Erosion Modeling Update for the West Valley PPA Model

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Implementing Erosion in the West Valley PPA Model

- Two different sets of parameters in the PPA Model:
  - Deterministic
  - Stochastic
- Both will be informed by several lines of evidence, including aerial imagery, the work of the EWG, erosion models beyond those evaluated by the EWG, and potentially other expert elicitation or literature review
- The current presentation focuses only on the evaluation of recent data obtained from processing aerial photography and LiDAR tomography

Implementing Erosion in the West Valley PPA Model

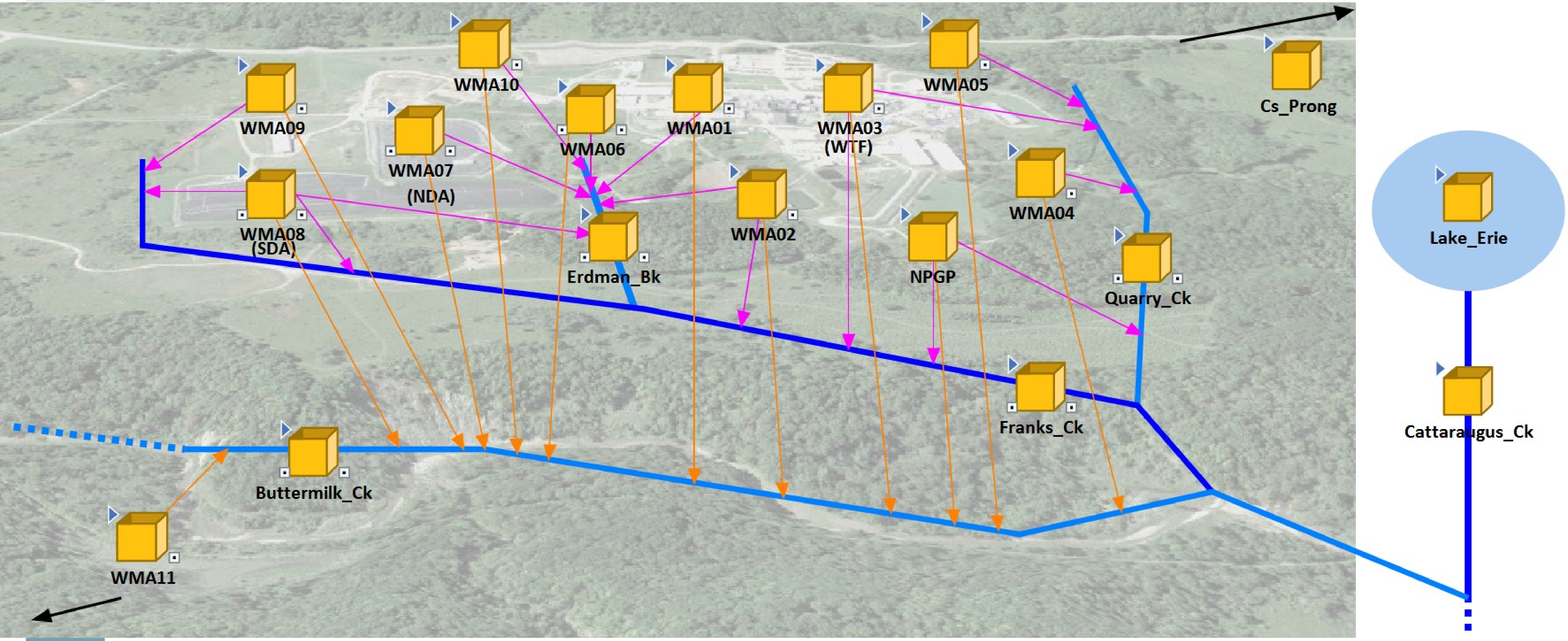
Deterministic

- Length of each creek measured from its mouth (e.g. the mouth of *FC* is at its confluence with *BC*)
- Beginning and end points for reaches in the creeks
- Initial distance from each Facility to the nearest creek(s), with reach also identified

Denote Franks Ck (FC), Erdman Bk (EB), Quarry Ck (QC), Buttermilk Ck (BC), and Cattaraugus Ck (CC)

Modeled Layout of WMAs

Each Waste Management Area (WMA) has one or more Facilities and Decision Units



Implementing Erosion in the West Valley PPA Model

Stochastic

- Rate of gully migration from each adjacent creek reach (one or two creeks) towards each associated Facility (length/time) *(the rate distribution could be the same for all Facilities or could be varied in space by creek or by reach)*
- Rate of hillslope failure migration from creek reaches towards each Facility (length/time) *(the rate distribution could be the same for all Facilities or could be varied in space by creek or by reach)*

Using Historical Imagery to Inform Erosion Model

Lidar Data

- Two different sets of LIDAR data from 2015 and 2010
- Orthorectified aerial photograph paired with the 2015 LIDAR data (i.e., a map of near-survey quality)

Historical Aerial Photographs

- Multiple historical aerial photographs from 1939, 1955, 1961, 1965, 1977, 1984, 1989

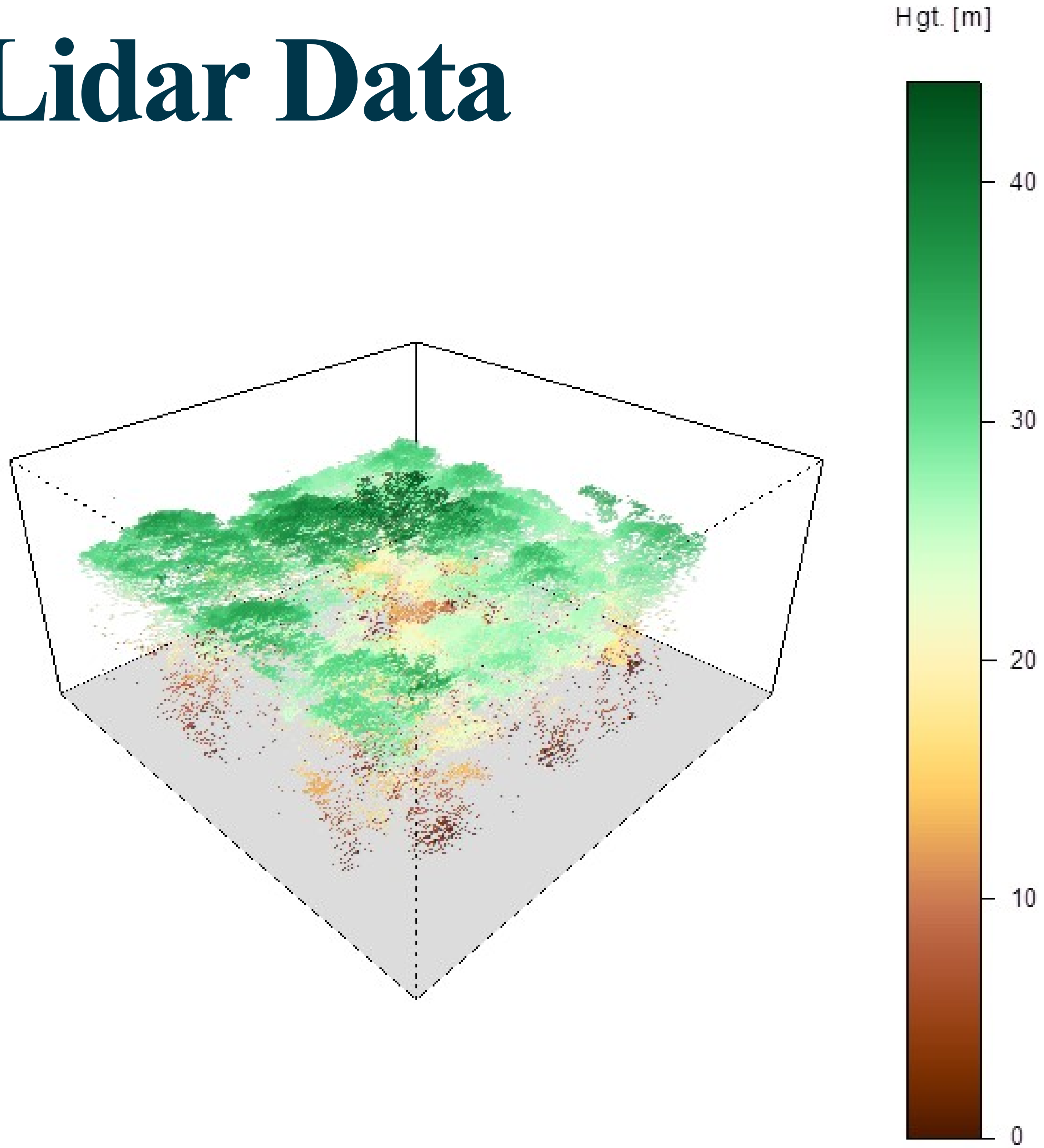
Overview of Approach

1. Use LIDAR and the orthorectified image to pick control points to compare to the historical images (e.g., fence line intersections, road intersections, buildings, railroad bridges, etc.)
2. Use control points to relate the historical images to the 2015 LIDAR data – results in orthorectified historical images
3. Review original aerial images under a stereoscope (pairs at a time allow a 3D view)
4. Record estimated locations of erosion impacts (gully heads, stream valley edge, trace a flow path, drainage area)
5. These features are mapped to the 2015 orthophoto and LIDAR data for comparison
6. Compute differences in feature locations from historical aerial images to 2015 data

Lidar Data

<u>Lidar Data</u>

- Information on both the vegetation structure and ground is obtained

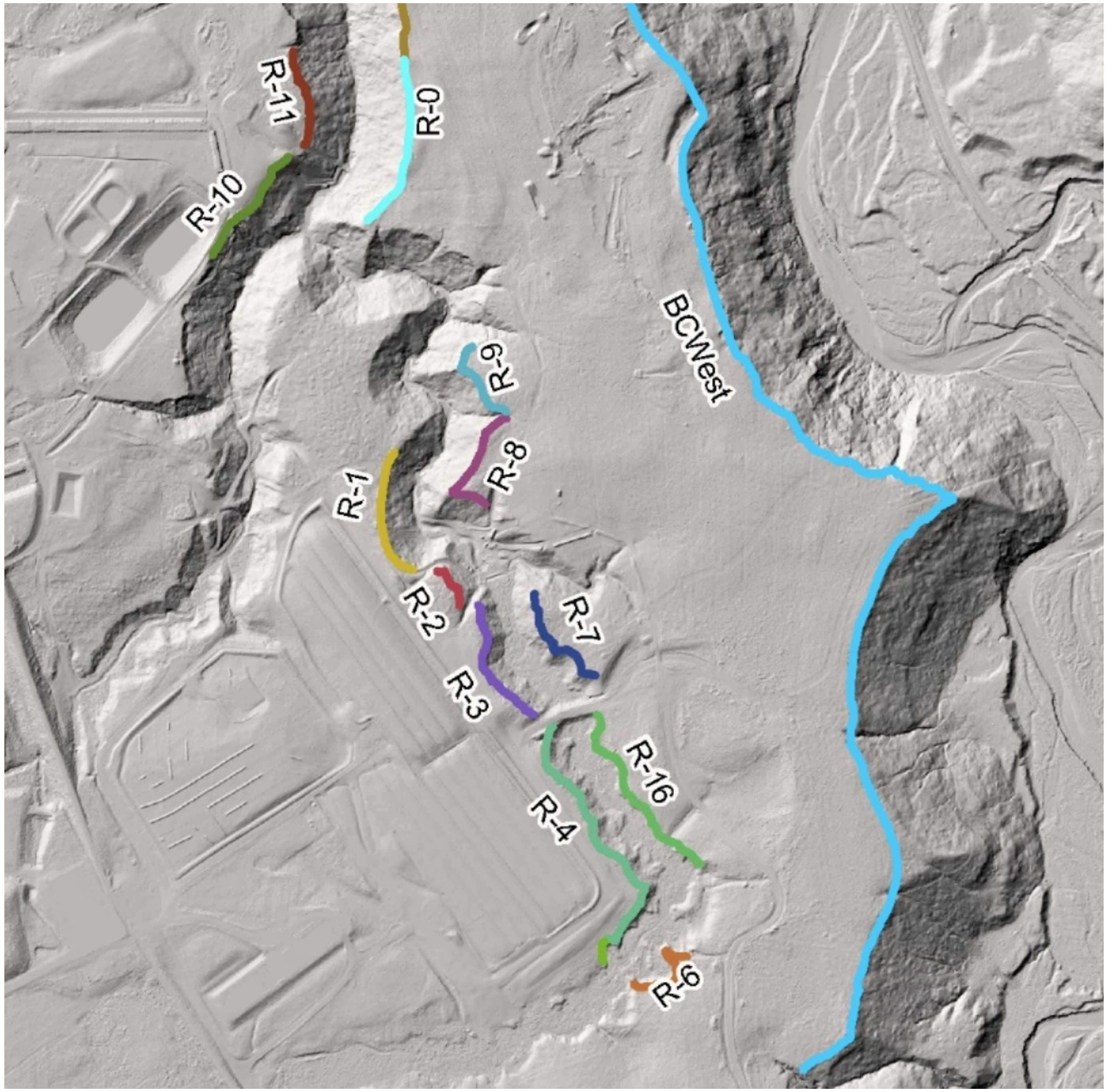


LIDAR Analysis

- The 2015 lidar data are used as a baseline for all comparisons of historical imagery
- Current state of hillslopes is characterized
- Reaches are established; gully head locations are identified

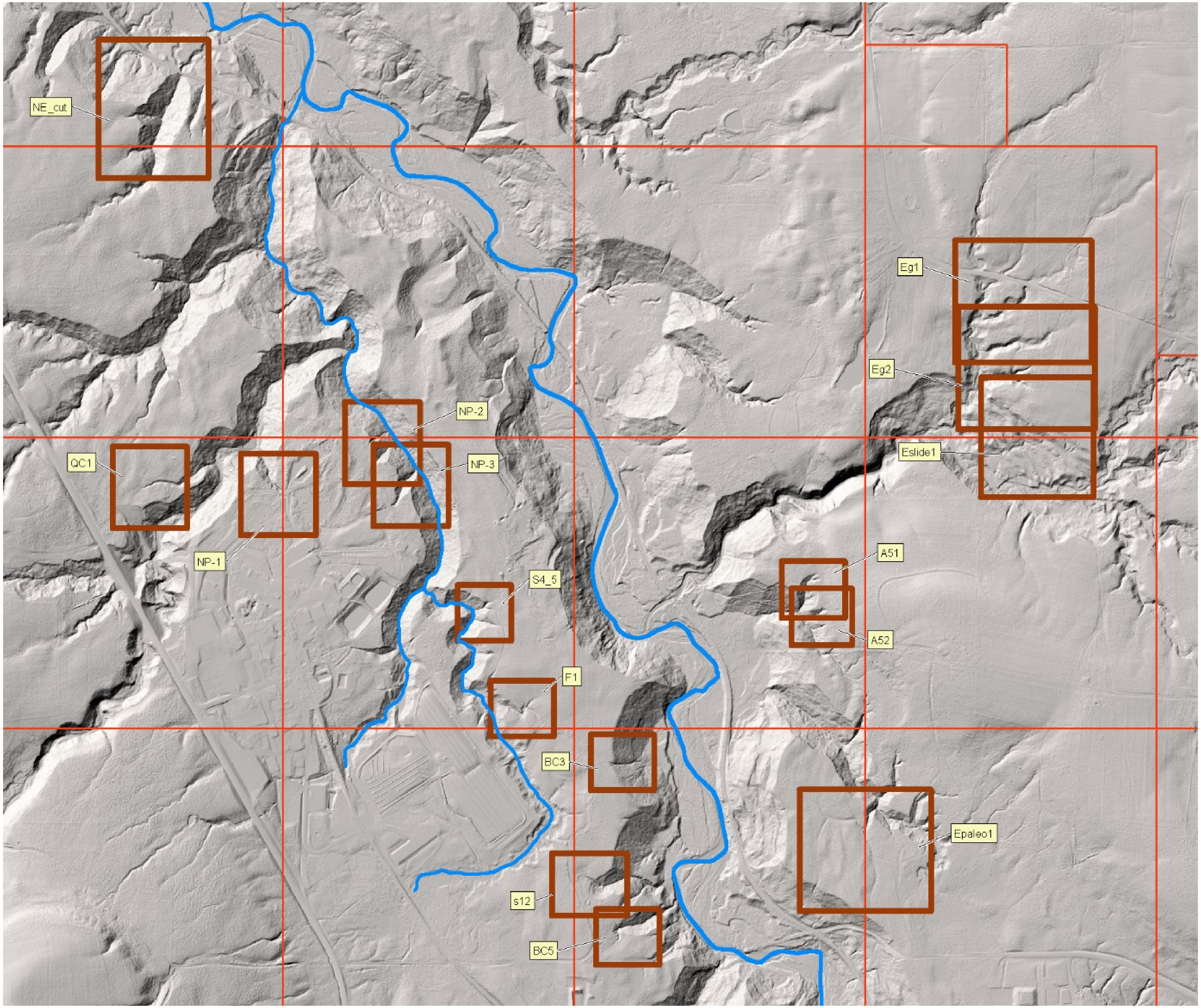
Lidar Data on Features in 2015

- Plateau boundary is characterized for 2015
- Different reaches have been named
- Do data support different rates for different reaches?

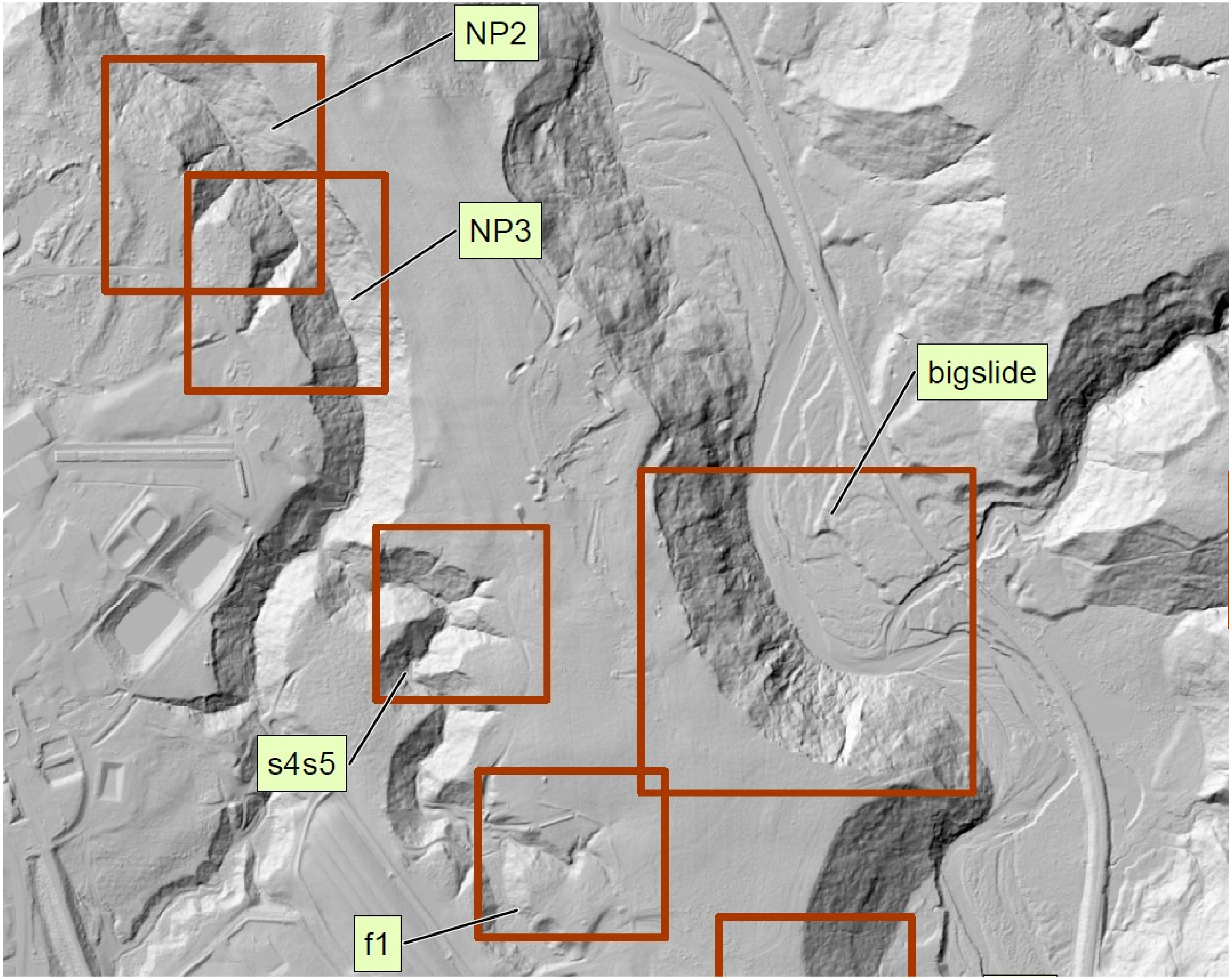


Example LIDAR Analysis

- 2015 lidar data are used for comparison with 2010 lidar data (Only looks at changes after 2010)
- High spatial resolution but short time period
- Multiple sites have been selected as areas of focus



NE_cut
Eg1
Eg2
NP-2
QC1
NP-3
Eslide1
NP-1
A51
S4_5
A52
F1
BC3
Epaleo1
s12
BC5



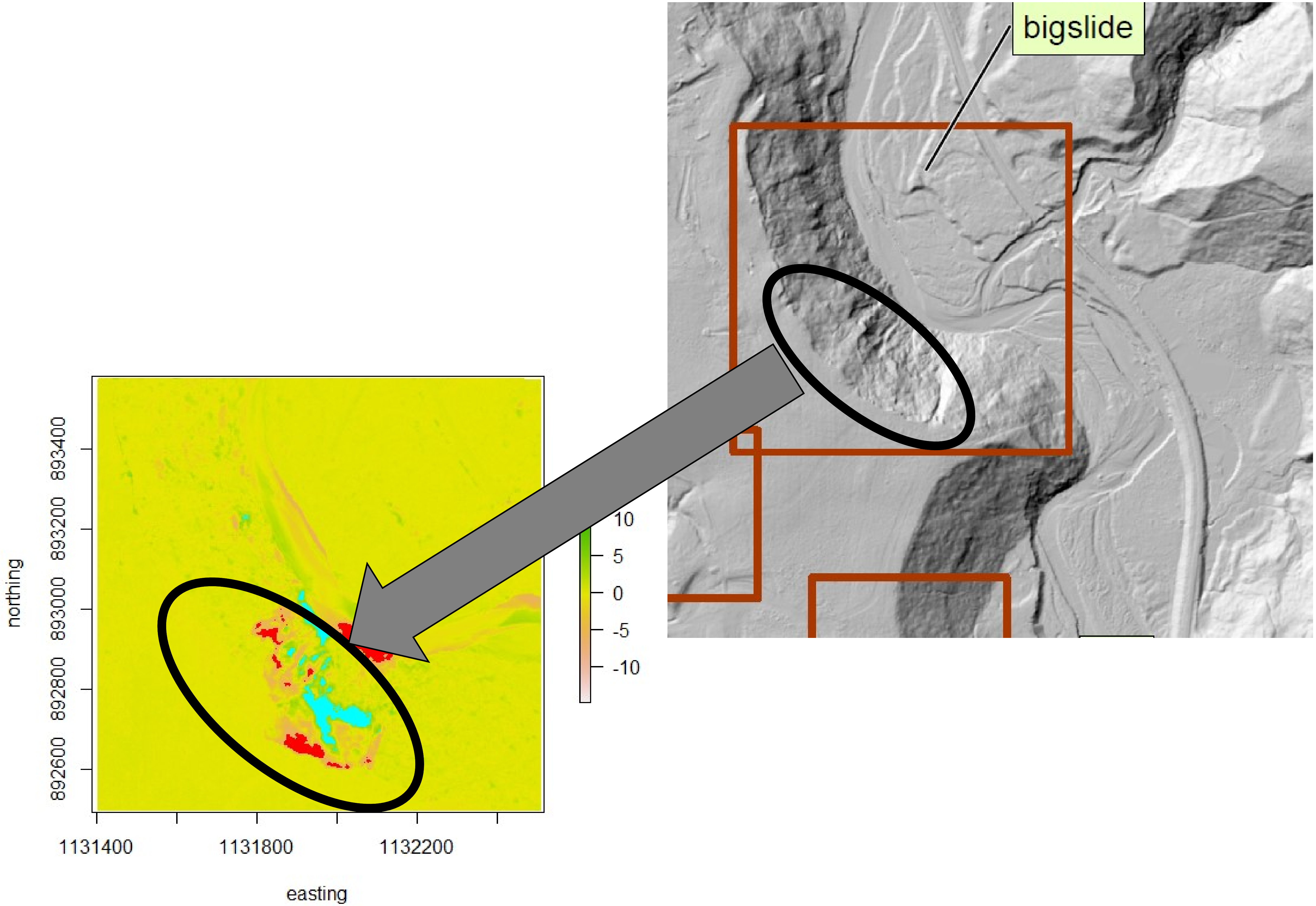
NP2
NP3
bigslide
s4s5
f1

Example LIDAR Analysis

- We can examine changes in the “Bigslide” area that have occurred between 2010 and 2015

- Difference in the height maps show changes in the plateau boundary

- This type of analysis is done at many areas


bigslide
northing
893400
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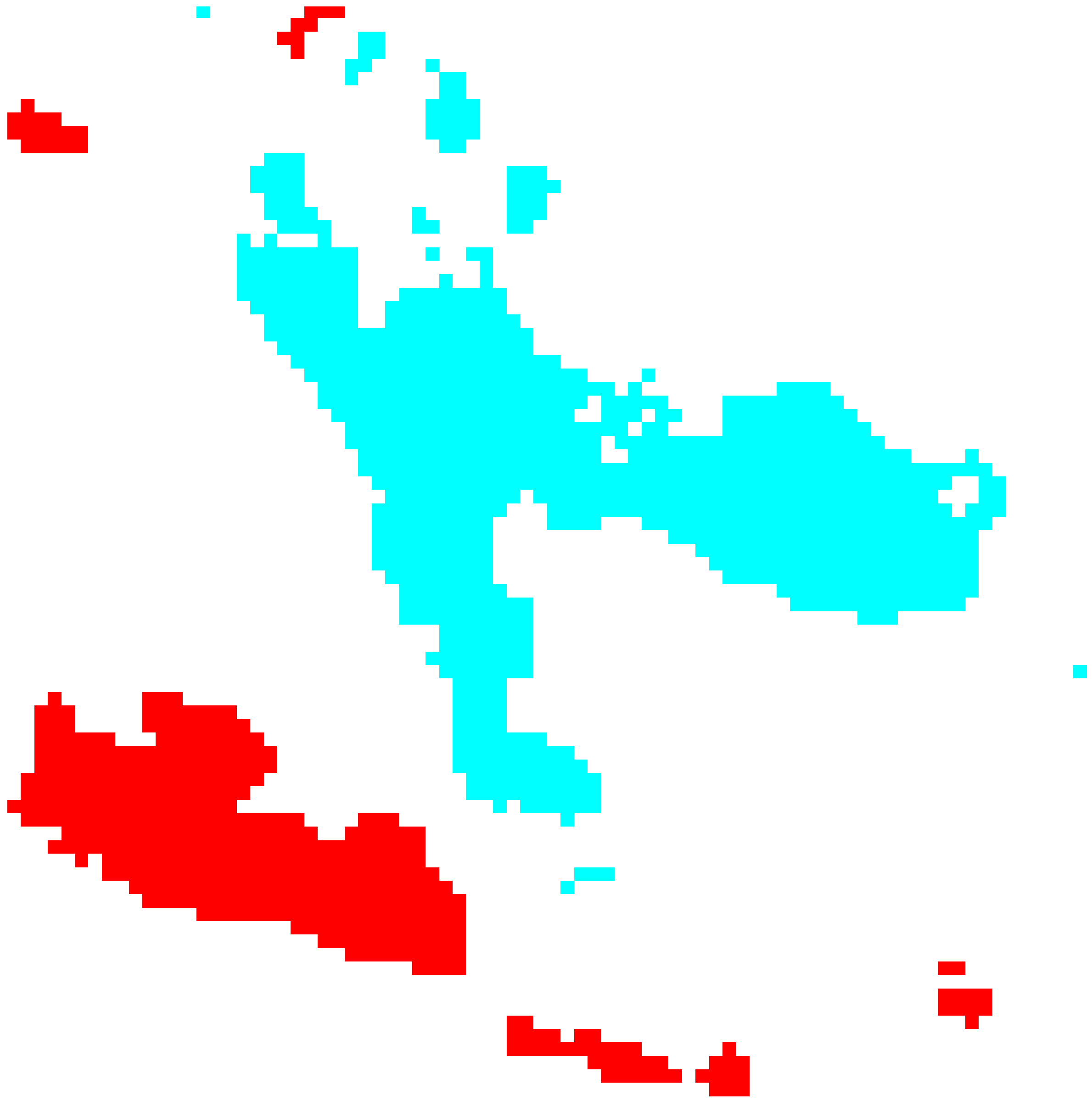
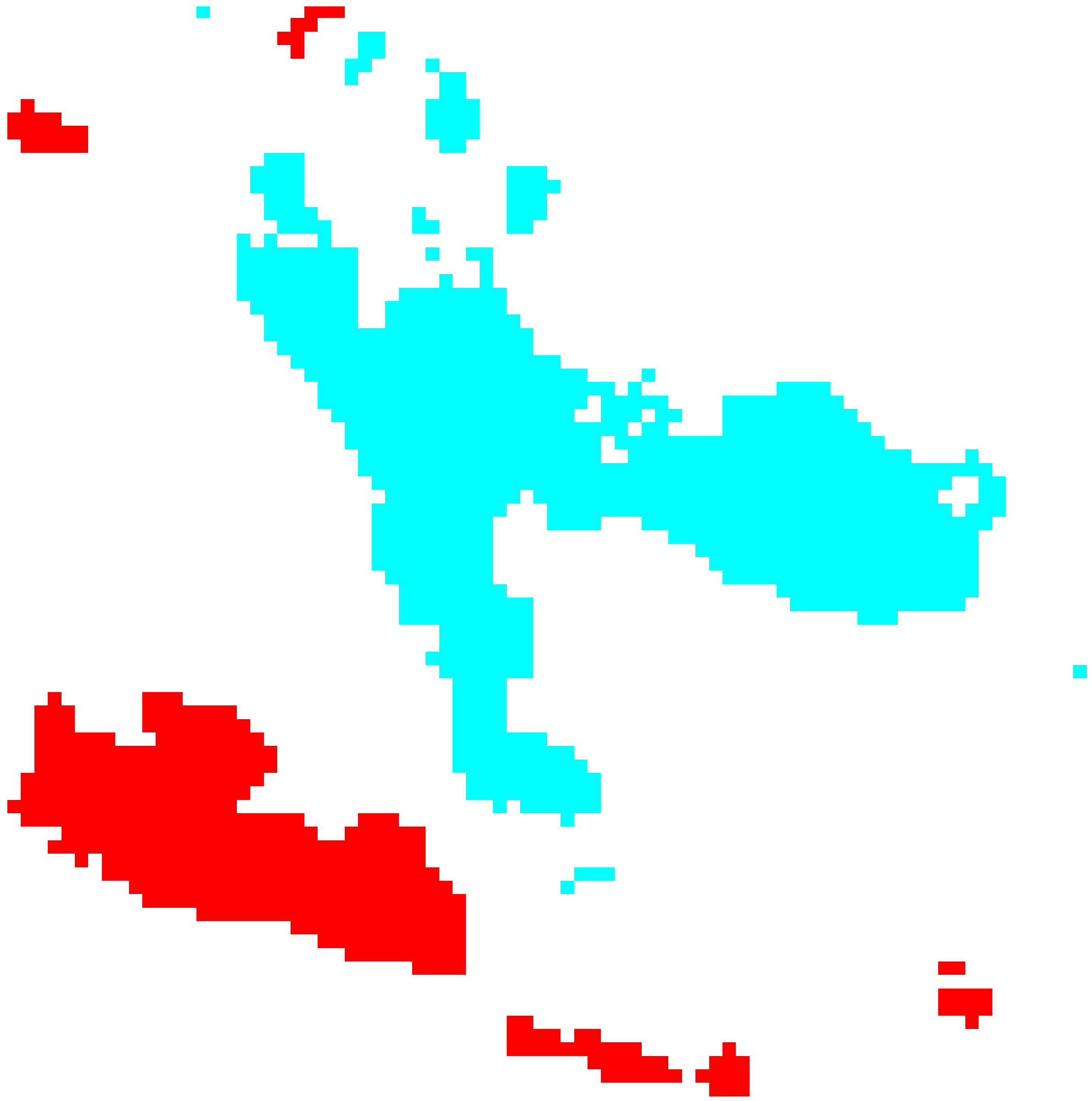
LIDAR Analysis

- Distributional analysis of the height differences (2015-2010)
- Areas of erosion are shown in red
- Areas of deposition are shown in blue



LIDAR Analysis cont.

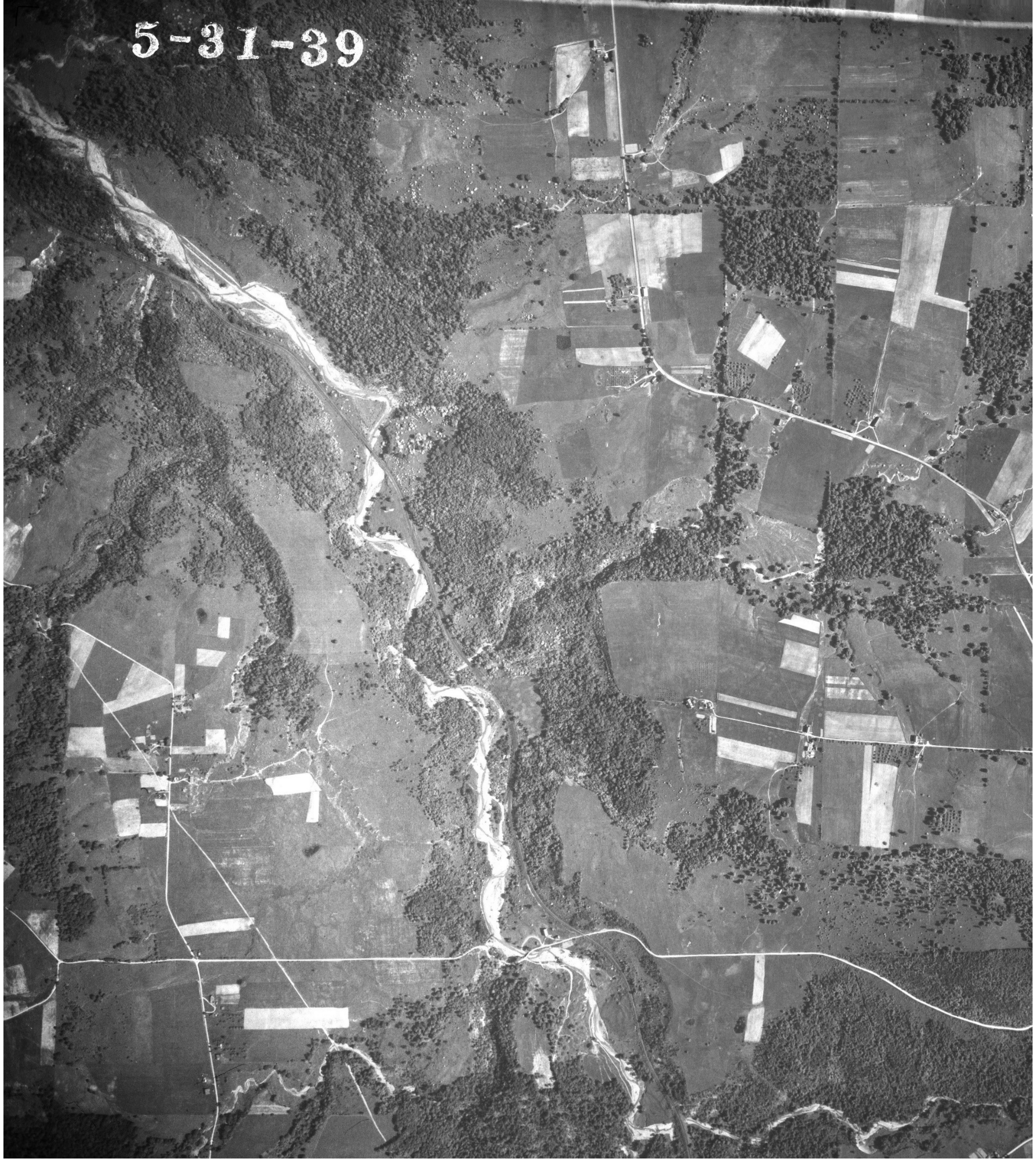
- Recent slope movement after the 2009 slide event
- Gradations in landslide and deposition are clearly visible demonstrating viability of the approach



Using Historical Imagery to Inform Erosion Model

Objectives

- Inform components of the erosion process (i.e. gully erosion and hillslope failure) within a PPA model of the site using historical information
- Quantify uncertainty associated with measurements to characterize observable “signal to noise” ratio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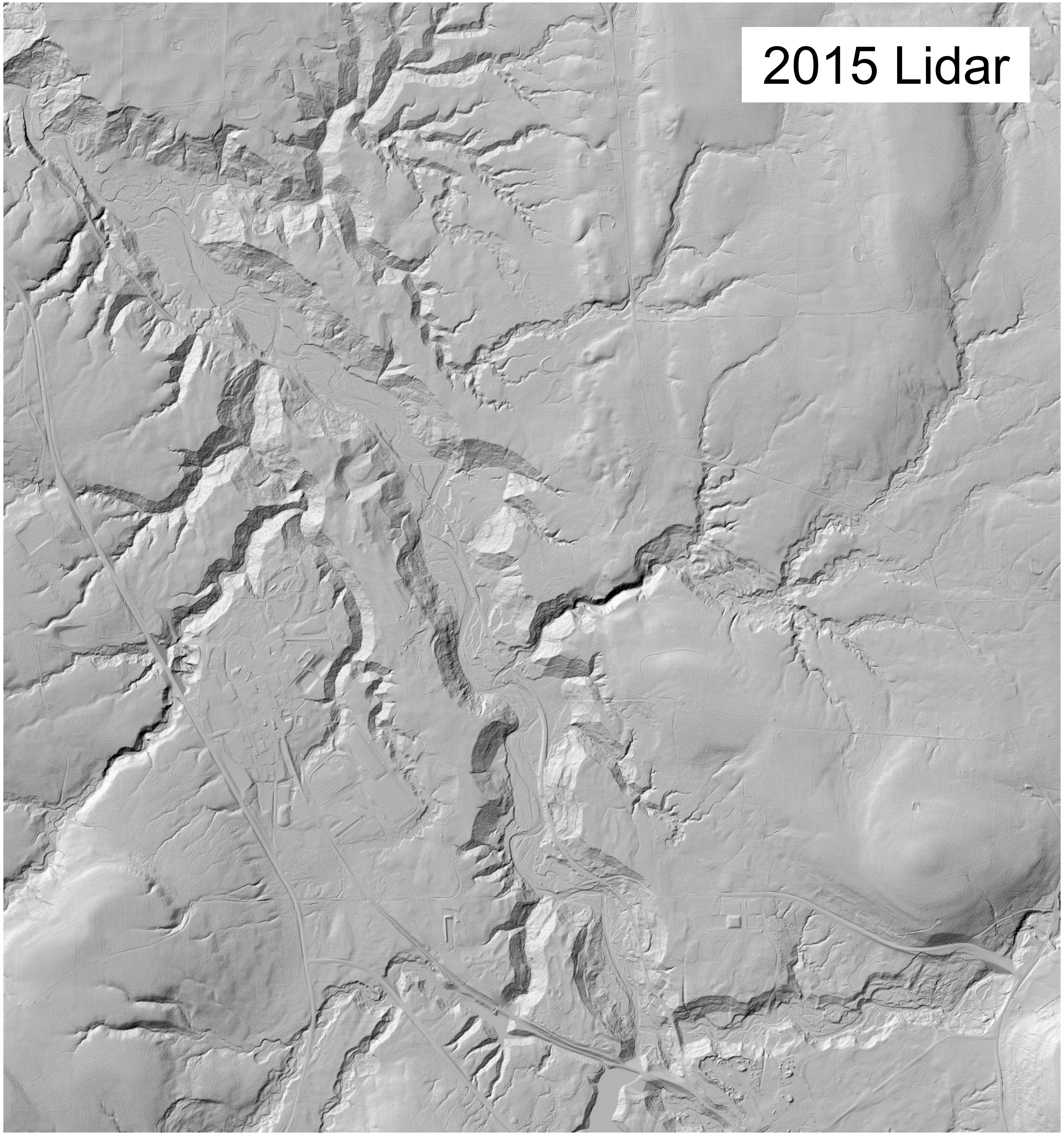
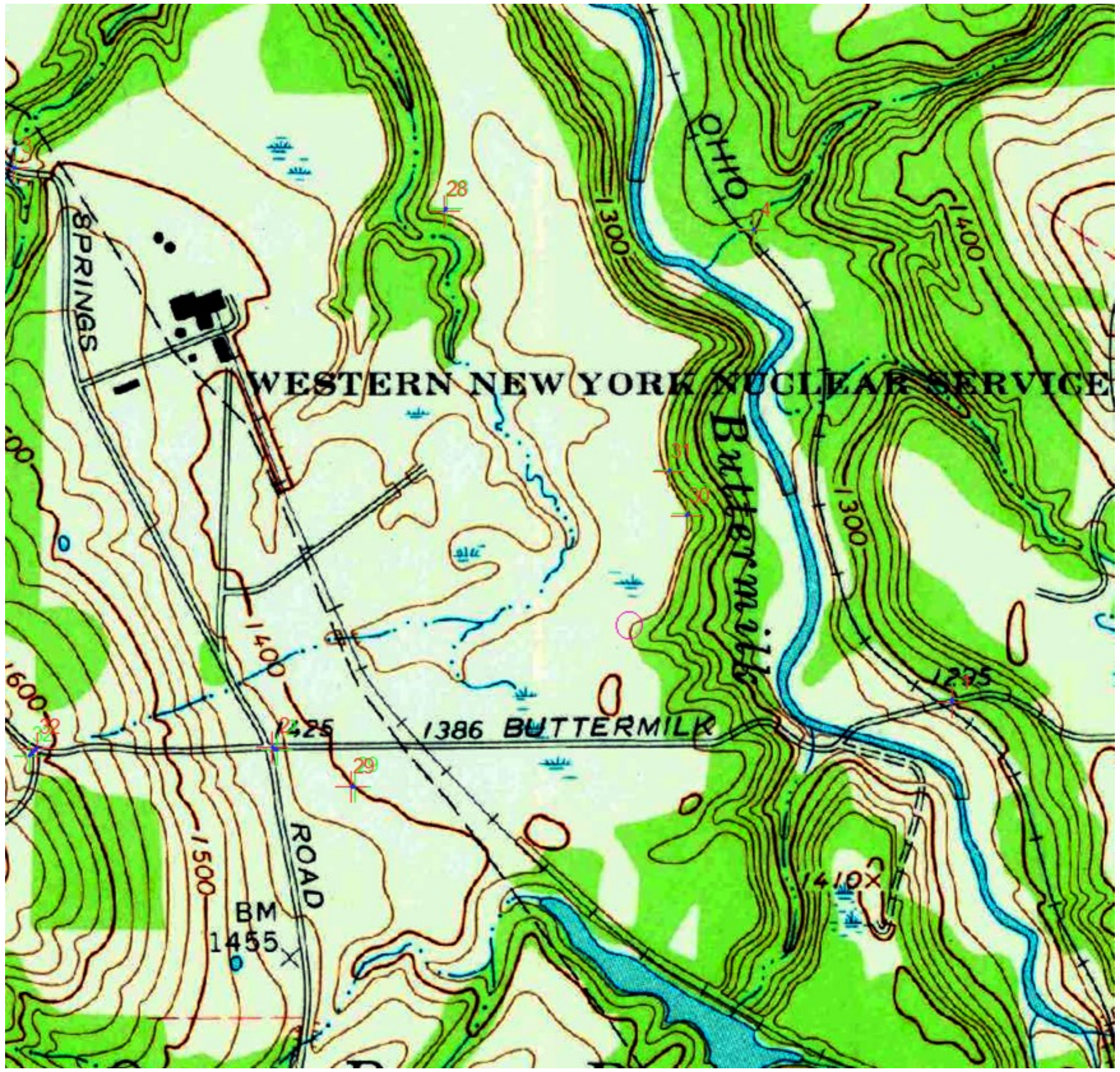

2015 Lidar

Historical Aerial Photo Analysis

- Points along features of interest are identified and recorded in a coordinate reference system
- Control point sources include Orthophotography, 2015 LiDAR, and historical 7.5’ topographic quad sheets



Observing Differences

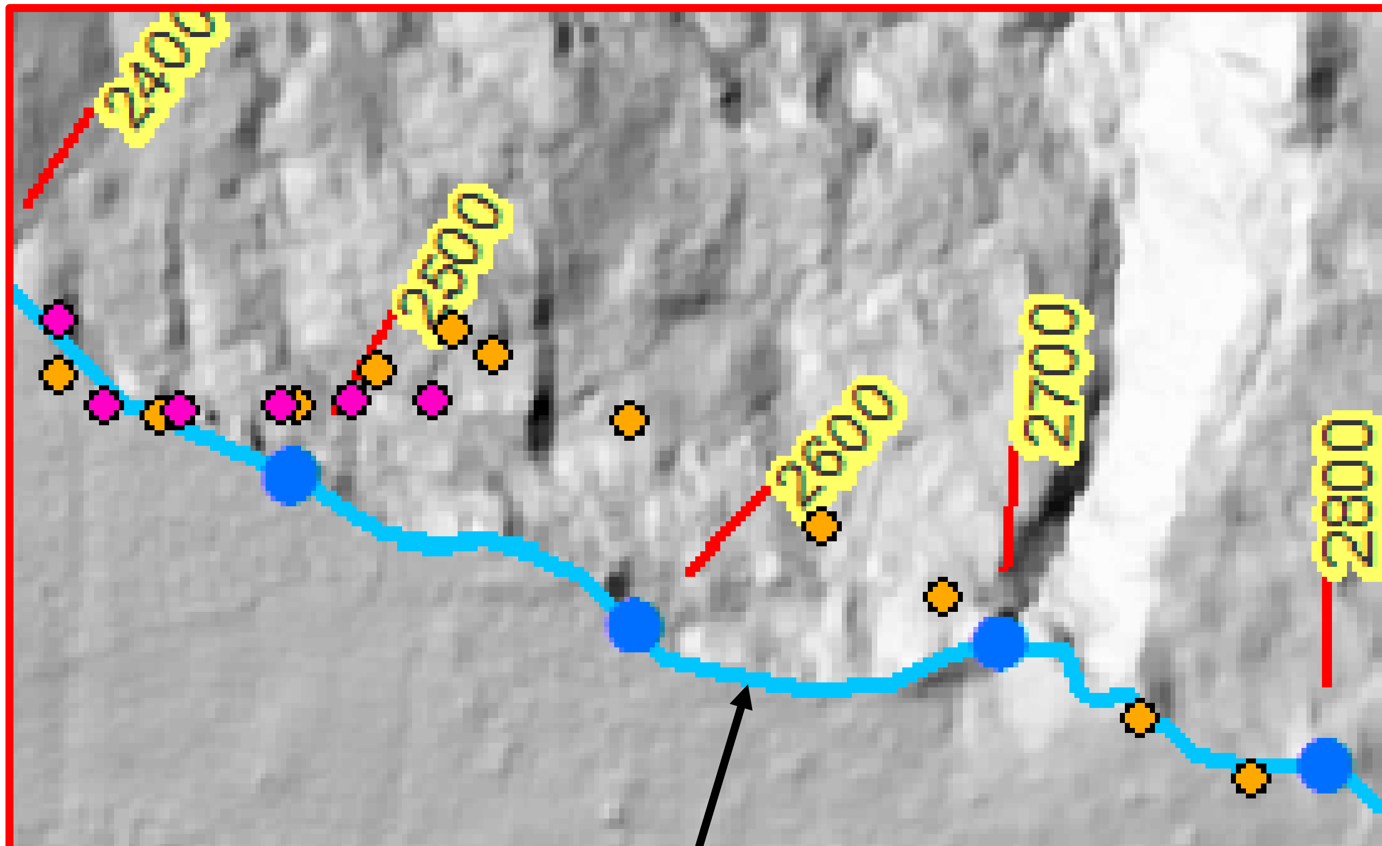
1. Control points and erosive features are identified on the historical imagery

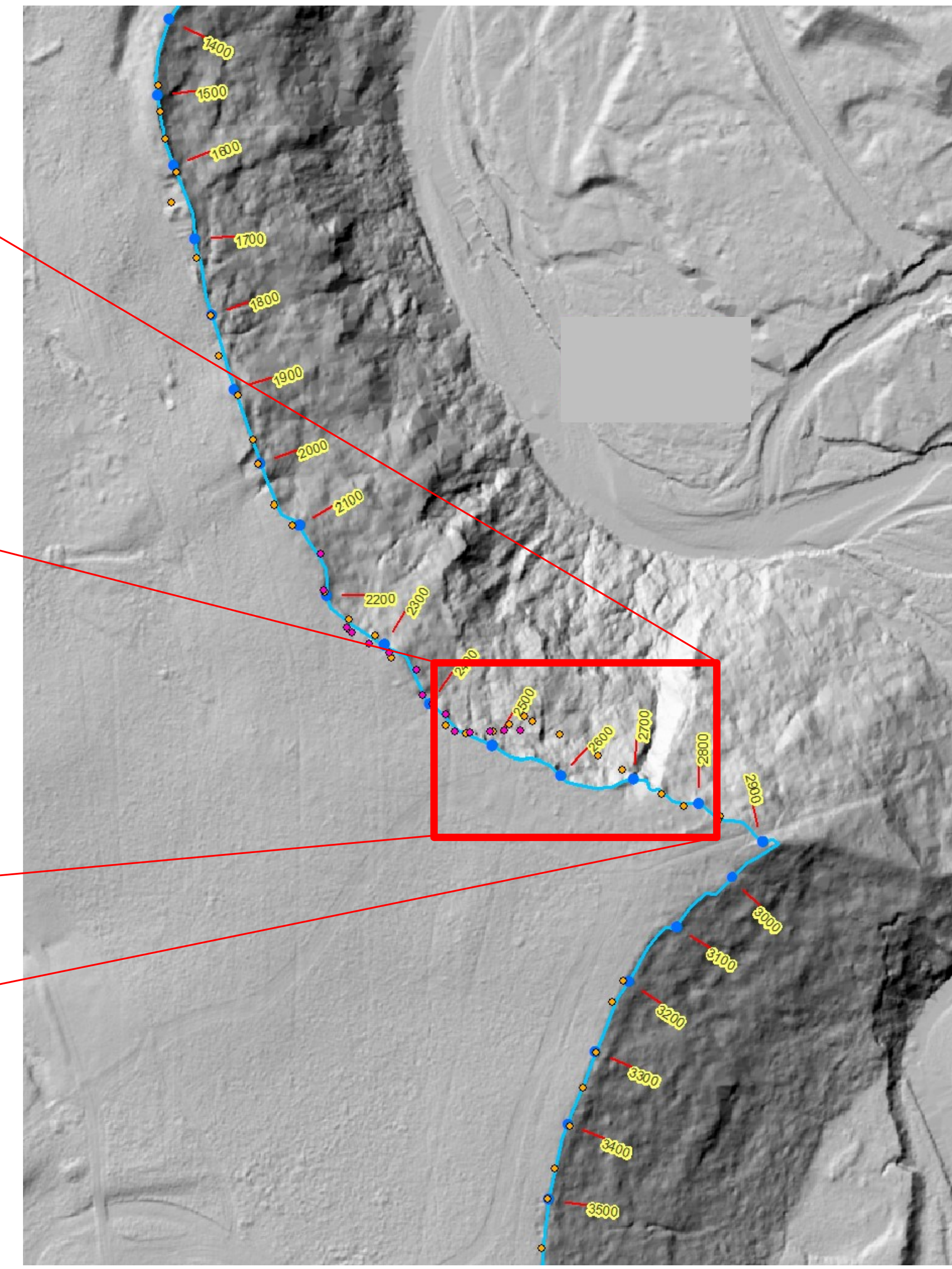
2. They are mapped back to the 2015 image and control points are used to estimate errors

3. Gully retreat and hillslope failure are quantified to inform the PPA

Buttermilk Creek West

- 1939 Boundary Estimate
- 1955 Boundary Estimate



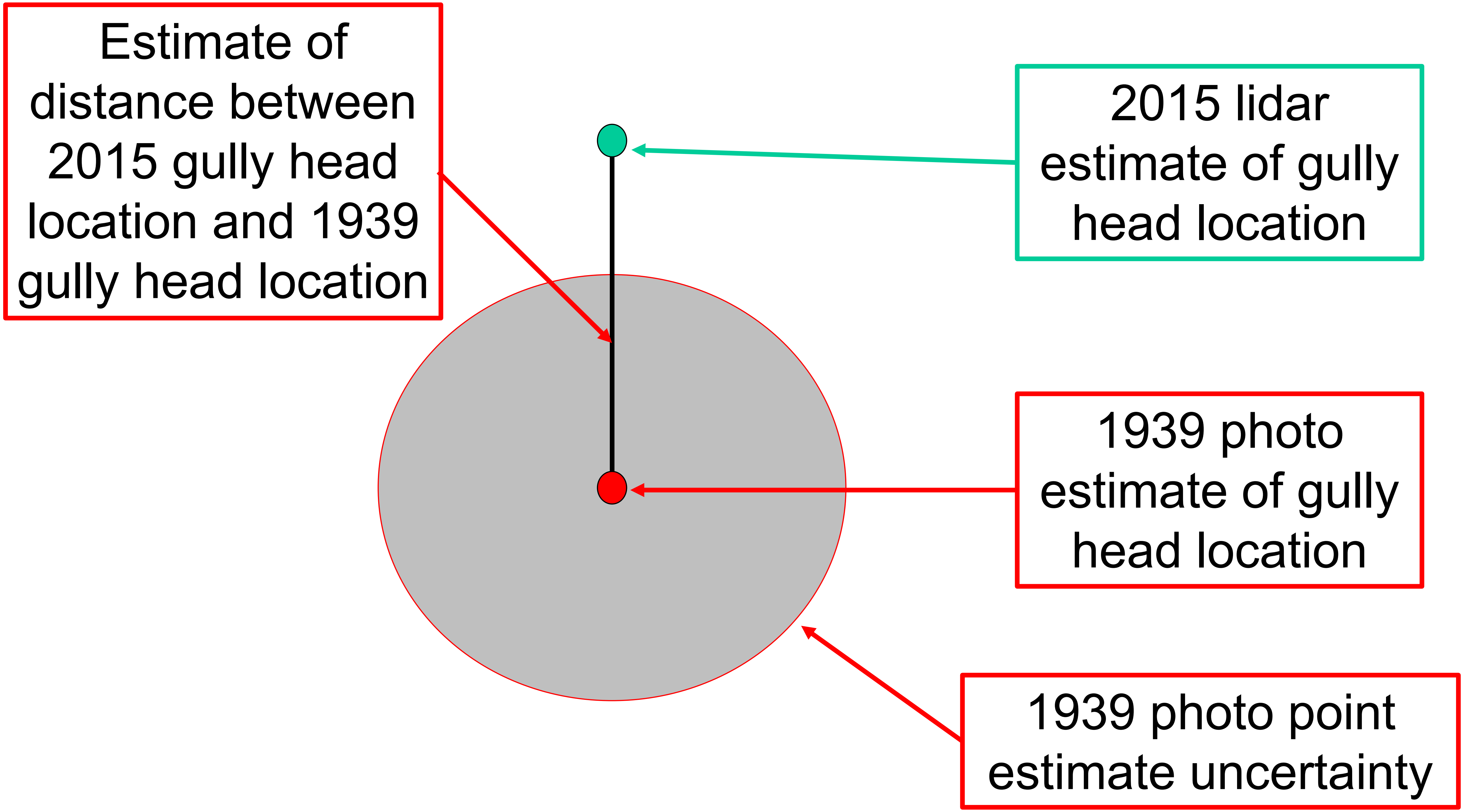


2015 Lidar Plateau Boundary

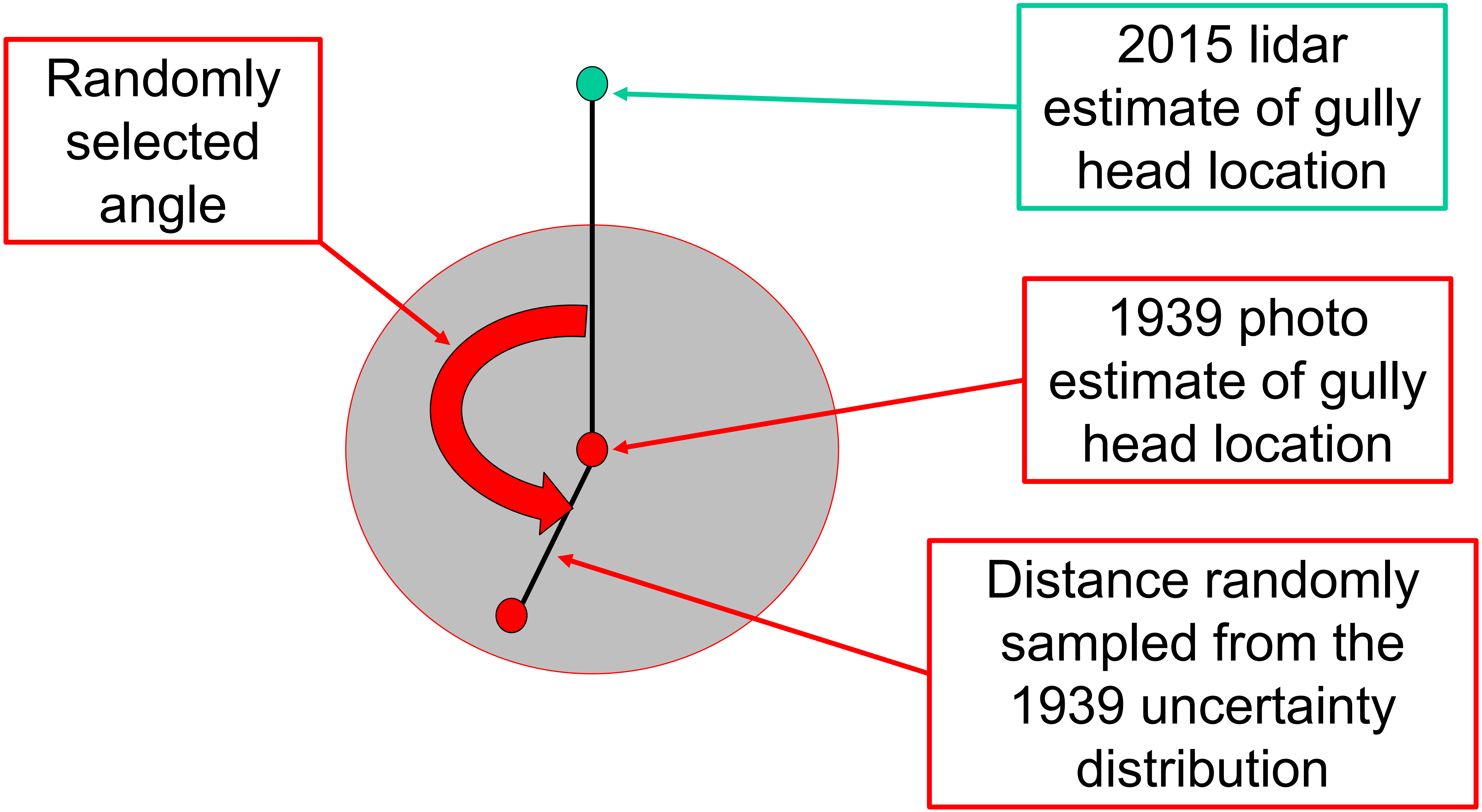
Uncertainty Propagation

- Estimates of gully heads from 2015 lidar are very accurate
- Estimates of gully heads from historical imagery have quantified uncertainty
- Uncertainty is estimated using multiple control points that exist in both the historical imagery and the 2015 lidar data

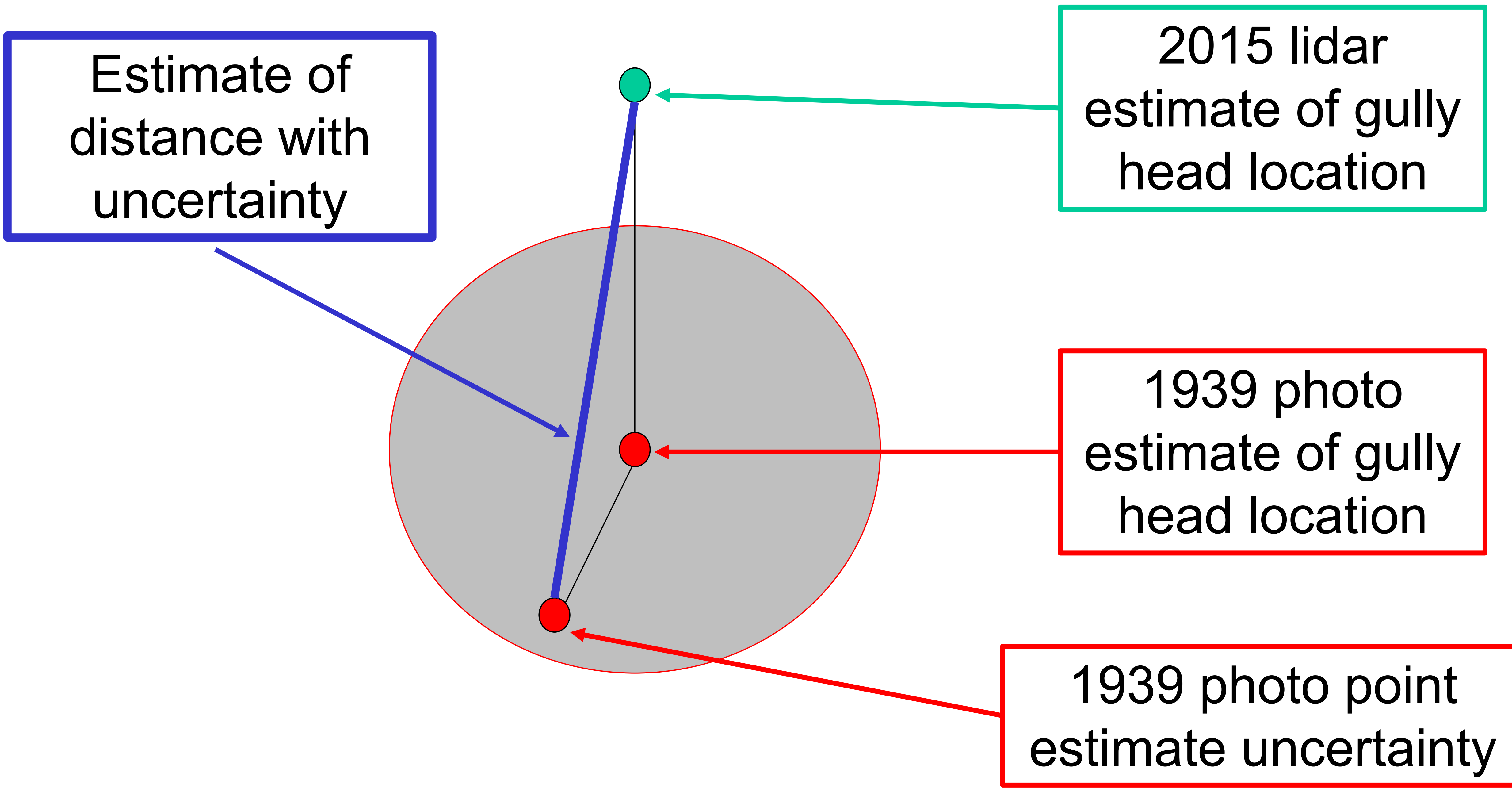
Uncertainty Propagation



Uncertainty Propagation



Uncertainty Propagation

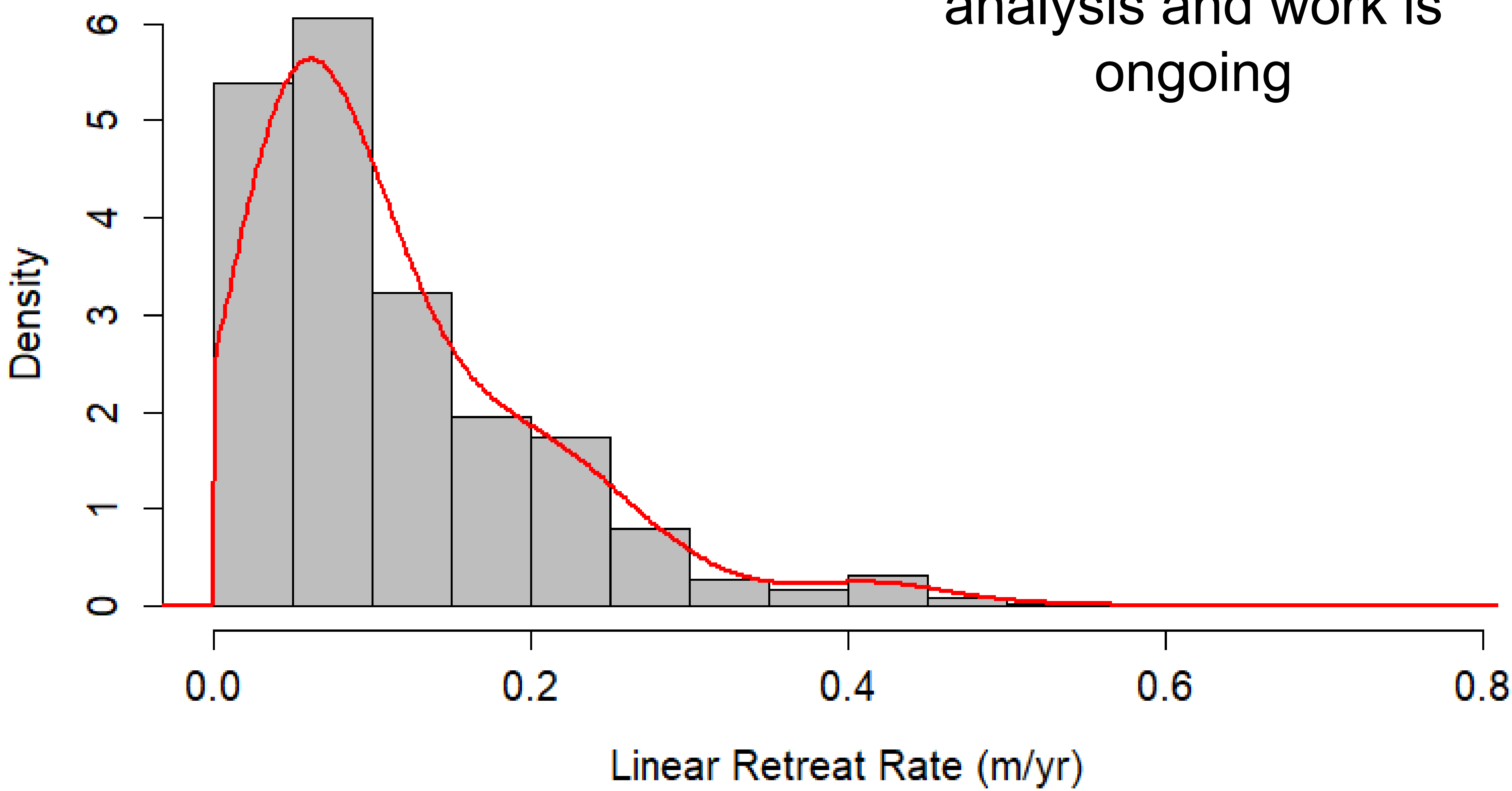


Preliminary Results

- A subset of gullies have been analyzed for linear retreat rates using the 1939 and 1955 images with 2015 Lidar as a baseline
- A different distribution of uncertainty is developed for each image that is compared to 2015
- This is done using the measurement error associated with the control points

Uncertainty Propagation

*Based on the current analysis and work is ongoing



Next Steps

- Complete the analysis of available historical imagery (just 1939 and 1955 images so far)
- Gully retreat and hillslope failure features
- Complete corresponding analysis of control points to refine uncertainty distribution
- Develop context for other lines of evidence including erosion modeling, work of the EWG, expert elicitation, and literature reviews to provide a comprehensive evaluation of retreat rates for gullies and hillslopes