AUTOMATED EXTRACTION OF AREAL EXTENTS FOR GNIS *SUMMIT* FEATURES USING THE EMINENCE-CORE METHOD

OHIO UNIVERSITY
1804
GEO DEPARTMENT OF GEOGRAPHY

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HOME

3DEP FEATURE EXTRACTION AND CONFLATION

DATA INTEGRATION

HIGH-PERFORMANCE COMPUTING

GEOSPATIAL SEMANTICS AND ONTOLOGY

MULTISCALE REPRESENTATION

NATIONAL TERRAIN MAPPING

National Terrain Mapping

The long-term objective of this research is to automatically extract and/or map terrain features for national mapping, and in so doing, set precedence for similar work in other subject matter realms.

The CEGIS 3DEP Initiative involves applications research projects, including pilots and test beds in areas such as the generation of derivative products from lidar that are National in scope, and creation of decision support systems with 3DEP and geospatial semantics. The modeling, identification, and extraction mechanisms for terrain features such as mountains, hills, and valleys are in part dependent on an understanding of their creation, on their morphometric properties such as shape and size, and on naïve perception of the physical landscape. Lidar data are being acquired as a part of the 3D Elevation Program (3DEP) and have sufficient resolution to capture the many and varied aspects of all types of terrain features. The ability to use these data as a source for extraction of geomorphologic and/or terrain features that can then be used to support spatial reasoning and natural language processing, and topographic science modeling and map generation, depends on a thorough understanding of both the features themselves and the everyday human conceptions of those features.

USGS GNIS: Mapping Toponyms

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Search

Mapping, Remote Sensing, and Geospatial Data

What is the Geographic Names Information System (GNIS)?

The Geographic Names Information System (GNIS) was developed by the U.S.Geological Survey (USGS) in cooperation with the U.S. Board on Geographic Names (BGN), which maintains cooperative working relationships with state names authorities to standardize geographic names. GNIS contains information about the official names for places, features, and areas in the 50 states, the District of Columbia, and the territories and outlying areas of the United States, including Antarctica. GNIS is the geographic names component of The National Map.

GNIS contains records on more than 2 million geographic names in the United States, including populated places, schools, lakes, streams, valleys, and ridges. It includes all feature types except for road and highway names.

Search the GNIS using its Query Form for the United States and Its Territories. A feature search on GNIS yields the longitude and latitude of the feature, the name of the topographic map on which the feature can be found, and feature information. There are also links to topographic maps as well as aerial photography via the National Map and other sources.

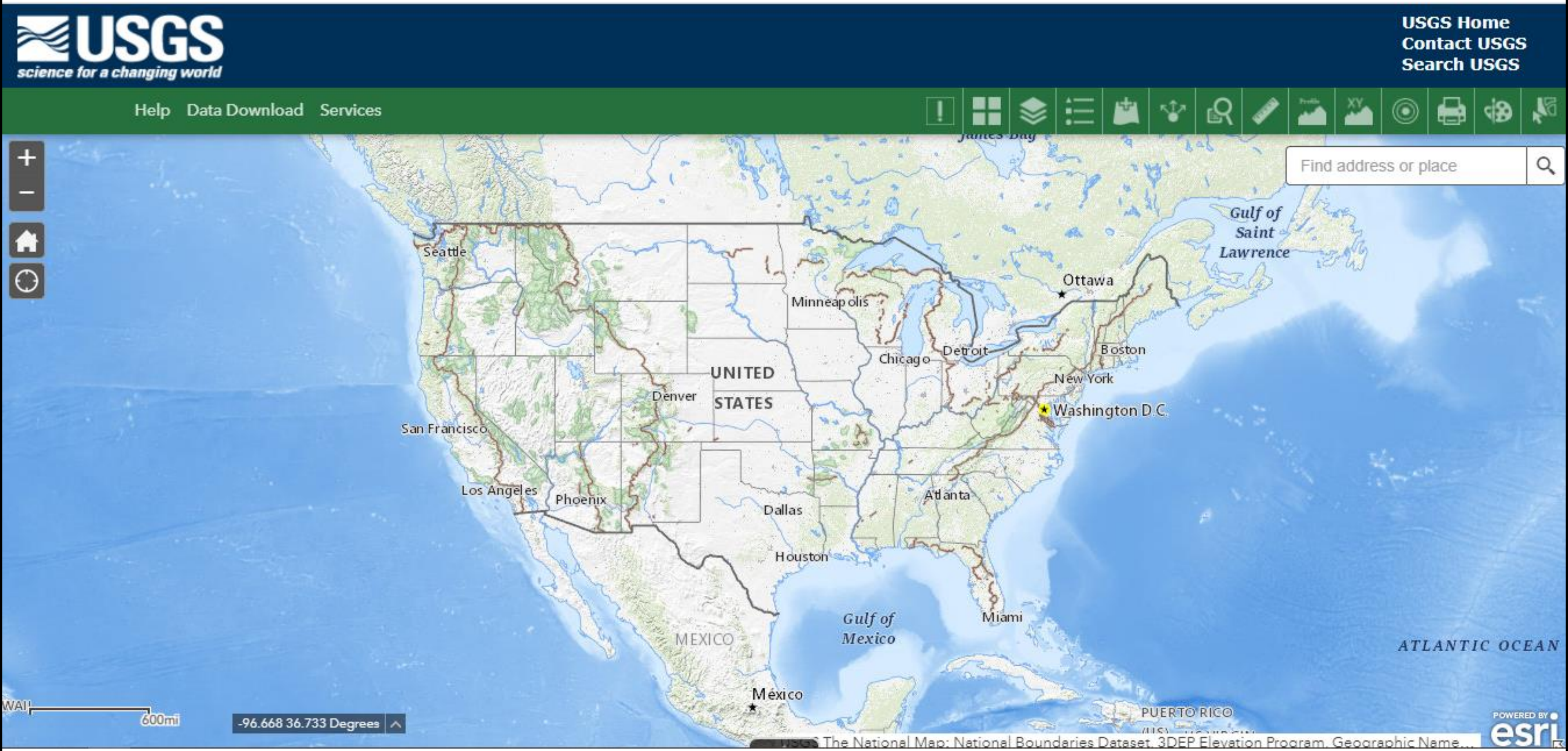
Learn more:

- Geographic Names Information Guide
- An Introduction to the United States Board on Geographic Names

Explore More Science

maps and atlases
National Geographic Names Information System (GNIS)
topographic maps
Mapping, Remote Sensing, and Geospatial Data

USGS: The National Map



https://apps.nationalmap.gov/viewer

GNIS Classes for Eminences

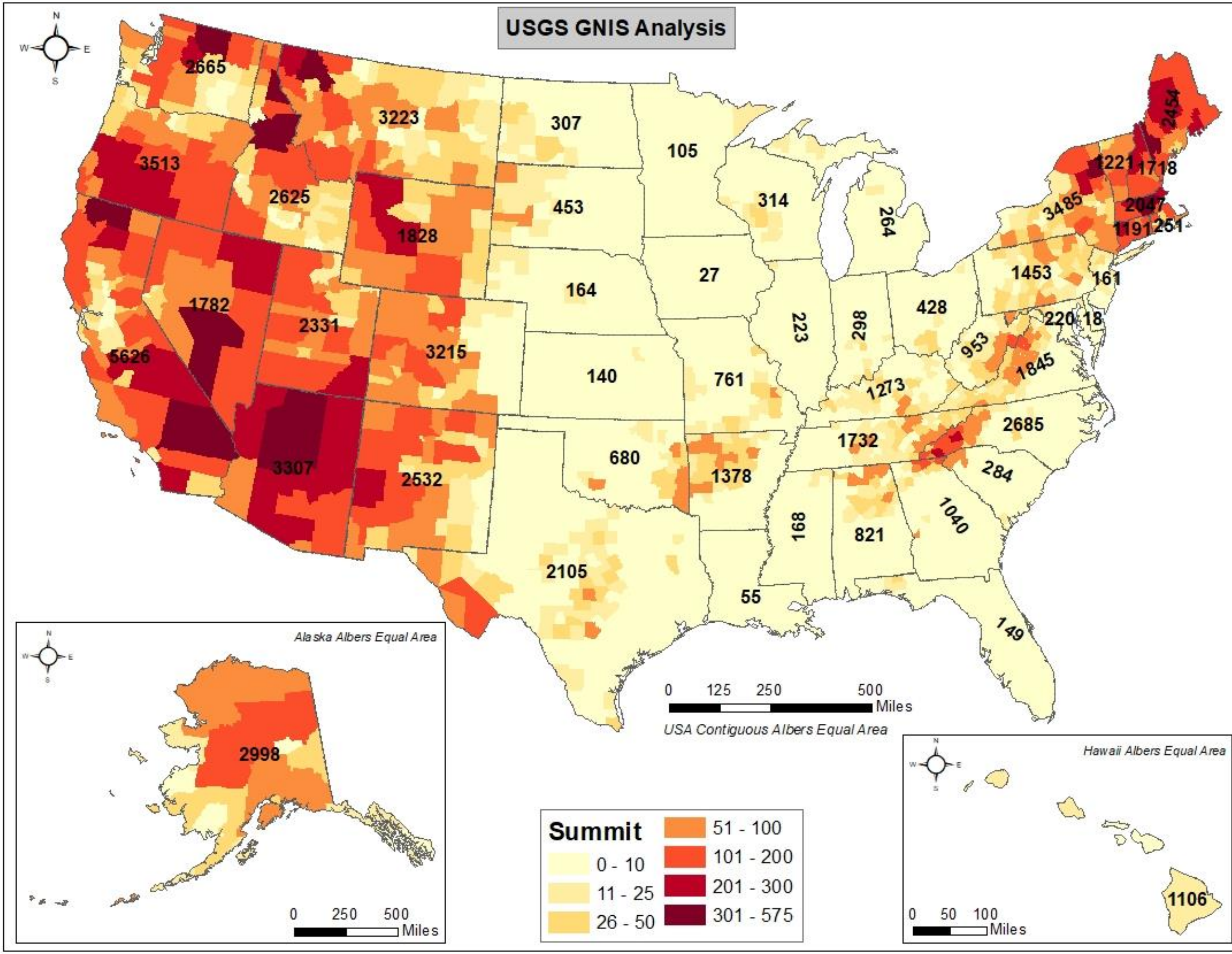
GNIS TYPE	DESCRIPTION
Cliff	**Very steep or vertical slope** *(bluff, crag, head, headland, nose, palisades, precipice, promontory, rim, rimrock)*
Pillar	**Vertical, standing, often spire-shaped, natural rock formation** *(chimney, monument, pinnacle, pohaku, rock tower)*
Range	**Chain of hills or mountains; a somewhat linear, complex mountainous or hilly area** *(cordillera, sierra)*
Ridge	**Elevation with a narrow, elongated crest which can be part of a hill or mountain** *(crest, cuesta, escarpment, hogback, lae, rim, spur)*
Summit	**Prominent elevation rising above the surrounding level of the Earth's surface; does not include pillars, ridges, or ranges** *(ahu, berg, bald, butte, cerro, colina, cone, cumbre, dome, head, hill, horn, knob, knoll, mauna, mesa, mesita, mound, mount, mountain, peak, puu, rock, sugarloaf, table, volcano)*

GNIS Eminence Type Counts

1	CLASS	GENERIC	FREQ
2	Summit	MOUNTAIN	21,413
3	Summit	HILL	16,765
4	Summit	PEAK	7,042
5	Summit	BUTTE	3,914
6	Summit	KNOB	3,774
7	Summit	POINT	1,597
8	Summit	MESA	1,380
9	Summit	ROCK	1,179
10	Summit	HILLS	636
11	Summit	TOP	601
12	Summit	KNOLL	512
13	Summit	MOUND	363
14	Summit	BUTTES	358
15	Summit	PEAKS	298
16	Summit	DOME	232
17	Summit	HEAD	231
18	Summit	ROCKS	219
19	Summit	SUMMIT	190
20	Summit	MOUNTAINS	182
21	Summit	CONE	106
22	Summit	KNOBS	101
23	Summit	KNOLLS	90
24	Summit	TABLE	90
25	Summit	RIDGE	81
26	Summit	MOUNDS	57
27	Summit	HUMP	48
28	Summit	LOOKOUT	48
29	Summit	ROUNDTOP	45
30	Summit	NIPPLE	42
31	Summit	TEMPLE	40
32	Summit	NEST	40

CLASS	GENERIC	FREQ
Range	MOUNTAINS	893
Range	HILLS	866
Range	RANGE	405
Range	MOUNTAIN	82
Range	BUTTES	59
Range	BREAKS	14
Range	KNOBS	14
Range	PEAKS	8
Range	SISTERS	6
Range	RIDGE	6
Pillar	ROCK	1,337
Pillar	ROCKS	115
Pillar	PINNACLE	68
Pillar	MONUMENT	50
Pillar	TOWER	34
Pillar	PINNACLES	18
Pillar	NEEDLES	15
Pillar	NEEDLE	15
Pillar	PEAK	13
Pillar	POINT	13
Pillar	CASTLE	12
Pillar	SPIRE	12
Pillar	CHIMNEYS	10
Pillar	CHIMNEY	9
Pillar	PILLAR	9
Pillar	THUMB	8
Pillar	CRAGS	8
Pillar	TOOTH	6
Pillar	HEAD	6

CLASS	GENERIC	FREQ
Ridge	RIDGE	12,525
Ridge	MOUNTAIN	482
Ridge	DIVIDE	209
Ridge	HILL	181
Ridge	POINT	163
Ridge	SPUR	108
Ridge	HILLS	97
Ridge	BACKBONE	97
Ridge	MOUNTAINS	78
Ridge	HOGBACK	60
Ridge	LEAD	43
Ridge	KNOBS	35
Ridge	RIDGES	34
Ridge	RANGE	34
Ridge	REEF	27
Ridge	CREST	24
Ridge	BUTTE	20
Ridge	RIM	18
Ridge	WALL	17
Ridge	BACK	16
Ridge	MORAINE	16
Ridge	BUTTES	15
Ridge	NARROWS	14
Ridge	ROCKS	13
Ridge	CLEAVER	12
Ridge	MESA	12
Ridge	PEAKS	11
Ridge	BLUFF	10
Ridge	ROCK	10
Ridge	ISLAND	8
Ridge	ARM	8


USGS GNIS Analysis
2665
3223
307
105
2454
3513
2625
453
314
264
1221
1718
3485
2047
1191
251
1828
27
164
1453
161
1782
2331
223
298
428
220
18
5626
3215
953
140
761
1845
1273
2685
1732
680
3307
2532
1378
284
1040
168
821
2105
55
149
Alaska Albers Equal Area
2998
0 250 500 Miles
0 125 250 500 Miles
USA Contiguous Albers Equal Area
Summit
0 - 10
11 - 25
26 - 50
51 - 100
101 - 200
201 - 300
301 - 575
Hawaii Albers Equal Area
1106
0 50 100 Miles

USGS GNIS: Mapping Toponyms

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Query Form For The Uni

Feature Name:

Exact Match

State: Ohio

County:

Feature Query Results

Click the feature name for details and to access map services
Click any column name to sort the list ascending ▲ or descending ▼

Feature Name	ID	Class	County	State	Latitude	Longitude	Ele(ft*)	Map**	BGN Date	Entry Date
Acme Hill	1063506	Summit	Medina	OH	410135N	0814756W	1214	Seville	-	01-OCT-1991
Allen Knob	1048452	Summit	Fairfield	OH	394133N	0823920W	1145	Amanda	-	12-JUL-1979
Anstine Hill	1963544	Summit	Hardin	OH	403531N	0835019W	1102	Roundhead	-	11-SEP-2002
Asher Hill	1037515	Summit	Ross	OH	391956N	0831455W	1283	Bourneville	-	12-JUL-1979
Backus Knob	1056212	Summit	Tuscarawas	OH	401636N	0813001W	1194	Newcomerstown	-	12-JUL-1979
Bacon Hill	1067182	Summit	Portage	OH	410012N	0811728W	1217	Suffield	-	01-FEB-1992
Bald Hill	1037589	Summit	Ross	OH	392332N	0825602W	1250	Kingston	-	12-JUL-1979
Bald Knob	1062578	Summit	Ashland	OH	403916N	0821421W	1224	Loudonville	-	01-APR-1991
Bald Knob	1048483	Summit	Ross	OH	391506N	0831917W	1115	South Salem	-	12-JUL-1979
Bald Knob	1048482	Summit	Pike	OH	390154N	0830432W	1007	Piketon	-	12-JUL-1979
Bald Knob	1061350	Summit	Licking	OH	400204N	0822224W	1201	Hanover	-	12-JUL-1979
Bald Knob	1060841	Summit	Licking	OH	400640N	0821133W	1112	Toboso	-	12-JUL-1979
Bald Knob	1048481	Summit	Logan	OH	401726N	0834142W	1437	Zanesfield	-	12-JUL-1979
Ball Knob	1037599	Summit	Ross	OH	391314N	0830441W	1306	Summithill	-	12-JUL-1979
Ballards Hill	1067569	Summit	Geauga	OH	413523N	0810835W	1230	Chardon	-	01-FEB-1992

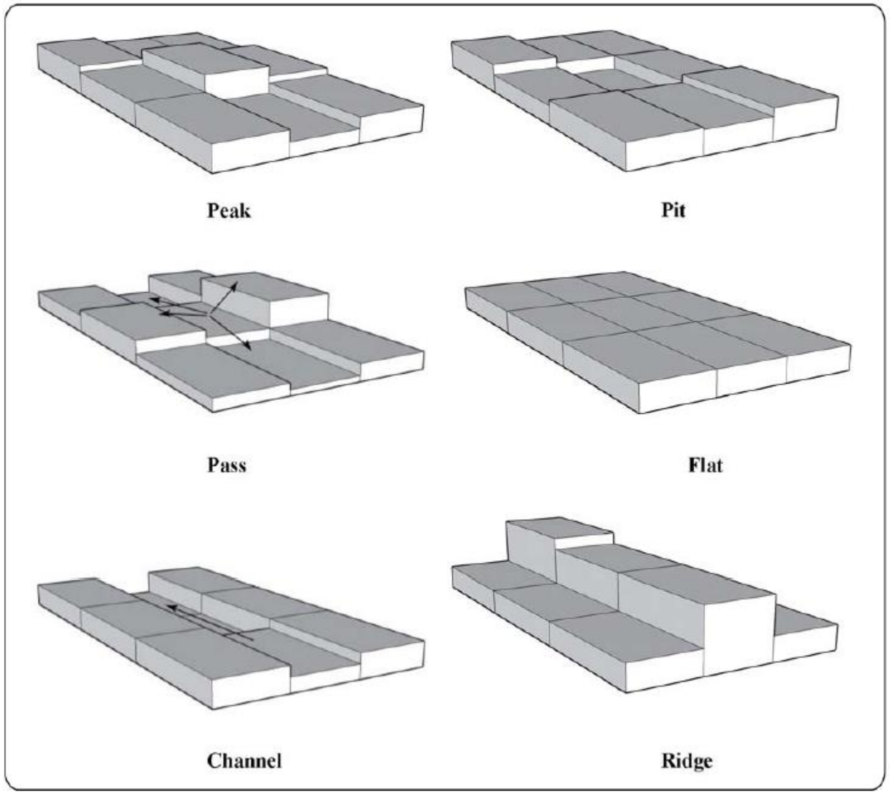
row(s) 1 - 15 of 243

View & Print all   Save as pipe "|" delimited file

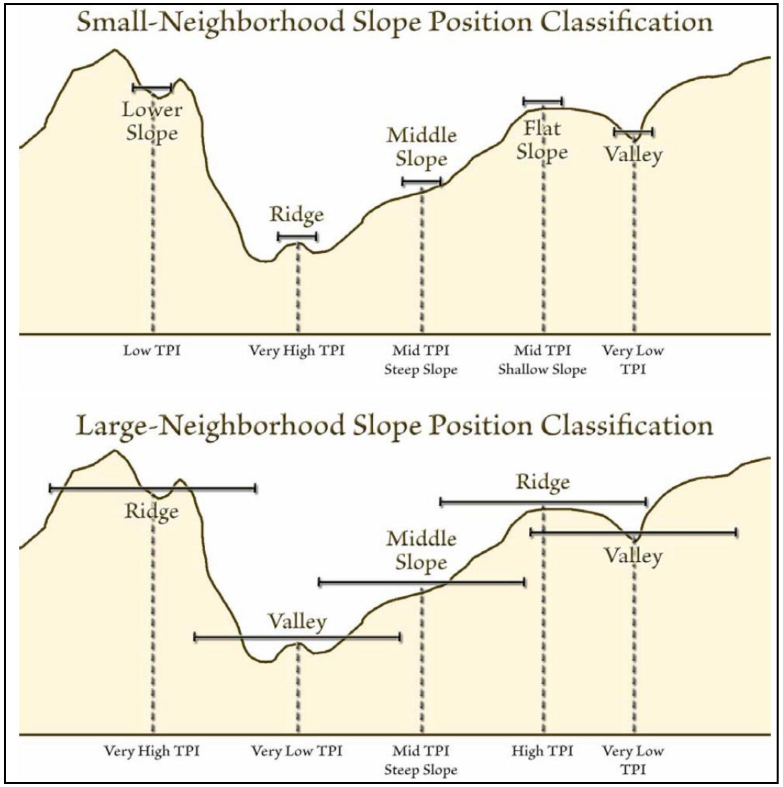
Screenshot from https://geonames.usgs.gov

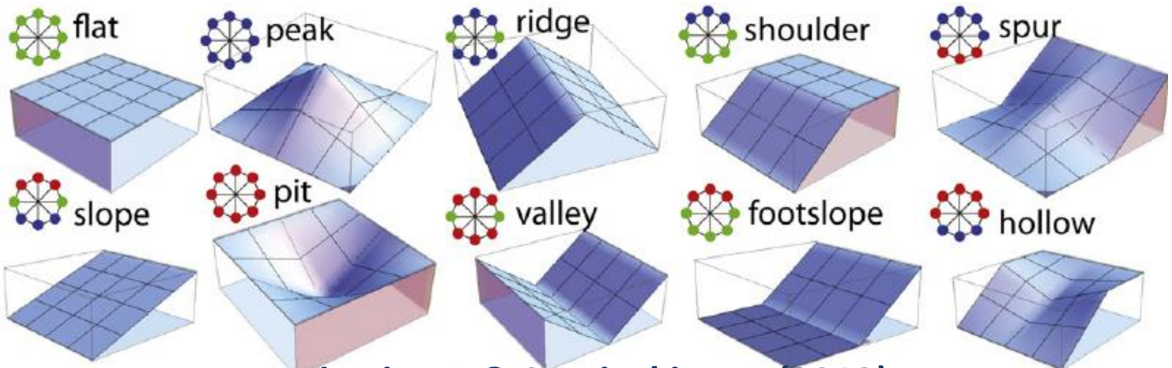
General Terrain Feature Extraction

Wood, J. (1996)



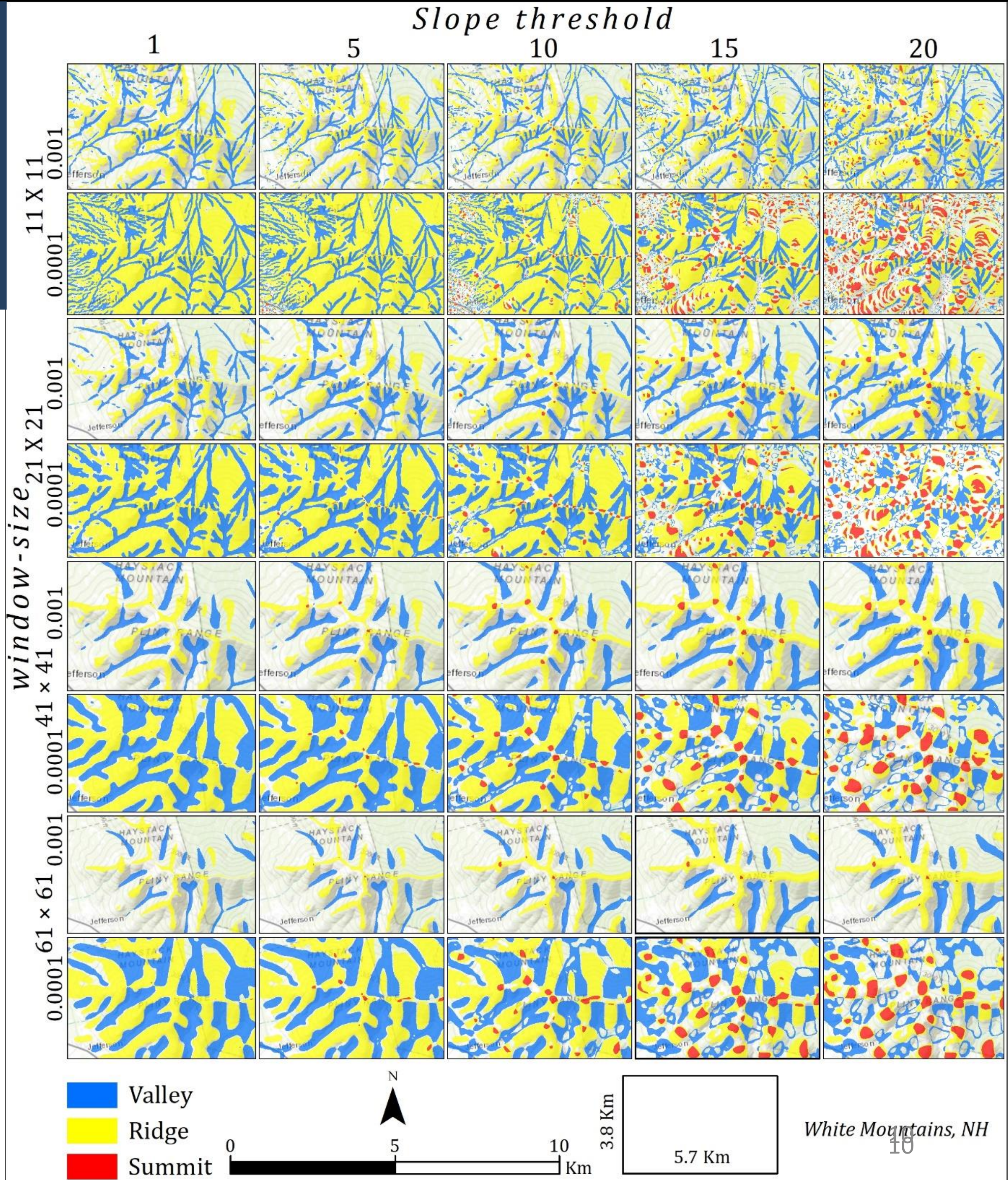
Weiss, (2001) & Jenness, J. (2006)





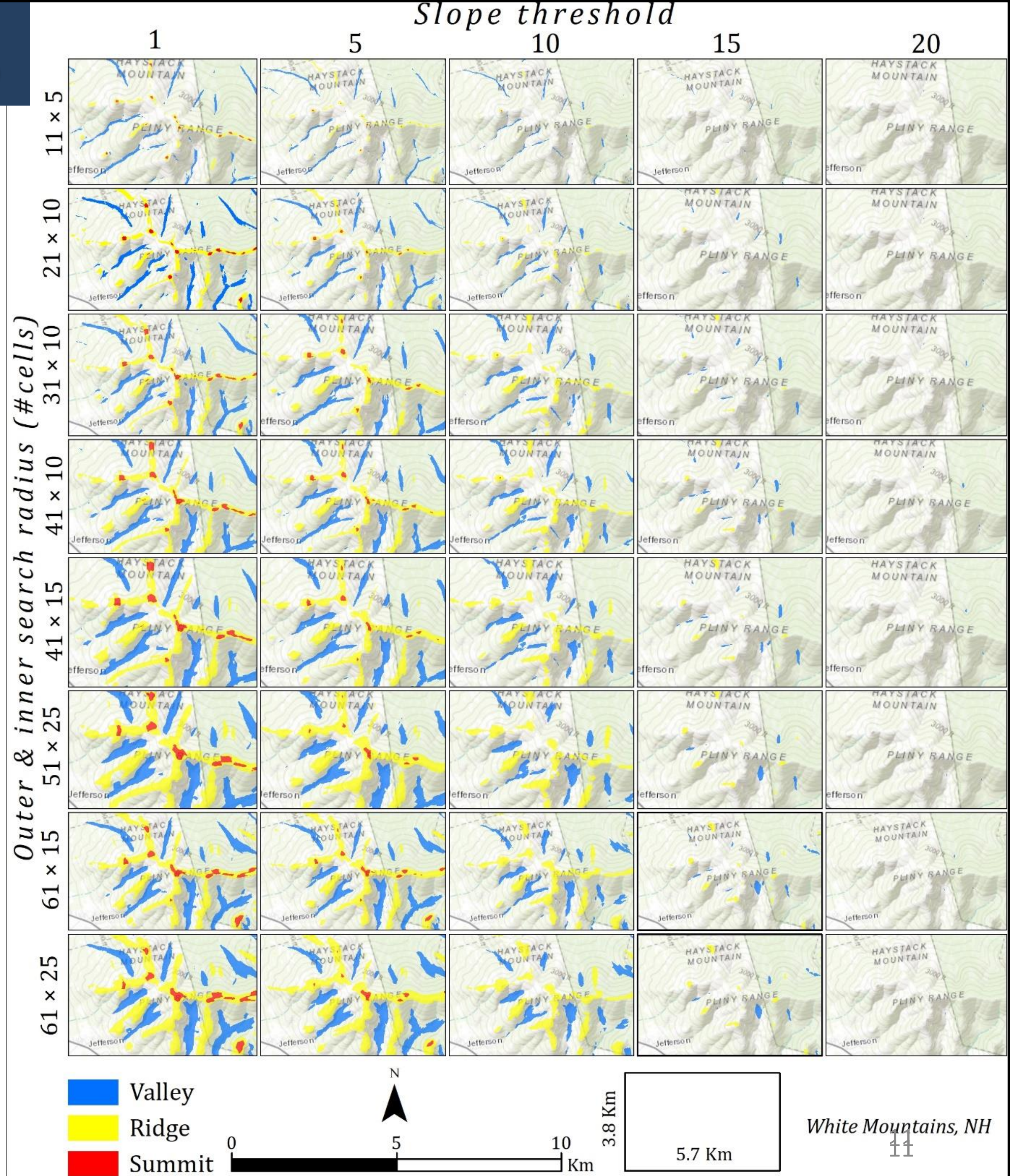
Jasiewicz, J. & Stepinski, T. F. (2012).

Wood's Morphometric Features



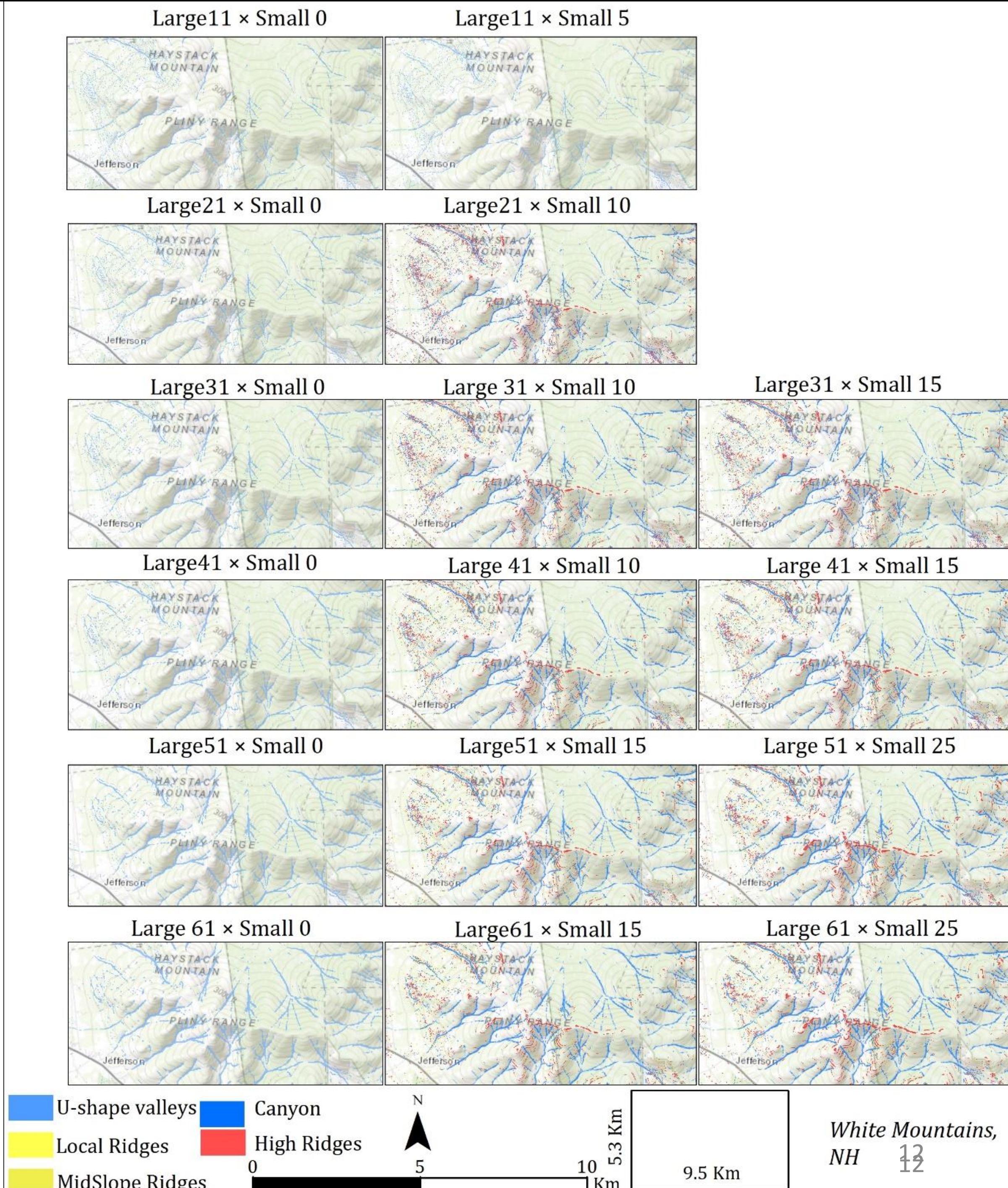
Wael Hassan (2020). ***Comparing Geomorphometric Pattern Recognition Methods for Semi-Automated Landform Mapping****. MS Thesis, Department of Geography, Ohio University, USA.*

Geomorphons



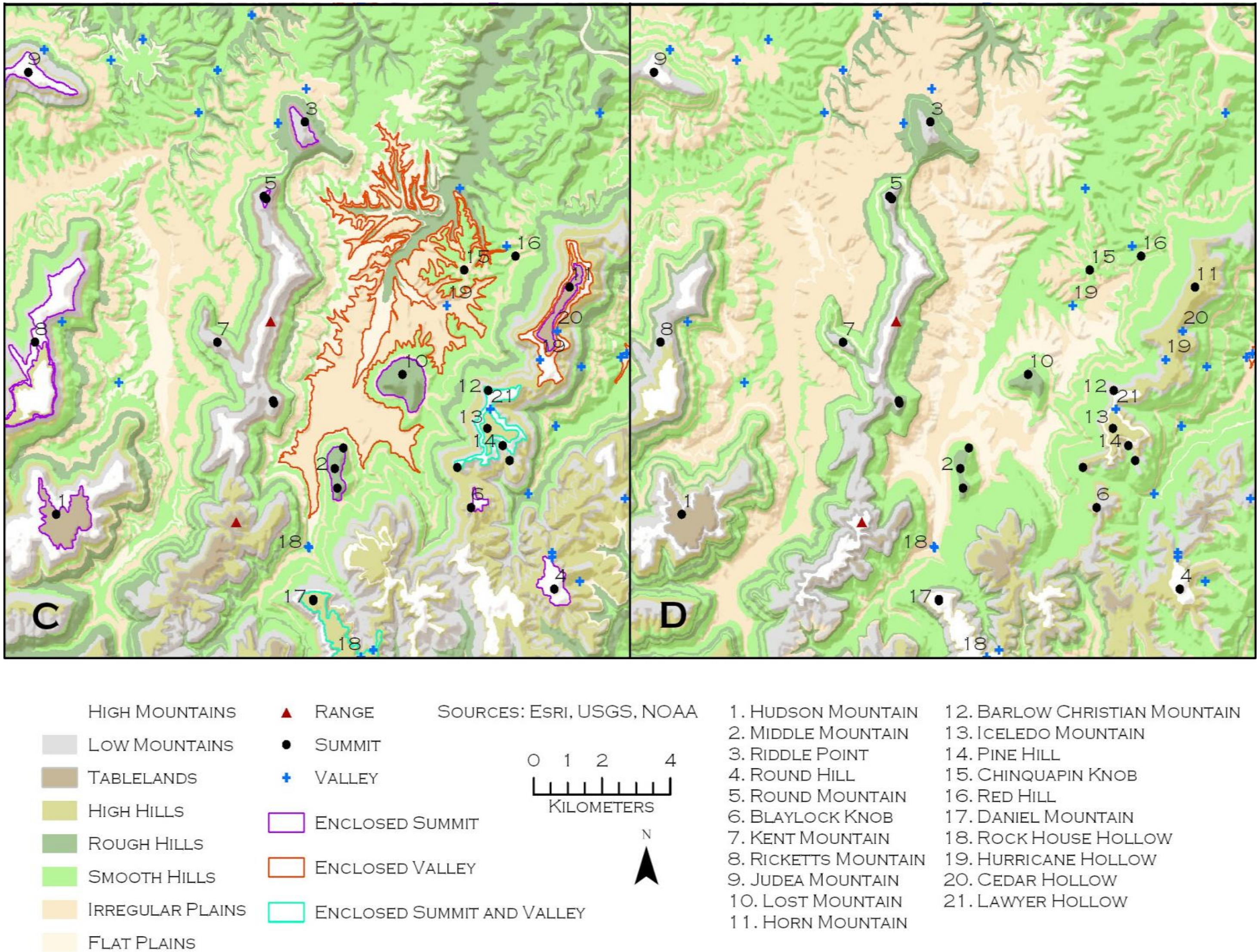
*Wael Hassan (2020). **Comparing Geomorphometric Pattern Recognition Methods for Semi-Automated Landform Mapping**. MS Thesis, Department of Geography, Ohio University, USA.*

Topographic Position Index (TPI)



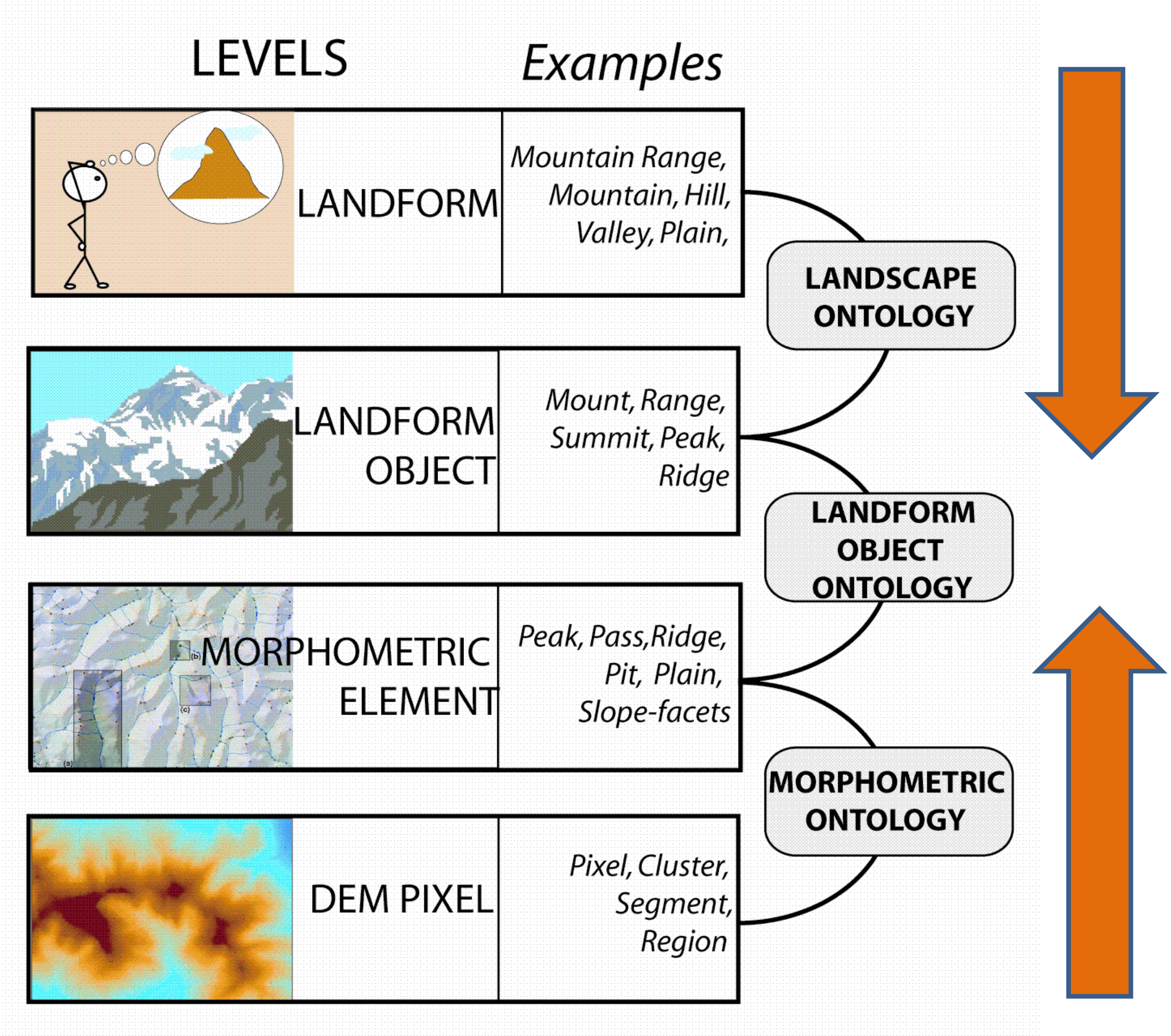
*Wael Hassan (2020). **Comparing Geomorphometric Pattern Recognition Methods for Semi-Automated Landform Mapping**. MS Thesis, Department of Geography, Ohio University, USA.*

GEOBIA Segmentation & Classification

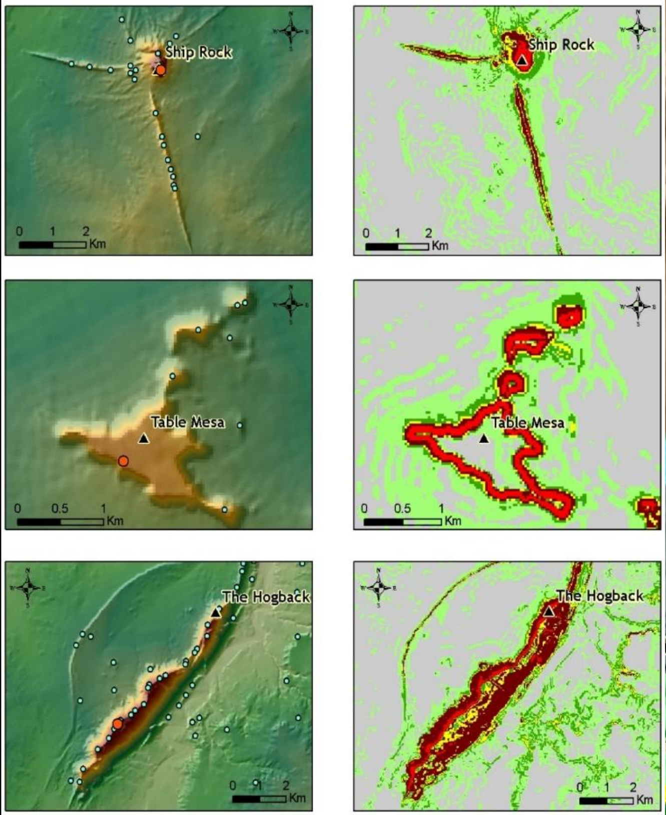


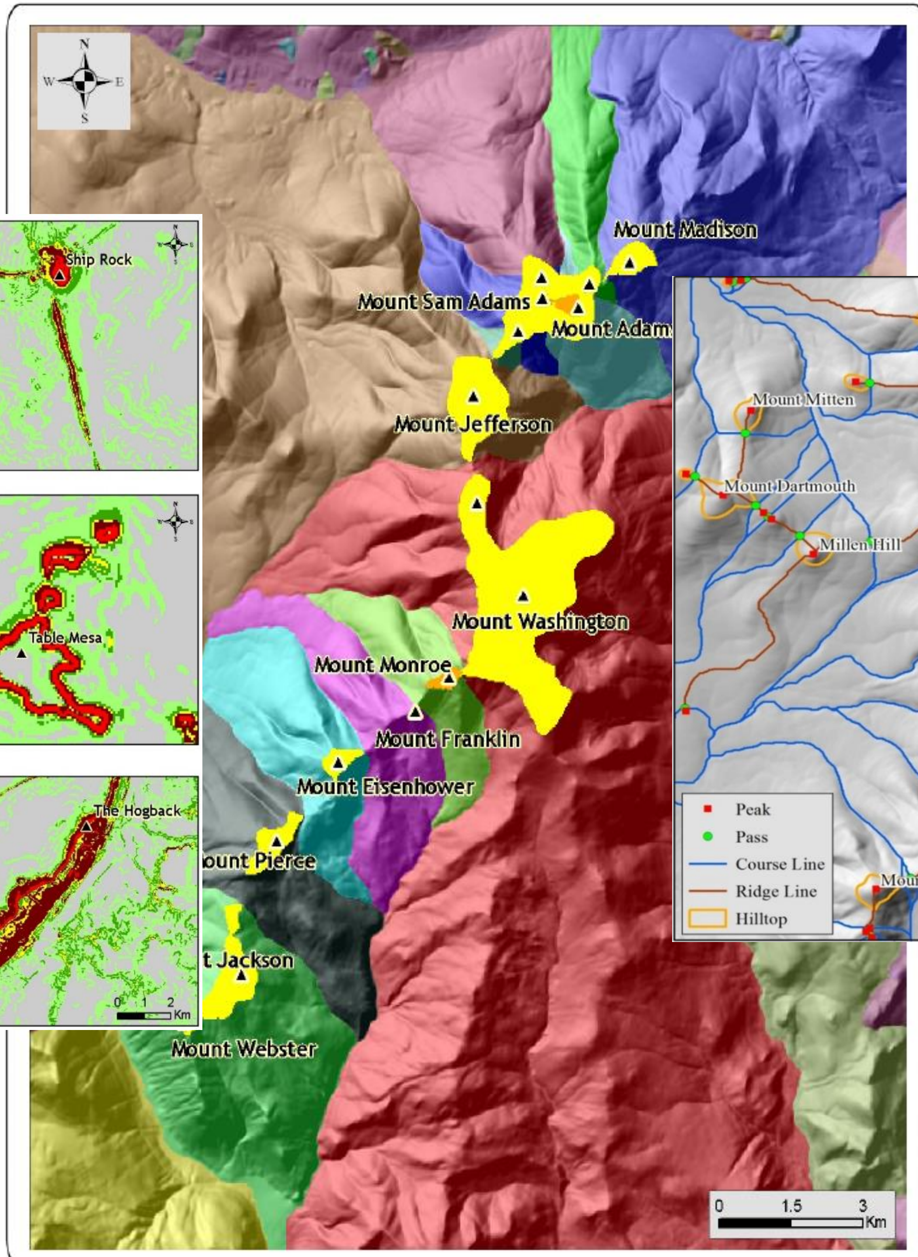
Arundel S.T. , Sinha G. (2018). ***Validating the use of object-based image analysis to map commonly recognized landform features in the United States.*** *Cartography and GIS, 46(5), 441-455.*
DOI: 10.1080/15230406.2018.1526652

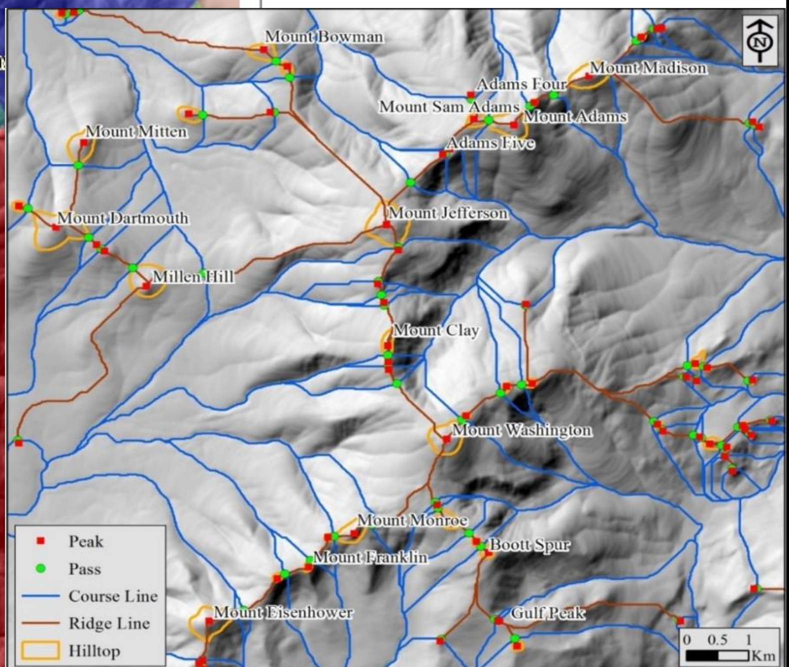
Hierarchical Integrated Reasoning



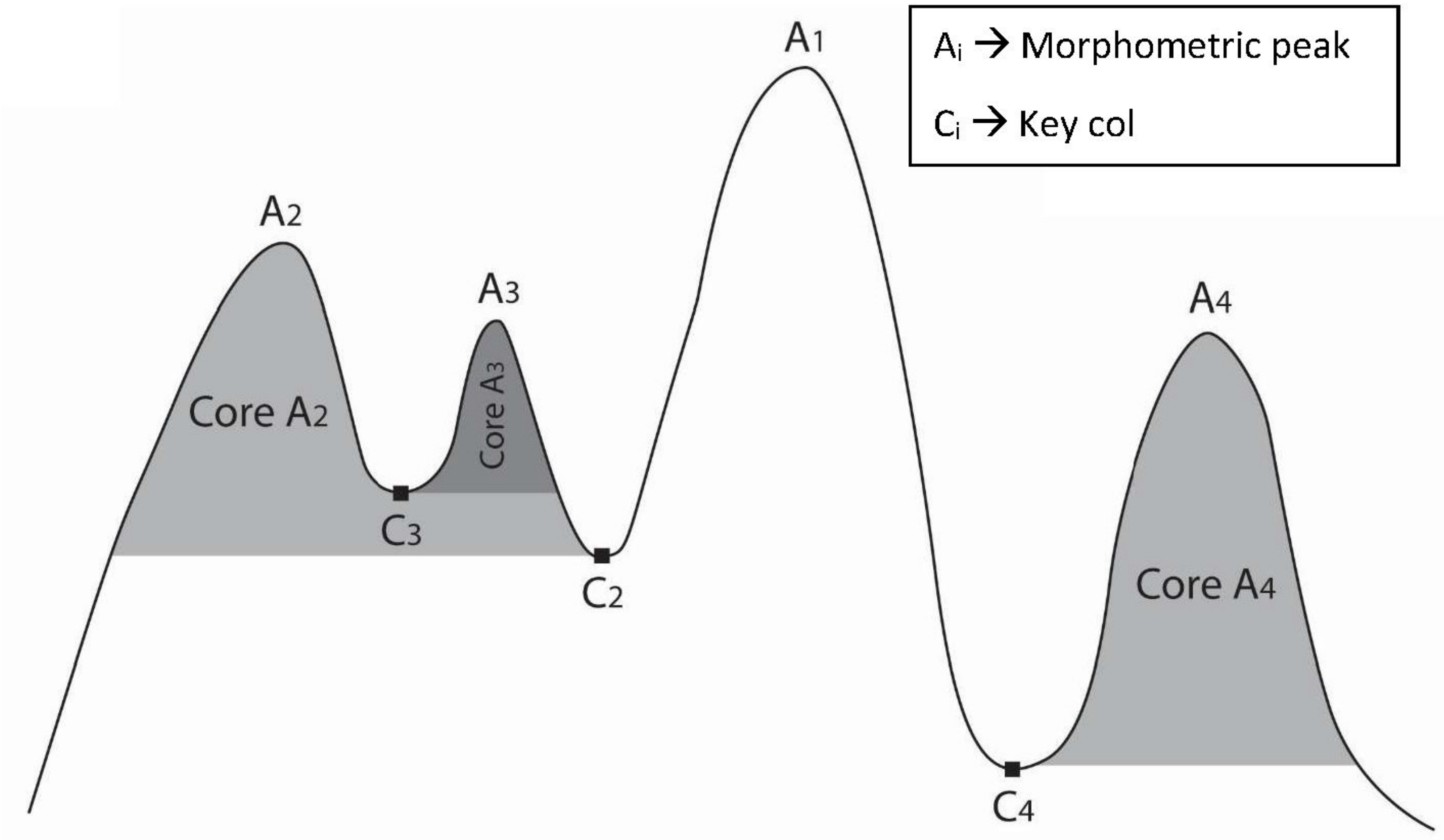
Individual Feature Extraction





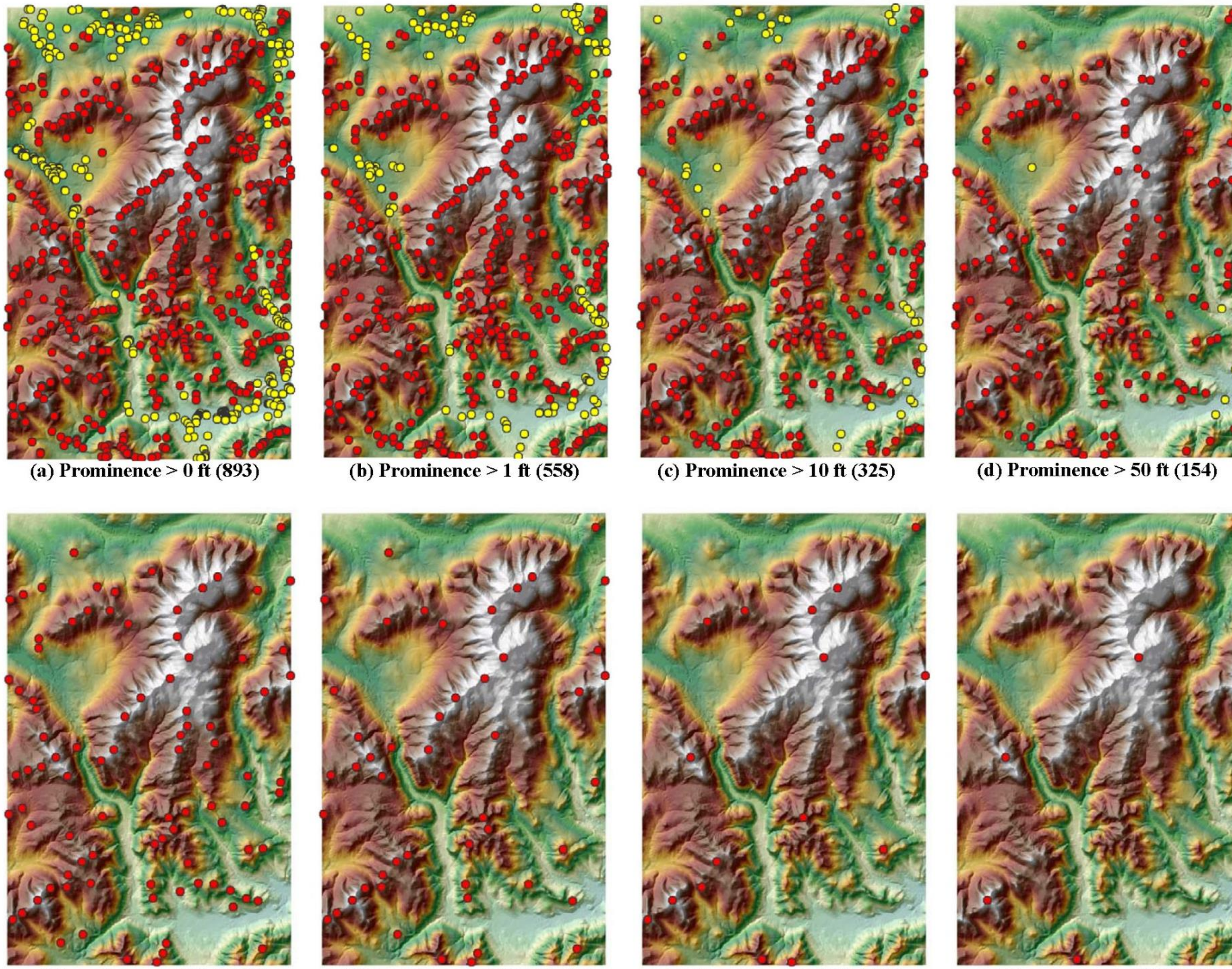


Key Col & Prominence



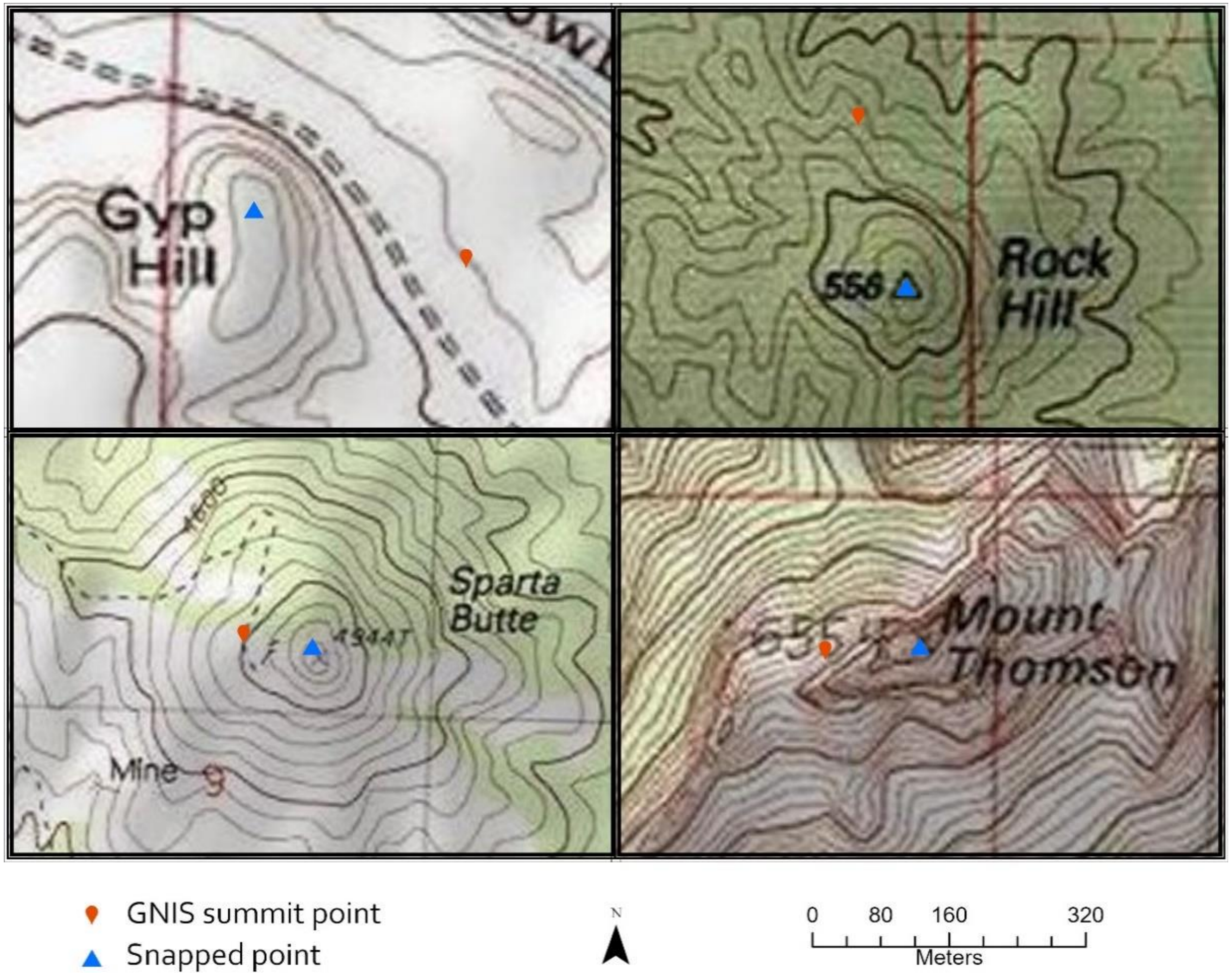
Conceptual diagram for illustrating the core area and key cols ($C_2 - C_4$) of peaks ($A_2 - A_4$). The highest peak A_1's key col is beyond the area shown.

Prominence Filtering of Peaks



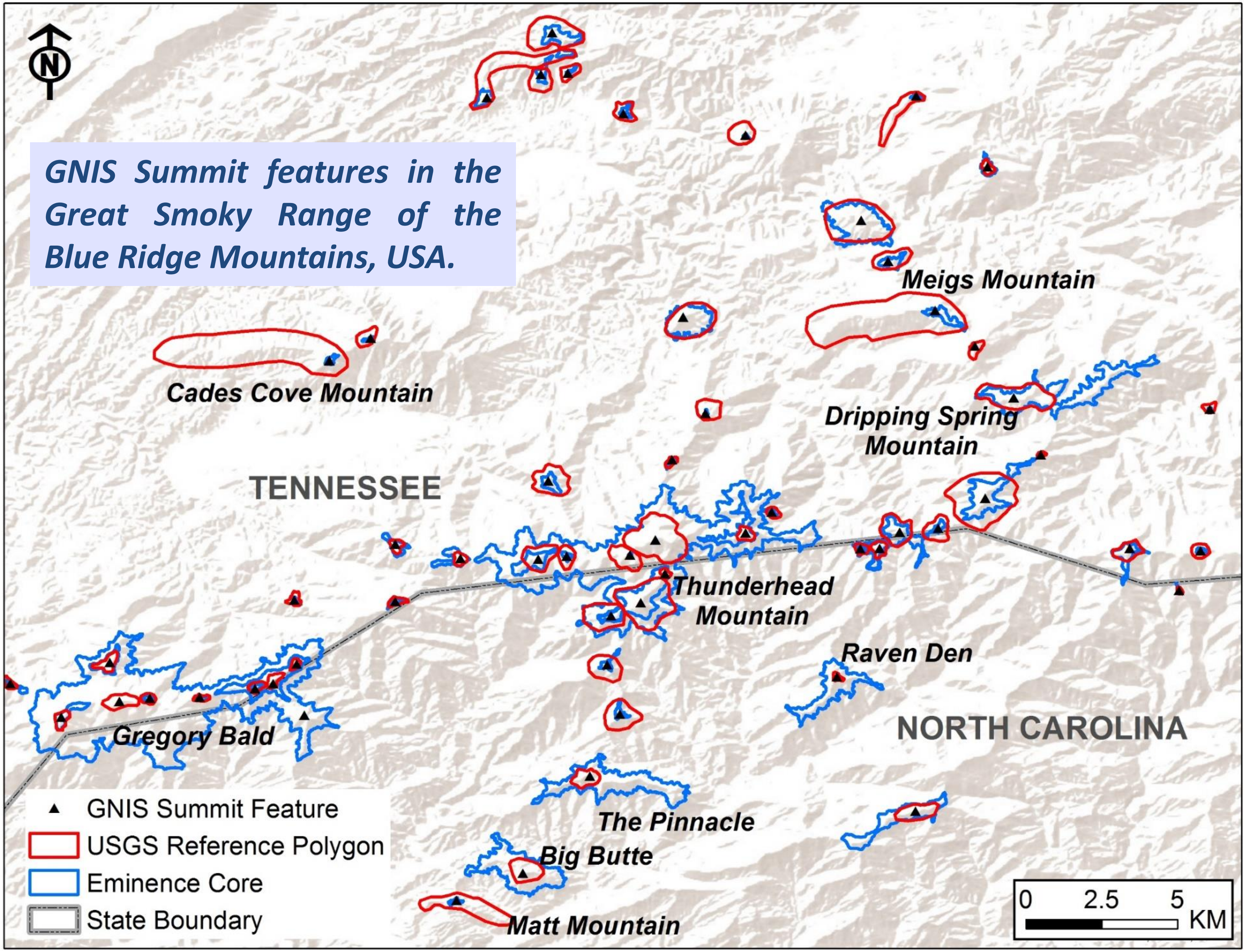
(a) Prominence > 0 ft (893)
(b) Prominence > 1 ft (558)
(c) Prominence > 10 ft (325)
(d) Prominence > 50 ft (154)
(e) Prominence > 100 ft (92)
(f) Prominence > 200 ft (49)
(g) Prominence > 500 ft (16)
(h) Prominence > 1000 ft (5)

Snapping GNIS Summits to Peaks

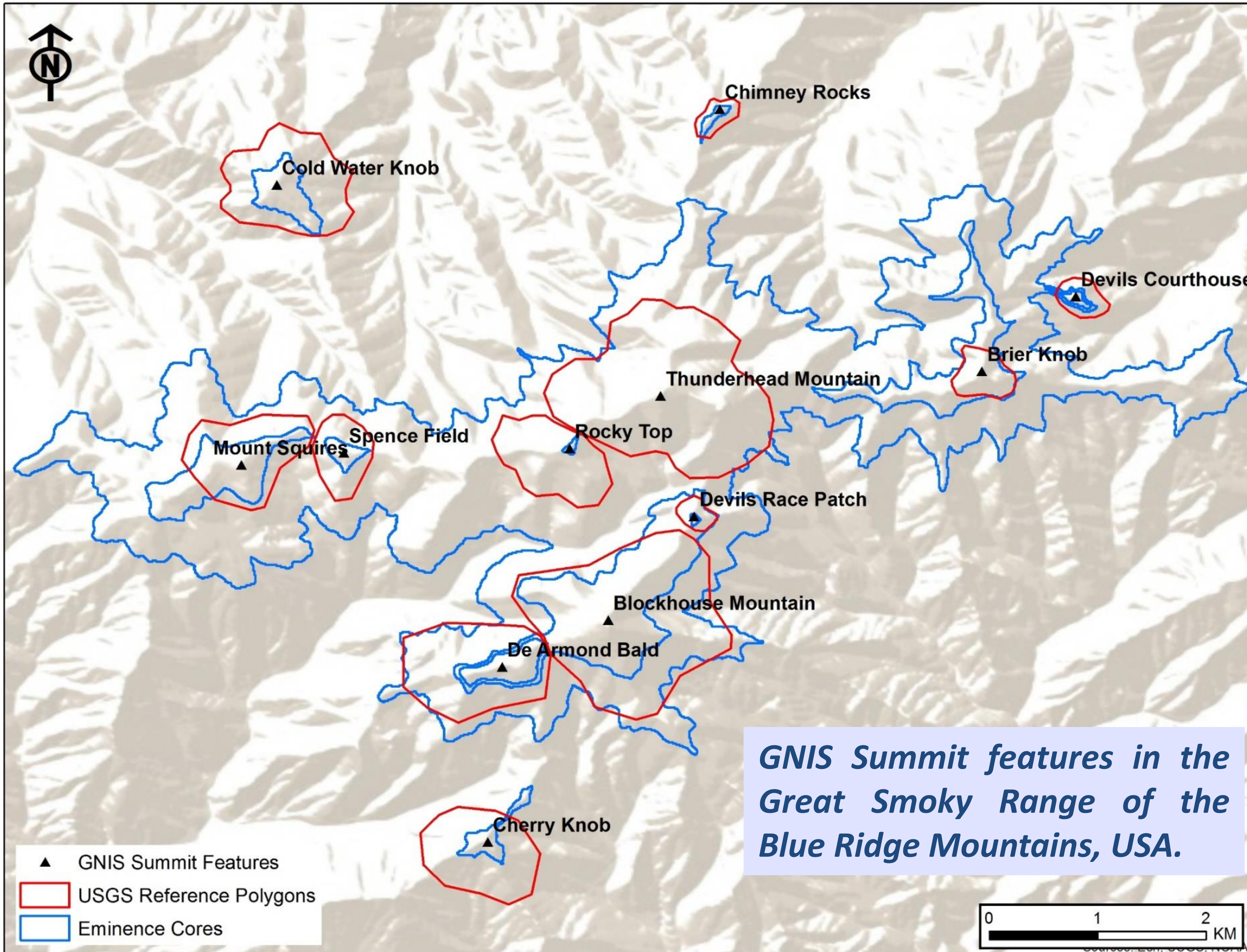


Source: Samantha T. Arundel & Gaurav Sinha (2020): ***Automated location correction and spot height generation for named summits in the coterminous United States.***
International Journal of Digital Earth: https://doi.org/10.1080/17538947.2020.1754936

Manual vs. Automated Cores

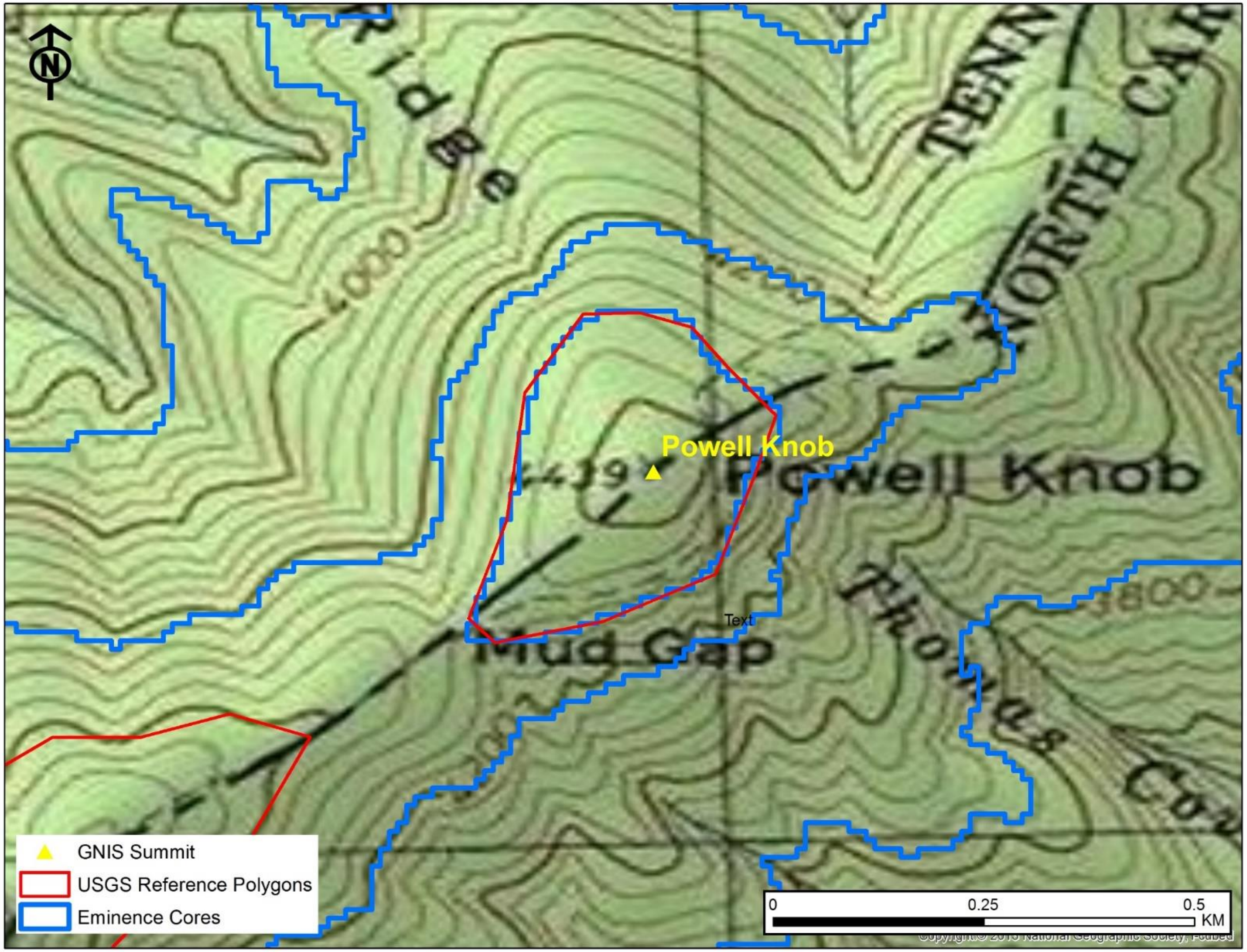


Manual vs. Automated Cores

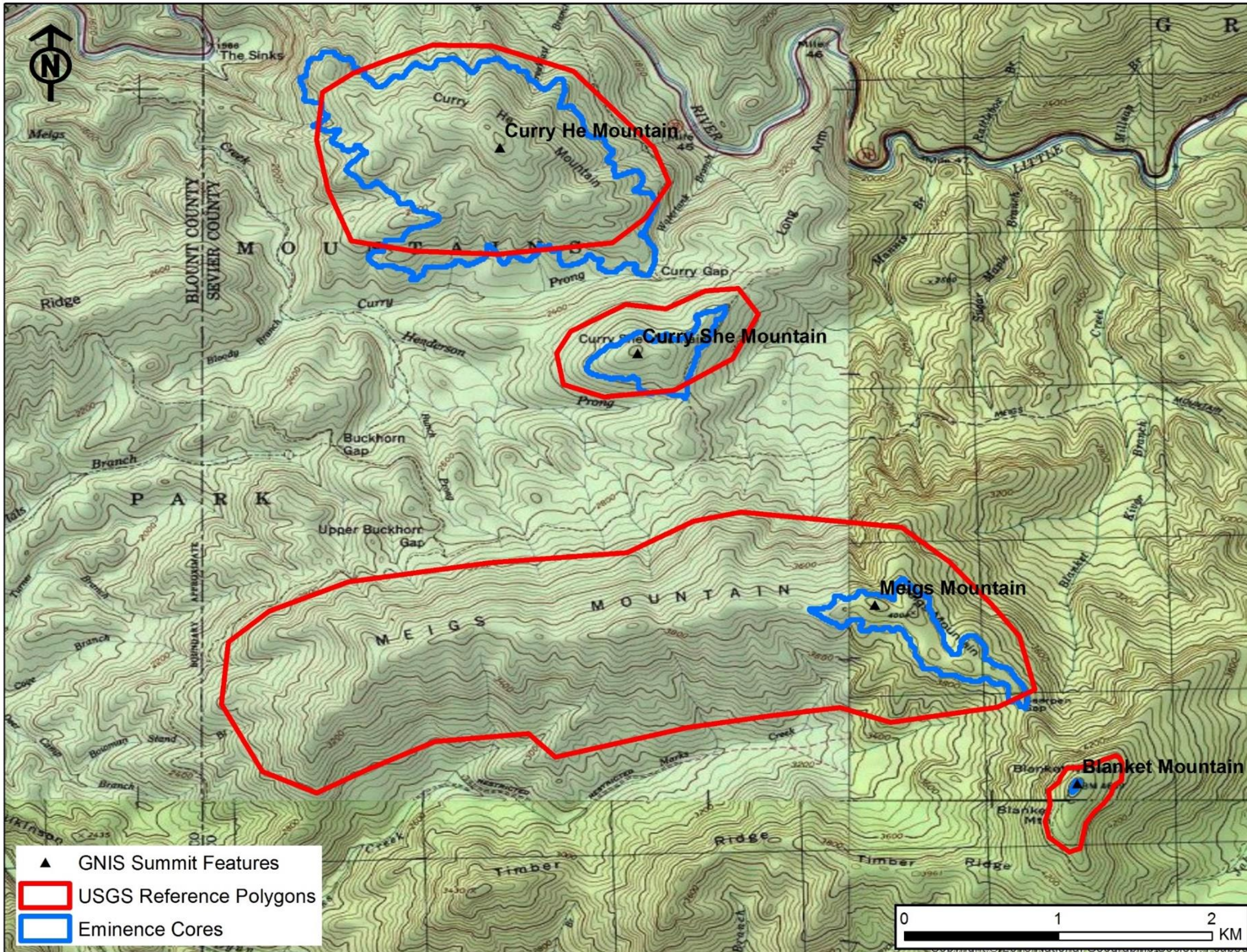


GNIS Summit features in the Great Smoky Range of the Blue Ridge Mountains, USA.

Small Eminences (Knob)

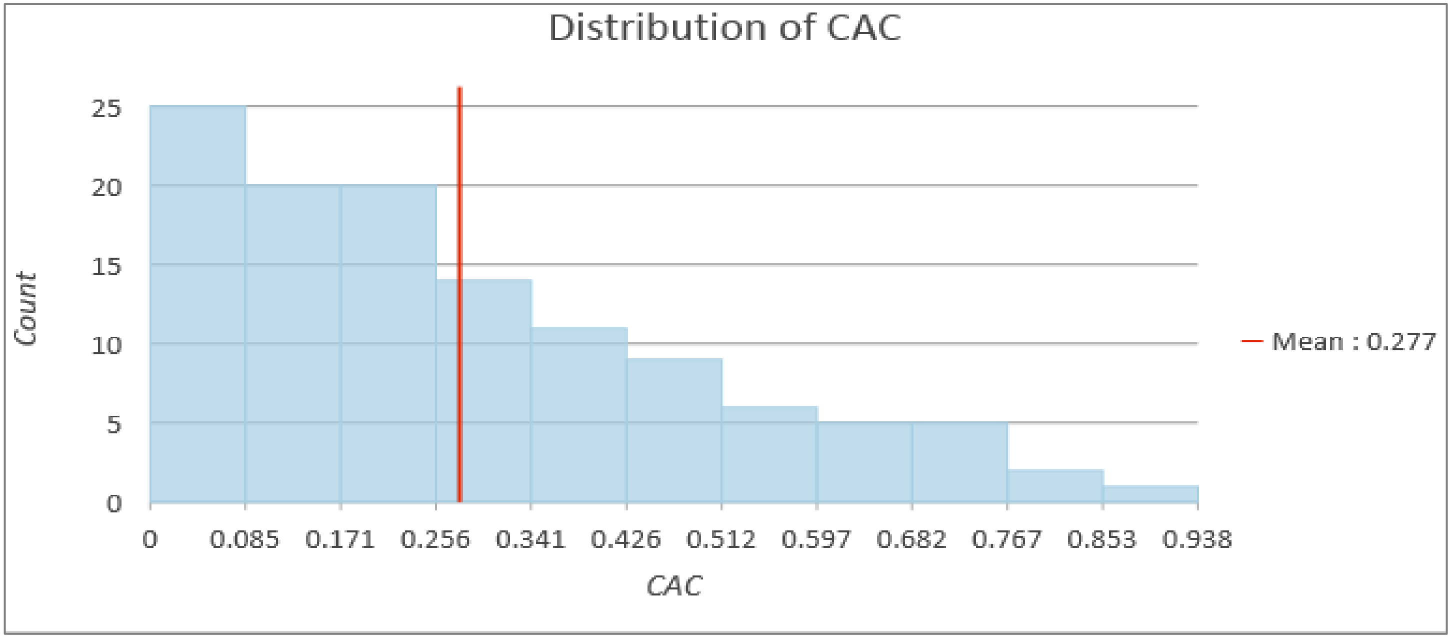


Elongated Eminences (Ridges?)



Quantitative Comparison

Property	Statistic	Automated Core	Manual Polygon	Percent Difference
Area (m^2)	***Min***	603	11,281	1.4
	Max	17,276,850	9,795,338	74,863
	Mean	1,397,879	1,001,331	1,893
	Std. Dev	3,600,661	1,636,711	3,246
Perimeter (m)	***Min***	142	401	0.3
	Max	101,708	18,192	1,733
	Mean	9,233	3,497	123
	Std. Dev	17,406	3,246	253



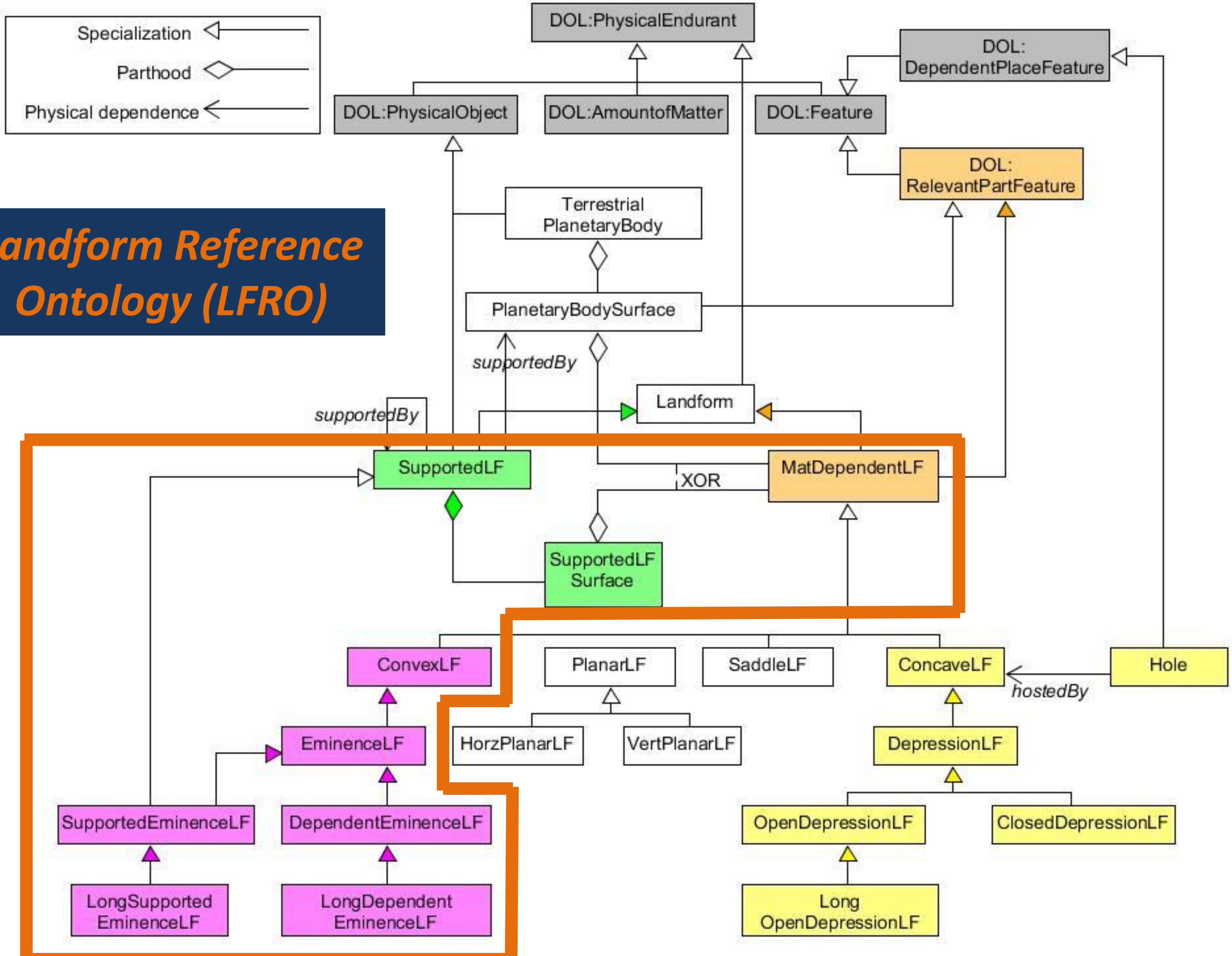
Summary…

- At least, one method to create individualized representations of culturally salient eminences (*or a core footprint of their peaks*)
- Other methods may be even better, we have not explored yet!

- Visual and geometric comparison of automated and manually delineated extents confirms that GNIS *Summit* feature class is a general category that includes a wide variety of eminences

- Mapping areal representations of the individual eminence features will reveal hitherto unknown information about the range of shapes and sizes of eminences, not just in the United States, but anywhere in the world.

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

Next Steps…

- **Test other termination criteria instead of key col**
- **Test boundary contraction and morphological complexity**
- **Further explore application of Wood's quadratic polynomial and geomorphon based terrain characterization**
- **Context and multi-parameter eminence-core mapping framework being developed**
- **USGS exploring machine learning based workflow for automating feature footprint extraction for terrain features**
- **Landform Reference Ontology (LFRO) guided feature extraction for multiple types of landforms, not just eminences**

- ***ULTIMATE GOAL… Creating comprehensive open-source toolkit for extracting eminences*!**

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