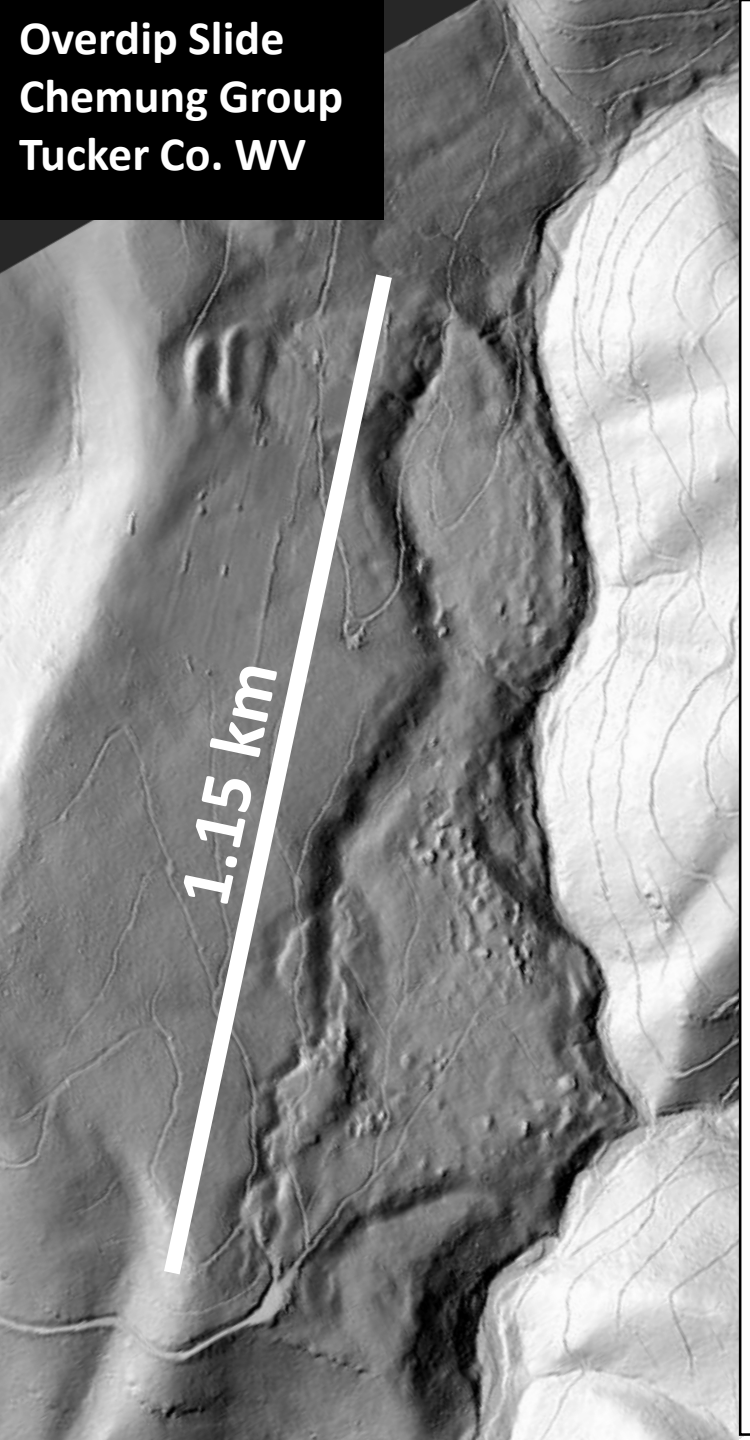


West Virginia GIS Technical Center

West Virginia University
DEPARTMENT OF GEOLOGY AND GEOGRAPHY

Landslide Risk Assessment in the Mountain State of West Virginia: Broad-Scale Geologic and Physiographic Influences on Landslide Susceptibility and Slope Failure Types

J. Steven Kite*, Shannon M. Maynard, Aaron E. Maxwell, Maneesh Sharma,

Kurt Donaldson, Matthew L. Bell**, Rachel E. Yesenchak, & Elizabeth Hanwell

West Virginia GIS Technical Center (WV GIS TC)

West Virginia University Department of Geology & Geography

Not a Geological Survey

Session 207 T42: Landslide Hazards: Inventories, Hazard Maps, Risk Analysis, and Warning Systems

Paper 9: https://gsa.confex.com/gsa/2021AM/meetingapp.cgi/Paper/370833

10:30-10:45 - AM, Wednesday, 13 October 2021

Oregon Convention Center - Portland Ballroom 254

2018-2022 Effort Funded by FEMA Hazard Mitigation Grant Program & WV Division of Homeland Security and Emergency Preparedness

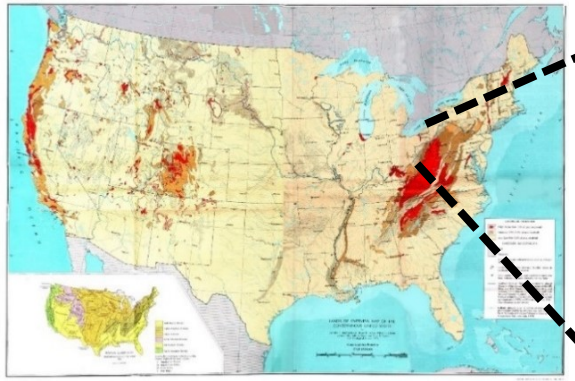
*** Presenter Contact: jkite@wvu.edu**

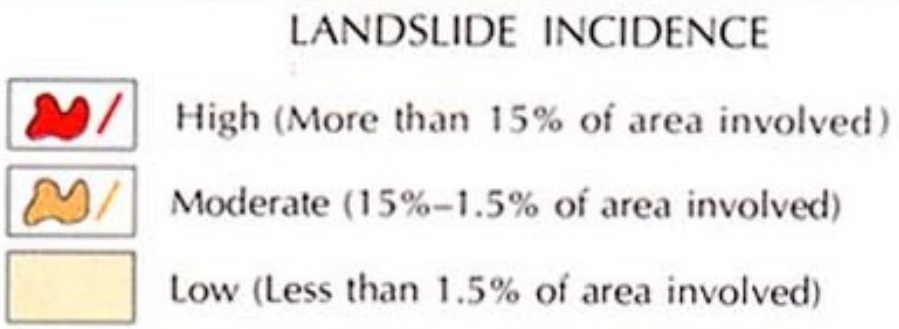
**** Matt Bell is now affiliated with Meiser & Earl Hydrogeologists**

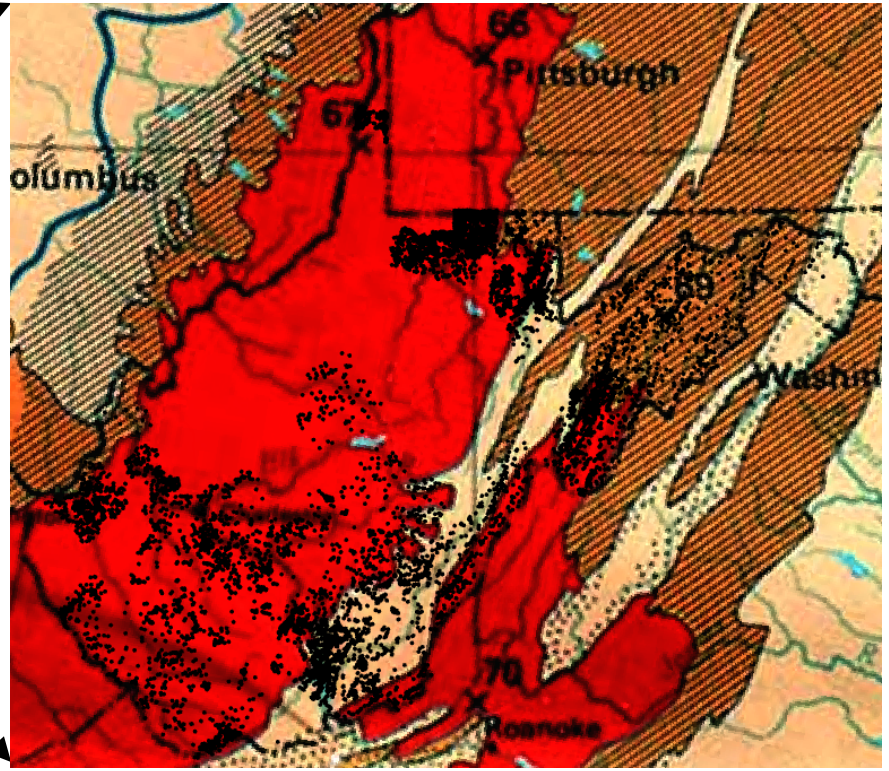
Why Assess West Virginia Landslide Risk?

- **Landslides = #2 West Virginia Hazard** (FEMA).
- **West Virginia = #1 in *Per Capita* Landslide $** in 48 states (USGS OF 84-486).
- **~70% of West Virginia = "High Landslide Incidence"** (USGS PP 1183).
  - ***No Other State >25%***

Coterminous U.S. Landslide Overview Map USGS PP 1183







Existing Physiographic Maps Not Adequate for WV Landslide Project

MLRA Boundaries Better

Provinces & Subdivisions

Appalachian Plateaus

- Kanawha Section
- Logan Plateau #
- Allegheny Mountains
  - Southern vs Northern

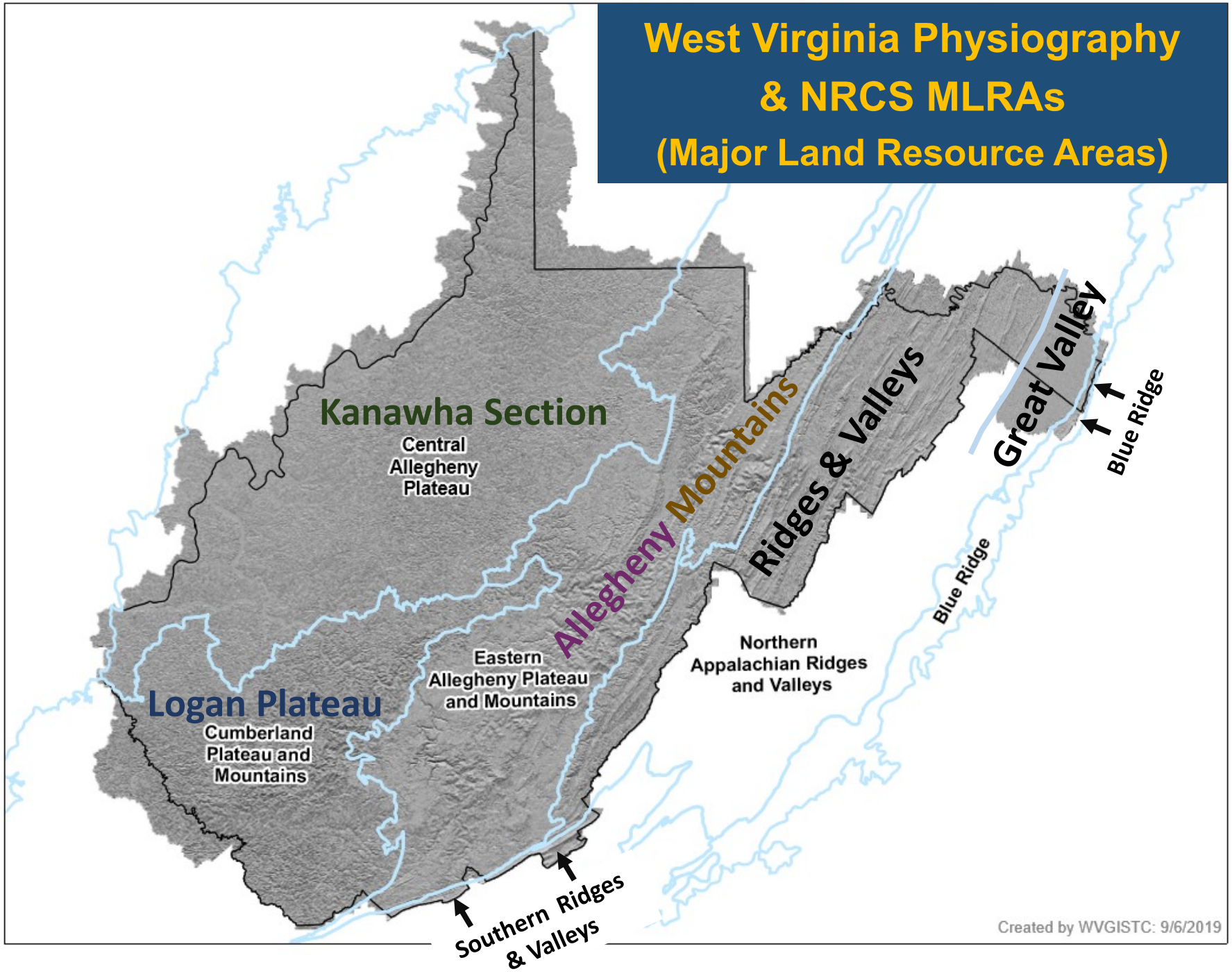
Valley & Ridge

- Ridge & Valley
  - Southern *vs.*
  - Northern
- Great Valley

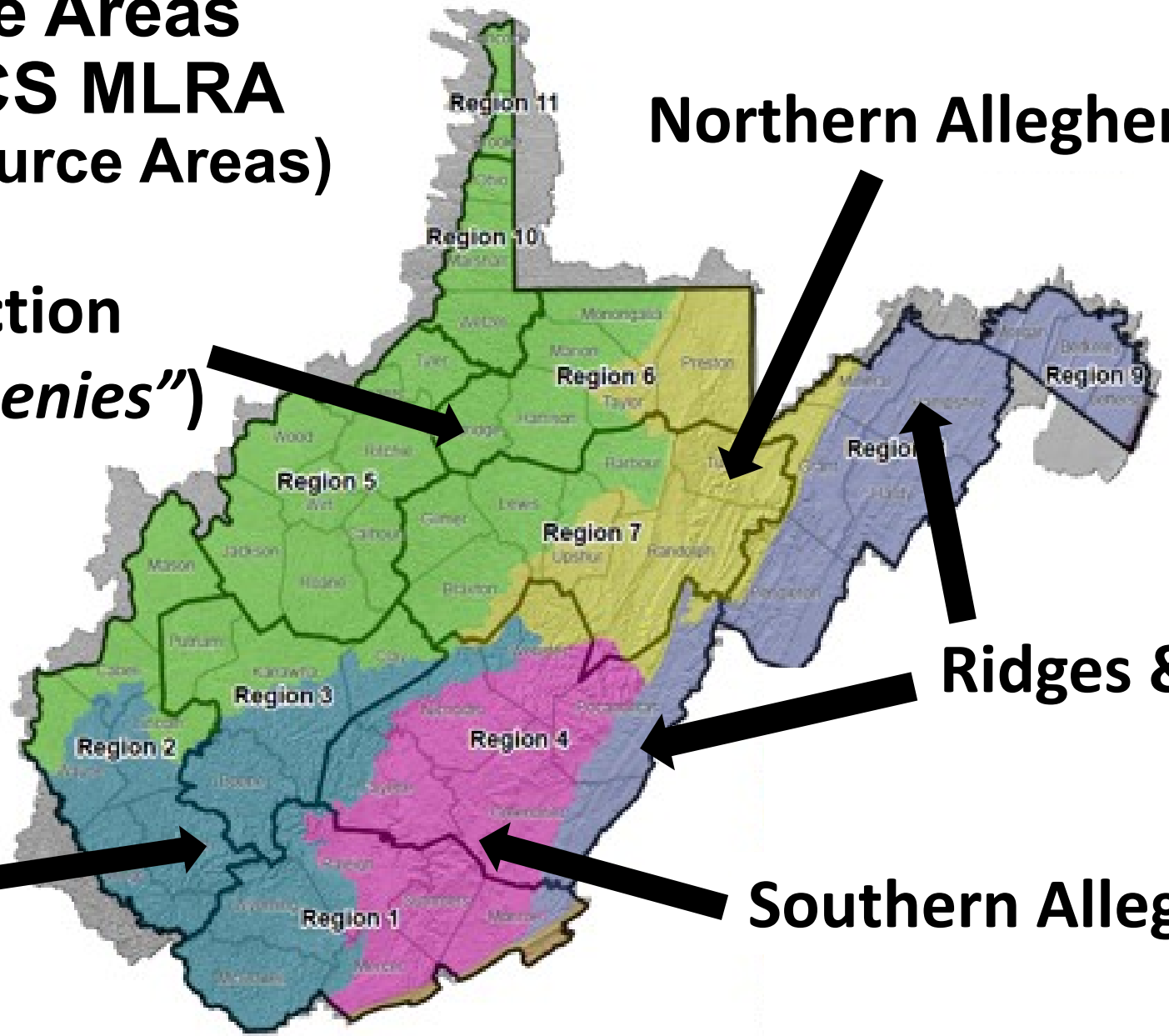
Blue Ridge

Combined into **Ridges & Valleys** for this talk

See Outerbridge, W.F., 1987 USGS Bulletin 1620
https://pubs.usgs.gov/bul/1620/report.pdf



WV Landslide Areas Based on NRCS MLRA (Major Land Resource Areas)



Northern Alleghenies

Kanawha Section (*Central "Alleghenies"*)

Ridges & Valleys

Logan (*Cumberland*) Plateau

Southern Alleghenies

West Virginia Landslide Mapping

- **QL2 & QL3-4 LiDAR** 1 m or 2m DEMs
  - **Good** Coverage in **Eastern & Southern WV**
  - **3 m DEMs = Useless** in Mapping
- **Used** Best Available **Hill-Shade**
- **>10 m Minimum Width**
- **Very Conservative in Landslide ID**

County Boundary

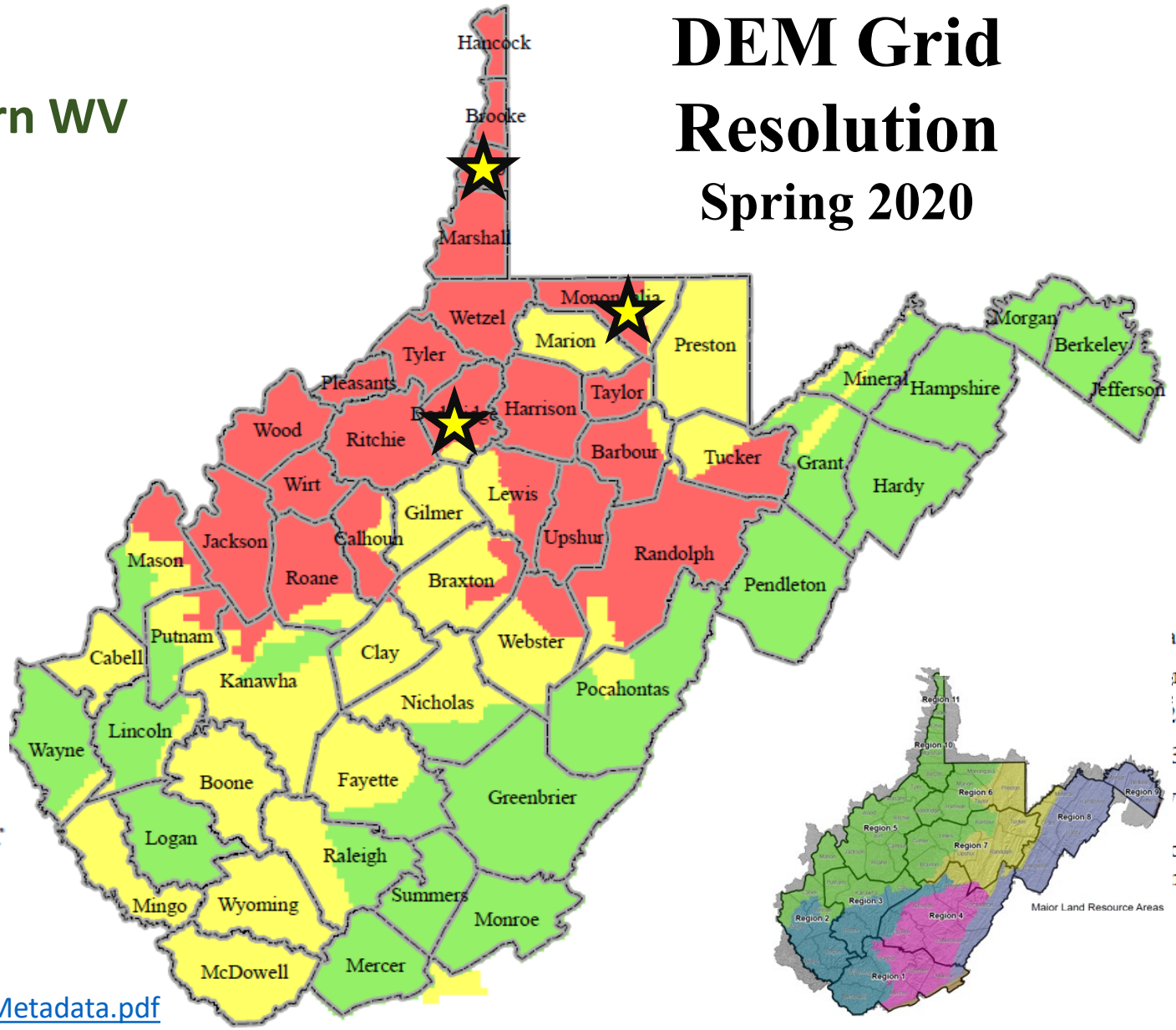
DEM Grid Resolution

1m FEMA QL2 LiDAR

2m Legacy QL3-4 LiDAR

3m SAMS Elevation (2003)

★ Non-public, 2-foot resolution DEMs exist for Doddridge, Monongalia, and Ohio Counties.



- **Best-Available WV Elevation Sources:**
  www.mapwv.gov/floodtest/docs/WV_FloodTool_ElevationSource_Metadata.pdf

West Virginia Landslide Mapping Progress

October 2021

WV Landslide Tool

http://wvu.maps.arcgis.com/apps/webappviewer/index.html?id=cb01c47cfa884309b4f38dcd7542f805/

>65,000

Landslide Initiation Points

Mapped by Shannon Maynard, Matthew Bell, & Rachel Yesenchak

Slope, Geology, & Soil

Attributes of

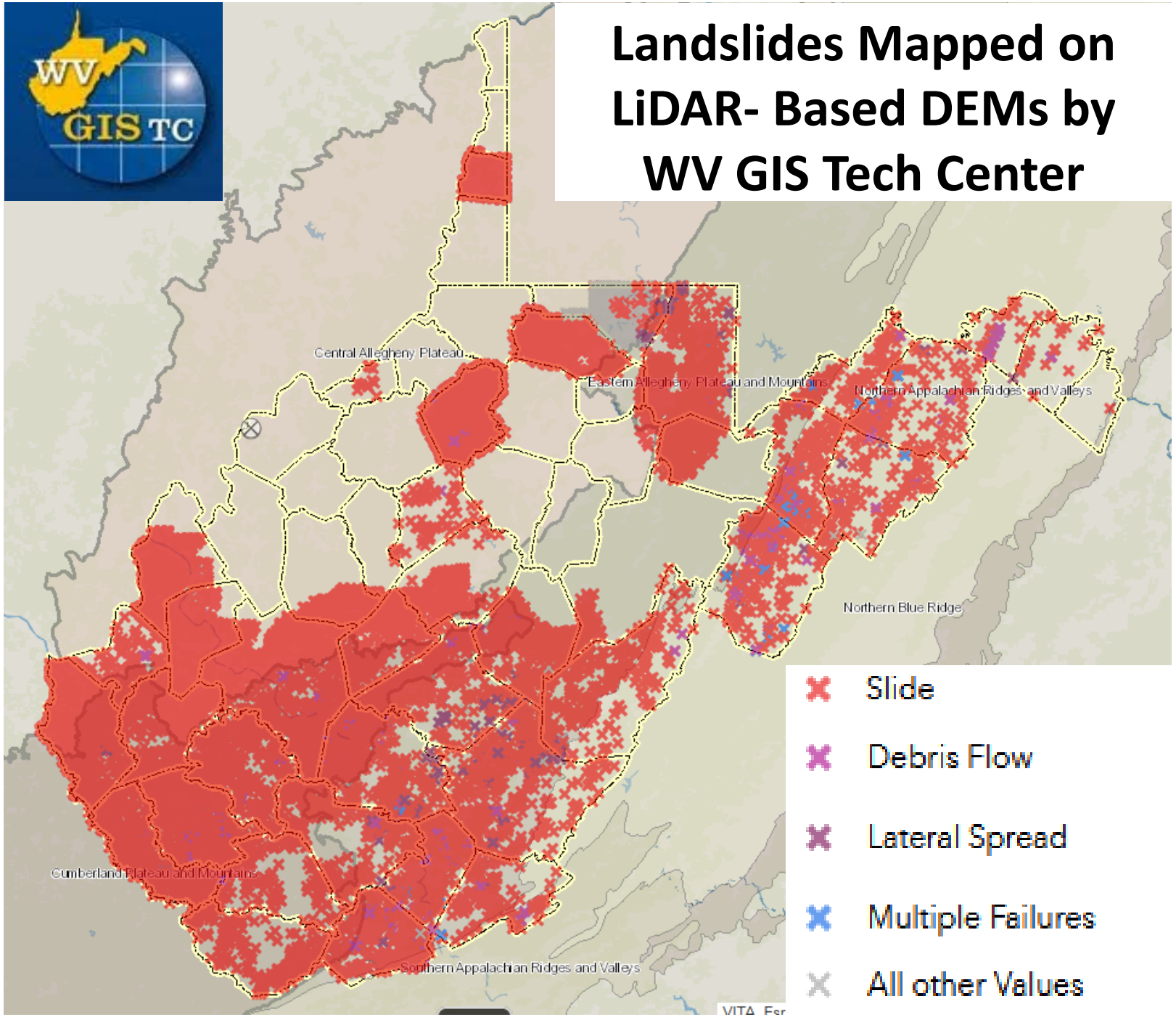
41,730 Landslides

compared to

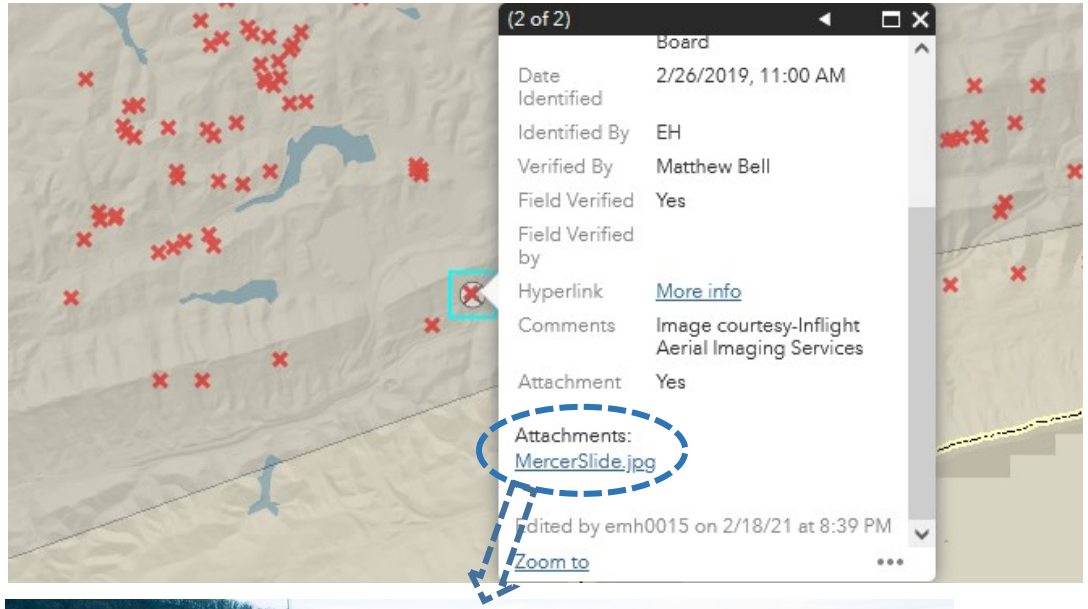
>463,000 Random Non-Landslide Points

in the same areas

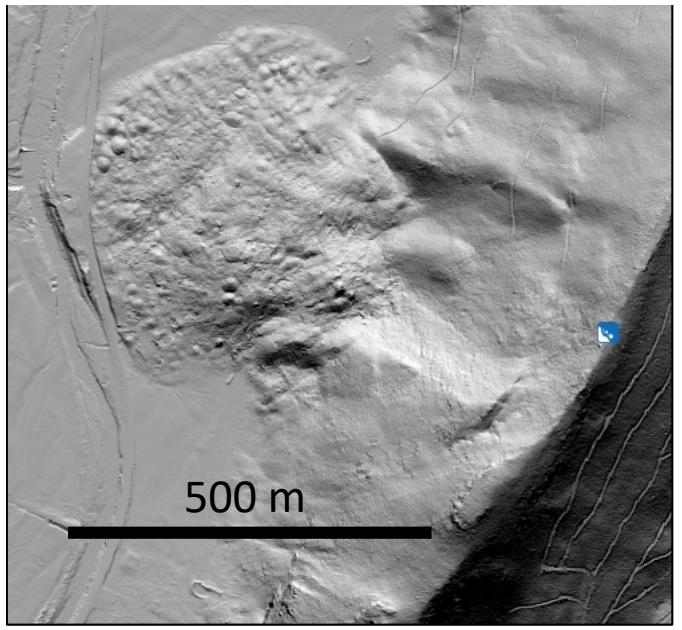
Landslides Mapped on LiDAR- Based DEMs by WV GIS Tech Center

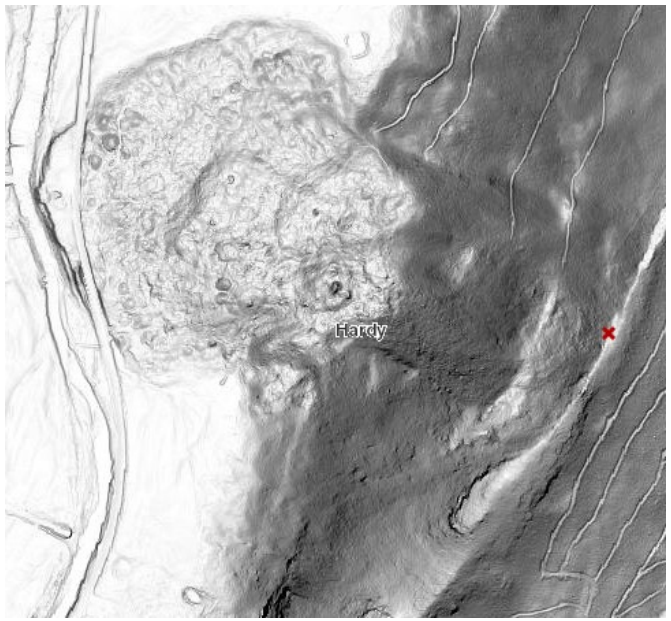


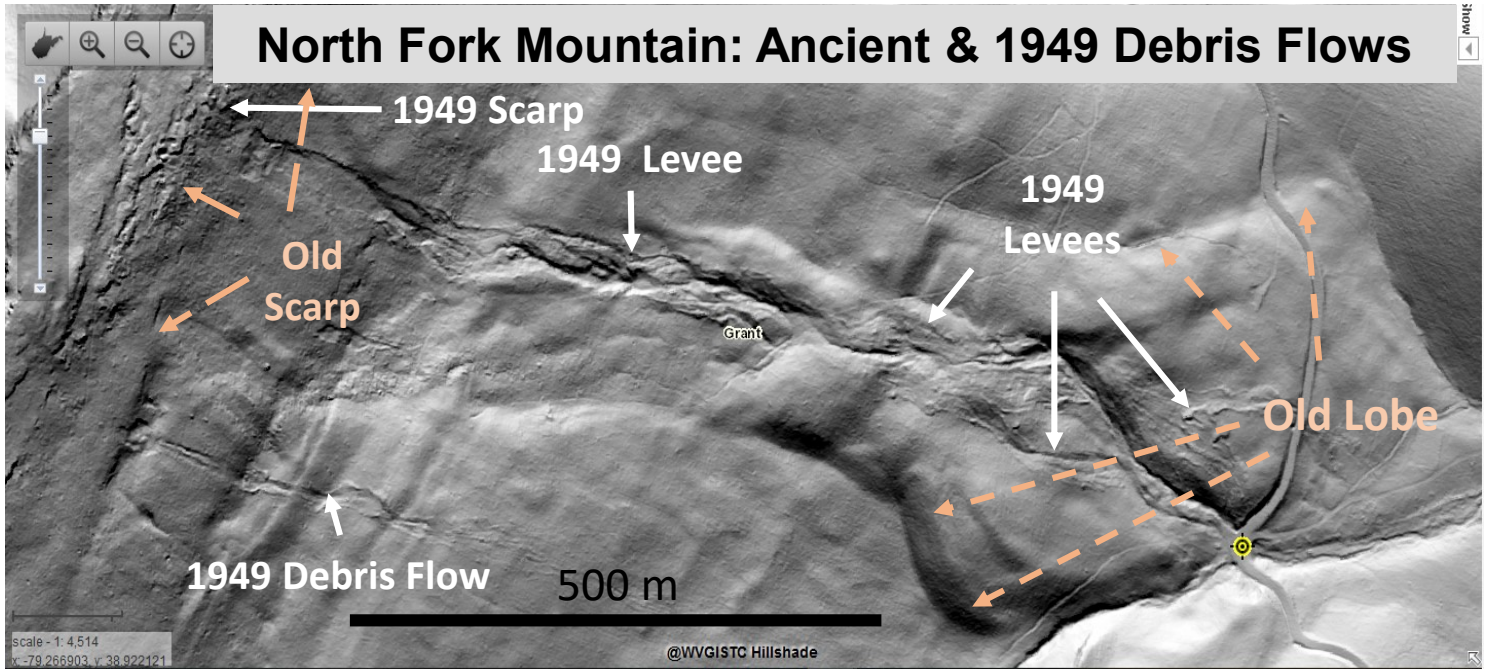
"WV Landslide Tool"



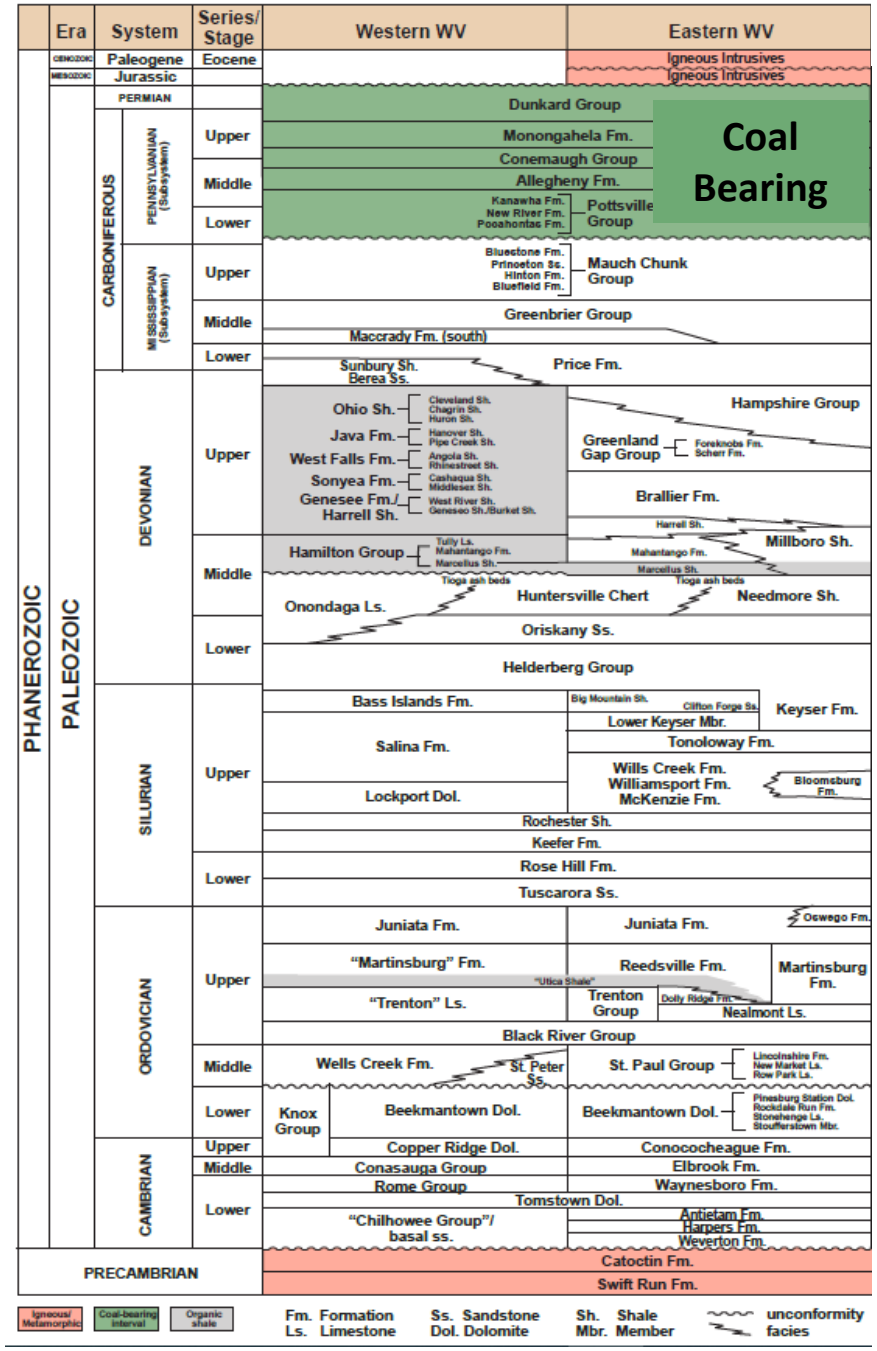
Hillshade Lost River Rock Slide Slope Shade







WVGES Bedrock Stratigraphy



Section within MLRA

KANAWHA

LOGAN

NORTHERN ALLEGEHNIES

NORTHERN ALLEGEHNIES

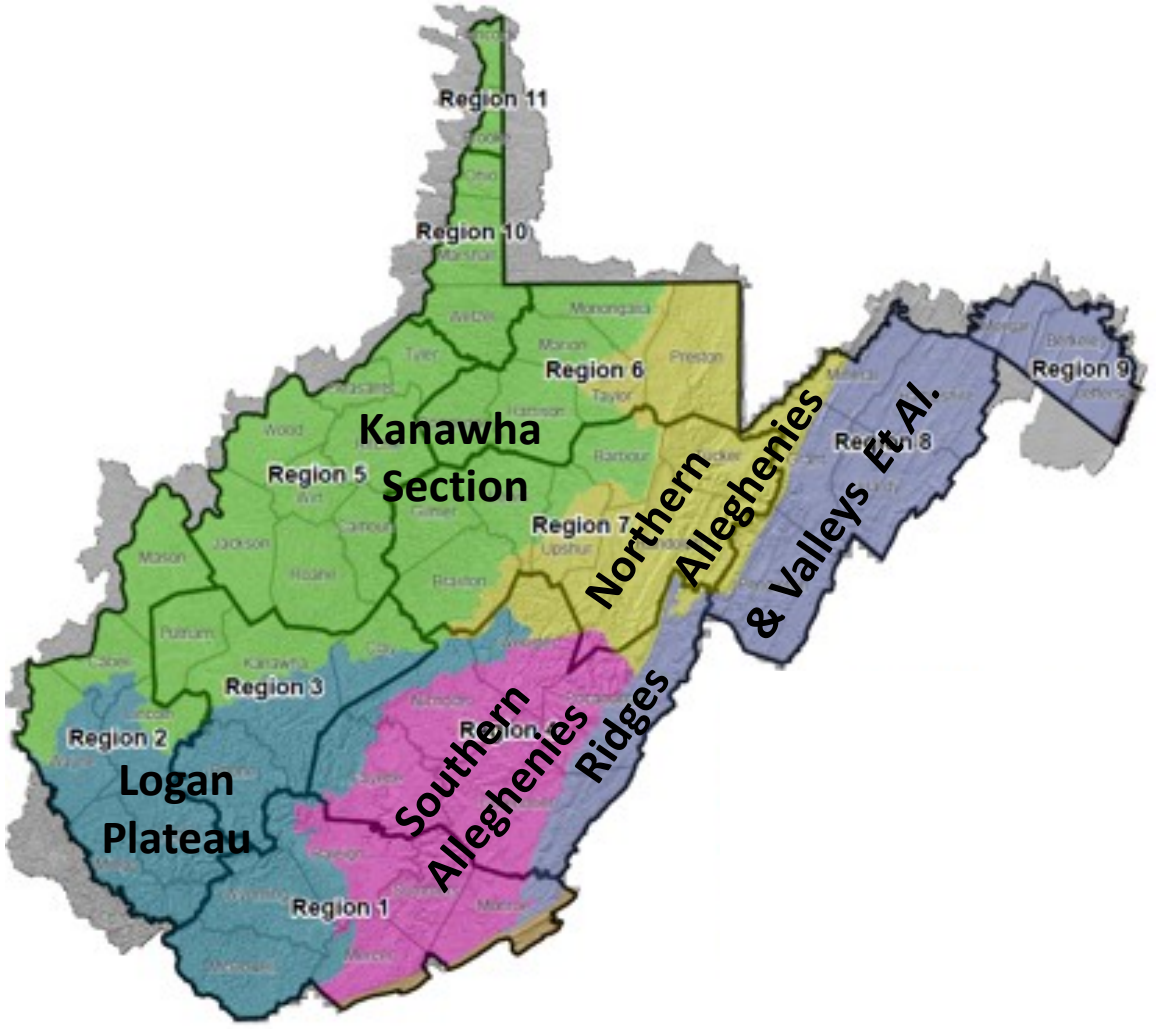
RIDGES & VALLEYS

GREAT VALLEY

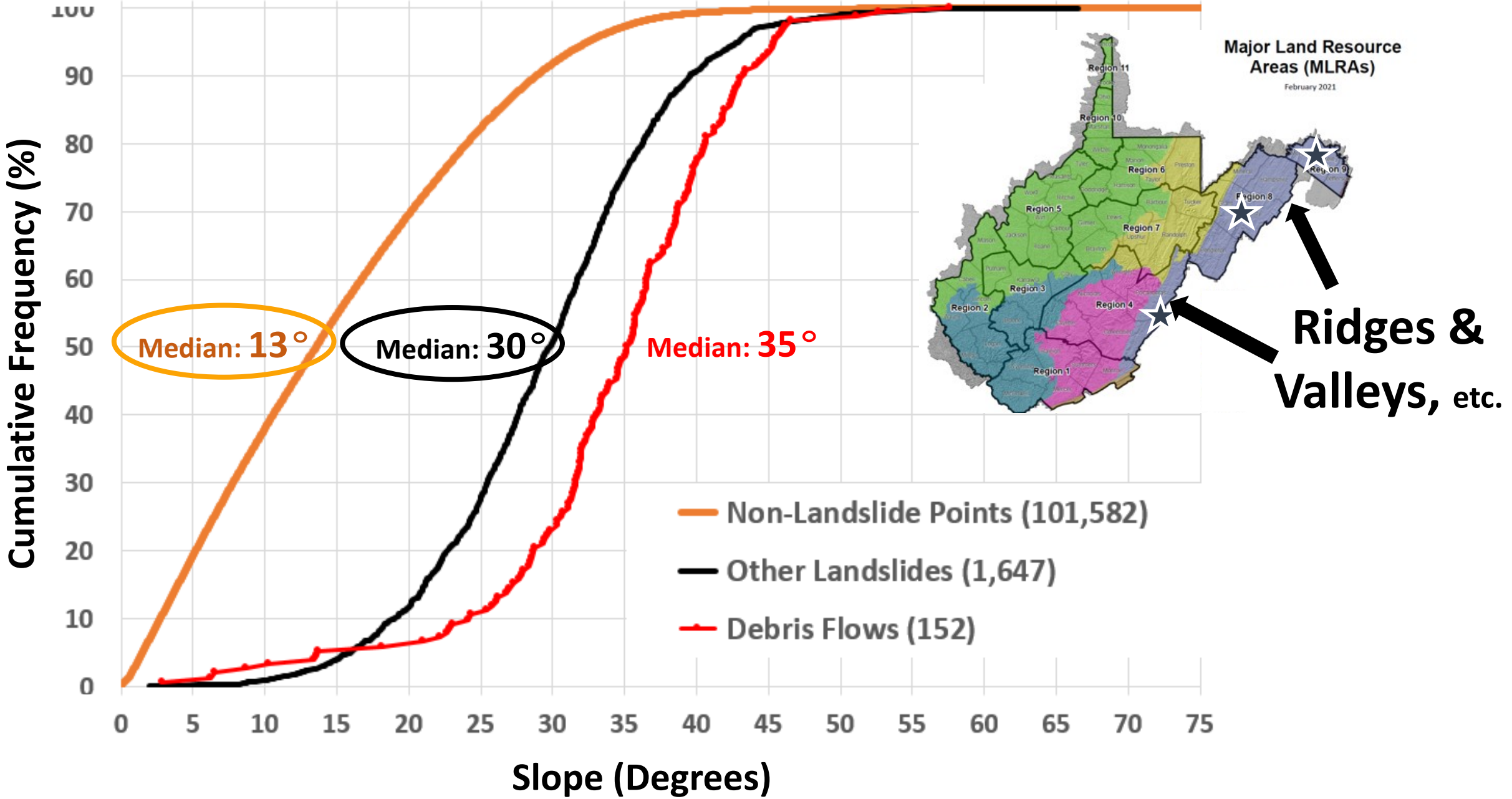
BR

West Virginia Landslide Areas

Based on NRCS MLRA

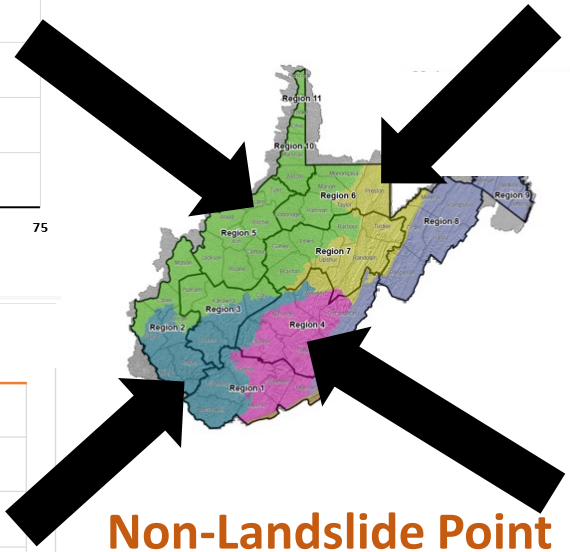


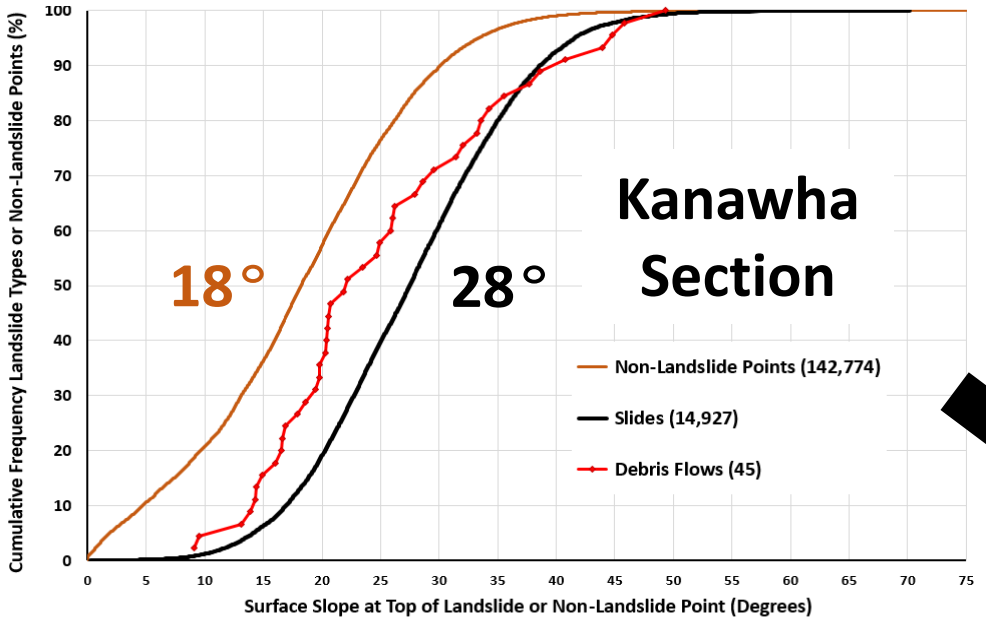
Slope at Debris Flow & Other Landslide Initiation Points vs. Random Points

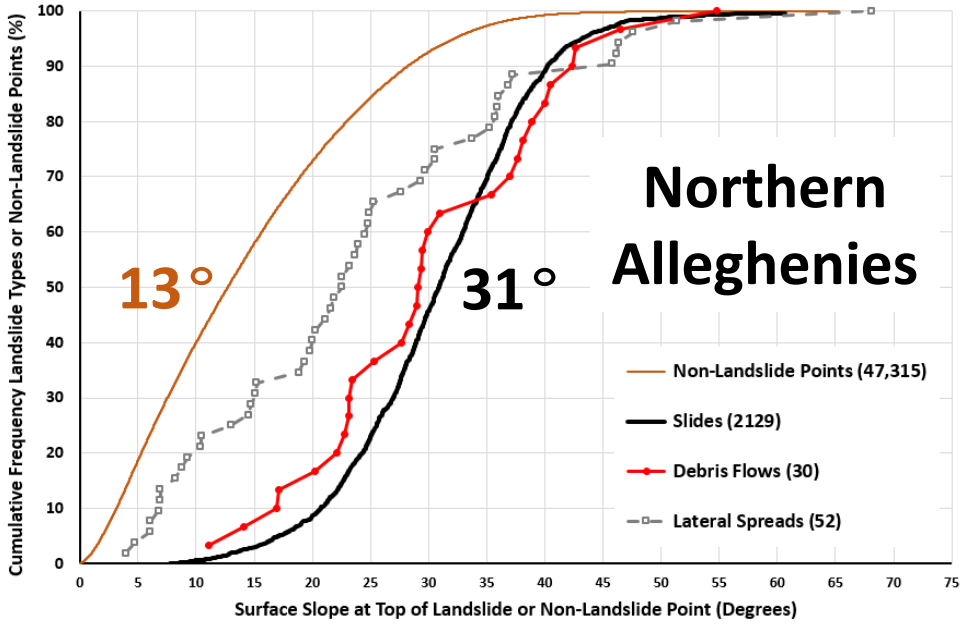


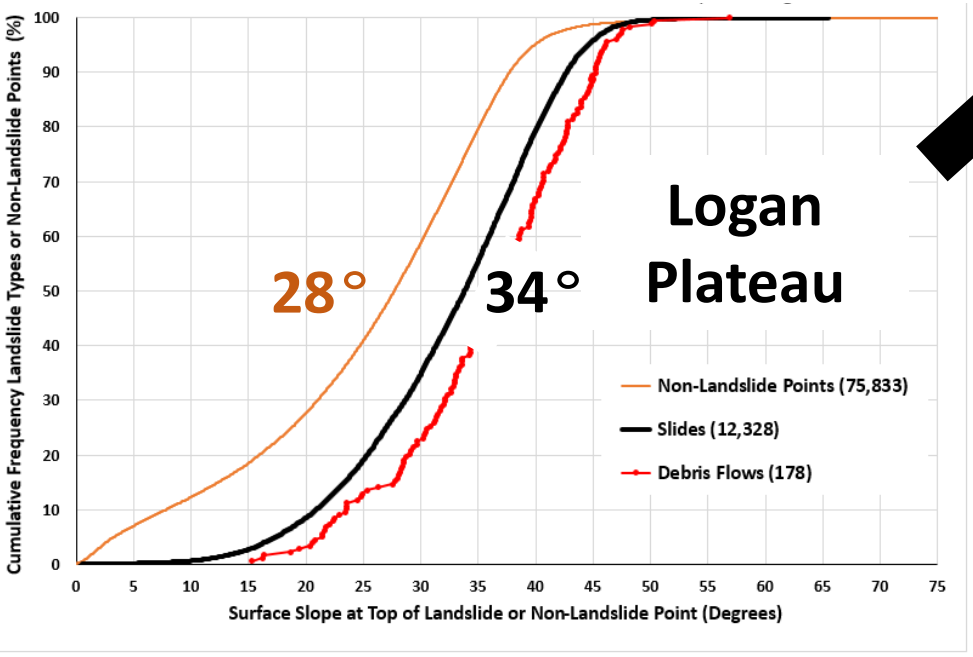
Cumulative Frequency of Slope (Degrees)

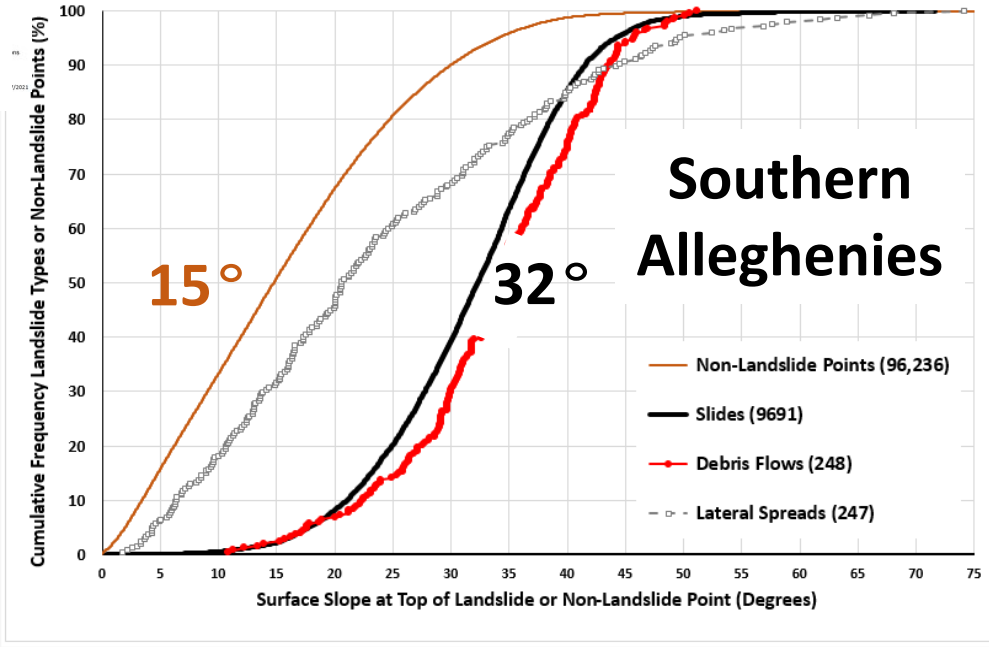
Initiation Points vs. Random Points in Other 4 MLRAs











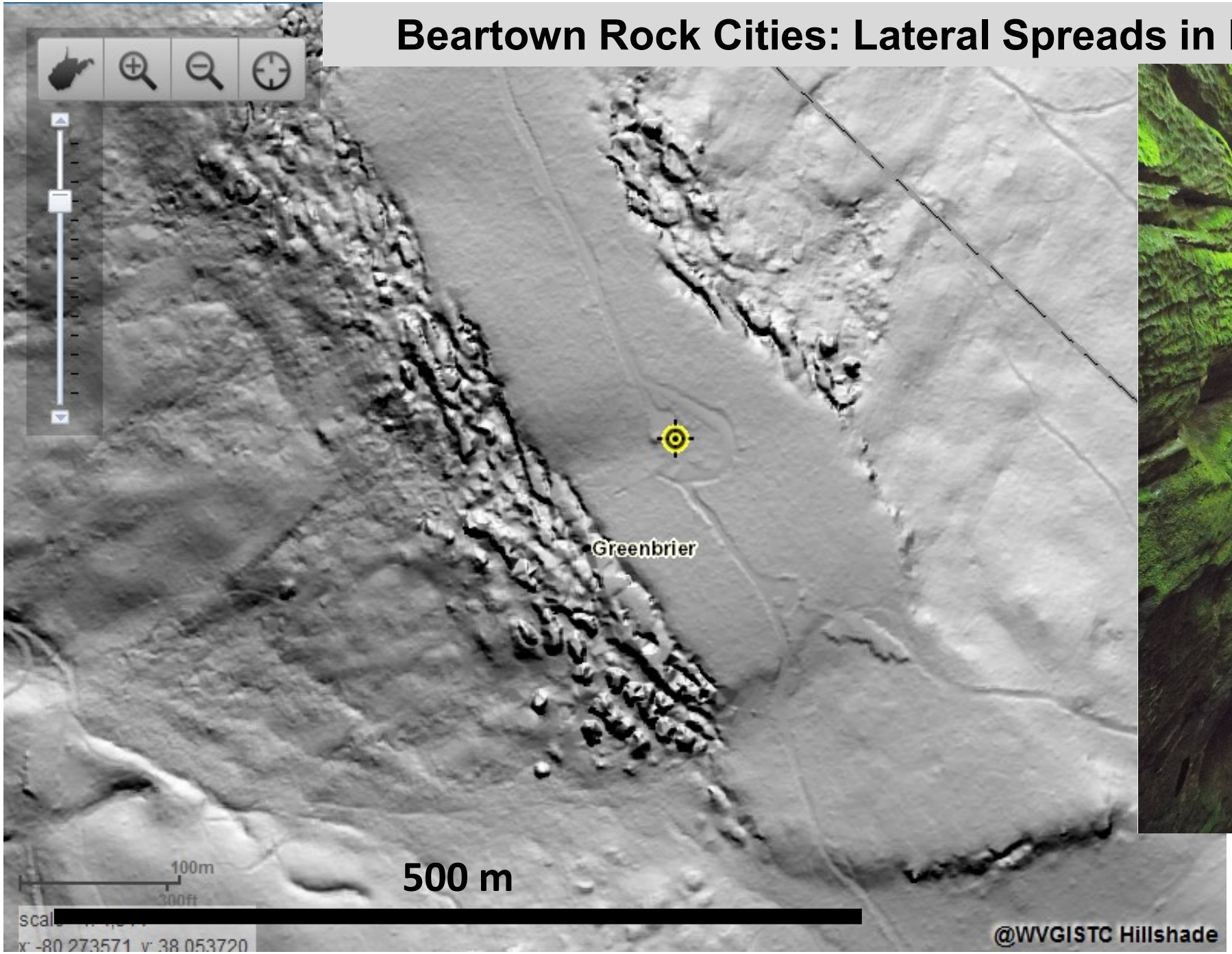
Non-Landslide Point Median Slope

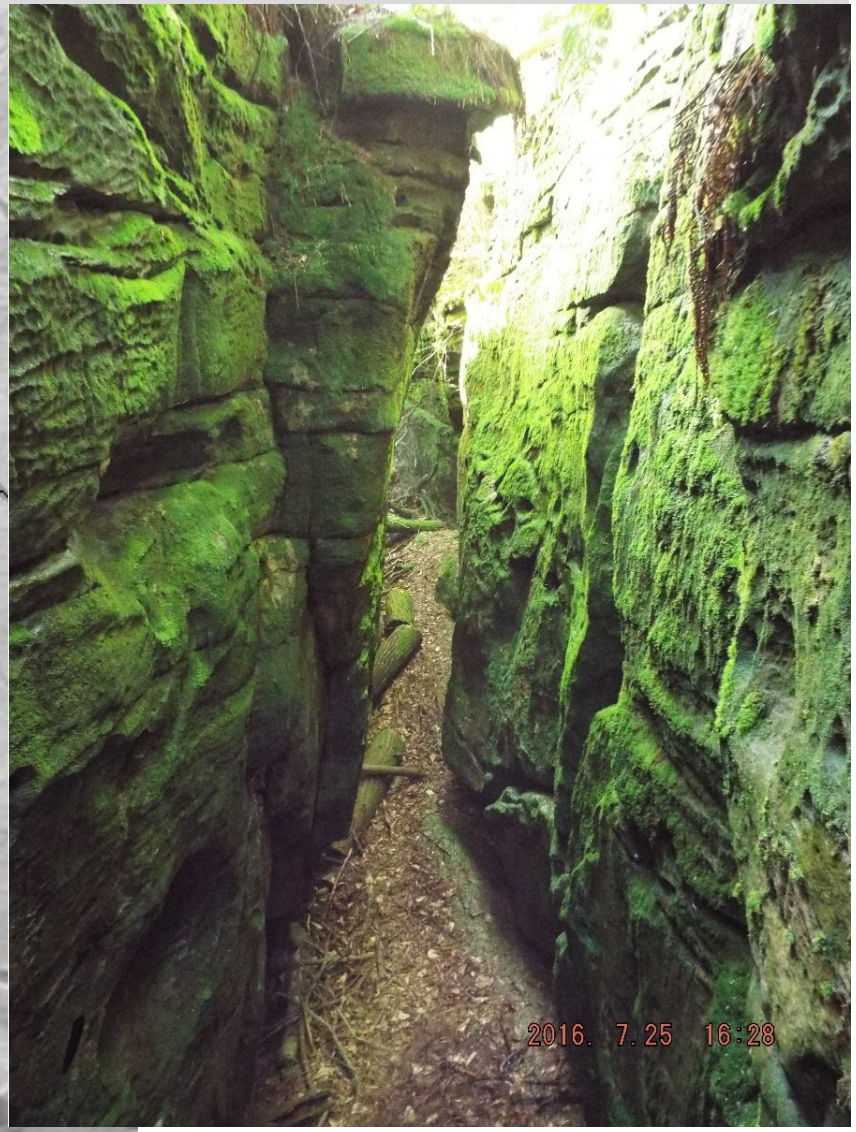
Logan Plateau Slopes = 10-15 ° Steeper

Landslide Initiation Point Median Slope

Varies by Only 6°

Beartown Rock Cities: Lateral Spreads in Mauch Chunk Group





Beartown State Park

https://www.naturallyamazing.com/americasparks/19454.jpg

314 Mapped Lateral Spreads

(>100 Fold MLRA Variation)

Pottsville Group: 65 %

Mauch Chunk Group: 28 %

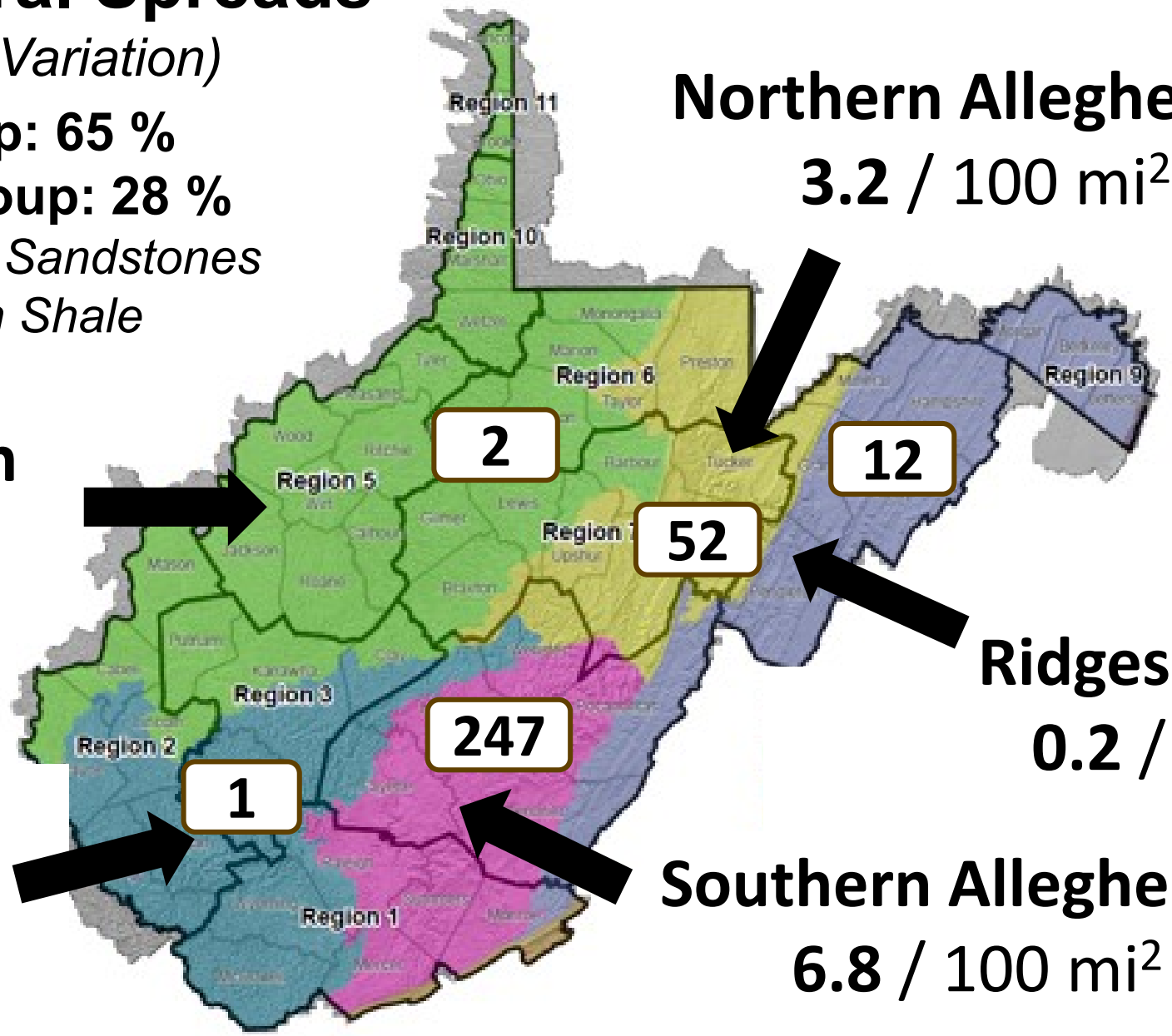
Gently Dipping, Thick Sandstones Interbedded with Shale

Kanawha Section

0.06 / 100 mi²

Logan Plateau

0.02 / 100 mi²



Northern Alleghenies

3.2 / 100 mi²

Ridges & Valleys

0.2 / 100 mi²

Southern Alleghenies

6.8 / 100 mi²

Caution: Mapped Slope Failures / Area Values Are for Comparison Only, Not Exact Estimations of Susceptibility

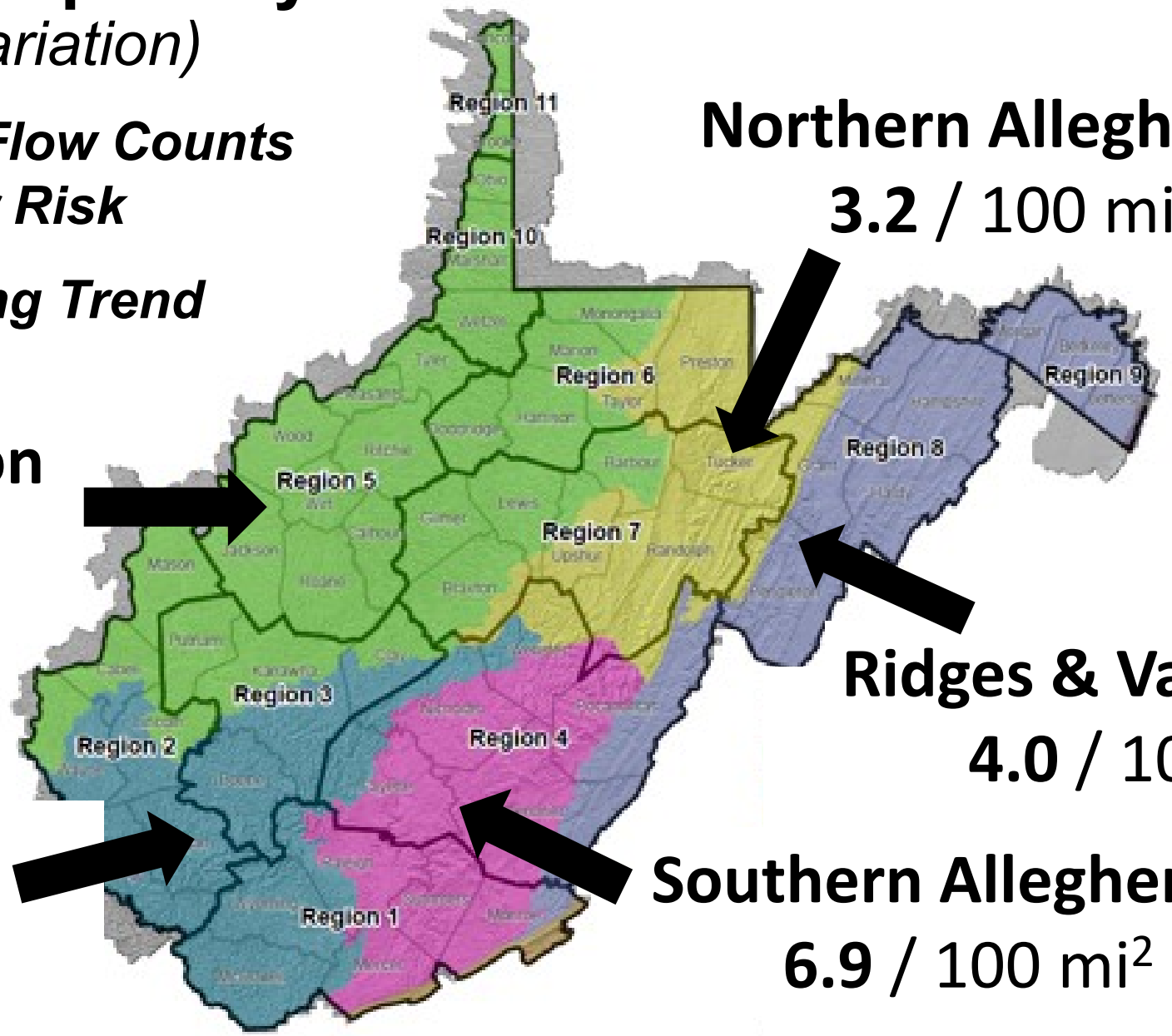
Debris Flow Susceptibility

(5 Fold MLRA Variation)

Data Reflect Debris Flow Counts
NOT Extent or Risk

SE-NW Decreasing Trend

Kanawha Section
1.3 / 100 mi^2



Northern Alleghenies
3.2 / 100 mi^2

Ridges & Valleys et al.
4.0 / 100 mi^2

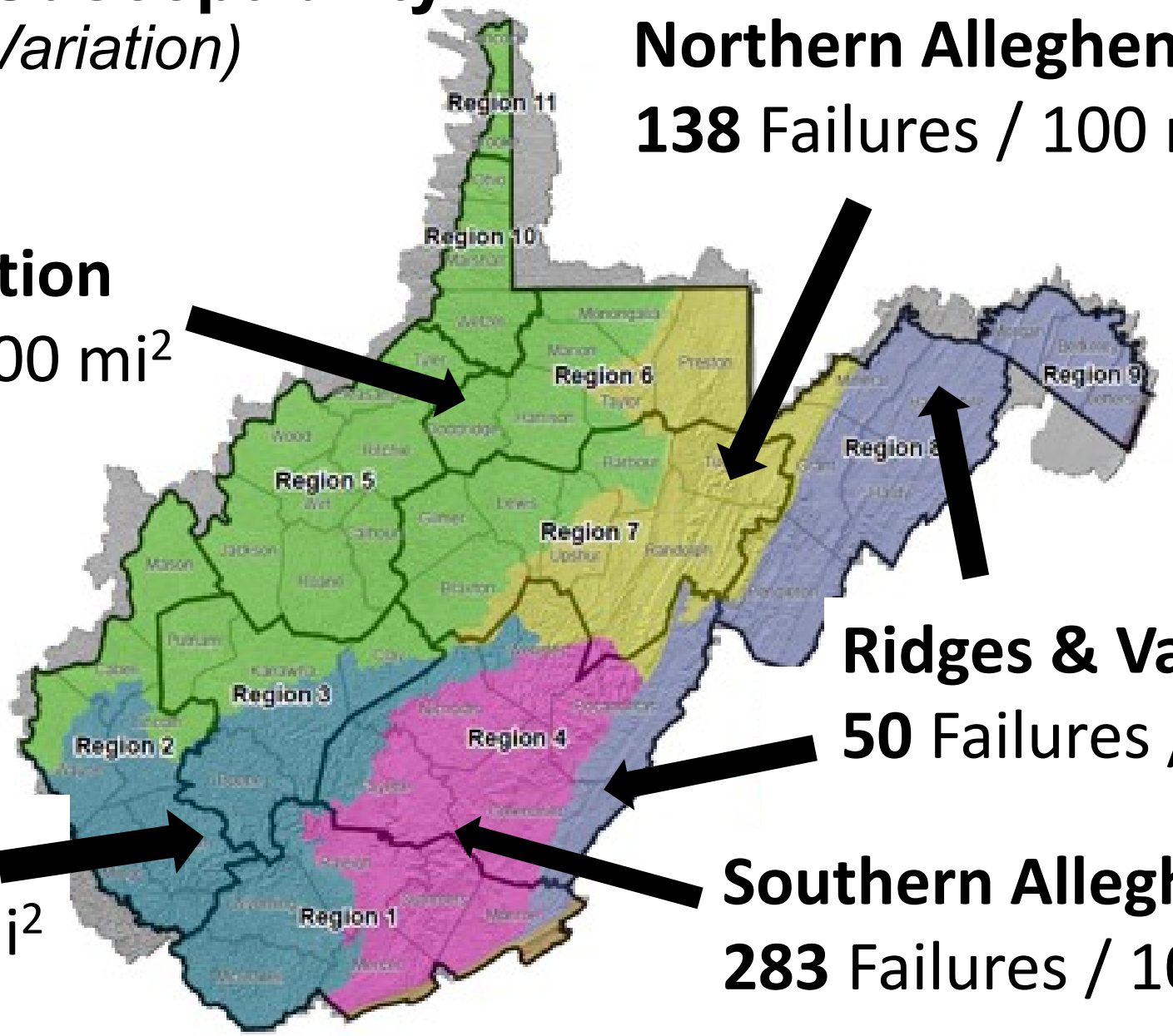
Logan Plateau
4.0 / 100 mi^2

Southern Alleghenies
6.9 / 100 mi^2

Caution: Mapped Slope Failures / Area Values Are for Comparison Only, Not Exact Estimations of Susceptibility

Overall Landslide Susceptibility

(8 Fold MLRA Variation)



Northern Alleghenies
138 Failures / 100 mi^2

Kanawha Section
414 Failures / 100 mi^2

Ridges & Valleys et al.
50 Failures / 100 mi^2

Logan Plateau
279 Failures / 100 mi^2

Southern Alleghenies
283 Failures / 100 mi^2

Caution: Mapped Slope Failures / Area Values Are for Comparison Only, Not Exact Estimations of Susceptibility

Logan Plateau Landslide Geology Data

WVGES Geologic Map Unit	Period	Mapped Landslide Count	% of All Landslides	Unit Area mi²	Mapped Landslides /100 mi²
Alluvium	Q	0	0.0	15.9	0
Monongahela Group	Penn	0	0.0	23.2	0
Conemaugh Group	Penn	198	1.6	406.9	49
Allegheny Formation	Penn	993	7.9	654.3	152
Kanawha Formation	**Penn**	**10,146**	**81.0**	**2382.3**	**426**
New River Formation	Penn	642	5.1	776.3	83
Pocahontas Formation	Penn	509	4.1	200.2	254
Bluestone & Princeton Formations	Miss	38	0.3	33.1	115
Hinton Formation *	Miss	0	0.0	0.1	*
Overall MLRA 125		**12,526**	**100.0**	**4492.3**	**279**

Geologic map units, in stratigraphic order. Data include all landslides, including debris flows. * Hinton Formation extent is too small for calculation of failures/100 mi².

Why is the Kanawha a "Bad Actor" in the Logan Plateau?

Caution: Mapped Slope Failures / Area Values Are for Comparison Only, Not Exact Estimations of Susceptibility

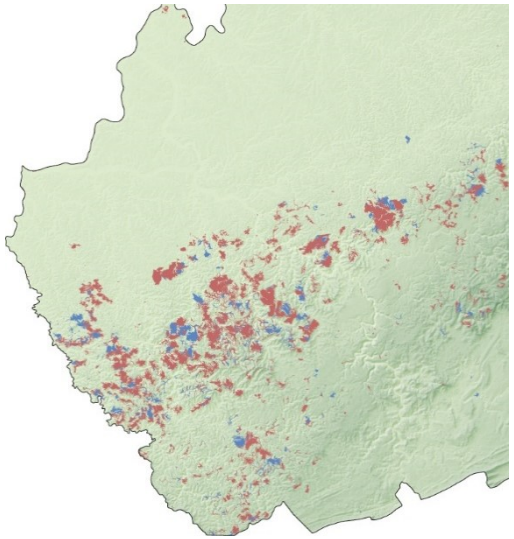
Logan Plateau Landslide Soil Parent Material Data

NRCS Soil Parent Material	Mapped Landslide Count	% of All Failures	Unit Area mi² (Approx.)	Mapped Failures /100 mi²
Colluvium	7598	60.66	3089.0	246
Mining Regolith	**3047**	**24.33**	**403.5**	**755**
Residuum, Acid Clastic	1458	11.64	729.8	200
Disturbed Areas	406	3.24	99.7	407
Recent Alluvium	13	0.10	114.2	11
Residuum, Calcareous Clastic	2	0.02	0.4	482
Old Terrace Alluvium	1	0.01	35.7	3
Water	1	0.01	20.1	5
Overall MLRA Total	12,526	100.00	4492.3	279

Dominant soil parent material for all landslides mapped in the Logan Plateau, listed in decreasing order by number of landslides of all types.

Caution: Mapped Slope Failures / Area Values Are for Comparison Only, Not Exact Estimations of Susceptibility

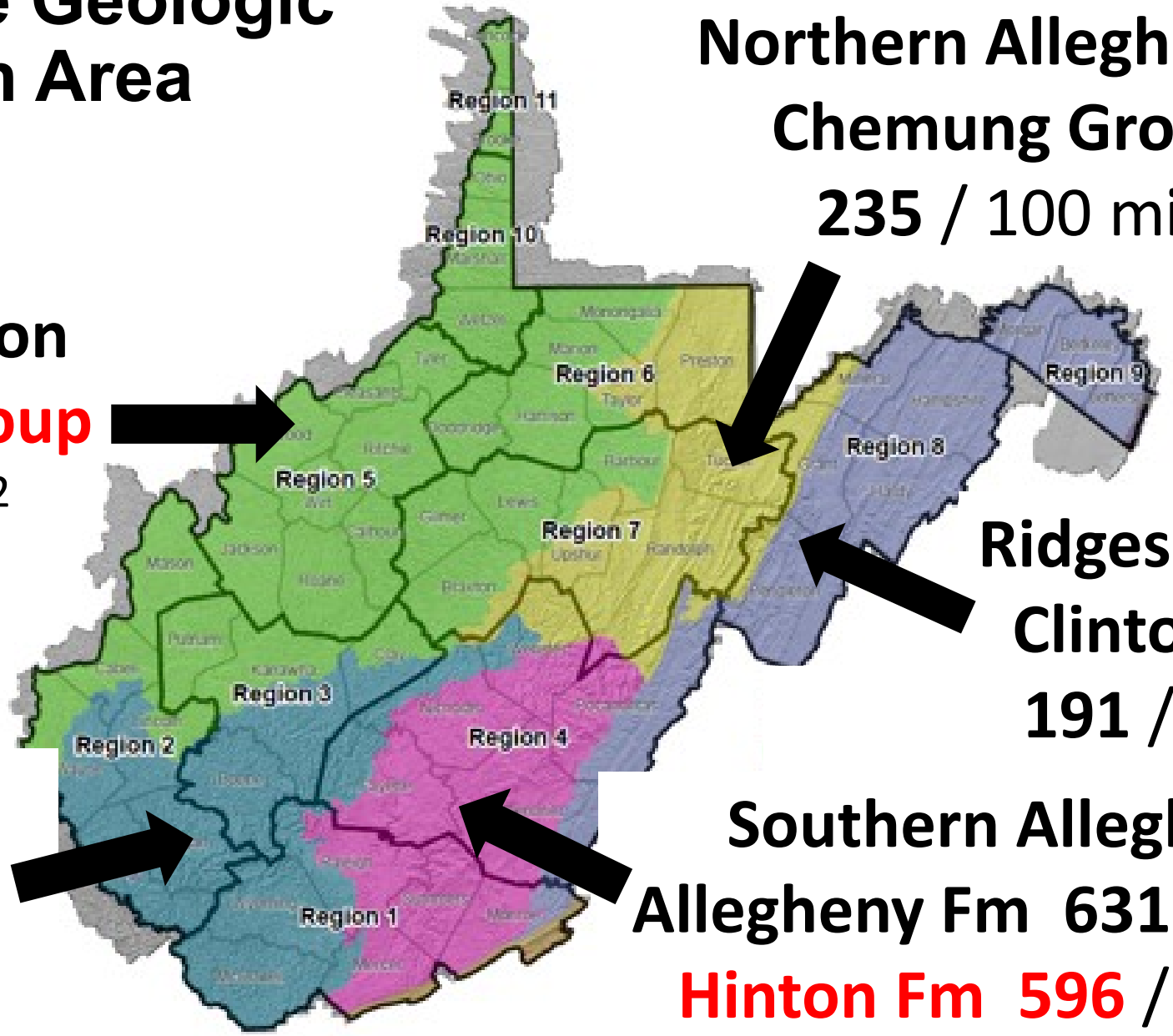
Why is the Kanawha a "Bad Actor" in the Logan Plateau?



Mining Permits (NASA)

https://visibleearth.nasa.gov/images/8344/mining-permits-across-west-virginia

Most Susceptible Geologic Units in Each Area



Northern Alleghenies
Chemung Group
235 / 100 mi²

Kanawha Section
Conemaugh Group
731 / 100 mi²

Ridges & Valleys
Clinton Group
191 / 100 mi²

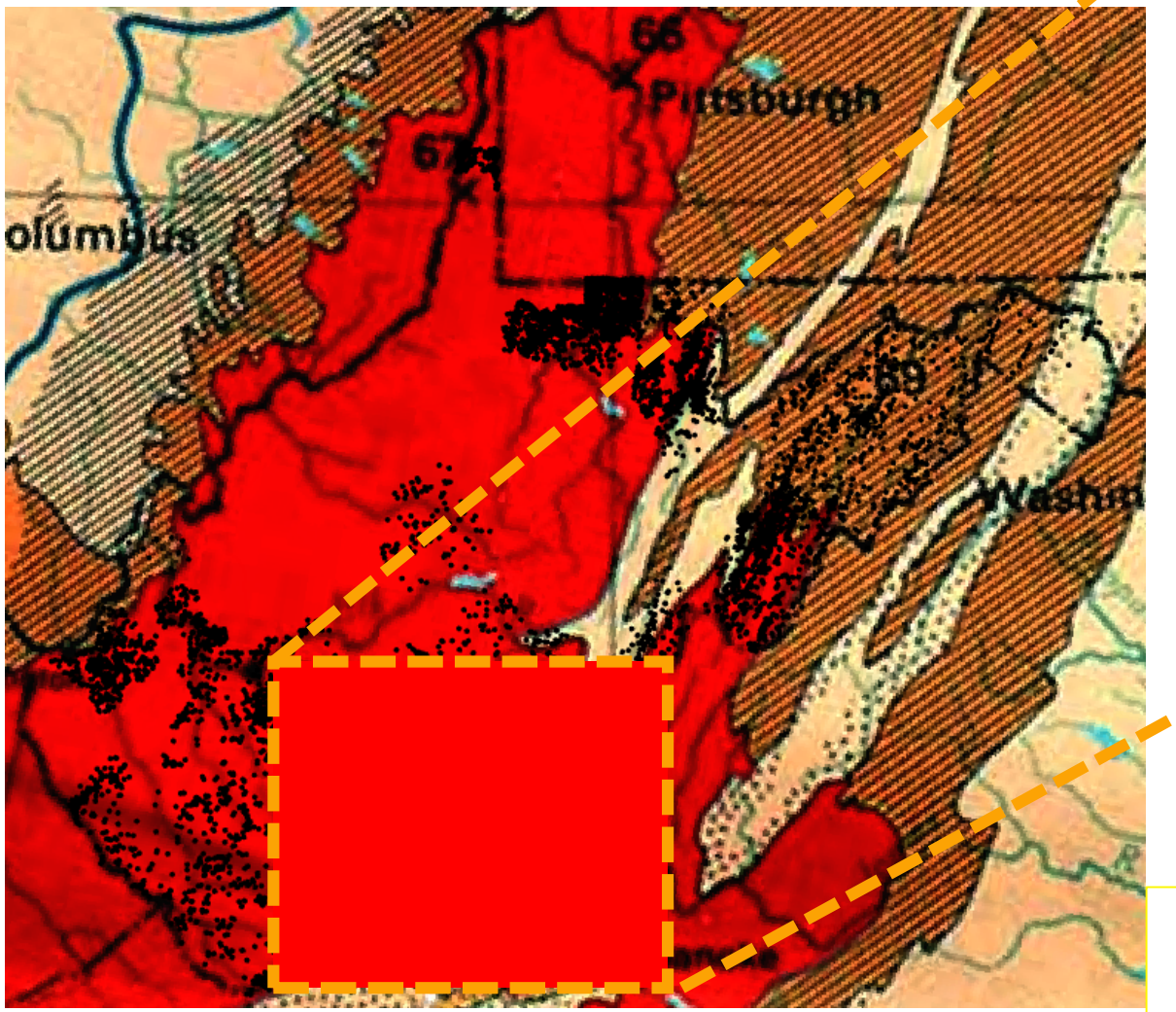
Logan Plateau
Kanawha Formation
426 / 100 mi²

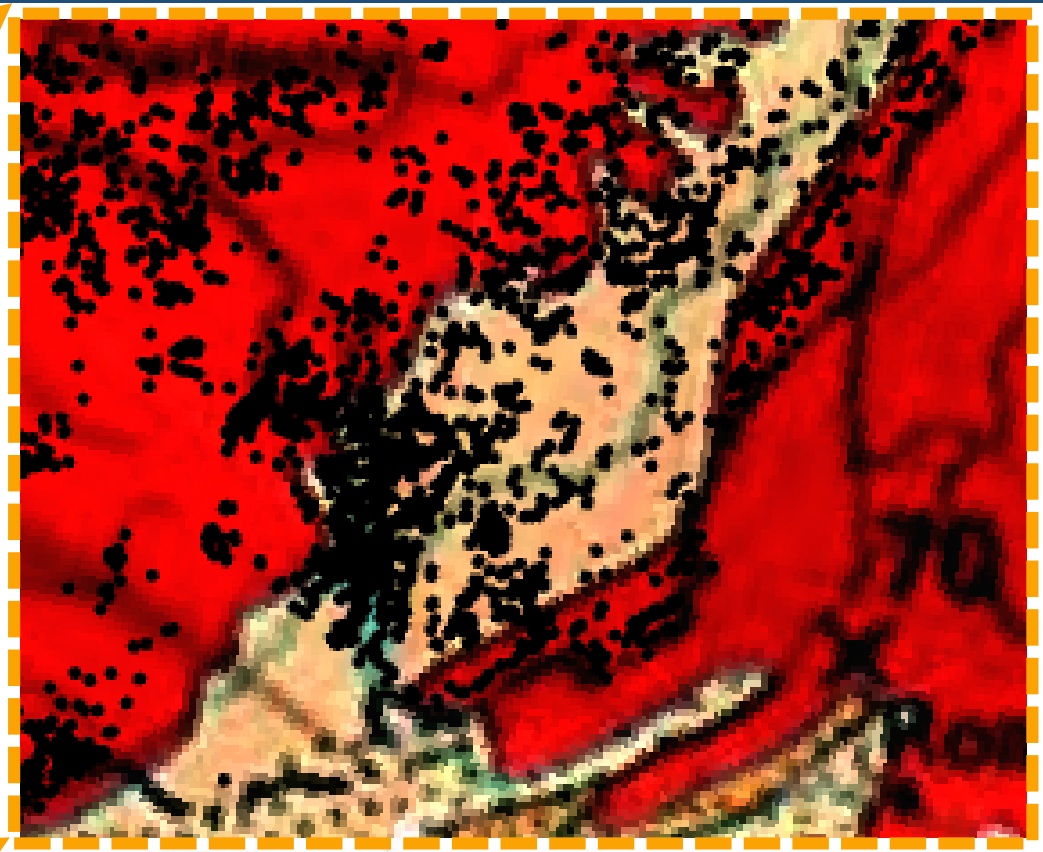
Southern Alleghenies
Allegheny Fm 631 / 100 mi²
Hinton Fm 596 / 100 mi²

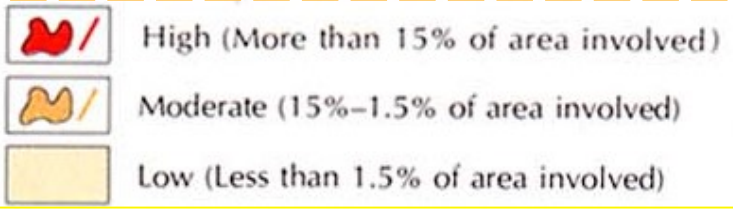
Caution: Mapped Slope Failures / Area Values Are for Comparison Only, Not Exact Estimations of Susceptibility

Landslide Mapping Shows USGS Landslide Overview Map Understates Landslide Susceptibility in the Hinton Formation

Newly Mapped Landslides on LiDAR-Based DEMs
Plotted vs. USGS PP 1183 Landslide Overview Map







~ ~~70~~ 75% of WV = "High Landslide Incidence"

An Example of Why We Map Landslides!

Search:

“WV Landslide Tool”

Contact Kite:

jkite@wvu.edu