

GIS 592

City of Portland Landslide Risk Map

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Purpose

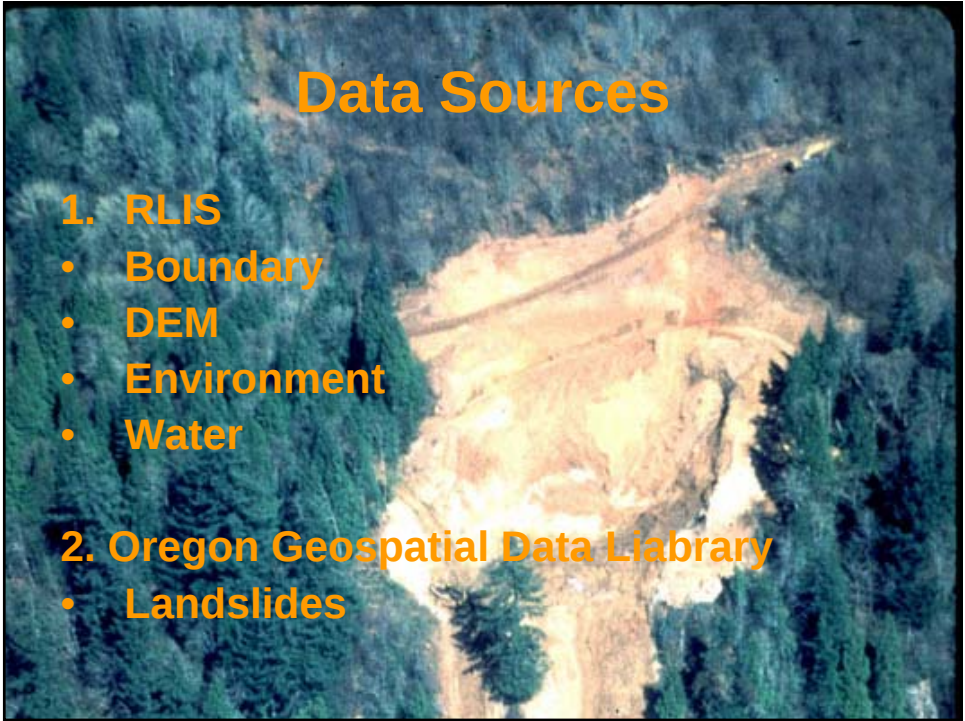
- What factors cause landslides
- Create a model
- Test the model



What is a Landslide

Landslides can be initiated by

- Rainfall
- Earthquakes
- Volcanic Activity
- Changes in Ground Water
- Disturbance and Change of a Slope by man made construction activities.
- Combination of any of the factor these factors



Data Sources

1. RLIS
 - Boundary
 - DEM
 - Environment
 - Water
2. Oregon Geospatial Data Liabrary
 - Landslides

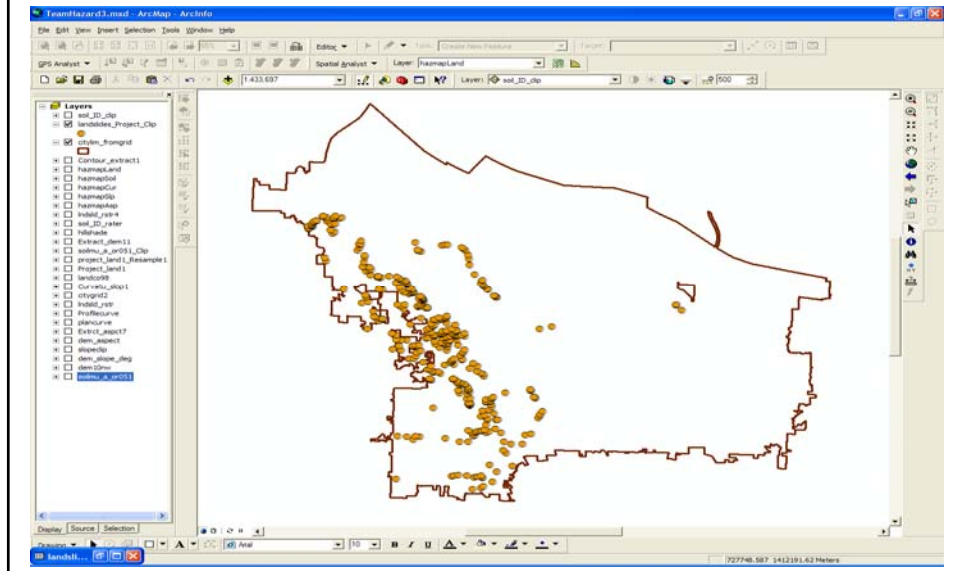
Data Issues-Restrictions

• Landslides

• Rainfall

Attributes of Landslides Project - Chp													
PID	Shape	LANDSLIDE	LOCATION	DATES	COUNTY	QUADRANGLE	CITY	SP EASTING	SP NORTH	LONGITUDE	LATITUDE	PROCESS	
88	Point	LO-109	S. end of Ross Mt. S&G lower lot	Feb-9	Multnomah	Lake Oswego	Portland	7648451	672380	-122.65525	45.49079	Debris Side	
89	Point	LO-105	S. end of Ross Mt. S&G lower lot	Feb-9	Multnomah	Lake Oswego	Portland	7649350	672471	-122.65555	45.49090	Debris Side	
90	Point	LO-104	4200 SW Council Crest Dr	Feb-9	Multnomah	Lake Oswego	Portland	7630656	673177	-122.69741	45.49212	Slump-Earthflow/Debris	
92	Point	LO-3	35.5 m S of Corbett overpass	Feb-9	Multnomah	Lake Oswego	Portland	7644892	673327	-122.6799	45.49256	Slump-Earthflow	
94	Point	LO-107	N. end of Ross Mt. S&G lower lot	Feb-9	Multnomah	Lake Oswego	Portland	7648857	673742	-122.65771	45.49443	Debris Side	
97	Point	LO-163	SW Fairmount Blvd @ SW McDonnell Ter	Feb-9	Multnomah	Lake Oswego	Portland	7630690	673540	-122.69735	45.49397	Slump-Earthflow	
98	Point	LO-106	N. end of Ross Mt. S&G lower lot	Feb-9	Multnomah	Lake Oswego	Portland	7648794	673857	-122.65796	45.49474	Debris Side	
99	Point	LO-164	SW Fairmount -50 m N of LO-163	Feb-9	Multnomah	Lake Oswego	Portland	7638736	673586	-122.69719	45.49435	Slump-Earthflow	
100	Point	LO-105	N. end of Ross Mt. S&G lower lot	Feb-9	Multnomah	Lake Oswego	Portland	7648721	674044	-122.65627	45.49525	Debris Side	
101	Point	LO-165	SW Fairmount -50 m N of LO-164	Feb-9	Multnomah	Lake Oswego	Portland	7638762	674123	-122.69702	45.49473	Slump-Earthflow	
20	Point	LO-166	Reverview Cemetery	97	Multnomah	Lake Oswego	Portland	7644441	661675	-122.67366	45.49102	Slump-Earthflow	
26	Point	LO-172	in Shadow Creek Alpha parking lot -Multnomah & 51st	97	Multnomah	Lake Oswego	Portland	7629947	663891	-122.73636	45.48601	Slump-Earthflow	
225	Point	P194	HA Site Recreation Center	97	Multnomah	Portland	Portland	7636125	666374	-122.70660	45.52812	Earthflow	
205	Point	LX052	NW Thompson Rd. (west of Skyline)	97	Multnomah	Linton	Portland	7624464	692710	-122.7629	45.54445	Slump	
293	Point	LX051	NW Thompson Rd./Pinnacle Rd. (west of Skyline)	97	Multnomah	Linton	Portland	7622212	693182	-122.76331	45.54573	Slump-Earthflow	
1	Point	LO-155	SW Boones Ferry Rd. -300' SW of Stephenson St	96/97	Multnomah	Lake Oswego	Portland	7648072	653974	-122.68675	45.43664	Slump-Earthflow/Rockfall	
12	Point	LO-161	SW Arnold midway between SW Lancaster and SW 11th Dr	96/97	Multnomah	Lake Oswego	Portland	7639513	656485	-122.6962	45.48024	Slump-Earthflow/Debris	
19	Point	LO-187	Reverview Cemetery	96/97	Multnomah	Lake Oswego	Portland	7644788	661136	-122.67221	45.49587	Slump-Earthflow	
25	Point	LO-171	-SW Multnomah/SW 45th	96/97	Multnomah	Lake Oswego	Portland	7630954	664429	-122.7205	45.46756	Slump-Earthflow	
30	Point	LO-175	6100 block of SW Multnomah Blvd	96/97	Multnomah	Lake Oswego	Portland	7627260	664496	-122.74051	45.46745	Slump-Earthflow	
32	Point	LO-173	SW 51st St & SW Multnomah	96/97	Multnomah	Lake Oswego	Portland	7630390	664587	-122.7291	45.46780	Earthflow	
55	Point	LO-130	Oak Bottom (behind 1306 SE Yukon)	96/97	Multnomah	Lake Oswego	Portland	7649676	668252	-122.65277	45.47946	Slump-Earthflow	
72	Point	LO-191	behind 5005 SW 18th Pl	96/97	Multnomah	Lake Oswego	Portland	7630744	671060	-122.69605	45.49035	Earthflow	
255	Point	MT-4	Off of Rocky Butte Rd beneath radio tower	96/97	Multnomah	MT Tabor	Portland	7670662	690117	-122.56498	45.54106	Rockfall/Earthflow	
61	Point	LO-128	Oak Bottom (at W. end of SE Reedway St.)	96, r	Multnomah	Lake Oswego	Portland	7650565	668094	-122.65134	45.48152	Debris Side	
6	Point	LO-190	Up drainage from LO-155 (behind house on Stephenson)	96	Multnomah	Lake Oswego	Portland	7639602	653770	-122.69206	45.43898	Earthflow	
2	Point	LO-154	SW Boones Ferry Rd. -100' N of Stephenson St	96	Multnomah	Lake Oswego	Portland	7641198	654340	-122.68553	45.43661	Rockfall	
5	Point	LO-152	11620 SW Boones Ferry Rd.	96	Multnomah	Lake Oswego	Portland	7641616	656947	-122.68641	45.44333	Slump-Earthflow	
6	Point	LO-153	SW Boones Ferry Rd. -200' N of LO-152	96	Multnomah	Lake Oswego	Portland	7649975	656157	-122.68656	45.44503	Debris Side	
7	Point	LO-147	SW Arnold between SW 11th Dr and Creightonwood Pl	96	Multnomah	Lake Oswego	Portland	7639633	656215	-122.69181	45.44663	Debris Side	
11	Point	LO-148	SW Arnold @ SW 20th Dr	96	Multnomah	Lake Oswego	Portland	7636174	656356	-122.7053	45.44503	Slump-Earthflow	
13	Point	LO-149	SW Arnold -100' E from LO-148	96	Multnomah	Lake Oswego	Portland	7636452	656478	-122.70422	45.44618	Slump-Earthflow	
15	Point	LO-156	SW Arnold at NW corner of Arnold and SW Lancaster	96	Multnomah	Lake Oswego	Portland	7637126	656584	-122.70161	45.44652	Debris Side	
26	Point	LO-169	SW Multnomah Blvd across from Jerome F. Seaver Army Hs	96	Multnomah	Lake Oswego	Portland	7637214	656348	-122.70138	45.46532	Slump-Earthflow	
27	Point	LO-170	3223 SW Multnomah Blvd	96	Multnomah	Lake Oswego	Portland	7635131	664063	-122.71018	45.46887	Slump-Earthflow	
29	Point	LO-174	SW Multnomah Blvd across from Hidden Village Rtr. corner	96	Multnomah	Lake Oswego	Portland	7620905	664441	-122.73446	45.46744	Slump-Earthflow	
49	Point	LO-168	SW Terwilliger @ Burlingame Ter	96	Multnomah	Lake Oswego	Portland	7641632	666844	-122.69514	45.47499	Slump-Earthflow	
58	Point	LO-129	Oak Bottom (behind 1346 SE Rainona St.)	96	Multnomah	Lake Oswego	Portland	7650236	669713	-122.6516	45.48371	Earthflow	
63	Point	LO-127	Oak Bottom (W. of SE Harold St.)	96	Multnomah	Lake Oswego	Portland	7650709	669582	-122.65006	45.48316	Slump-Earthflow	
83	Point	LO-160	SW Fairmount @ SW 18th Dr just E. and across from site	96	Multnomah	Lake Oswego	Portland	7630507	672006	-122.69706	45.49012	Slump-Earthflow	
96	Point	LO-161	across from 2616 SW Fairmount below OPD towers	96	Multnomah	Lake Oswego	Portland	7639140	672289	-122.6954	45.49061	Slump-Earthflow	
91	Point	LO-159	SW Fairmount Blvd. -150 m SE from LO-158	96	Multnomah	Lake Oswego	Portland	7637459	673276	-122.70259	45.4903	Debris Side	
93	Point	LO-162	- 25 m W of LO-161 behind 4224 McDonnell Ter	96	Multnomah	Lake Oswego	Portland	7639645	673619	-122.69564	45.49337	Slump	
95	Point	LO-157	across from 4053 SW Indalee	96	Multnomah	Lake Oswego	Portland	7637340	673791	-122.70261	45.49371	Slump-Earthflow	
96	Point	LO-158	SW Fairmount Blvd -3 m S of SW Beaverfoot Ave	96	Multnomah	Lake Oswego	Portland	7637157	673827	-122.70333	45.49382	Slump-Earthflow	
267	Point	MT-1	Rocky Butte Rd. 2 m S of tunnel	96	Multnomah	MT Tabor	Portland	7692117	691149	-122.56897	45.54382	Slump-Earthflow	
268	Point	MT-2	Rocky Butte Rd. 2 m S of tunnel	96	Multnomah	MT Tabor	Portland	7692123	691206	-122.56875	45.54396	Slump-Earthflow	
271	Point	MT-3	Rocky Butte Rd. 2 m S of tunnel	96	Multnomah	MT Tabor	Portland	7692134	691272	-122.56871	45.54415	Slump-Earthflow	
205	Point	P199	NW Westover Rd./Flanders/4th	2097	Multnomah	Portland	Portland	7638162	685390	-122.70064	45.52057	Earthflow	
102	Point	LO-069	Marquand Hill Rd	2566	Multnomah	Portland	Portland	7634617	674529	-122.69771	45.49543	Earthflow	
103	Point	LO-068	across from 2614 SW Fairmount	2566	Multnomah	Portland	Portland	7638170	674680	-122.69847	45.497	Slump-Earthflow	
104	Point	LO-063	SW Fairmount	2596	Multnomah	Portland	Portland	7637862	675612	-122.70187	45.49357	Earthflow	
105	Point	LO-061	across from 2914 SW Fairmount	2596	Multnomah	Portland	Portland	7638214	675105	-122.69934	45.49738	Earthflow	
106	Point	LO-055	SW Fairmount/MT. Adams Dr.	2796	Multnomah	Portland	Portland	7637284	675120	-122.70205	45.49729	Debris Side	
107	Point	LO-062	SW Fairmount	2596	Multnomah	Portland	Portland	7637867	675271	-122.70148	45.49779	Slump-Earthflow	
108	Point	LO-054	across from 2654 SW Fairmount	2596	Multnomah	Portland	Portland	7637256	675386	-122.70311	45.49608	Earthflow	
170	Point	LX061	SW Fairmount/Portland Trail	1566	Multnomah	Portland	Portland	7615676	674748	-122.70471	45.49674	Earthflow	

Landslides within City of Portland



Process of Creating The Risk Map

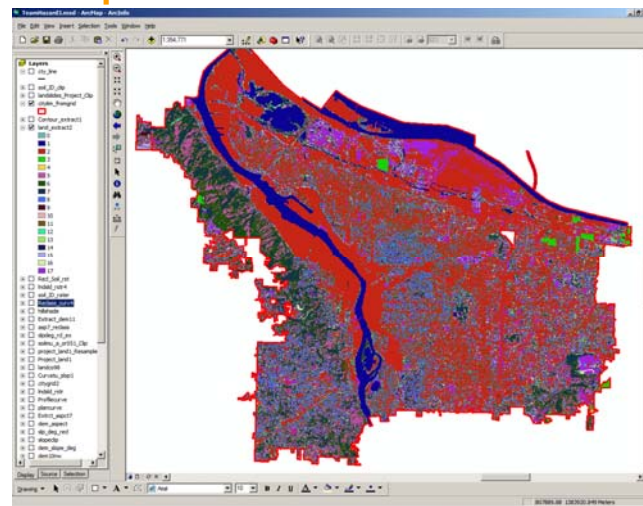


Reclassification of Landslide Factors

- Slope- 10 degree increments yielding 9 classes.
- Aspect- 45 degree increments yielding 9 classes.
- Curvature- 2 classes – Positive/Negative.
Positive = upwardly convex
Negative = upwardly concave

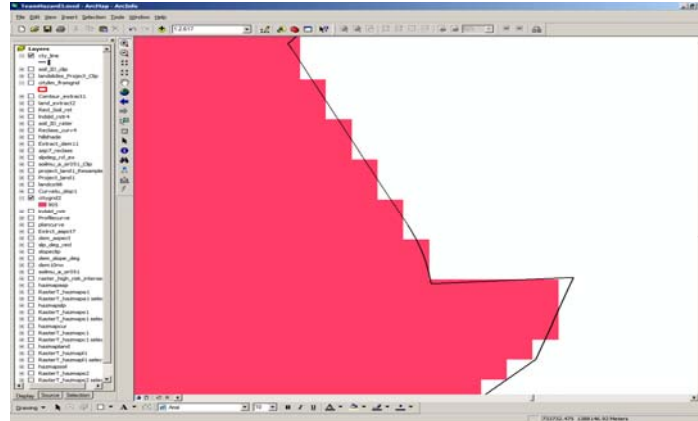
Landcover

- Landcover – original cell size was 82 feet.
Resampled to the cell size of the DEM.

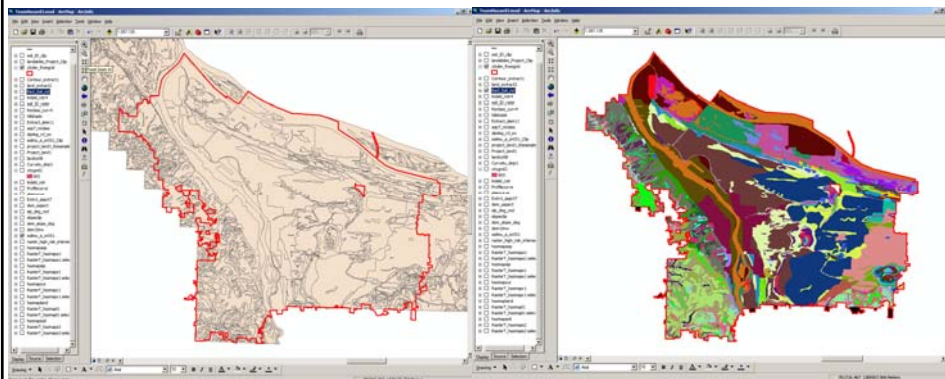


Study Area

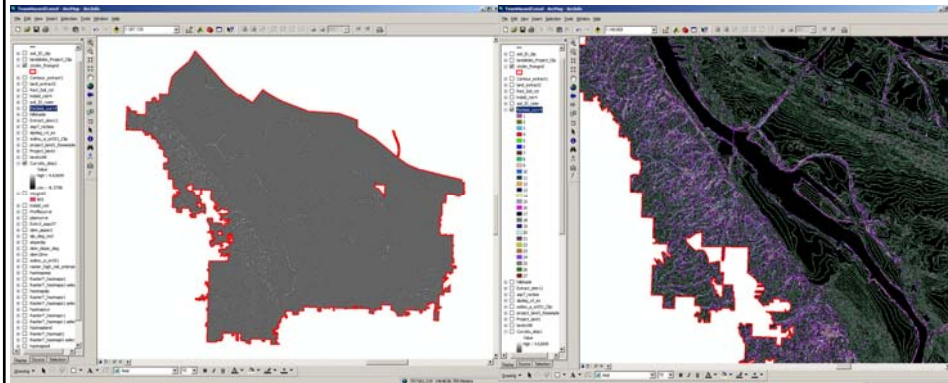
- City Shape file Rasterized
- Boundary created from city and snapped to DEM.



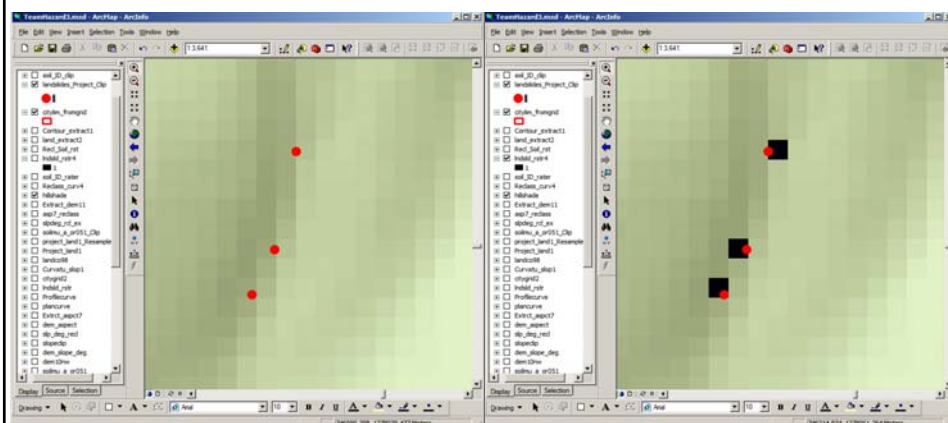
Soil Rasterized & Reclassed



Curvature Reclassed



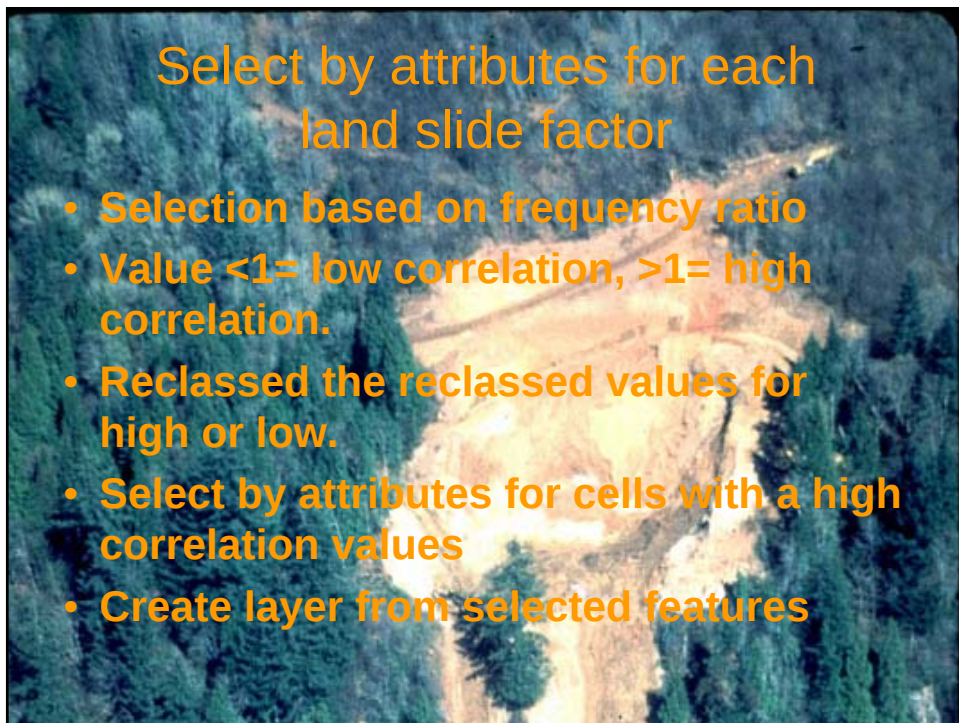
Landslide Points Rasterized



<u>Aspect</u>	Class		value (degrees)	total # pix in class	% total pix in class	# pix showing LS	% Pix showing LS	Frequency Ratio	Hazard Map	Correlati on
	1	Flat	-1 - 0	1,097,489	29.25%	0	0.00%	0.00	1	low
	2	NE	000 - 45	440,474	11.74%	41	10.35%	0.88	1	low
	3	ENE	045 - 90	286,799	7.64%	53	13.38%	1.75	2	high
	4	ESE	090 - 135	282,868	7.54%	57	14.39%	1.91	2	high
	5	ESSE	135 - 180	343,561	9.16%	68	17.17%	1.88	2	high
	6	SSW	180 - 225	435,593	11.61%	44	11.11%	0.96	1	low
	7	WSW	225 - 270	282,812	7.54%	40	10.10%	1.34	2	high
	8	WNW	280 - 315	287,346	7.66%	43	10.86%	1.42	2	high
	9	NNW	315 - 360	295,023	7.86%	50	12.63%	1.61	2	high
	Total			3,751,965	100.00%	396	100.00%		15	1.63

<u>Slope</u>	Class		value (degrees)	total # pix in class	% total pix in class	# pix showing LS	% Pix showing LS	Frequency Ratio	Hazard Map	Correlation
	1		00-10	3,200,388	85.30%	105	26.52%	0.31	1	low
	2		010-020	368,608	9.82%	132	33.33%	3.39	2	high
	3		20-30	139,772	3.73%	88	22.22%	5.97	2	high
	4		30-40	37,523	1.00%	62	15.66%	15.66	2	high
	5		40-50	5,361	0.14%	8	2.02%	14.14	2	high
	6		50-60	313	0.01%	1	0.25%	30.27	2	high
	Total			3,751,965	100.00%	396	100.00%		11	1.83

<u>Curvature</u>	Class	value	total # pix in class	% total pix in class	# pix showing LS	% Pix showing LS	Frequency Ratio	Hazard Map	Correlation
	13	-2.5 - -2.0	3,103	0.08%	1	0.25%	3.05	2	high
	14	-2.0 - -1.5	7,458	0.20%	6	1.52%	7.62	2	high
	15	-1.5 - -1.0	20,847	0.56%	14	3.54%	6.36	2	high
	16	-1.0 - -0.5	126,363	3.37%	61	15.40%	4.57	2	high
	17	-0.5 - 0.0	2,329,018	62.07%	116	29.29%	0.47	1	low
	18	0.0 - 0.5	1,112,199	29.64%	97	24.49%	0.83	1	low
	19	0.5 - 1.0	116,009	3.09%	61	15.40%	4.98	2	high
	20	1.0- 1.5	25,069	0.67%	23	5.81%	8.69	2	high
	21	1.5 - 2.0	6,837	0.18%	7	1.77%	9.70	2	high
	Total		3,751,965	100.00%	396	100.00%			1.46

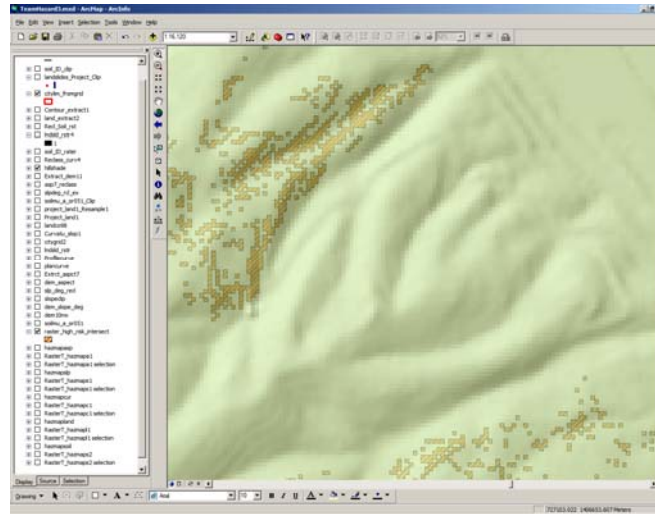


Select by attributes for each land slide factor

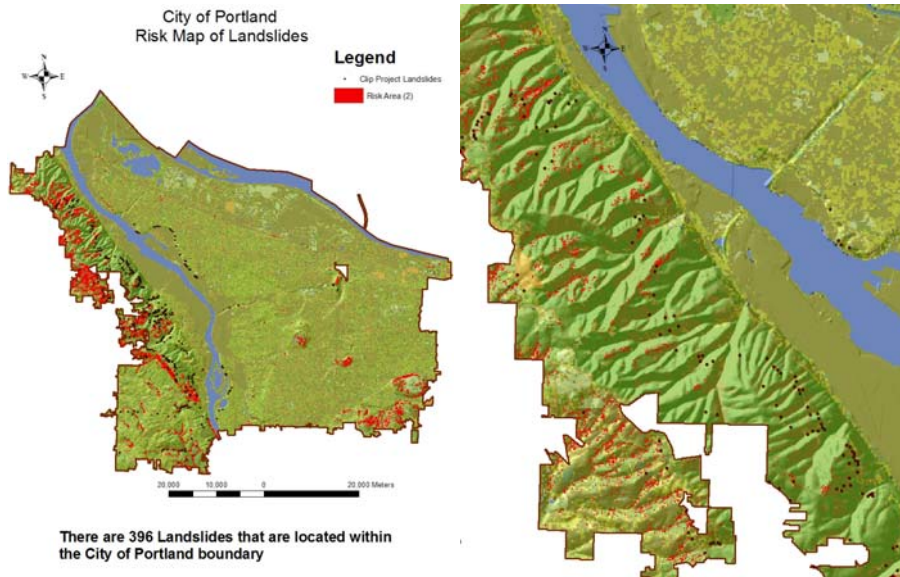
- Selection based on frequency ratio
- Value <1= low correlation, >1= high correlation.
- Reclassed the reclassified values for high or low.
- Select by attributes for cells with a high correlation values
- Create layer from selected features

Intersect

Combine new high correlation layer with intersect tool.



Risk Map



Risk Map

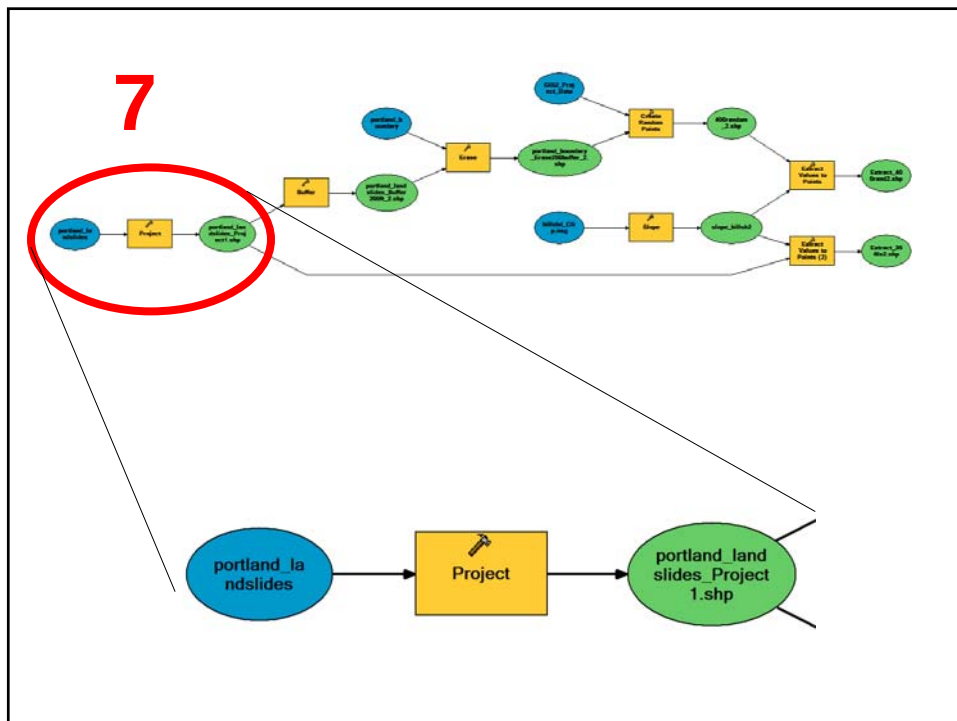


Guideline

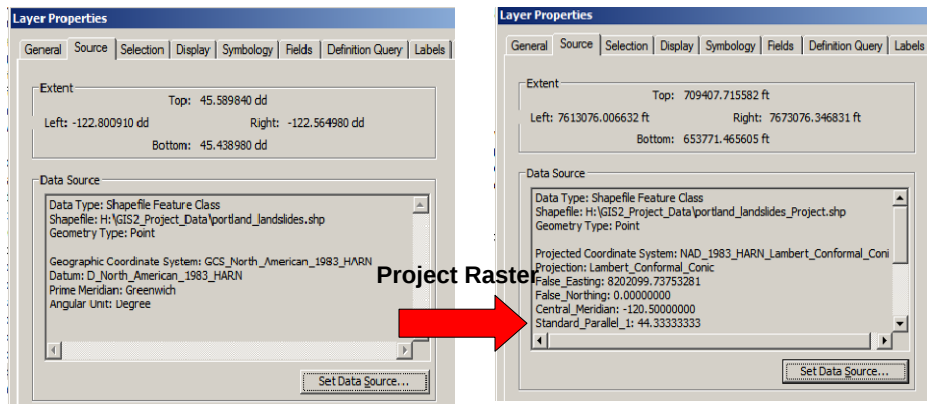
- Goal:
Evaluate efficiency of the risk model
(frequency ratio, multi-criteria, weight
factors, risk value map...)
- Method (18 slides)
- Result: T-test

Method

1. Use T-test to evaluate the model: compare the risk values of all 396 known landslides and 400 random choose positions.
2. Extract risk value to each known landslide points and random point
3. Calculate slope.
4. Create random points in the new polygon
5. Create a polygon without the buffer areas
6. Create 200 feet buffer of all 396 landslides. (why 200ft?)
7. Project the landslide data

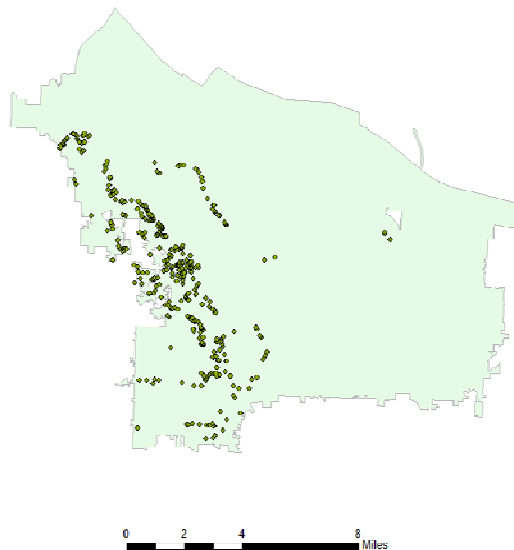


Project Raster *

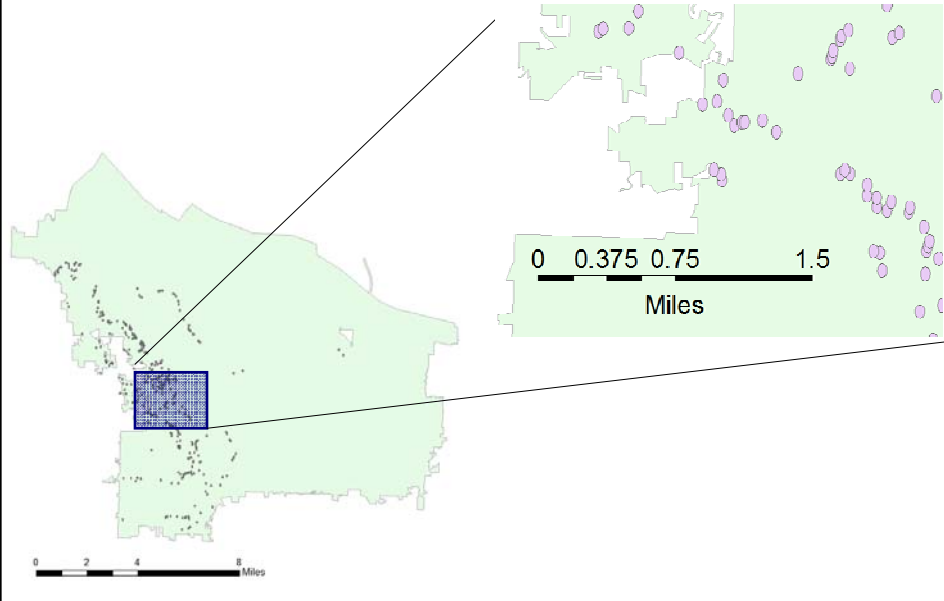


* The landslide data is not from RLIS and it needs to be projected to the map correctly.

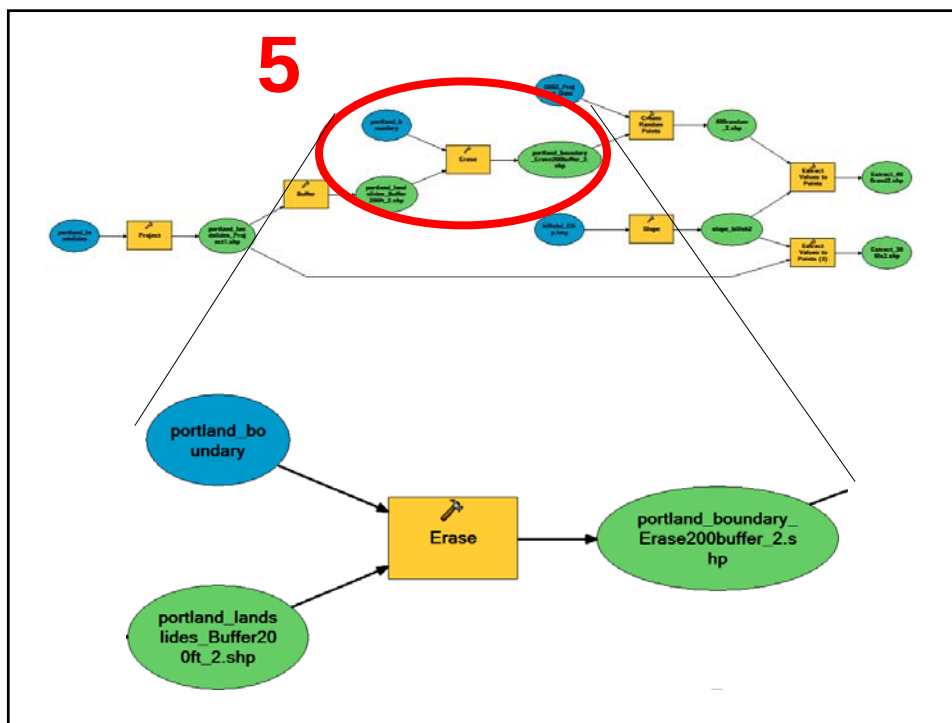
Landslides in Portland



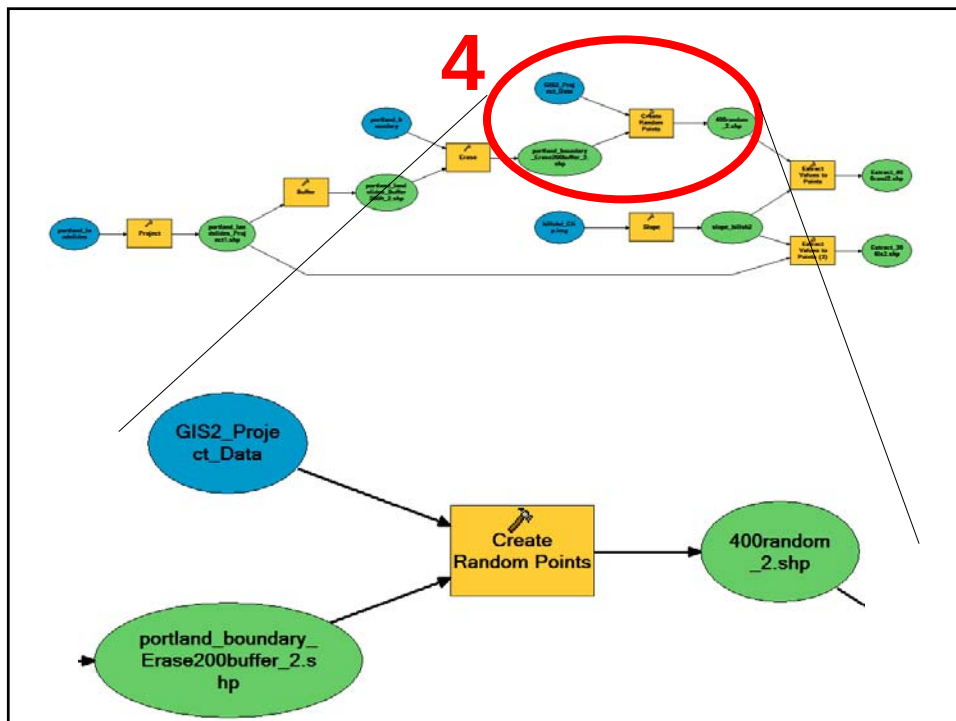
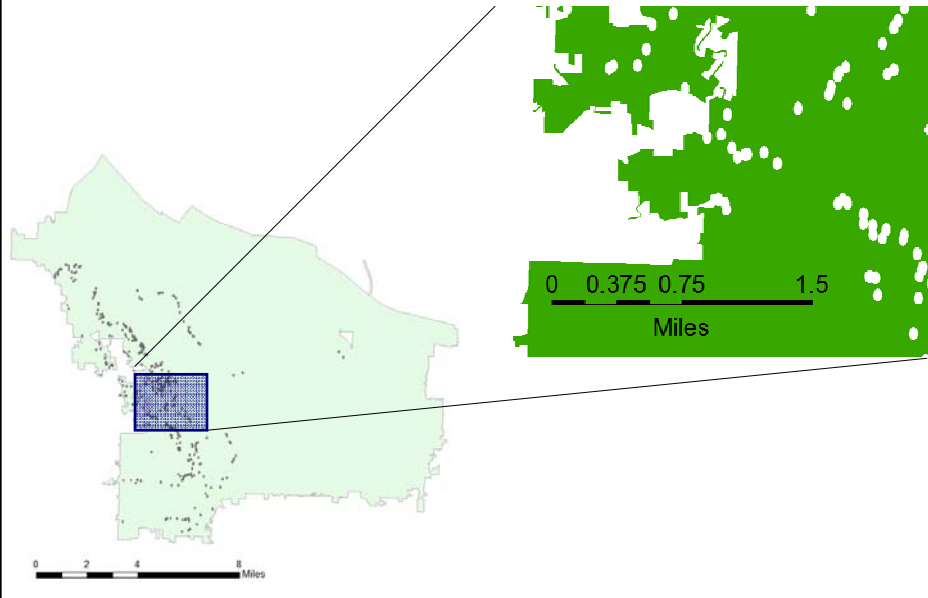
Create 200 feet buffer of landslide points



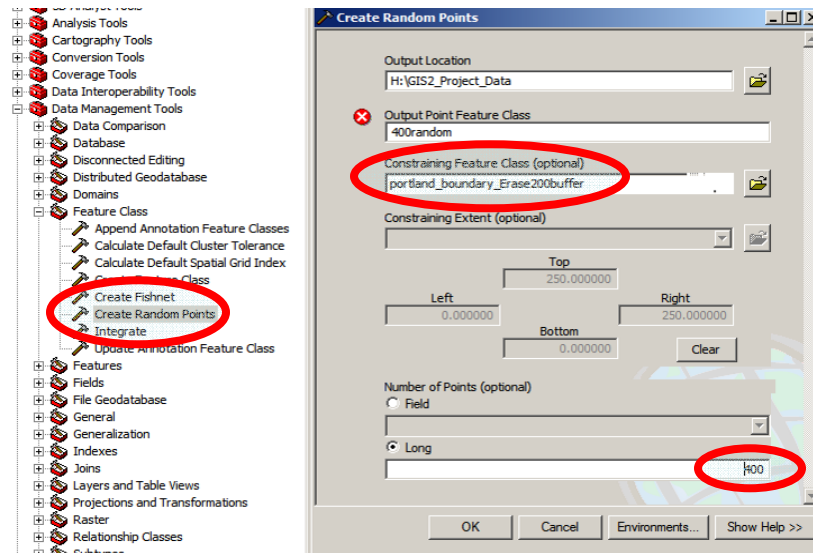
5



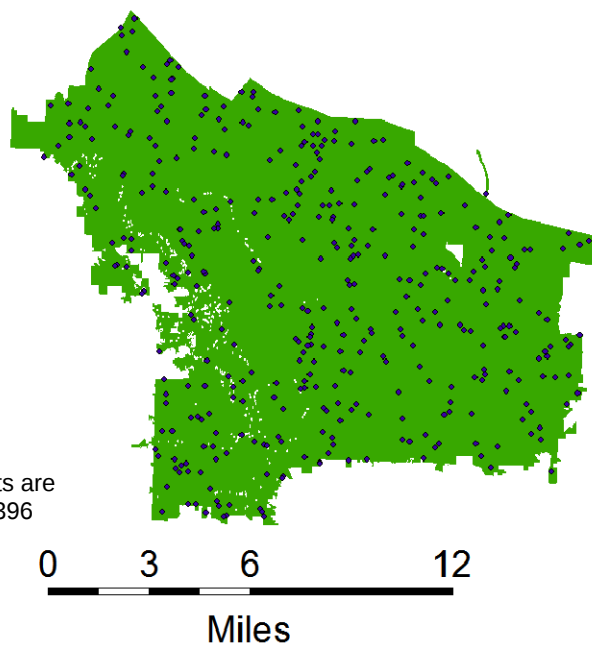
Remove the buffer areas



Create 400 random points



400 random points



NOTE:
None of these 400 random points are
in the 200ft buffer region of the 396
known landslide points.

Choose slope value as the ONLY risk value

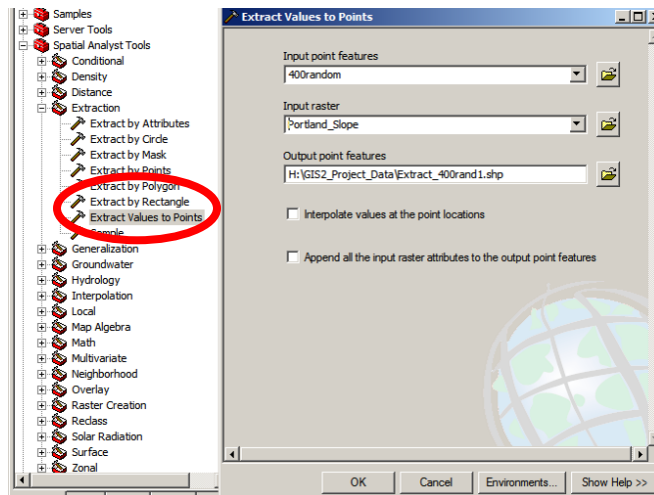
	Correlation
<u>Aspect</u>	1.63
<u>Slope</u>	1.83
<u>Curvature</u>	1.46
<u>Soil</u>	1.26
<u>Land cover</u>	1.56



Portland_Slope
High : 68.8 degree
Low : 0 degree



Extract value to points *



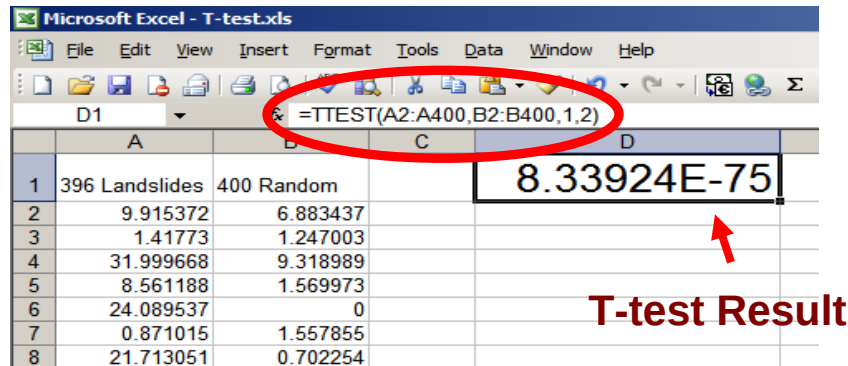
* Extract risk value to 400 random points and 396 known landslide points.

Extract value to points

Attributes of Extract_396ls		Attributes of Extract_400value			
SLIDECONT	RASTERVALU	FID	Shape	CID	RASTERVALU
1	9.915372	0	Point	0	6.883437
1	4.142023	1	Point	0	1.811703
1	31.999668	2	Point	0	9.31899
1	8.561188	3	Point	0	1.569973
1	24.089537	4	Point	0	0
1	0.871015	5	Point	0	1.557856
1	21.713051	6	Point	0	0.702254
1	25.338827	7	Point	0	0.973806
1	35.553955	8	Point	0	0
1	16.948523	9	Point	0	1.168518
1	26.903214	10	Point	0	0
1	14.764438	11	Point	0	0
1	14.99143	12	Point	0	0
1	28.395815	13	Point	0	2.096908
1	17.628313	14	Point	0	5.680277
1	33.965916	15	Point	0	5.28356
1	6.447433	16	Point	0	6.077788
1	16.1458	17	Point	0	0.550904
1	11.212178	18	Point	0	1.752473
1	17.998154	19	Point	0	0.435533
		20	Point	0	0

Each data set was assigned a new column. This column shows the risk value of each point.

T-test *



*

TTEST(array1,array2,tails,type)

Array1 is the first data set.

Array2 is the second data set.

Tails tails=1, TTEST returns the probability of a higher value of the t-statistic under the assumption that array1 and array2 are samples from populations with the same mean

Type is the kind of t-Test to perform. (Type3: Two-sample equal variance)

Conclusion

- The 10^{-74} p value indicates that the two sets of samples are not from the same population. One set came from the "risk cell" population and the other came from the "non-risk cell" population. Our risk model works.
- Slope is highly correlated with landslides
- The Model Builder can be used when the risk map is available.

