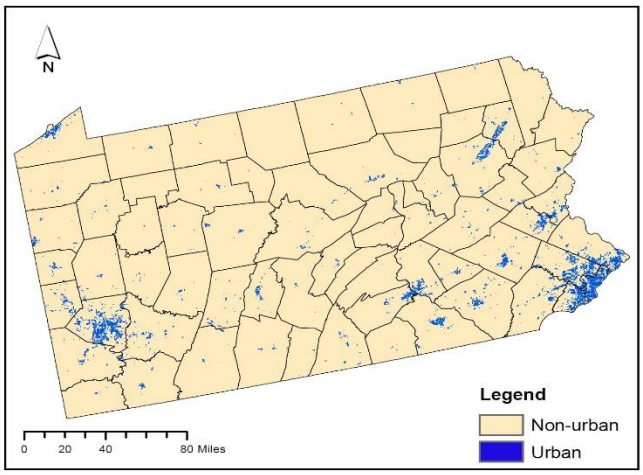
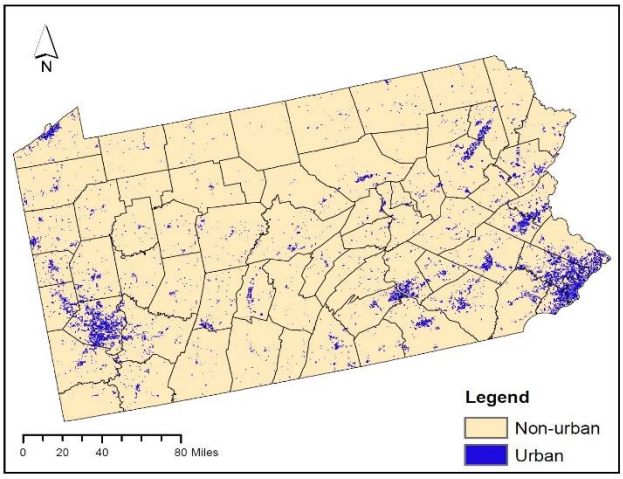
Urban Suitable Growth

Step 1: Urban Area change between 1992 and 2001 in Pennsylvania

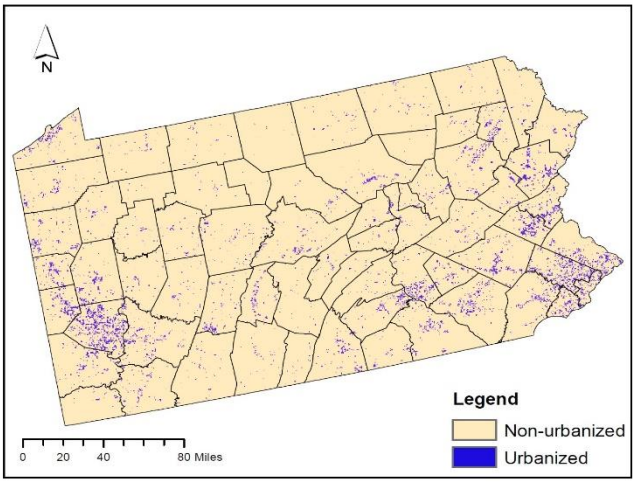
Pennsylvania Urban Locations in 1992



Pennsylvania Urban Locations in 2001



Pennsylvania Urbanized Locations between 1992 and 2001



The number of grid cells that were converted from 1992 to 2001 was 12408

Urbanized between 1992 and 2001

Rowid	VALUE	COUNT
0	0	401783
1	1	12408

Step 2: Table describing urban land, population change and ratio of two

Name	Sum	Urban land Conversion（Square Meter）	Pop Growth	Land Conversion Ratio
Cameron	3	749991.90	7270	103.1625722
Forest	13	3249964.90	5016	647.9196372
Sullivan	12	2999967.60	4180	717.6955981
Adams	78	19499789.40	23189	840.9068697
Wayne	79	19749786.70	20068	984.143248
Pike	132	32999643.60	30740	1073.50825
York	259	64749300.70	58042	1115.559435
Huntingdon	44	10999881.20	9090	1210.107943
Juniata	25	6249932.50	4797	1302.883573
Chester	329	82249111.70	53626	1533.754367
Montour	27	6749927.10	4257	1585.606554
Union	62	15499832.60	8583	1805.875871
Lancaster	398	99498925.40	52055	1911.41918
Potter	13	3249964.90	1698	1913.995819
Monroe	415	103748879.50	50065	2072.283621
Wyoming	48	11999870.40	5434	2208.294148
Berks	339	84749084.70	36913	2295.914304
Susquehanna	66	16499821.80	7002	2356.44413
Cumberland	267	66749279.10	26529	2516.087267
Centre	202	50499454.60	19168	2634.570879
Carbon	117	29249684.10	10812	2705.298197
Somerset	86	21499767.80	7903	2720.45651
Northampton	288	71999222.40	26018	2767.285049
Butler	311	77749160.30	26479	2936.257423
Bucks	462	115498752.60	38793	2977.309118
Warren	63	15749829.90	5256	2996.54298
Lehigh	345	86249068.50	27850	3096.914488
Bradford	90	22499757.00	6691	3362.689733
Snyder	61	15249835.30	4215	3617.991768
Columbia	104	25999719.20	6574	3954.931427
Clearfield	191	47749484.30	11549	4134.512451
Clinton	65	16249824.50	3883	4184.863379
Lycoming	187	46749495.10	11148	4193.532033
Elk	40	9999892.00	2086	4793.812081
Franklin	212	52999427.60	10485	5054.785656
Armstrong	97	24249738.10	4132	5868.765271
Mifflin	59	14749840.70	2307	6393.515692
Greene	54	13499854.20	1902	7097.715142
Montgomery	707	176748091.11	24762	7137.876226
Bedford	65	16249824.50	2264	7177.48432
Perry	55	13749851.50	1743	7888.61245
Dauphin	326	81499119.80	8754	9309.929153
Schuylkill	124	30999665.20	3280	9451.117439
Fayette	173	43249532.90	4490	9632.412673
Tioga	67	16749819.10	1661	10084.17766
Crawford	196	48999470.80	4786	10238.08416
Fulton	39	9749894.70	933	10450.04791
Erie	292	72999211.60	5964	12239.97512
Venango	99	24749732.70	1855	13342.17396
Lebanon	145	36249608.50	2708	13386.11835
Lawrence	215	53749419.50	3585	14992.86458
Mercer	258	64499303.40	4134	15602.1537
Blair	171	42749538.30	2357	18137.26699
Jefferson	91	22749754.30	918	24781.86743
McKean	53	13249856.90	353	37535.00538
Northumberland	101	25249727.30	299	84447.2485
Delaware	237	59249360.10	697	85006.25553
Lackawanna	224	55999395.20	59	949142.2916

Name	Sum	Urban land Conversion	Pop Growth	Land Conversion Ratio
Indiana	87	21749765.10	-111	-195943.8297
Clarion	77	19249792.10	-390	-49358.44128
Westmoreland	410	102498893.00	-4974	-20606.93466
Beaver	331	82749106.30	-5504	-15034.35798
Luzerne	294	73499206.20	-9359	-7853.318325
Washington	276	68999254.80	-10436	-6611.657225
Allegheny	1251	312746622.31	-55123	-5673.61396
Cambria	186	46499497.80	-12183	-3816.752672
Philadelphia	215	53749419.50	-68940	-779.6550551

It can be seen from the table that the **Cameron** has the most efficient urban land conversion. The **Indiana** has the most inefficient way of urban land conversion.

Firstly, the table is divided into two parts. The first part is the counties with positive change, the second on is the counties with negative change.

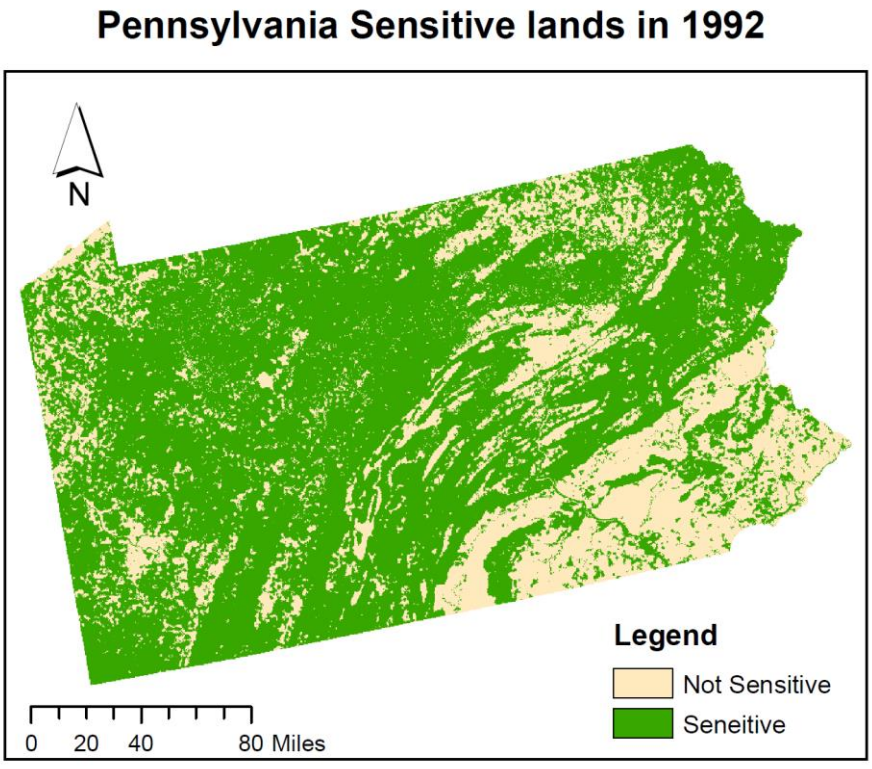
The Land Conversion Ratio is calculated by the Urban land Conversion divide the Population Growth. It is notable that if the ratio is smaller, the land conversion is more

effective. The effective way of urban conversion is when the county has the same urban conversion area, but it can take in more population growth. Or when the population growth is settled, the county needs less land than others.

This ratio is very important because this ratio represents the efficiency of the use of new land. If this is small or moderate, this means that the transition from non-urban to urban meets the needs of urban growth. If this ratio is large, it means that there is no obvious population growth in the city's conversion, which requires reconsidering whether it makes sense to continue urban development in the region.

However, this ratio I think is also flawed. If there is a small number of newly developed urban areas, the ratio will be small, but it may not be that their land use is very effective. Because it is very likely that these new land does not meet the needs of the new population, the area of the development area of the city is small because of the small county development capacity. To some extent, this ratio is not objective enough.

Step 3: Map describing 1992 Sensitive Lands and Table



The table indicate the amount grid cells and the area of the sensitive lands in 1992

County Name	Sum Grid Cells	AREA(Square Meters)
Clearfield	9402	2350474614.67
Potter	8691	2172726534.36
Centre	8389	2097227349.76
McKean	8296	2073977600.86
Lycoming	8168	2041977946.46
Somerset	7975	1993728467.56
Bedford	7866	1966478761.86
Clinton	7480	1869979804.05
Tioga	7367	1841730109.16
Huntingdon	7345	1836230168.56
Westmoreland	7322	1830480230.86
Warren	7075	1768730897.55
Indiana	6752	1687981769.65
Elk	6695	1673731923.55
Crawford	6656	1663982023.85
Luzerne	6597	1649232188.15
Washington	6426	1606482649.85
Fayette	6226	1556483189.85
Butler	6184	1545983303.25
Venango	5979	1494733856.74
Schuylkill	5971	1492733878.34
Wayne	5820	1454984286.04
Armstrong	5632	1407984793.64
Bradford	5558	1389484993.44
Cambria	5466	1366485241.84
Susquehanna	5161	1290236065.34
Greene	5124	1280986165.24
Jefferson	5068	1266986316.44
Pike	4902	1225486764.64
Monroe	4721	1180237253.33
Clarion	4627	1156737507.13
Perry	4147	1036738803.13
Mercer	4131	1032738846.33
Allegheny	4053	1013239056.93
Erie	3987	996739235.13

County Name	Sum Grid Cells	AREA(Square Meters)
Blair	3762	940089842.63
Forest	3729	932239931.73
Berks	3567	891740369.13
Sullivan	3549	887240417.73
Cameron	3539	884740444.73
Fulton	3420	854990766.03
Beaver	3404	850990809.23
Carbon	3189	797241389.72
Lackawanna	3133	783241540.92
Franklin	3060	764991738.02
Mifflin	2944	735992051.22
Dauphin	2889	722242199.72
Juniata	2861	715242275.32
Northumberland	2625	656242912.52
York	2496	623993260.82
Wyoming	2461	615243355.32
Columbia	2282	570493838.62
Bucks	2029	507244521.72
Lawrence	1982	495494648.61
Snyder	1970	492494681.01
Union	1922	480494810.61
Chester	1905	476244856.51
Cumberland	1864	465994967.21
Lancaster	1713	428245374.91
Adams	1452	362996079.61
Montgomery	1205	301246746.51
Lebanon	1174	293496830.21
Lehigh	1040	259997192.01
Northampton	1005	251247286.51
Delaware	729	182248031.71
Montour	275	68749257.50
Philadelphia	270	67499271.00

Description:

When using the raster calculator to identify if the place is sensitive, I use the select rule: “Water” | “Forest” | (“Pasture” &” Farm”)

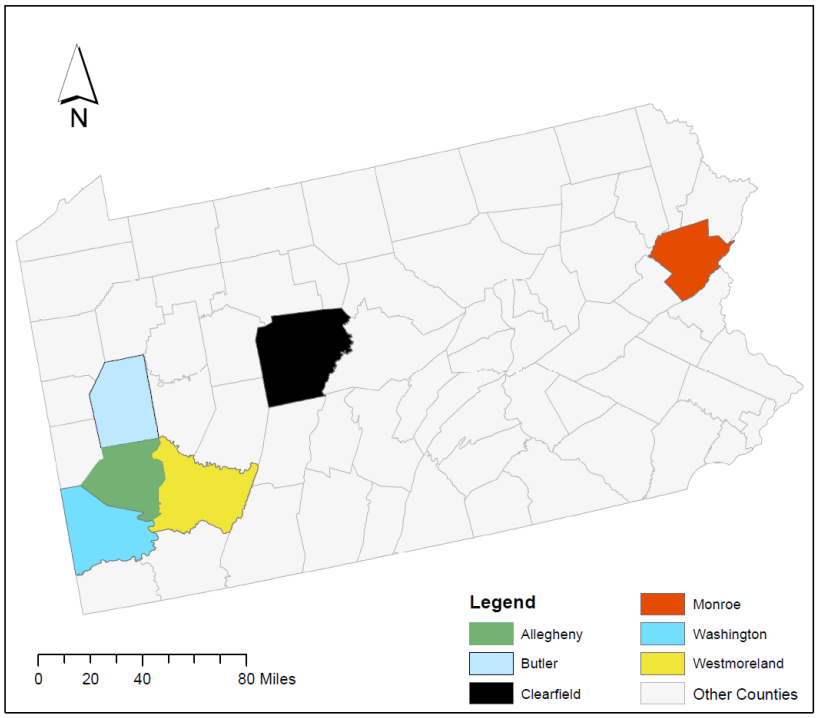
I assume that the Pasture should occur with Farm, it can be identified as sensitive.

Step 4: The table include the number of Grid cells which is sensitive in 1992 developed upon 2001

County Name	SUM Grid Cells	AREA(Square Meters)
Allegheny	285	71249230.50
Westmoreland	152	37999589.60
Monroe	137	34249630.10
Butler	116	28999686.80
Washington	116	28999686.80
Clearfield	115	28749689.50
Beaver	115	28749689.50
Cambria	84	20999773.20
Luzerne	83	20749775.90
Lawrence	83	20749775.90
Crawford	81	20249781.30
Mercer	81	20249781.30
Fayette	80	19999784.00
Centre	76	18999794.80
Schuylkill	76	18999794.80
Delaware	71	17749808.30
Pike	64	15999827.20
Montgomery	62	15499832.60
Lackawanna	60	14999838.00
Carbon	59	14749840.70
Venango	58	14499843.40
Blair	56	13999848.80
Erie	55	13749851.50
Jefferson	55	13749851.50
Berks	54	13499854.20
Armstrong	53	13249856.90
Dauphin	53	13249856.90
Wayne	49	12249867.70
Somerset	47	11749873.10
Bucks	45	11249878.50
Indiana	44	10999881.20
Chester	44	10999881.20
Clarion	41	10249889.30
Warren	40	9999892.00

County Name	SUM Grid Cells	AREA(Square Meters)
Philadelphia	39	9749894.70
Huntingdon	35	8749905.50
Perry	35	8749905.50
Bedford	35	8749905.50
McKean	33	8249910.90
Bradford	32	7999913.60
Susquehanna	32	7999913.60
Lehigh	32	7999913.60
Greene	32	7999913.60
Clinton	28	6999924.40
Northumberland	27	6749927.10
Cumberland	27	6749927.10
Lycoming	26	6499929.80
Columbia	26	6499929.80
Tioga	24	5999935.20
Lancaster	24	5999935.20
York	24	5999935.20
Northampton	23	5749937.90
Snyder	22	5499940.60
Lebanon	21	5249943.30
Mifflin	19	4749948.70
Elk	18	4499951.40
Fulton	18	4499951.40
Wyoming	16	3999956.80
Adams	15	3749959.50
Franklin	14	3499962.20
Union	12	2999967.60
Juniata	11	2749970.30
Potter	10	2499973.00
Sullivan	9	2249975.70
Forest	7	1749981.10
Montour	7	1749981.10
Cameron	3	749991.90

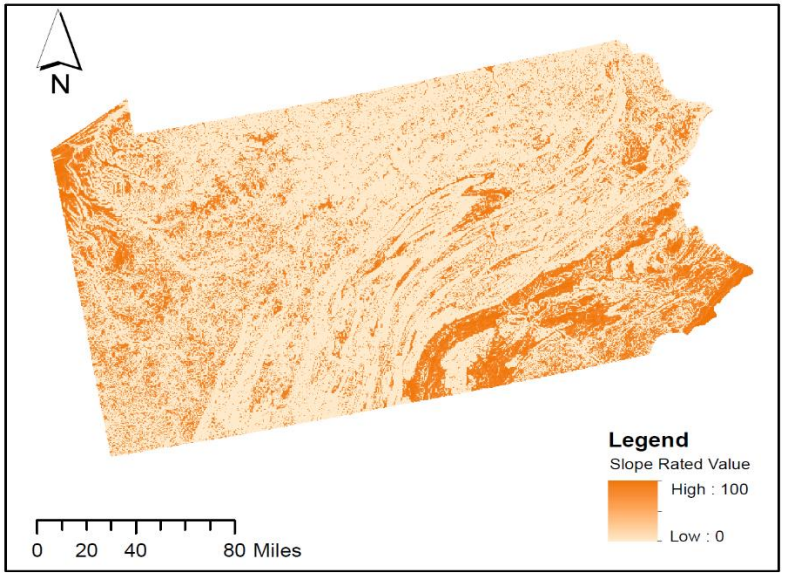
Top 6 Sensitive lands developed County



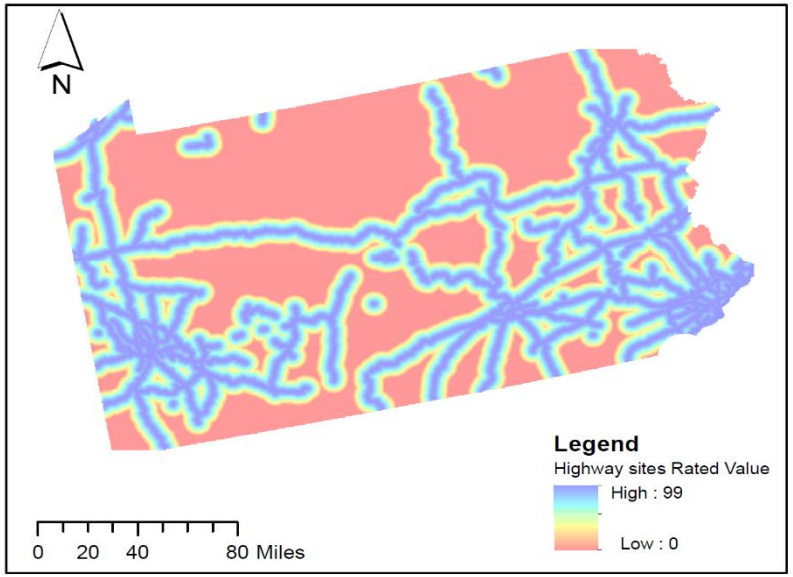
The Allegheny, Butler, Clearfield, Monroe, Washington and Westmoreland is the top 6 counties with urban growth threatening to the sensitive lands. From the map, it is notable that Most of them are gathered in the southwest, which shows that although the southwest is a sensitive area, the urban has expanded rapidly in recent years.

Step 6: Three Scaled Decision factors and Future Urbanization Index Map

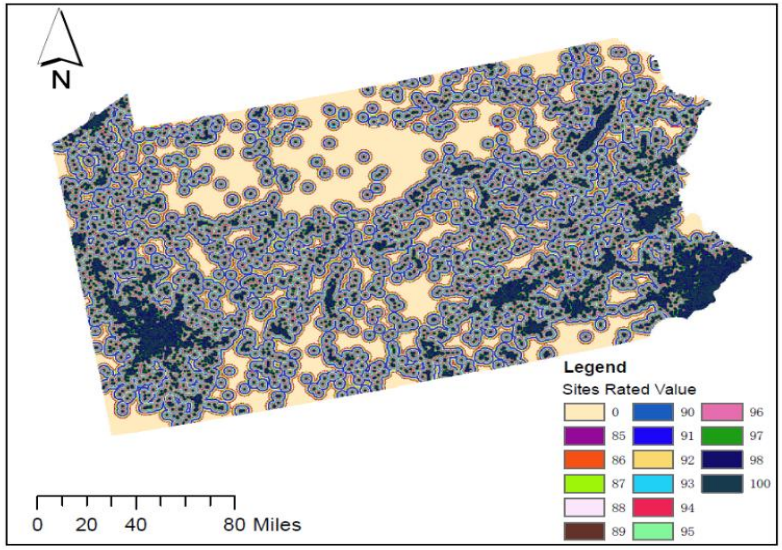
Pennsylvania Sites Slope less than 2 degrees in 2001



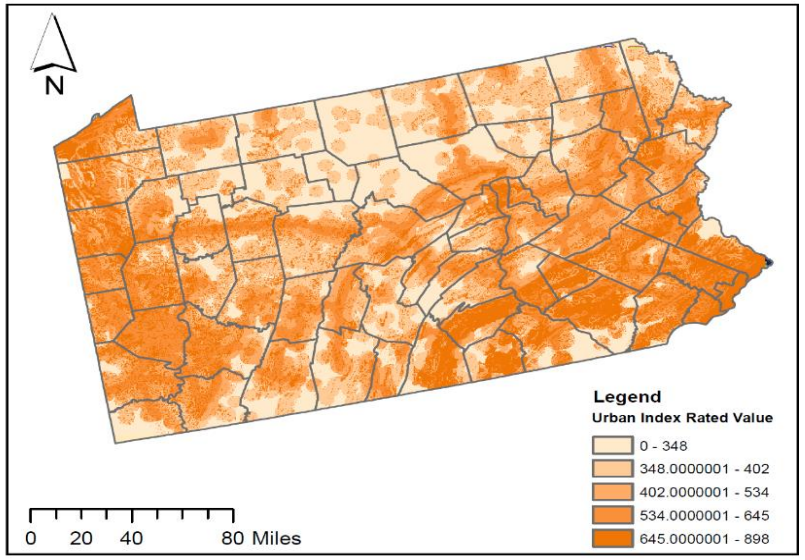
Pennsylvania Sites within 10km of 4-lane Highways in 2001



Pennsylvania Undeveloped Sites within 6km of Urban in 2001



Pennsylvania Future Urban Index



Description:

Use the Euclidean distance dealing with the sites are within 6 kilometers of urban and the sites within 10kilometers of 4-line. There is a tip for dealing with the sites within 6 kilometers of urban. For the problem that it can't be reclassify as quantile in 100 value. It is possible to use Euclidean distance without setting the distance and reclassify it into 100 value quantiles. And then do it twice with Euclidean distance with 6km distance, and then reclassify its value less than 6000 as 1, and then use raster calculator to multiply them together.

In the process of reclassification, the closer to the highway, the higher the score. The closer the city is to the existing city, the higher the score. The slope is less than or equal to 2 and the smaller, the higher the score.

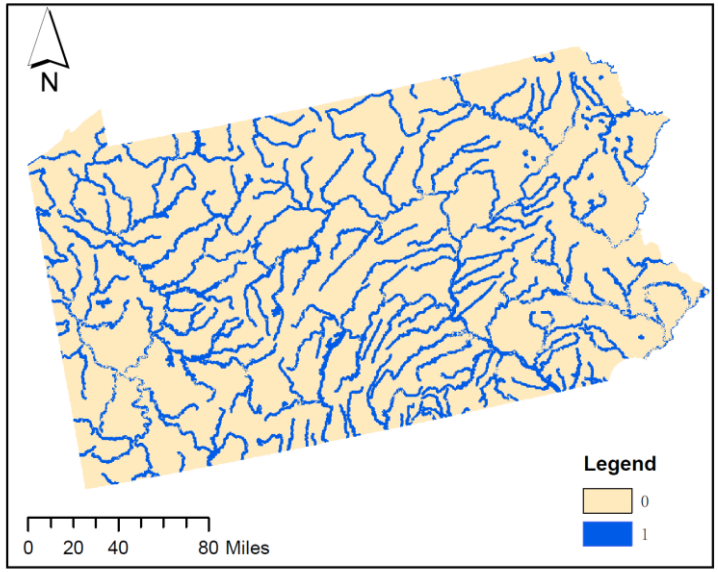
Calculate the final score by the given weight:

$$\begin{aligned}&\text{Future Urban Index}\\&\quad=(\text{slope score}\times 3+\text{Undeveloped sites Near Urban}\times 4\\&\quad+\text{road proximity}\times 2)\end{aligned}$$

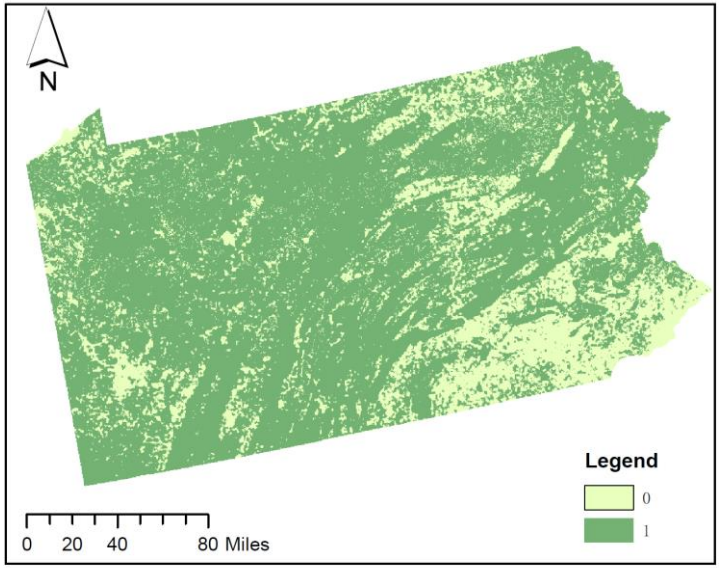
At last, making the Future Urban Index map with 5 Quantile Breaks.

Step 6: Environmental Sensitivity Index Decision Factors

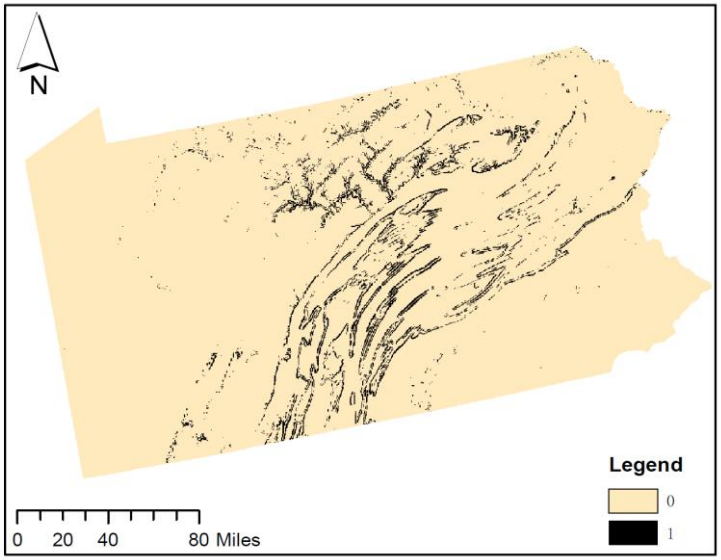
Pennsylvania Undeveloped sites within 1000 meters of river in 2001



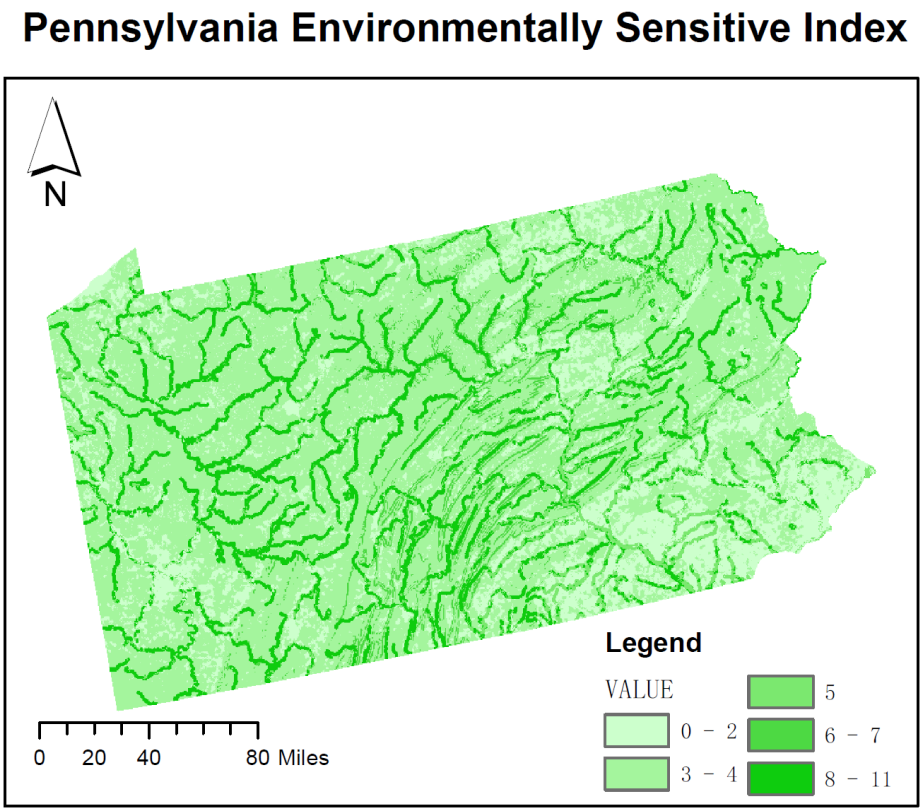
Pennsylvania Farm and Forest sites in 2001



Pennsylvania Hillsides with Slope of 15 degrees or more in 2001



Step 7: Final Environmental Sensitivity Index



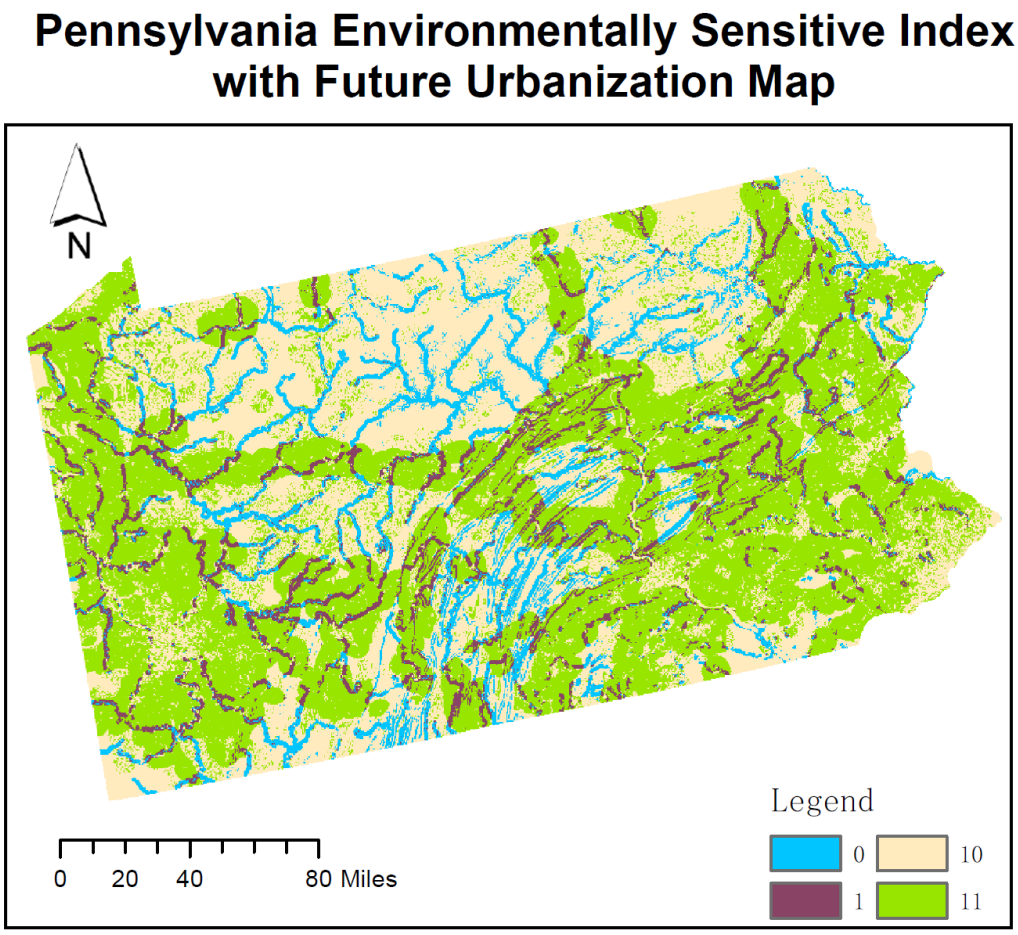
Description:

In step 6, there are three decision factors, they are the active farm and forest, the undeveloped sites with 1000 meters of river and the hillsides have slope more than 15. The three maps use binary 0 and 1 to describe the decision factors. The 1 means it is accord with the condition.

In step 7, I set the weights by myself, I give the undeveloped sites with 1000 meters of river a weight of 5, the hillsides have slope more than 15 a weight of 2 and active farm and forest a weight of 4. Undeveloped sites with 1000 meters of river has the highest weight because River basins are large in area. In addition, few governments regularly monitor to ensure the ecological quality of river basins. At the same time, the impact of human behavior on water resources is enormous. Farms and forests are one point lower than rivers because I think they are regularly protected and monitored. For example, if the farm is destroyed, the farmer will keep it in time. There are abnormal events in forests, such as fires, private logging, etc., and related department will find it in time. I gave the minimum weight 2 for the slope, because slopes greater than 15 are often forests and mountains, and secondly, such landforms are not suitable for construction, so his reflection on ecological sensitivity should not be particularly obvious. So the final Environmental Index:

$$\text{Final Enviromental Index} = (\text{undeveloped sites with 1000 meters of river} \times 5 + \text{farm and forest} \times 4 + \text{slope} >= 15 \times 2)$$

Step 8: 4 Categories combing the Environment Sensitivity with Future Urbanization



Description:

I give the area **can be developed** the value **1**, **can not be developed** the value **0**. I give the area are **sensitive** the value **0**, **not sensitive** the value **10**. Through the addition to add them together in raster calculator.

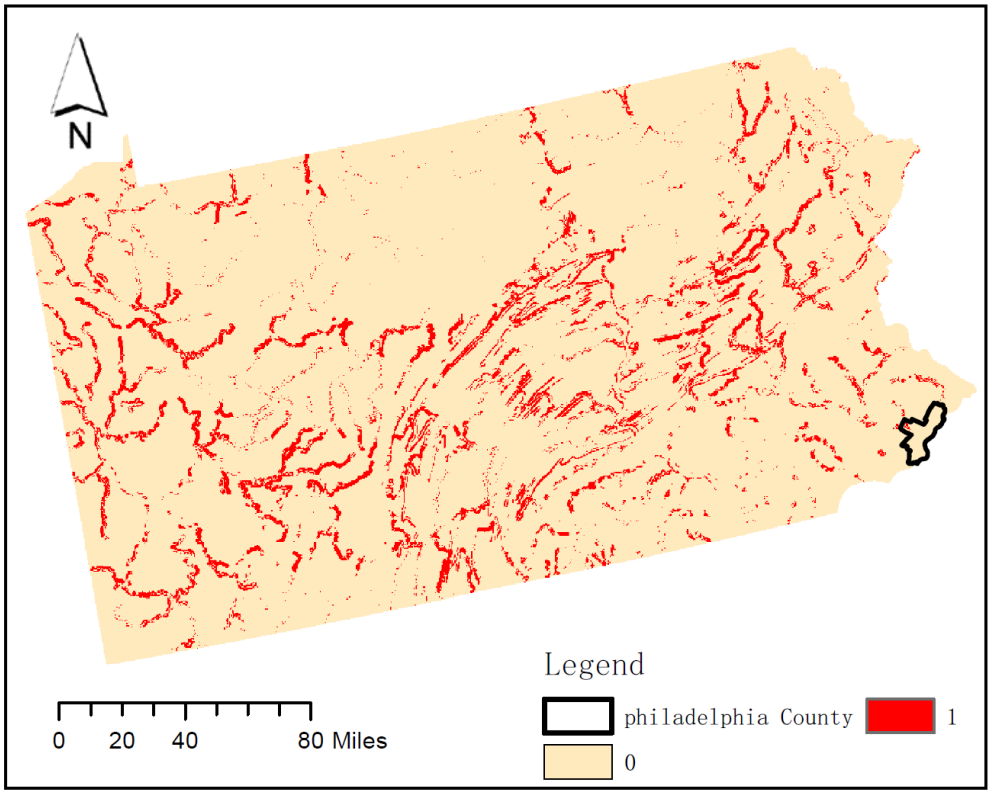
The reason for this assignment value is that sensitivity should be the main factor to be considered. Because if the area is sensitive, then this area has a weak self-recovery ability for the damage caused by urban construction.

The disruption caused by construction in sensitive areas greatly exceeds the benefits of new urbans, and it also reduces the living conditions of existing urbans.

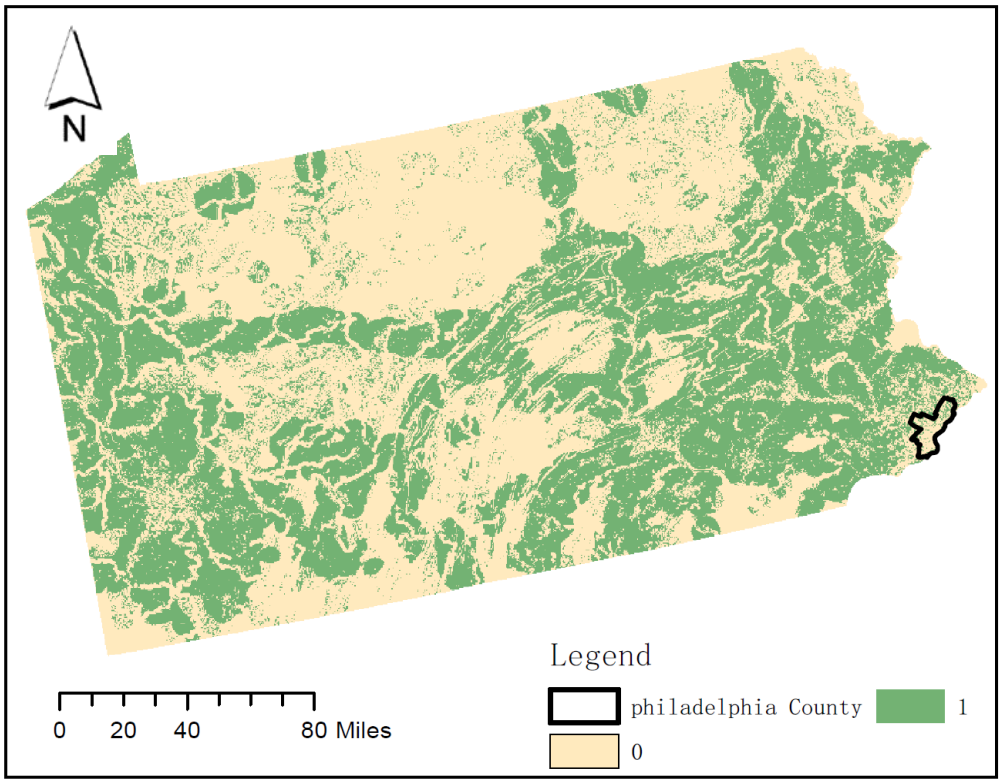
11	The area is not sensitive and might be developed
10	The area is not sensitive and might not be developed
1	The area is sensitive and might be developed.
0	The area is sensitive and might not be developed

Step 9: Maps showing the two case might be developed

Pennsylvania Environmentally Sensitive and Might be Developed Area



Pennsylvania Not Environmentally Sensitive and Might be Developed Area



Description：

In general, there are few development sites available in Philadelphia. This is reasonable because the urbanization process in Philadelphia itself is very early. The level of urbanization is also high, and the lack of a development environment within the Philadelphia county is also a reality.

From the map, Philadelphia's ecologically sensitive and developable areas are few, with only a small portion of the northwest, and Philadelphia's non-sensitive developable areas are concentrated in the northeast. This part is larger than the ecologically sensitive and developable area. These areas should be considered when urban construction needs increase. This shows that Philadelphia has potential for expansion in the future in the northern region.