EVALUATING METHODS FOR AUTOMATED MAPPING OF APEXES OF NON-LINEAR EMINENCES

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1804
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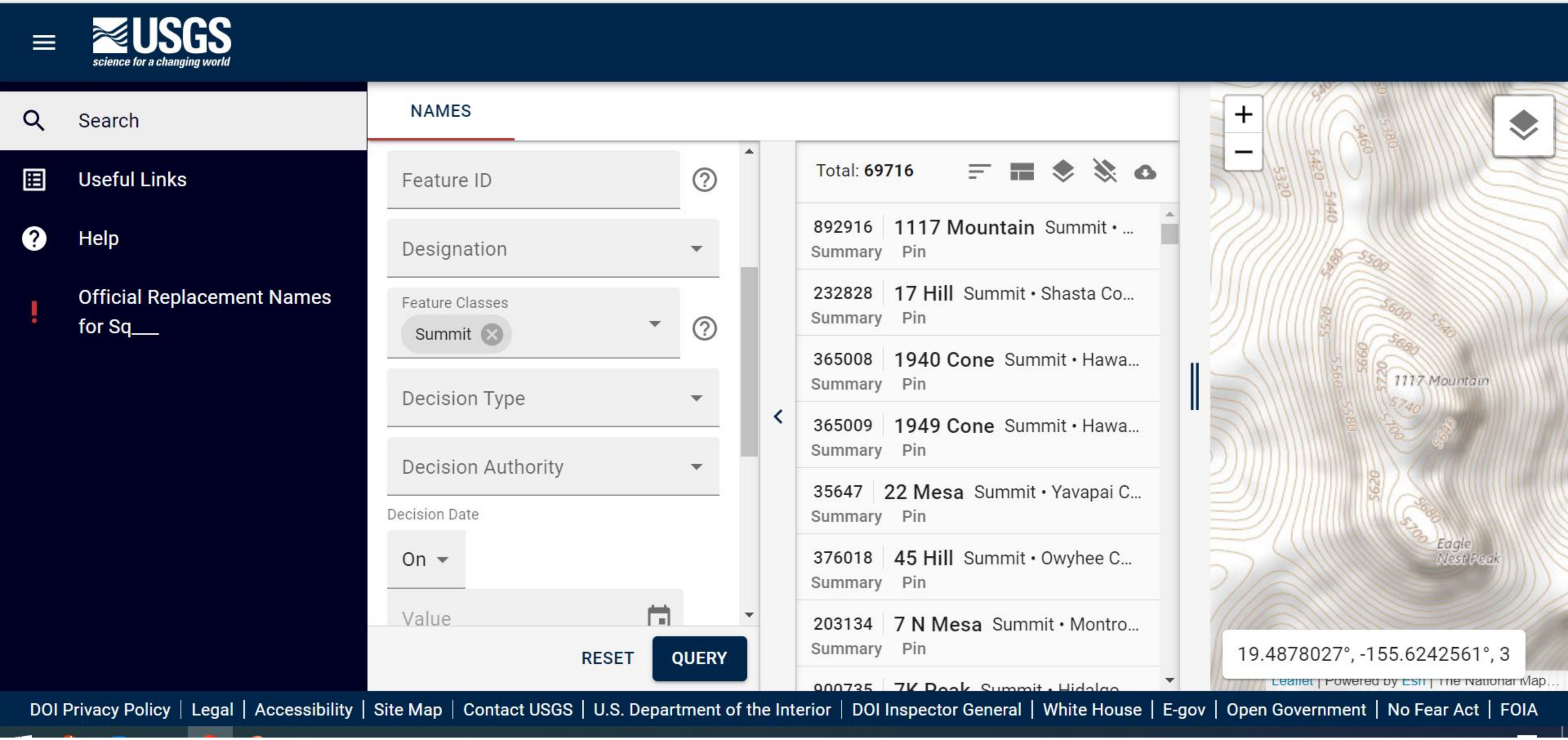
USGS GNIS



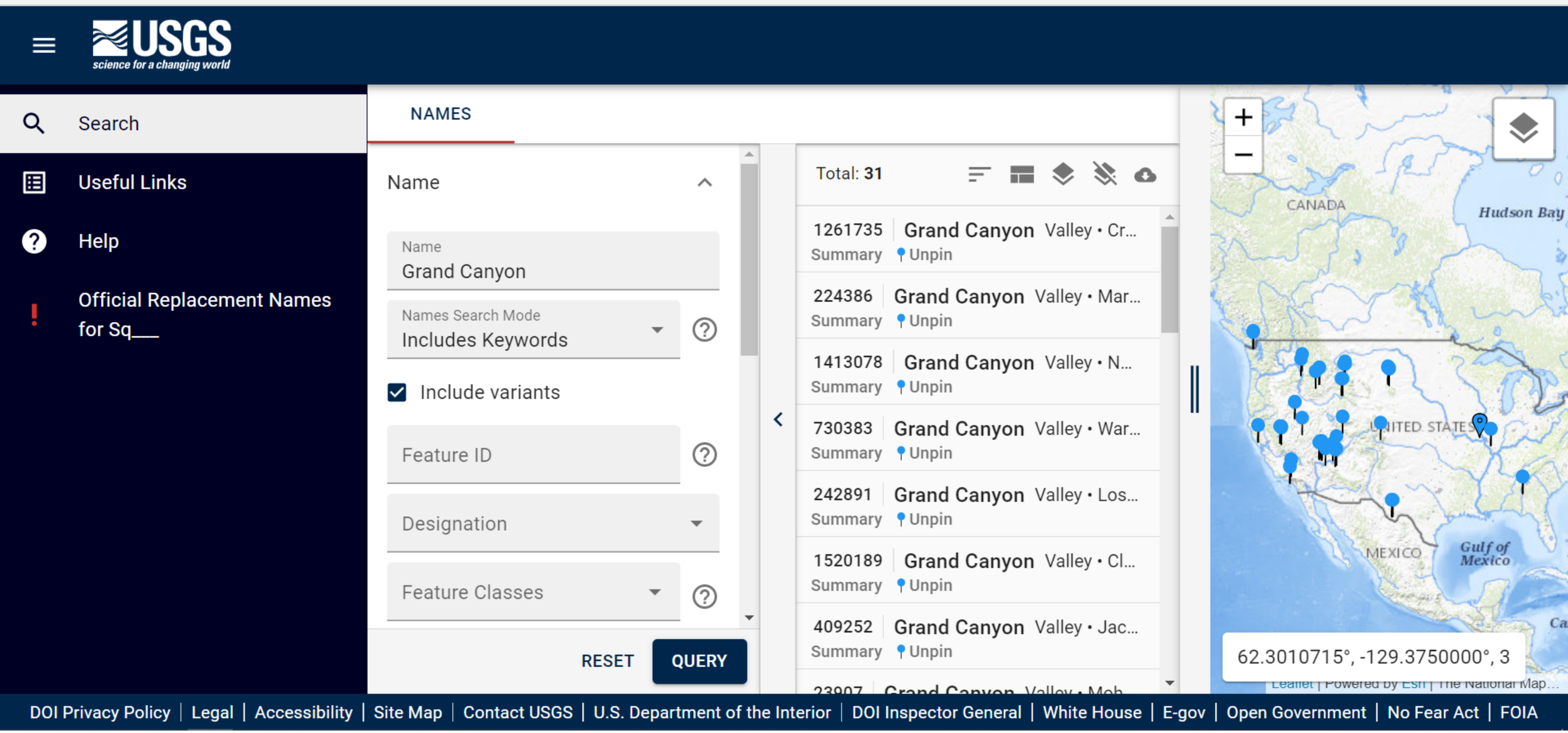
Screenshot from USGS The National Map Viewer website

GNIS Feature Classes

GNIS Class	Count	Percent
Stream	230,951	38.11%
Lake	69,746	11.51%
Summit	69,645	11.49%
Valley	69,403	11.45%
Spring	38,526	6.36%
Island	17,514	2.89%
Cape	15,253	2.52%
Ridge	14,937	2.46%
Bay	13,238	2.18%
Flat	10,441	1.72%
Gap	8,249	1.36%
Swamp	7,570	1.25%
Bar	4,986	0.82%
Cliff	4,416	0.73%
Basin	4,273	0.71%
Channel	3,541	0.58%
Gut	3,447	0.57%

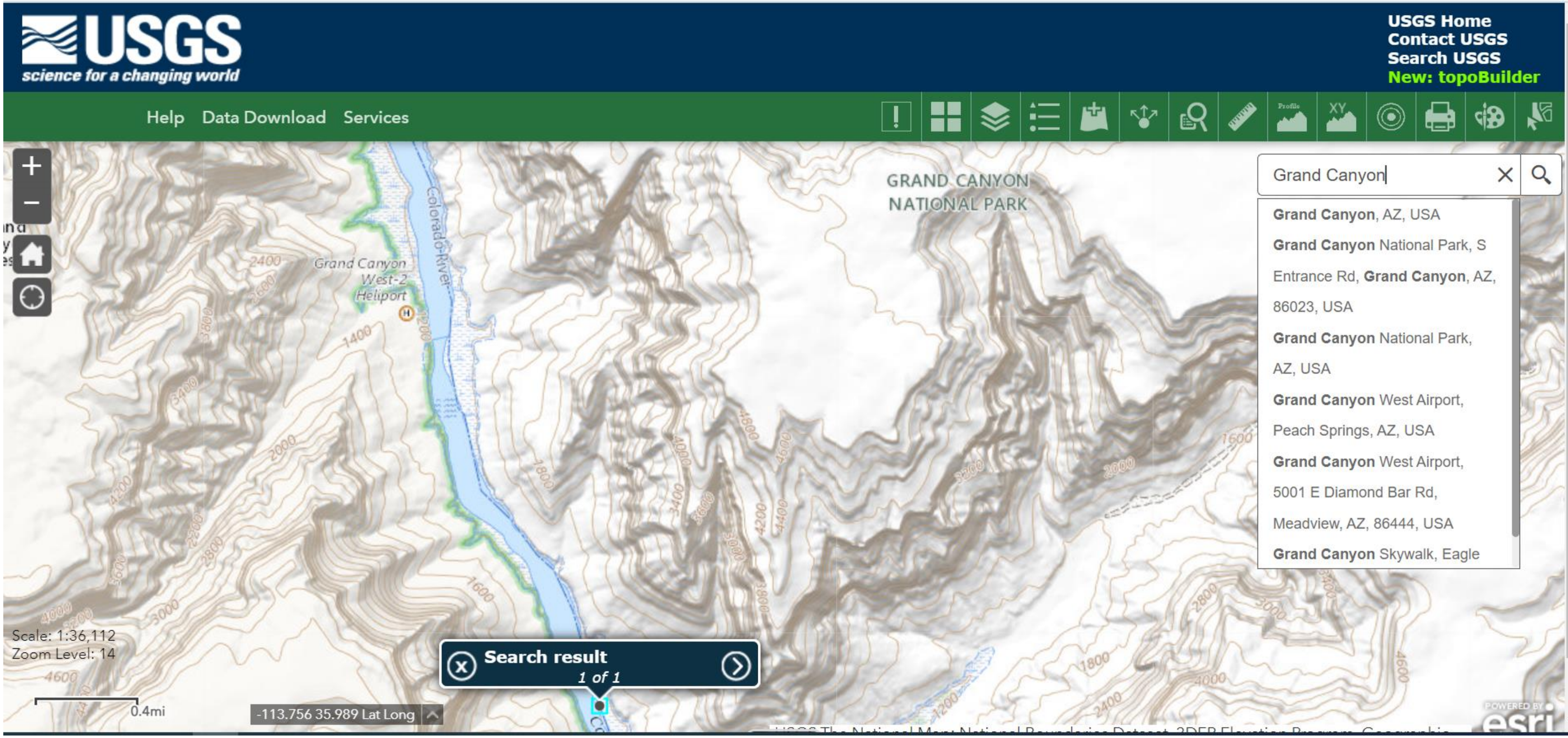
GNIS Class	Count	Percent
Bend	2,787	0.46%
Falls	2,512	0.41%
Range	2,477	0.41%
Area	2,329	0.38%
Pillar	2,091	0.35%
Beach	2,070	0.34%
Rapids	1,068	0.18%
Glacier	1,020	0.17%
Bench	724	0.12%
Tunnel	722	0.12%
Arch	720	0.12%
Arroyo	466	0.08%
Plain	260	0.04%
Crater	238	0.04%
Slope	236	0.04%
Lava	168	0.03%
Isthmus	27	0.00%
Sea	25	0.00%

Mapping Grand Canyon…



Screenshot from USGS The National Map Viewer website

Mapping Grand Canyon…



Screenshot from USGS The National Map Viewer website

Grand Canyon

Grand Canyon

From Wikipedia, the free encyclopedia

This article is about the canyon in the southwestern United States. For other Grand Canyons, see

The **Grand Canyon** (Hopi: *Ongtupqa*;[2] Yavapai: *Wi:ka'i:la*, Navajo: *Tsékooh Hatsoh*, Spanish: *Gran*
River in Arizona, United States. The Grand Canyon is 277 miles (446 km) long, up to 18 miles (29 km
1,857 meters).[3]

The canyon and adjacent rim are contained within Grand Canyon National Park, the Kaibab National
Hualapai Indian Reservation, the Havasupai Indian Reservation and the Navajo Nation. President Th
of the Grand Canyon area, and visited it on numerous occasions to hunt and enjoy the scenery.

Nearly two billion years of Earth's geological history have been exposed as the Colorado River and it
rock while the Colorado Plateau was uplifted.[4] While some aspects about the history of incision of th
studies support the hypothesis that the Colorado River established its course through the area about
Colorado River has driven the down-cutting of the tributaries and retreat of the cliffs, simultaneously c

For thousands of years, the area has been continuously inhabited by Native Americans, who built set
Pueblo people considered the Grand Canyon a holy site, and made pilgrimages to it.[8] The first Euro
García López de Cárdenas from Spain, who arrived in 1540.[9]

Grand Canyon

View of the Colorado River flowing through the Grand Canyon.

Location	Arizona, U.S.
Floor elevation	approx. 2,600 feet (800 m)
Long-axis length	277 miles (446 km)
Width	4 to 18 miles (6.4 to 29.0 km)
Geology	
Age	5–6 million years[1]
Geography	
Coordinates	36°18′N 112°36′W
Watercourses	Colorado River

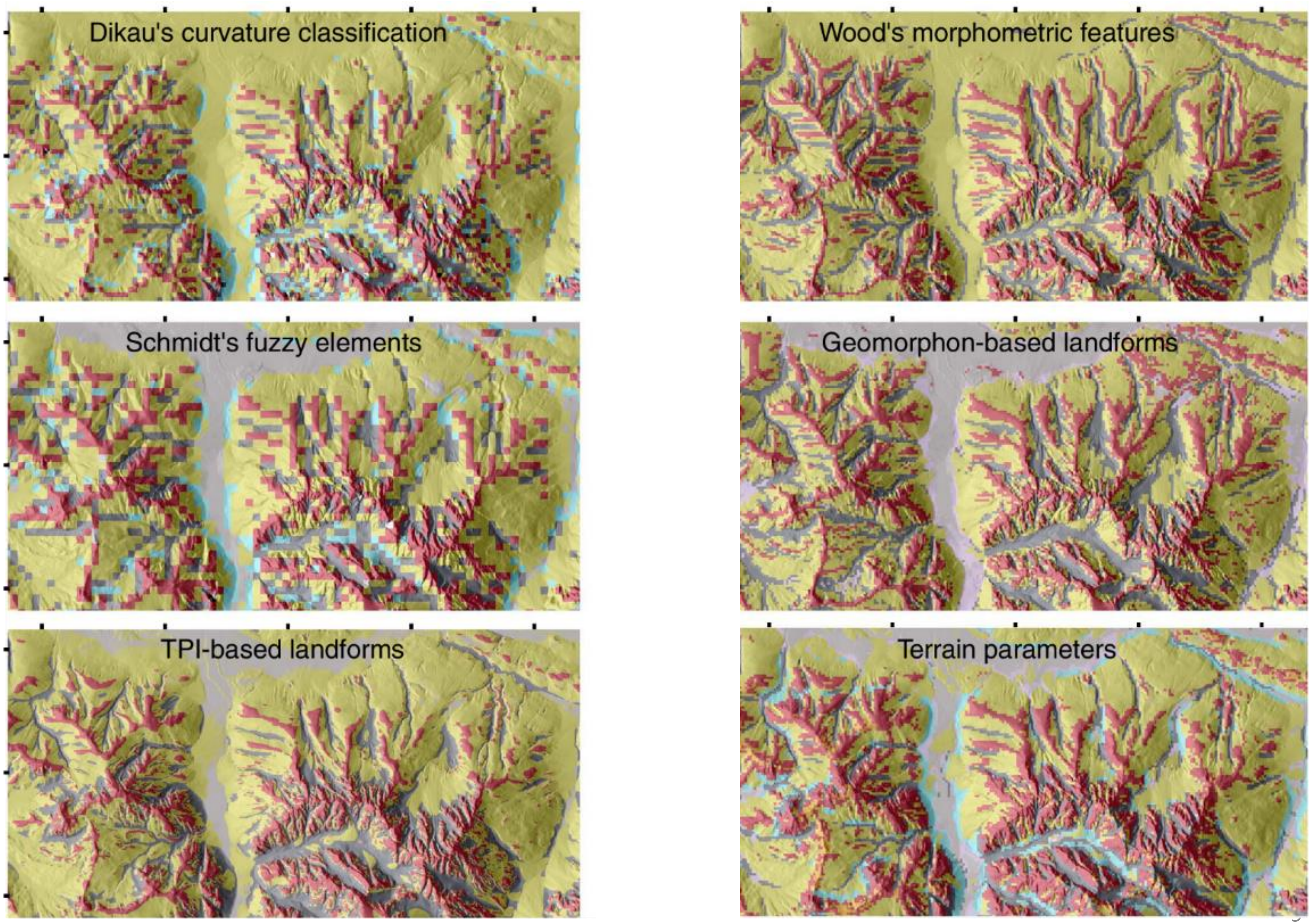
Screenshot from Wikipedia

Potential Applications

- ✓ *Topographic mapping*
- ✓ *3D digital terrain modeling*
- ✓ *Geovisualization*
- ✓ *Digital landscape modeling*
- ✓ *K-12 education*
- ✓ *Tourism promotion*
- ✓ *Conservation*
- ✓ *Indigenous culture documentation / mapping*
- ✓ *Landscape art*

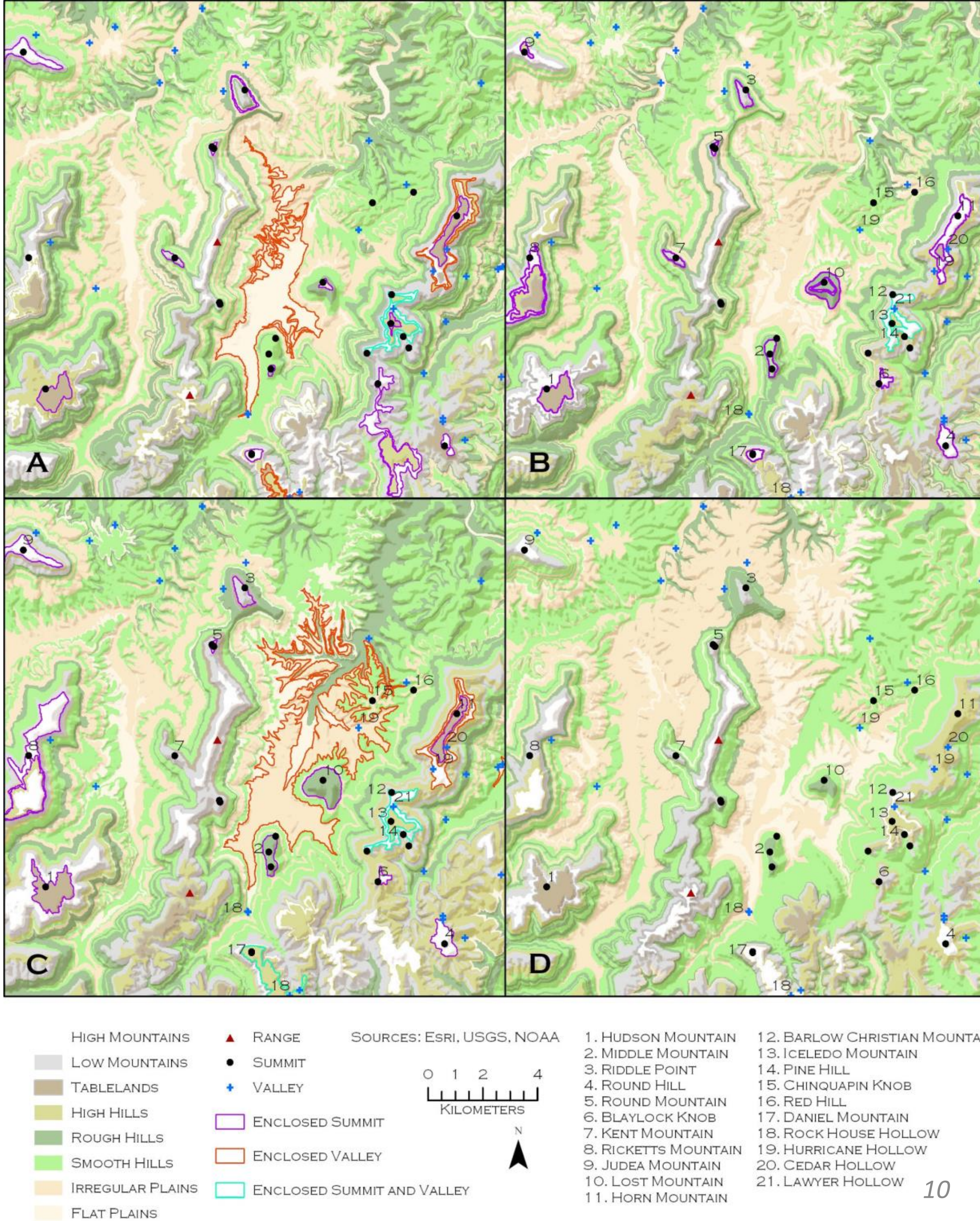
GENERAL GEOMORPHOMETRY

Geomorphometric Mapping Methods



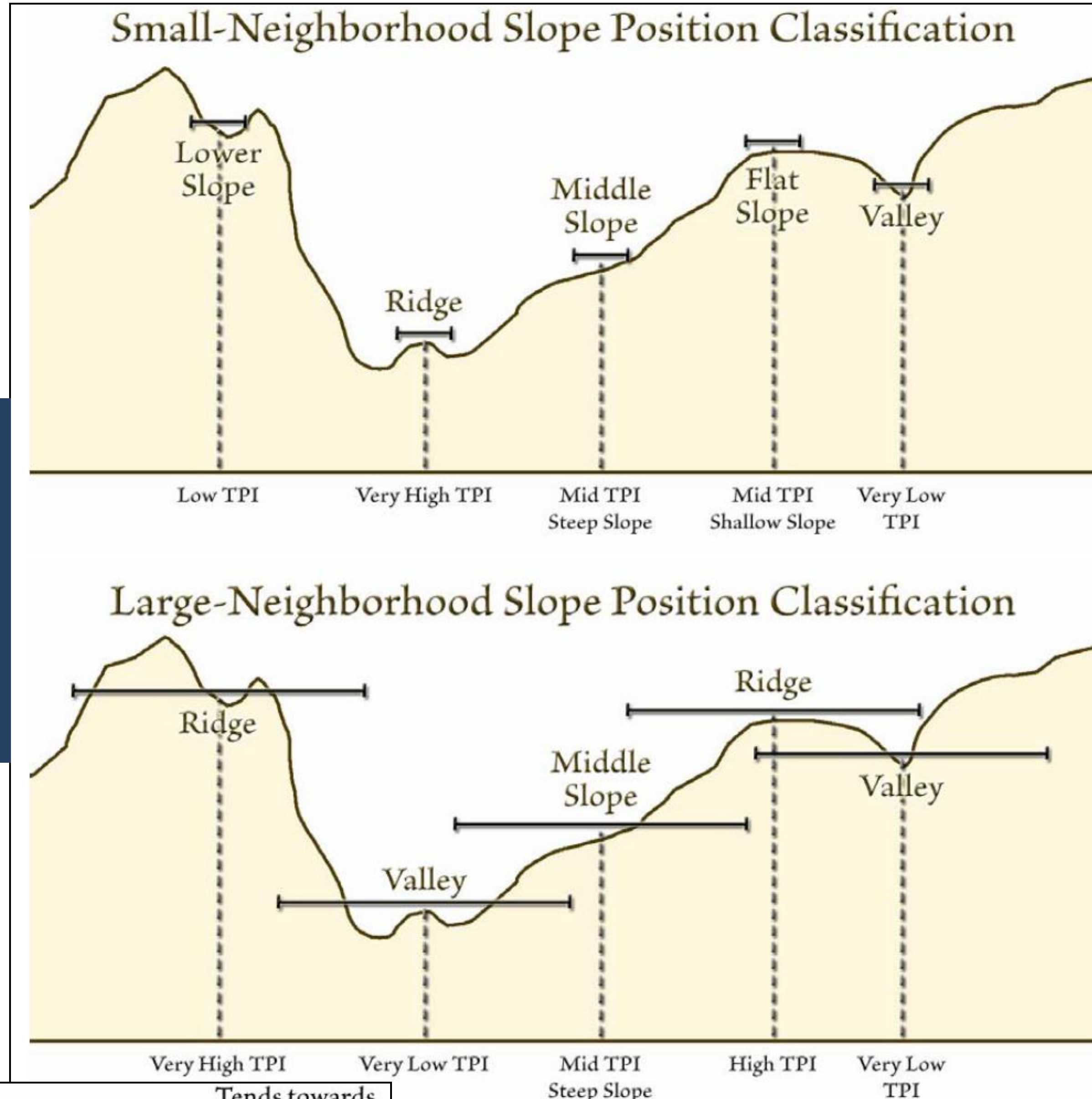
Gruber et al. (2017). Geoderma 308, 9–25.

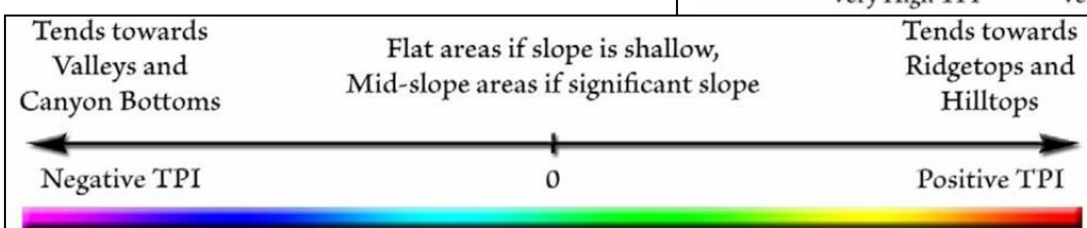
GEOBIA Segmentation & Classification



***Arundel ST, Sinha G (2018)**. Validating the use of object-based image analysis to map commonly recognized landform features in the United States. **Cartography and GIS, 46(5), 441-455**.*

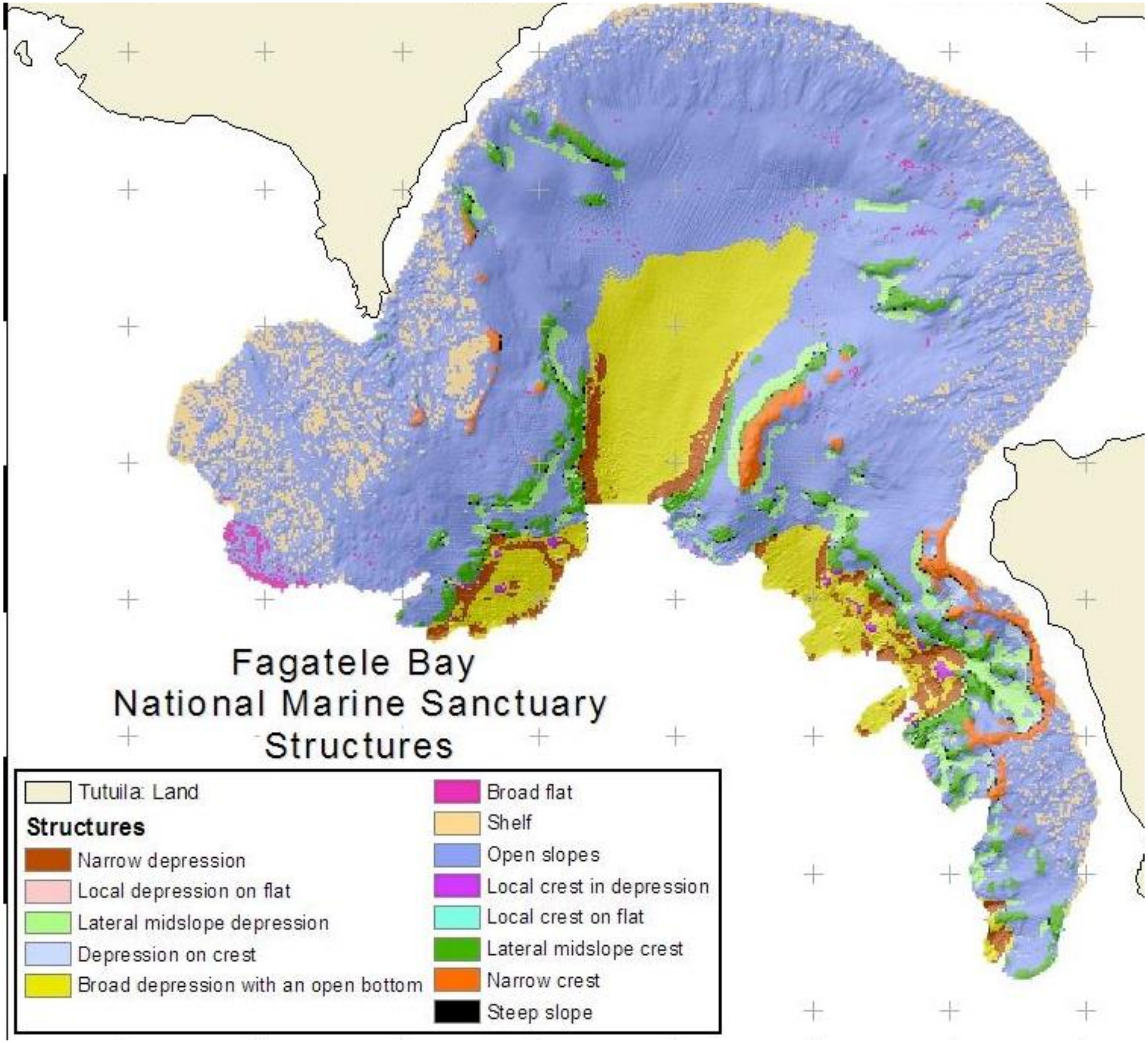
Topographic Position Index (TPI)





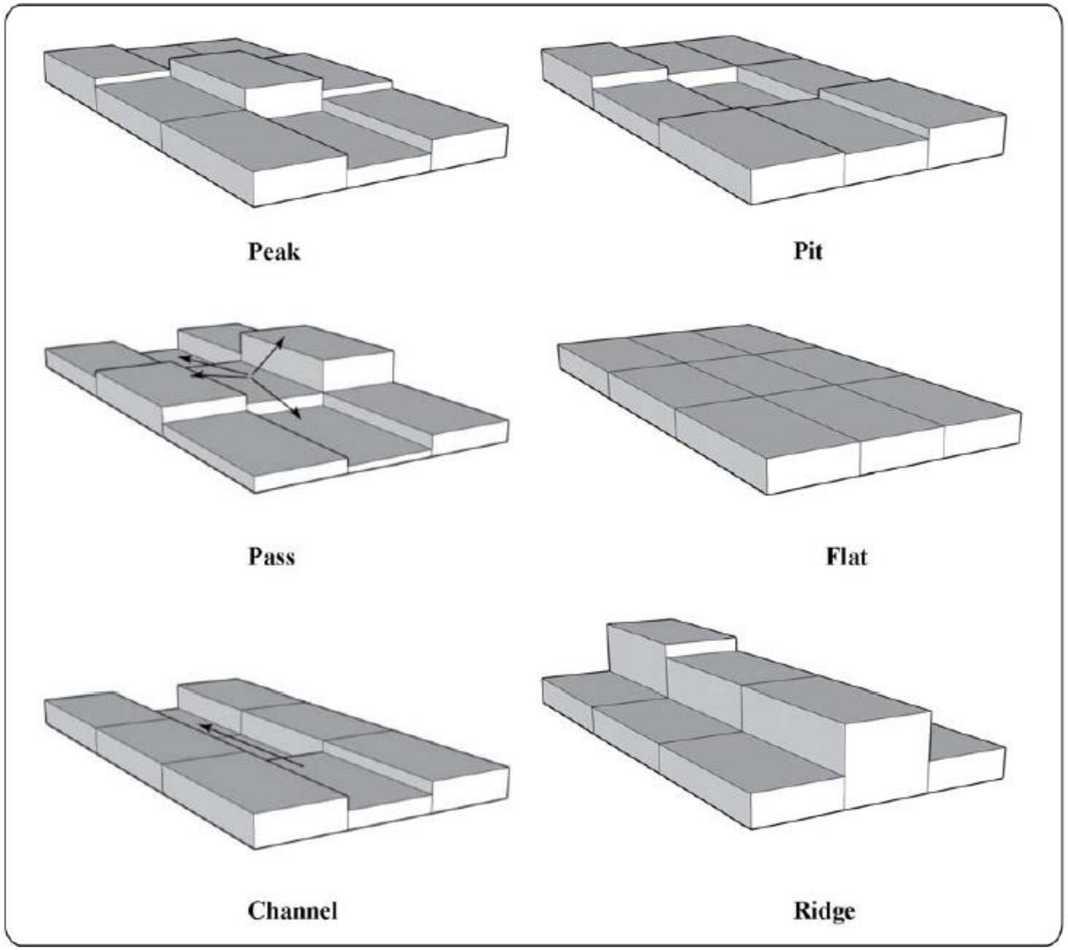
Source: Jenness, J. (2006). ***Topographic Position Index (TPI) Manual***.

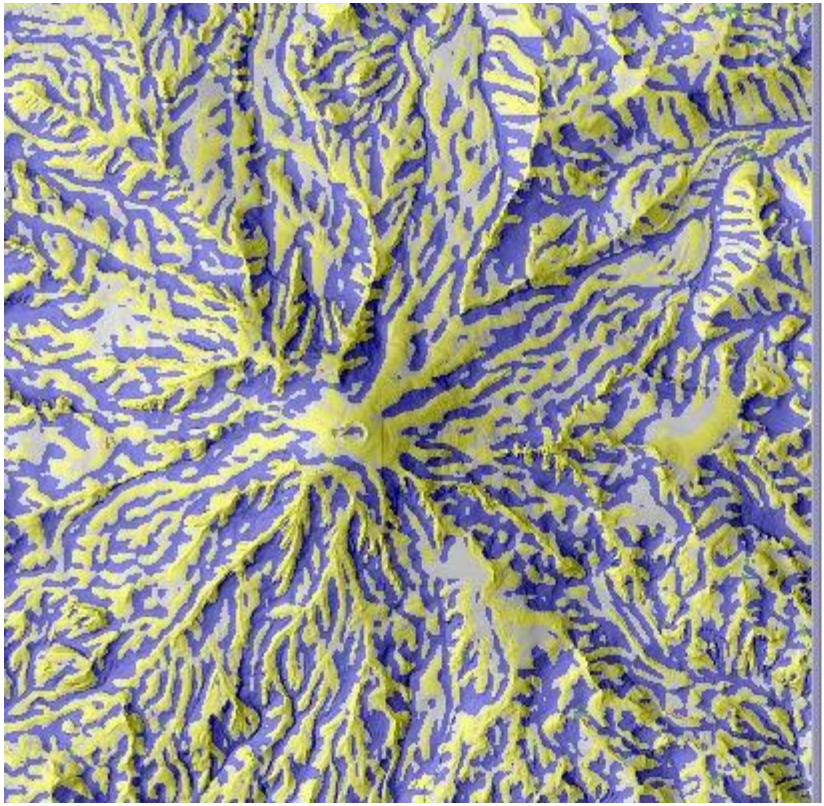
Benthic Terrain Modeler



Source: NOAA Office for Coastal Management

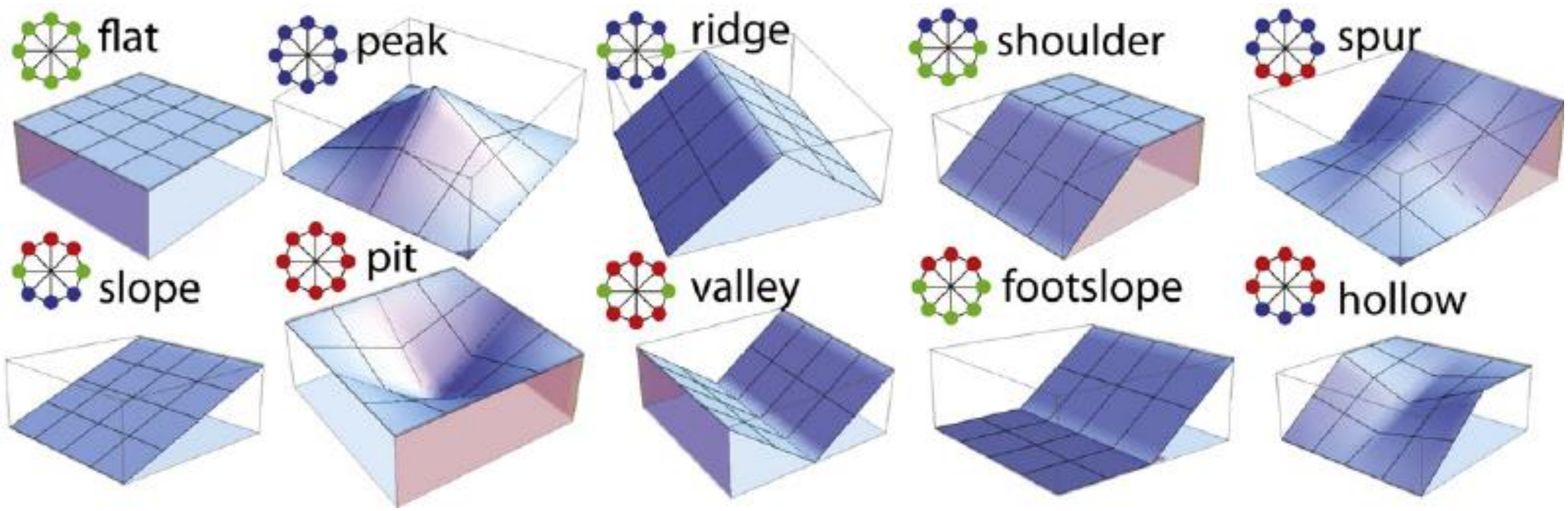
Morphometric Features

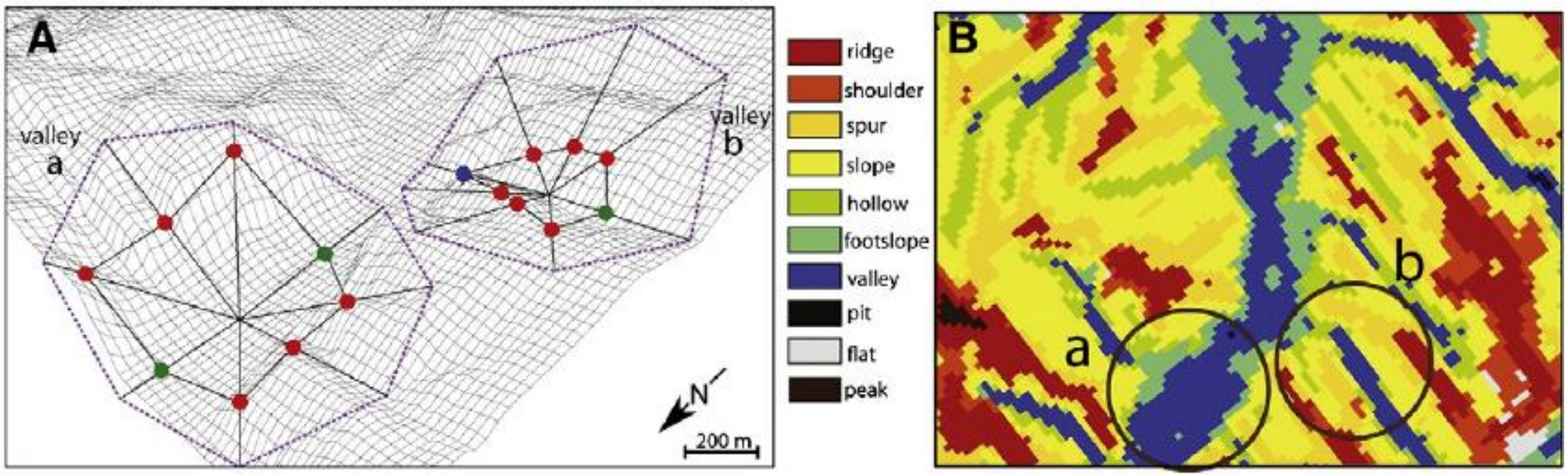




Wood J, 1996. The geomorphological characterisation of digital elevation models. PhD Dissertation.

Geomorphons





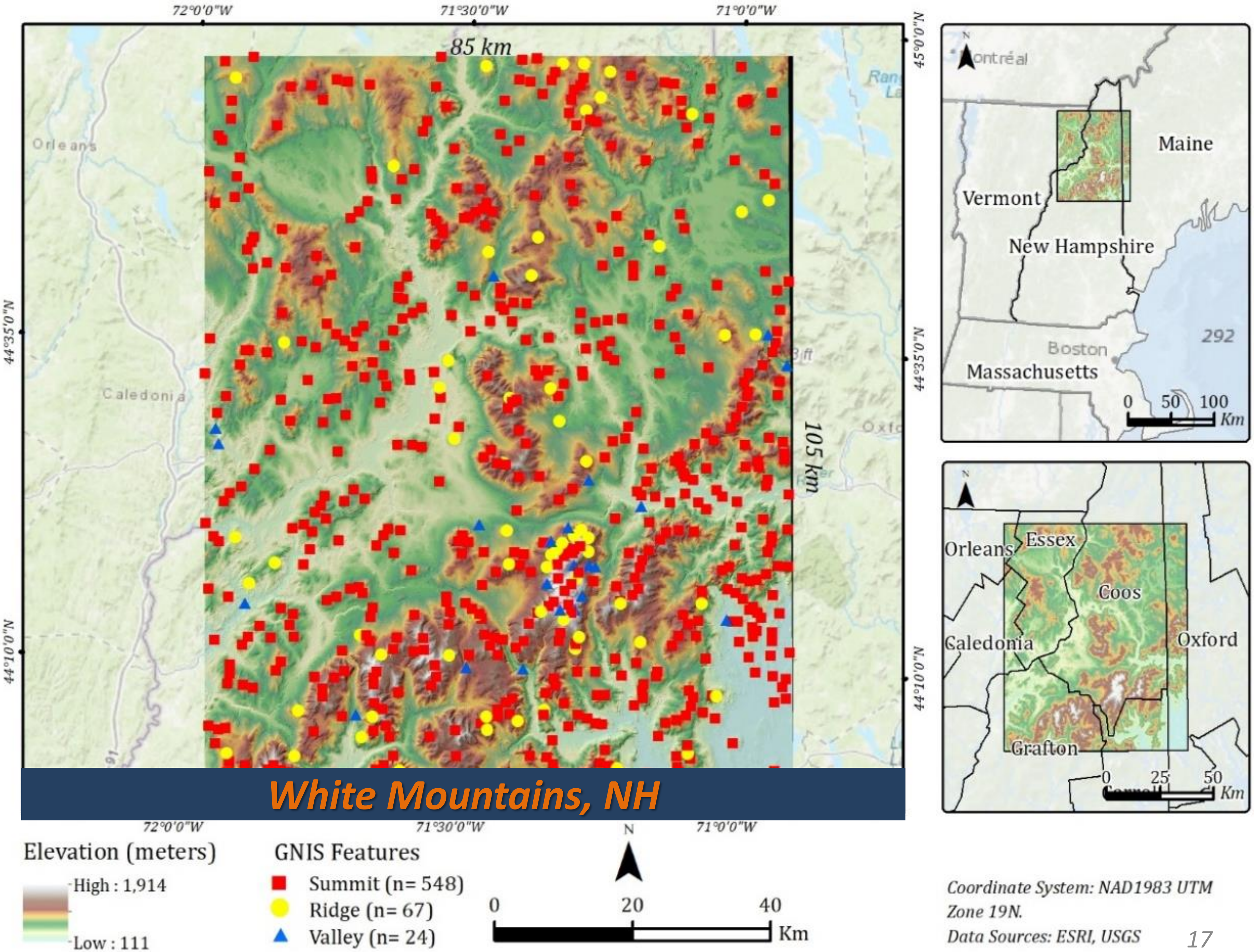
Jasiewicz, J & Stepinski, T. F. (2012). Geomorphons-a pattern recognition approach to classification and mapping of landforms. Geomorphology (182)

COMPARE PARAMETERIZED MODELS

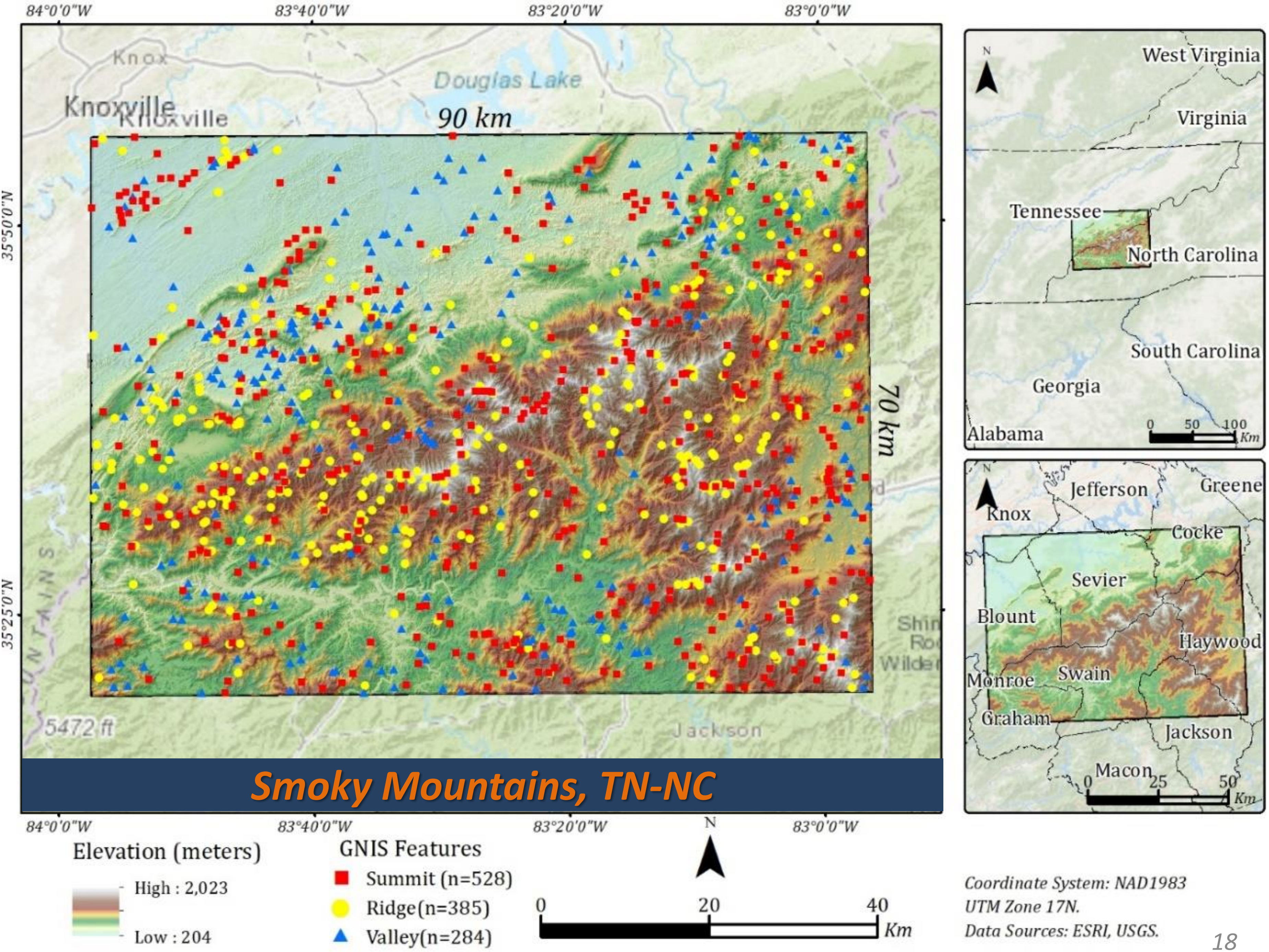
Parameterization

	Morphometric Features	Geomorphons	
	Window size (# cells)	Outer search radius (# cells)	Inner search radius (# cells)
Neighborhood Size (# cells)	11	11	0, 5
	21	21	0, 10
	31	31	0, 10, 15
	41	41	0, 10, 15
	51	51	0, 15, 25
	61	61	0, 15, 25
Slope threshold	1, 5, 10, 15, 20	1, 5, 10, 15, 20	
Curvature	0.001, 0.0001	N/A	
Total # of runs	60	80	

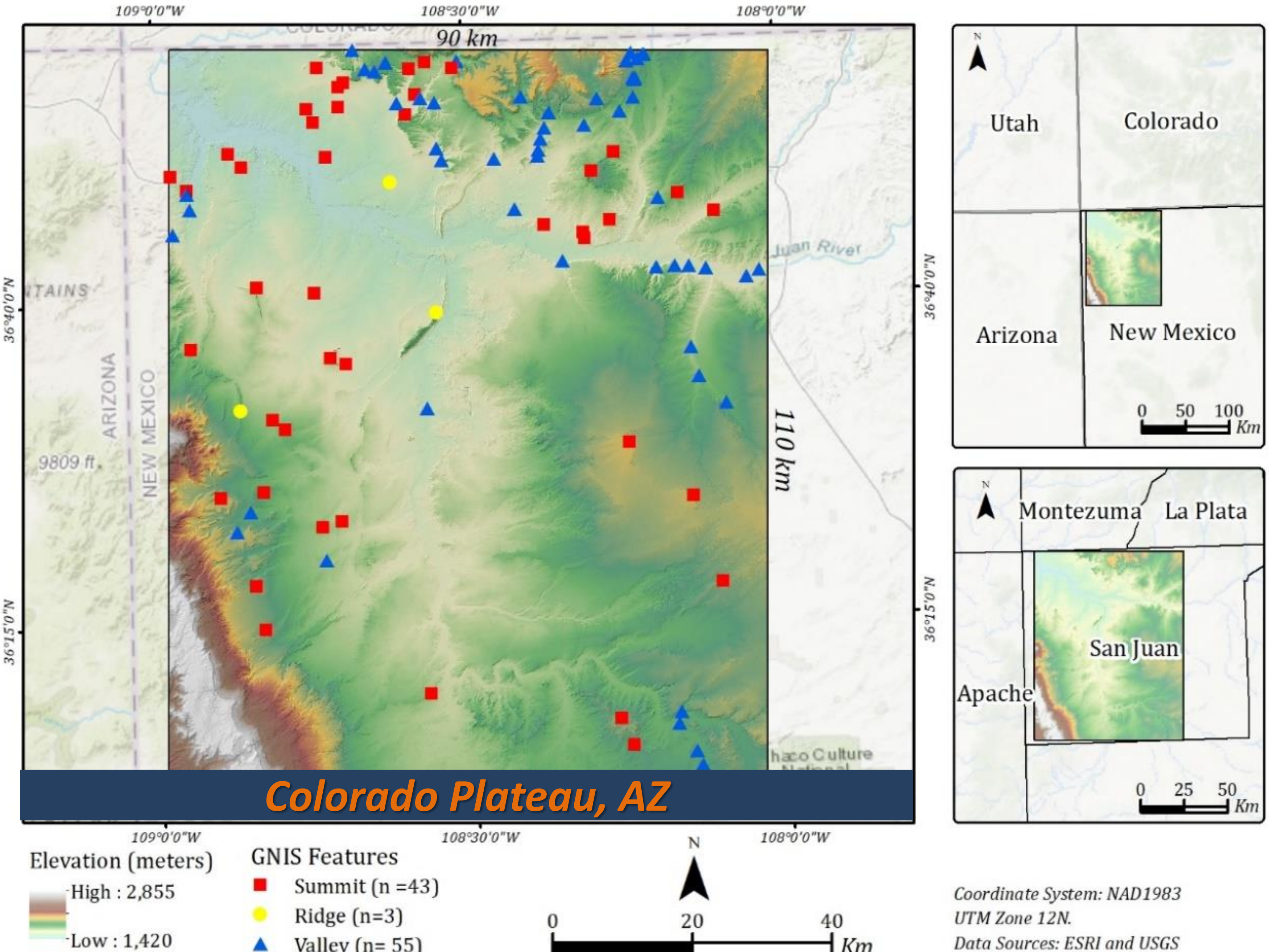
White Mountains, NH



Wael Hassan, Master's Thesis, Ohio University, 2020.



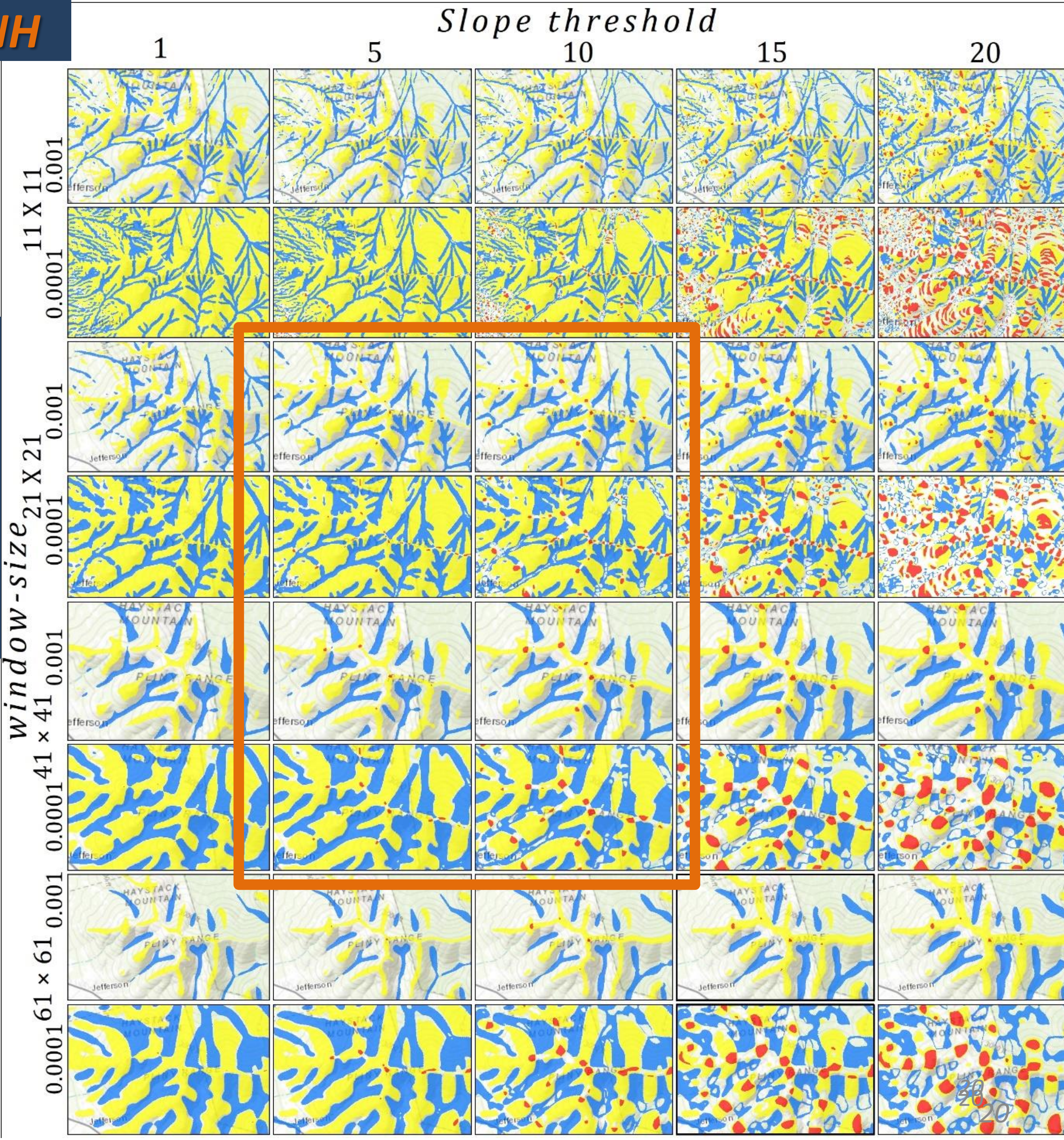
Wael Hassan, Master's Thesis, Ohio University, 2020.



Wael Hassan, Master's Thesis, Ohio University, 2020.

White Mountains, NH

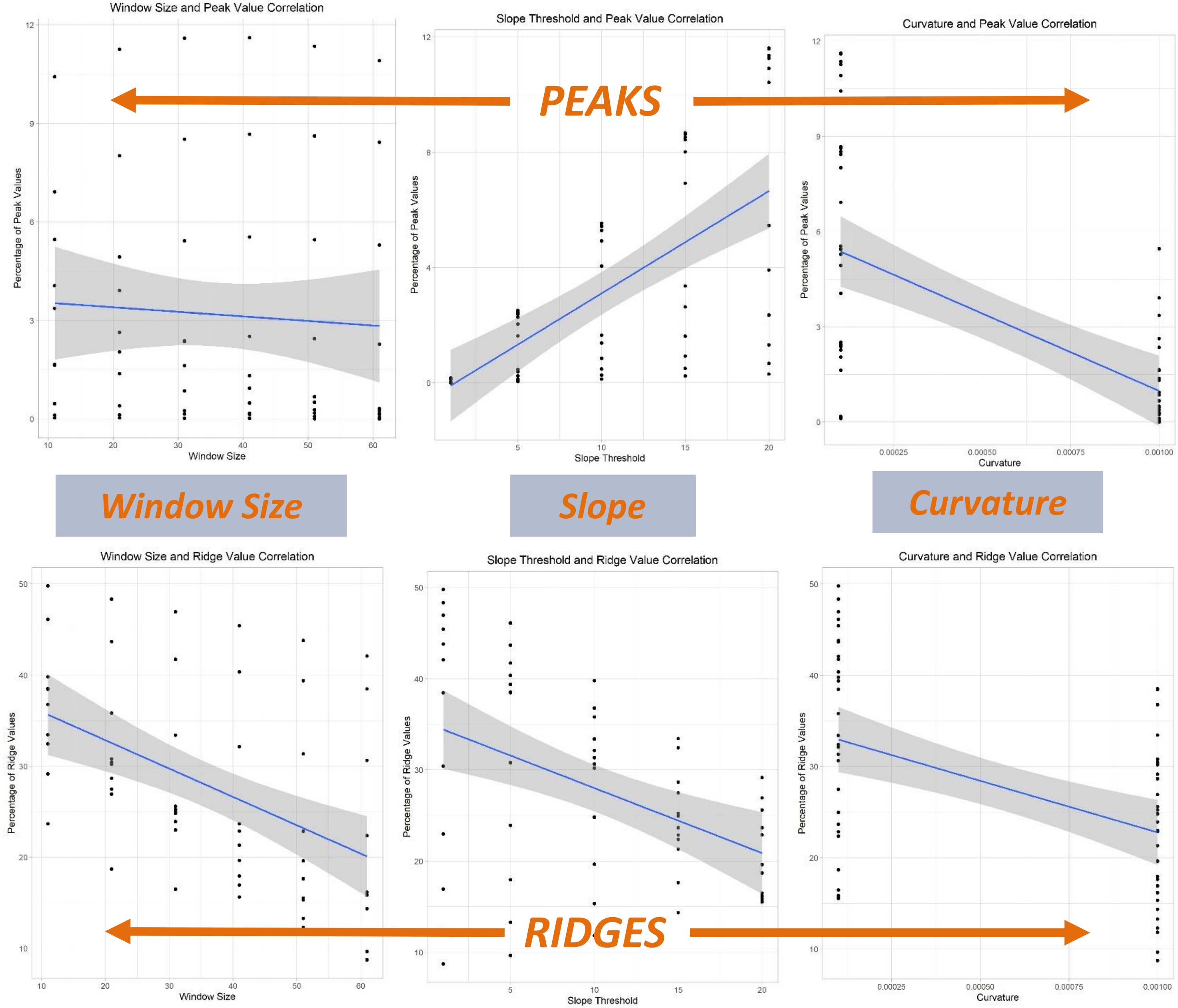
Morpho-metric Features



Wael Hassan, Master's Thesis, Ohio University, 2020.s

Morphometric Features Parameterization

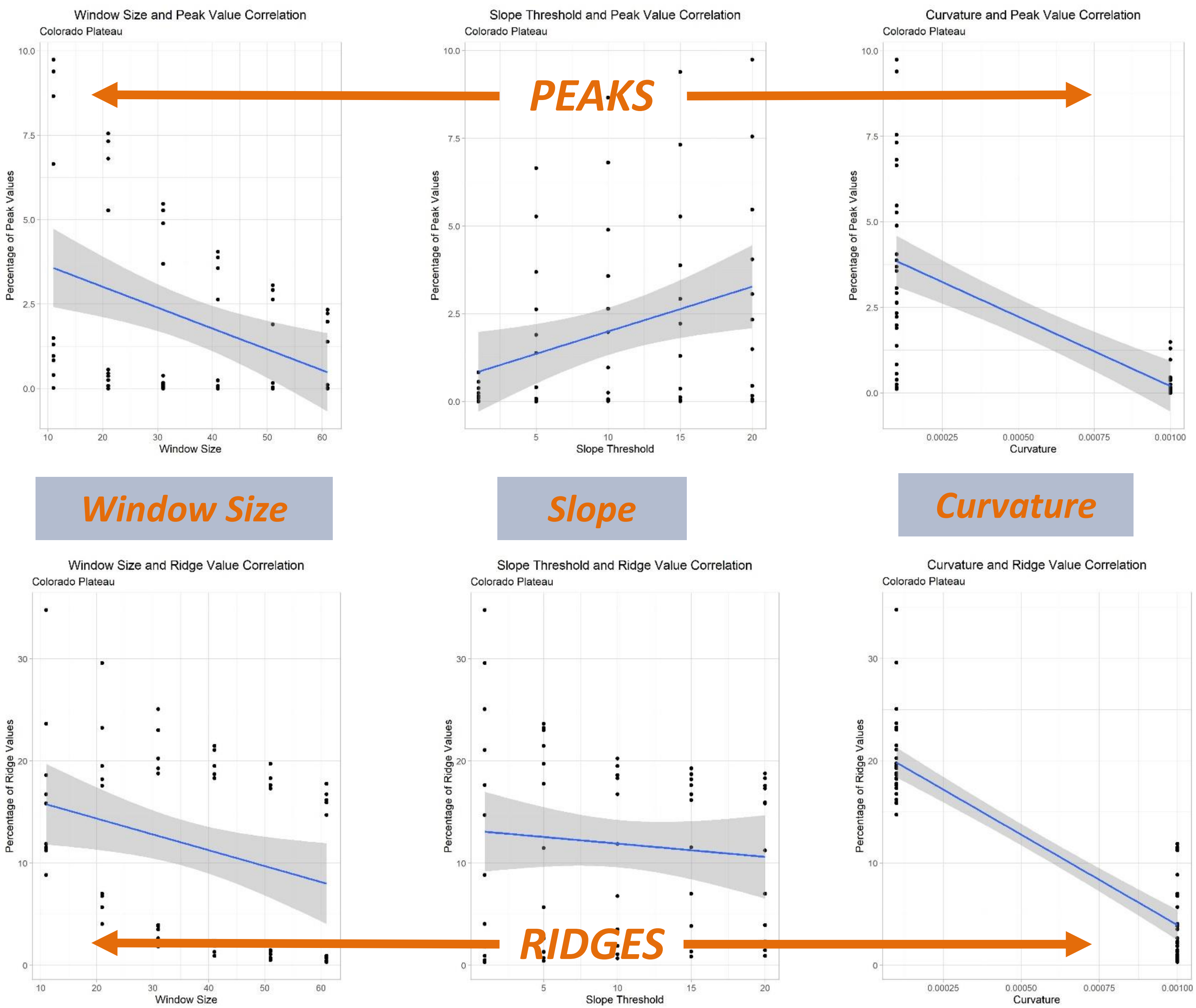
White Mountains, NH



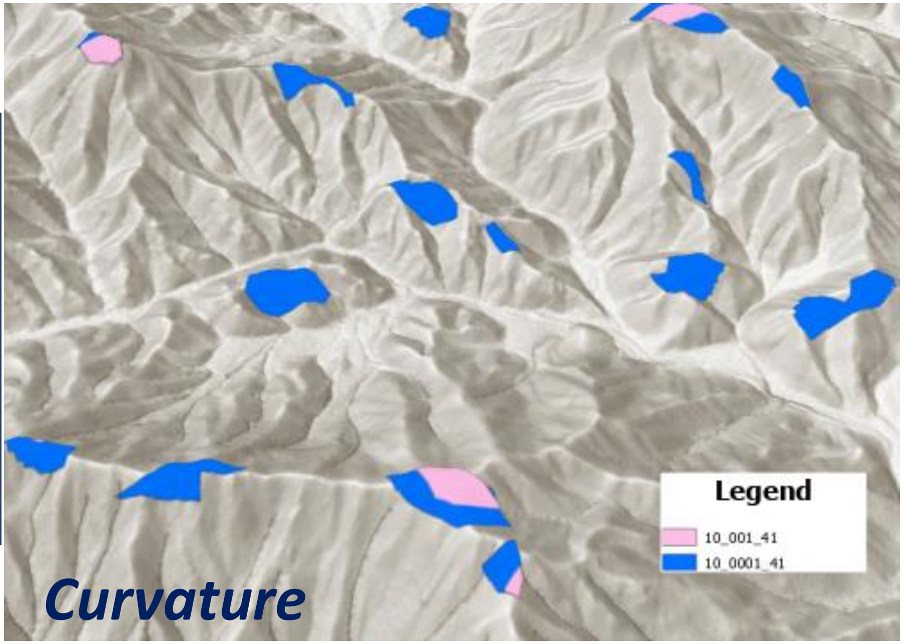
Smoky Mountains, TN-NC

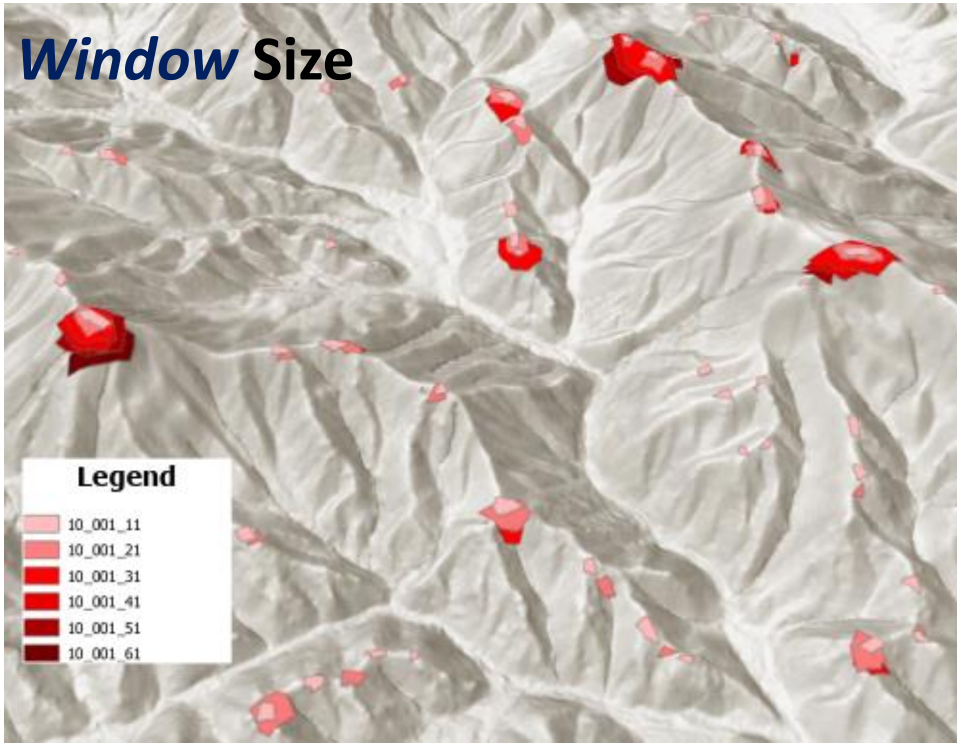
Morphometric Features Parameterization

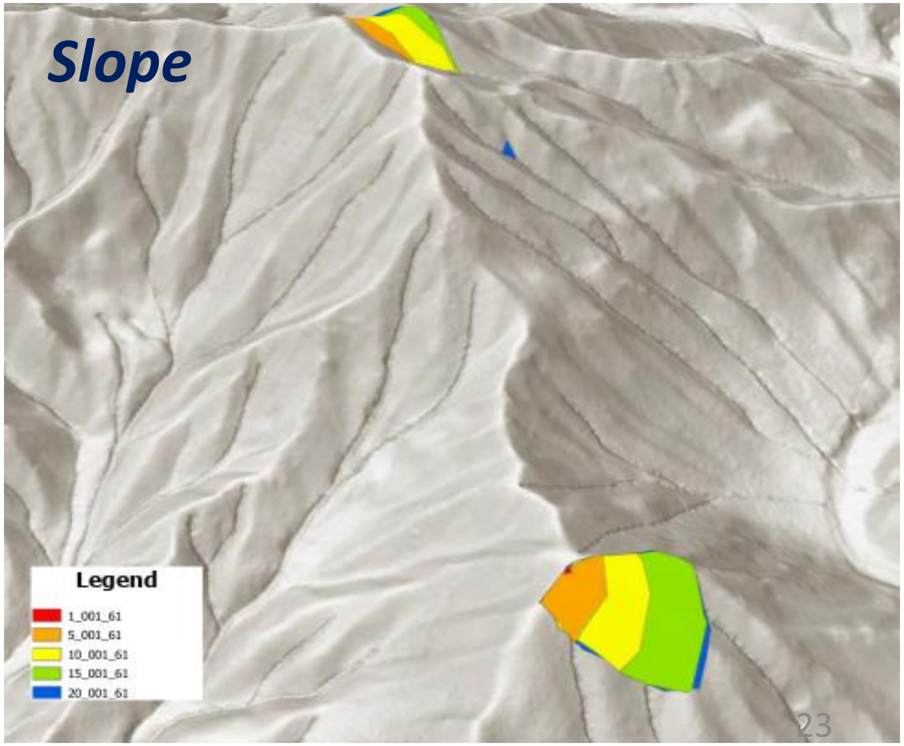
Colorado Plateau, AZ



Morphometric Features Parameterization







Morphometric Features Parameterization

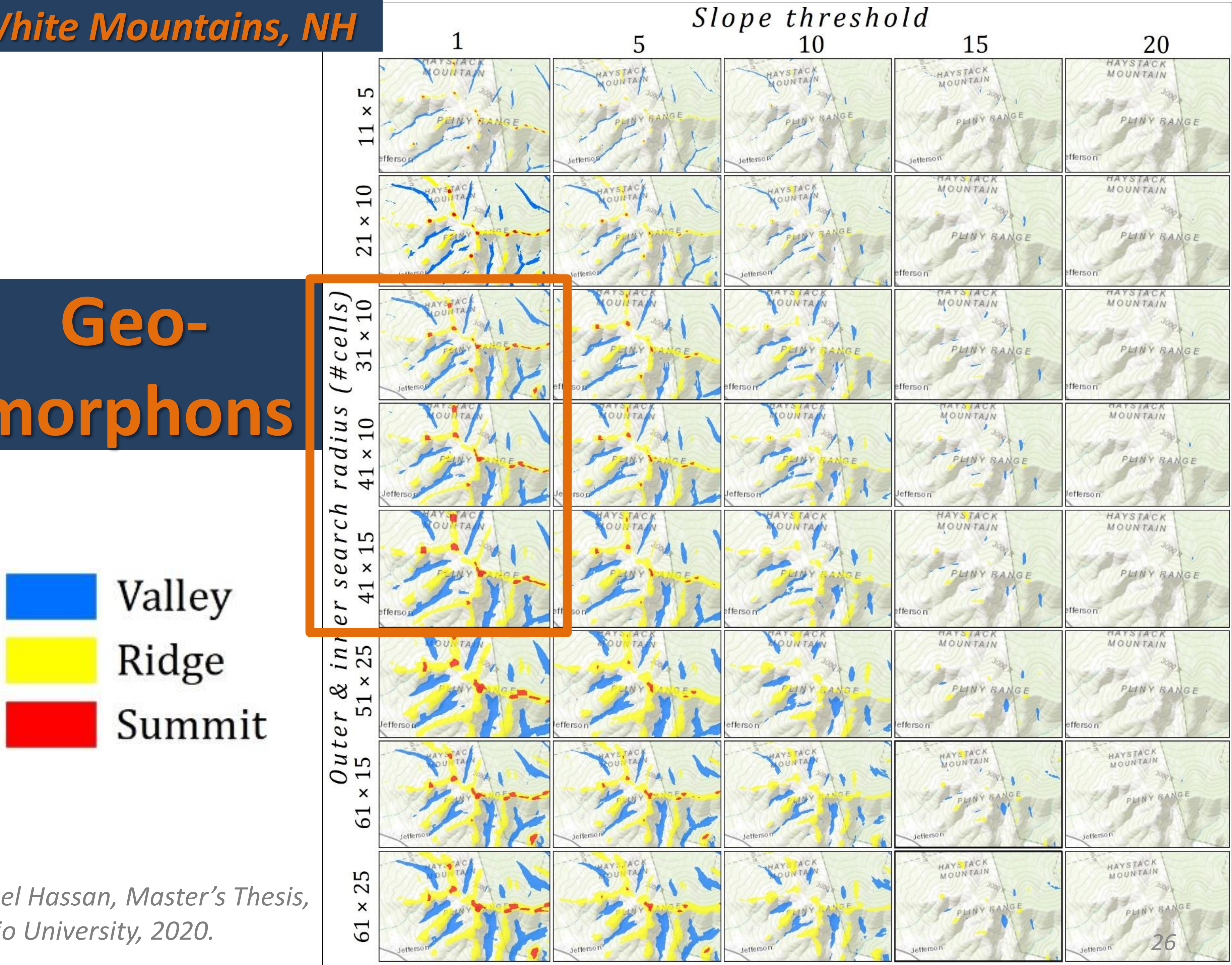
- ✓ Study area does not induce significant differences in the choice of best parameter values
- ✓ Window size best between 300 to 400m
  - ➢ **< 300 m** → *disjointed features and noisy pattern*
  - ➢ **> 400 m** → *misses a lot of features; thick ridges and valleys*
- ✓ Slope thresholds vary for linear and non-linear features
  - ➢ *Peak (non-linear eminences) → ~5° slope*
  - ➢ *Linear eminences / depressions → ~5° - 10° slope*
- ✓ Curvature thresholds also vary for linear and non-linear features
  - ➢ *Peak (non-linear eminences) → ~ 0.001 curvature*
  - ➢ *Linear eminences / depressions → ~ 0.0001 curvature*

Morphometric *Peaks* vs. GNIS *Summits*

- ✓ Overlaying extracted Wood's peak polygons with GNIS Summit features suggests that …
  - ➢ ***It will be practically impossible to use the Wood's method to reliably identify salient non-linear eminence peaks and areal extents***
  - ➢ *Too many extraneous peaks needed to capture all GNIS summits inside some peak polygon*
  - ➢ *Best parameters selected to maximize visual appeal of extracted peaks leads to several missed GNIS Summit features*
  - ➢ *If parameters are selected to maximize proximity of peak polygons to GNIS Summit features, the quality of extracted peaks is unacceptable*

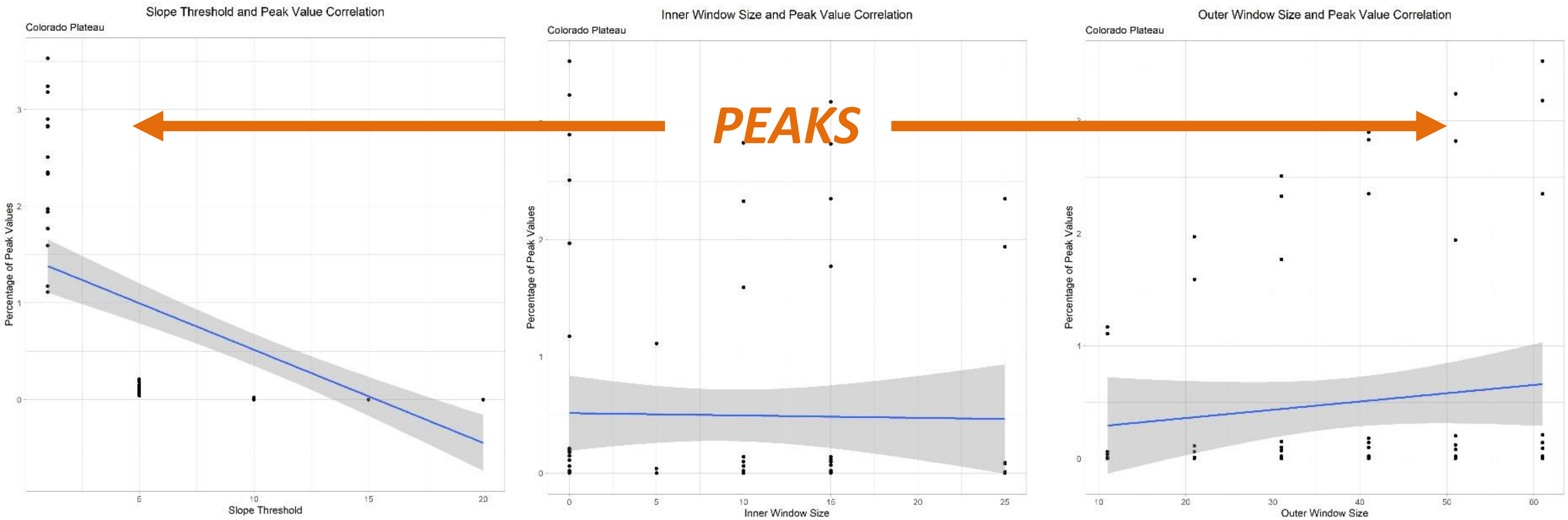
White Mountains, NH

Geo-morphons

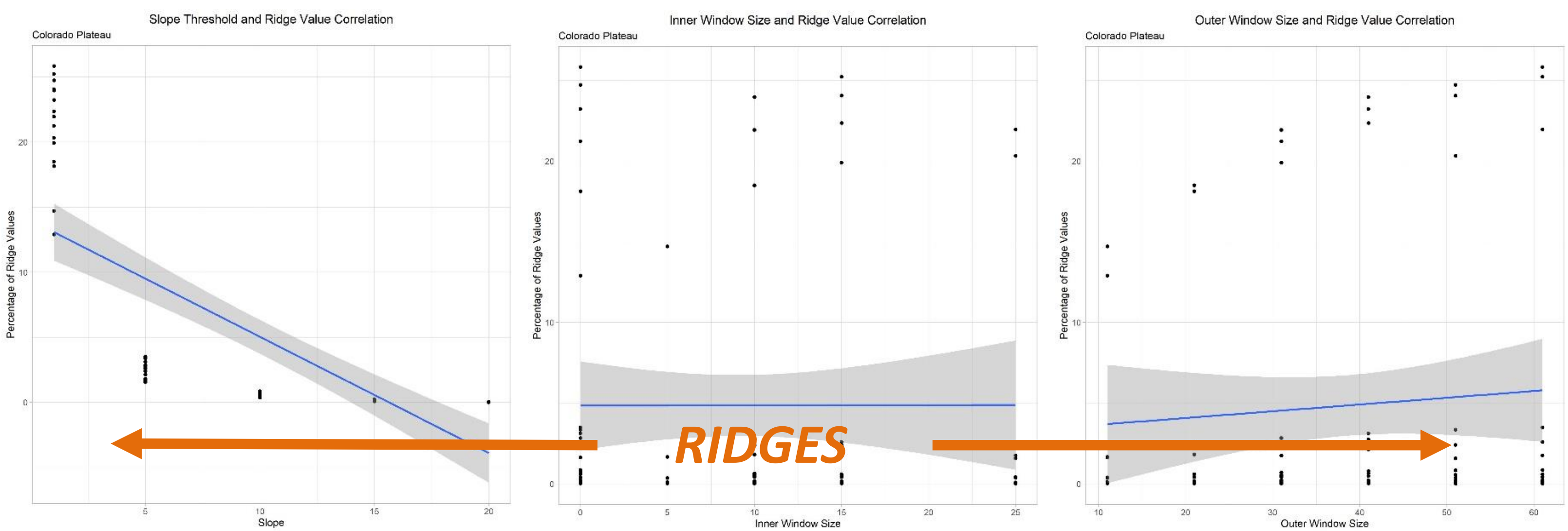


Wael Hassan, Master's Thesis, Ohio University, 2020.

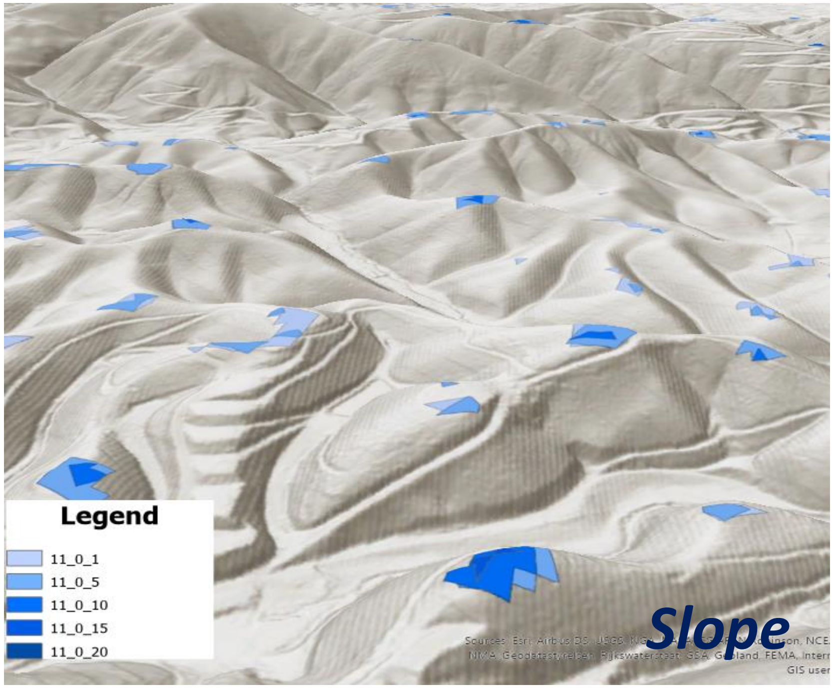
Geomorphon Parameterization

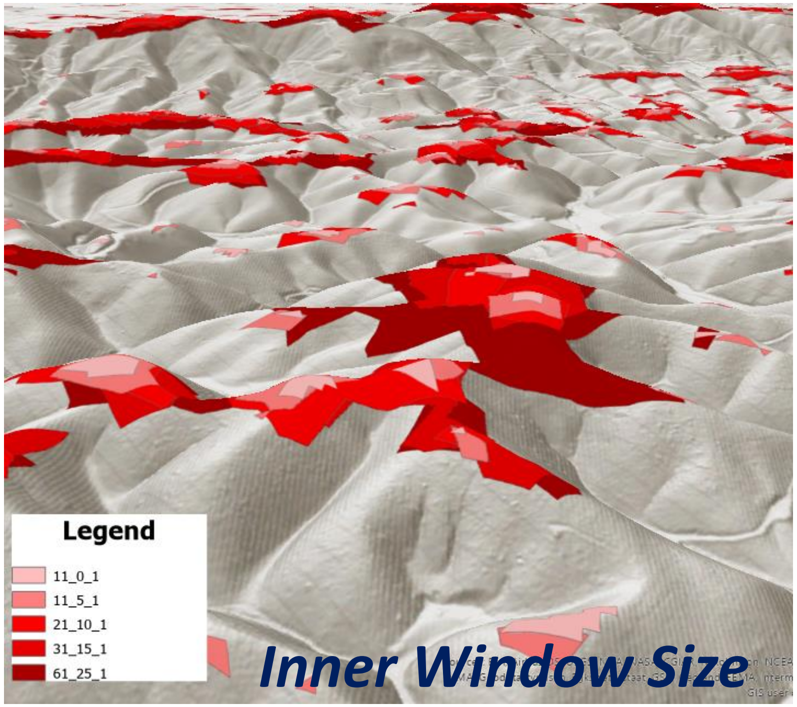


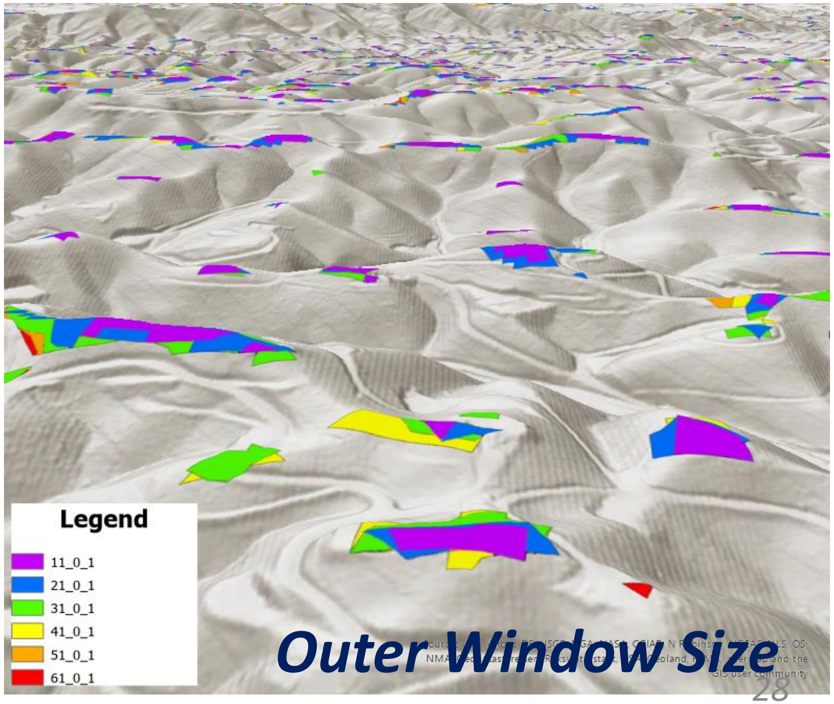
Window Size | **Slope** | **Curvature**



Geomorphon Parameterization







Geomorphon Parameterization

- ✓ ***Study area*** does not induce significant differences in the choice of best parameter values

- ✓ ***Best parameter values similar*** for non-linear eminences (summits) and linear eminences (ridges) / depressions (valleys)
  - ➢ *Outer window size ~ 300 - 400m*
  - ➢ *Inner window ~ 150m*
  - ➢ *Slope threshold ~ 1°*

Geomporhon *Summits* vs. GNIS *Summits*

- ✓ Overlaying extracted geomorphon derived summit polygons with GNIS Summit features suggests ***better (than Wood's) correspondence with GNIS Summit features***

- ✓ ***UNLIKE for Wood's morphometric features,*** best parameter values for window sizes and slope threshold selected to maximize visual appeal of extracted summits ALSO maximizes the number of GNIS features at close proximity to the extracted summit polygons

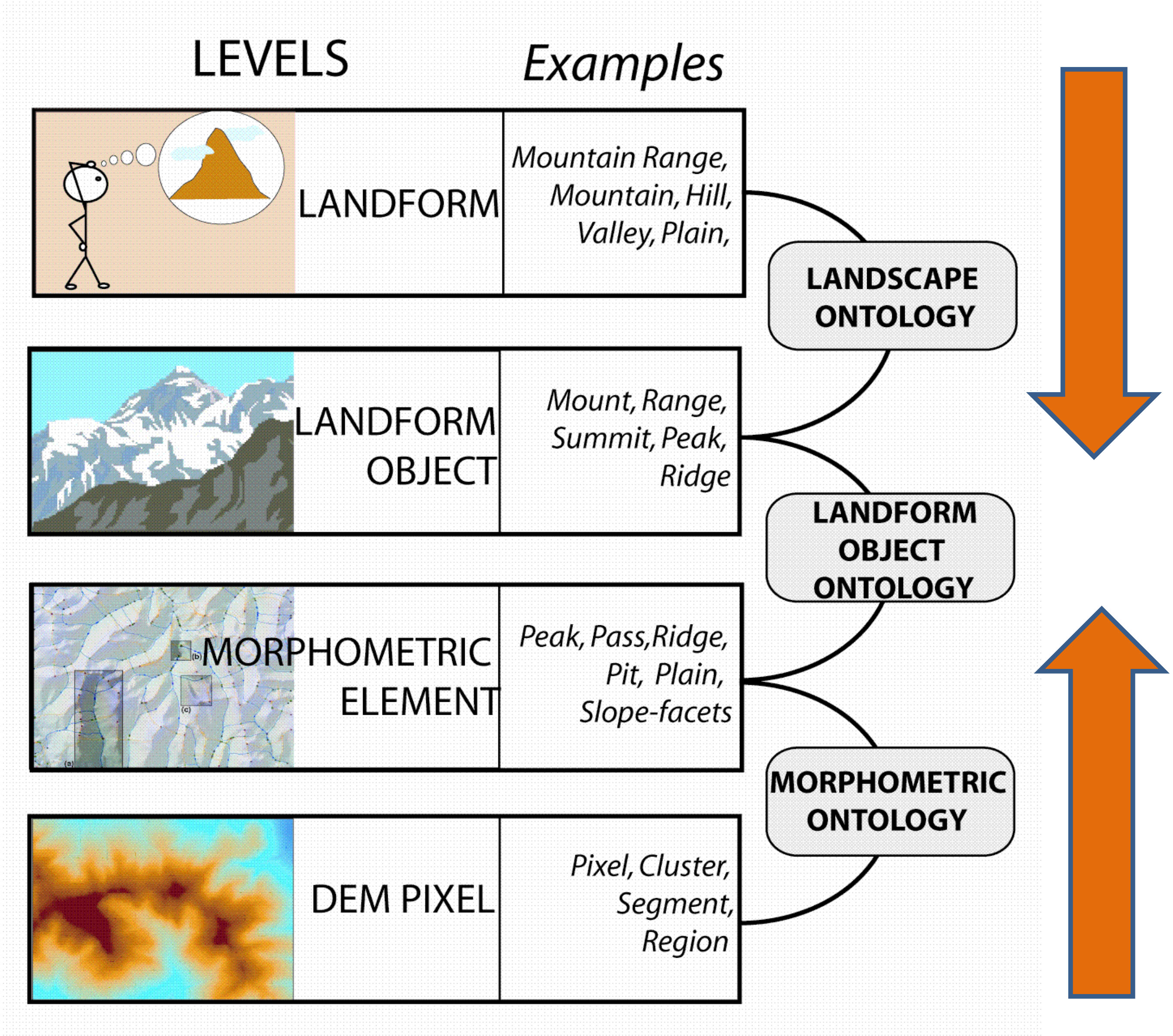
Semantic Similarity Assessment

- ✓ ***Within-method*** confusion matrix for the same method (*Wood vs. Wood Geomorphon vs. Geomorphon*) analysis of a few good and bad (*determined from visual analysis*) models were constructed
    - *High overall similarity between the best two models and low similarity between good and bad models confirms the selections from visual analysis*

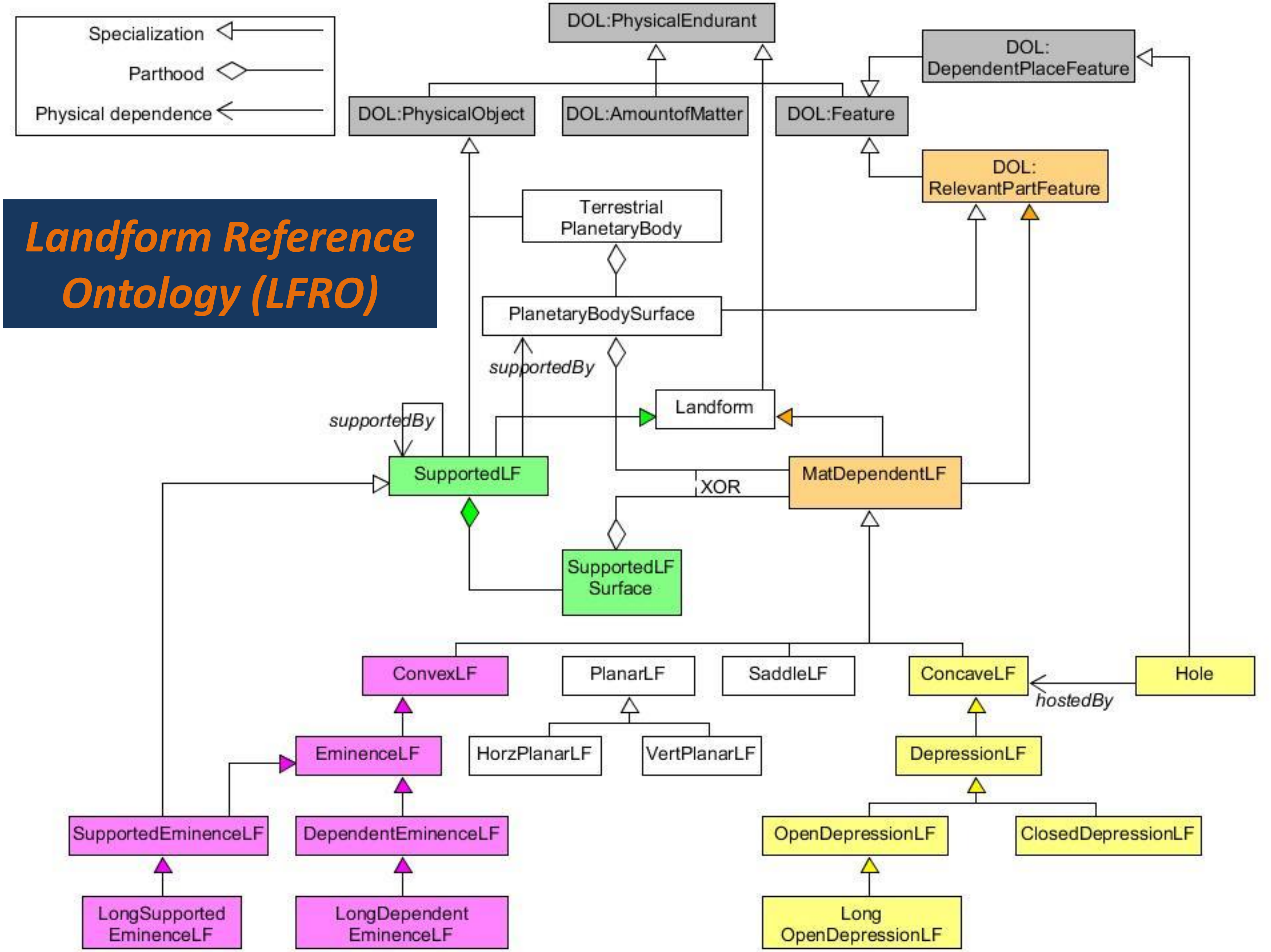
- ***Cross-method*** confusion matrices between Wood and Geomorphon methods were generated to compare semantic similarity of equivalent categories
    - *Good match between (Wood's) Peak and Geomorphon's (Summit) polygons*

SPECIFIC GEOMORPHOMETRY

Hierarchical Integrated Reasoning

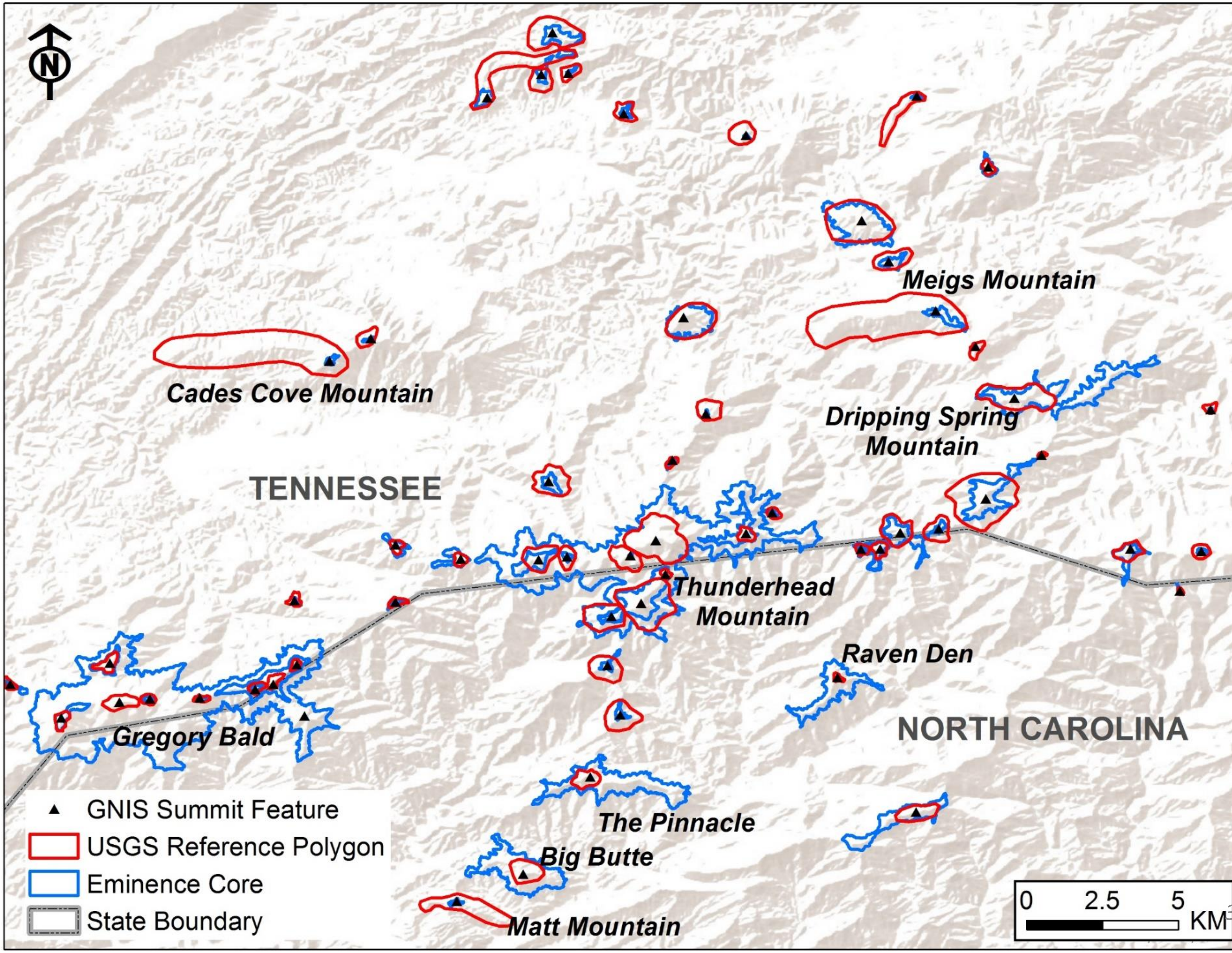


Landform Reference Ontology (LFRO)



Sinha G, Arundel S, Hahmann T, Stewart K, Usery EL, Mark DM (2018). The Landform Reference Ontology (LFRO): A foundation for exploring linguistic and geospatial conceptualization of landforms. GIScience 2018, LIPICS Vol. 114. DOI: [10.4230/LIPIcs.GISCIENCE.2018.59](https://doi.org/10.4230/LIPIcs.GISCIENCE.2018.59)

Manual *vs.* Automated Mapping



KEEP IN MIND THE SUBJECTIVE CULTURAL , COGNITIVE & LINGUISTIC FOUNDATIONS OF LANDFORM MAPPING