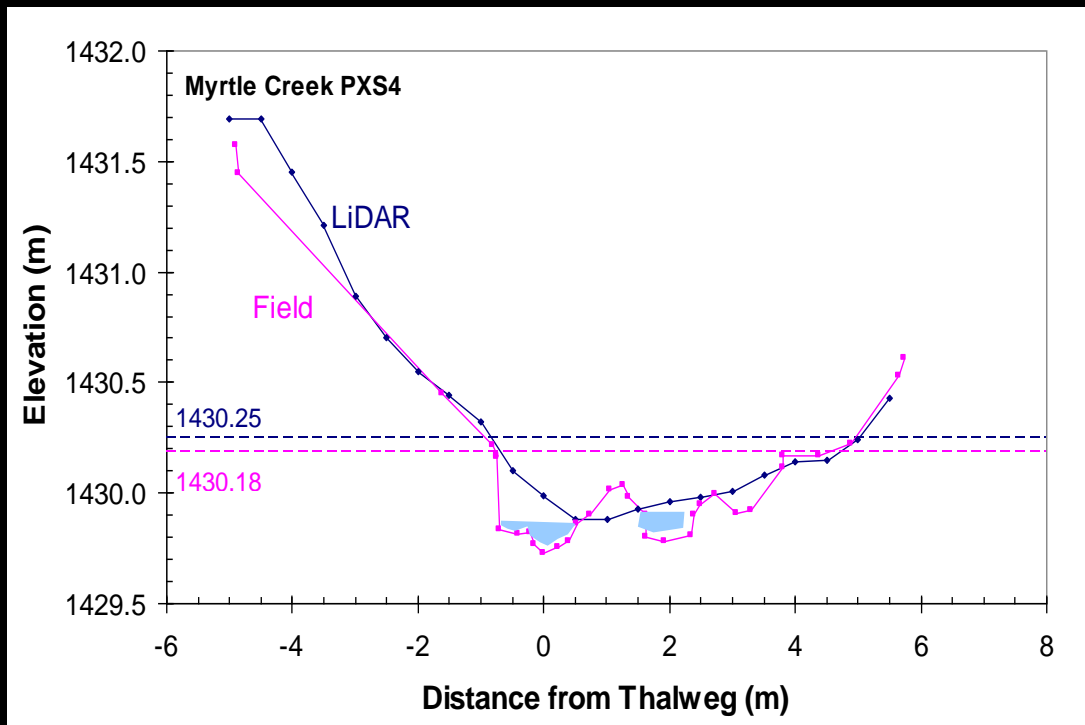
Calculation of Bankfull Elevation and Width



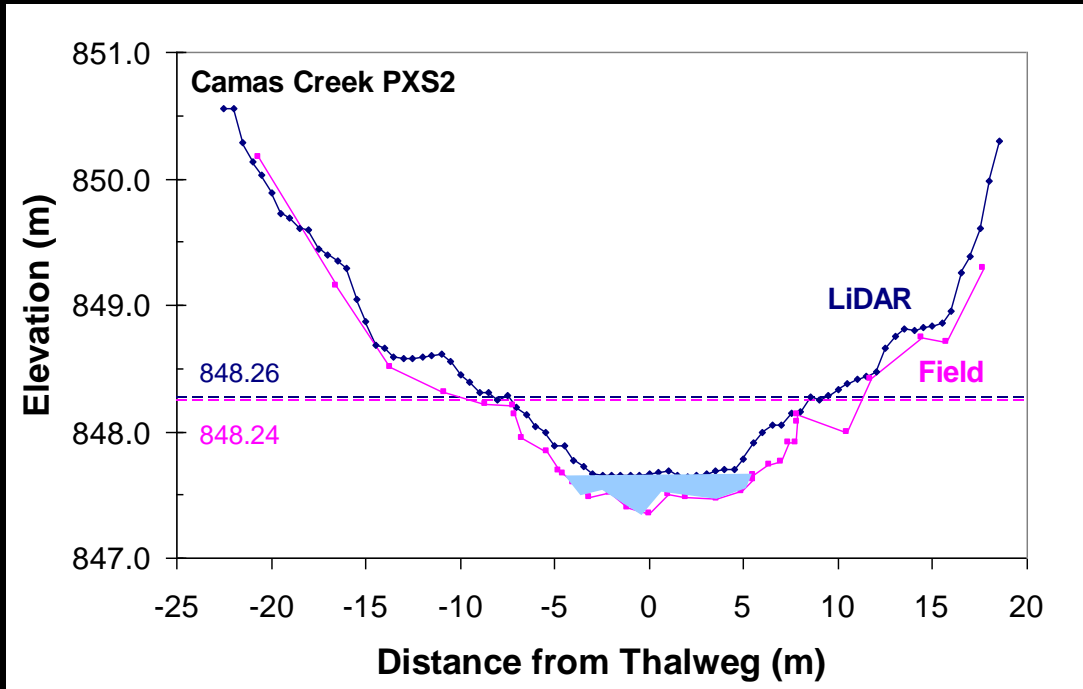
Cross Sections Comparisons Tinker Creek



Cross Section Comparisons Myrtle Creek

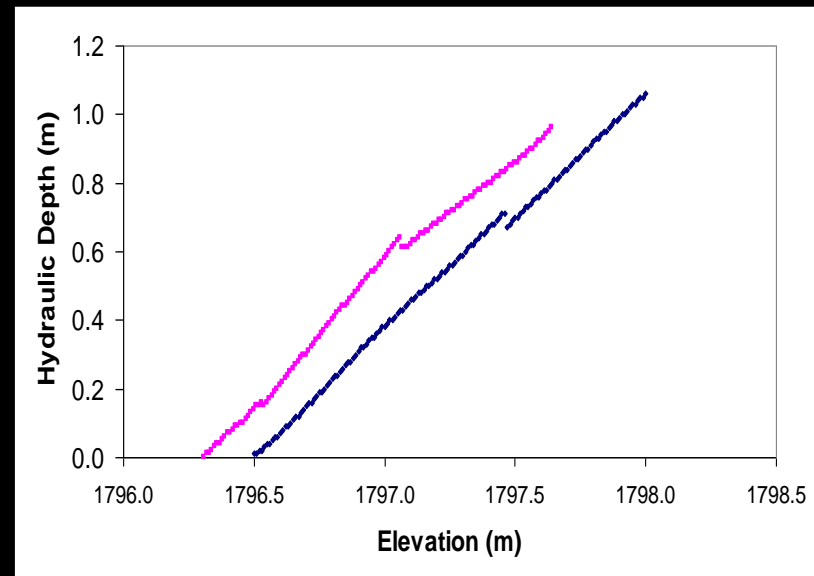
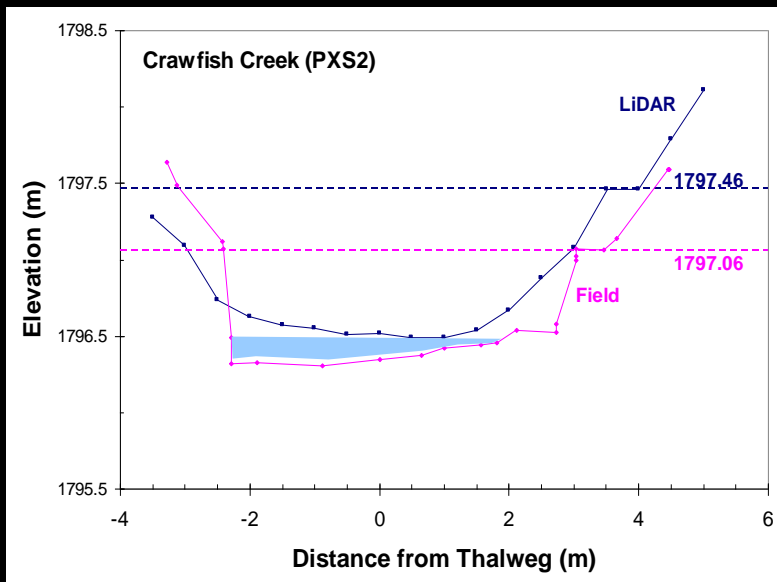


Cross Section Comparisons Camas Creek



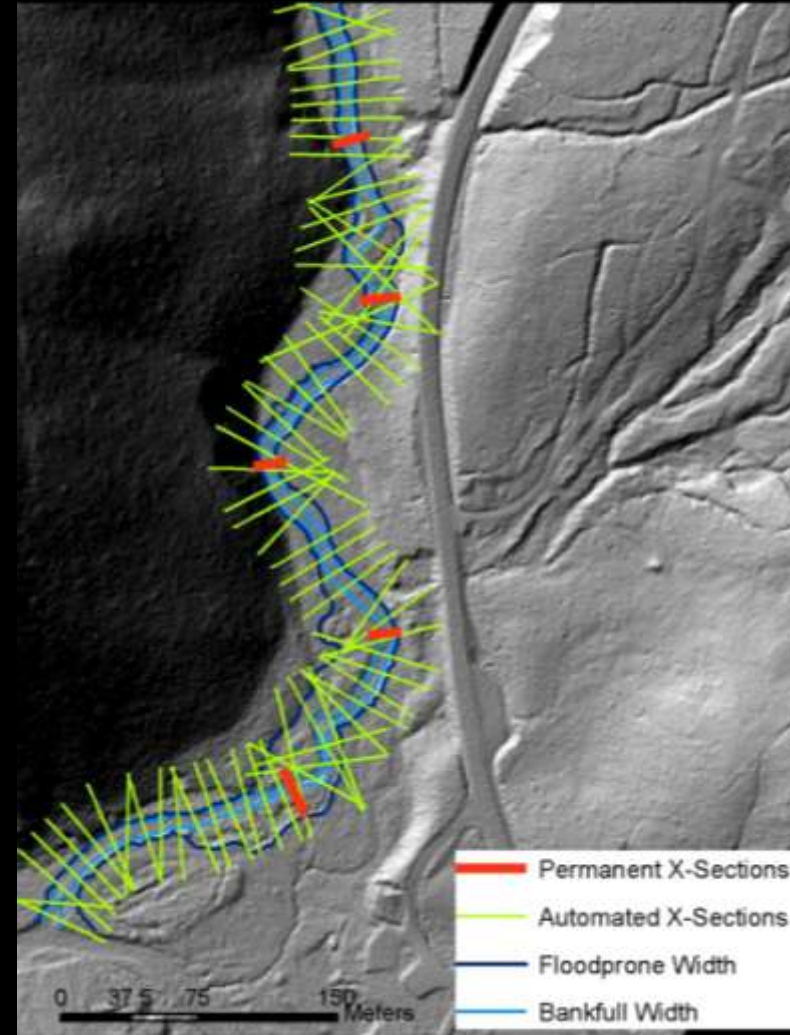
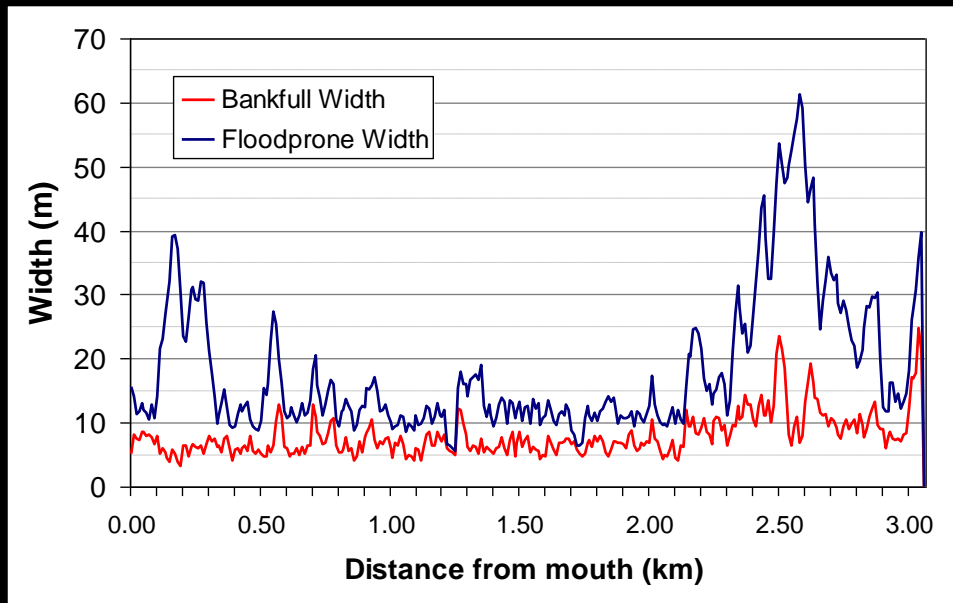
LiDAR DEM Compared to Field Transects

- Median difference in bankfull widths (based on 20 transects for each channel type, 5 per site):
 - Plane-bed: LiDAR within 16.2%
 - Pool-riffle: LiDAR within 9.2%
 - Step-pool: LiDAR within 42.5%
- Plane-bed and pool-riffle consistent with observer variability.
- Confined channels (step-pool) showed greater errors in both bankfull width and depth.



Streams Have a High Degree of Spatially Variability

Channel geometry can be characterized longitudinally by automated sampling of LiDAR DEM

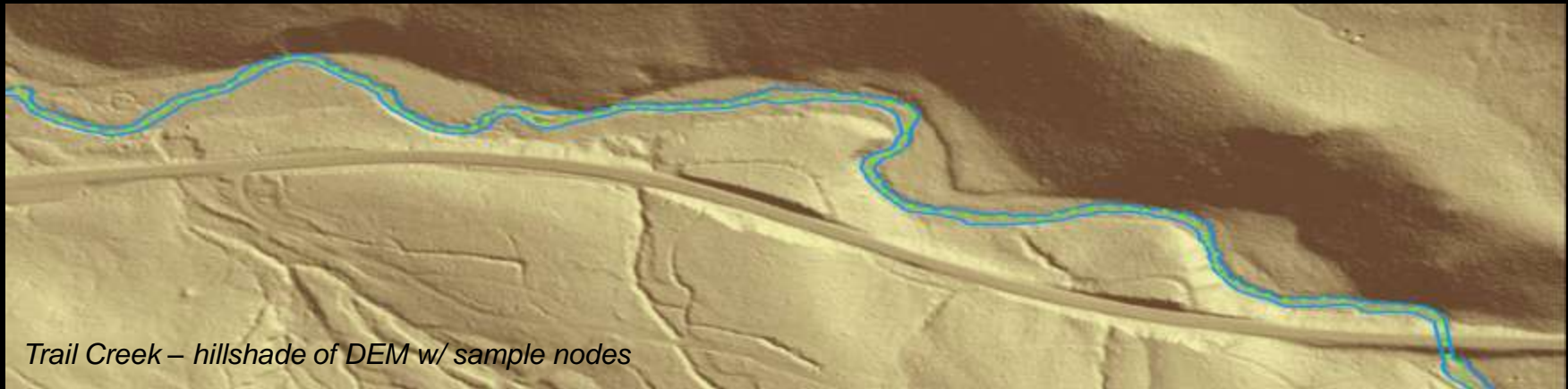


Channel Geometry - Repeatability and Consistency

Methods can be applied throughout the watershed with increased spatial coverage.

Temporal comparisons possible by comparing LiDAR DEM's and sampling at the precisely the same location.

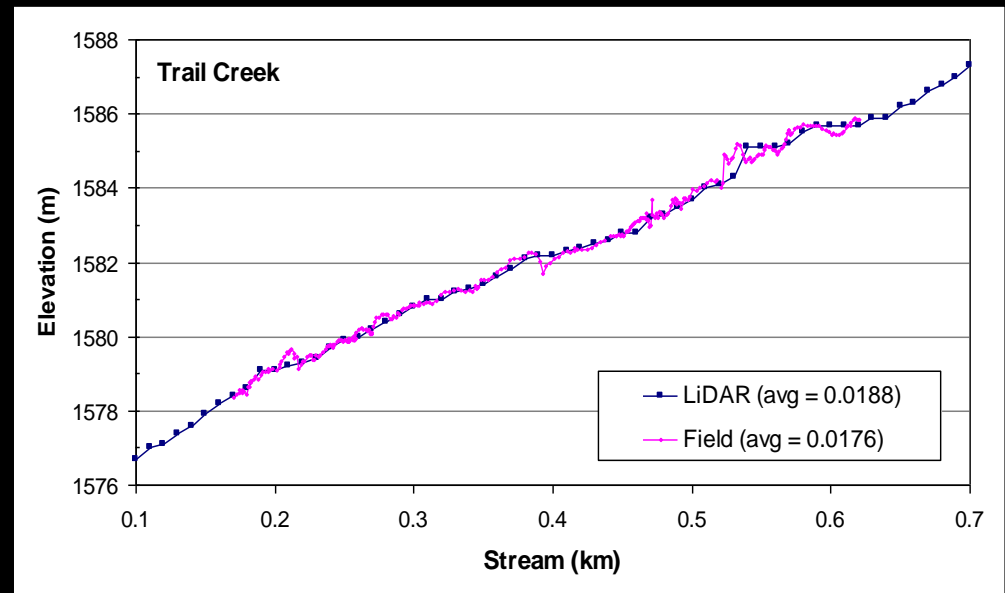
Stream Channel Slope and Sinuosity



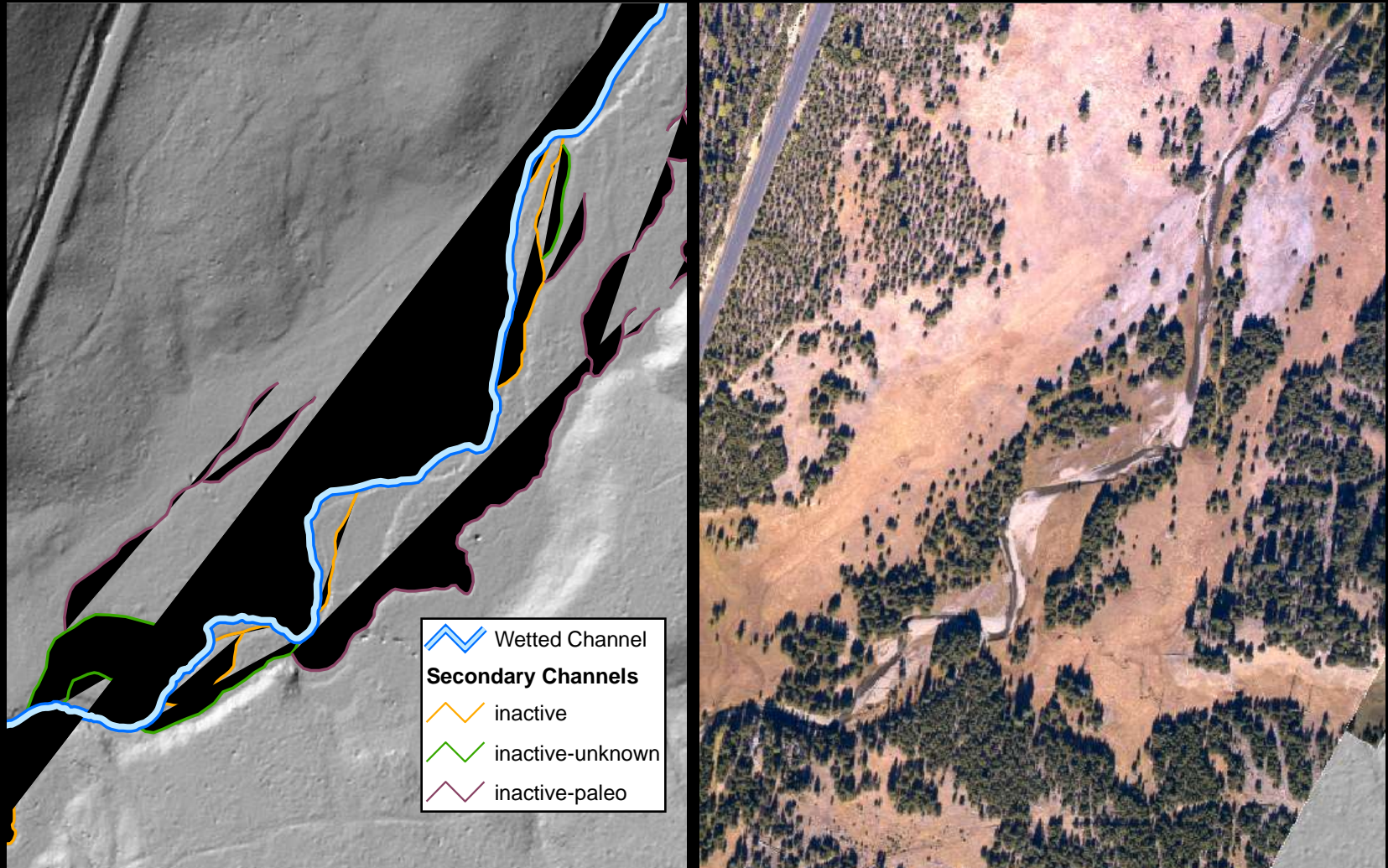
Elevations can be sampled directly from the DEM at user defined intervals over the entire reach.

Gradient defines stream stability and bed-load transport.

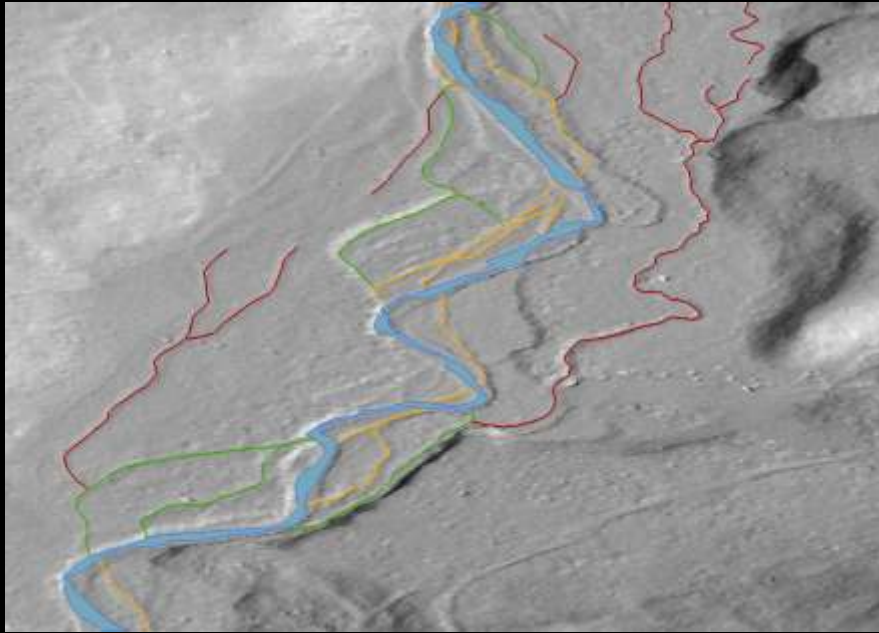
Stream gradient and sinuosity were consistent with field measurements.



Channel Complexity – Inactive and Paleo-channels

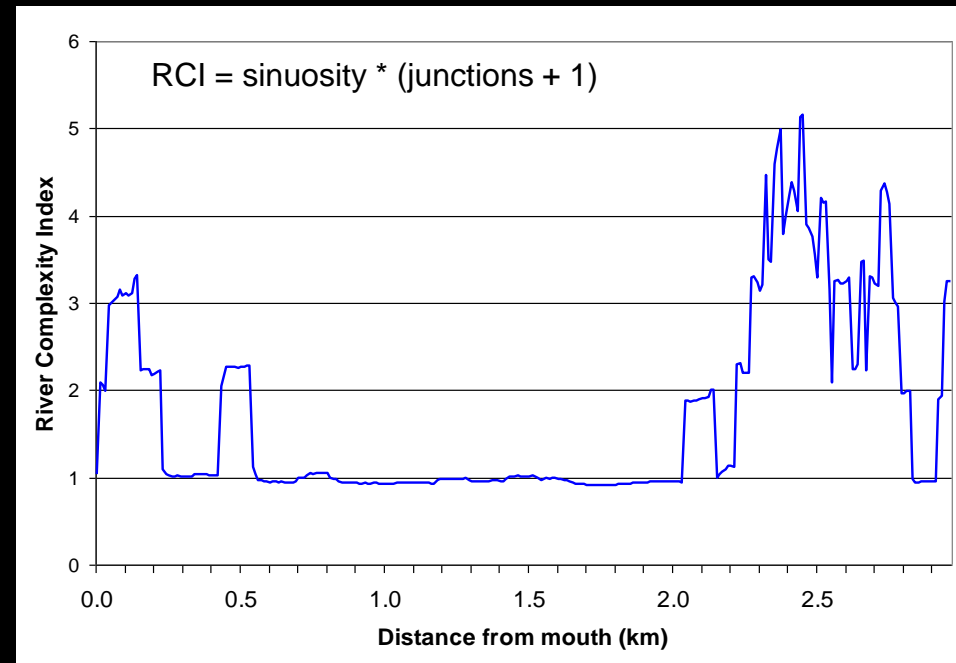


Channel Complexity – River Complexity Index

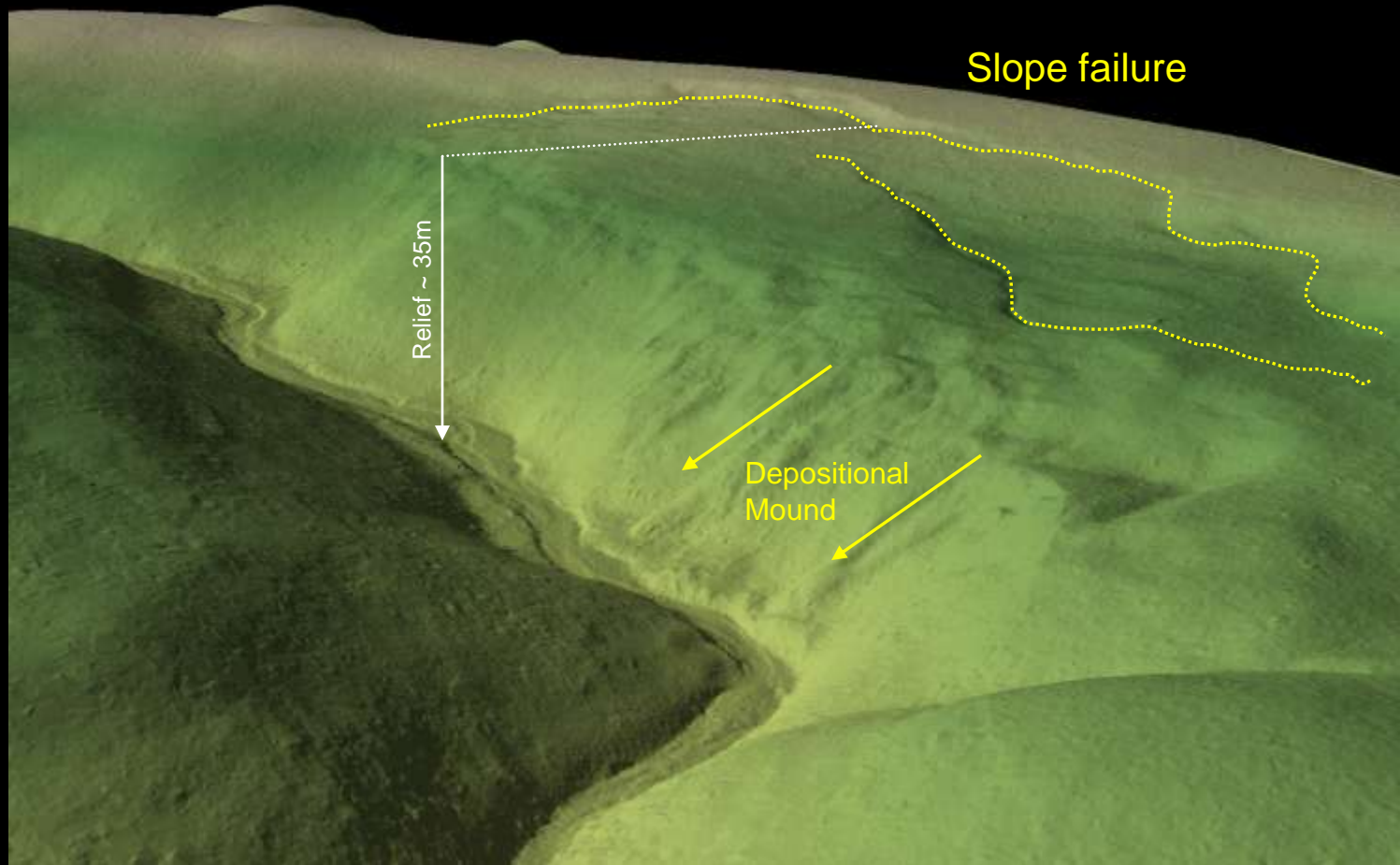


RCI provides a method for describing channel connectivity/complexity longitudinally

Mapping of side channels can provide a measure for Large Wood Debris (LWD) accumulation, sub-surface flow pathways, and habitat suitability (Jones 2006)



Landslide Detection: (Potomus Creek)



Combined Elevation Model (all points)
Heavily Forested Canyon

Bare Earth Model
Steep Walled Canyon

Stream Channel and Habitat Attributes

Measurable Using LiDAR/Multi-Spectral Remote Sensing

Measurable Parameter	Measurable With Limitations	Not Measurable
Reach Length	Channel Cross Section	Pool Depth
Valley Cross Section	Pool Frequency and Length	Gradient (stream bed)
Longitudinal Profile	Large Wood	Discharge
Gradient (water surface)	Bankfull Depth	Substrate
Sinuosity	Bank Angle	Water Chemistry/Quality
Bank-full Width	Bank Type	Biological
Road Density	Partial blockages to salmon migration and rearing	Bank Stability
Stream Crossing Density		
Vegetation		
Channel Connectivity		
Landslides		
Bank Incision		
Impervious surfaces		

Airborne LiDAR for Aquatic Habitat Monitoring

- LiDAR DEM is spatially continuous and offers the means to apply a consistent and repeatable methodology anywhere in the watershed.
- Accurate measurement of physical habitat attributes including stream gradient, sinuosity, and bankfull elevations.
- LiDAR terrain model maps side channels and subtle changes in floodplain topography that are not detectable during ground level monitoring.
- The LiDAR data inherently contains information about upslope and riparian processes, which are also difficult to quantify from ground level observation.

Airborne LiDAR for Aquatic Habitat Monitoring

Relative Cost/Benefit

- Increased accuracy and spatial coverage
 - Field crews can focus efforts within the wetted channel.
- Captures the complexity and variability of the ecosystem condition.
- Regional initiatives are making high resolution LiDAR more available.

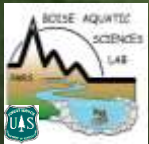
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