

Measuring the Puget Lowland landscape with lidar

Ralph Haugerud¹, Hans-Erik Andersen²,
Bob McGaughey³, Steve Reutebuch³

- 1) *U.S. Geological Survey; UW Dept. Earth and Space Sciences*
- 2) *UW College of Forest Resources*
- 3) *U.S. Forest Service; UW College of Forest Resources*



OUTLINE

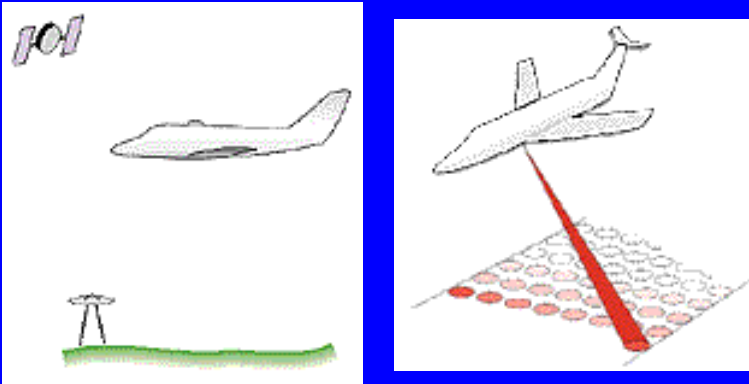
1. Lidar (Light Detection And Ranging), a new surveying technology
2. Looking at the land surface with lidar
3. Describing the forest canopy with lidar
4. A lidar data acquisition effort



A lidar instrument

- measures distance by measuring the time-of-flight for a pulse of light

A lidar survey system



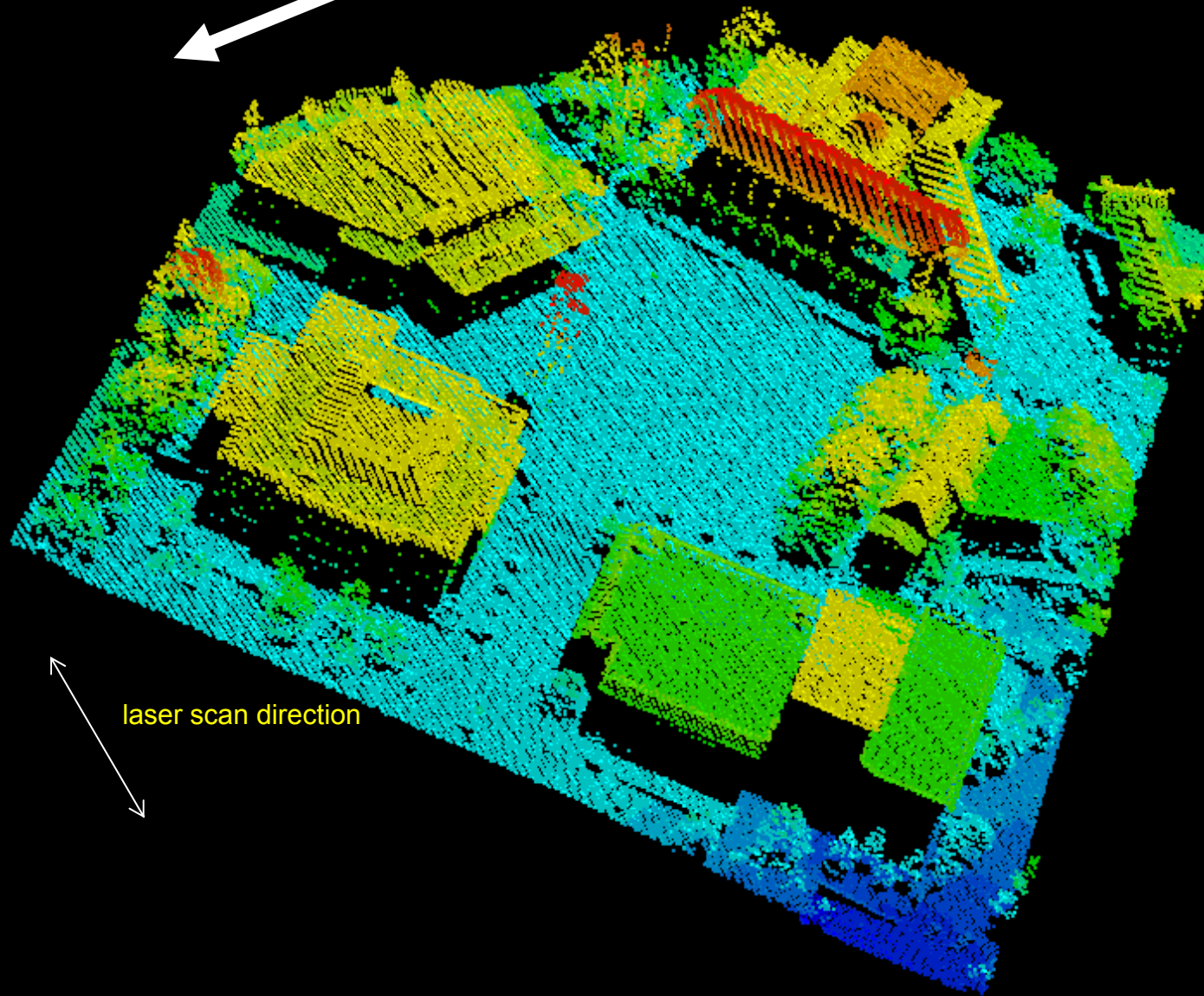
* | a j @ & [~ | c ^ Á p æ | æ Ü ^ • [~ | & ^ Á ð æ æ æ æ

- Differential GPS—aircraft position
- IMU (inertial measurement unit)—aircraft orientation
- Scanning laser rangefinder— scan angle, distance
- 3 data streams
 - GPS @ 1-2 Hz
 - IMU @ 1-200 Hz
 - rangefinder @ 20-100 kHz
- Extensive computer processing to get ground coordinates

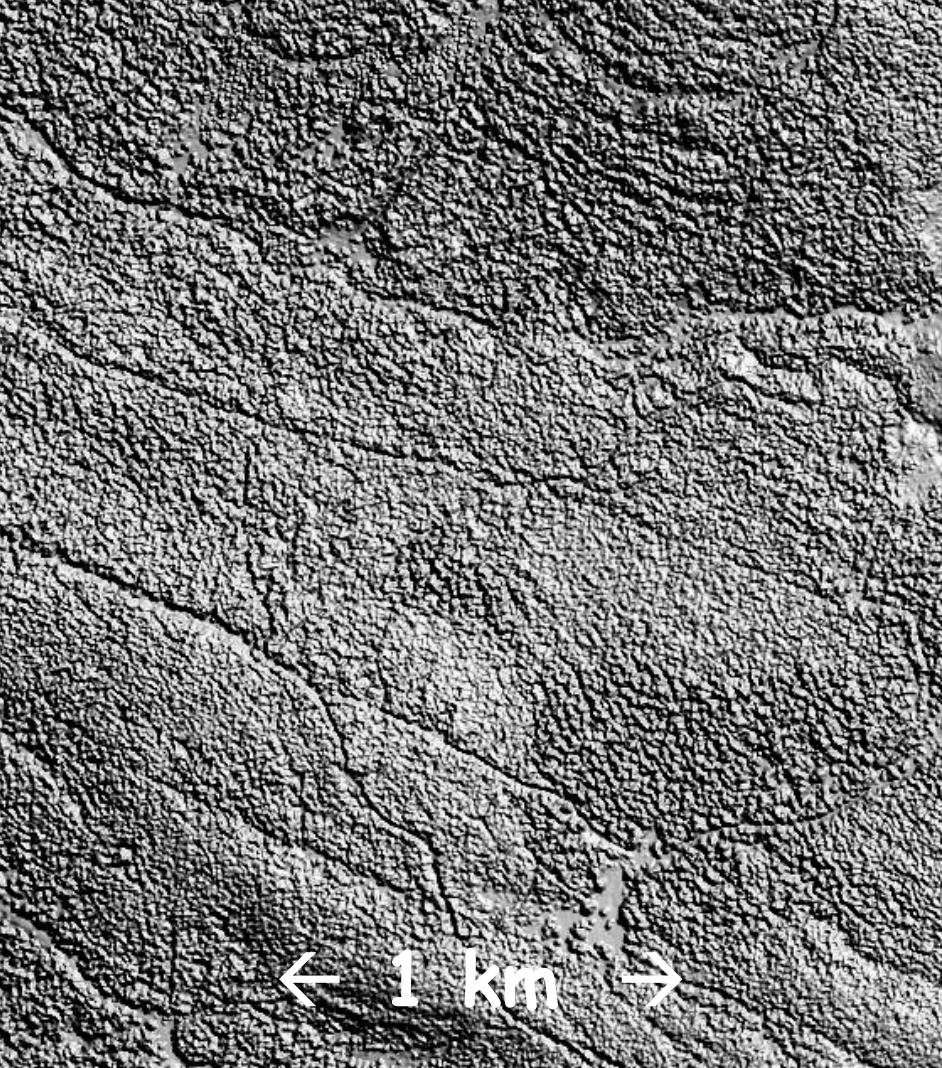
aircraft motion

each spot is a single XYZ measurement

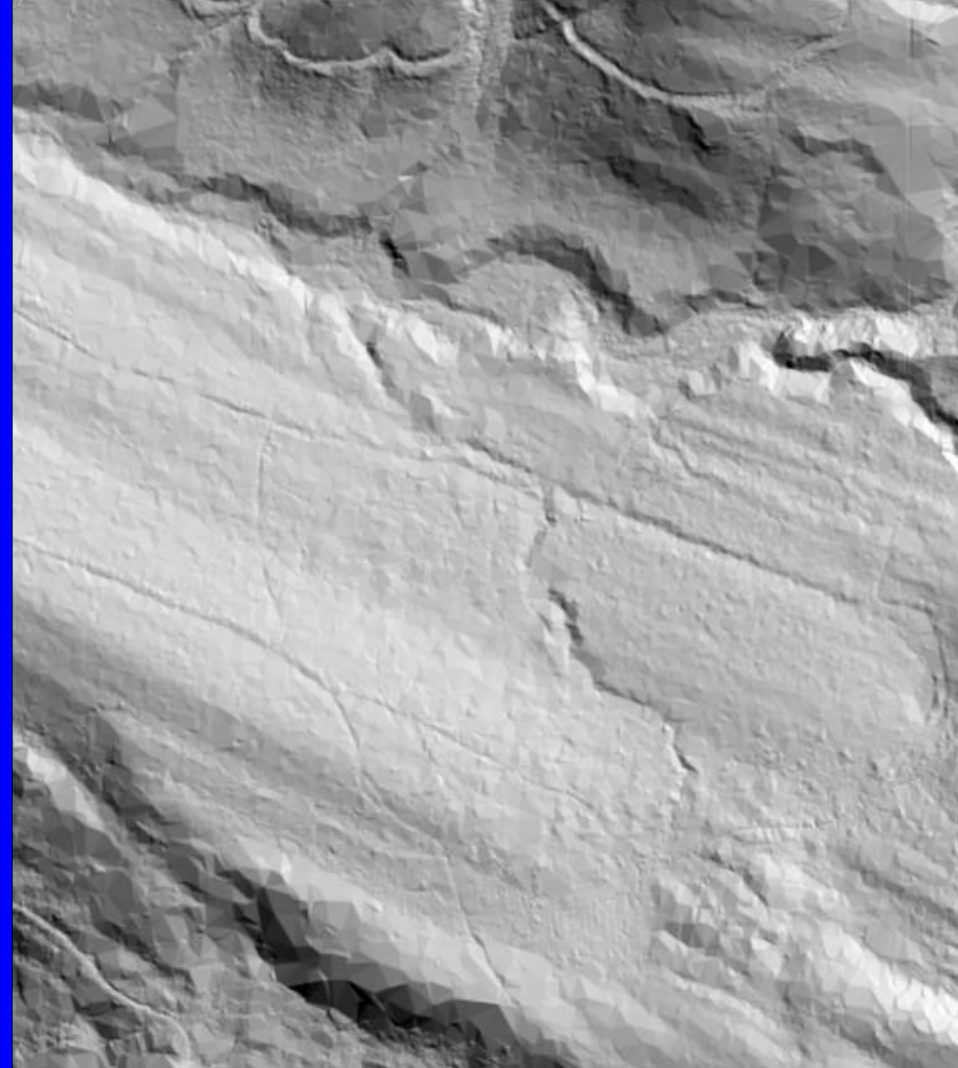
spot colors assigned by height (Z)



laser scan direction

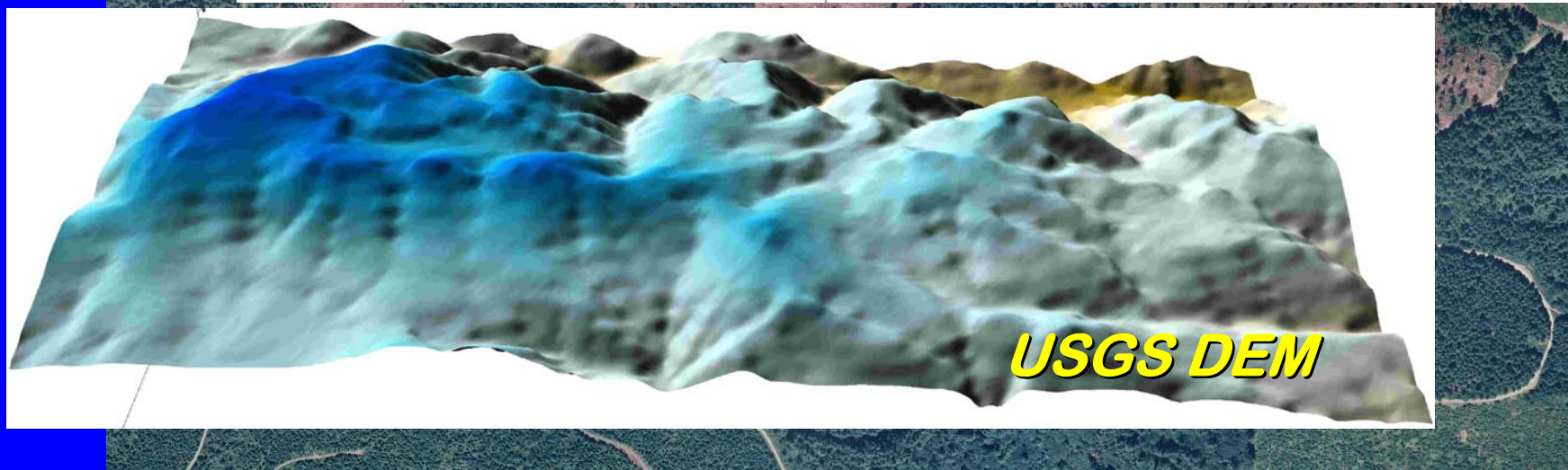
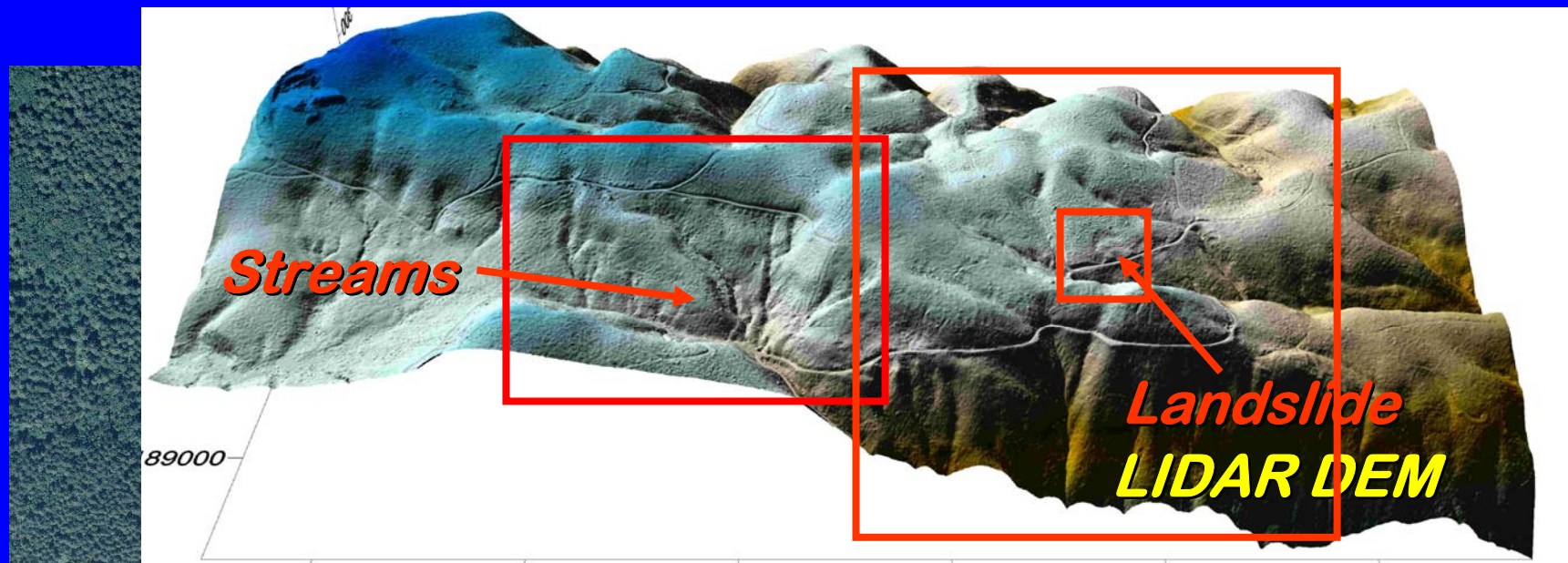


all surveyed points



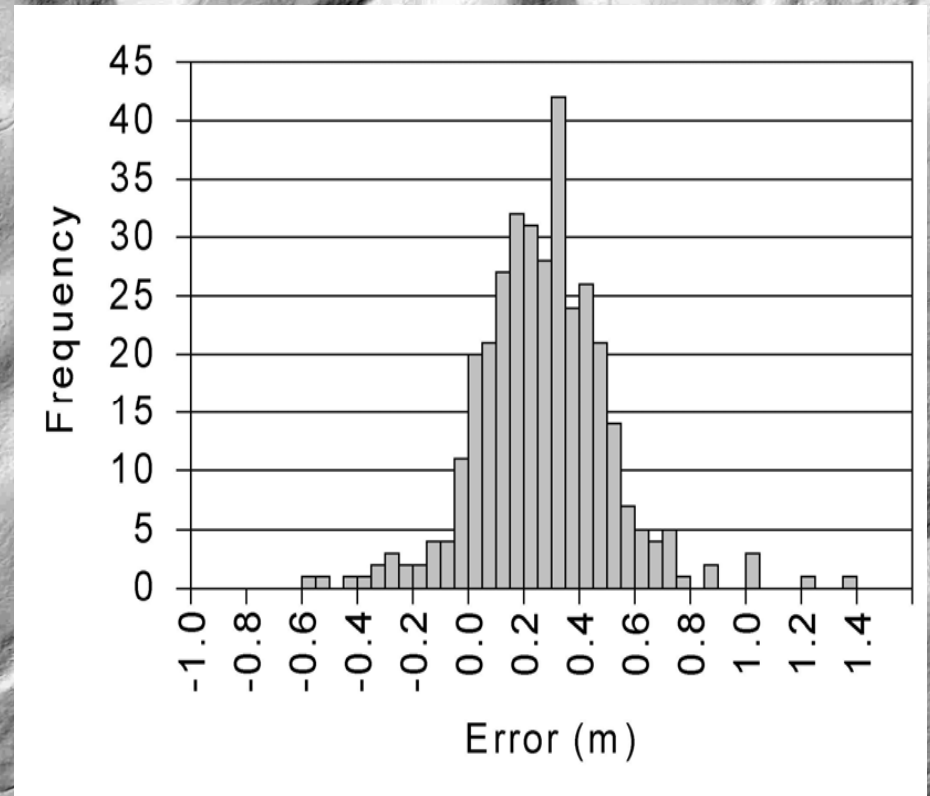
DEM interpolated from
ground points identified
by semi-automatic
processing

Lidar topography in forests

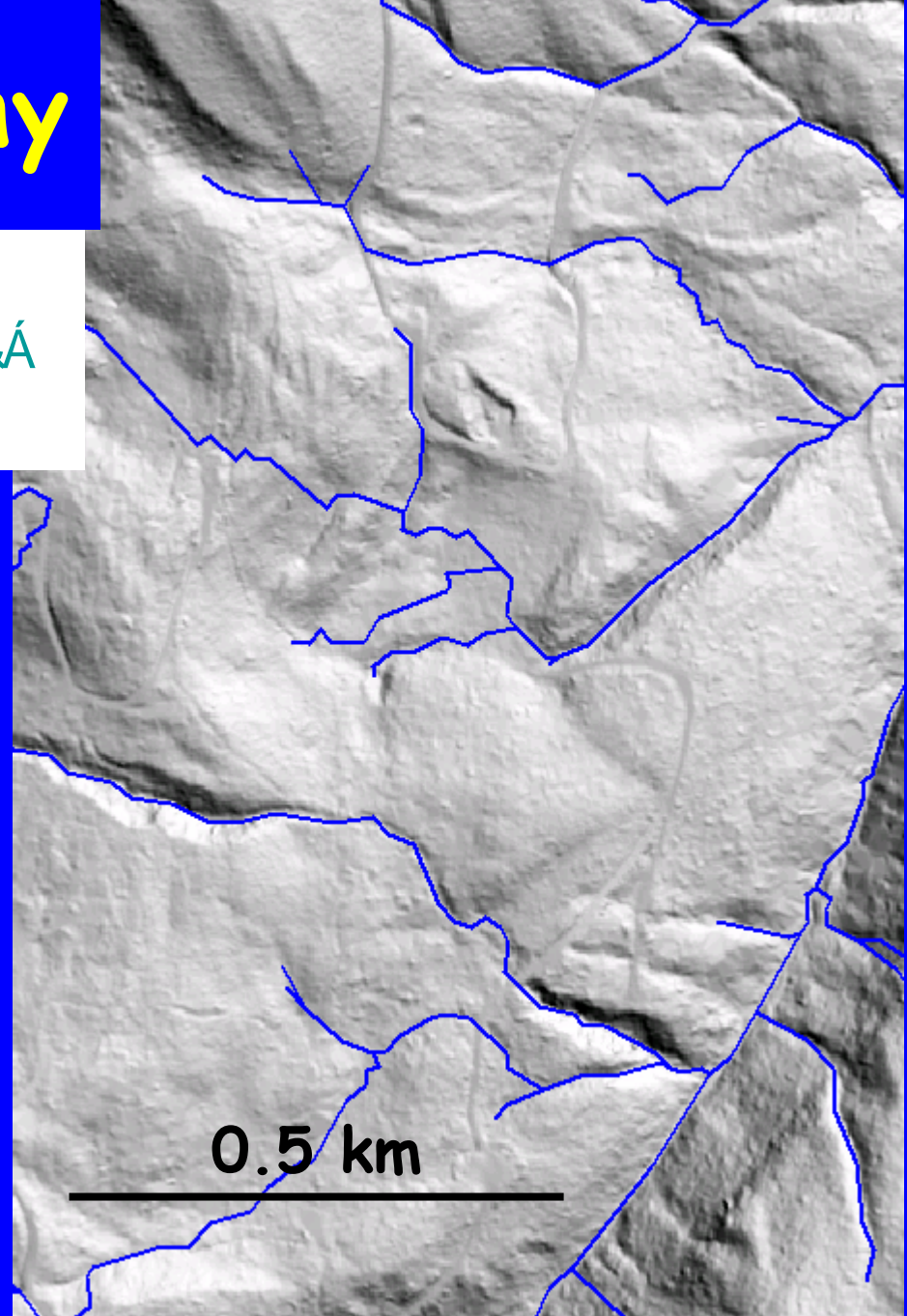
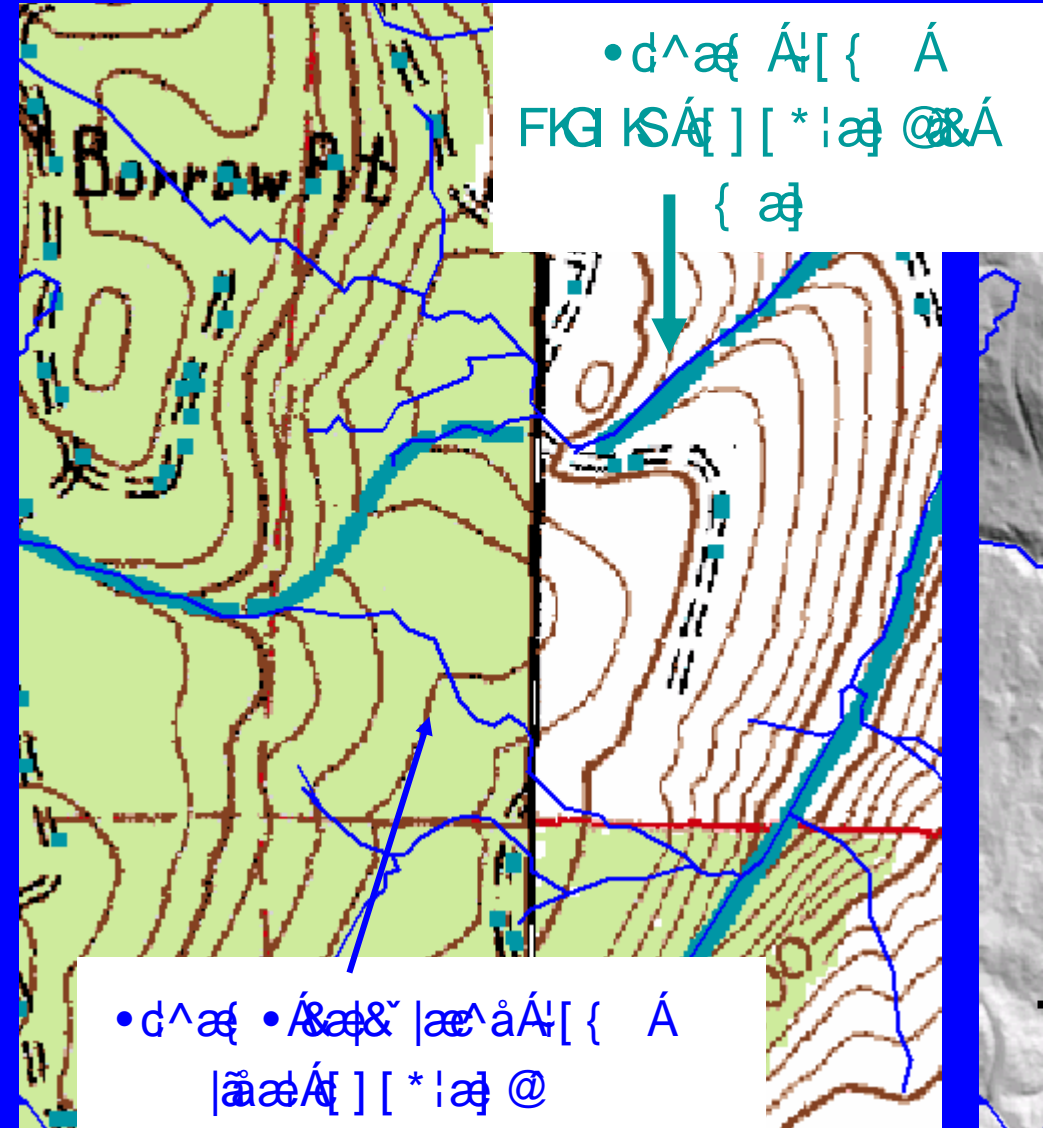


Lidar accuracy

- Mean LIDAR DEM error: +22 cm, stdev: 24 cm!
≈ 9" Field boot height!
- Maximum errors: +1.3 m, -0.6 m



Better hydrography



Deer Creek, SW of Mt Rainier

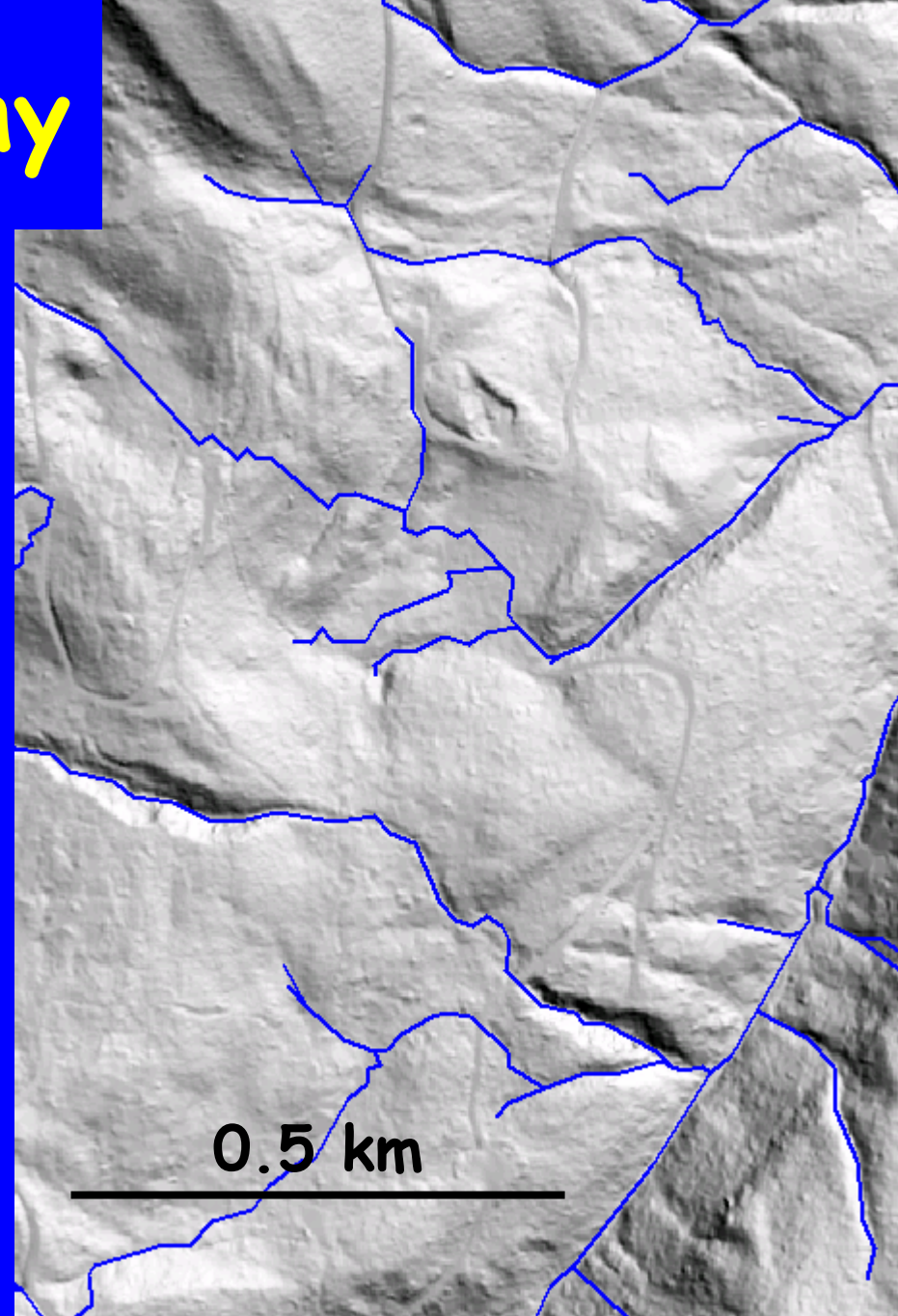
Better hydrography

More accurate

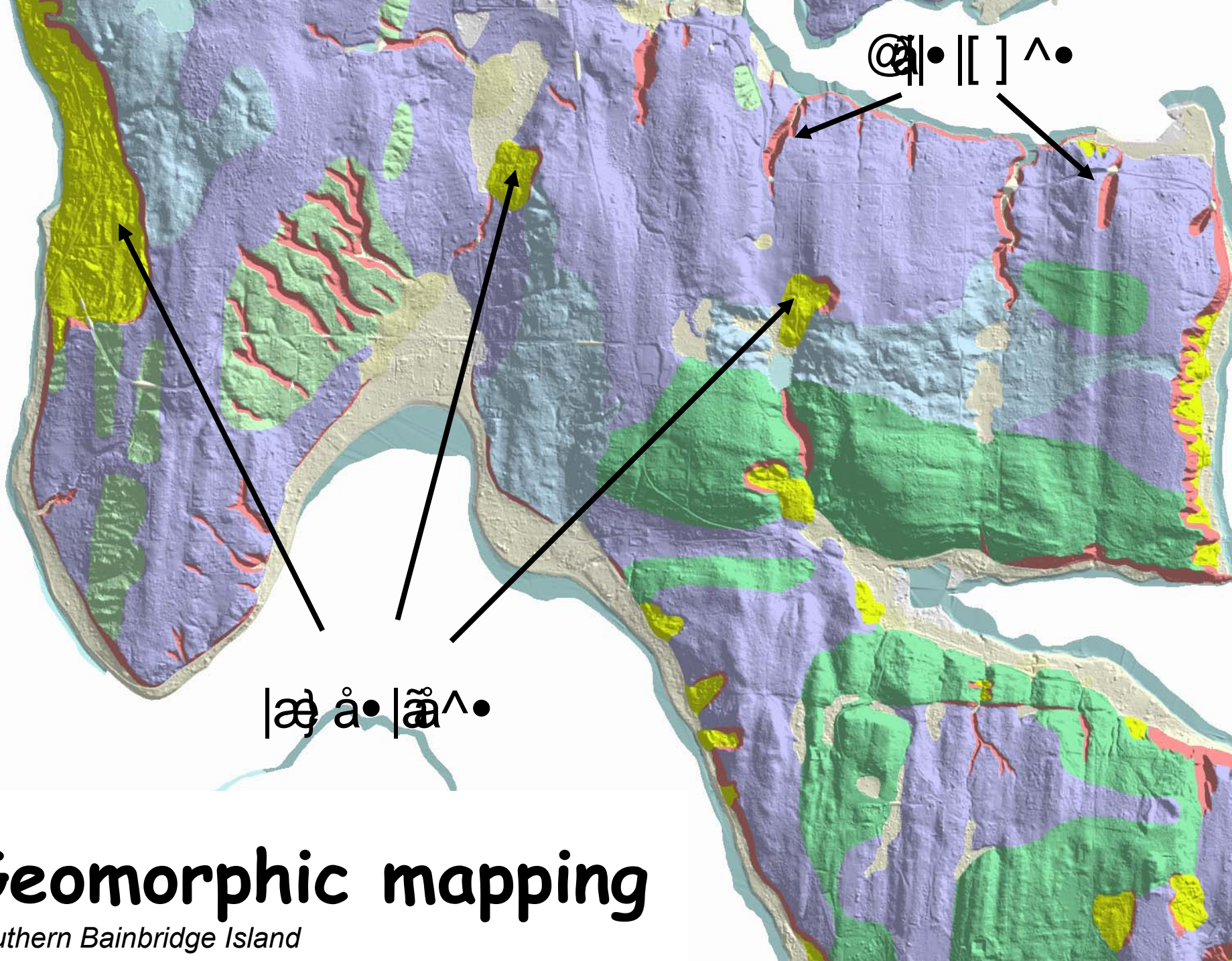
- Channel locations
- Channel gradients
- Drainage basin delineation

Mapping of channel migration zones

Location of abandoned side channels in forested floodplains



0.5 km



æ å • ä ^ •

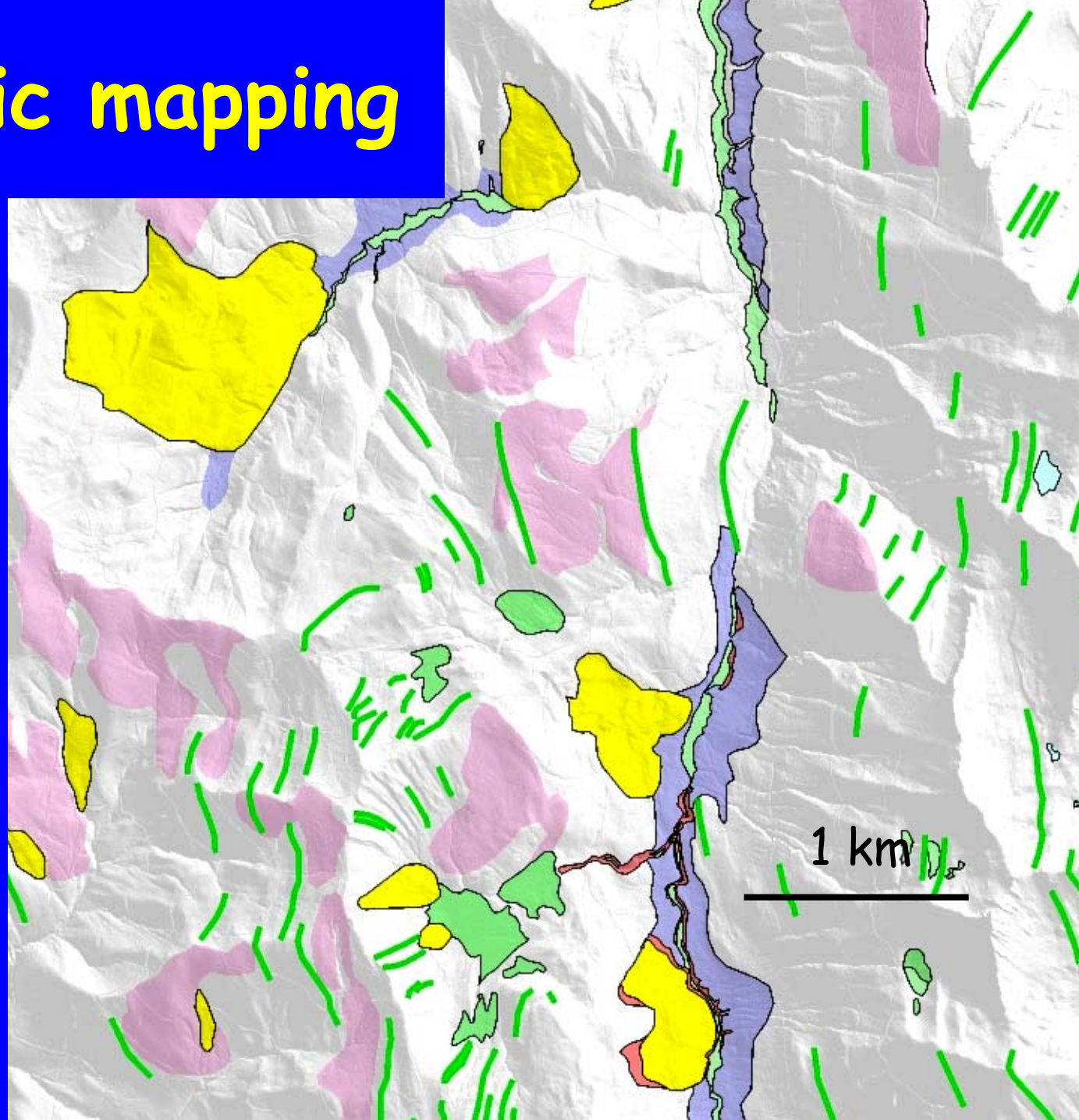
ä • [[] ^ •

Geomorphic mapping

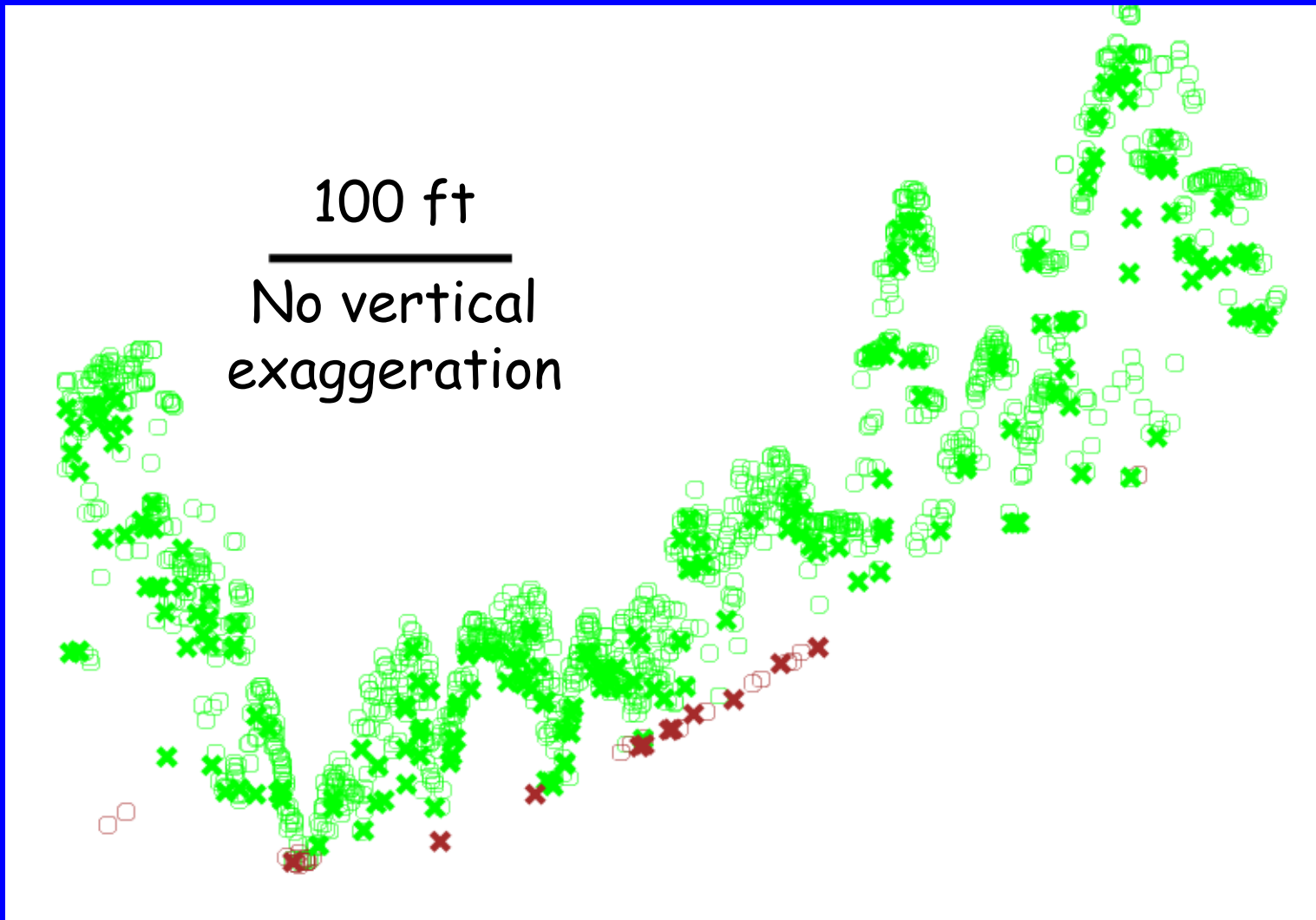
southern Bainbridge Island

Geomorphic mapping

- landslide
- alluvial flat, alluvial fan
- glacial valley-floor complex
- smooth, low-slope upland
- bedding trace



A lidar point cloud—pure XYZ position *in profile view*



Canopy height

"ÁÁHÉÉóÁ^||•

" JÉÉ F•c
|^č |} • Á Á
^æ&@Á^||

ÁÁÁÁ€óÁ ^!&^} ç^Á
@ã @

≥150'

120'

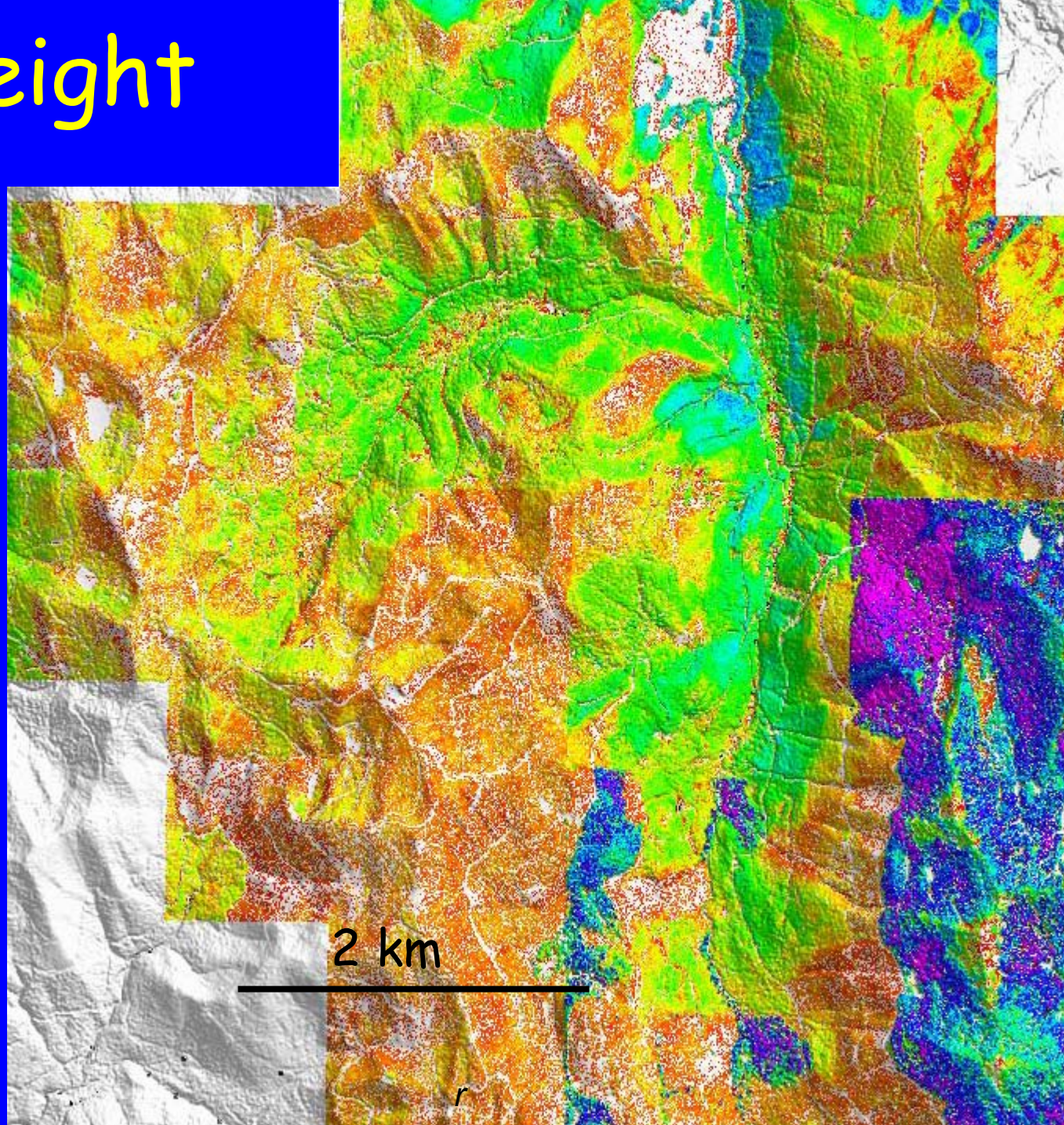
90'

60'

30'

5'

&æ [] ^ Á&æ& |ææ } • Á
æ^Á~ || ^ Áæ ç { æ^á

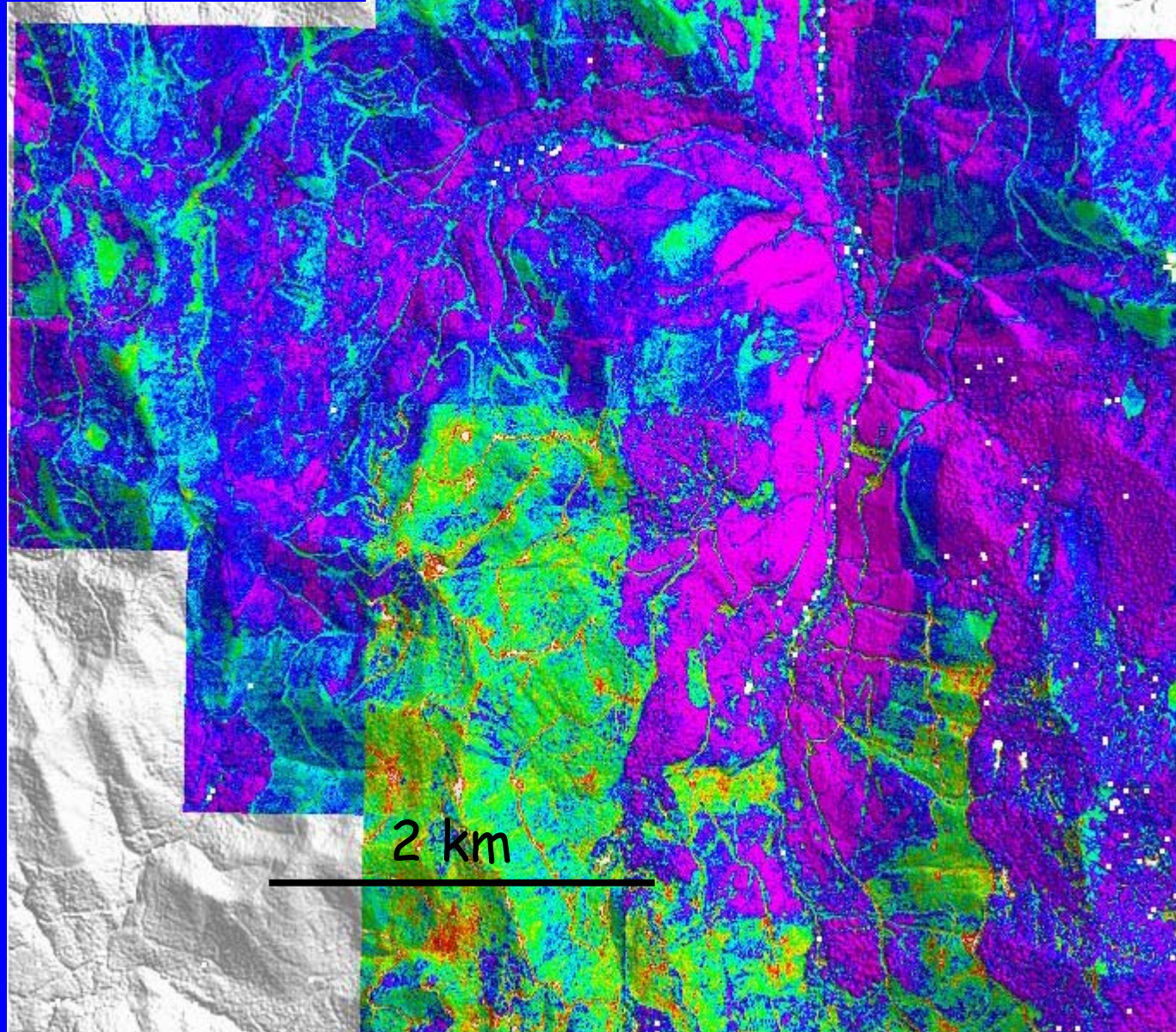


2 km

Canopy openness

↑æ&ā } Á•c
!^č !} •Á } Á
* ! [ˇ } á

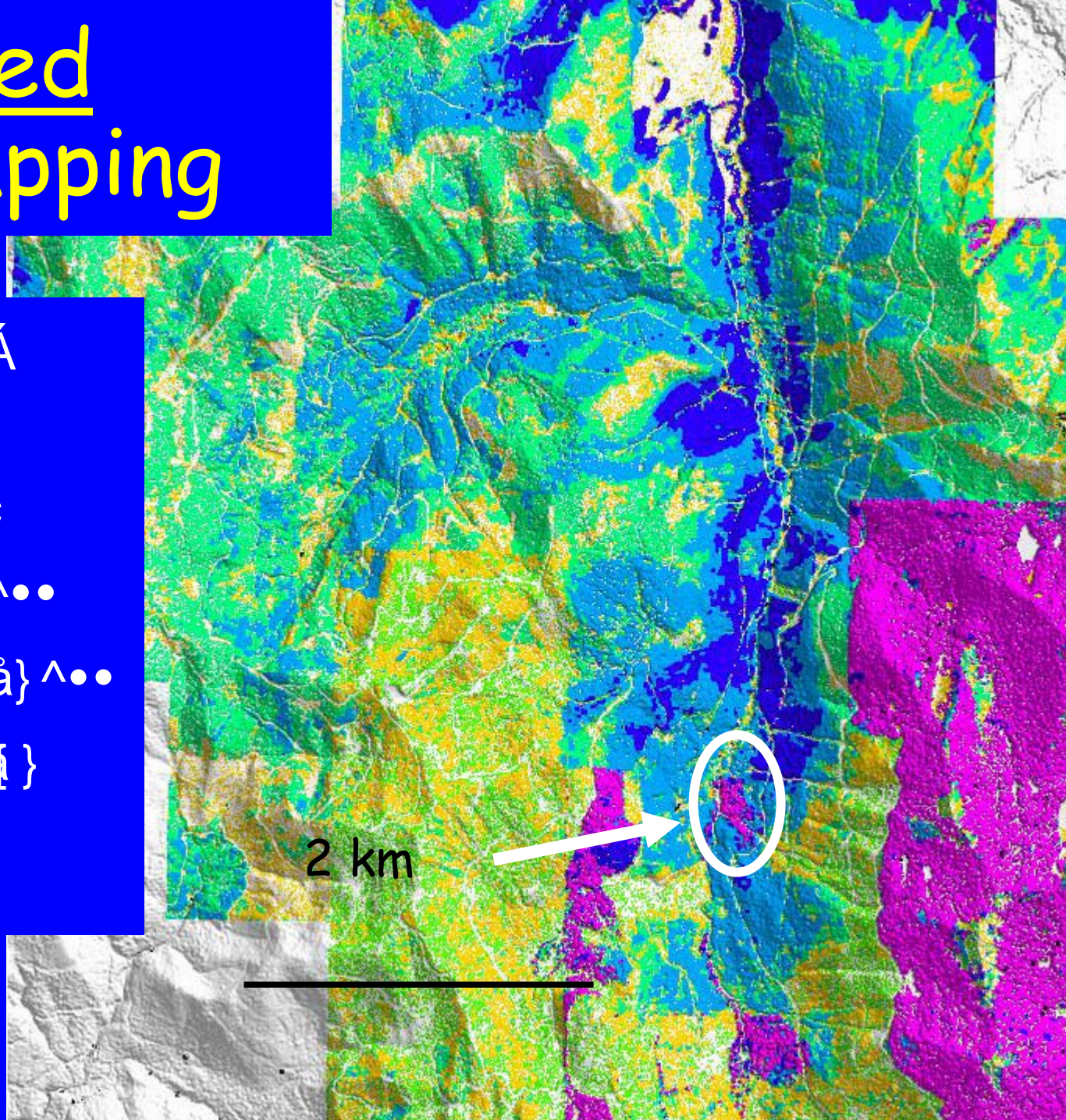
0%
20%
40%
60%
80%
97%



2 km

Automated stand mapping

œ Á } • ~] ^ | ç ã ^ â Á
& | æ • ã ã ã æ æ } Á | {
. & æ [] ^ Á @ ã @
. & æ [] ^ Á [] ^ } } ^ • •
. & æ [] ^ Á æ * ^ â } ^ • •
. * | [~ } â Á | ç æ æ }
Ö ^ •] ^ & | ^ â

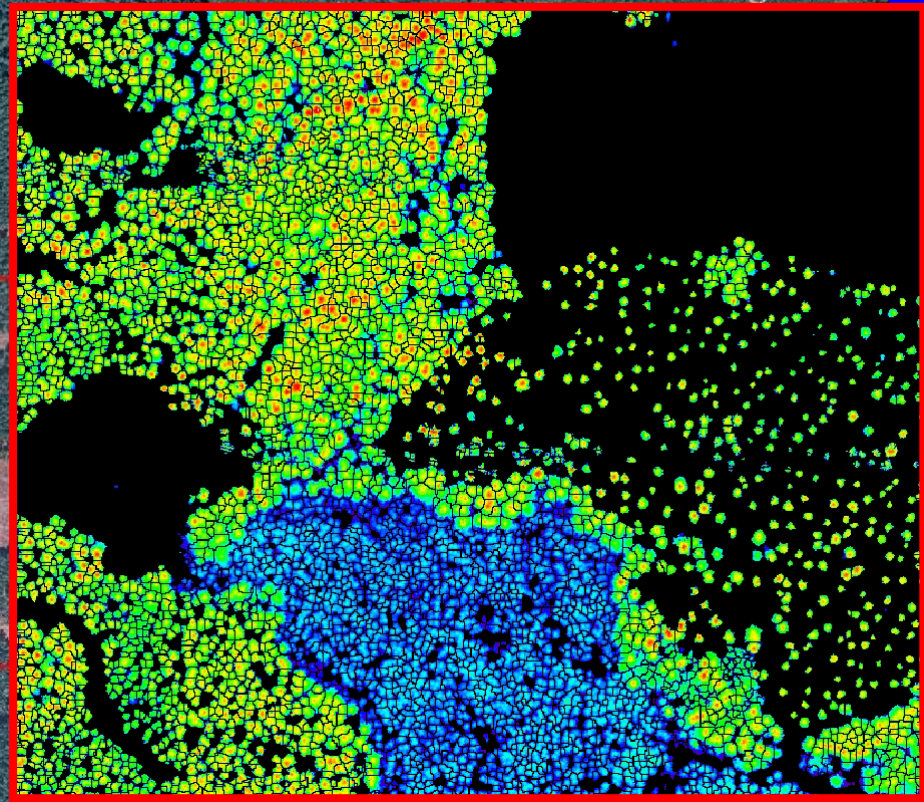




Automated individual tree recognition



Orthophoto

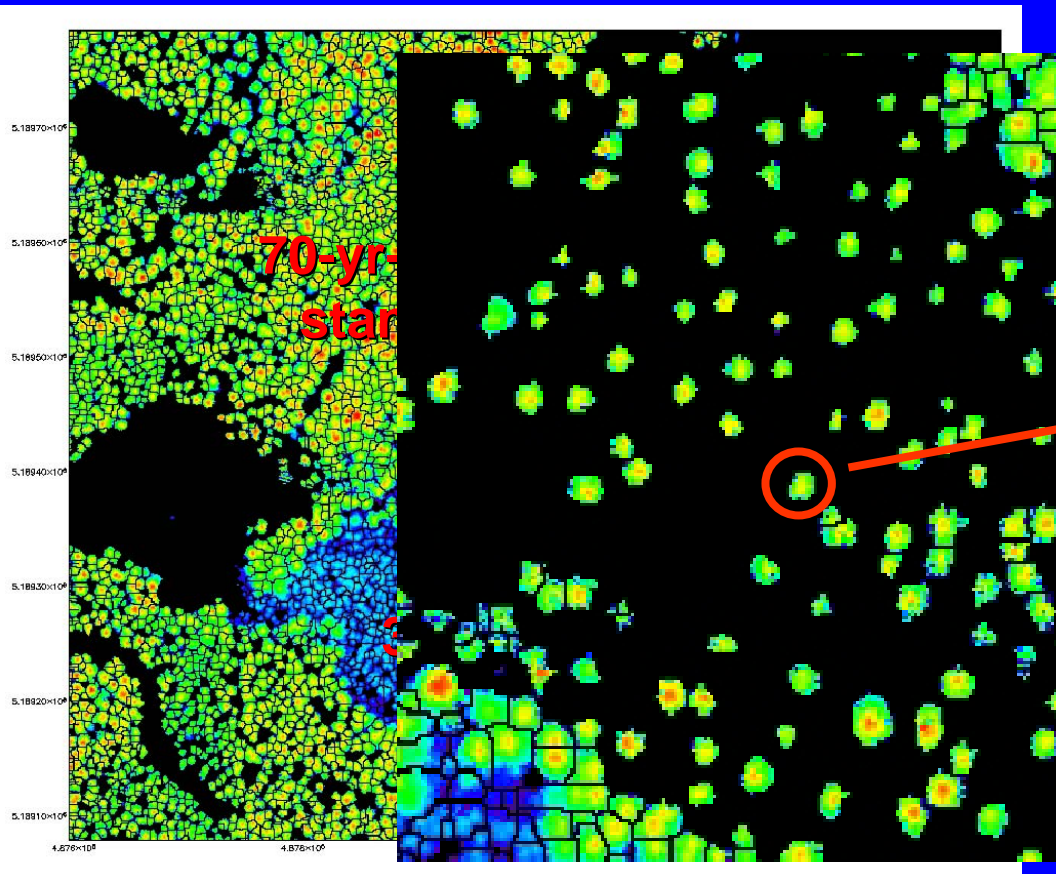


Automated segmentation of individual tree crowns

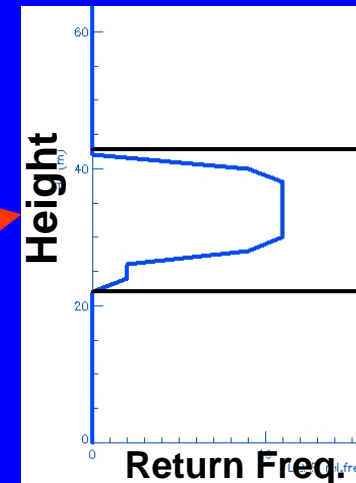
Automated individual tree measurements

- LIDAR height data are extracted for each segmented tree crown: individual crown surveys
- Individual tree measurements are computed from this LIDAR height data cloud
 - Tree height
 - Vertical & horizontal vegetation structure
 - Crown base height
 - Crown area
 - $DBH = f(\text{height, crown area})$
 - $\text{Stem volume} = f(\text{height, DBH, crown area \& length})$

Automated individual tree measurements



LIDAR returns height distribution



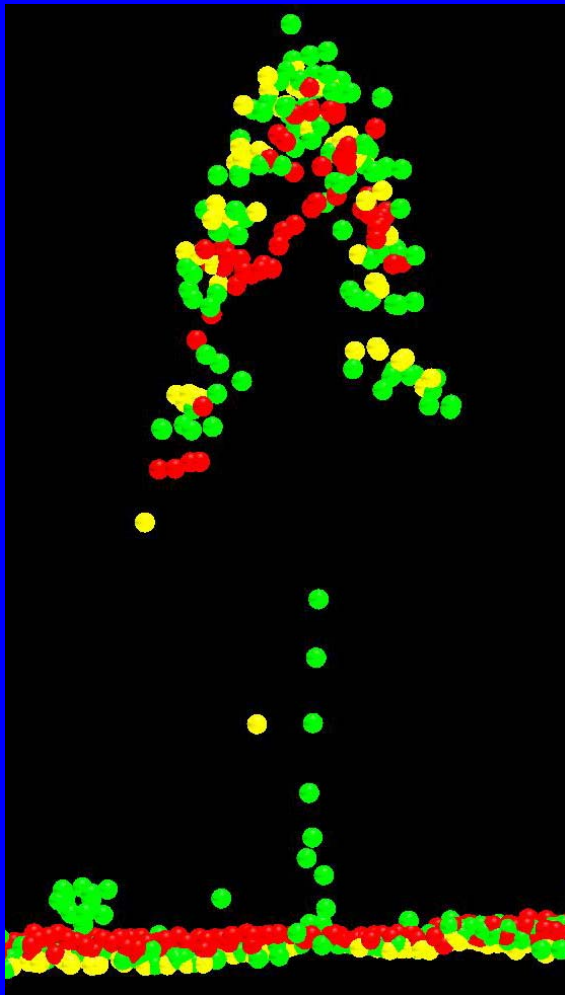
Tree ht: 43 m

Crown
Base ht: 22 m

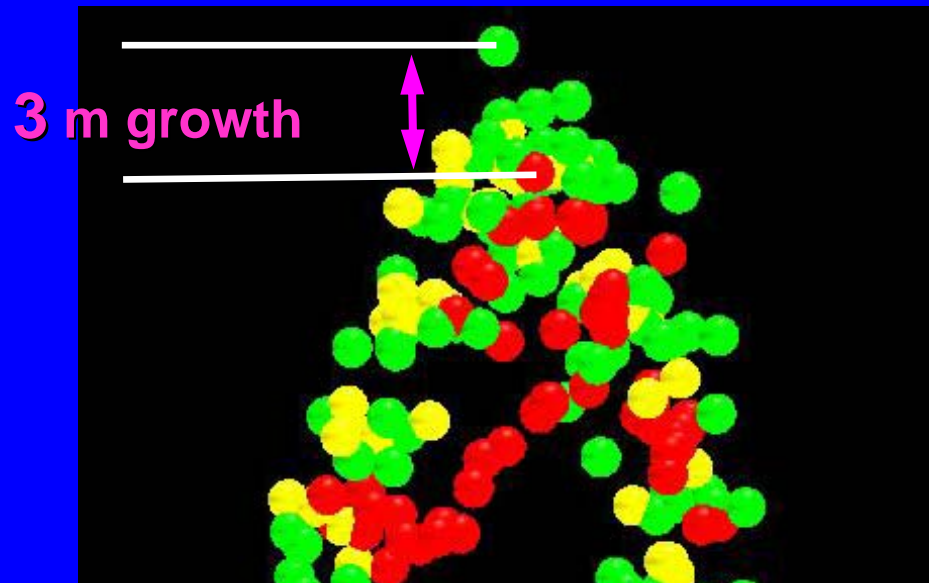
Ground Level

Estimated DBH:
65 cm

With repeat surveys, watch trees grow



Individual Tree LIDAR Datasets

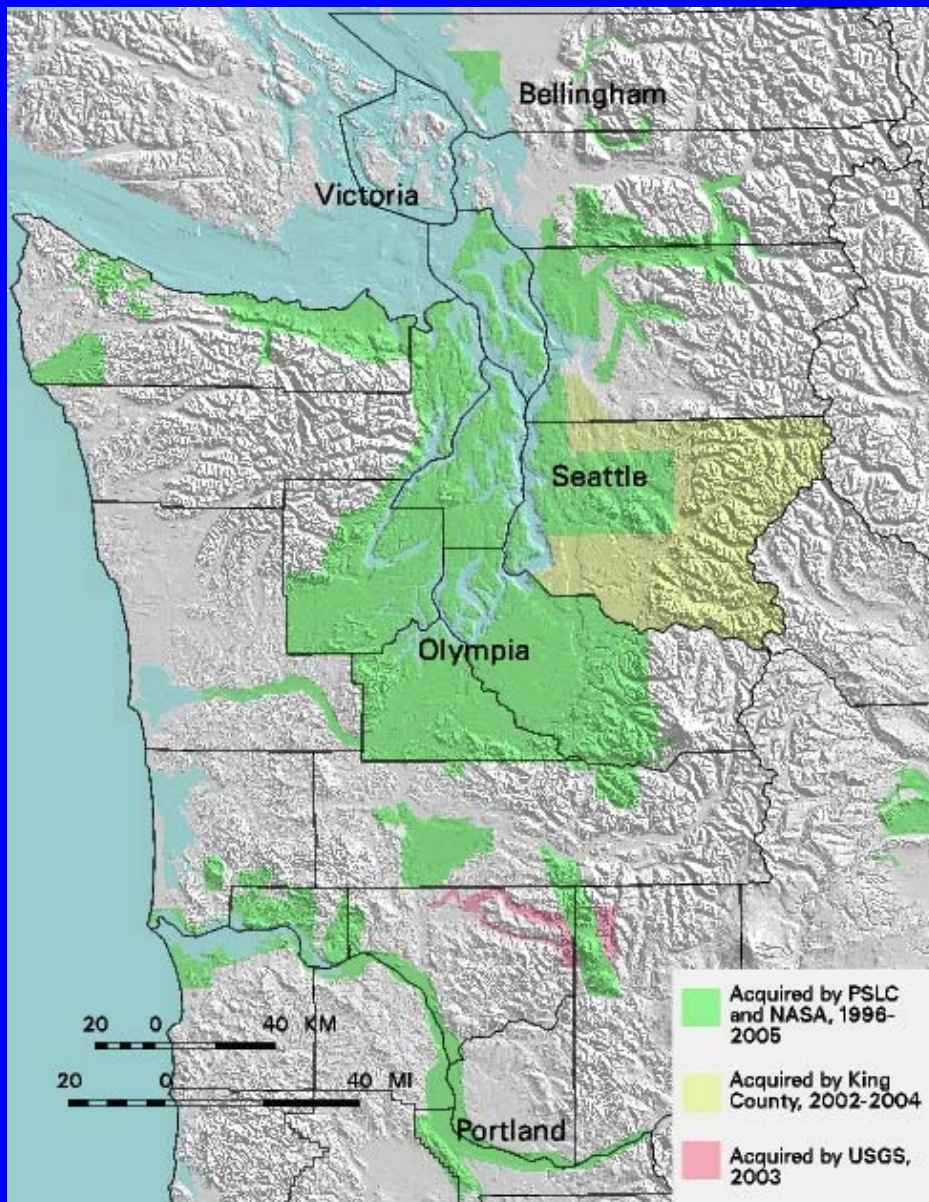


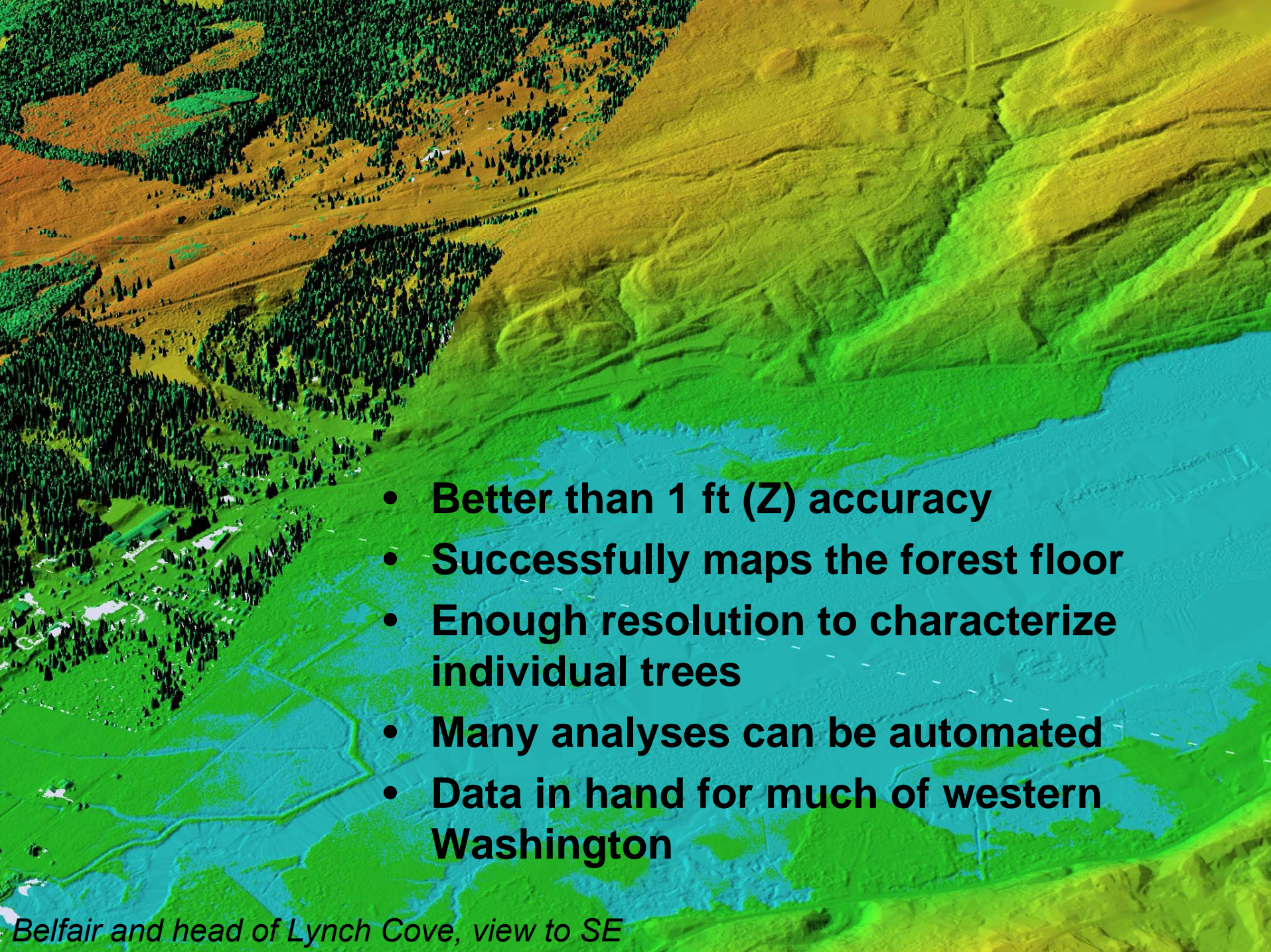
Puget Sound Lidar Consortium

Public-domain high-resolution lidar topography for the Pacific Northwest, 1999—

Puget Sound Regional Council, Kitsap County, U.S. Geological Survey, and numerous collaborators

<http://pugetsoundlidar.org>
hosted by UW Earth and Space Sciences



- 
- An aerial photograph of a forested landscape, likely in western Washington, overlaid with a color-coded topographic map. The map uses a color gradient from blue (low elevation) to red (high elevation) to show terrain features. The forest floor is visible through the map overlay, and a river and a lake are also present. The view is from the southeast.
- **Better than 1 ft (Z) accuracy**
 - **Successfully maps the forest floor**
 - **Enough resolution to characterize individual trees**
 - **Many analyses can be automated**
 - **Data in hand for much of western Washington**

Belfair and head of Lynch Cove, view to SE