What is the Surface Area of Idaho?

Shark-A-Hack Q3 2022

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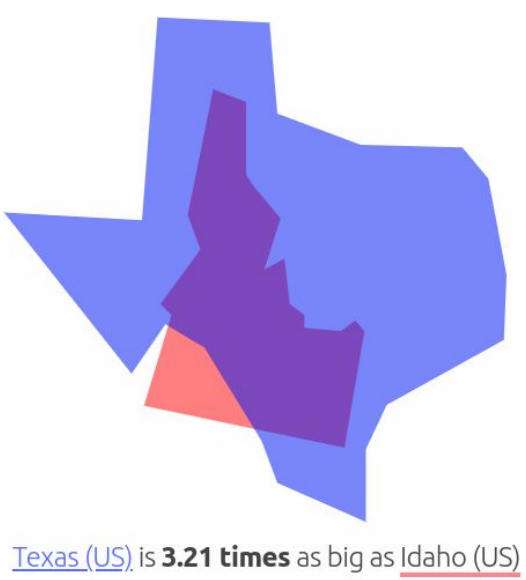
Infra-Eng :: Accelerate :: Insights


GTON
MO
IDAHO
Salt Lake City
NEVADA

Fact or Exaggeration?

- From 20 Things You Probably Didn't Know About Idaho: If all of Idaho's mountains, hills, and gorges were ironed out flat, it'd be the largest state in the Lower 48



Questions:

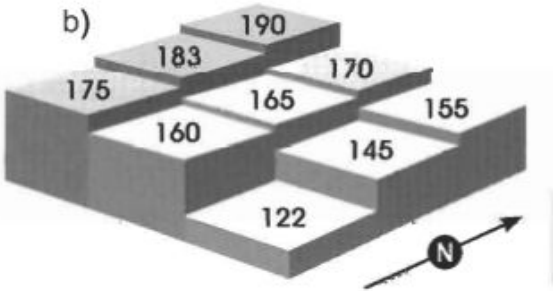
- How do you calculate land surface area?
- How big of a difference does elevation make?
- Would most states flattened beat Texas?
- Can we prove the fact?
- Can we use a vector database to match surface formations?

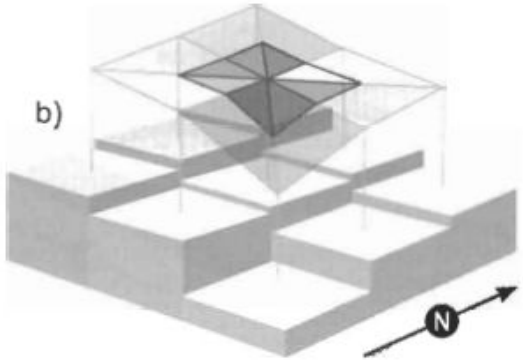
Rank Percentage of State Area in Flat, Flatter, and Flattest Categories	State or District	Rank Percentage of State Area in Flattest Category
1	Florida	1
2	Illinois	3
3	North Dakota	7
4	Louisiana	2
5	Minnesota	5
6	Delaware	6
8	Texas	8
32	Idaho	40
34	Montana	39
35	Oregon	44

Build a Model

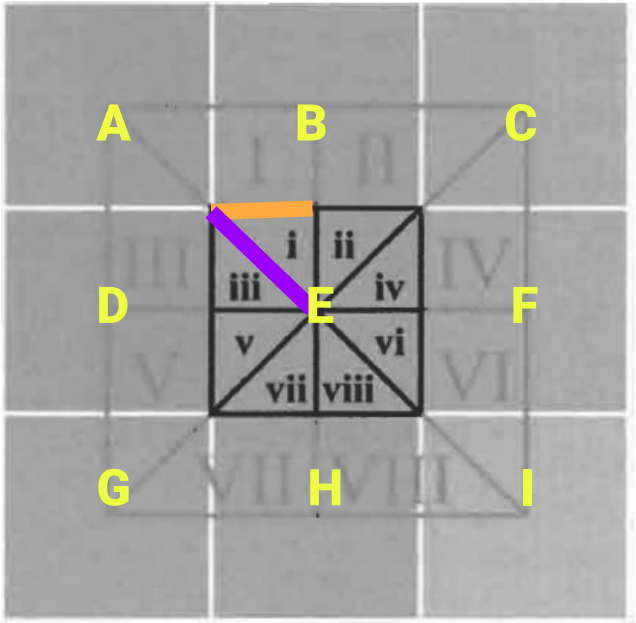
- Found a paper from the Wildlife Society Bulletin 2004: [Calculating landscape surface area from digital elevation models]

210	190	170	155	140	135
204	183	165	145	125	120
200	175	160	122	110	100
208	187	165	150	126	120





Build a Model



1) Find lengths of 3D triangle edges
   a) Planimetric length
   b) Elevation difference
   c) Surface length / 2
2) Calculate Surface Area
3) Add up all of the triangles

Build a Model

Table 2. Calculations of true surface area for triangles i–viii (Figure 4a) based on the 16 edge lengths from Table 1.

Triangle	Edges	Edge lengths (m)	Triangle area (m^2)
i	$\overline{EA}$, $\overline{AB}$, $\overline{BE}$	71.81, 50.99, 50.06	1,276.22
ii	$\overline{BE}$, $\overline{BC}$, $\overline{EC}$	50.06, 50.56, 70.89	1,265.48
iii	$\overline{AD}$, $\overline{DE}$, $\overline{EA}$	50.12, 50.80, 71.81	1,272.95
iv	$\overline{EC}$, $\overline{CF}$, $\overline{EF}$	70.89, 50.25, 50.99	1,280.88
v	$\overline{DE}$, $\overline{DG}$, $\overline{EG}$	50.80, 50.16, 70.89	1,273.94
vi	$\overline{EF}$, $\overline{FI}$, $\overline{EI}$	50.99, 51.31, 73.91	1,306.88
vii	$\overline{EG}$, $\overline{EH}$, $\overline{GH}$	70.89, 50.06, 50.56	1,265.48
viii	$\overline{EH}$, $\overline{EI}$, $\overline{HI}$	50.06, 73.91, 53.49	1,338.64

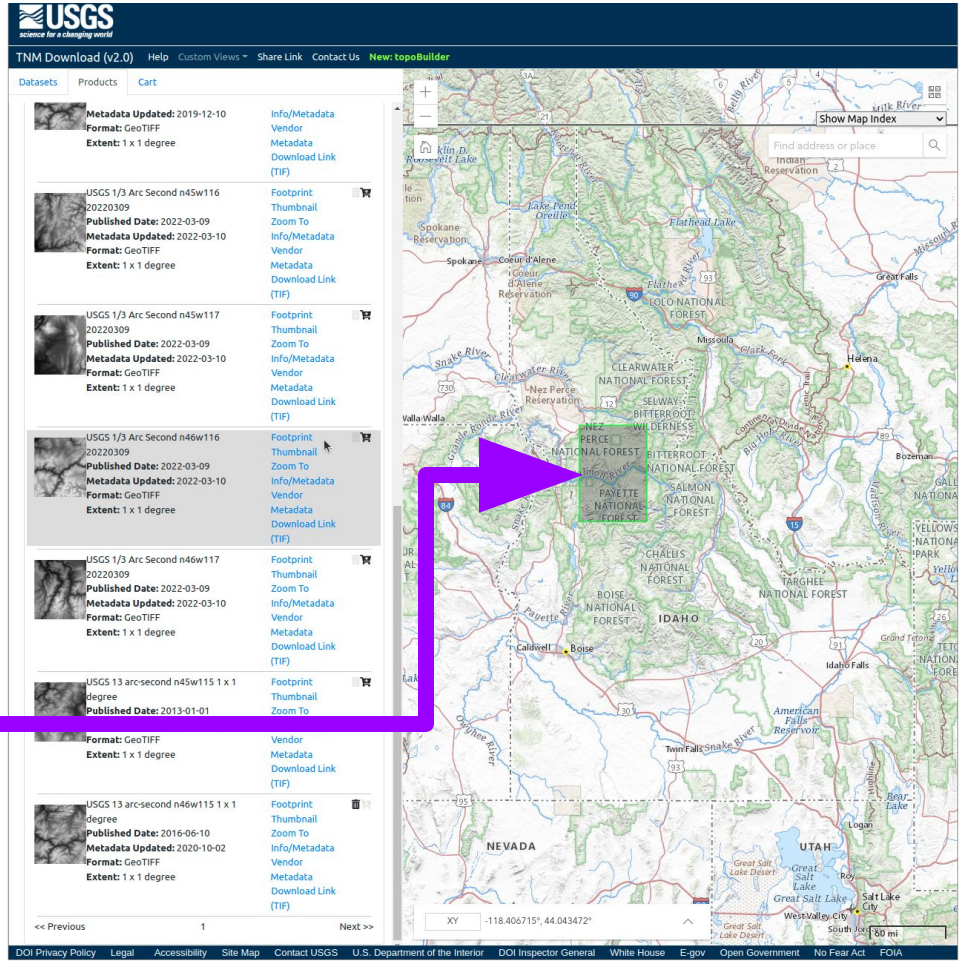
```
root@idaho:~# python test_new2.py
Running vert
Running horiz
Running l_up
Running r_up
Surface area for i: 1276.29
Surface area for ii: 1265.53
Surface area for iii: 1273.1
Surface area for iv: 1280.87
Surface area for v: 1274.02
Surface area for vi: 1306.77
Surface area for vii: 1265.53
Surface area for viii: 1338.67
```

10,280.48 m^2

```
total_sa: 10280.78,  lapsed_time: 240.0
```

Use Real Data

- DEM (Digital Elevation Model)
  - Data set for each lat/ long
  - Open source from USGS (United States Geological Survey)
  - Fetch using NationalMap ui or api
- Resolutions
  - ⅓ arc second (10m)
  - 1 arc second (30m)
- Initial area chosen
  - n46w116_20220309



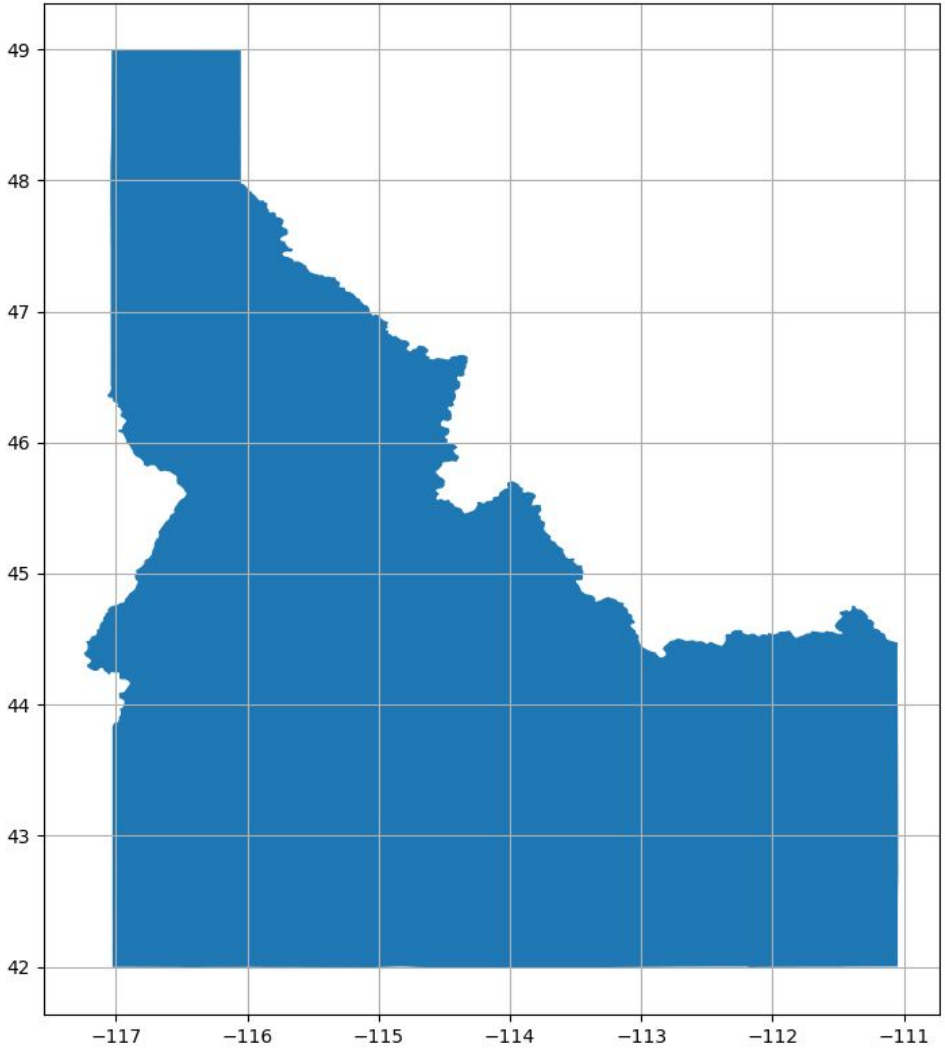
Use Real Data

- Areas for n46w116_20220309

Type	Surface Area (meters^2)	Surface Area (miles^2)	Delta
Surface Area 1/3 arc-second	12,672,148,875	4,893	-
Surface Area 1 arc-second	12,643,444,954	4,882	0.2%

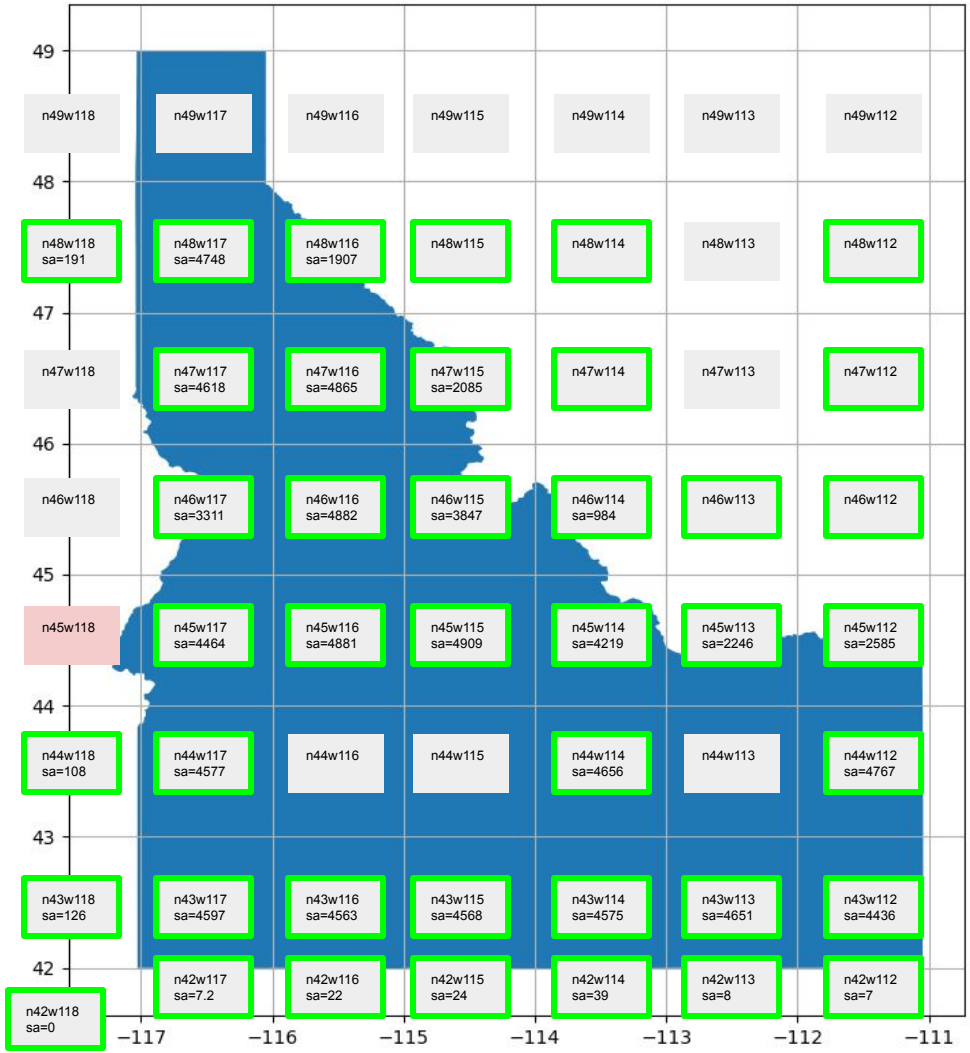
All of Idaho

- Created a polygon map to check if map points are within the boundary
- Handles data sets both in/ partially in/ out of the boundary
- Ran through 40+ datasets that cover Idaho
- Sum the results!



All of Idaho

- Ref: [google sheets]
- Planimetric area: 4,511 miles^2



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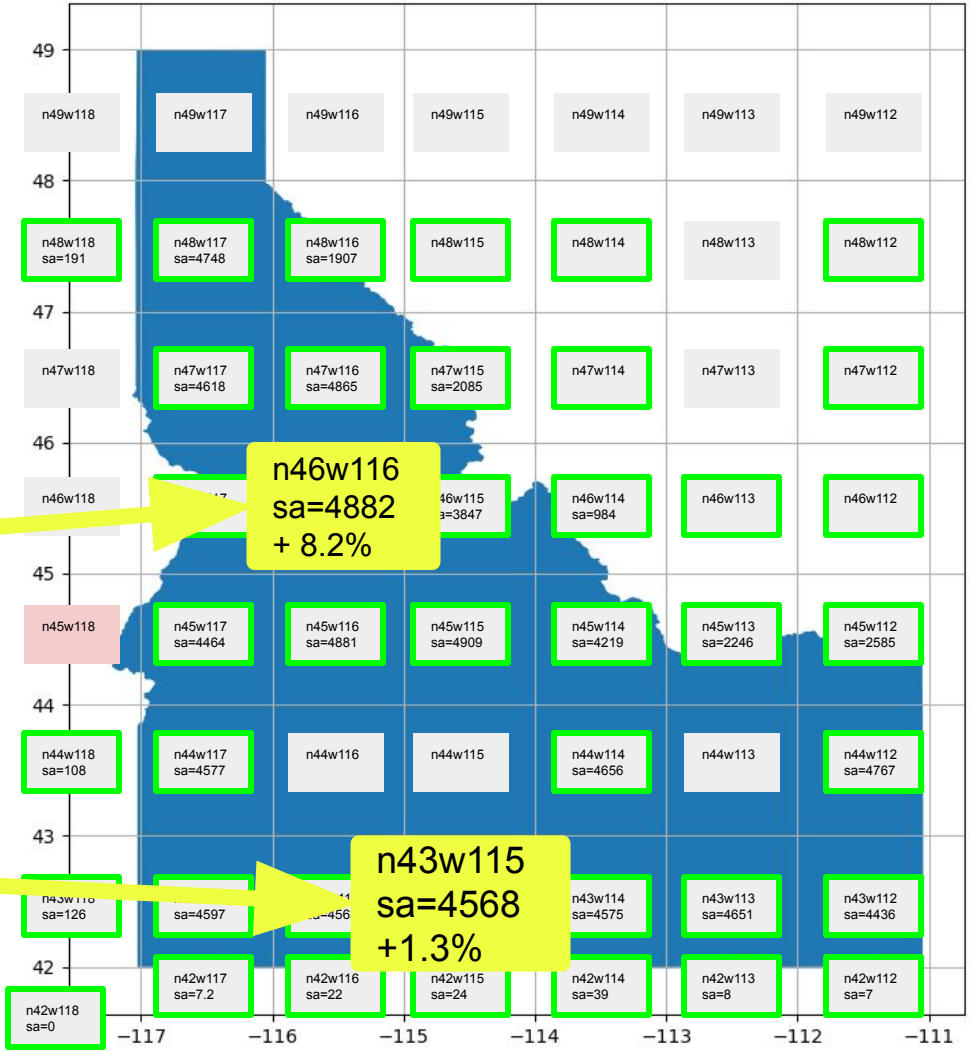
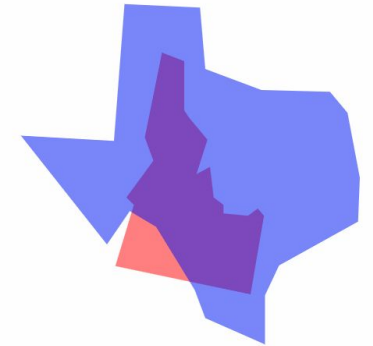


All of Idaho

Type	Surface Area (meters^2)	Surface Area (miles^2)	Delta
Planimetric Area Idaho	2.166318e+11	83,642	-
Surface Area 1 arc-sec Idaho	2.855445+11	**110,249	132%
Planimetric Area Texas	6.95663e+11	268,597	321%

Not larger than Texas

** some data missing



Texas (US) is **3.21 times** as big as Idaho (US)

Future

- For Surface Area:
  - Improve accuracy of calculations
    - More checks vs known real data
    - Data on the edge of the datasets is currently lost due to df shifting
    - Boundary skip logic missed n45w188
  - Utilize USGS NationalMap api for fetching data
  - Get a list of surface areas for every state!
  - Make the tool interactive. The tool can find the surface area of any coordinate polygon
- Extension:
  - Use DEM data to calculate slopes. Could setup a dataset to match on/ explore similar geographic features over the US.

Resources

- Code (Needs to be cleaned up): https://github.com/cem8301/Idaho
- 20 Things You Probably Didn’t Know About Idaho
- Map Fight
- Calculating landscape surface area from digital elevation models
- THE FLATNESS OF U. S. STATES
- How to use USGS TIF files
- Simple US state boundaries

Backup

Lessons Learned

- Dataframe element wise calculations don’t know their neighbors but it is too costly to iterate over so much data. Instead created four data frames (did math!) and shifted rows/columns to get locations to match. Change went from 4+hrs to 4 minutes.
- Dataframe manipulation can be very memory intensive. Spent a day dealing with OOM kills
- Data type from float32 to float16 is an easy change and makes makes a big difference on memory usage
- Sometimes math with float16 gives Inf? Used mix of float16 and single
- Grabbed a memory optimized droplet. Much better than my laptop and could leave overnight!

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