Report on:

Sub-Task 2.c Geospatial mapping for Puget Sound recovery

September 2022

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Descriptive text for this sub-task (copied from the Work Plan):

> *List of themes & products being worked on (e.g., analyses and products that anticipate or project future conditions, identification of areas where exempt wells are likely to affect stream flow, pressure on critical areas, etc.)*

Background

The focus of this sub-task is on developing a model to simulate future land cover change due to development in the Puget Sound region. PSI's decision to embark on this project grew out of an assessment of needs in 2020. It was clear that describing land cover change over the recent past, and anticipating change in the near future (e.g. next planning cycle), were well attended by others (e.g. Department of Commerce). Anticipating land cover change over multiple future decades was not. Similar projections had been initiated by two independent groups >10 years ago (led by John Bolte and Marina Alberti), but both efforts lapsed. PSI decided to develop of a spatially explicit simulation model intended to project land cover change over multiple decades. In parallel, PSP and John Bolte's group Common Futures have begun a collaboration to compare outcomes of the current growth trajectory ('Business As Usual') with preferred alternative scenarios, yet to be specified, that could conceivably be achieved over the long-term future. Whereas the Common Futures approach to simulating change is 'agent-based', PSI's approach is algorithmically-based, by which the probability of future land cover change is based on a random forest algorithm identifying patterns based on variables known to be correlated with change in the recent past. The two approaches are complementary, each superior for different applications.

PSI's Approach to Simulation

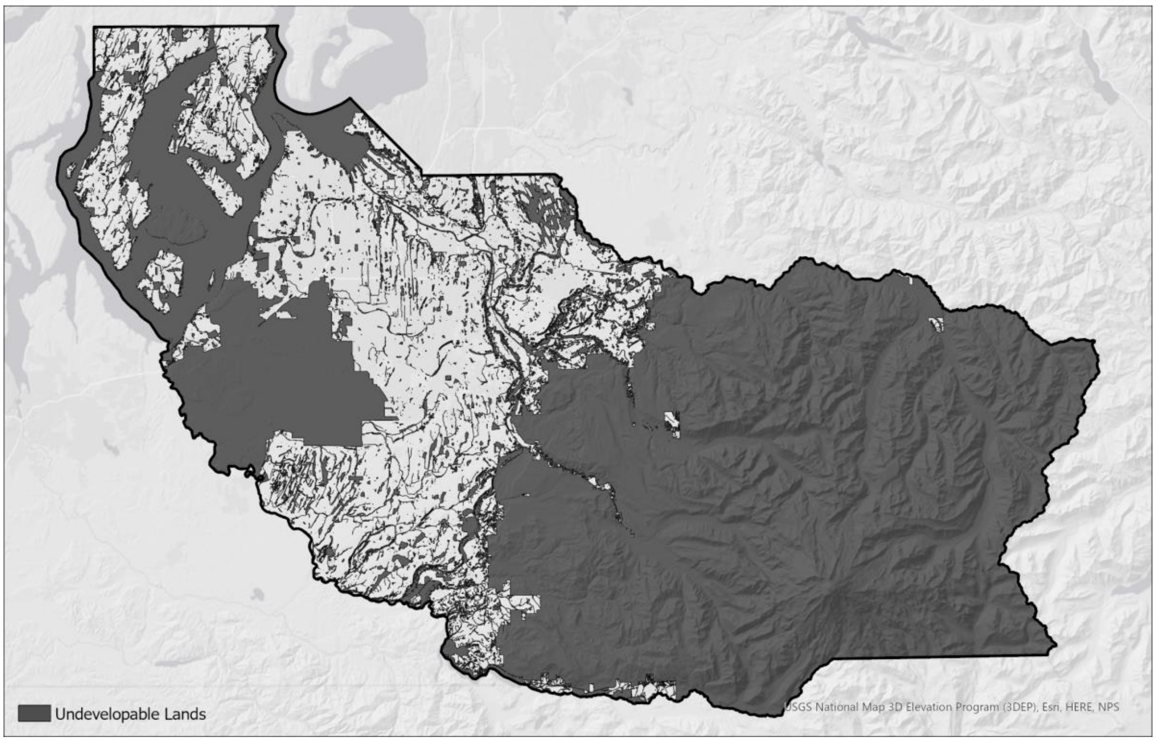
Rather than duplicating Common Futures' agent-based approach, PSI is developing a State-and-Transition Simulation model (STSM) to model future changes in land use and land cover. STSMs are grounded in alternative stable state theory and largely powered by a Markov chain. In PSI's STSM the landscape is divided into discreet spatial units, and assigned an initial state based on classifications in the National Land Cover Dataset (NLCD) at the initial time step. The Markov chain, derived by analyzing NLCD-based development trends between 2001 and 2011, in conjunction with random forest-derived spatial multipliers derived establish state transitions for each timestep in a stochastic process which, after thousands of iterations, results in a probabilistic indication of the land use/land cover composition of the landscape at the ending time step.

Rather than attempting to simulate the entire region at once, a piecemeal approach is progressing by individual county, focused initially on four 'pilot' counties in the Puget Sound region (King, Pierce, Snohomish, and Clallam). These were selected to represent four principal groups that emerged from a clustering analysis of counties, based on economic, population, housing, and education attributes that are related to growth and development (Appendix 1).

Model Development

PSI has successfully developed STSMs and run 2500 Monte Carlo simulations for each of the four pilot counties to forecast land use/land cover change between 2011 and 2016. At the time the model entered development, 2016 was selected as the ending time step as it was the most recent NLCD data against which PSI was able to evaluate model results.

Model development began by determining lands that were undevelopable and thus excluded from consideration in the model (Figure 1). The remaining lands were used to calculate a Markov chain to establish the year-over-year transition probabilities for each state class.



Lands excluded from consideration:

- National Parks
- National Forests
- Military Lands
- State Parks
- State Forests
- County/Municipal Parks
- Golf Courses
- Schools
- Cemeteries
- Airports
- Wetlands
- Open Water
- Slopes > 30%
- Wildlife Areas
- Natural Resource Areas
- Habitat Conservation Areas
- Common Areas

Figure 1: Undevelopable lands and list of excluded lands. Darker areas indicate lands excluded from consideration in the model.

Transition probabilities were calculated by comparing NLCD classified images from 2001 and 2011. Starting with county tax parcels, the NLCD data were aggregated using a majority rule, to yield a classification with one land use/land cover category for each parcel in a county. The aggregated NLCDs served as inputs to calculate change rasters using GIS. The change rasters identified and tallied all parcels that remained in the same state or transitioned from one state to another. This data was used to calculate the total change area for each transition type. Total change areas were used to construct a matrix presenting probabilities that each state will transition to each of the other states, or remain in the same state (Figure 2). Values from the probability matrix were transferred into the model's Markov chain, which serves to govern the yearly transitions (Figure 3). After the calculation of the Markov chain, an initial non-spatial version of the model was constructed to test the ability of the chain to accurately estimate LULC area at the 2016 timestep. The results of the initial non-spatial model presented a range of the total predicted LULC area at the ending 2016 timestep and, when compared to the observed NLCD LULC changes between 2011-2016, the observed fell within the range of predicted (Figure 4). This initial finding provided evidence that the State-and-Transition Simulation modeling approach had the potential to reasonably forecast future LULC composition.

	Agriculture	High Intensity	Low Intensity	Medium Intensity	Open Space	Forest		Yearly Chg
Agriculture*	***0.9939***							**0.9939**
High Intensity	0.0012	***1.0000***	0.0012	0.0003	0.0007	0.0003		**1.0037**
Low Intensity	0.0018		***0.9976***		0.0002	0.0012		**1.0008**
Medium Intensity	0.0019		0.0012	***0.9997***	0.0031	0.0014		**1.0073**
Open Space	0.0010				***0.9960***	0.0009		**0.9979**
Forest**						***0.9963***		**0.9963**

Figure 2: Sample probability matrix. Degrees of 'Intensity' refer to development intensity as classified by the NLCD.
**Combined NLCD Classes: Pasture/Hay, Cultivated Crops*
***Combined NLCD Classes: Perennial Snow/Ice, Barren Land, Deciduous Forest, Evergreen Forest, Mixed Forest, Shrub/Scrub, Grassland/Herbaceous, Woody Wetlands, Emergent Herbaceous Wetlands*

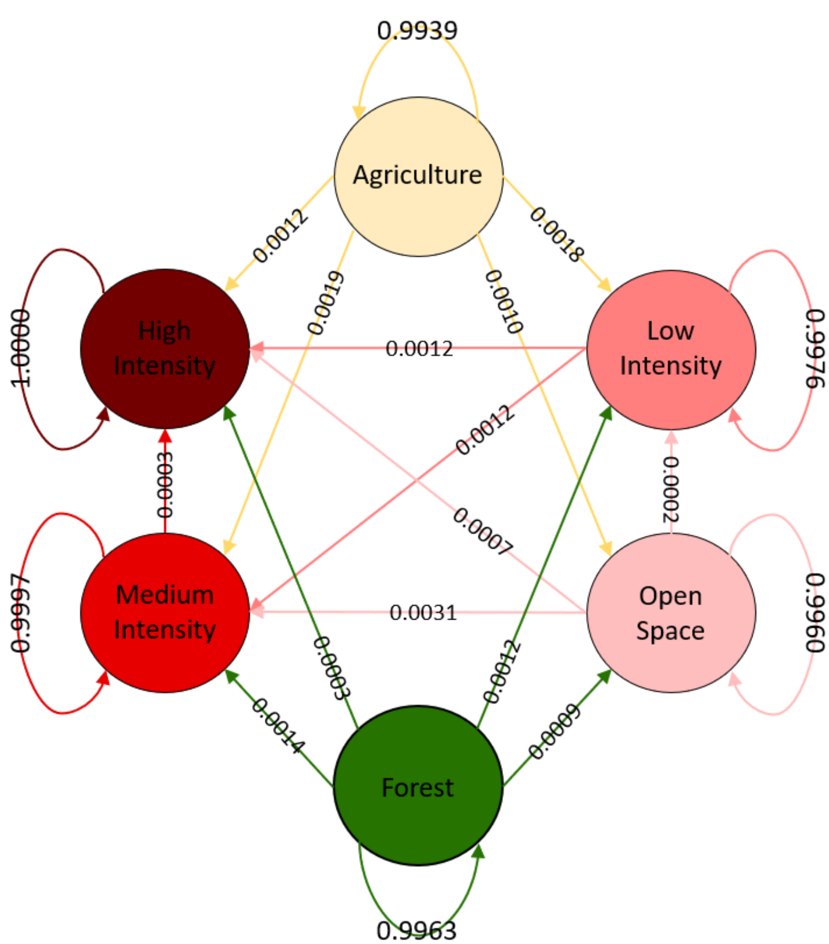


Figure 3: Markov chain derived from probability matrix in Fig. 2. At the model's highest level, the Markov chain governs yearly LULC transitions.

	State Class Area (Square Kilometers): 2016			
	Mean	Max	Min	Actual
Agriculture	117.0291	121.9386	112.1451	**119.195099**
Developed High Intensity	61.0142	66.3317	56.8987	**58.8177**
Developed Low Intensity	277.4922	285.9053	268.4813	**277.676101**
Developed Medium Intensity	163.2546	169.7047	156.7267	**158.5053**
Developed Open Space	196.0644	203.1409	189.4119	**195.1452**
Forest	1188.9163	1200.6703	1176.5770	**1194.431399**

Figure 4: Initial non-spatial model results showing that the actual LULC area in 2016 falls within the range of model-predicted LULC area.

While the Markov chain is responsible for the model's yearly proportional transitions, the spatial distribution of each transition is governed by a random forest algorithm. The PSI random forest algorithm is comprised of 100 individual regression trees individually generated and trained from a random bootstrap sampling of the original input data. GIS was used to calculate measurements of distances from the center of each parcel to nine dependent variables for each observed LULC transition. Based on observations from previous iterations of the model and discussions with John Bolte, the nine variables selected consist of: distances to urban growth areas, regional growth centers, manufacturing industrial centers, the interstate, other freeway/expressways, principal arterials, minor arterials, major collectors, and minor collectors. The inclusion of these variables allowed each regression tree in each random forest to take the presence or absence of a LULC transition as well as the distances to the nine variables into account when calculating splits in the trees. This ensured that the trees split at the distance from one of the variables with the greatest impact on the change in probability that a parcel would transition. Each tree calculates regression-based branches from a random slice of the full input dataset. Additionally, at each split in each tree the model must select from a subset of seven of the nine input variables until it arrives at a final LULC transition probability output. The outputs of all individual trees in the forest are then aggregated to provide the average probability a given parcel will transition from one LULC to another (Figure 5). This process is repeated for each observed transition during the input time period.

In order to be compatible with the model each random forest transition was interpolated to a floating-point raster surface using an Inverse-Distance Weighted (IDW) method. IDW interpolation was performed to spatially direct transition probabilities to future LULC transitions regardless of current LULC. For instance, high intensity and forest parcels have different transition probabilities; generally, a forest parcel can transition to any other type of parcel but a high intensity parcel can only remain a high intensity parcel or transition to a medium intensity parcel. Performing an IDW interpolation on the random forest-derived transition probabilities allows the different transition probabilities associated with each different type of parcel to be correctly attributed to each parcel if it transitions in the future. This transformation from random forest to IDW floating raster allows each raster to function as a spatial multiplier within the model to spatially target each transition into the areas defined by its unique forest (Figure 6).

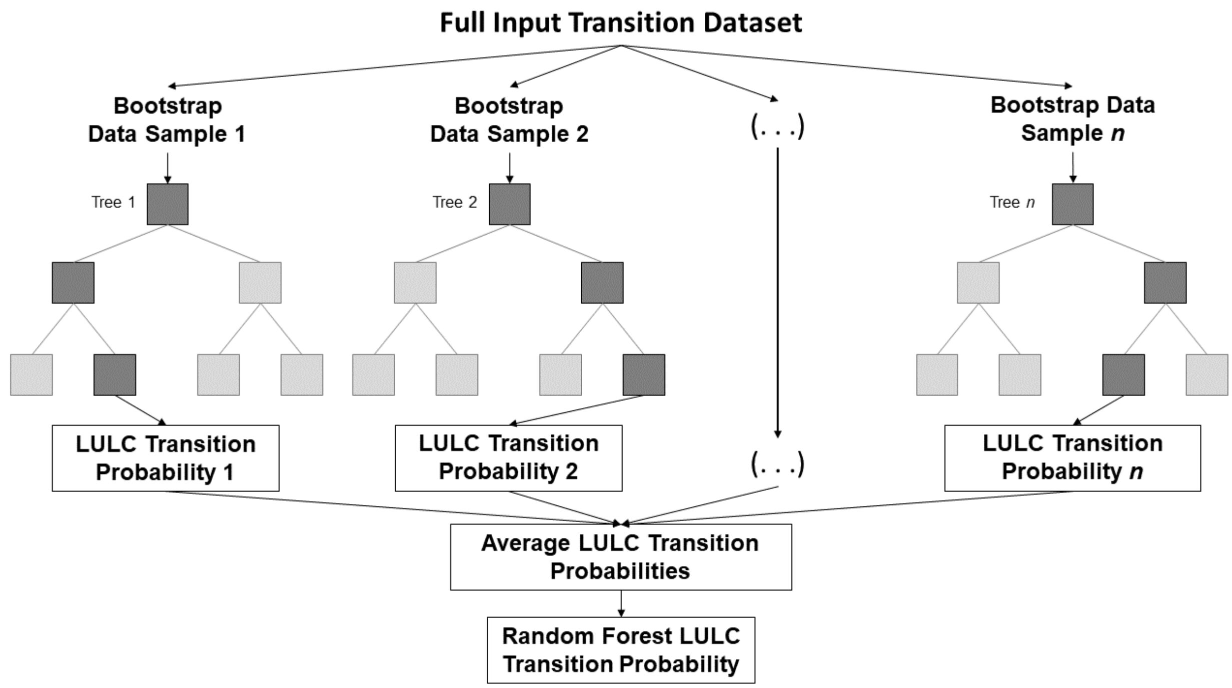


Figure 5: Sample random forest. Each tree samples a random slice of the input data to find parcel transitional probabilities. Outputs, or predictions, of each tree are averaged to arrive at the final transition probability prediction for each LULC transition for every parcel.

Figure 6: Sample spatial multiplier derived from Pierce County's agriculture-to-high intensity transition random forest. Lighter areas indicate a higher probability of transition from agriculture lands to high intensity development but only current and future agriculture parcels that do not intersect undevelopable lands are subject to the transitional probabilities.

Following the translation of each observed transition from random forest to floating point raster, the undevelopable lands were excluded from consideration and the model completed 2500 Monte Carlo iterations allowing the different land use/land cover transitions to compete for developable land based on their unique spatial multiplier. Individual cell transition probabilities were then aggregated at the parcel level to obtain the mean of the parcel's transitional probability for each possible transition. This aggregate output serves as the model's land use/land cover predictions at the ending timestep (Figure 7). At the conclusion of 2500 model runs for each of the four pilot counties, focus switched from model development to model evaluation for each pilot county.

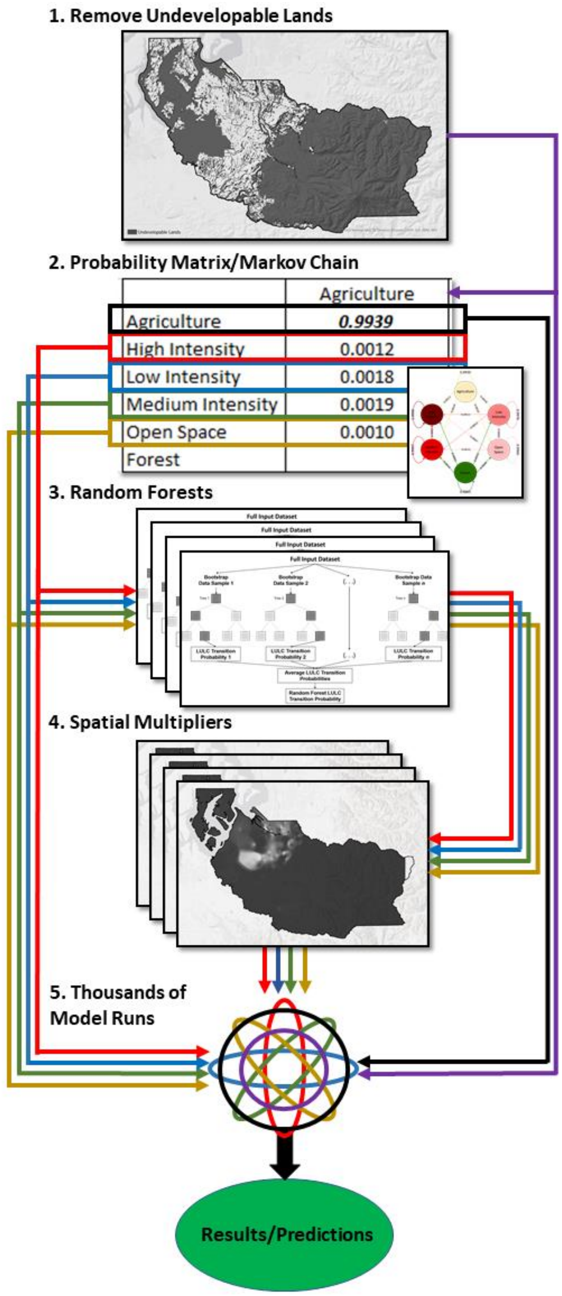


Figure 7: STSM workflow illustrating Agriculture transitions. Steps 2-4 are completed for all observed transitions then model is run thousands of times to determine the probabilistic indication of land use/land cover transition at the ending timestep.

Model Evaluation
Model evaluation consisted of a comparison between the NLCD observed LULC transitions between 2011 and 2016 and model-predicted transition probabilities at timestep 2016. The percentage of observed NLCD transitions between 2011 and 2016 that occurred within areas the STSM found to have a non-zero transitional probability was over 99% in each pilot county. It is important to note that in each county there were transitions that were observed in the 2001-2011 timeline that did not occur between 2011-2016, and/or transitions that were not observed in the 2001-2011 timeline that were observed between 2011-2016 (Appendix 2). As the model's input timeframe expands to include more recent NLCD data, the differences in transition probability will be reflected in the Markov chain and probability matrix. It is also important to note that observed transitions did not necessarily occur in areas that the model predicted to be the most probable, only that the transitions occurred in an area that the model did predict at least once. Future iterations of the model will seek to improve the precision of predicted LULC transitions so that there is a stronger relationship between higher-probability model-predicted transition areas and observed transition areas.

Discussion
Initial model development and evaluation have exceeded initial expectations showing that it is possible to forecast development derived from past trends with relatively few variables. However, there are still numerous avenues through which the model can be improved and calibrated.

The distance calculation from each parcel to each variable is problematic in that only straight-line distance was calculated which does not consider obstacles between a parcel and a given variable. For instance, the lands to the southeast of Joint Base Lewis McChord, toward the southern end of the Key Peninsula, and on the islands in Puget Sound are considered to be in close proximity to an interstate highway when, in fact, the actual distance may be much further or non-existent when obstacles like the military base or Puget Sound are accounted for. This problem is particularly acute in Pierce and King counties where the Puget Sound divides the land mass into multiple unconnected areas. Altering the distance calculation should lead to more nuanced transitional probability calculation and produce more realistic LULC distribution on the landscape.

The current iteration of the model treats a county border as a hard stop when the reality is likely quite different. Segmenting the model into counties ignores the likelihood that areas near a county border are likely influenced as much by a neighboring county as the county in which they reside. Creating a model that encompasses all the counties that comprise the Puget Sound would help by holistically forecasting Sound-wide future land use rather than segmenting predictions into individual counties. It is possible that this could be accomplished by altering the variable distance calculations to include features outside a county's geographic area while retaining county boundaries as the model's spatial scale to keep processing times manageable.

The model's input variables have shown that LULC transitions can be accurately modeled with relatively few variables. However, expanding those variables may help to more precisely forecast LULC changes. The model has shown that proximity to the aforementioned variables have an impact on development probability, it is likely that the inclusion of additional variables would improve the precision the projections. While additional variables are currently unidentified, potentially they would include additional parcel characteristics such as area, slope, and taxable value and potentially a range of economic and demographic census data.

Despite promising initial results, the model's relatively short 10-year input timeframe and even shorter 5-year future projections are perhaps not enough to properly calculate, train and evaluate a model. At the time of initial model development, these timeframes were the best that were available. Moving forward the model will continue to incorporate the latest 2019 NLCD data which would expand the input timeframe to include the years 2001-2019, nearly doubling the Markov chain's input data. This expansion should equate to better transitional predictions in future iterations of the model.

In the process of model development, it became clear that simply including a variable measurement of distance from each parcel to the nearest urban growth area (UGA) was not sufficient to precisely project future development. As such, it was determined that it would be beneficial in future iterations of the model to incorporate a mechanism to proportionally direct projected development inside or outside an UGA based on historical observed trends (Appendix 4).

An analysis was conducted using NLCD data between years 2001 and 2019 which found that, during that time span, a total of 233.60km2 transitioned from one type of land use to another with 74.75% (174.60km2) of transitions occurring within the boundary of a UGA. Examining only the developed class transitions – developed high, medium and low intensity and developed open space – that transitioned from one type of development to another shows that 88.63% (66.14km2 of 74.62km2) of transitions occur within a UGA boundary while examining the non-developed class transitions – agriculture and forest – that transitioned to a developed class shows that 78.35% (104.51km2 of 133.39km2) of transitions occur within a UGA boundary. Analysis showed that there was a relatively small but not-insignificant amount of land that transitioned either from a developed class to a non-developed class or transitioned between non-developed classes. Of the 25.58km2 that fit this description, 76.03% (19.45km2) of these transition cases were either agriculture that transitioned to forest or vice versa (14.09km2 and 5.37km2 respectively) with only 0.09% (1.77km2) occurring within a UGA boundary. Moving forward, these calculations will be instrumental in funneling LULC transitions into appropriate locations on the landscape.

Potential Applications

Examples of potential applications for PSI's LULC STSM are:

1. Project alternate growth scenarios, e.g. compliance with regulations vs. degrees of non-compliance; or status quo vs. new growth paradigms, possibly in collaboration with Common Futures/PSP.
2. Map future distributions and loadings of toxics and nutrients. The growth projection model will be dovetailed with a watershed simulation model (e.g. VELMA) from the start, such that outputs of future growth simulations (e.g. relating to water quality, and factors affecting it) can become inputs to simulations of future watershed conditions and processes (e.g. under contrasting climate warming scenarios).
3. Assess where growth is likely to occur beyond urban growth boundaries.
4. Map future distribution of permit-exempt wells.
5. Map future growth pressure on Critical Areas.
6. Assess implications of growth and climate scenarios on spatial aspects of environmental justice.

Collective participation and input are needed to design and prioritize applications.

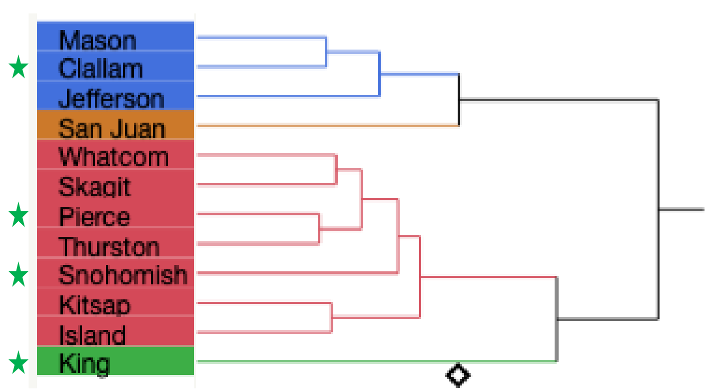
Appendix 1. Clustering of Puget Sound counties based on economic, population, housing, and education variables

For each of the 12 Puget Sound counties, data for 23 variables relating to growth and development (Table A.1) were assembled from https://ofm.wa.gov/washington-data-research/county-and-city-data. These data were used for hierarchical clustering by Ward's method (Figure A1).

Table A1. Variables used in clustering

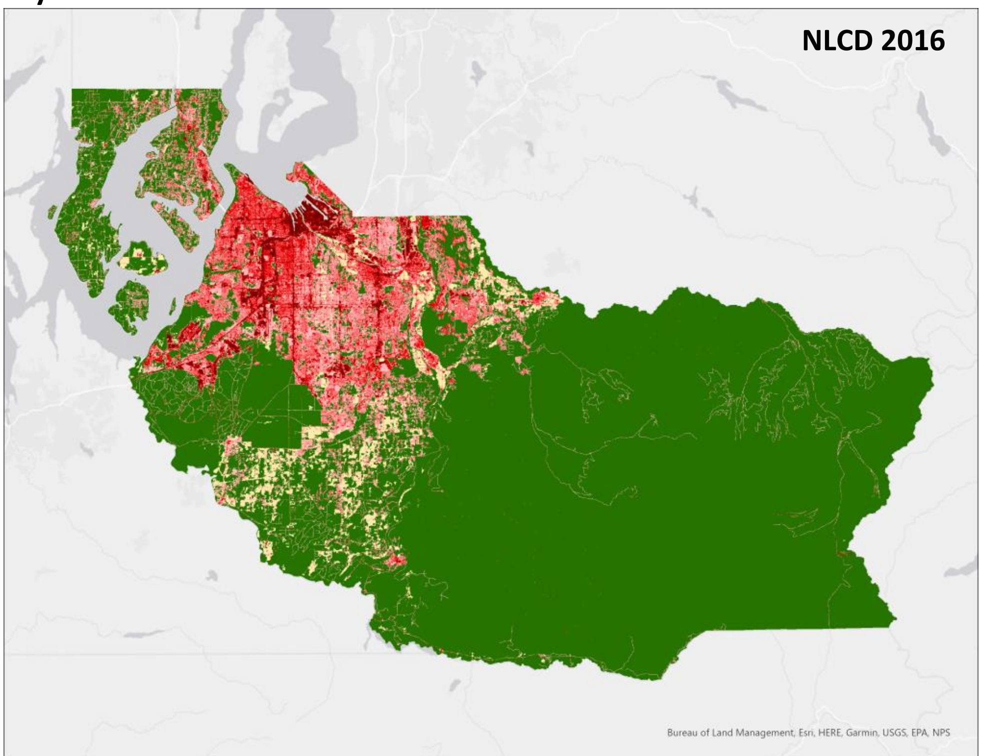
1	Population, percent change - April 1, 2010 (estimates base) to July 1, 2019, (V2019)
2	Persons 65 years and over, percent
3	White alone, not Hispanic or Latino, percent
4	Veterans, 2015-2019
5	Foreign born persons, percent, 2015-2019
6	Owner-occupied housing unit rate, 2015-2019
7	Median value of owner-occupied housing units, 2015-2019
8	Median gross rent, 2015-2019
9	Persons per household, 2015-2019
10	Living in same house 1 year ago, percent of persons age 1 year+, 2015-2019
11	Language other than English spoken at home, percent of persons age 5 years+, 2015-2019
12	Households with a broadband Internet subscription, percent, 2015-2019
13	Bachelor's degree or higher, percent of persons age 25 years+, 2015-2019
14	Persons without health insurance, under age 65 years, percent
15	Mean travel time to work (minutes), workers age 16 years+, 2015-2019
16	Per capita income in past 12 months (in 2019 dollars), 2015-2019
17	Persons in poverty, percent
18	Total employment, percent change, 2018-2019
19	housing units per capita
20	Building permits per capita
21	In civilian labor force, total, percent of population age 16 years+, 2015-2019
22	Total retail sales per capita, 2012(c)
23	Population per square mile, 2010

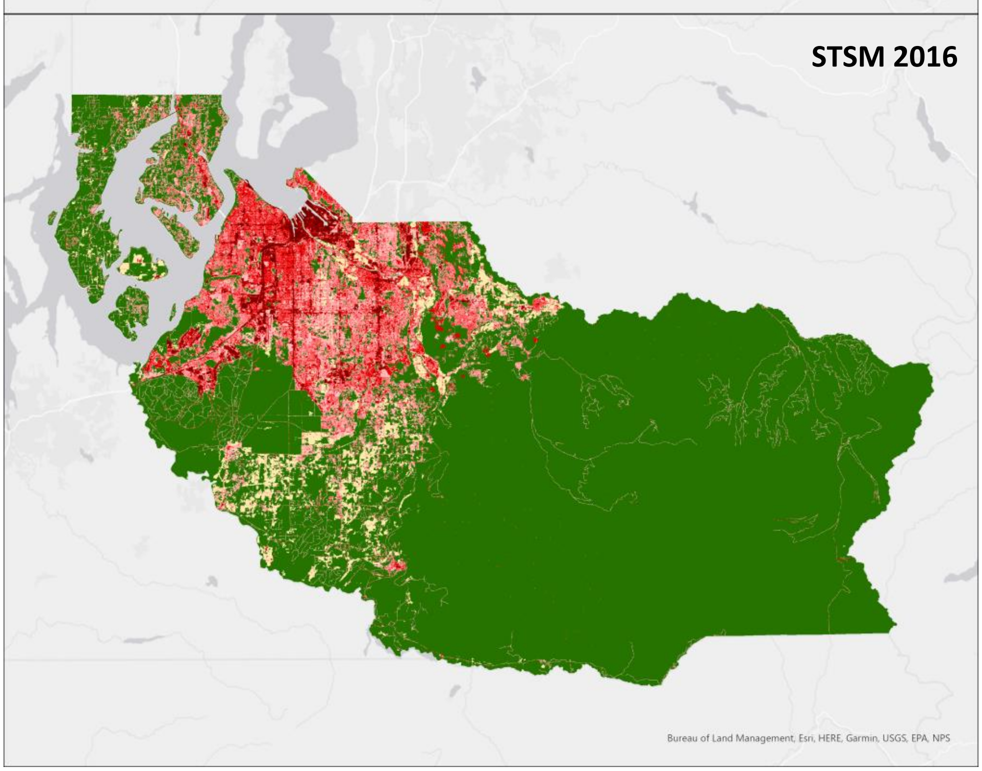
Figure A1. Puget Sound counties clustered by economic, population, housing, and education characteristics. Four principal clusters are shown by color code. Counties selected for initial land cover change projection are marked with green stars.



Appendix 2. NLCD observed land use/land cover transitions between 2011-2016 against model-predicted transitions in the four pilot counties. Images show 2016 land use/land cover per the NLCD (top) and per STSM (bottom), tables show percentage of land use/land cover transition per the NLCD occurred in areas identified by the model as having a non-zero probability of transition,

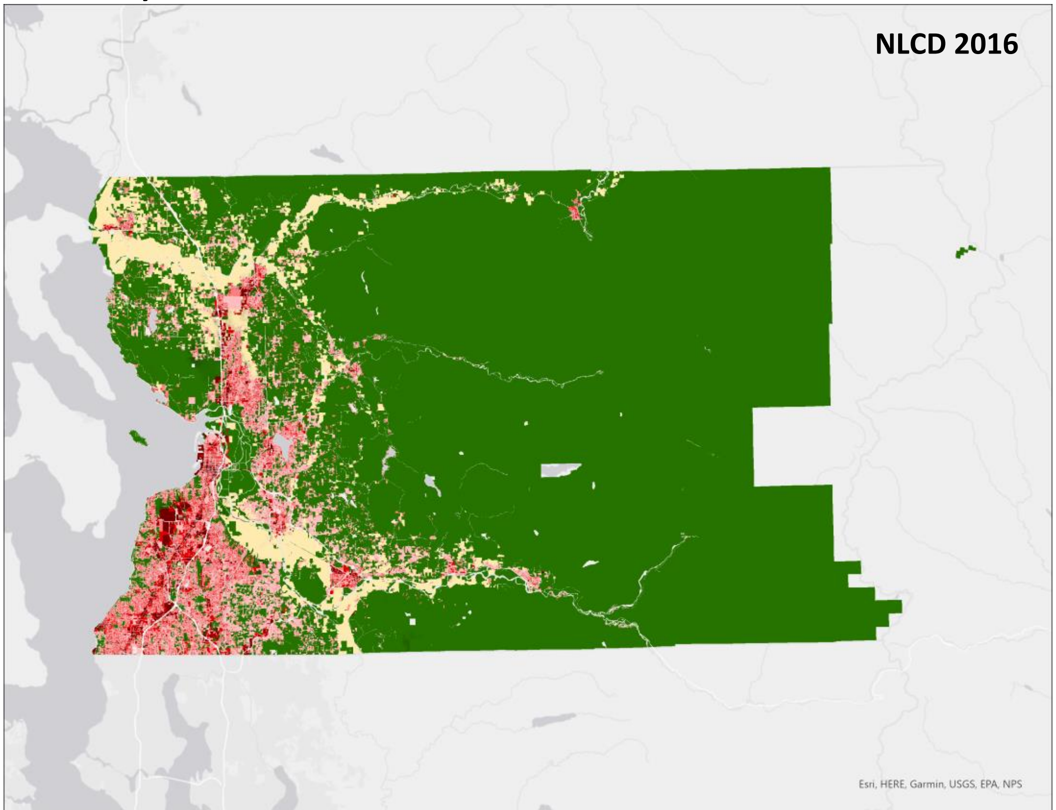
Pierce County

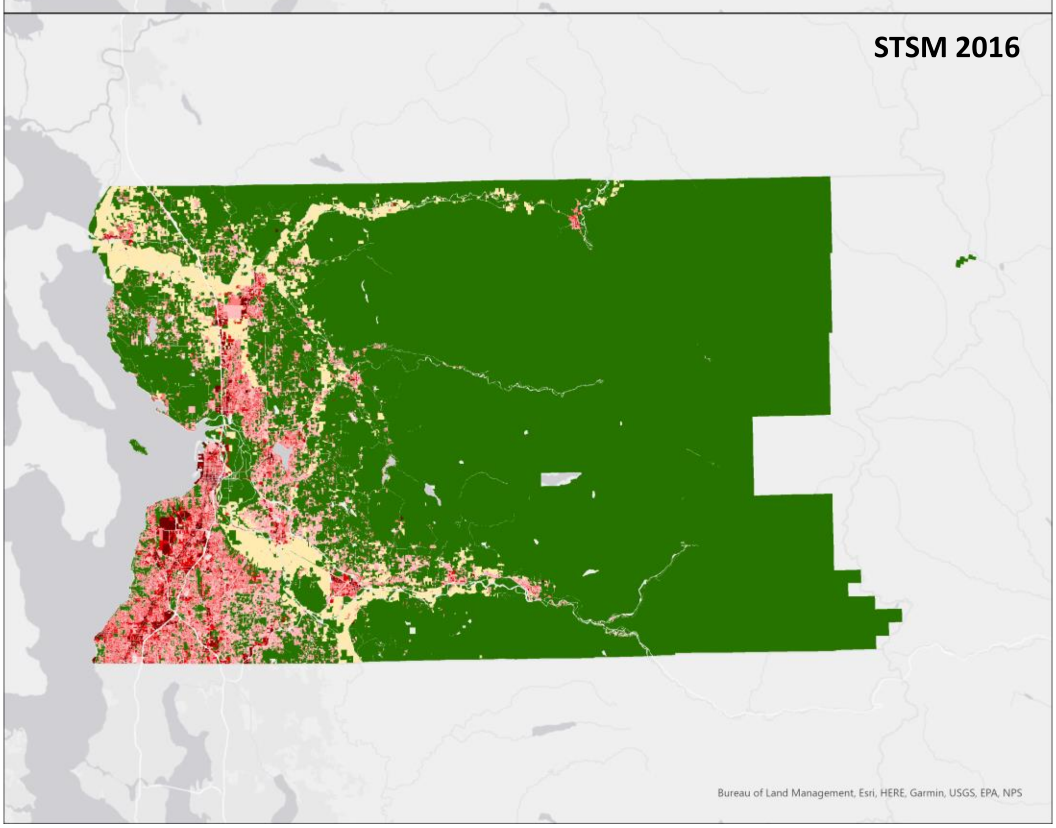




Transition (2011-2016)	Non-predicted Transition Area (km)*	Total Transition Area (km)**	Pct. Non-predicted
Ag to Forest	0.0009	0.3861	0.23%
Ag to High Intensity	0	0.4968	0.00%
Ag to Low Intensity	0	0.306	0.00%
Ag to Medium Intensity	0	0.378	0.00%
Ag to Open Space	0	0.3474	0.00%
Open Space to High Intensity	0	0.441	0.00%
Open Space to Low Intensity	0.0099	0.459	2.16%
Open Space to Medium Intensity	0	1.8261	0.00%
Forest to High Intensity	0.0018	0.3924	0.46%
Forest to Low Intensity	0	1.0206	0.00%
Forest to Medium Intensity	0	1.0215	0.00%
Forest to Open Space	0	1.1529	0.00%
Total	**0.0126**	**8.2278**	**0.15%**
Low Intensity to High Intensity	No Transition	No Transition	
Low Intensity to Medium Intensity	No Transition	No Transition	
Medium Intensity to High Intensity	No Transition	No Transition	
*Total area for each transition that occurred outside any predicted area between 2011 and 2016 after 2500 model runs			
**Total area for each transition that occurred between 2011-2016			

Snohomish County





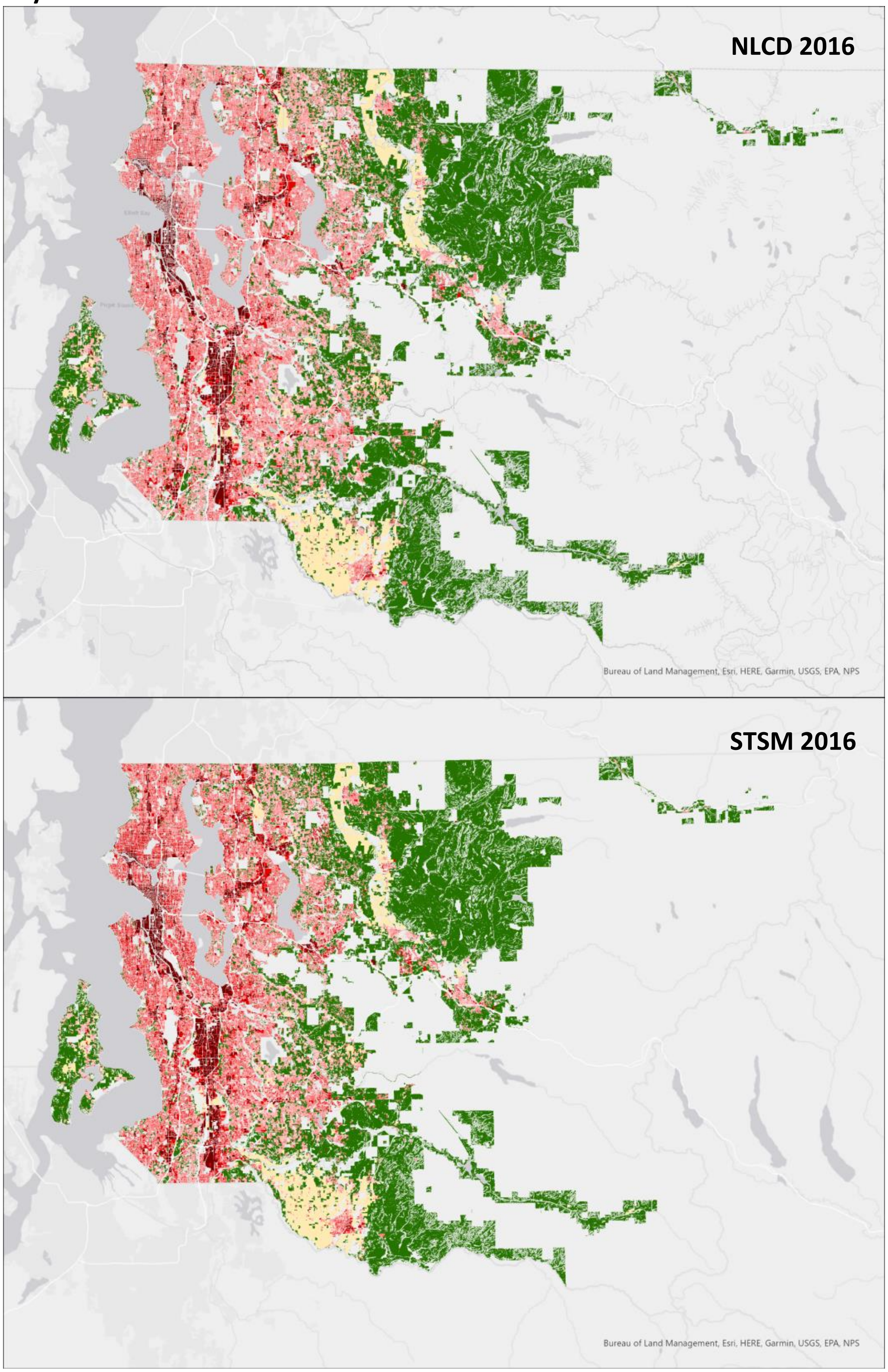
Transition (2011-2016)	Non-predicted Transition Area (km)*	Total Transition Area (km)**	Pct. Non-predicted
Ag to Forest	0	1.23	0.00%
Ag to High Intensity	0.0018	0.095	1.89%
Ag to Low Intensity	0	0.153	0.00%
Ag to MediumIntensity	0	0.049	0.00%
Forest to Agriculture	0.0009	0.88	0.10%
Forest to High Intensity	0.0153	0.29	5.28%
Forest to Low Intensity	0.0036	1.23	0.29%
Forest to Medium Intensity	0.0099	0.63	1.57%
Forest to Open Space	0	1.32	0.00%
High Intensity to Medium Intensity	0	0.0405	0.00%
Low Intensity to Forest	0	0.37	0.00%
Low Intensity to Medium Intensity	0	0.175	0.00%
Low Intensity to Open Space	0	0.018	0.00%
Medium Intensity to Low Intensity	0	0.0054	0.00%
Open Space to Forest	0	0.62	0.00%
Open Space to High Intensity	0.0009	0.253	0.36%
Open Space to Low Intensity	0	1.47	0.00%
Open Space to Medium Intensity	0	1.32	0.00%
Total	**0.0324**	**10.1489**	**0.32%**
Ag to Open Space***	0.9657	0.9657	
Low Intensity to Agriculture***	0.0135	0.0135	
Low Intensity to High Intensity	No Transition	No Transition	
Medium Intensity to High Intensity	No Transition	No Transition	
Medium Intensity to Forest***	0.0081	0.0081	
Open Space to Agriculture***	0.1665	0.1665	

*Total area for each transition that occurred outside any model-predicted area between 2011 and 2016 after 2500 model runs

**Total area for each transition that occurred between 2011-2016

***No observed transitions for the 2001-2011 time period, therefore not included in Markov Chain

King County



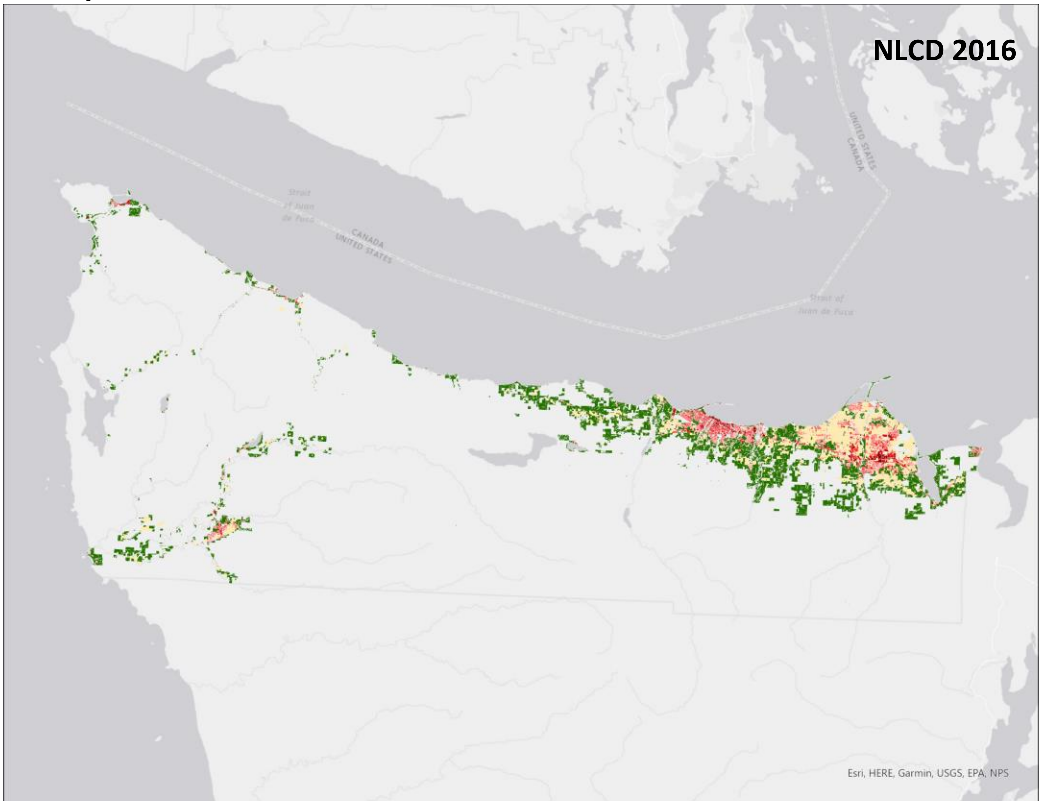
A change in the model was made for King and Clallam Counties to include only developable land. This change allowed for faster processing

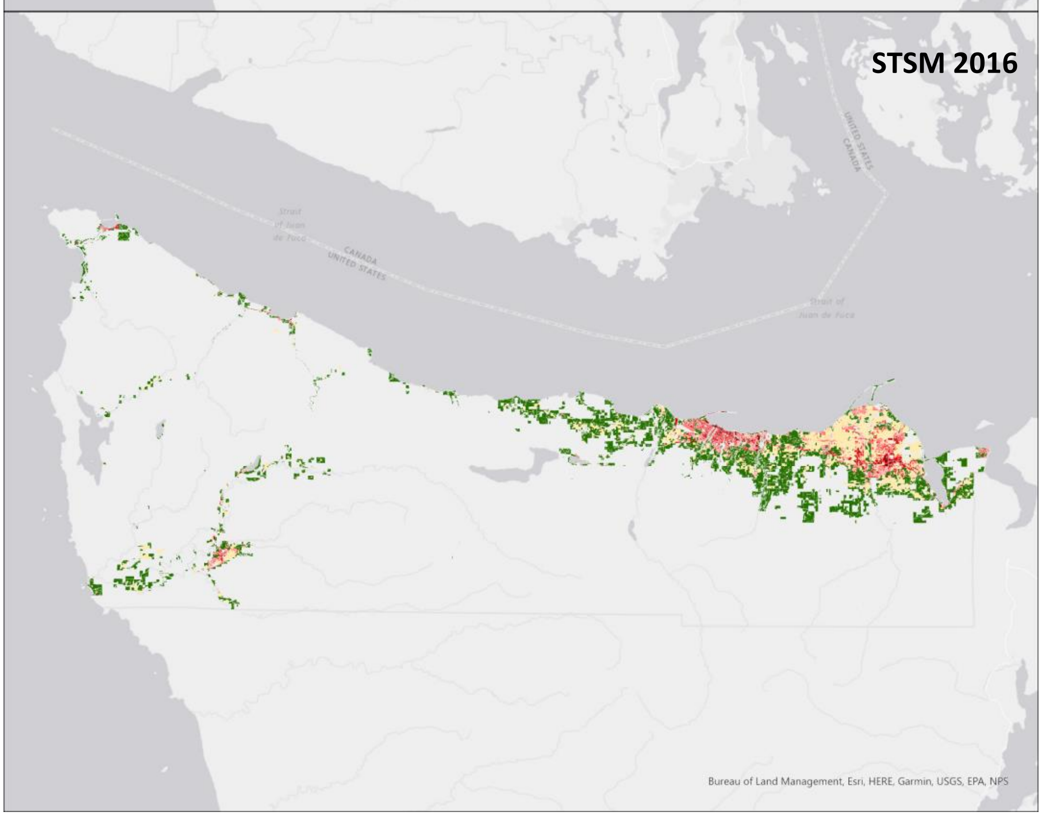
Transition (2011-2016)	Non-predicted Transition Area (km)*	Total Transition Area (km)**	Pct. Non-predicted
Ag to Forest	0.0000	0.3400	0.00%
Ag to High Intensity	0.0000	0.0027	0.00%
Ag to Low Intensity	0.0000	0.1230	0.00%
Ag to Medium Intensity	0.0009	0.0360	2.50%
Ag to Open Space	0.0009	0.1620	0.56%
Forest to High Intensity	0.0324	0.2400	13.50%
Forest to Low Intensity	0.0081	1.3500	0.60%
Forest to Medium Intensity	0.0180	0.7500	2.40%
Forest to Open Space	0.0009	0.8900	0.10%
High Intensity to Medium Intensity	0.0000	0.0550	0.00%
Low Intensity to Forest	0.0000	0.6200	0.00%
Low Intensity to High Intensity	0.0000	0.0063	0.00%
Low Intensity to Medium Intensity	0.0000	0.1360	0.00%
Low Intensity to Open Space	0.0000	0.0270	0.00%
Medium Intensity to Low Intensity	0.0000	0.0090	0.00%
Open Space to Forest	0.0000	0.3660	0.00%
Open Space to High Intensity	0.0018	0.0730	2.47%
Open Space to Low Intensity	0.0009	1.2000	0.08%
Open Space to Medium Intensity	0.0000	1.0900	0.00%
Total	**0.0639**	**7.4760**	**0.85%**
Medium Intensity to High Intensity	No Transition	No Transition	

*Total area for each transition that occurred outside any model-predicted area between 2011 and 2016 after 2500 model runs

**Total area for each transition that occurred between 2011-2016

Clallam County





A change in the model was made for King and Clallam Counties to include only developable land. This change allowed for faster processing.

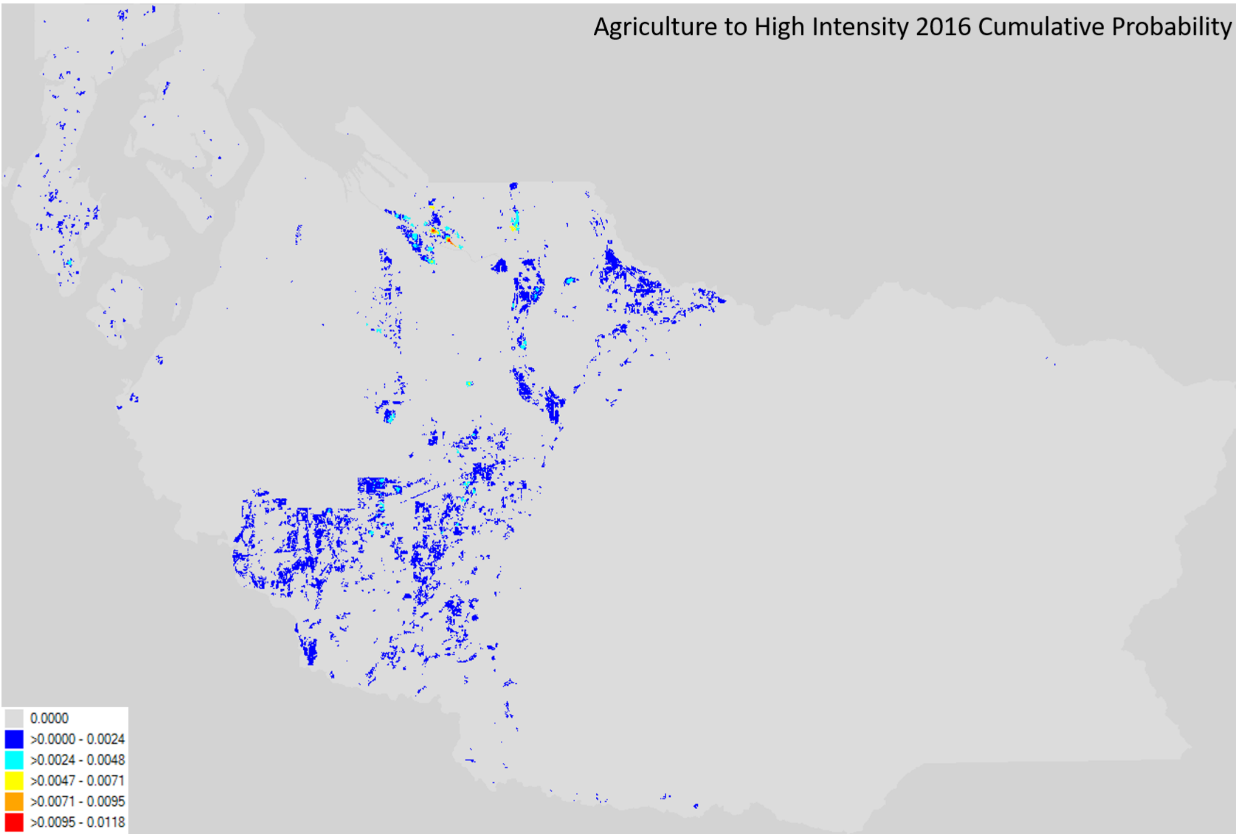
Transition (2011-2016)	Non-predicted Transition Area (km)*	Total Transition Area (km)**	Pct. Non-predicted
Ag to Forest	0	0.32	0.00%
Ag to Medium	0	0.0009	0.00%
Ag to Open	0	0.054	0.00%
Low to Medium	0	0.0144	0.00%
Low to Forest	0	0.039	0.00%
Open to Ag	0	0.0234	0.00%
Open to High	0	0.025	0.00%
Open to Low	0.0018	0.066	2.73%
Open to Medium	0	0.0072	0.00%
Open to Forest	0	0.17	0.00%
Forest to Ag	0	0.35	0.00%
Forest to Low	0.0027	0.29	0.93%
Forest to Medium	0.0009	0.0027	33.33%
Forest to Open	0	0.148	0.00%
Total	**0.0054**	**1.5106**	**0.36%**
Ag to Low Intensity	No Transition	No Transition	
Ag to High Intensity	No Transition	No Transition	
High Intensity to Open Space	No Transition	No Transition	
Low Intensity to High Intensity	No Transition	No Transition	
Low Intensity to Open Space	No Transition	No Transition	
Medium Intensity to Low Intensity	No Transition	No Transition	
Medium Intensity to Open	No Transition	No Transition	

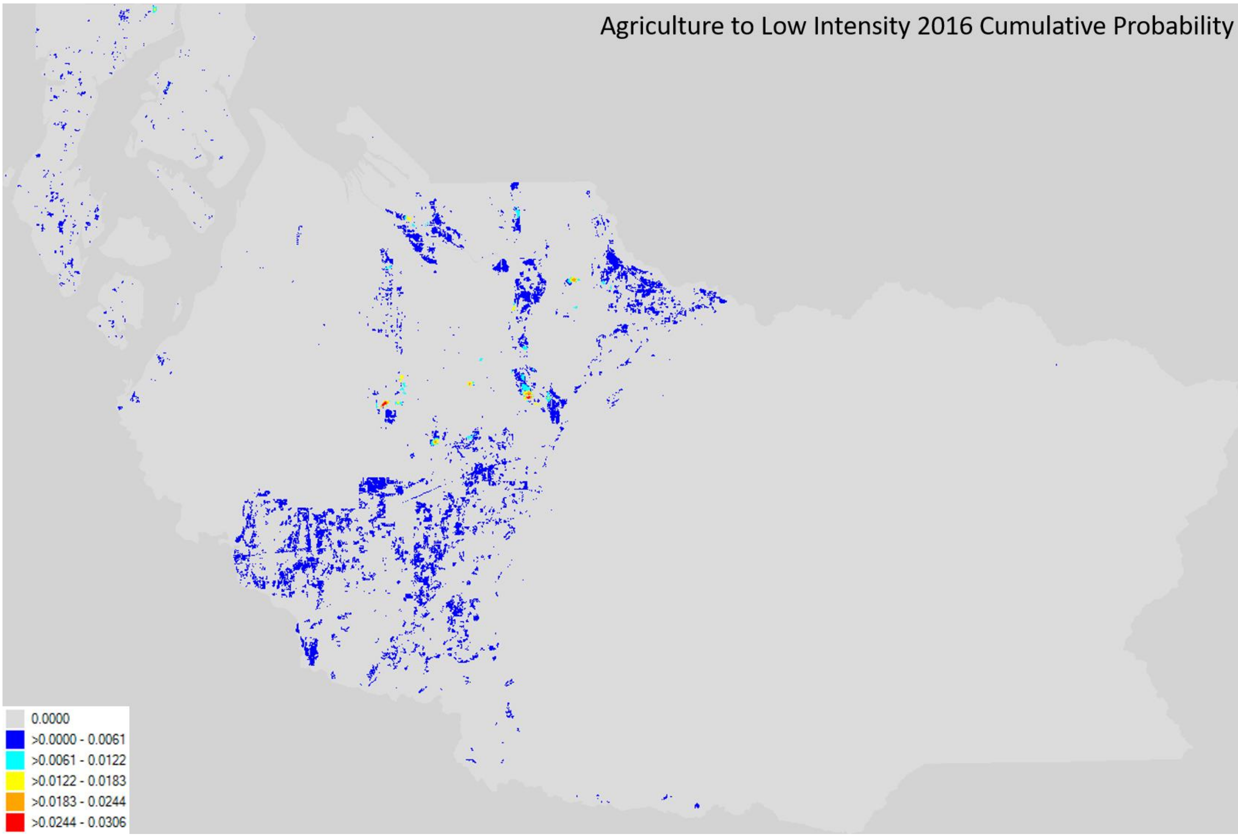
*Total area for each transition that occurred outside any model-predicted area between 2011 and 2016 after 2500 model runs

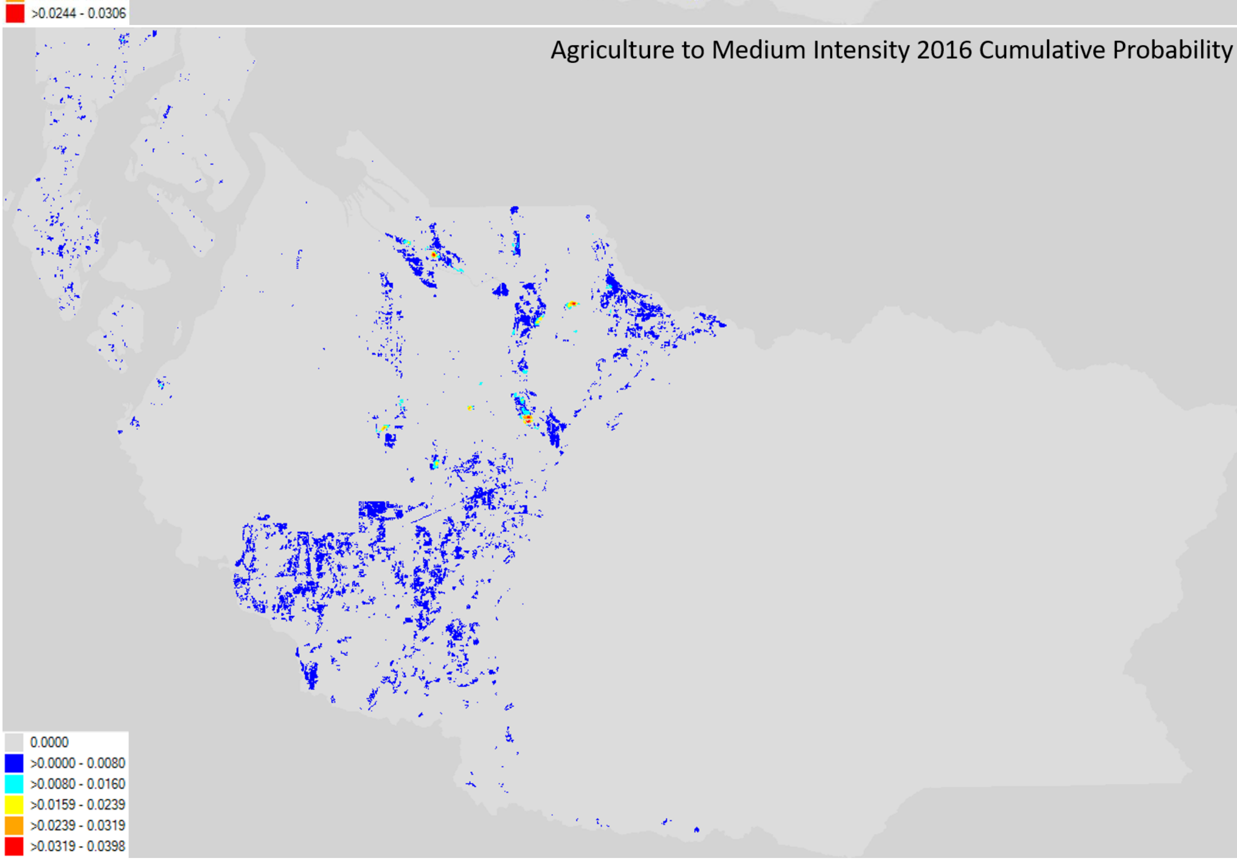
**Total area for each transition that occurred between 2011-2016

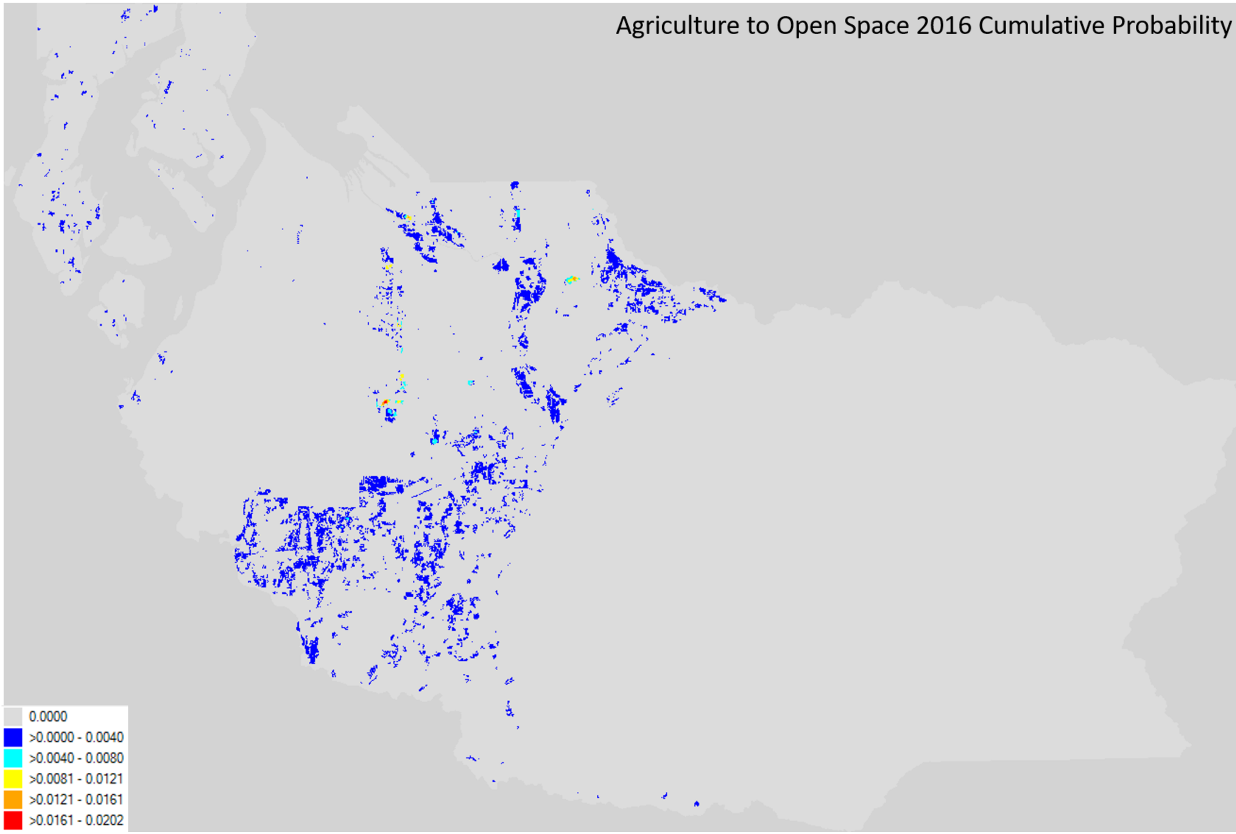
Appendix 3: Heat maps illustrating areas by likelihood of each model-predicted LULC transition for Pierce, Snohomish, King, and Clallam counties.

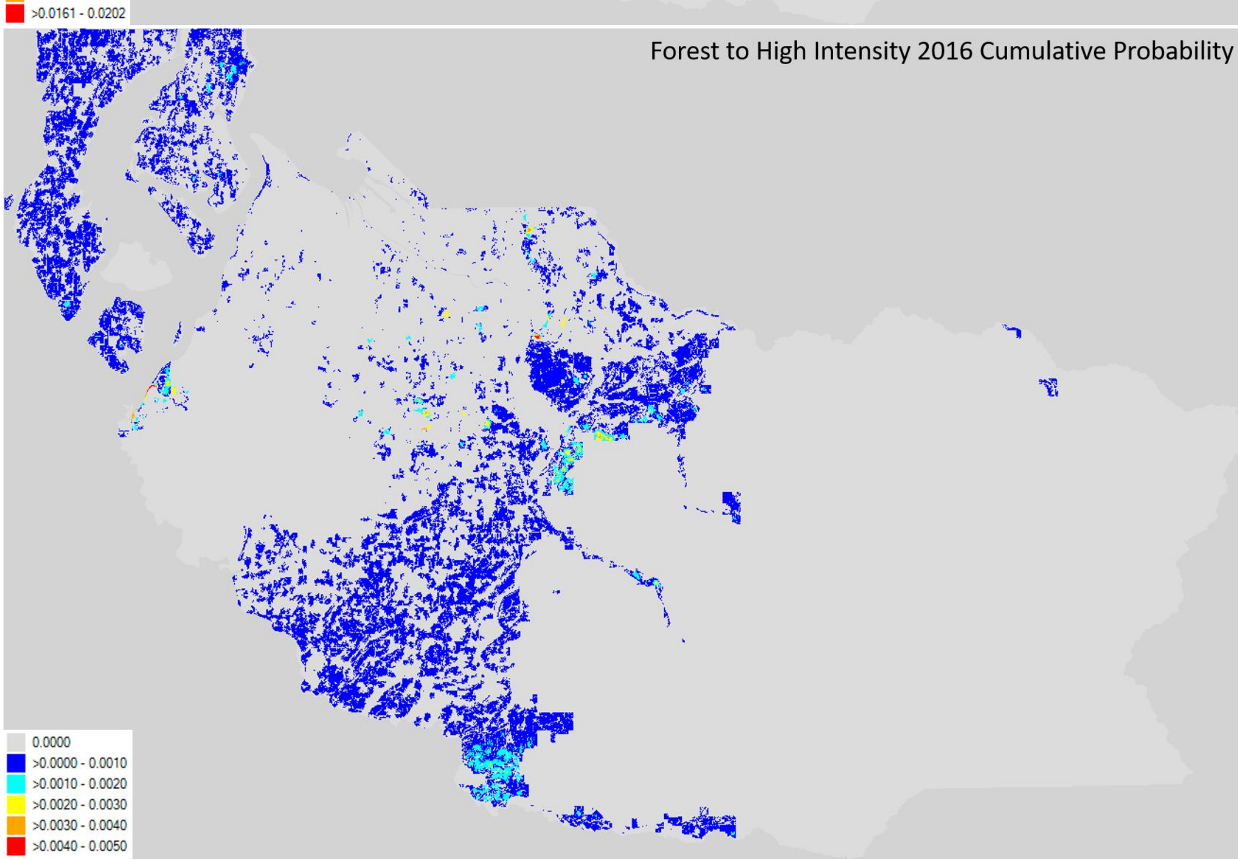
Pierce County

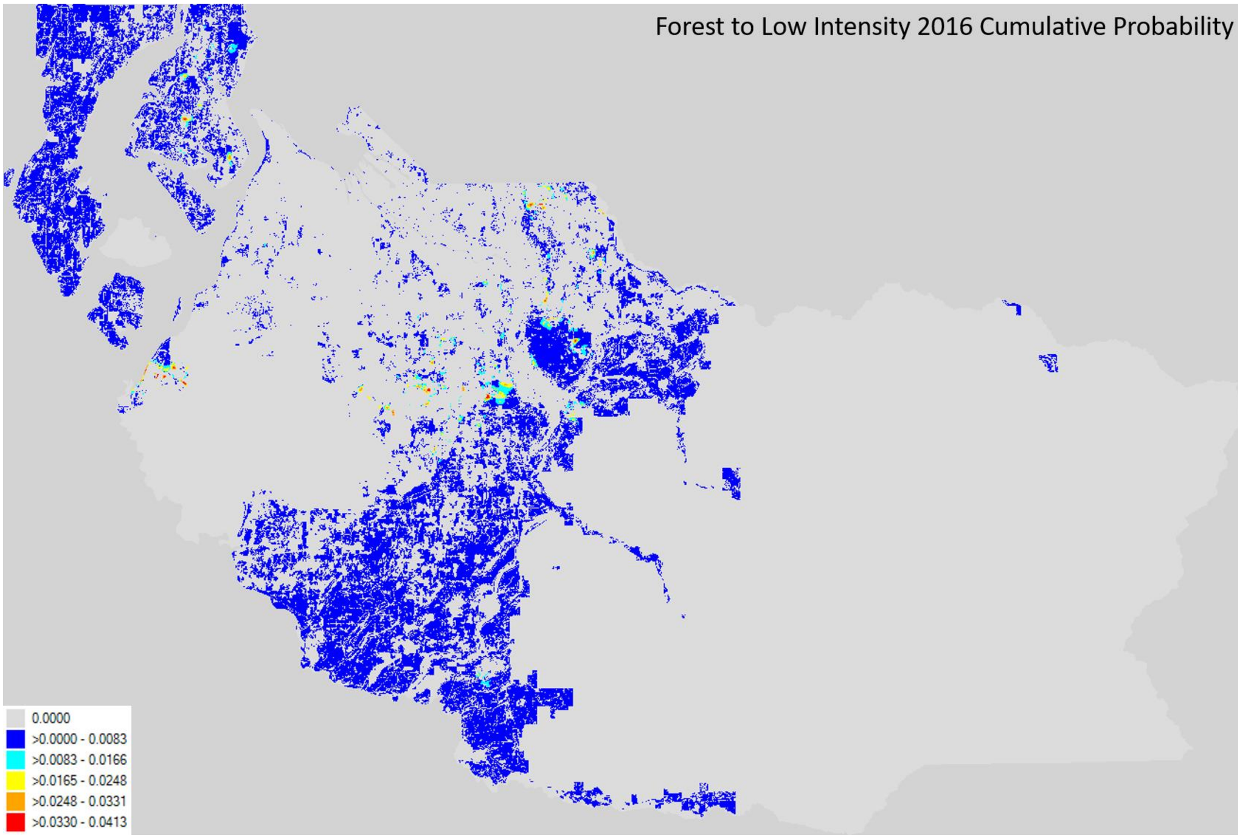


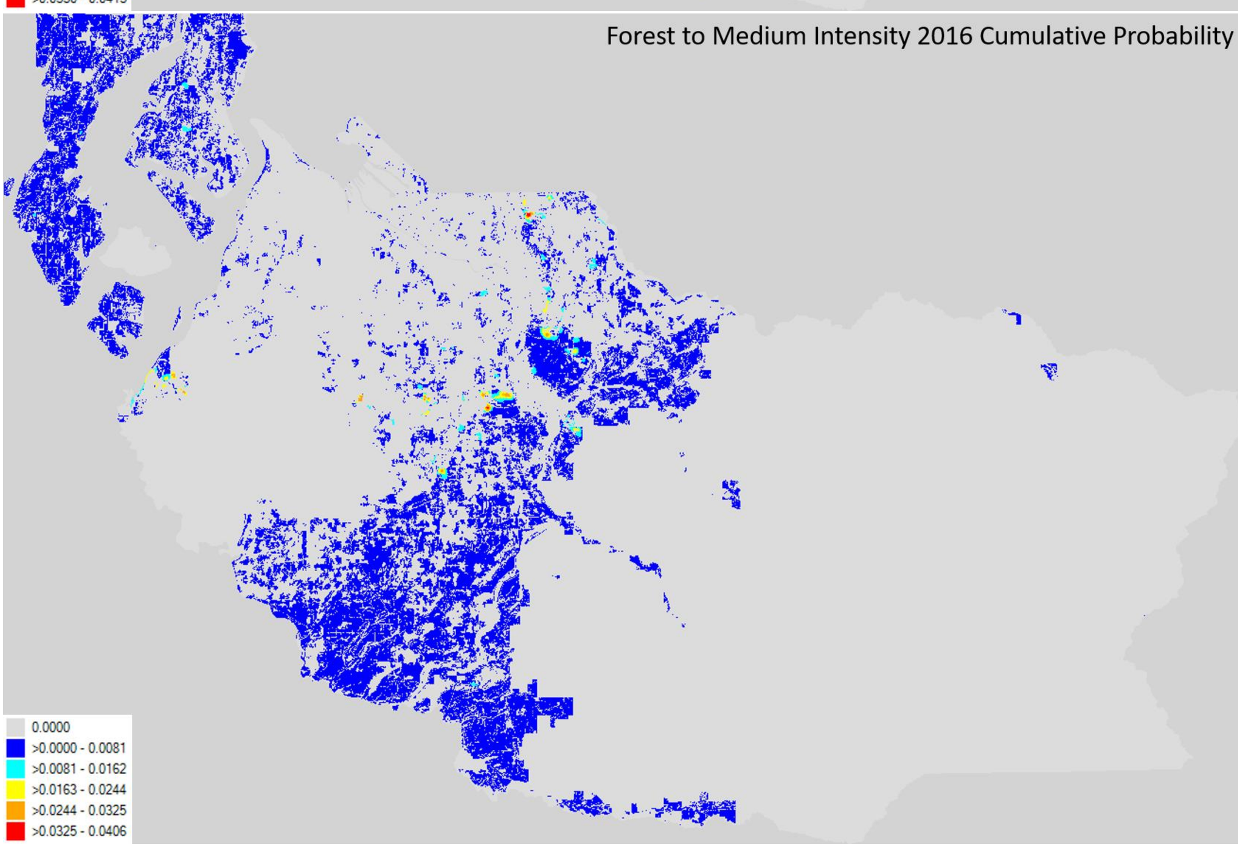

Agriculture to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0061
>0.0061 - 0.0122
>0.0122 - 0.0183
>0.0183 - 0.0244
>0.0244 - 0.0306

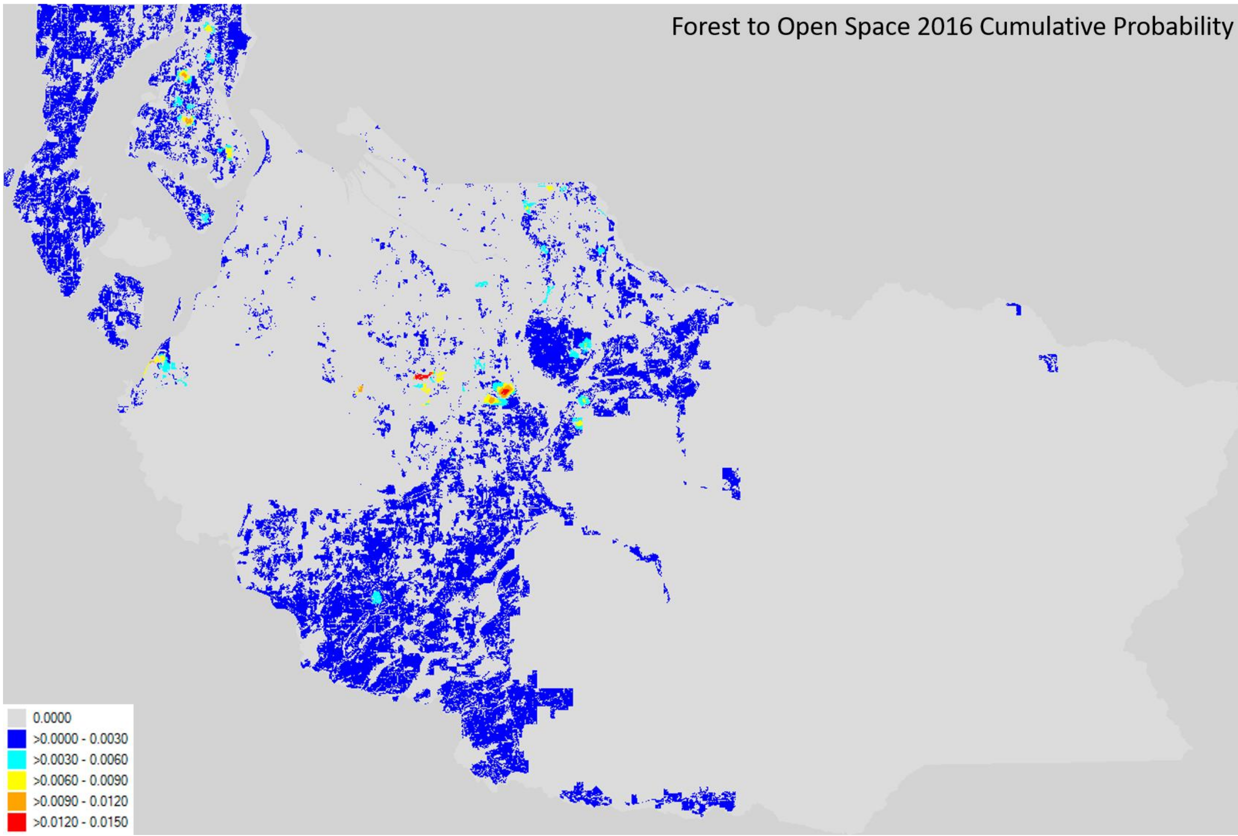

Agriculture to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0080
>0.0080 - 0.0160
>0.0159 - 0.0239
>0.0239 - 0.0319
>0.0319 - 0.0398

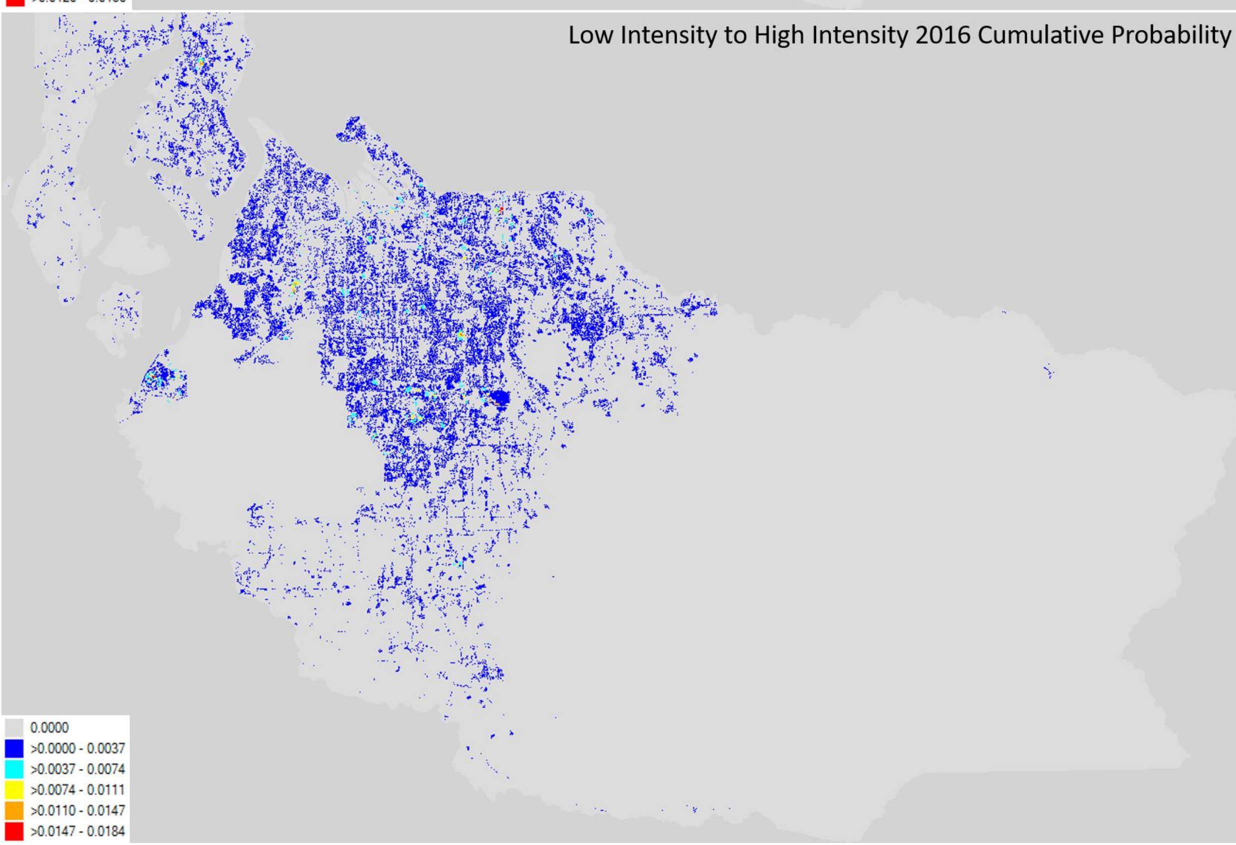

Agriculture to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0040
>0.0040 - 0.0080
>0.0081 - 0.0121
>0.0121 - 0.0161
>0.0161 - 0.0202

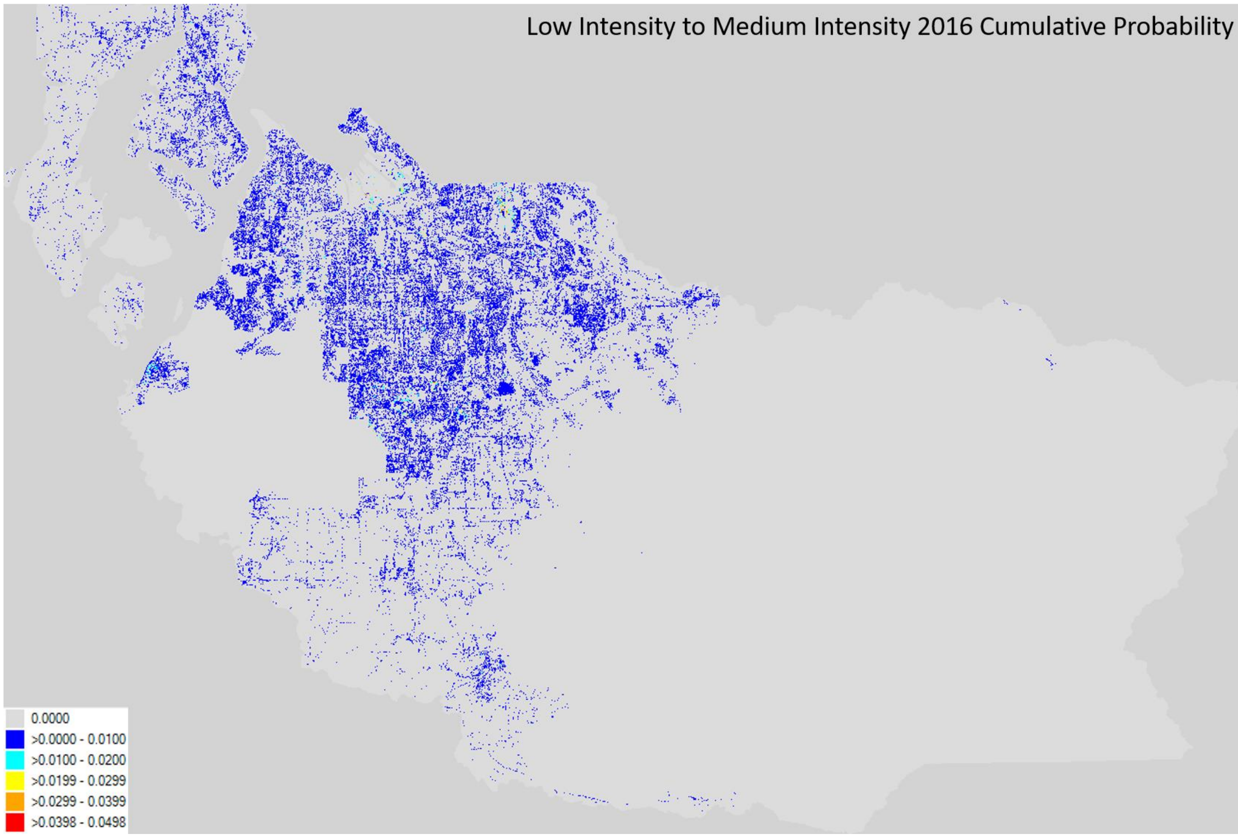

Forest to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0010
>0.0010 - 0.0020
>0.0020 - 0.0030
>0.0030 - 0.0040
>0.0040 - 0.0050

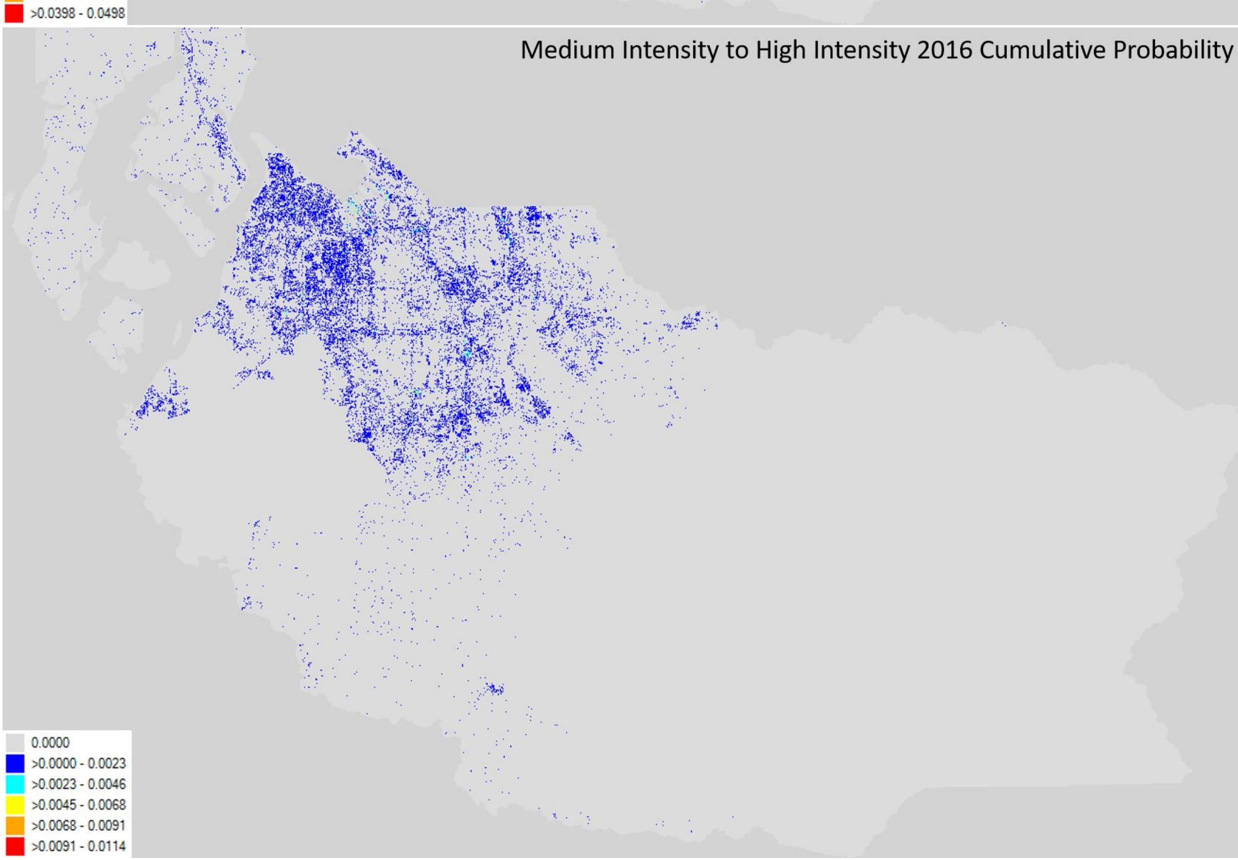

Forest to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0083
>0.0083 - 0.0166
>0.0165 - 0.0248
>0.0248 - 0.0331
>0.0330 - 0.0413

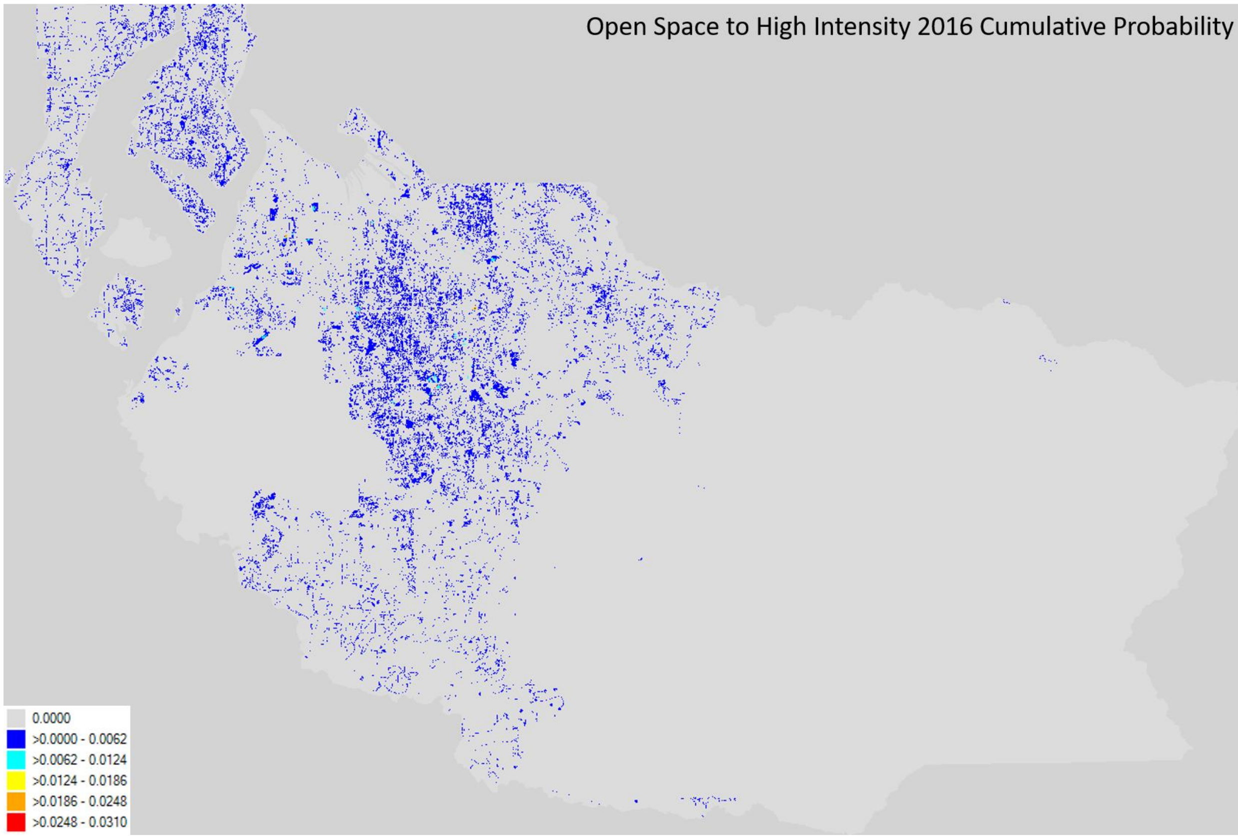

Forest to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0081
>0.0081 - 0.0162
>0.0163 - 0.0244
>0.0244 - 0.0325
>0.0325 - 0.0406


Forest to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0030
>0.0030 - 0.0060
>0.0060 - 0.0090
>0.0090 - 0.0120
>0.0120 - 0.0150

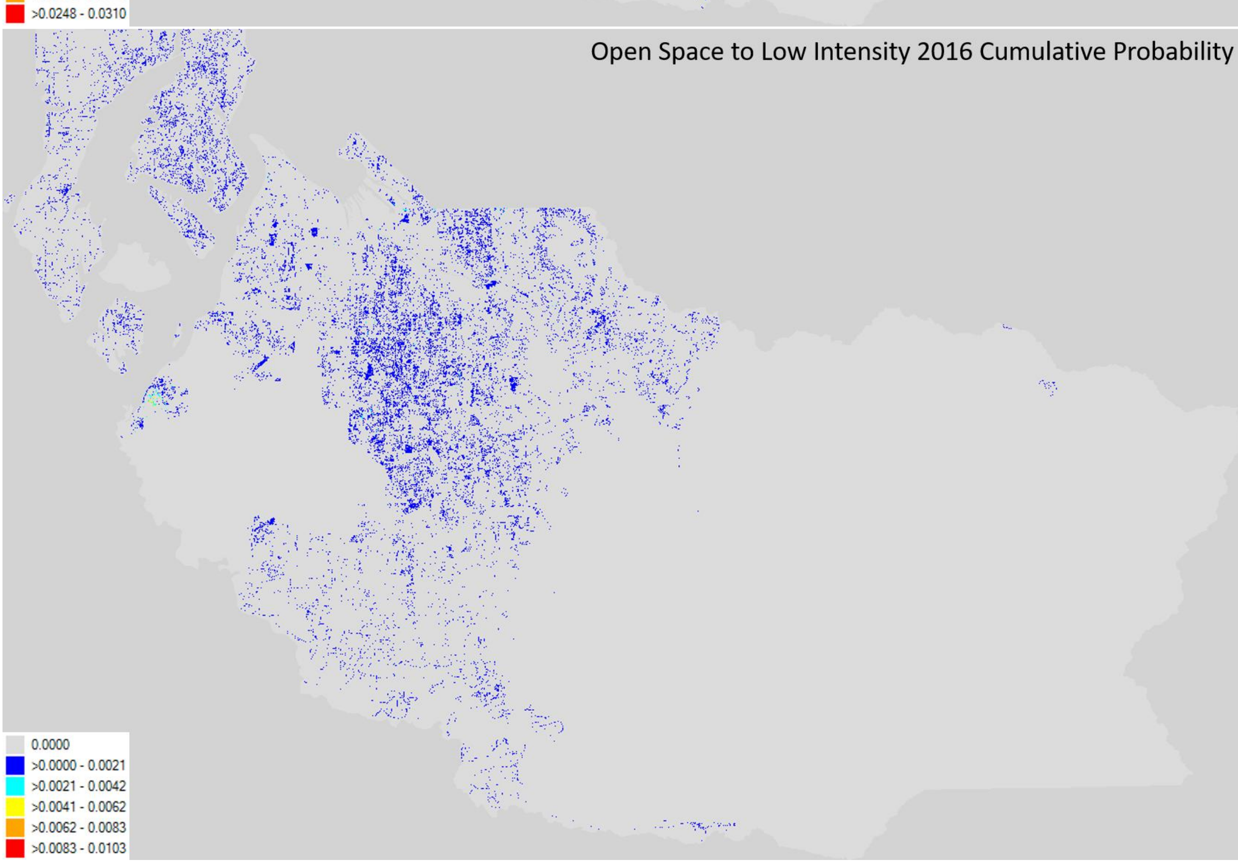

Low Intensity to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0037
>0.0037 - 0.0074
>0.0074 - 0.0111
>0.0110 - 0.0147
>0.0147 - 0.0184


Low Intensity to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0100
>0.0100 - 0.0200
>0.0199 - 0.0299
>0.0299 - 0.0399
>0.0398 - 0.0498

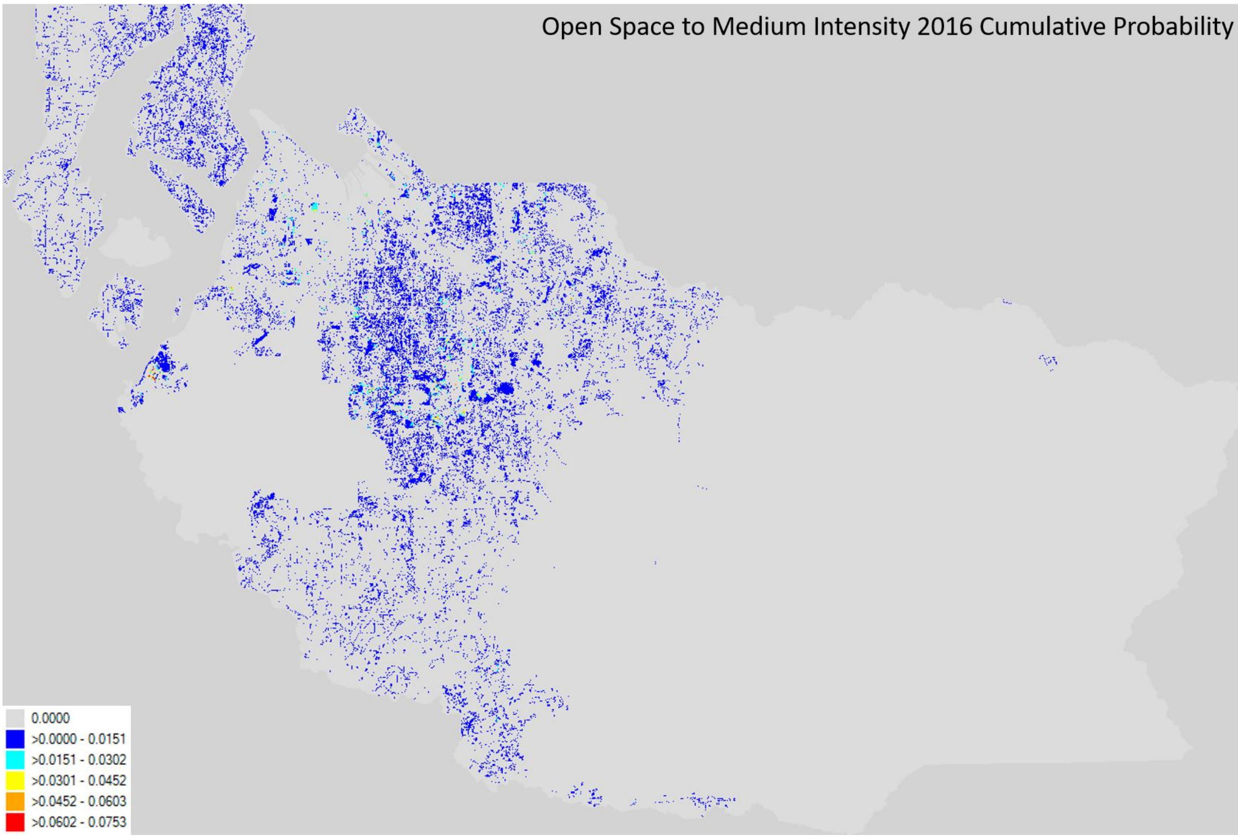

Medium Intensity to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0023
>0.0023 - 0.0046
>0.0045 - 0.0068
>0.0068 - 0.0091
>0.0091 - 0.0114



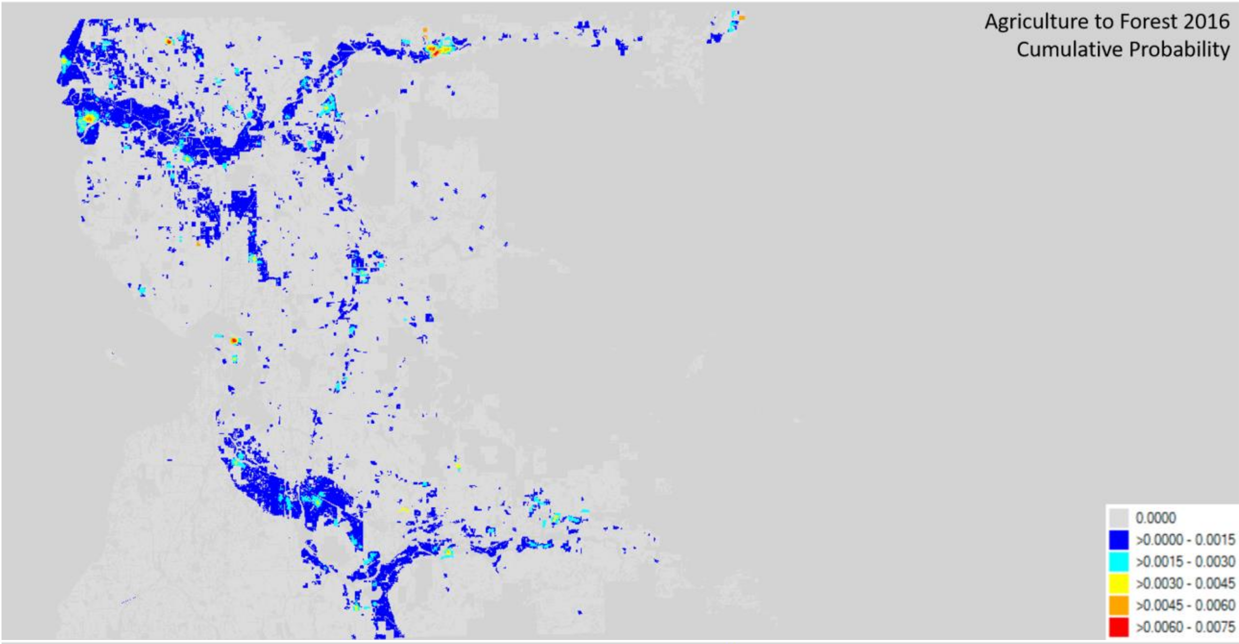
Open Space to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0062
>0.0062 - 0.0124
>0.0124 - 0.0186
>0.0186 - 0.0248
>0.0248 - 0.0310

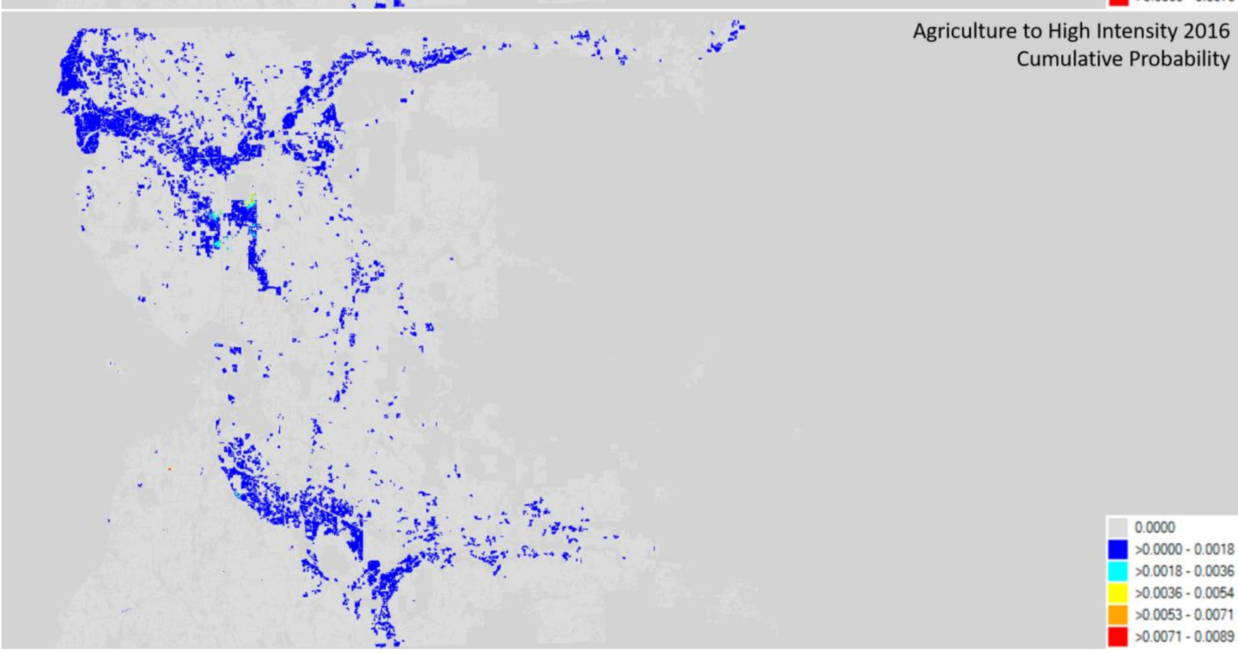


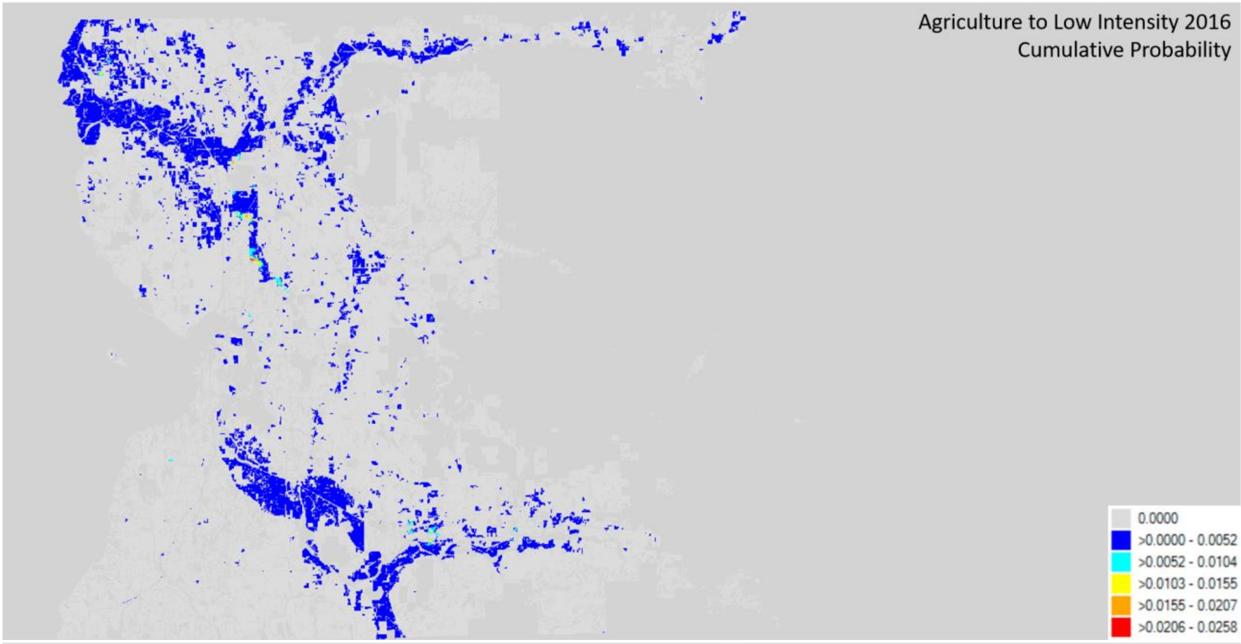
Open Space to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0021
>0.0021 - 0.0042
>0.0041 - 0.0062
>0.0062 - 0.0083
>0.0083 - 0.0103

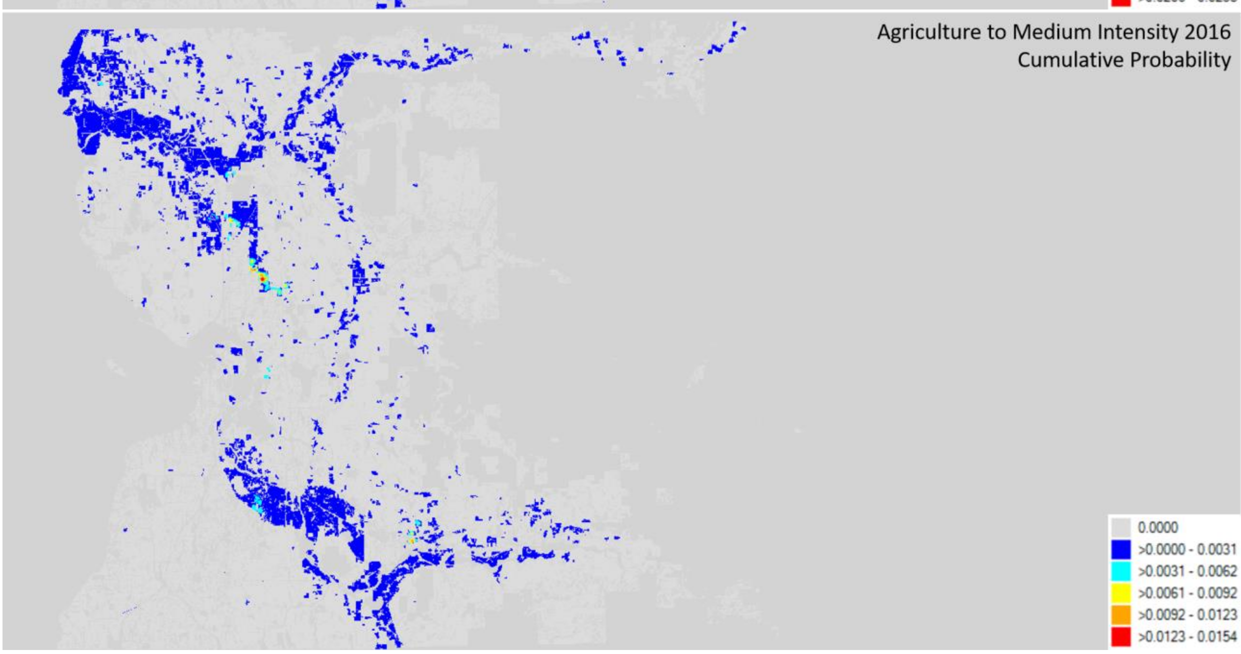

Open Space to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0151
>0.0151 - 0.0302
>0.0301 - 0.0452
>0.0452 - 0.0603
>0.0602 - 0.0753

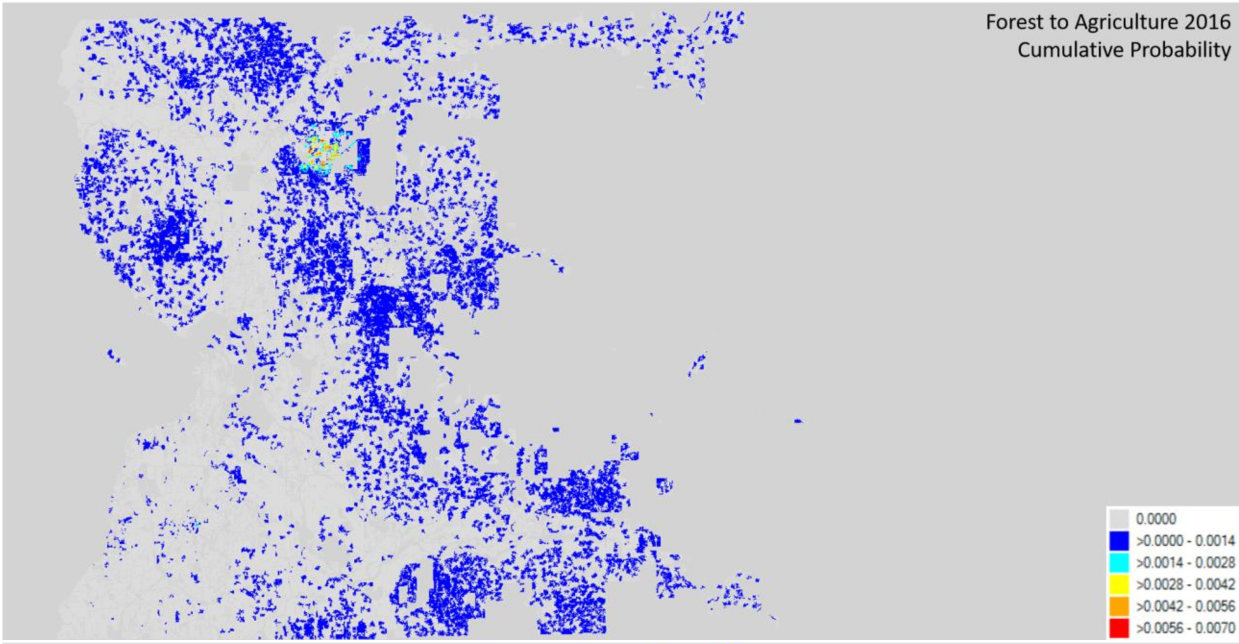
Snohomish County

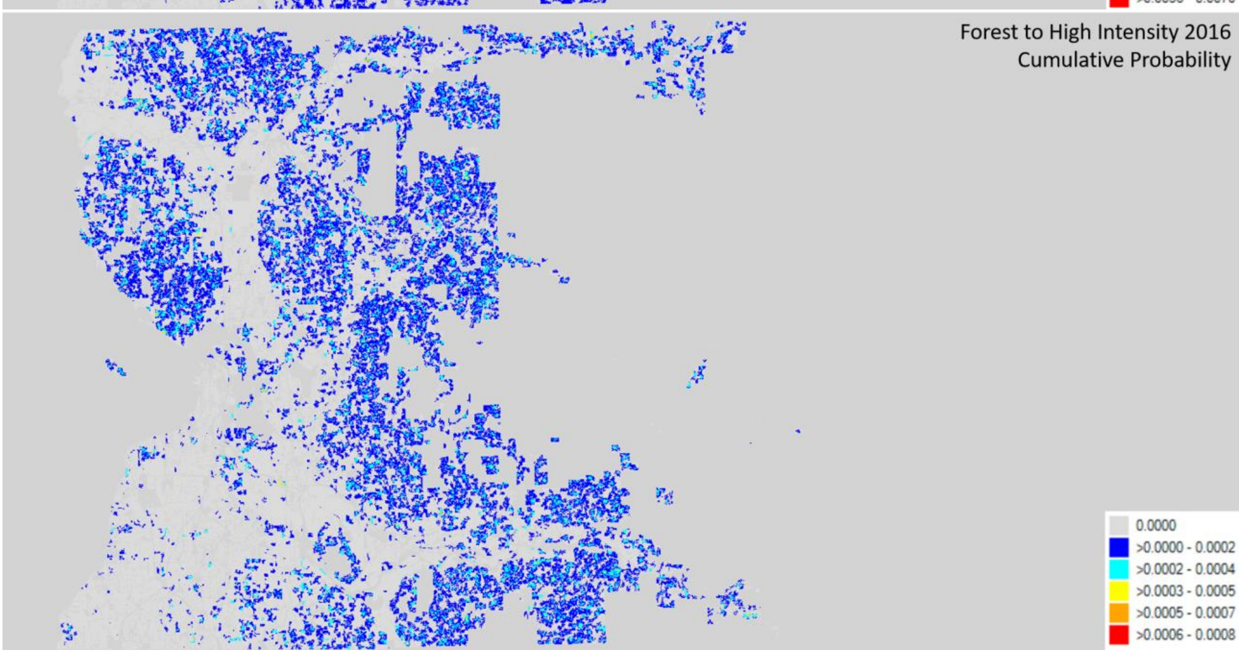


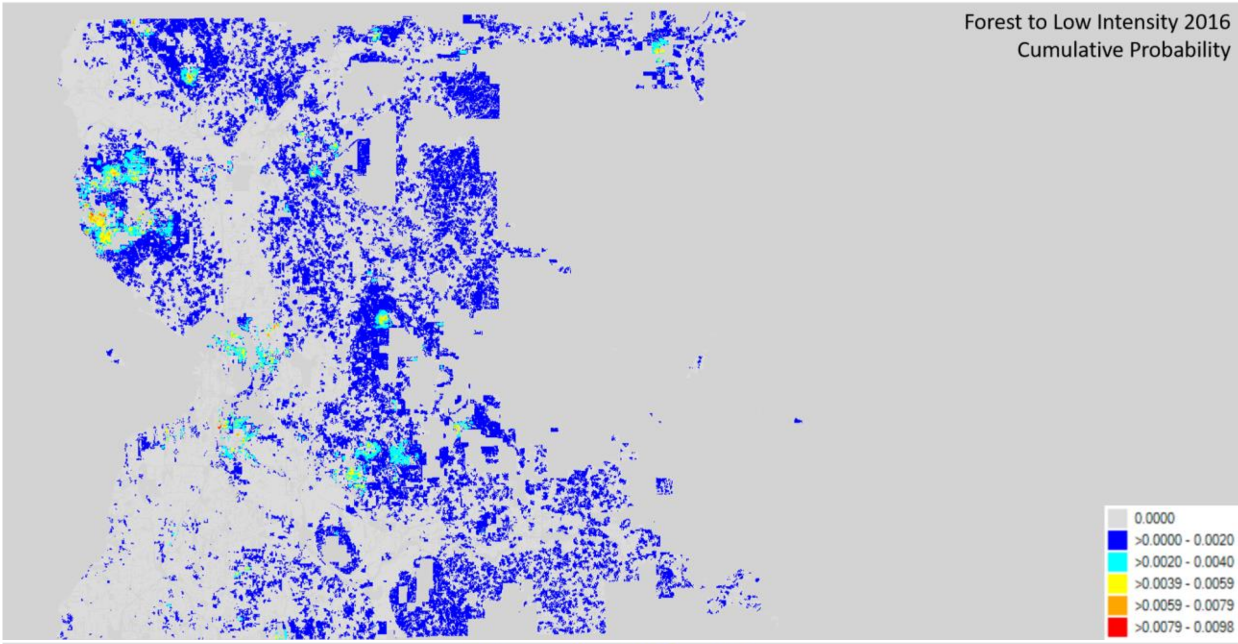


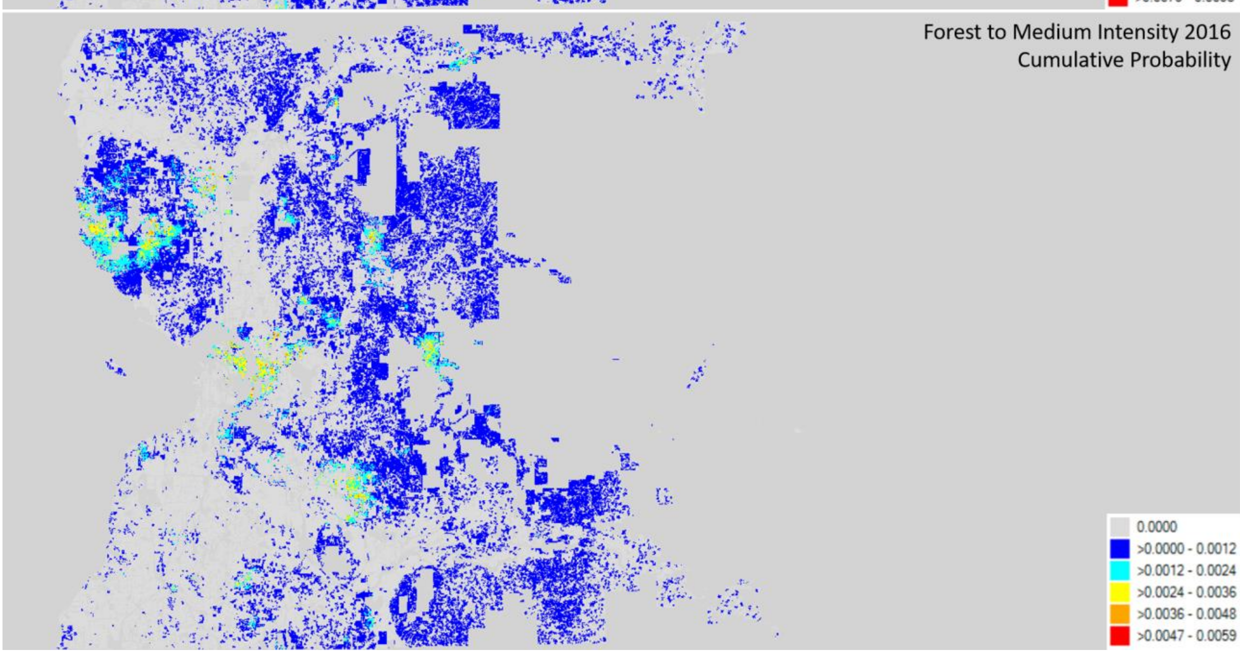

Agriculture to Low Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0052
>0.0052 - 0.0104
>0.0103 - 0.0155
>0.0155 - 0.0207
>0.0206 - 0.0258

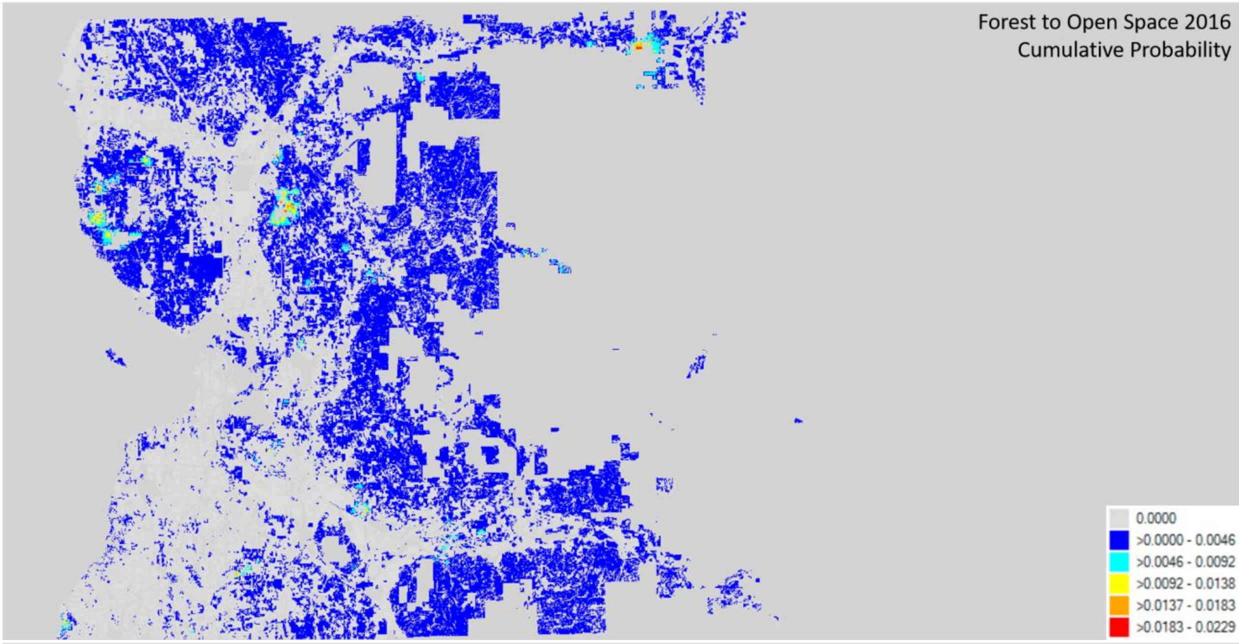

Agriculture to Medium Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0031
>0.0031 - 0.0062
>0.0061 - 0.0092
>0.0092 - 0.0123
>0.0123 - 0.0154

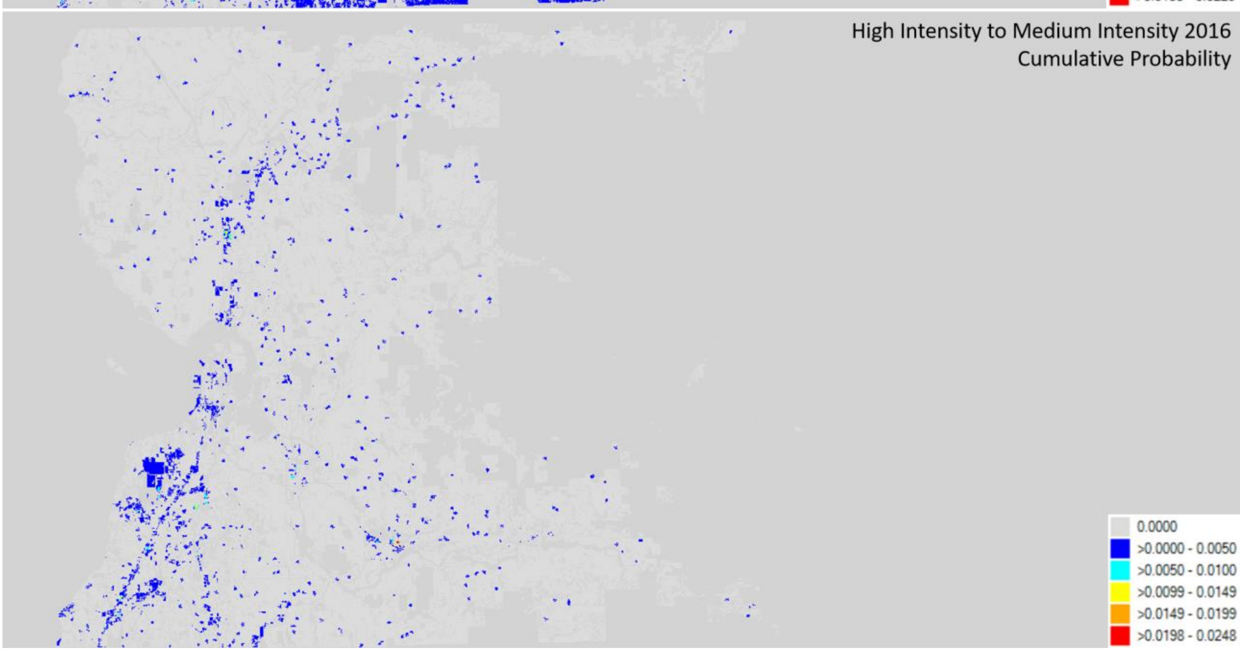

Forest to Agriculture 2016
Cumulative Probability
0.0000
>0.0000 - 0.0014
>0.0014 - 0.0028
>0.0028 - 0.0042
>0.0042 - 0.0056
>0.0056 - 0.0070

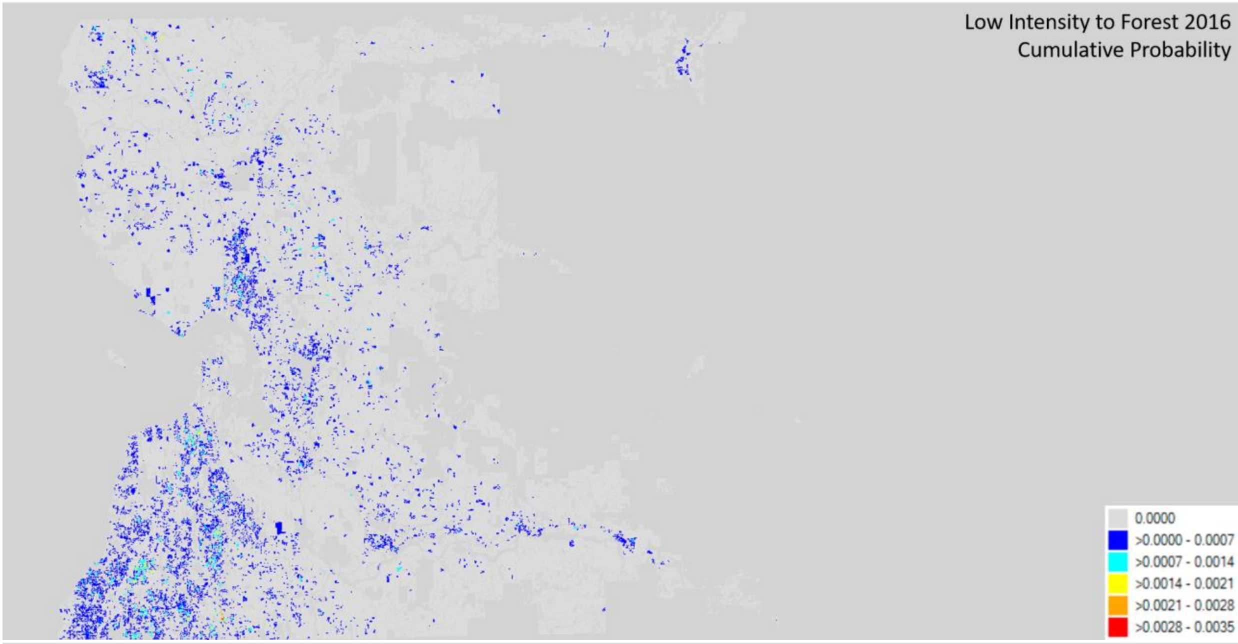

Forest to High Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0002
>0.0002 - 0.0004
>0.0003 - 0.0005
>0.0005 - 0.0007
>0.0006 - 0.0008

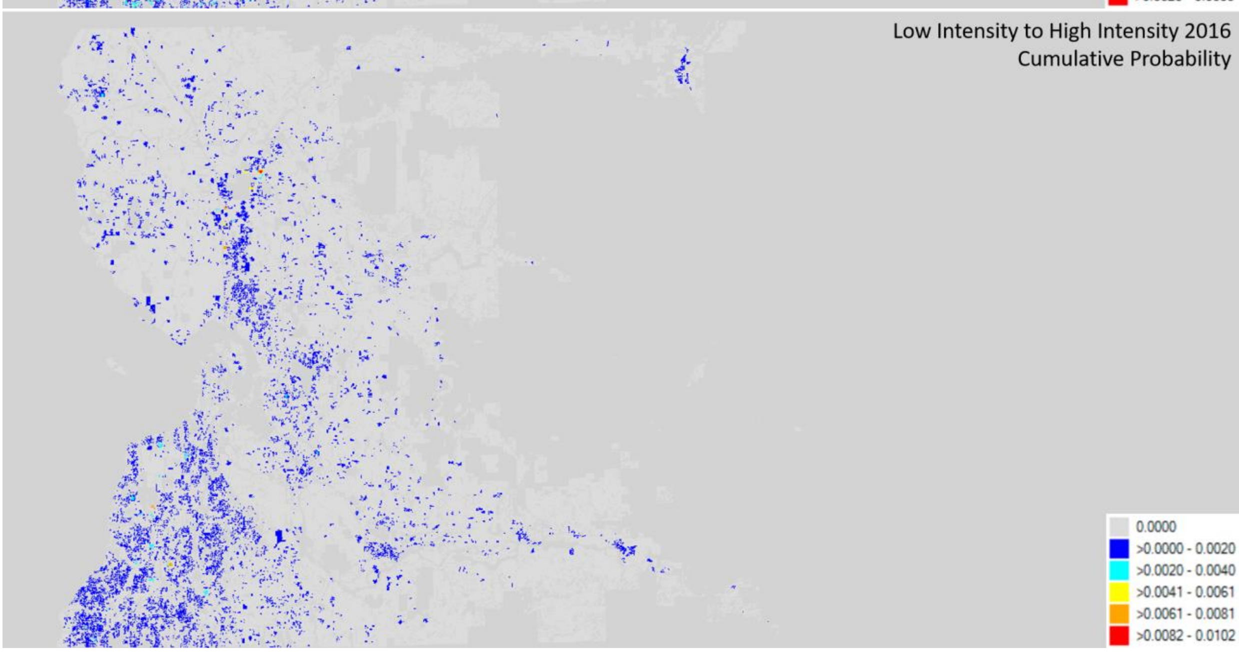

Forest to Low Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0020
>0.0020 - 0.0040
>0.0039 - 0.0059
>0.0059 - 0.0079
>0.0079 - 0.0098

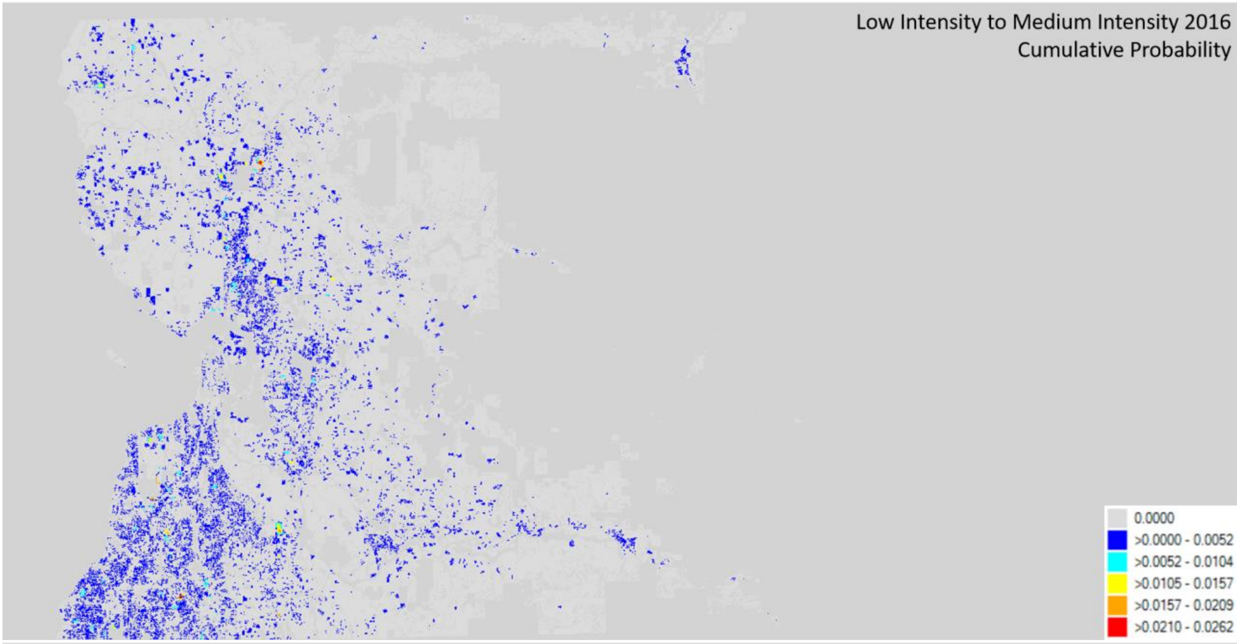

Forest to Medium Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0012
>0.0012 - 0.0024
>0.0024 - 0.0036
>0.0036 - 0.0048
>0.0047 - 0.0059

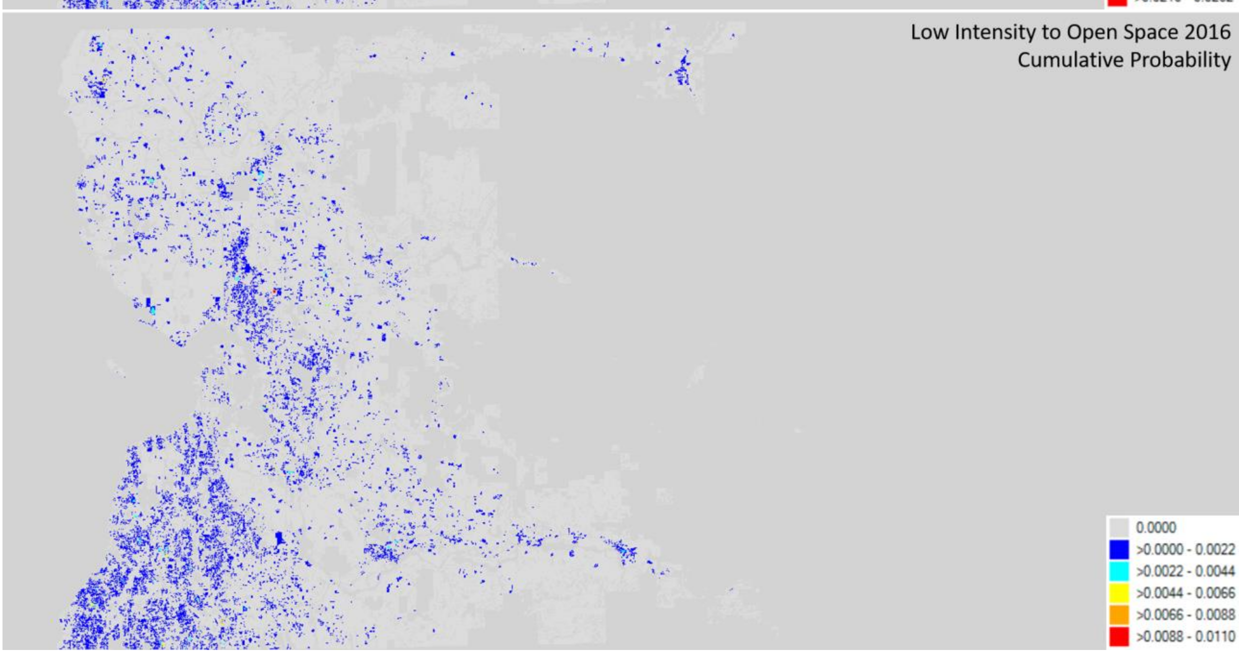

Forest to Open Space 2016
Cumulative Probability
0.0000
>0.0000 - 0.0046
>0.0046 - 0.0092
>0.0092 - 0.0138
>0.0137 - 0.0183
>0.0183 - 0.0229

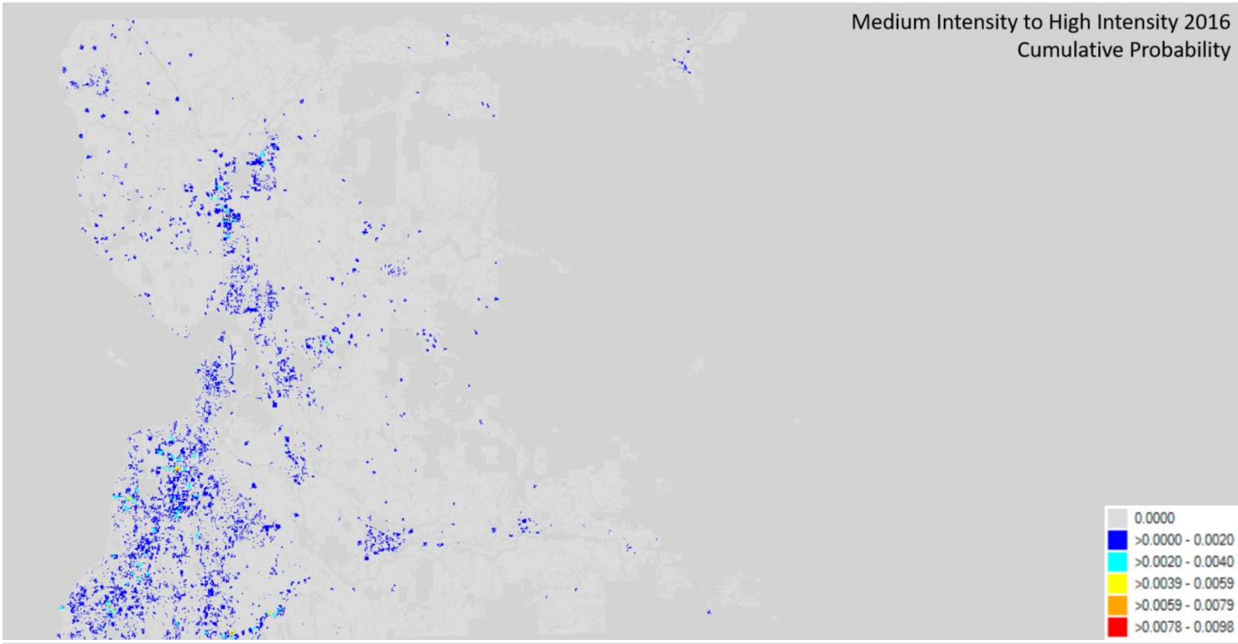

High Intensity to Medium Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0050
>0.0050 - 0.0100
>0.0099 - 0.0149
>0.0149 - 0.0199
>0.0198 - 0.0248

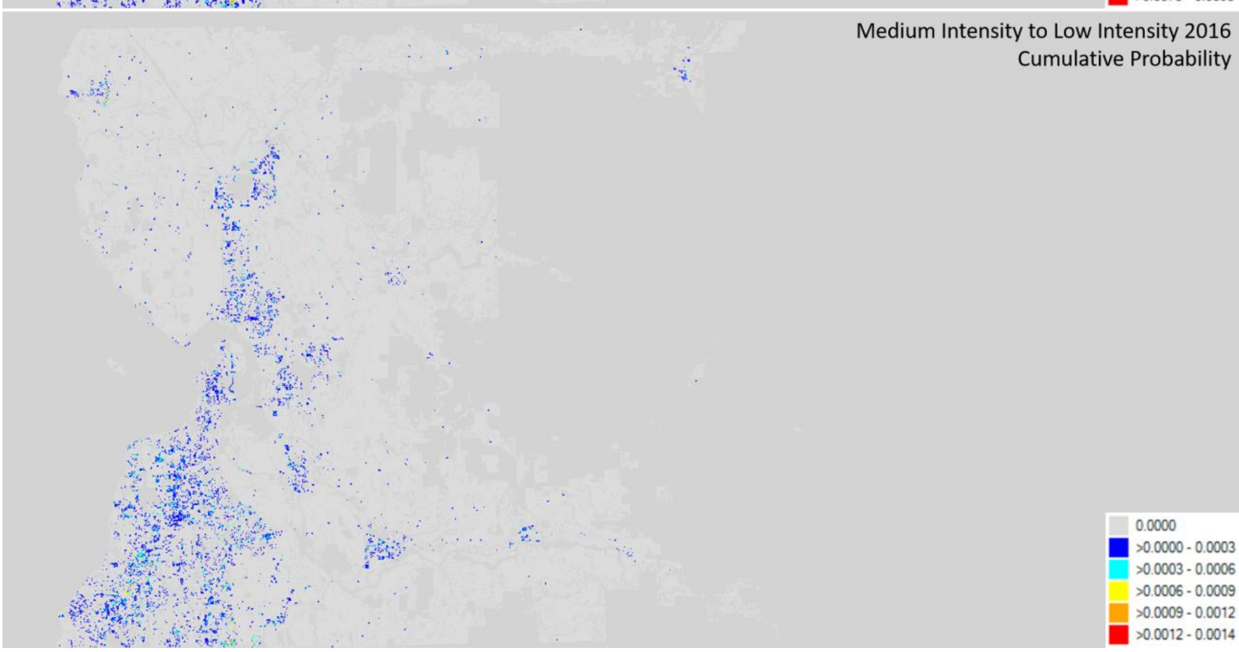

Low Intensity to Forest 2016
Cumulative Probability
0.0000
>0.0000 - 0.0007
>0.0007 - 0.0014
>0.0014 - 0.0021
>0.0021 - 0.0028
>0.0028 - 0.0035

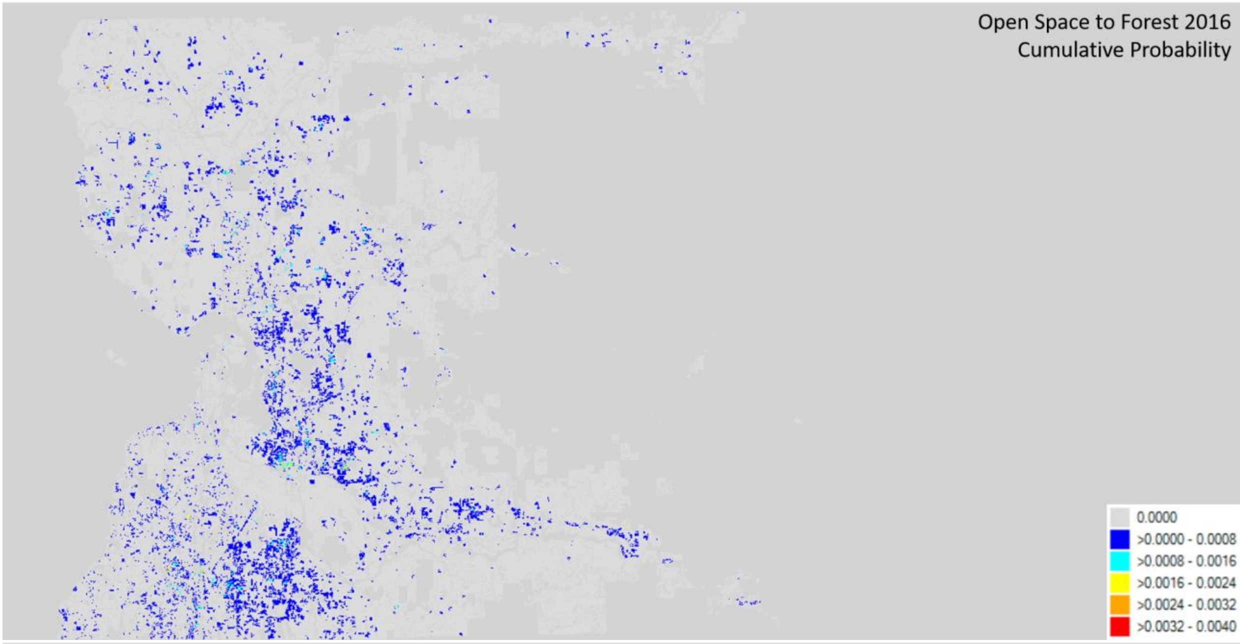

Low Intensity to High Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0020
>0.0020 - 0.0040
>0.0041 - 0.0061
>0.0061 - 0.0081
>0.0082 - 0.0102

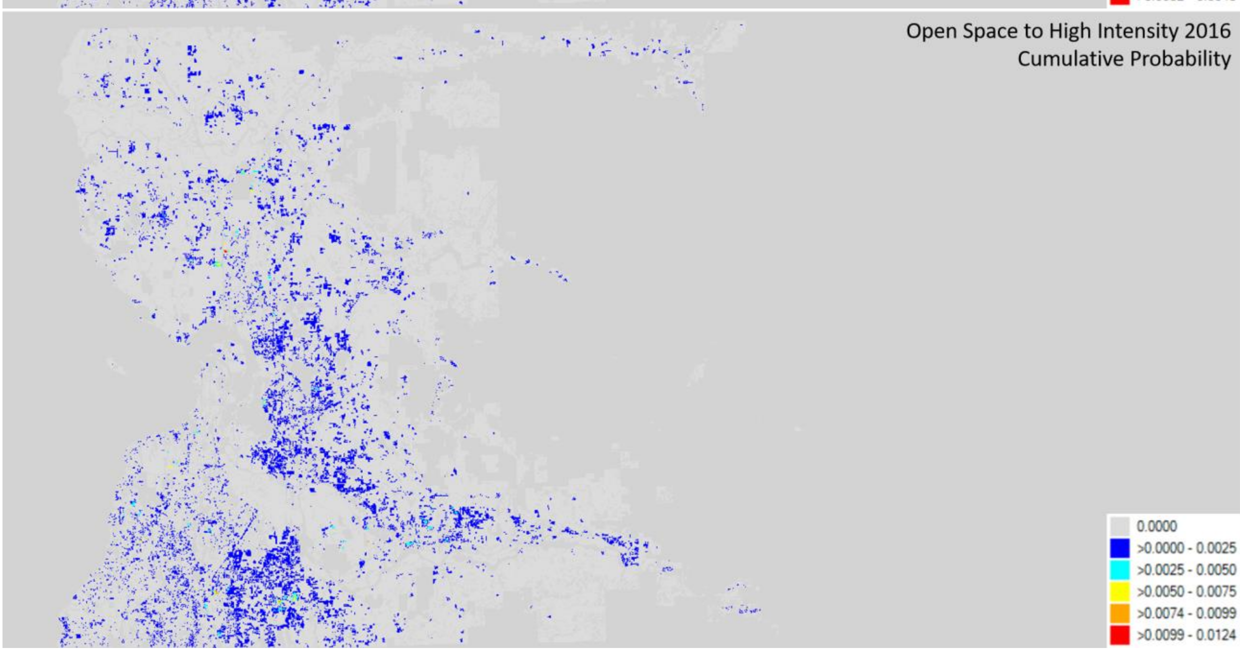

Low Intensity to Medium Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0052
>0.0052 - 0.0104
>0.0105 - 0.0157
>0.0157 - 0.0209
>0.0210 - 0.0262

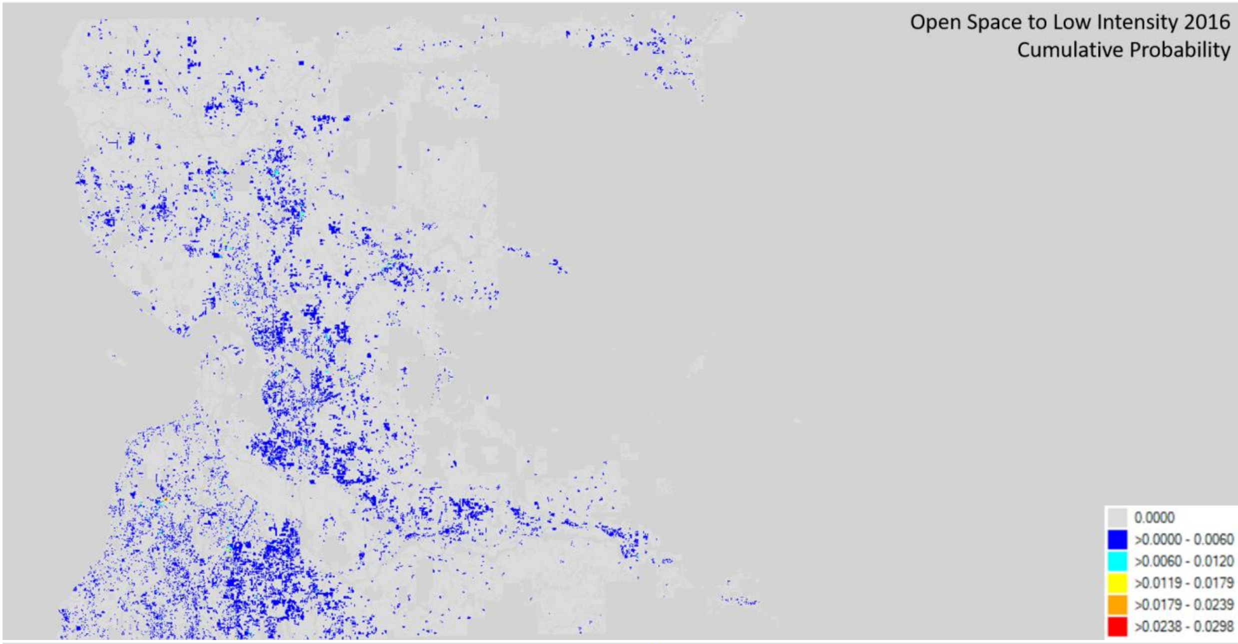

Low Intensity to Open Space 2016
Cumulative Probability
0.0000
>0.0000 - 0.0022
>0.0022 - 0.0044
>0.0044 - 0.0066
>0.0066 - 0.0088
>0.0088 - 0.0110

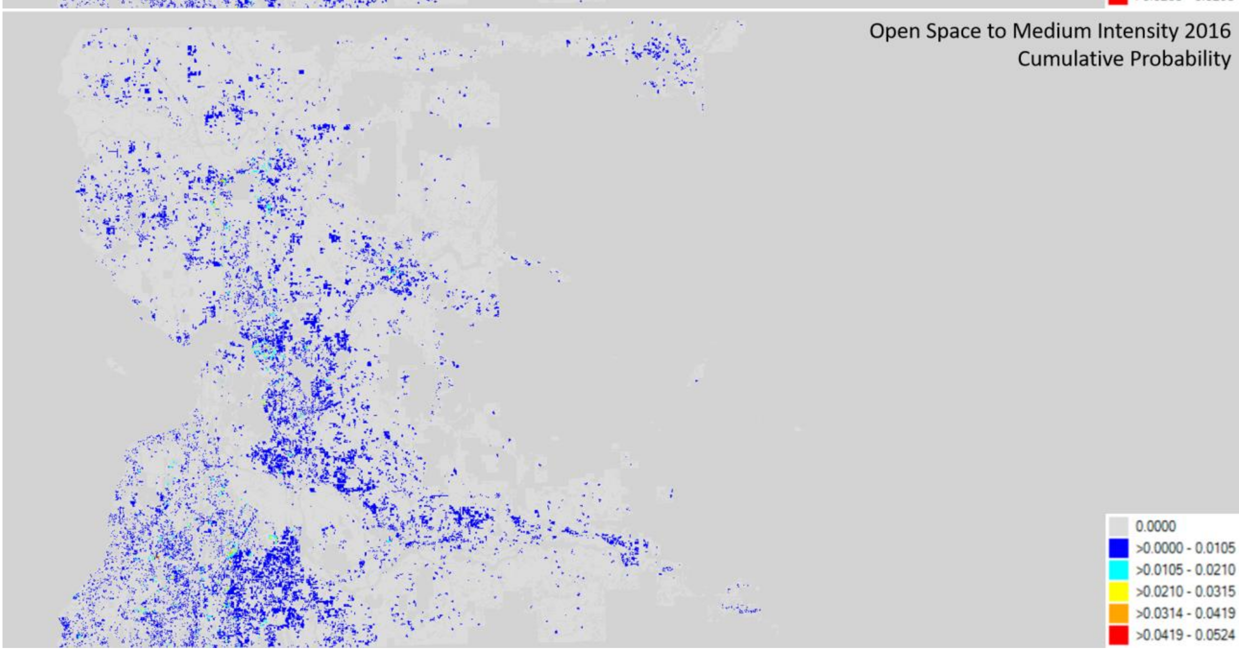

Medium Intensity to High Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0020
>0.0020 - 0.0040
>0.0039 - 0.0059
>0.0059 - 0.0079
>0.0078 - 0.0098


Medium Intensity to Low Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0003
>0.0003 - 0.0006
>0.0006 - 0.0009
>0.0009 - 0.0012
>0.0012 - 0.0014

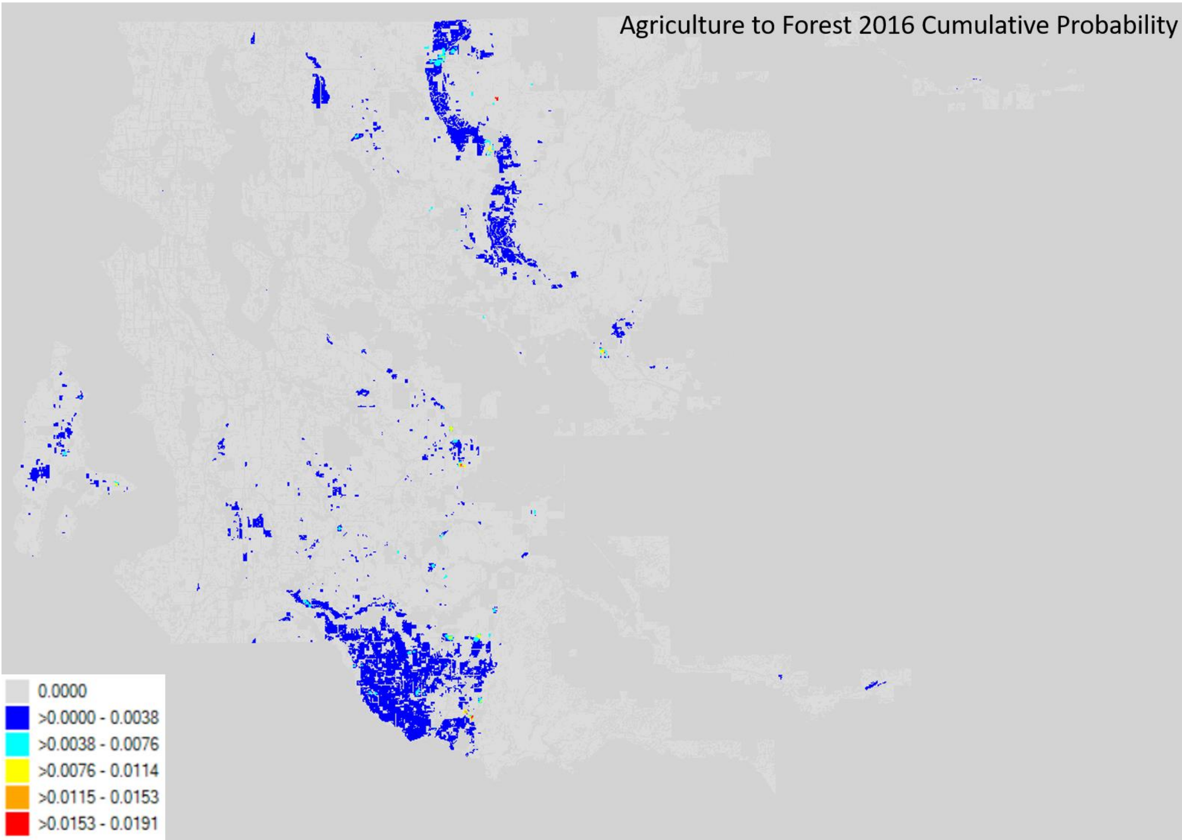

Open Space to Forest 2016
Cumulative Probability
0.0000
>0.0000 - 0.0008
>0.0008 - 0.0016
>0.0016 - 0.0024
>0.0024 - 0.0032
>0.0032 - 0.0040


Open Space to High Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0025
>0.0025 - 0.0050
>0.0050 - 0.0075
>0.0074 - 0.0099
>0.0099 - 0.0124

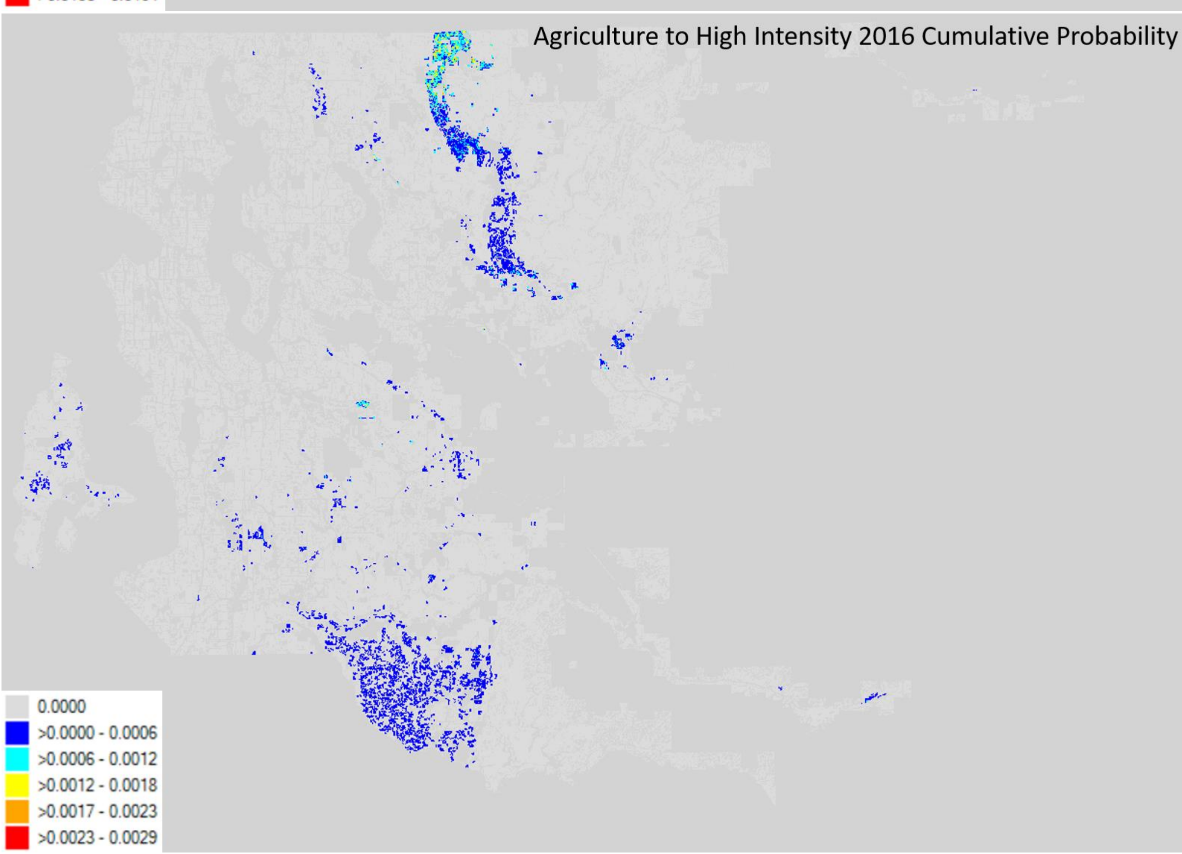

Open Space to Low Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0060
>0.0060 - 0.0120
>0.0119 - 0.0179
>0.0179 - 0.0239
>0.0238 - 0.0298


Open Space to Medium Intensity 2016
Cumulative Probability
0.0000
>0.0000 - 0.0105
>0.0105 - 0.0210
>0.0210 - 0.0315
>0.0314 - 0.0419
>0.0419 - 0.0524

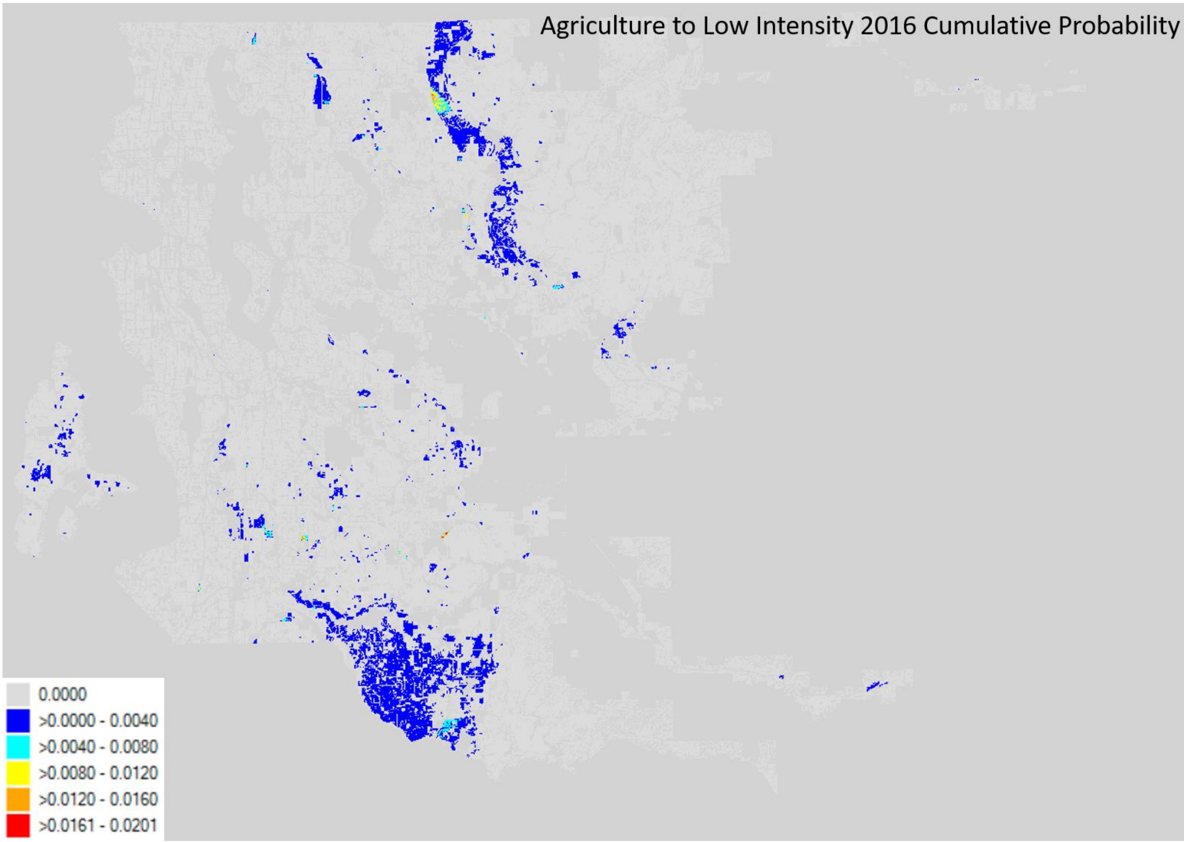
King County

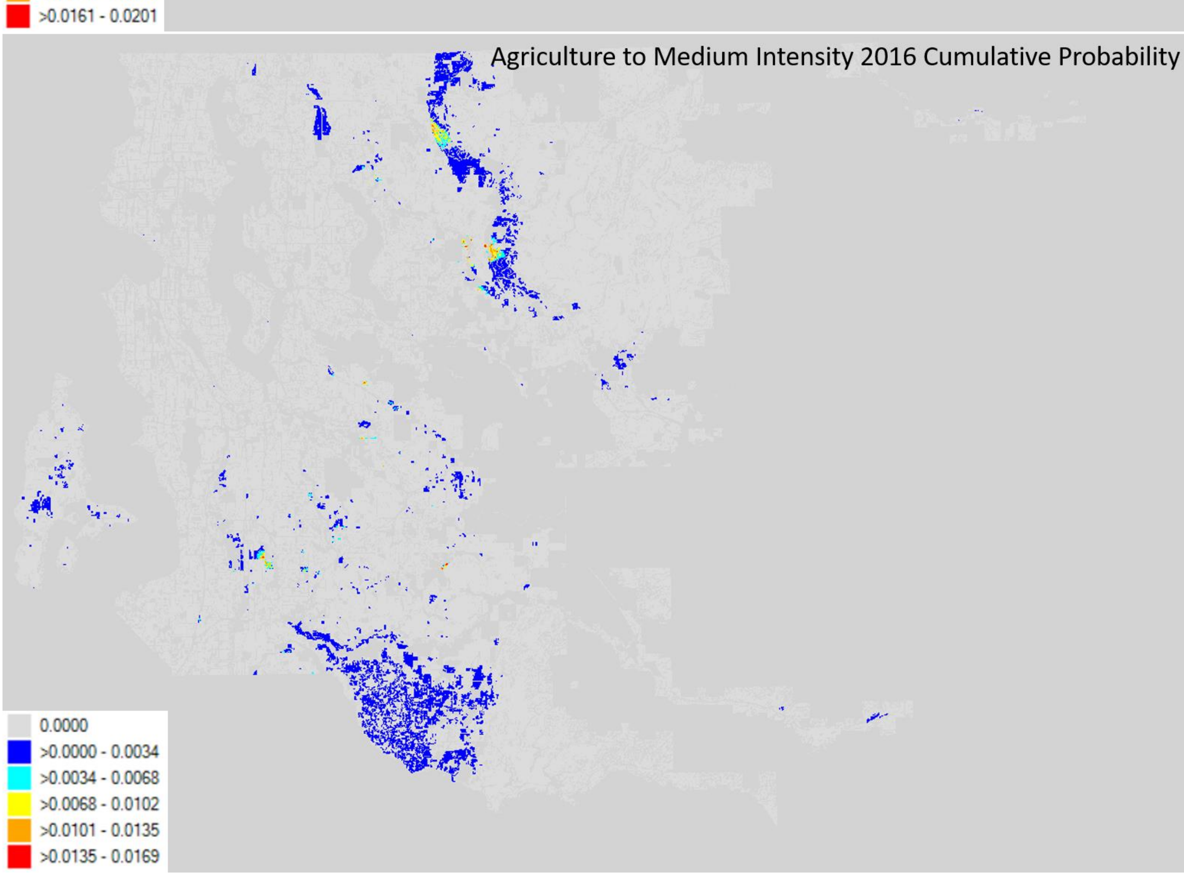


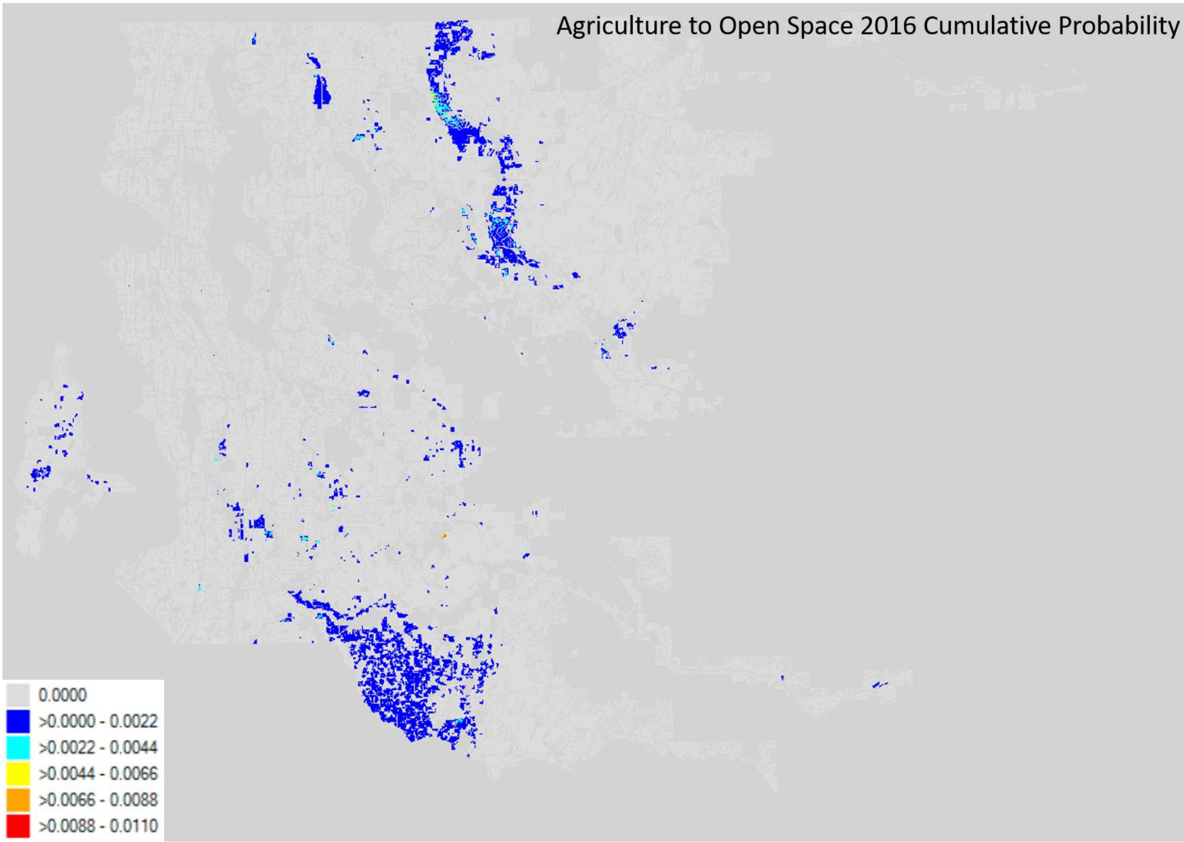
Agriculture to Forest 2016 Cumulative Probability
0.0000
>0.0000 - 0.0038
>0.0038 - 0.0076
>0.0076 - 0.0114
>0.0115 - 0.0153
>0.0153 - 0.0191

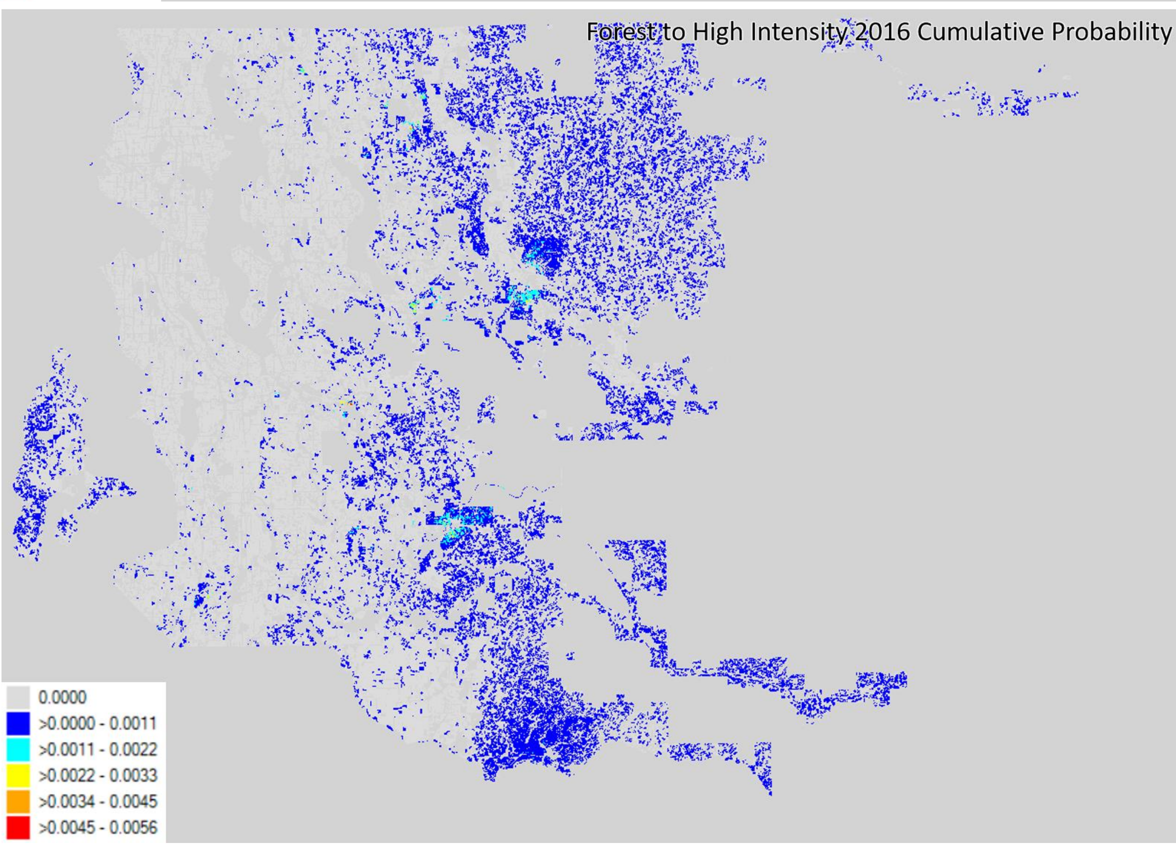


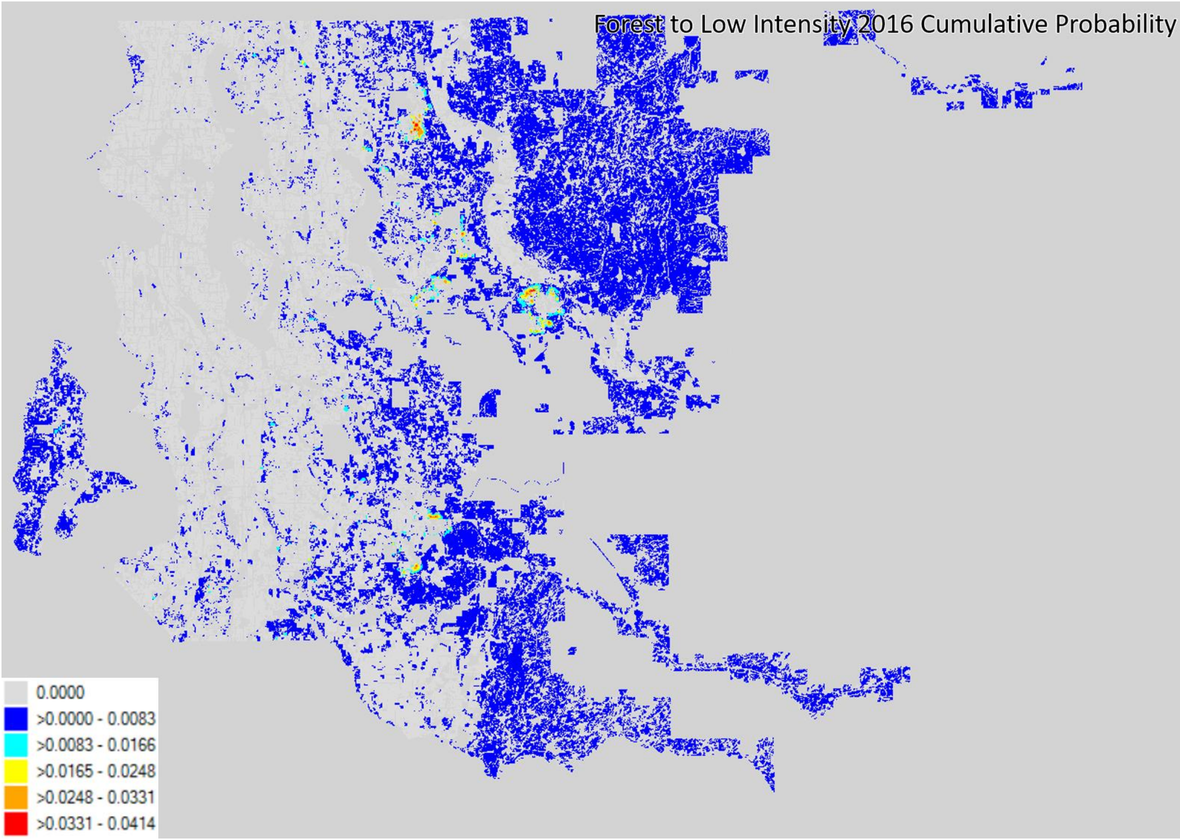
Agriculture to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0006
>0.0006 - 0.0012
>0.0012 - 0.0018
>0.0017 - 0.0023
>0.0023 - 0.0029

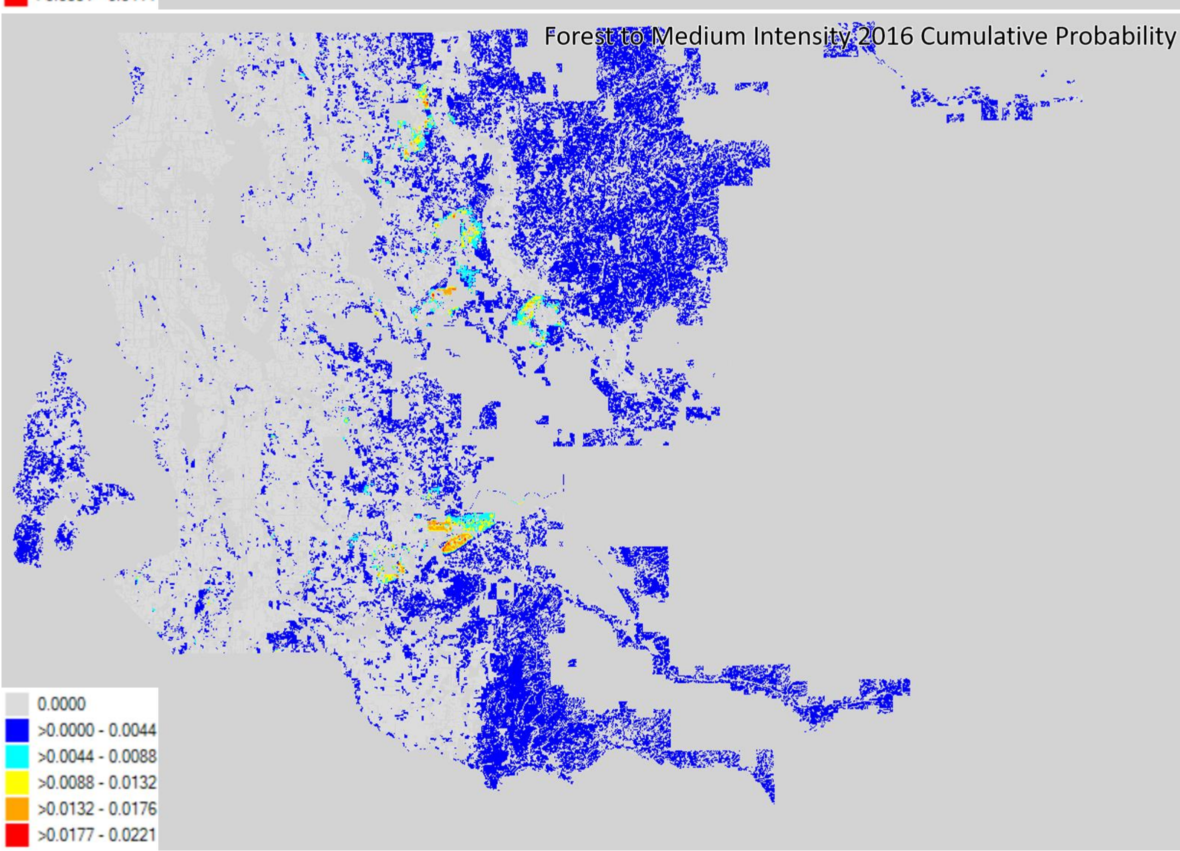

Agriculture to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0040
>0.0040 - 0.0080
>0.0080 - 0.0120
>0.0120 - 0.0160
>0.0161 - 0.0201

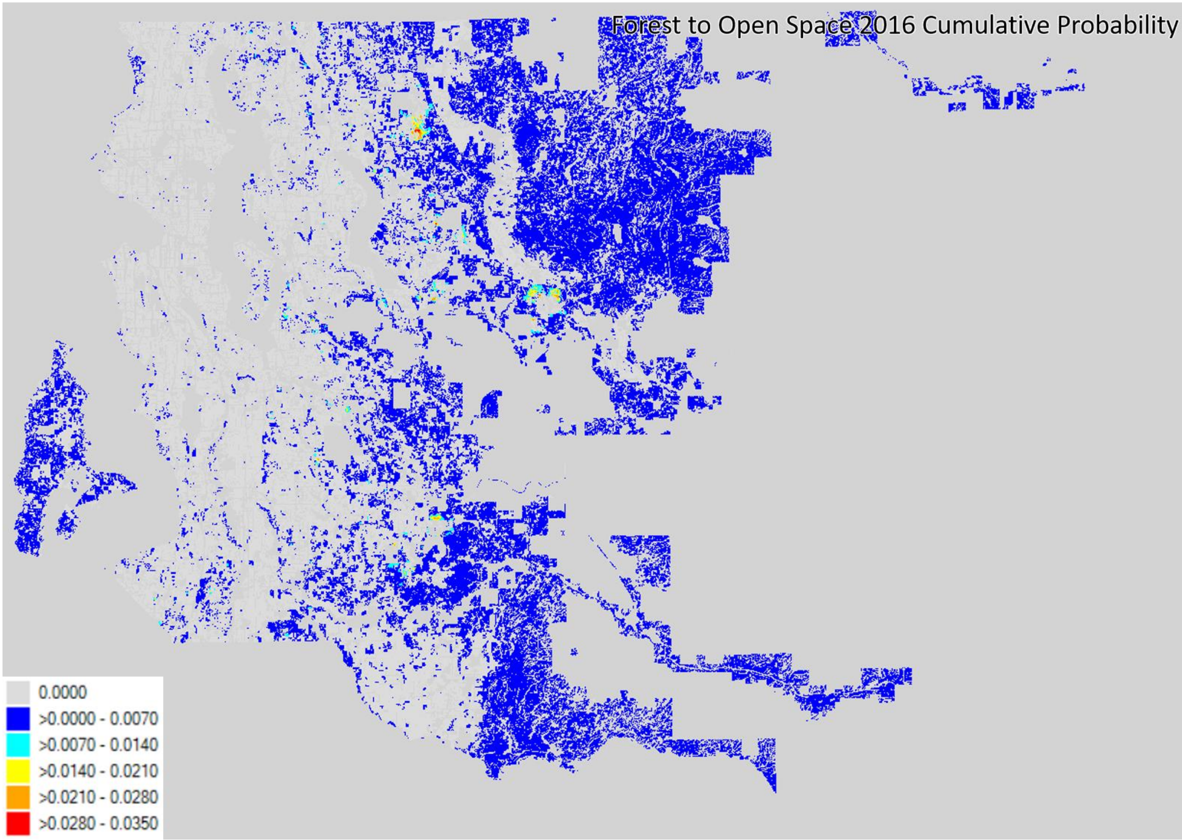

Agriculture to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0034
>0.0034 - 0.0068
>0.0068 - 0.0102
>0.0101 - 0.0135
>0.0135 - 0.0169

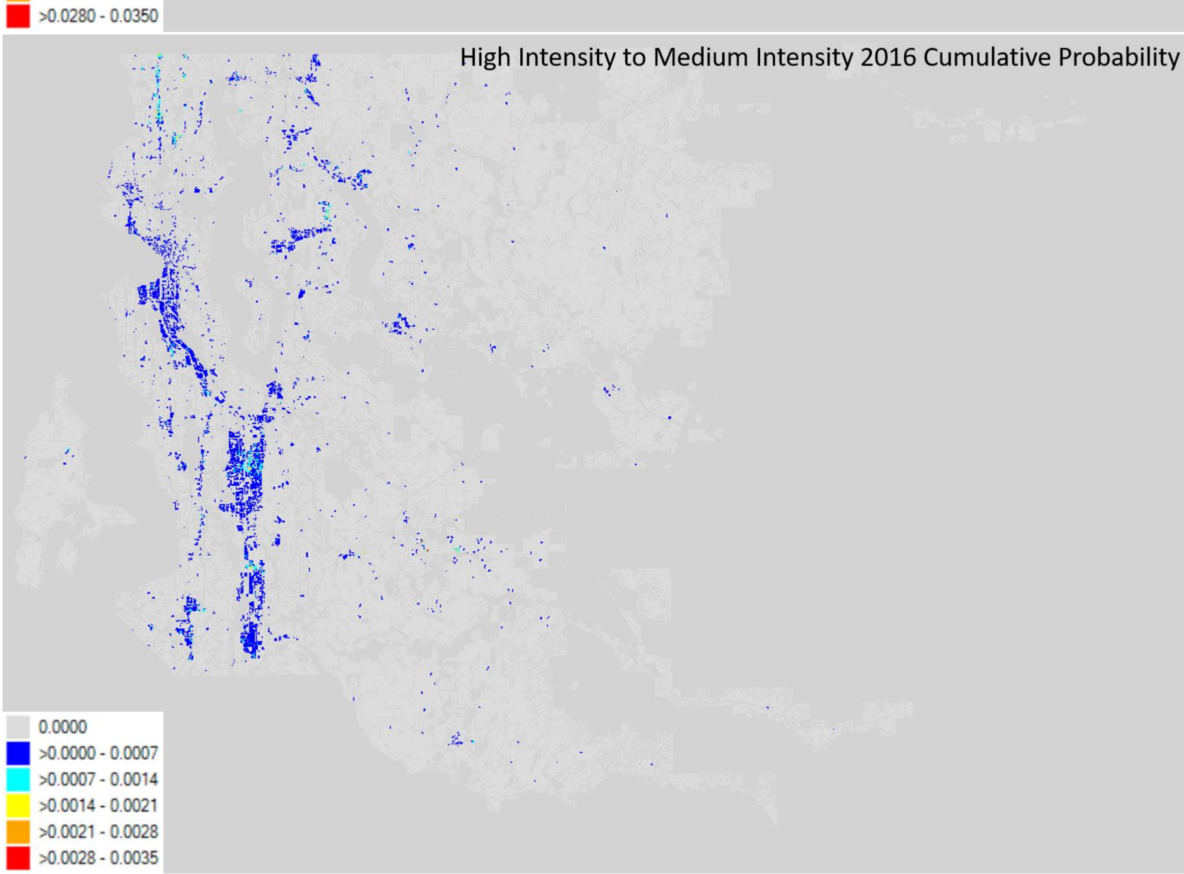

Agriculture to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0022
>0.0022 - 0.0044
>0.0044 - 0.0066
>0.0066 - 0.0088
>0.0088 - 0.0110

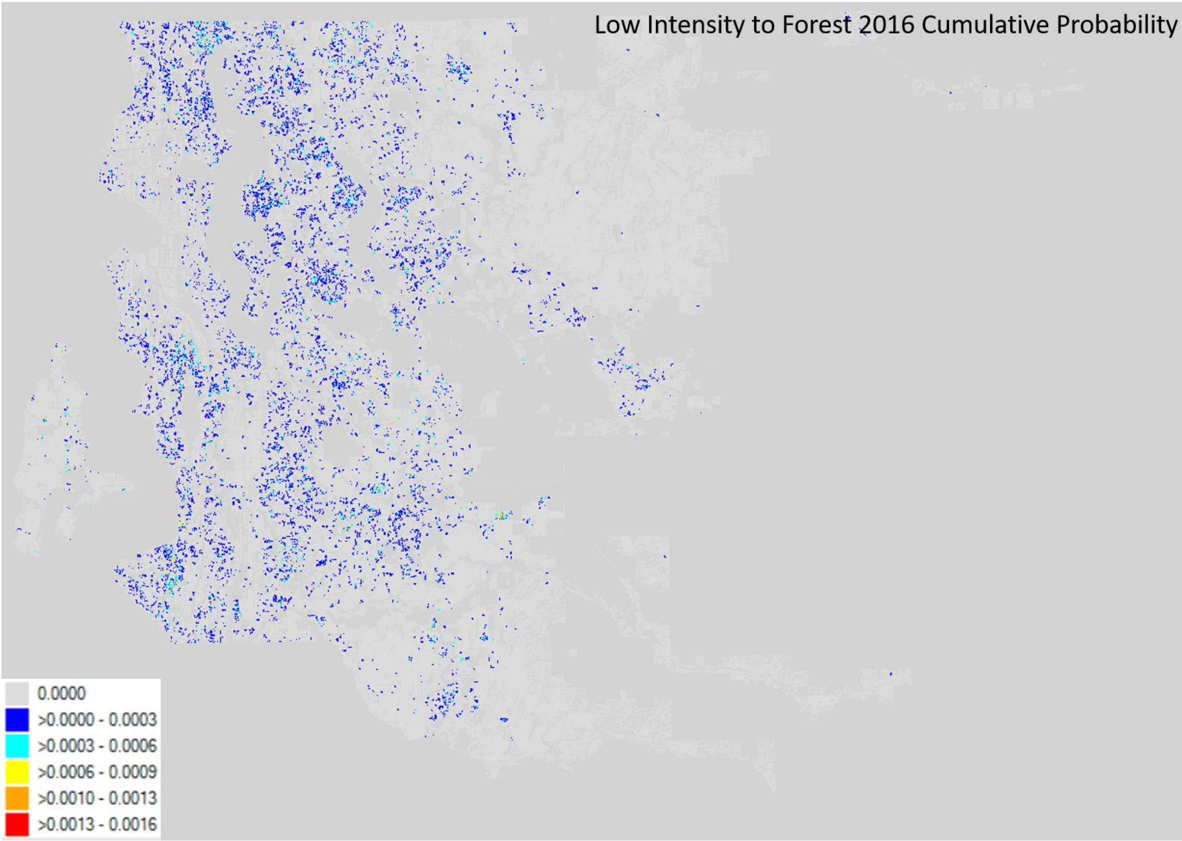

Forest to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0011
>0.0011 - 0.0022
>0.0022 - 0.0033
>0.0034 - 0.0045
>0.0045 - 0.0056

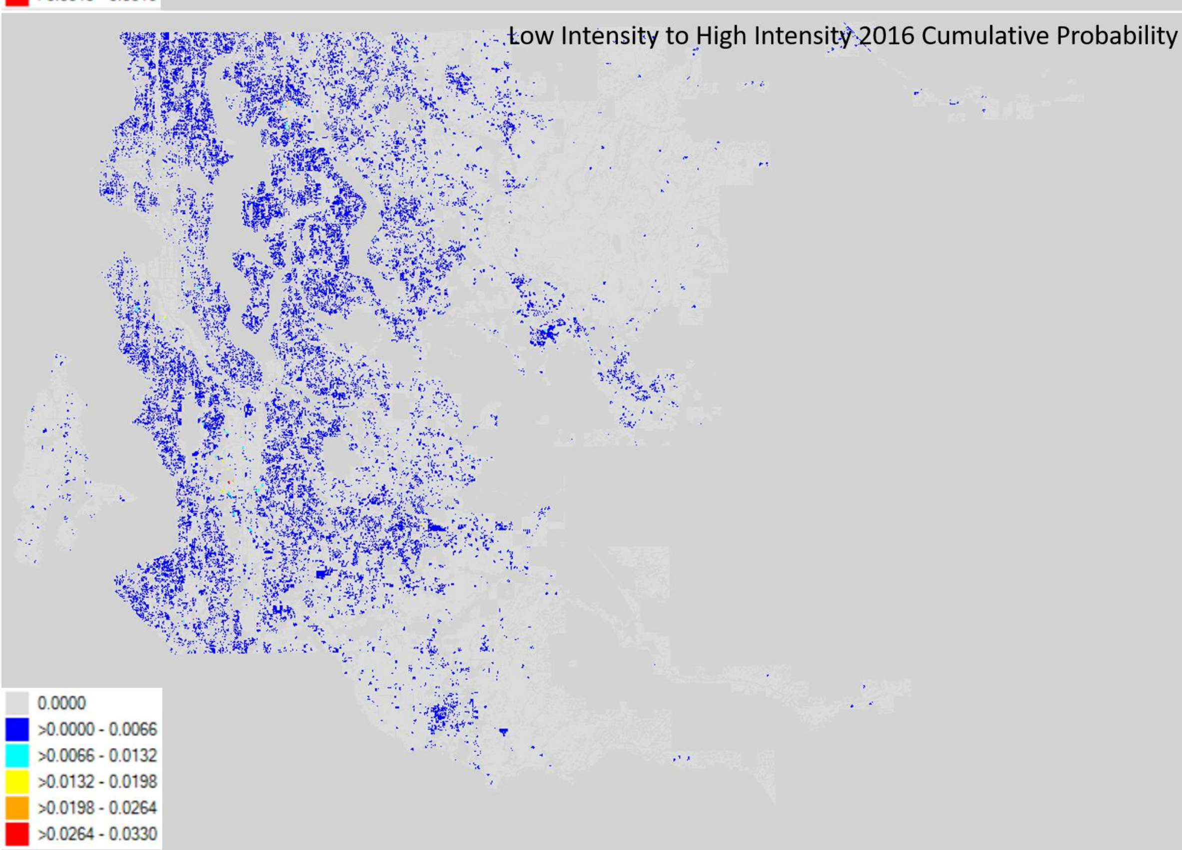

Forest to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0083
>0.0083 - 0.0166
>0.0165 - 0.0248
>0.0248 - 0.0331
>0.0331 - 0.0414

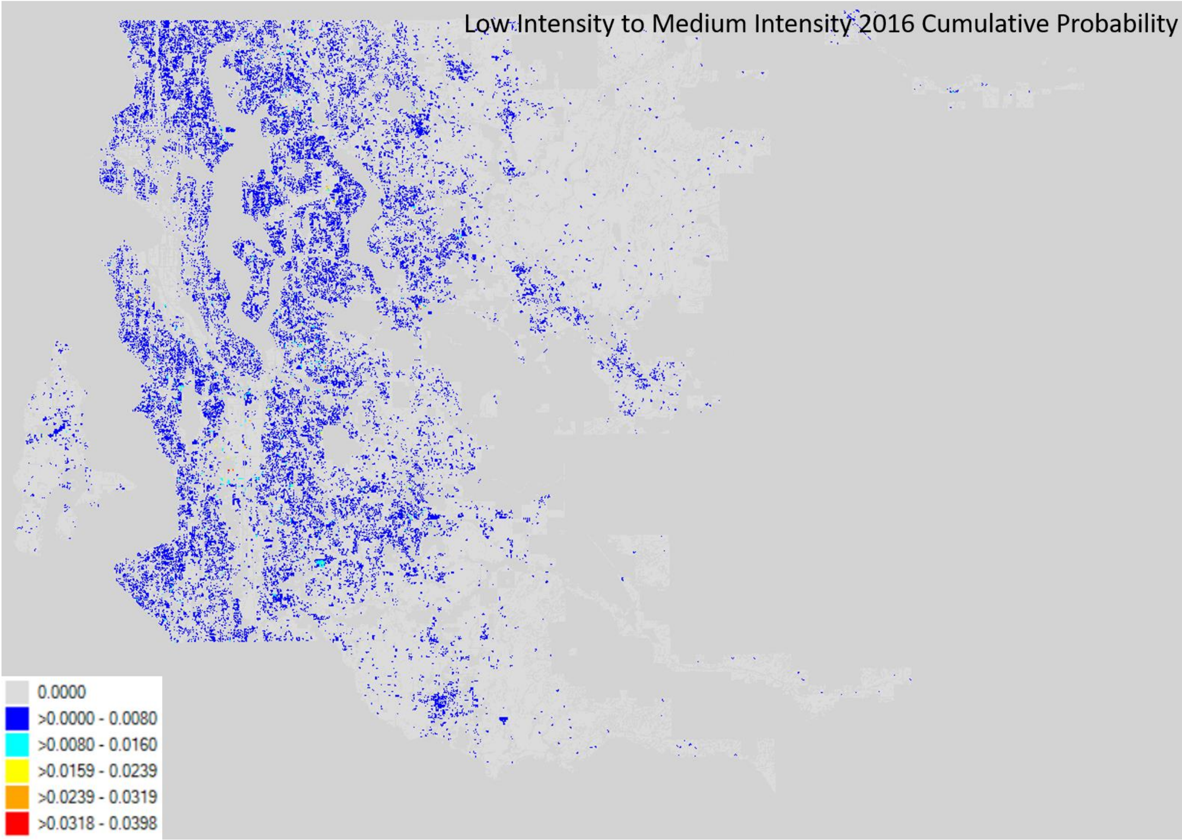

Forest to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0044
>0.0044 - 0.0088
>0.0088 - 0.0132
>0.0132 - 0.0176
>0.0177 - 0.0221


Forest to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0070
>0.0070 - 0.0140
>0.0140 - 0.0210
>0.0210 - 0.0280
>0.0280 - 0.0350

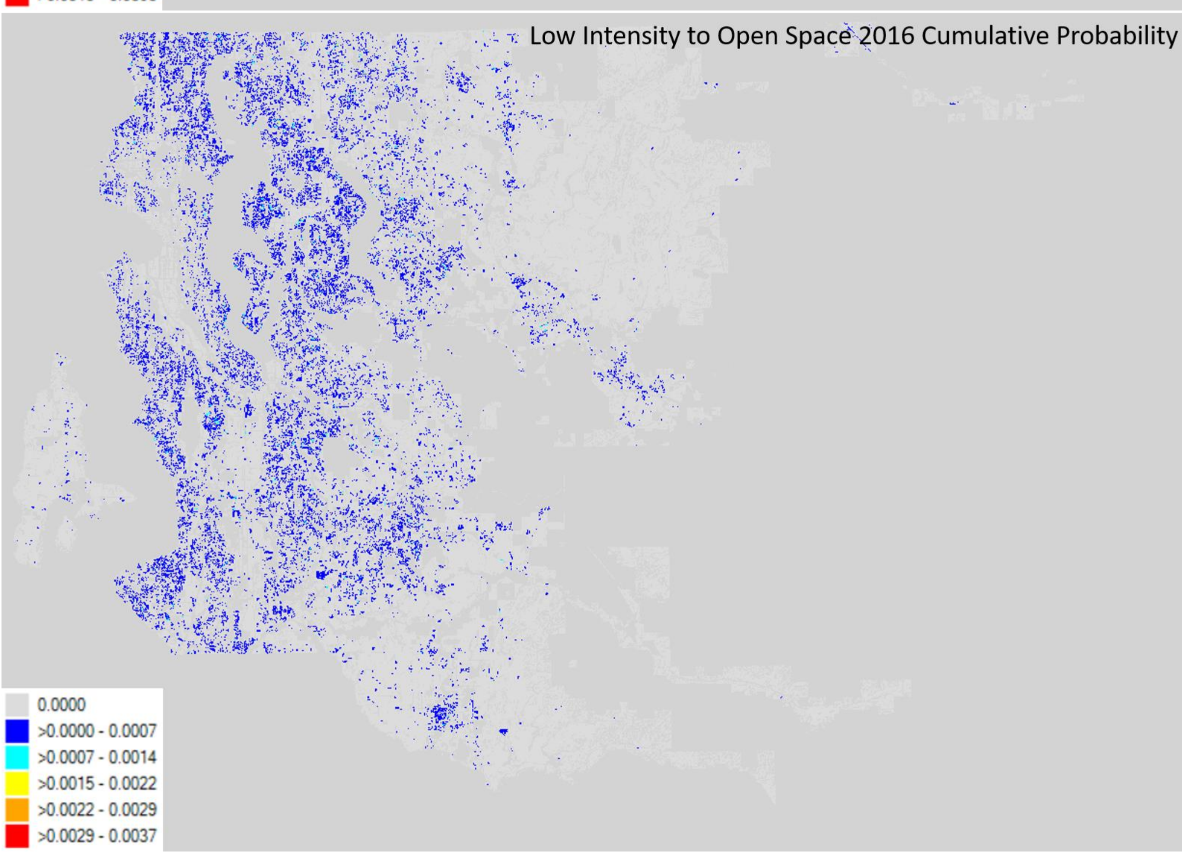

High Intensity to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0007
>0.0007 - 0.0014
>0.0014 - 0.0021
>0.0021 - 0.0028
>0.0028 - 0.0035


Low Intensity to Forest 2016 Cumulative Probability
0.0000
>0.0000 - 0.0003
>0.0003 - 0.0006
>0.0006 - 0.0009
>0.0010 - 0.0013
>0.0013 - 0.0016

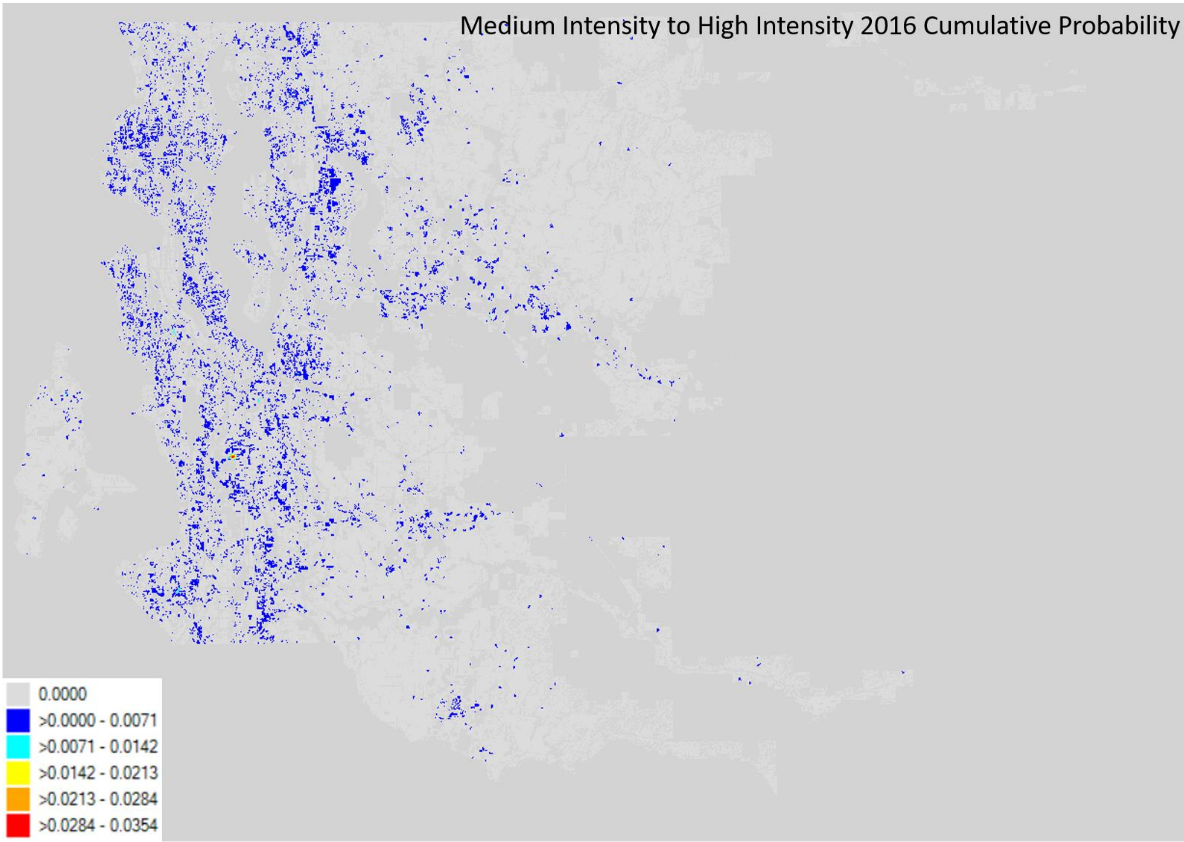

Low Intensity to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0066
>0.0066 - 0.0132
>0.0132 - 0.0198
>0.0198 - 0.0264
>0.0264 - 0.0330

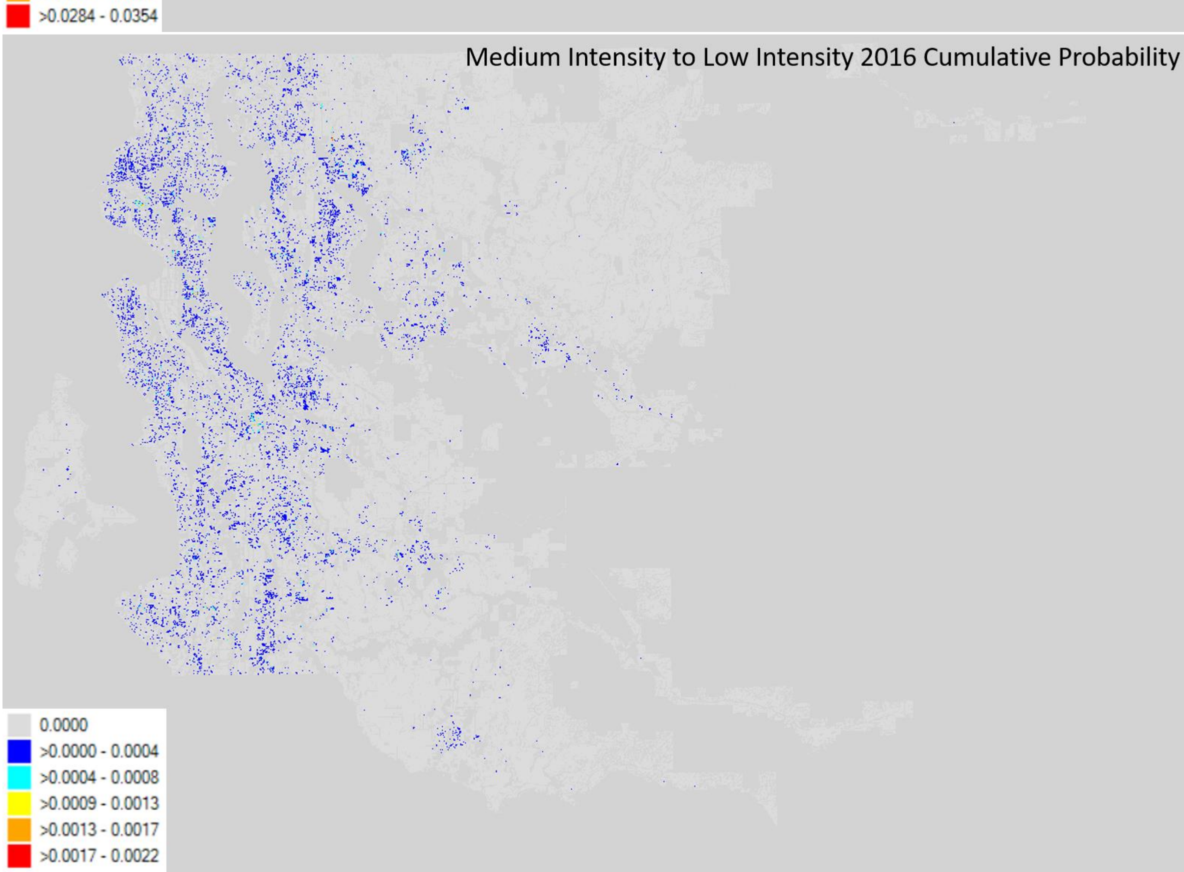


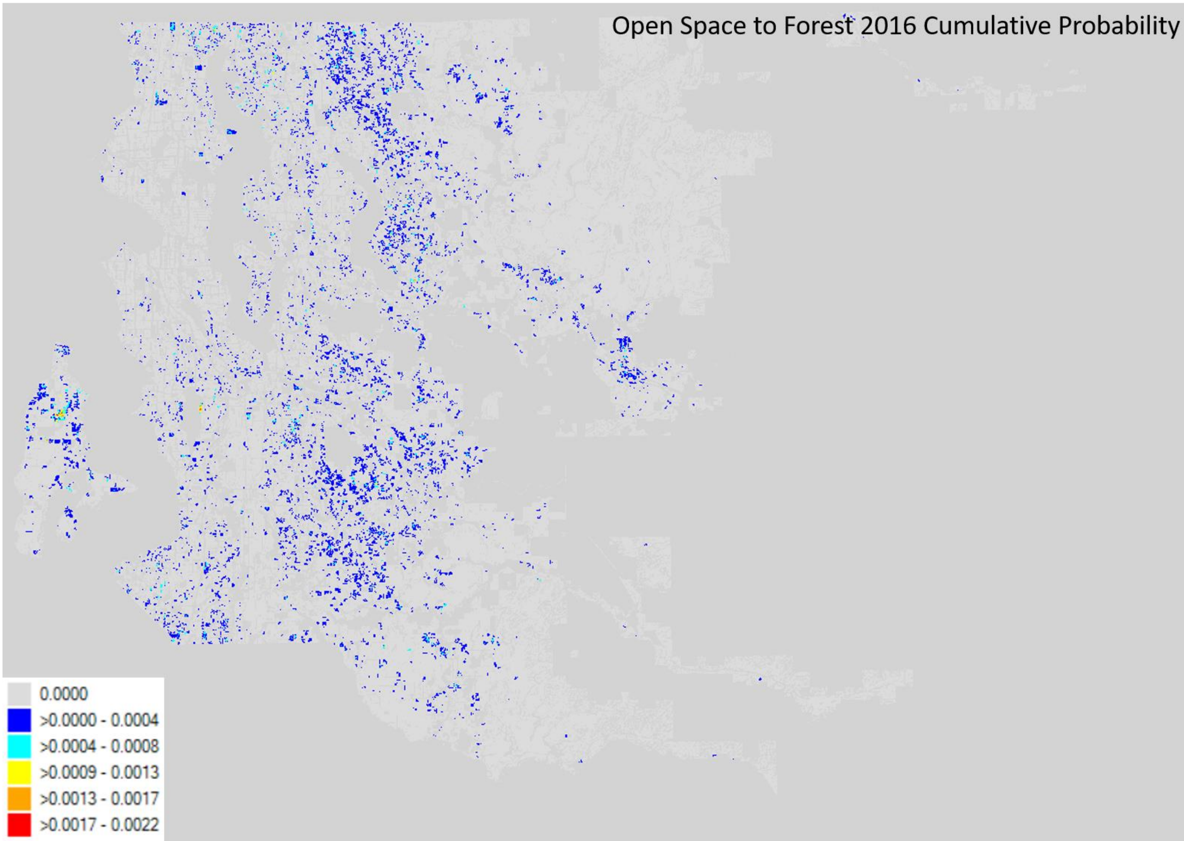
Low Intensity to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0080
>0.0080 - 0.0160
>0.0159 - 0.0239
>0.0239 - 0.0319
>0.0318 - 0.0398

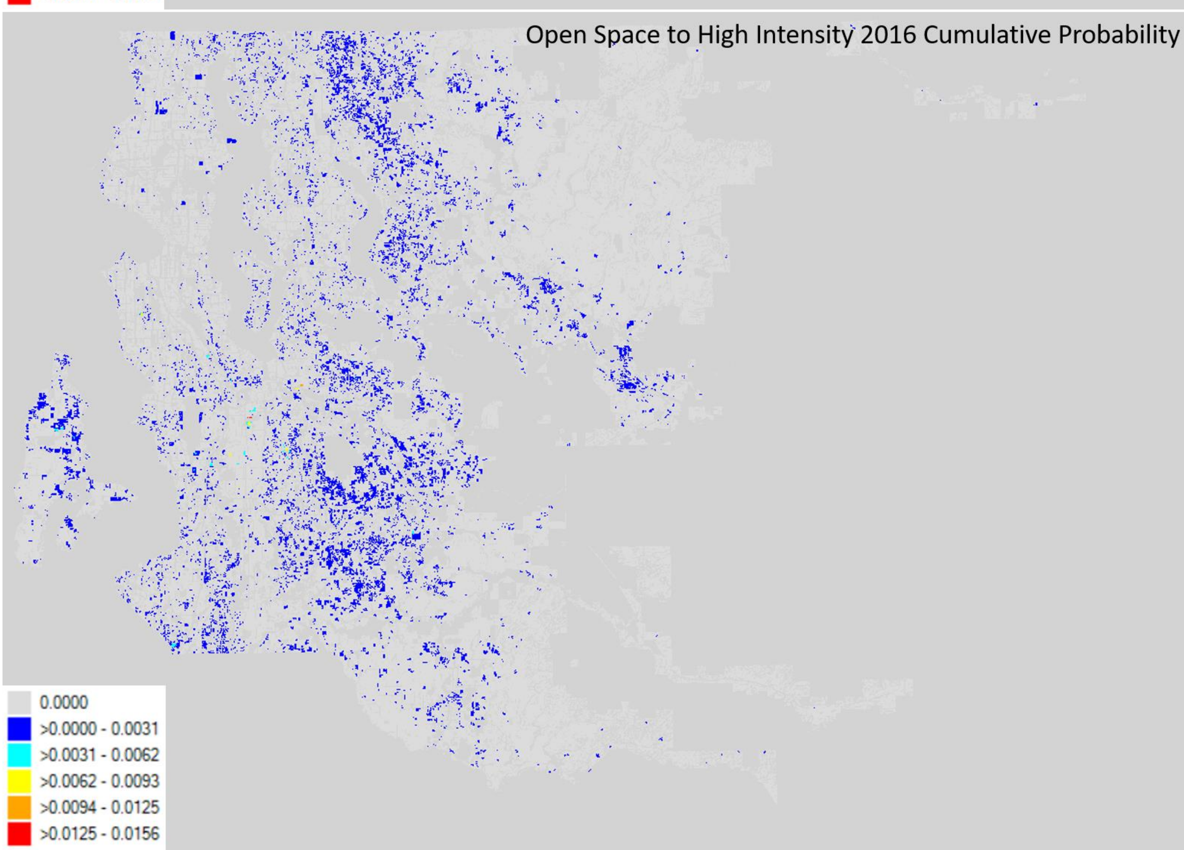


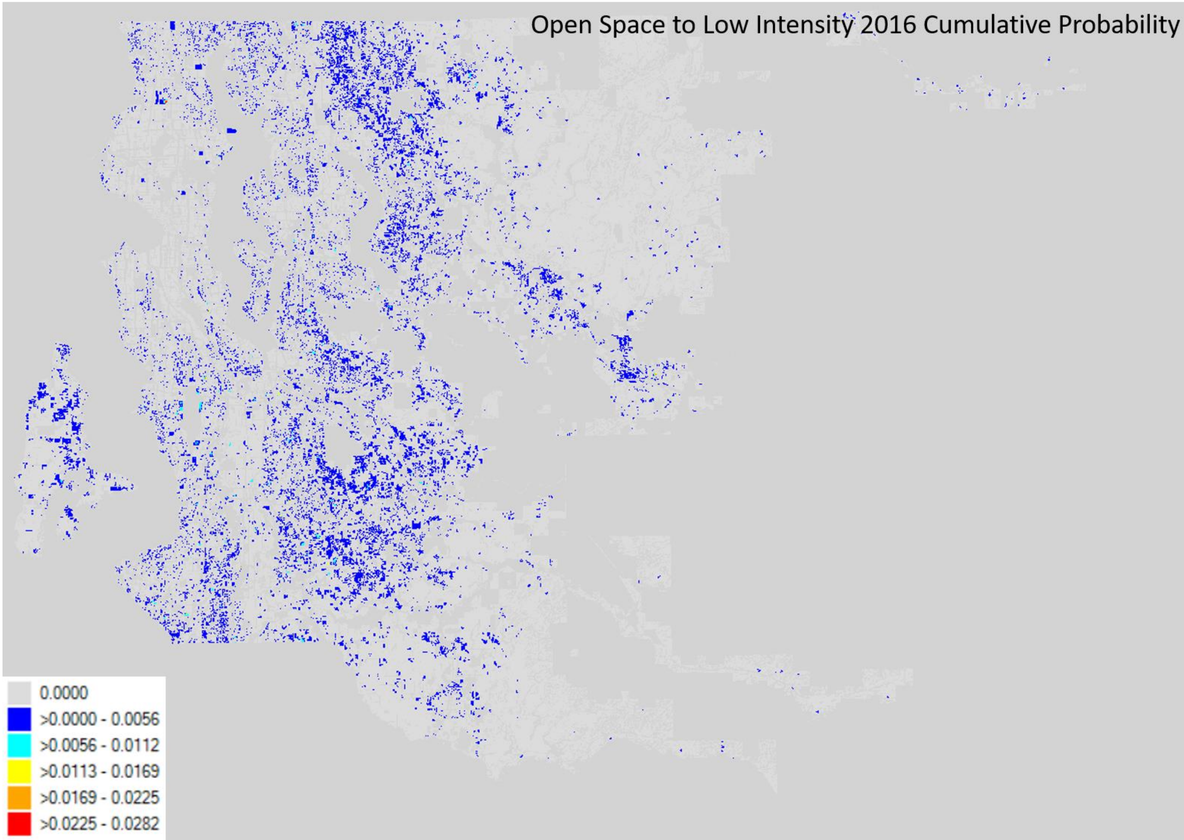
Low Intensity to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0007
>0.0007 - 0.0014
>0.0015 - 0.0022
>0.0022 - 0.0029
>0.0029 - 0.0037

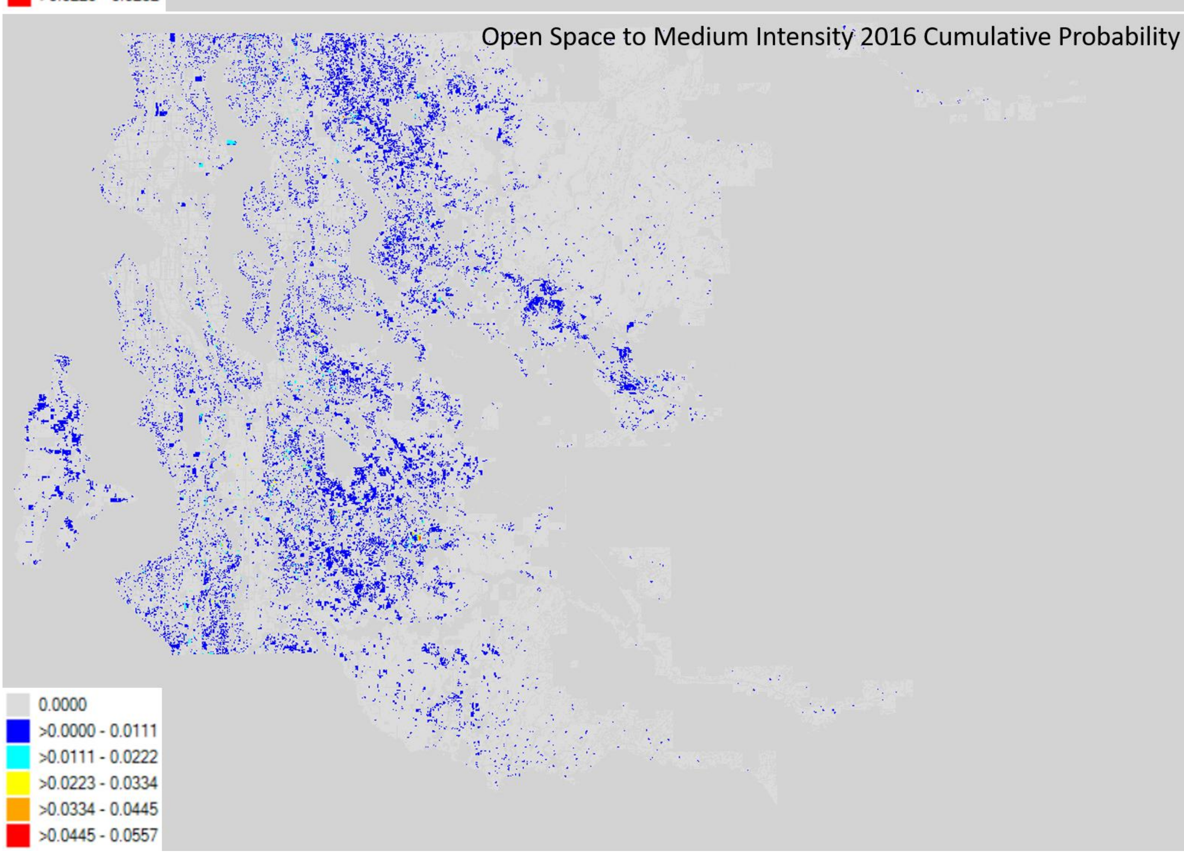

Medium Intensity to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0071
>0.0071 - 0.0142
>0.0142 - 0.0213
>0.0213 - 0.0284
>0.0284 - 0.0354


Medium Intensity to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0004
>0.0004 - 0.0008
>0.0009 - 0.0013
>0.0013 - 0.0017
>0.0017 - 0.0022

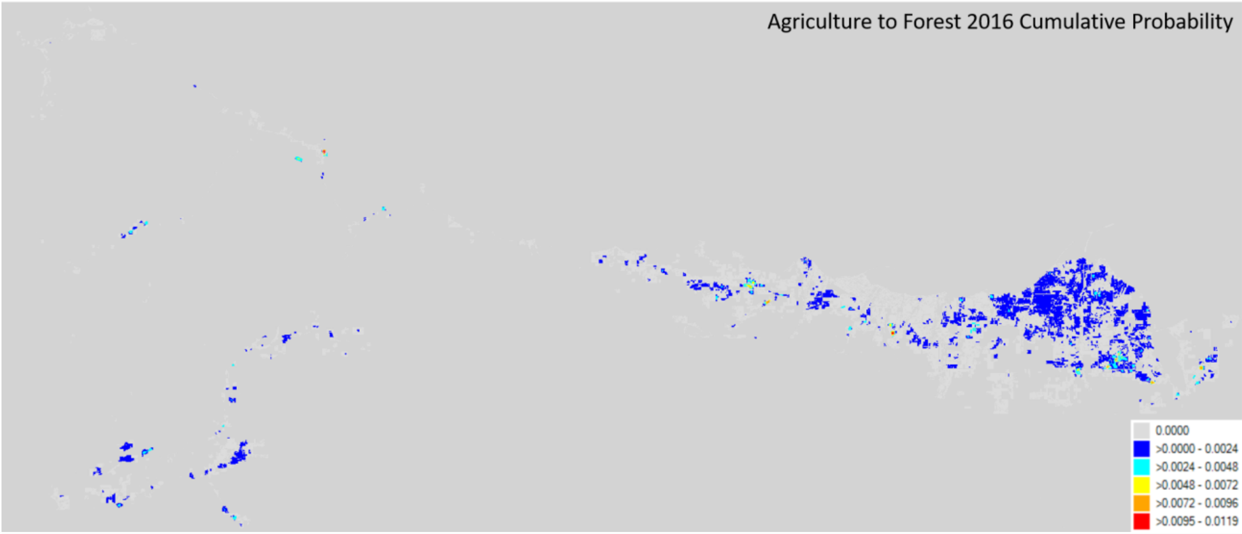

Open Space to Forest 2016 Cumulative Probability
0.0000
>0.0000 - 0.0004
>0.0004 - 0.0008
>0.0009 - 0.0013
>0.0013 - 0.0017
>0.0017 - 0.0022

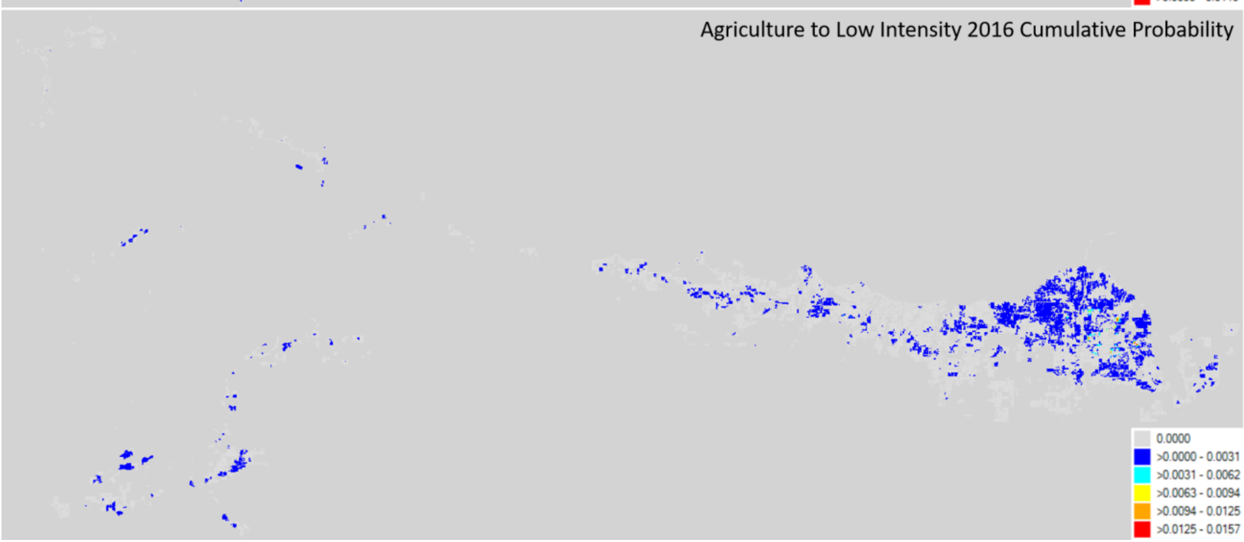

Open Space to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0031
>0.0031 - 0.0062
>0.0062 - 0.0093
>0.0094 - 0.0125
>0.0125 - 0.0156

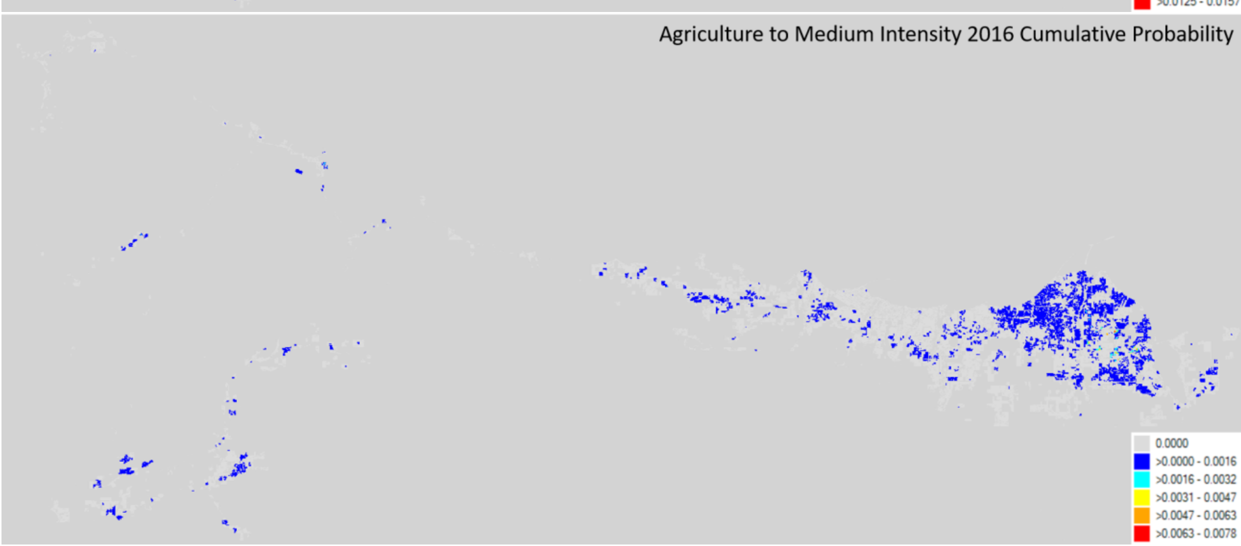

Open Space to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0056
>0.0056 - 0.0112
>0.0113 - 0.0169
>0.0169 - 0.0225
>0.0225 - 0.0282

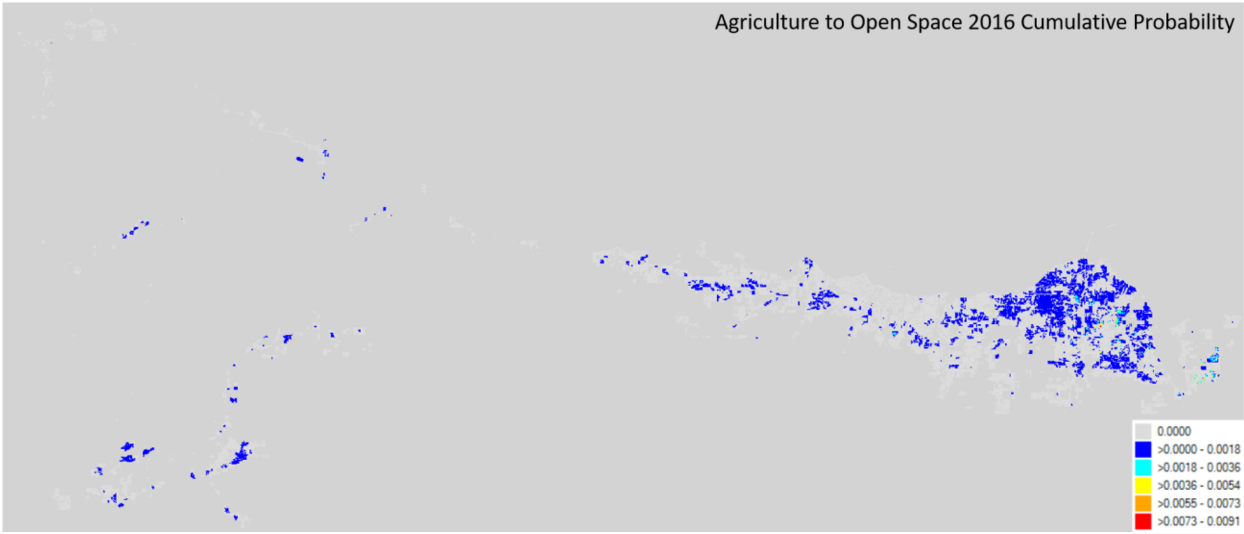

Open Space to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0111
>0.0111 - 0.0222
>0.0223 - 0.0334
>0.0334 - 0.0445
>0.0445 - 0.0557

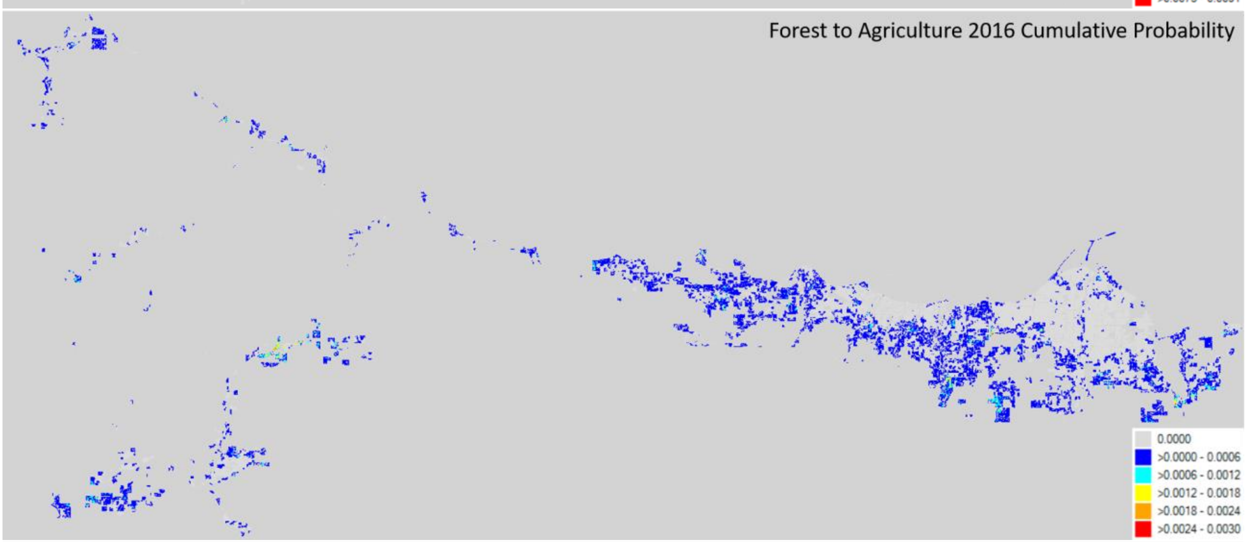
Clallam County

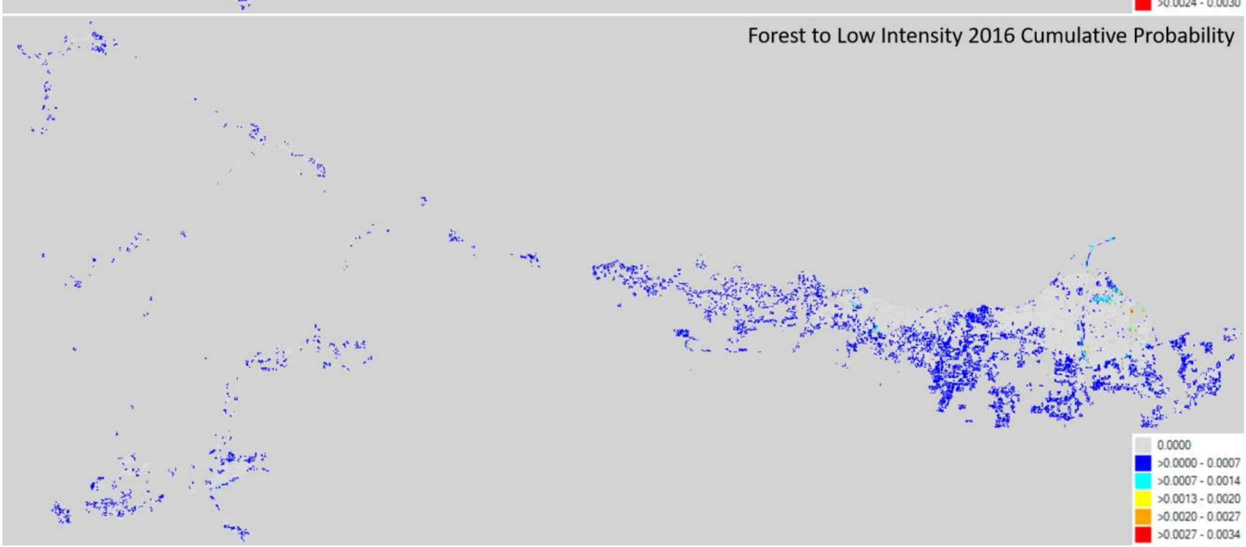


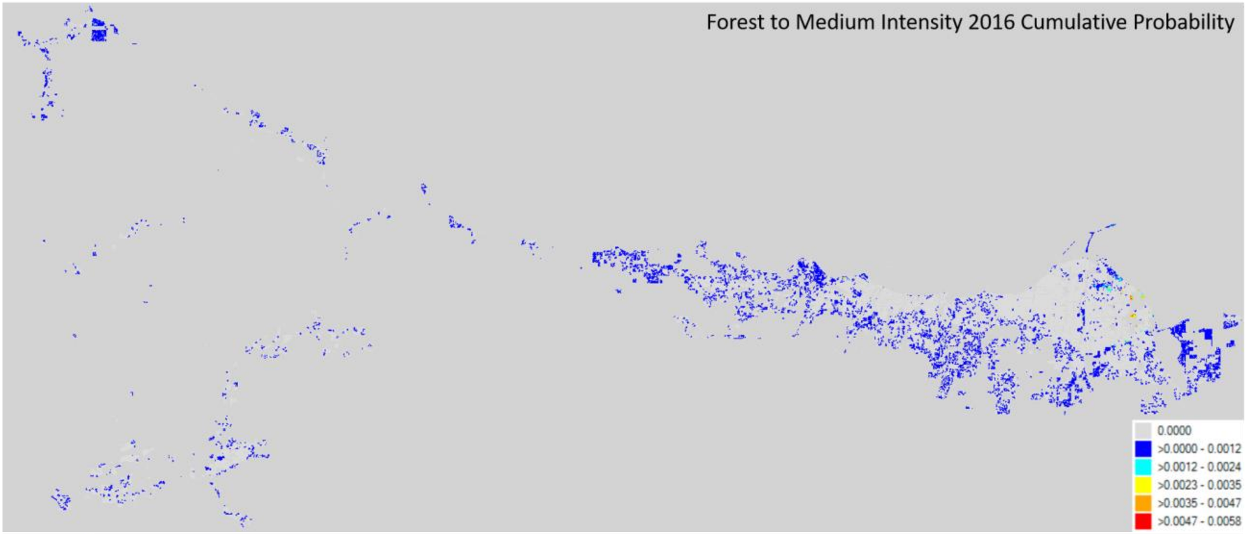


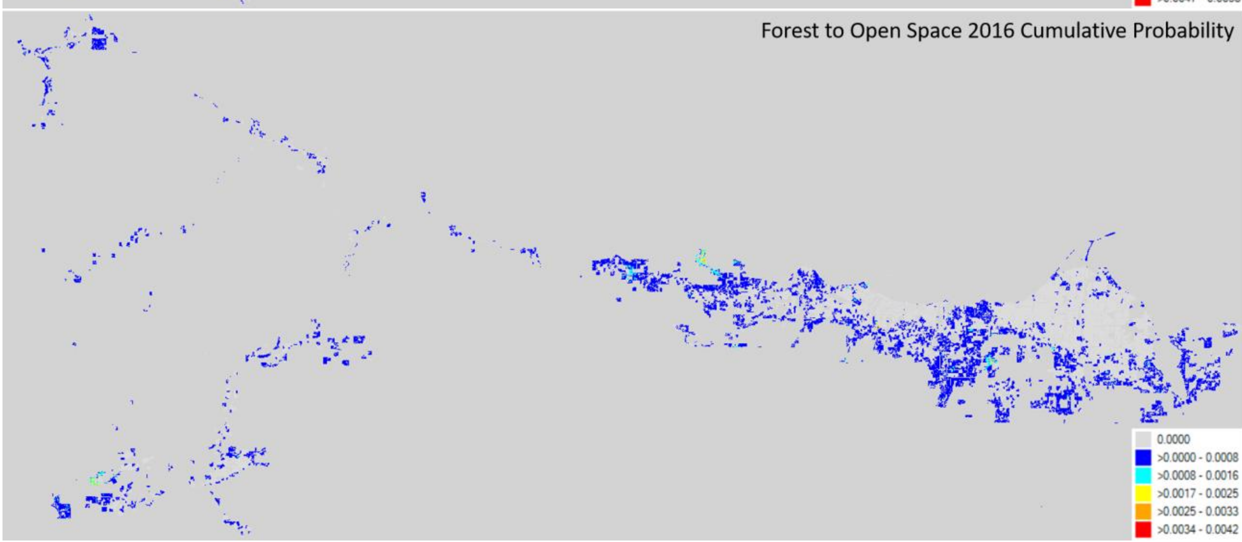


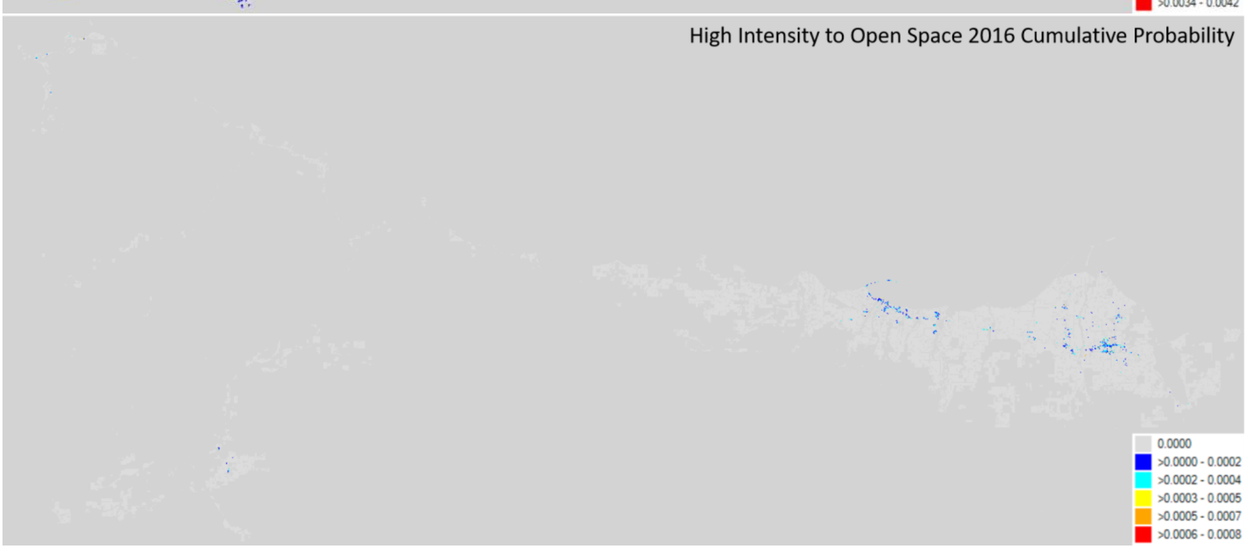

Agriculture to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0018
>0.0018 - 0.0036
>0.0036 - 0.0054
>0.0055 - 0.0073
>0.0073 - 0.0091

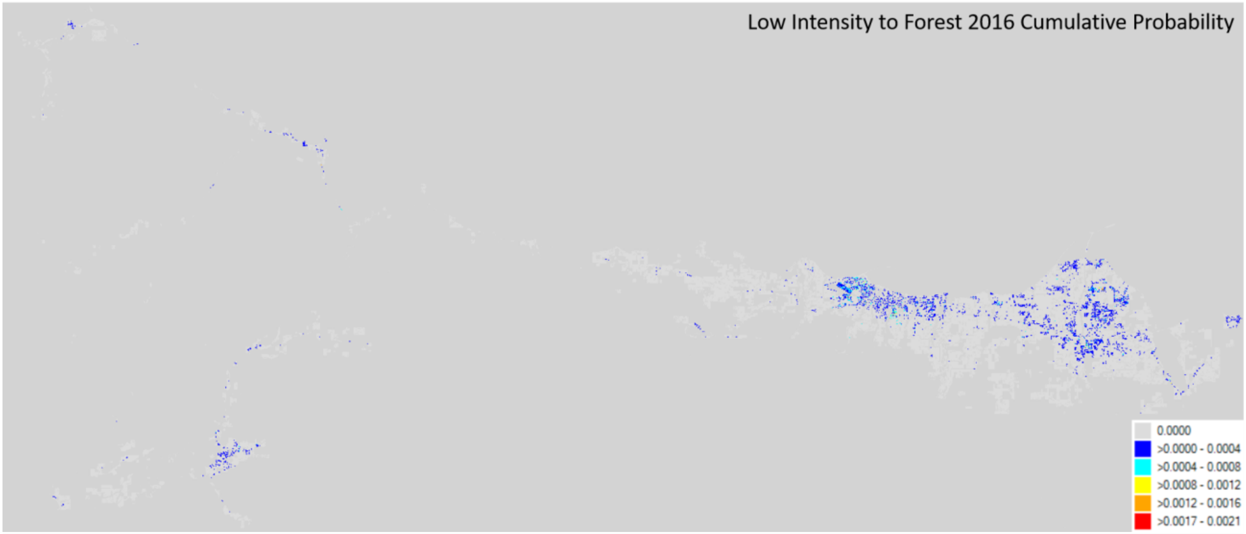
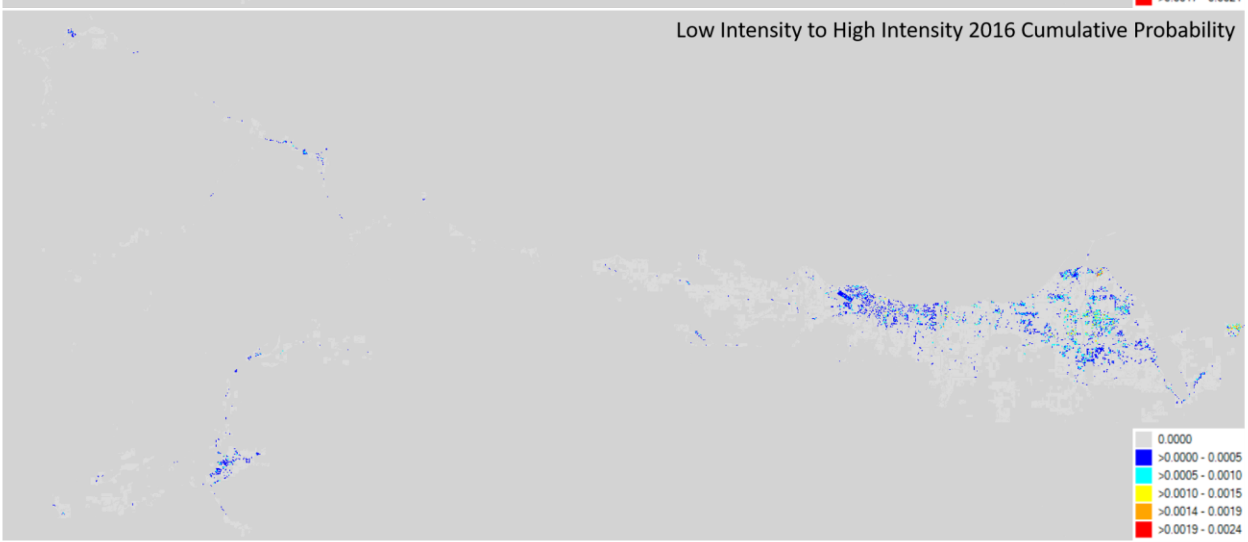
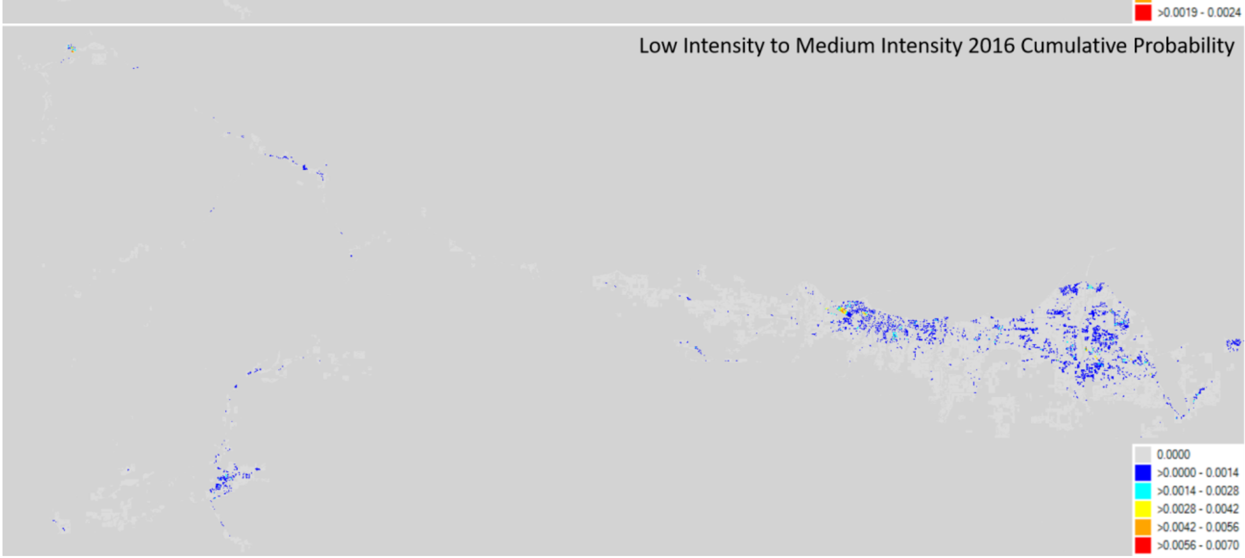

Forest to Agriculture 2016 Cumulative Probability
0.0000
>0.0000 - 0.0006
>0.0006 - 0.0012
>0.0012 - 0.0018
>0.0018 - 0.0024
>0.0024 - 0.0030

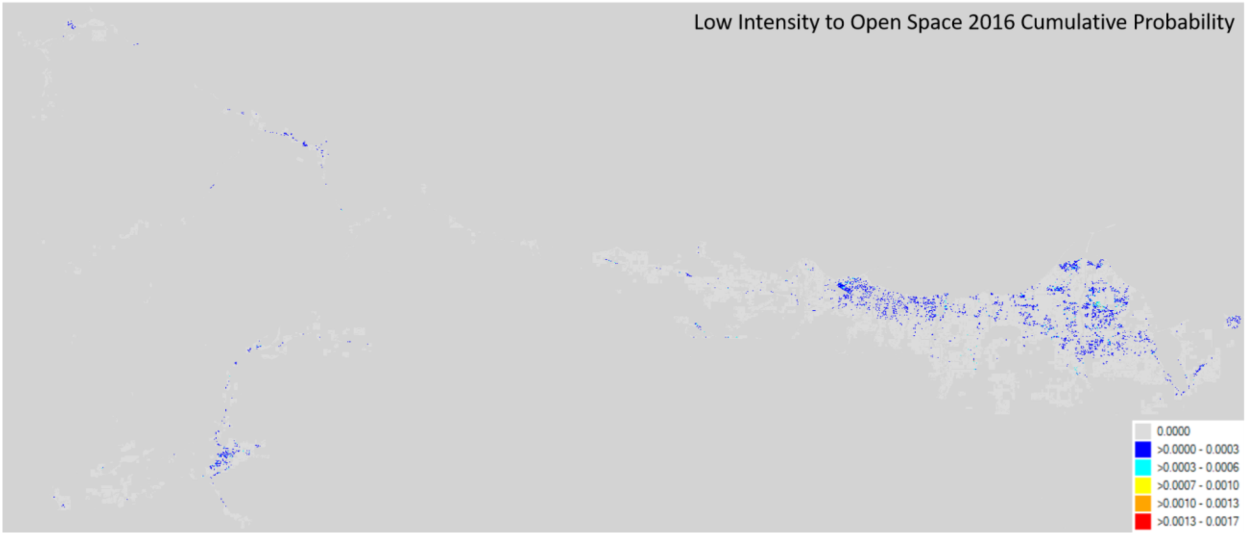

Forest to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0007
>0.0007 - 0.0014
>0.0013 - 0.0020
>0.0020 - 0.0027
>0.0027 - 0.0034

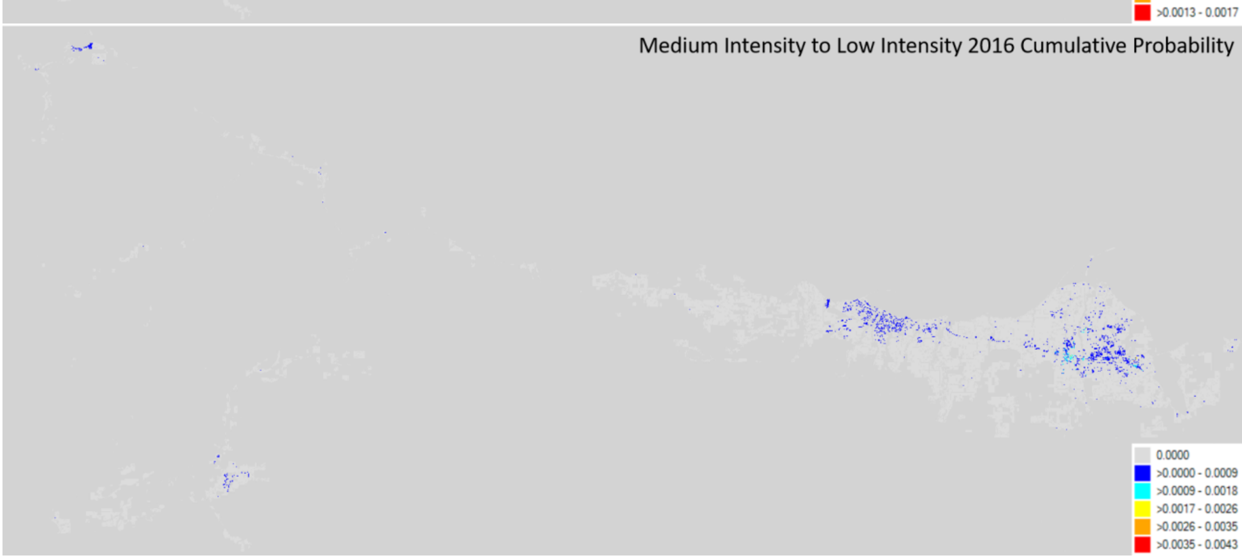

Forest to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0012
>0.0012 - 0.0024
>0.0023 - 0.0035
>0.0035 - 0.0047
>0.0047 - 0.0058

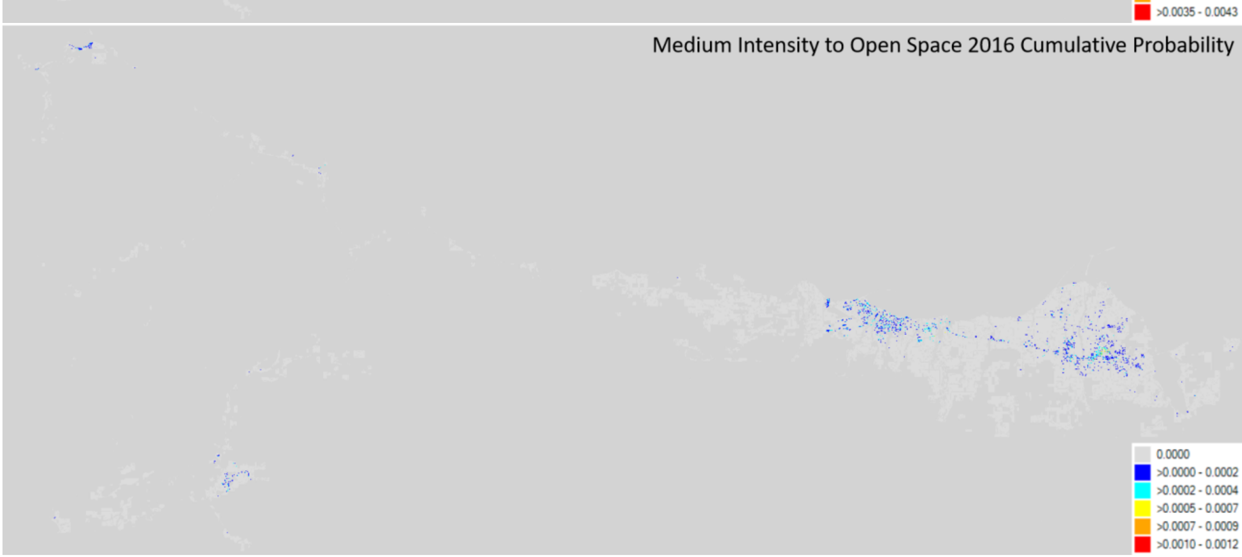

Forest to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0008
>0.0008 - 0.0016
>0.0017 - 0.0025
>0.0025 - 0.0033
>0.0034 - 0.0042

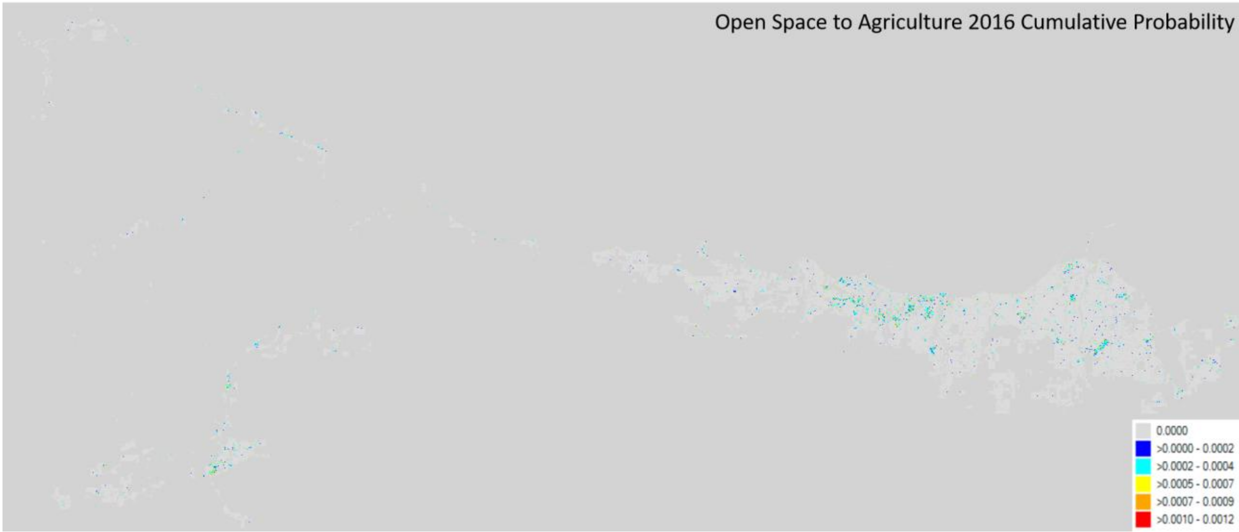

High Intensity to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0002
>0.0002 - 0.0004
>0.0003 - 0.0005
>0.0005 - 0.0007
>0.0006 - 0.0008

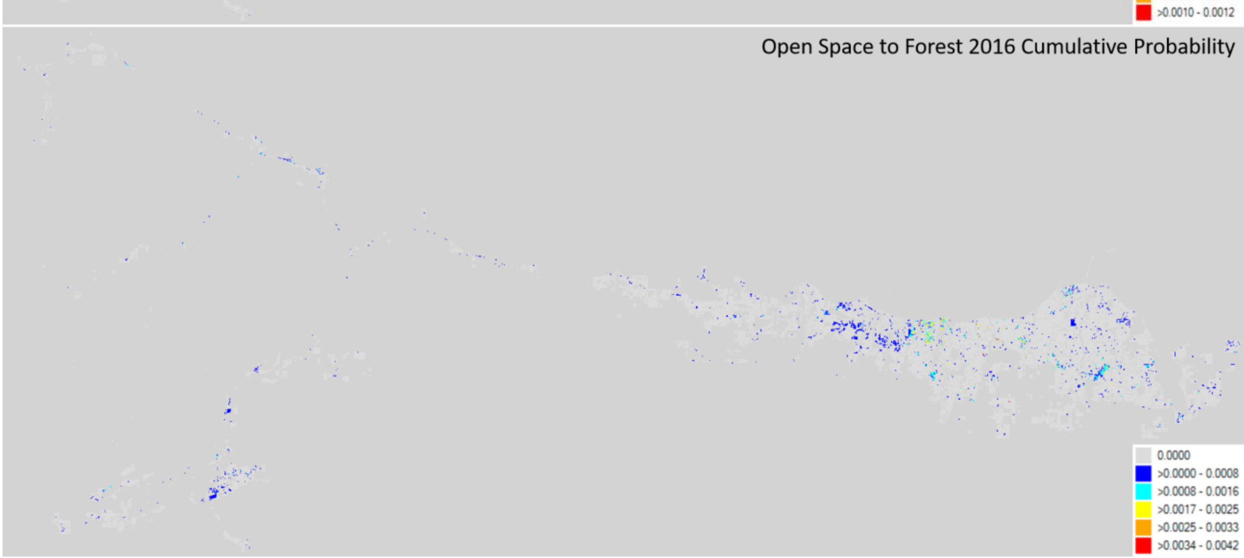

Low Intensity to Forest 2016 Cumulative Probability
0.0000
>0.0000 - 0.0004
>0.0004 - 0.0008
>0.0008 - 0.0012
>0.0012 - 0.0016
>0.0017 - 0.0021

Low Intensity to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0005
>0.0005 - 0.0010
>0.0010 - 0.0015
>0.0014 - 0.0019
>0.0019 - 0.0024

Low Intensity to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0014
>0.0014 - 0.0028
>0.0028 - 0.0042
>0.0042 - 0.0056
>0.0056 - 0.0070

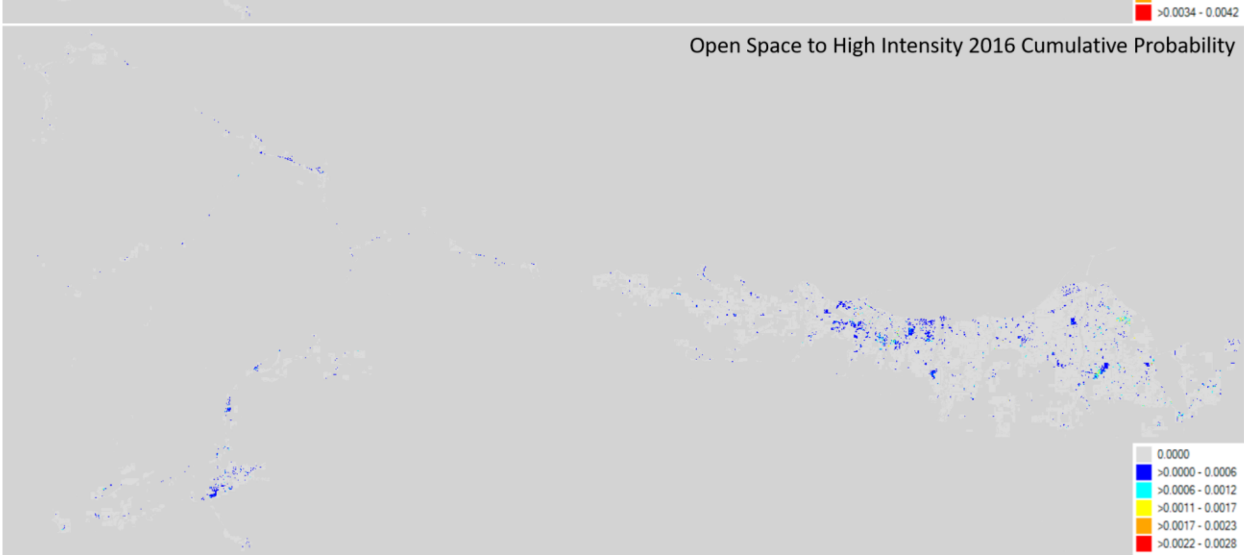

Low Intensity to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0003
>0.0003 - 0.0006
>0.0007 - 0.0010
>0.0010 - 0.0013
>0.0013 - 0.0017

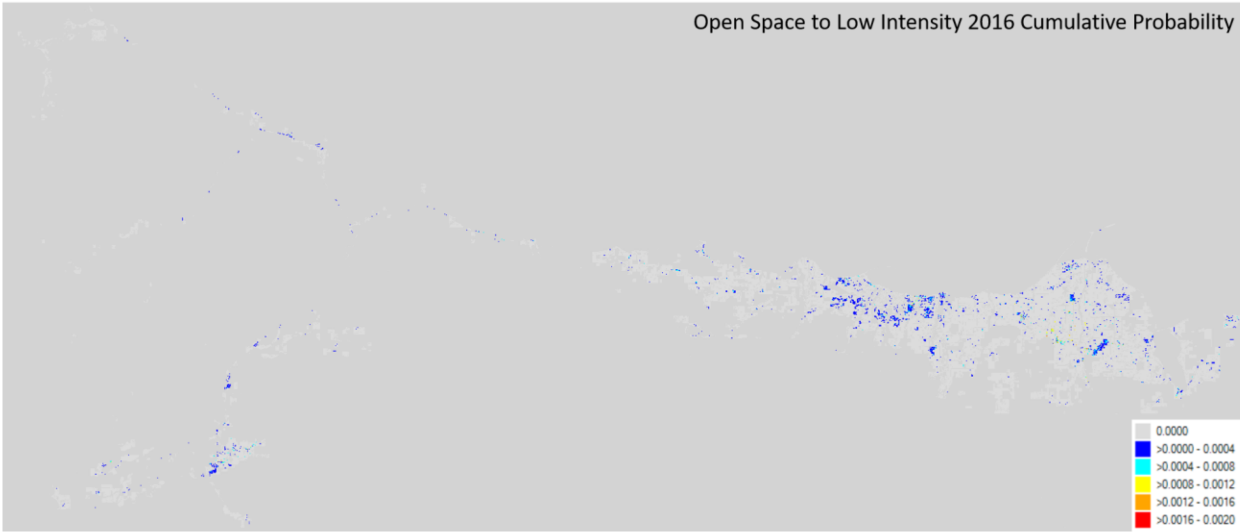

Medium Intensity to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0009
>0.0009 - 0.0018
>0.0017 - 0.0026
>0.0026 - 0.0035
>0.0035 - 0.0043

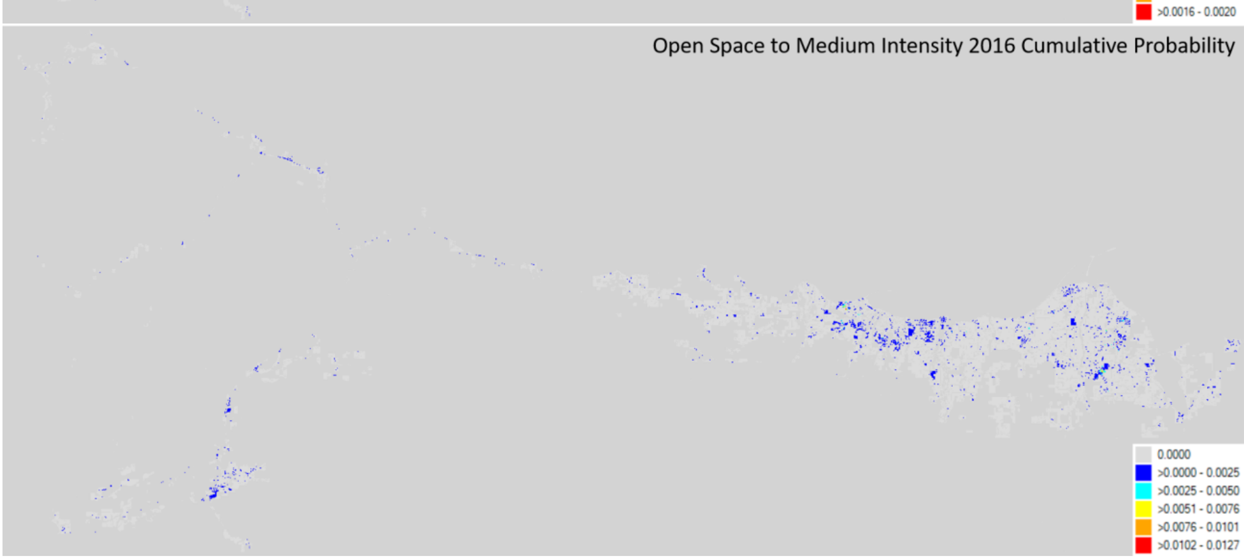

Medium Intensity to Open Space 2016 Cumulative Probability
0.0000
>0.0000 - 0.0002
>0.0002 - 0.0004
>0.0005 - 0.0007
>0.0007 - 0.0009
>0.0010 - 0.0012


Open Space to Agriculture 2016 Cumulative Probability
0.0000
>0.0000 - 0.0002
>0.0002 - 0.0004
>0.0005 - 0.0007
>0.0007 - 0.0009
>0.0010 - 0.0012


Open Space to Forest 2016 Cumulative Probability
0.0000
>0.0000 - 0.0008
>0.0008 - 0.0016
>0.0017 - 0.0025
>0.0025 - 0.0033
>0.0034 - 0.0042


Open Space to High Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0006
>0.0006 - 0.0012
>0.0011 - 0.0017
>0.0017 - 0.0023
>0.0022 - 0.0028


Open Space to Low Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0004
>0.0004 - 0.0008
>0.0008 - 0.0012
>0.0012 - 0.0016
>0.0016 - 0.0020


Open Space to Medium Intensity 2016 Cumulative Probability
0.0000
>0.0000 - 0.0025
>0.0025 - 0.0050
>0.0051 - 0.0076
>0.0076 - 0.0101
>0.0102 - 0.0127

Appendix 4: 2001-2019 LULC UGA analysis illustrating the percentage of each transition that occurs within a UGA boundary in each of the four pilot counties – Pierce, Snohomish, King and Clallam.

Class_name	County	Inside UGA km2	Total km2	Pct. Inside UGA	Transition Pct Inside UGA
Agriculture (No Transition)	Pierce	14.53	138.54	10.49%	
Agriculture->Developed High Intensity	Pierce	3.80	3.95		96.24%
Agriculture->Developed Low Intensity	Pierce	1.74	3.04		57.07%
Agriculture->Developed Medium Intensity	Pierce	3.28	3.78		86.83%
Agriculture->Developed Open Space	Pierce	1.56	3.17		49.32%
Agriculture->Forest	Pierce	0.23	5.14		4.52%
Developed High Intensity (No Transition)	Pierce	52.90	55.20	95.84%	
Developed High Intensity->Developed Medium Intensity	Pierce	0.20	0.21		98.27%
Developed High Intensity->Forest	Pierce	0.00	0.00		100.00%
Developed Low Intensity (No Transition)	Pierce	124.68	210.48	59.23%	
Developed Low Intensity->Agriculture	Pierce	0.08	0.29		27.63%
Developed Low Intensity->Developed High Intensity	Pierce	2.63	2.80		93.85%
Developed Low Intensity->Developed Medium Intensity	Pierce	5.09	5.84		87.13%
Developed Low Intensity->Developed Open Space	Pierce	0.40	0.75		54.15%
Developed Low Intensity->Forest	Pierce	0.17	0.56		29.79%
Developed Medium Intensity (No Transition)	Pierce	100.71	115.01	87.57%	
Developed Medium Intensity->Developed High Intensity	Pierce	1.40	1.44		97.03%
Developed Medium Intensity->Developed Low Intensity	Pierce	0.18	0.23		80.34%
Developed Medium Intensity->Developed Open Space	Pierce	0.01	0.01		100.00%
Developed Medium Intensity->Forest	Pierce	0.04	0.06		67.43%
Developed Open Space (No Transition)	Pierce	50.04	116.57	42.93%	
Developed Open Space->Agriculture	Pierce	0.01	0.17		5.49%
Developed Open Space->Developed High Intensity	Pierce	2.59	2.64		97.90%
Developed Open Space->Developed Low Intensity	Pierce	0.98	1.82		53.86%
Developed Open Space->Developed Medium Intensity	Pierce	5.93	6.86		86.41%
Developed Open Space->Forest	Pierce	0.15	0.83		18.53%
Forest (No Transition)	Pierce	104.30	1963.88	5.31%	
Forest->Agriculture	Pierce	0.04	0.76		5.41%
Forest->Developed High Intensity	Pierce	5.50	5.66		97.18%
Forest->Developed Low Intensity	Pierce	6.75	9.19		73.45%
Forest->Developed Medium Intensity	Pierce	12.91	14.56		88.69%
Forest->Developed Open Space	Pierce	5.27	7.80		67.51%

Class_name	County	Inside UGA km2	Total km2	Pct. Inside UGA	Transition Pct Inside UGA
Agriculture (No Transition)	Snohomish	18.25	244.17	7.47%	
Agriculture->Developed High Intensity	Snohomish	1.01	1.01		99.80%
Agriculture->Developed Low Intensity	Snohomish	1.02	1.87		54.77%
Agriculture->Developed Medium Intensity	Snohomish	2.70	2.87		94.04%
Agriculture->Developed Open Space	Snohomish	0.50	1.93		25.76%
Agriculture->Forest	Snohomish	0.27	5.42		4.95%
Developed High Intensity (No Transition)	Snohomish	41.50	42.21	98.32%	
Developed High Intensity->Developed Low Intensity	Snohomish	0.33	0.33		99.55%
Developed High Intensity->Developed Medium Intensity	Snohomish	0.75	0.75		100.00%
Developed High Intensity->Forest	Snohomish	0.00	0.00		61.54%
Developed Low Intensity (No Transition)	Snohomish	95.06	145.76	65.22%	
Developed Low Intensity->Agriculture	Snohomish	0.01	0.07		10.89%
Developed Low Intensity->Developed High Intensity	Snohomish	2.18	2.25		96.84%
Developed Low Intensity->Developed Medium Intensity	Snohomish	4.95	5.63		87.88%
Developed Low Intensity->Developed Open Space	Snohomish	0.35	0.67		51.44%
Developed Low Intensity->Forest	Snohomish	0.18	0.40		45.54%
Developed Medium Intensity (No Transition)	Snohomish	79.39	83.01	95.64%	
Developed Medium Intensity->Developed High Intensity	Snohomish	1.49	1.50		99.79%
Developed Medium Intensity->Developed Low Intensity	Snohomish	0.19	0.19		97.82%
Developed Medium Intensity->Developed Open Space	Snohomish	0.02	0.02		100.00%
Developed Open Space (No Transition)	Snohomish	39.20	114.23	34.31%	
Developed Open Space->Agriculture	Snohomish	0.08	0.33		23.88%
Developed Open Space->Developed High Intensity	Snohomish	1.39	1.40		99.16%
Developed Open Space->Developed Low Intensity	Snohomish	1.16	1.88		61.33%
Developed Open Space->Developed Medium Intensity	Snohomish	7.51	8.14		92.22%
Developed Open Space->Forest	Snohomish	0.36	0.82		43.42%
Forest (No Transition)	Snohomish	99.68	3987.17	2.50%	
Forest->Agriculture	Snohomish	0.49	3.30		14.72%
Forest->Developed High Intensity	Snohomish	2.10	2.17		96.80%
Forest->Developed Low Intensity	Snohomish	5.08	7.63		66.64%
Forest->Developed Medium Intensity	Snohomish	8.72	9.67		90.23%
Forest->Developed Open Space	Snohomish	5.19	9.54		54.39%

Class_name	County	Inside UGA km2	Total km2	Pct. Inside UGA	Transition Pct Inside UGA
Agriculture (No Transition)	King	17.25	158.97	10.85%	
Agriculture->Developed High Intensity	King	0.58	0.63		92.22%
Agriculture->Developed Low Intensity	King	1.55	1.85		83.66%
Agriculture->Developed Medium Intensity	King	1.91	2.17		87.98%
Agriculture->Developed Open Space	King	1.18	2.00		59.10%
Agriculture->Forest	King	0.26	2.20		11.92%
Developed High Intensity (No Transition)	King	136.91	138.00	99.21%	
Developed High Intensity->Developed Low Intensity	King	0.04	0.04		100.00%
Developed High Intensity->Developed Medium Intensity	King	0.20	0.20		100.00%
Developed High Intensity->Forest	King	0.00	0.00		100.00%
Developed Low Intensity (No Transition)	King	256.27	319.47	80.21%	
Developed Low Intensity->Agriculture	King	0.01	0.04		18.34%
Developed Low Intensity->Developed High Intensity	King	3.85	3.91		98.39%
Developed Low Intensity->Developed Medium Intensity	King	8.00	8.45		94.59%
Developed Low Intensity->Developed Open Space	King	0.47	0.72		64.79%
Developed Low Intensity->Forest	King	0.39	0.60		64.58%
Developed Medium Intensity (No Transition)	King	215.94	219.82	98.24%	
Developed Medium Intensity->Agriculture	King	0.00	0.00		100.00%
Developed Medium Intensity->Developed High Intensity	King	2.00	2.01		99.90%
Developed Medium Intensity->Developed Low Intensity	King	0.27	0.27		99.01%
Developed Medium Intensity->Developed Open Space	King	0.00	0.02		10.71%
Developed Medium Intensity->Forest	King	0.00	0.00		100.00%
Developed Open Space (No Transition)	King	90.31	174.72	51.69%	
Developed Open Space->Agriculture	King	0.09	0.16		55.15%
Developed Open Space->Developed High Intensity	King	1.73	1.80		96.05%
Developed Open Space->Developed Low Intensity	King	1.57	2.16		72.86%
Developed Open Space->Developed Medium Intensity	King	6.84	7.39		92.50%
Developed Open Space->Forest	King	0.55	1.24		44.06%
Forest (No Transition)	King	208.58	4157.41	5.02%	
Forest->Agriculture	King	0.08	0.75		10.49%
Forest->Developed High Intensity	King	3.29	3.41		96.59%
Forest->Developed Low Intensity	King	8.50	10.31		82.45%
Forest->Developed Medium Intensity	King	10.59	11.05		95.83%
Forest->Developed Open Space	King	7.69	10.47		73.46%

Class_name	County	Inside UGA km2	Total km2	Pct. Inside UGA	Transition Pct Inside UGA
Agriculture (No Transition)	Clallam	10.92	96.81	11.28%	
Agriculture->Developed High Intensity	Clallam	0.01	0.01		86.97%
Agriculture->Developed Low Intensity	Clallam	0.47	1.08		43.20%
Agriculture->Developed Medium Intensity	Clallam	0.60	0.71		84.13%
Agriculture->Developed Open Space	Clallam	0.17	0.32		52.41%
Agriculture->Forest	Clallam	0.01	1.32		0.48%
Developed High Intensity (No Transition)	Clallam	5.98	7.68	77.83%	
Developed High Intensity->Developed Medium Intensity	Clallam	0.01	0.01		100.00%
Developed Low Intensity (No Transition)	Clallam	14.35	45.40	31.61%	
Developed Low Intensity->Agriculture	Clallam	0.00	0.03		9.90%
Developed Low Intensity->Developed High Intensity	Clallam	0.30	0.51		59.10%
Developed Low Intensity->Developed Medium Intensity	Clallam	0.34	0.58		57.96%
Developed Low Intensity->Developed Open Space	Clallam	0.04	0.08		53.28%
Developed Low Intensity->Forest	Clallam	0.00	0.24		1.48%
Developed Medium Intensity (No Transition)	Clallam	18.34	28.61	64.12%	
Developed Medium Intensity->Developed High Intensity	Clallam	0.13	0.13		97.34%
Developed Medium Intensity->Developed Low Intensity	Clallam	0.02	0.04		49.54%
Developed Medium Intensity->Forest	Clallam	0.02	0.06		23.69%
Developed Open Space (No Transition)	Clallam	5.34	15.97	33.44%	
Developed Open Space->Agriculture	Clallam	0.04	0.08		50.27%
Developed Open Space->Developed High Intensity	Clallam	0.11	0.13		84.06%
Developed Open Space->Developed Low Intensity	Clallam	0.10	0.25		38.13%
Developed Open Space->Developed Medium Intensity	Clallam	0.42	0.54		76.67%
Developed Open Space->Forest	Clallam	0.01	0.11		13.12%
Forest (No Transition)	Clallam	27.88	4293.36	0.65%	
Forest->Agriculture	Clallam	0.38	0.56		67.91%
Forest->Developed High Intensity	Clallam	0.02	0.06		27.71%
Forest->Developed Low Intensity	Clallam	0.22	0.67		32.73%
Forest->Developed Medium Intensity	Clallam	0.40	0.51		77.87%
Forest->Developed Open Space	Clallam	0.20	0.31		66.34%