Simulating Alternations for Temporary Crops
GEOG 360-01-F23

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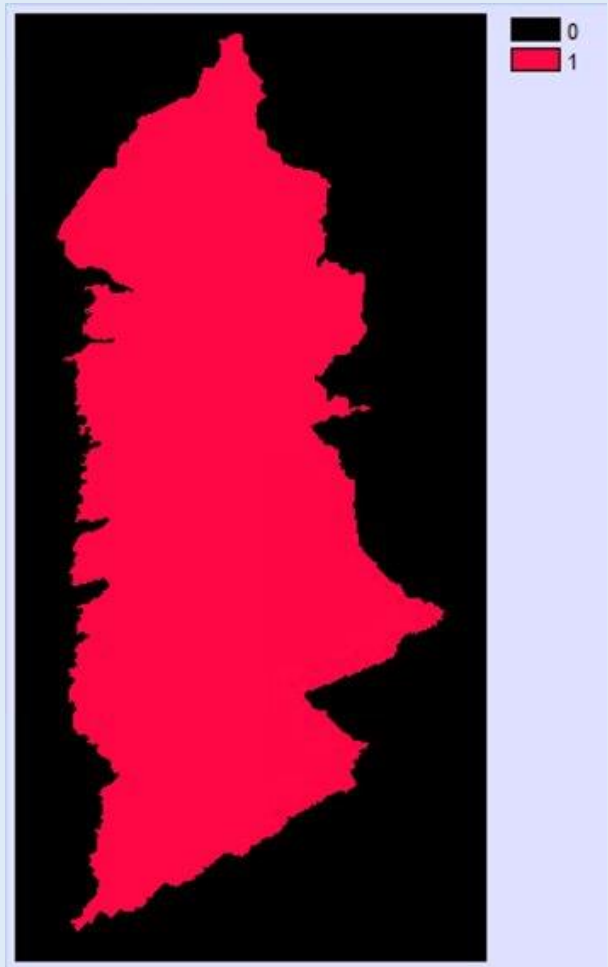
Objectives and Intended Product

Research Objective: Simulate gross gains and losses and attempt to simulate alternations for the time interval of 2000 to 2020 using temporary crop data from Bahia, Brazil using TerrSet's Land Change Modeler(LCM).

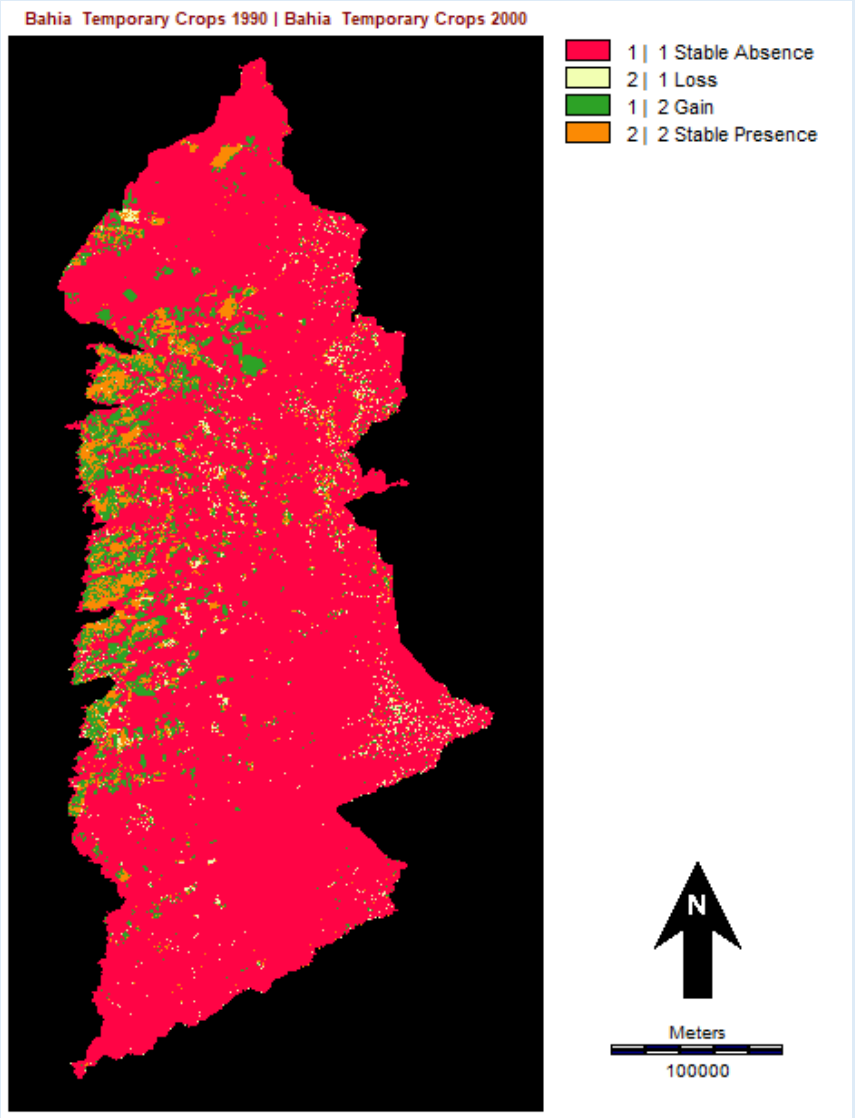
Our intended final product is a report on the software issues we encountered during our analysis which include striping and masking errors, to Tammy Woodard of Clark Labs.



Our study area: Bahia, Brazil

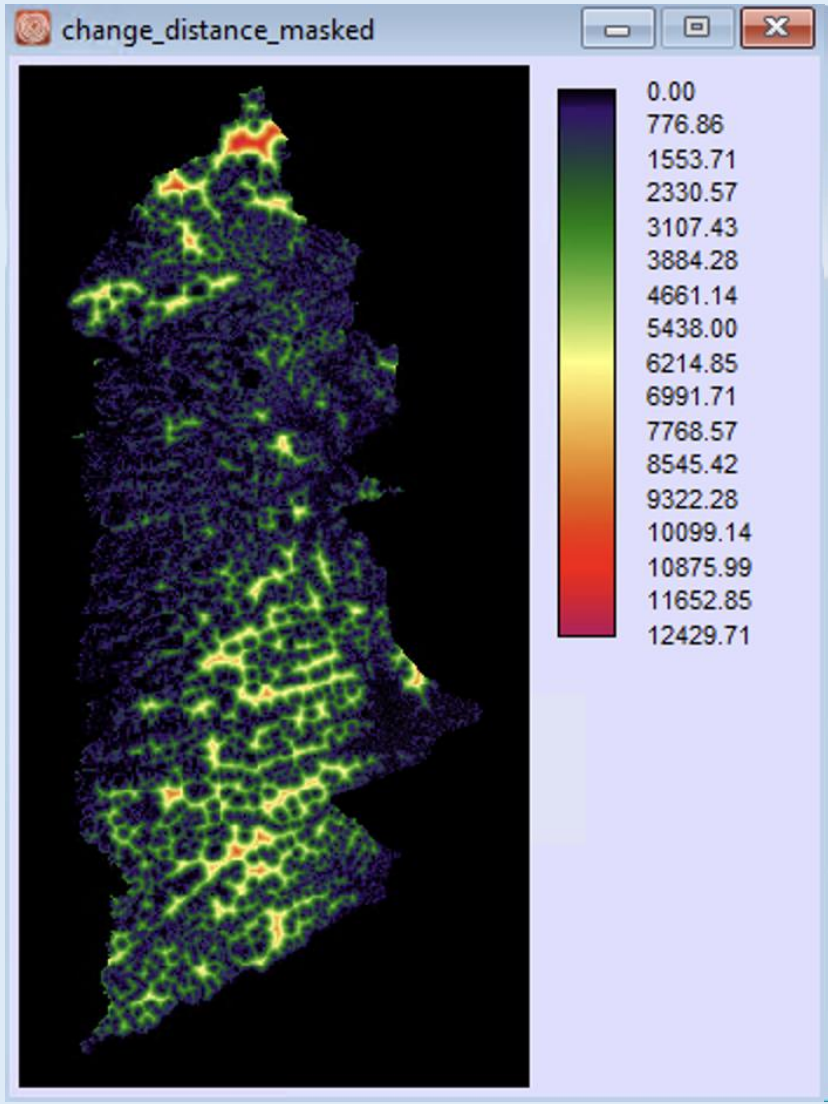
Data and Methodology

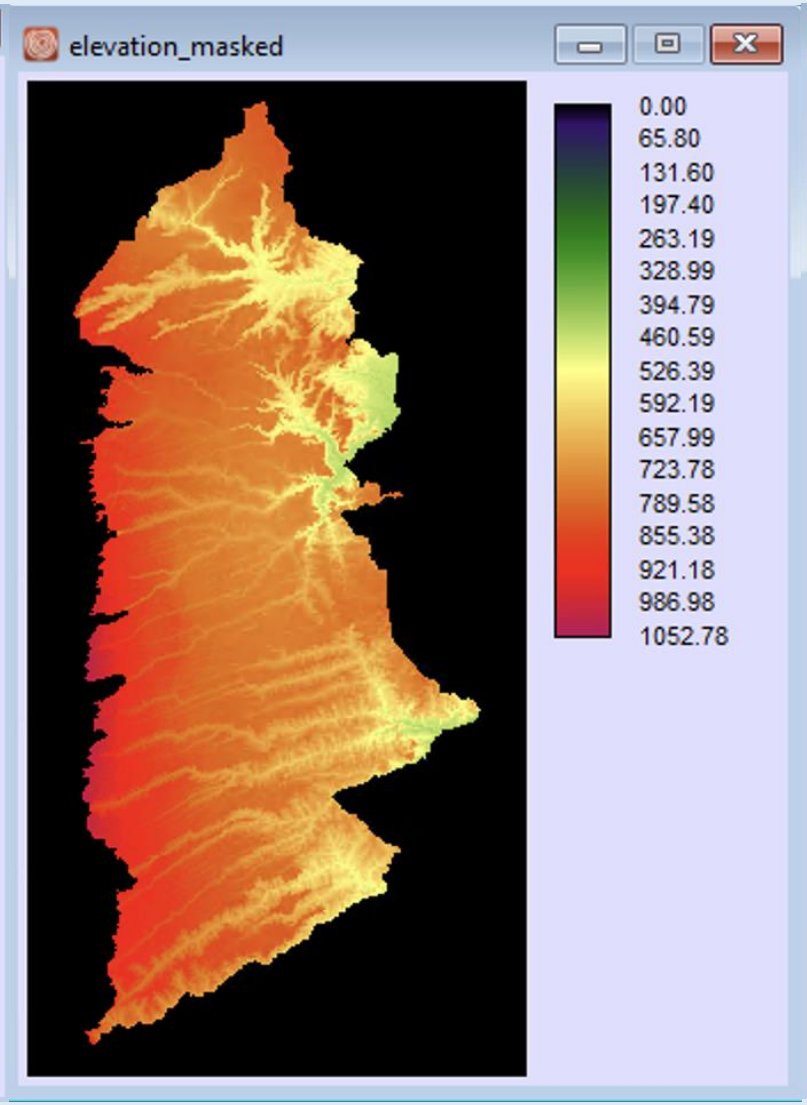
- All data is at a resolution of 120m.
- We used TerrSet's Land Change Modeler to run the analysis using the MLP algorithm, grouped all variables, and included two recalculation stages with soft prediction checked.
- We used a calibration interval of 10 years. 1990 and 2000 were used as inputs for the earlier and later land cover images respectively.
- The Bahia municipalities were masked to make sure all the simulated change occurs within Bahia.

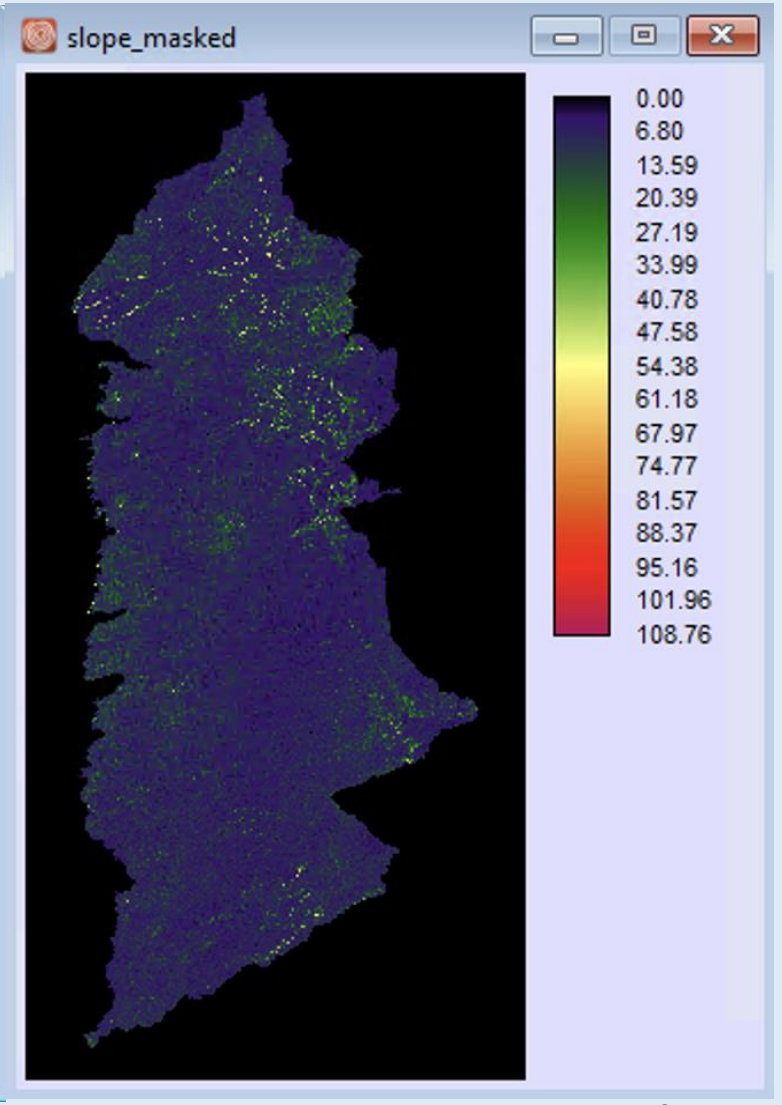


CrossTab: Temporary Crops 1990 and Temporary Crops 2000

Variables Used







Methodology

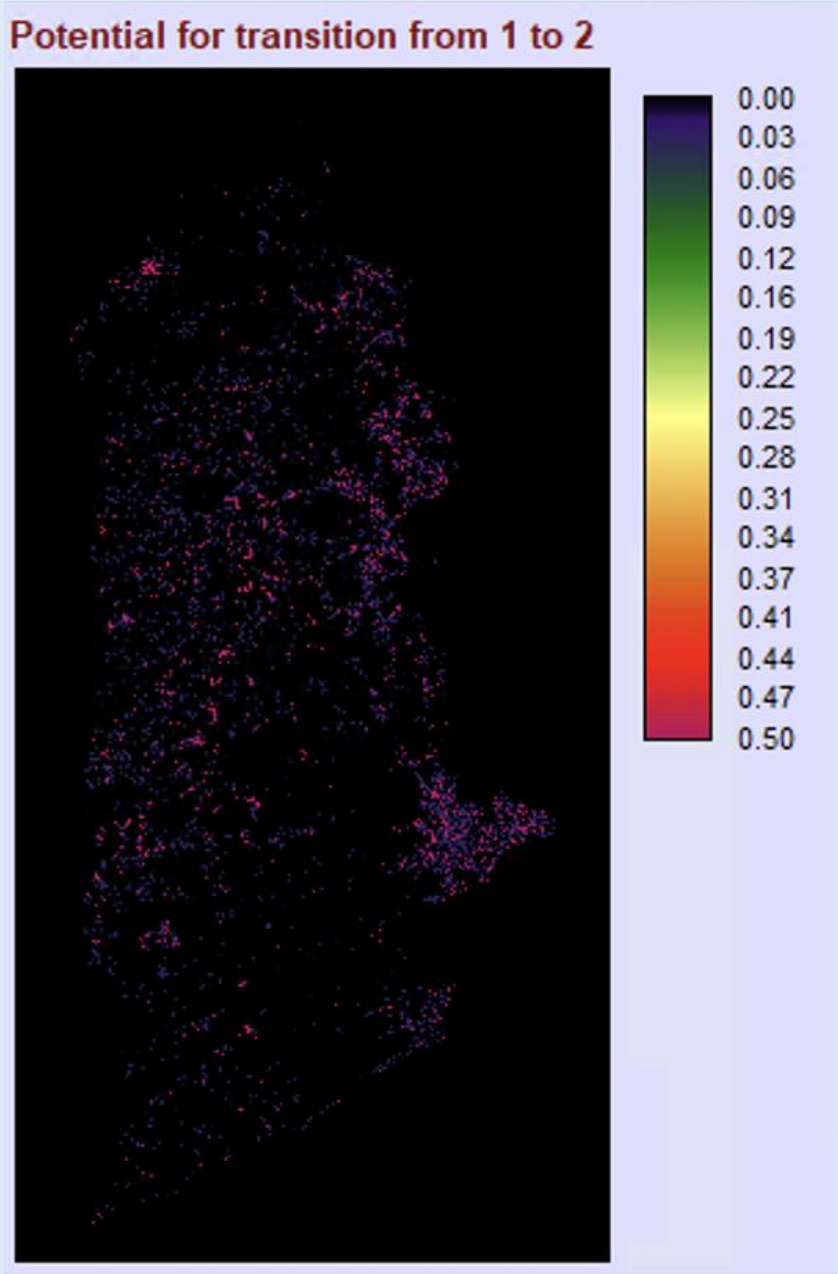
- The Multi-Layer-Perceptron sub-model in TerrSet was used to run the analysis to create model-simulated images in two stages where the Markov matrix was in the default setting.
- The Variables used are:
  - Distance to Change (DTC), 1990 – dynamic/static variables
  - Elevation – static variable
  - Slope – static variable
- We simulated five runs using different combinations of the variables:
  - **Run 1: one variable,** DTC (Static)
  - **Run 2: two variable,** DTC (Static) and Elevation
  - **Run 3: one variable,** DTC (Dynamic)
  - **Run 4: two variables,** DTC (Dynamic), and Elevation
  - **Run 5: three variables,** DTC (Dynamic), Elevation, and Slope

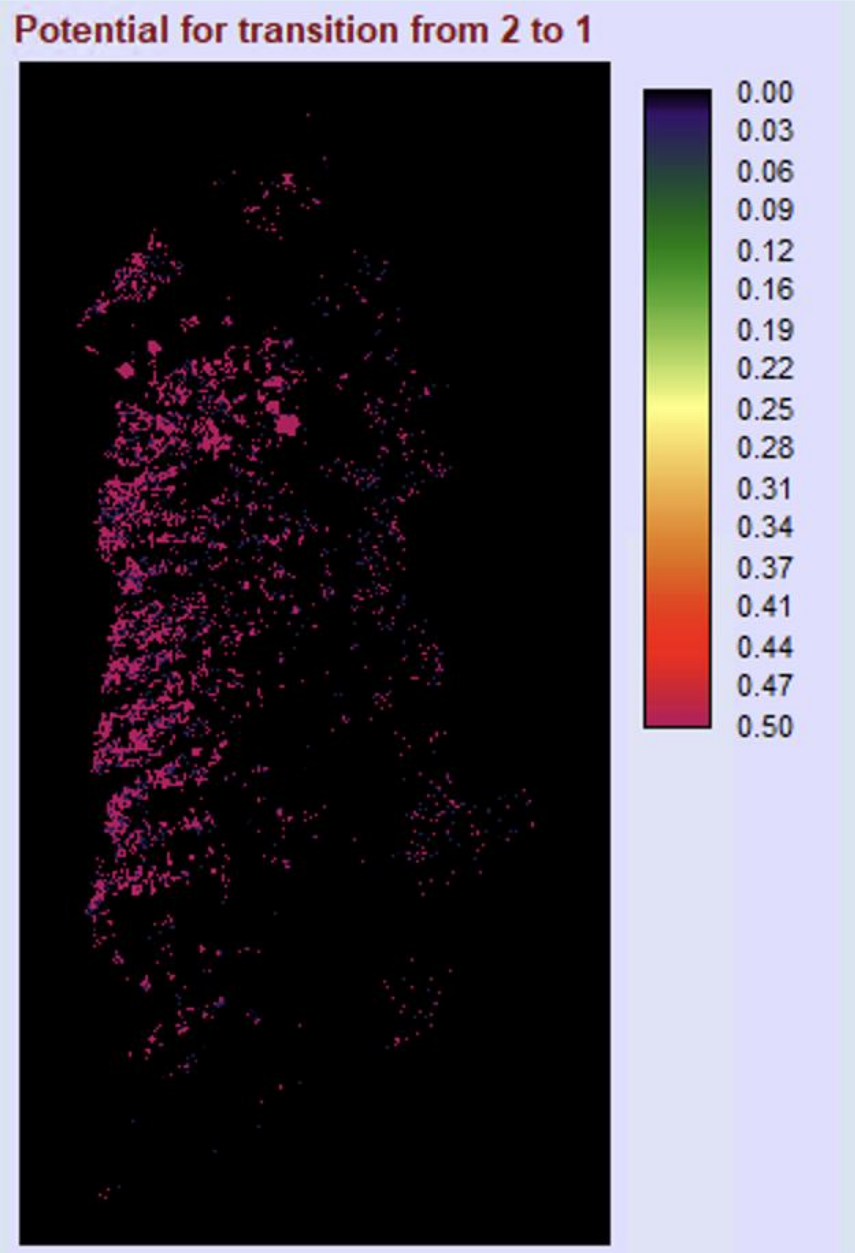
Markov Default	
0.87	0.13
0.48	0.52

Run1: DTC (static)

One variable

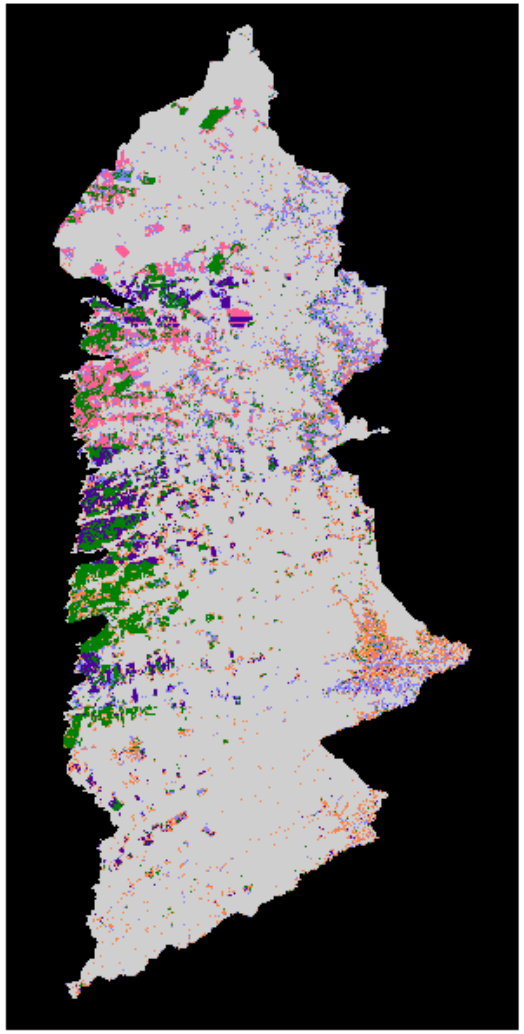
Transition Potential Maps for 2 Stages DTC (Static)





CROSSTAB- DTC (Static)

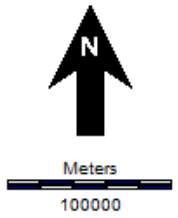
2000| 2010 Simulation | 2020 Simulation



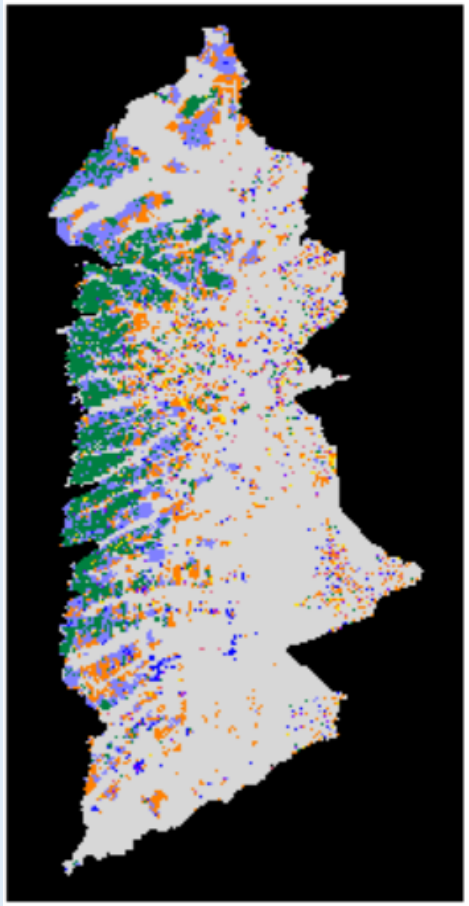
1 | 1 | 1 Stable Absence and the Stable Absence
2 | 1 | 1 Loss then Stable Absence
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence and then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Loss(2&3) : 351,912
Gain(4&5): 658,704

Category	Cells	Legend
0	7381141	
1	4339626	1|1|1 Stable Absence and then Stable Absence
2	175956	2|1|1 Loss then Stable Absence
3	0	1|2|1 Gain then Loss
4	175956	2|2|1 Stable Presence then Loss
5	329352	1|1|2 Stable Absence and then Gain
6	0	2|1|2 Loss then Gain
7	329352	1|2|2 Gain then Stable Presence
8	375817	2|2|2 Stable Presence then Stable Presence

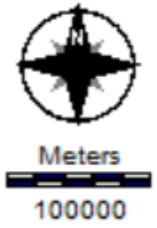


Reference Change 2000| 2010 | 2020



1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence and then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Category	Cells	Legend
0	7381141	
1	3815336	1 | 1 | 1 Stable Absence and then Stable Absence
2	45143	2 | 1 | 1 Loss then Stable Absence
3	73819	1 | 2 | 1 Gain then Loss
4	29500	2 | 2 | 1 Stable Presence then Loss
5	499966	1 | 1 | 2 Stable Absence and then Gain
6	46115	2 | 1 | 2 Loss then Gain
7	609209	1 | 2 | 2 Gain then Stable Presence
8	606971	2 | 2 | 2 Stable Presence and Stable Presence



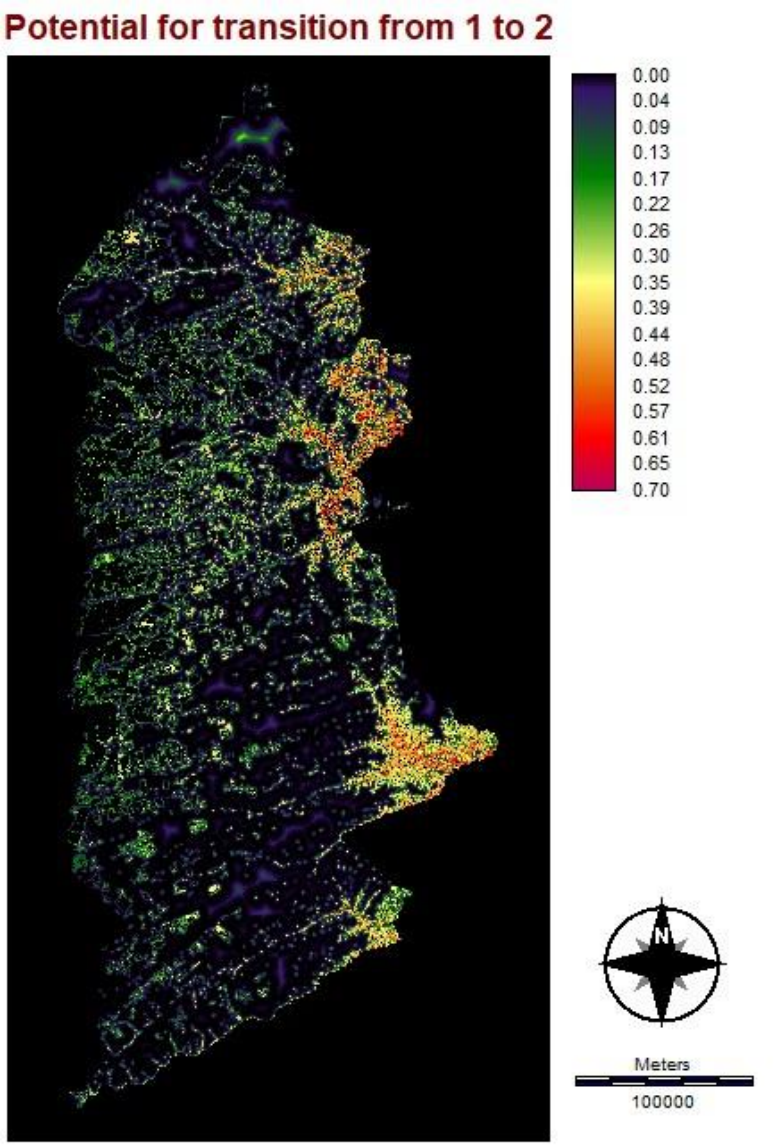
Loss(2,3,4) : 148,462
Gain (5,6,7): 1,155,290

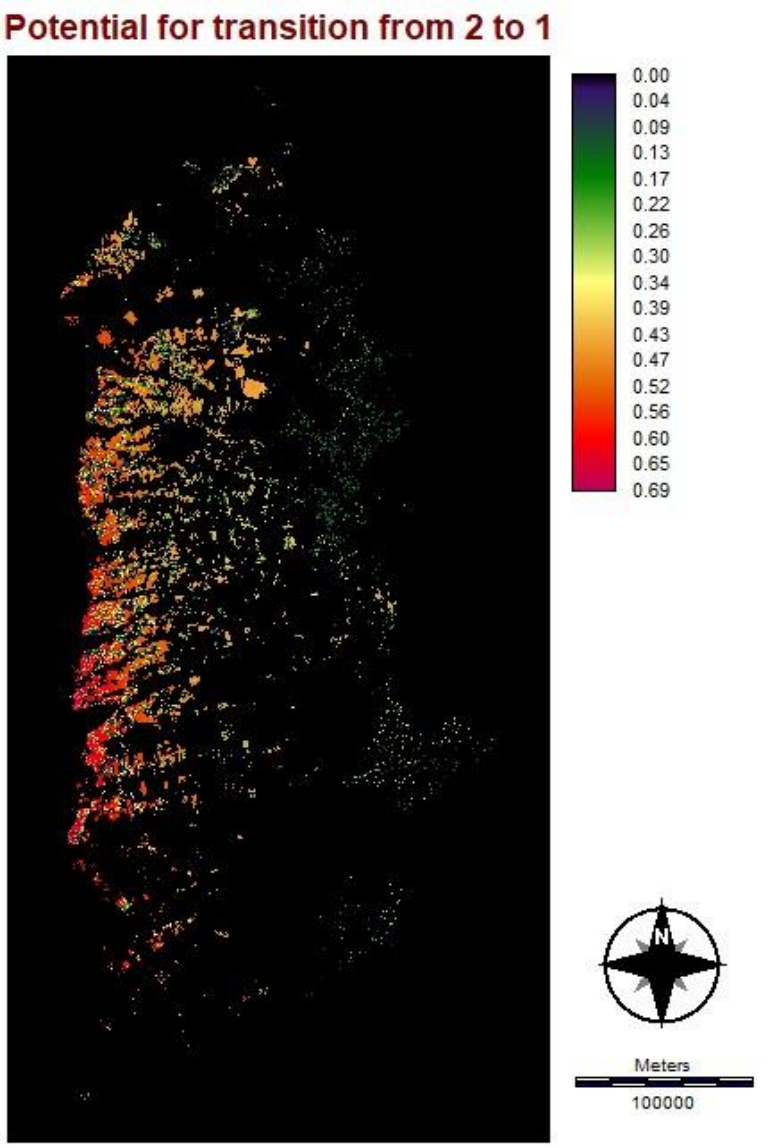
Absence of Alternation in Simulation:
1 | 2 | 1 Gain then Loss
2 | 1 | 2 Loss then Gain

Run2: DTC (static) and Elevation (static)

Two variables

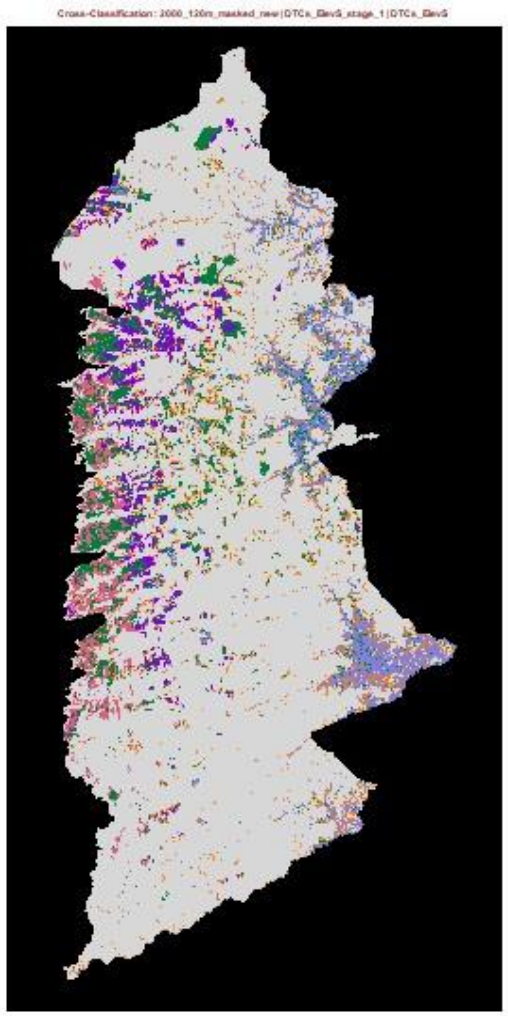
Transition Potential Maps for 2 stages for DTC (static) and elevation (static)





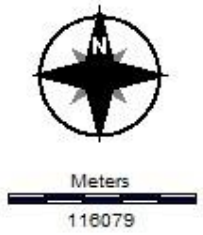
CROSSTAB – Two variables: DTC (static) & elevation

2000| 2010 Simulation | 2020 Simulation



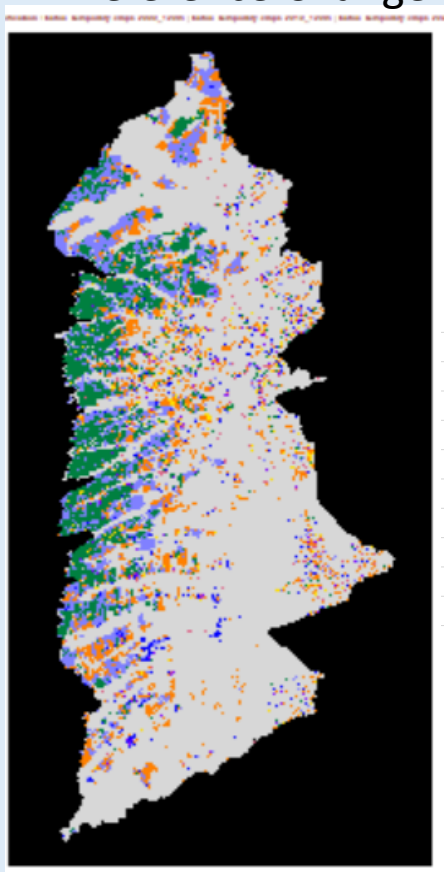
1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
2 | 2 | 1 Stable Presence then Gain
1 | 1 | 2 Stable Absence then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence then Stable Presence

Category	Cells	Legend
0	7381141	
1	4339550	1 | 1 | 1 Stable Absence and then Stable Absence
2	175965	2 | 1 | 1 Loss then Stable Absence
3	0	1 | 2 | 1 Gain then Loss
4	175965	2 | 2 | 1 Stable Presence then Gain
5	329390	1 | 1 | 2 Stable Absence then Gain
6	0	2 | 1 | 2 Loss then Gain
7	329390	1 | 2 | 2 Gain then Stable Presence
8	375799	2 | 2 | 2 Stable Presence then Stable Presence



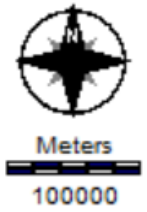
Loss (2,3,4): 351,930
Gain (5,6,7): 658,780

Reference Change 2000| 2010 | 2020



1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence and then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Category	Cells	Legend
0	7381141	
1	3815336	1 | 1 | 1 Stable Absence and then Stable Absence
2	45143	2 | 1 | 1 Loss then Stable Absence
3	73819	1 | 2 | 1 Gain then Loss
4	29500	2 | 2 | 1 Stable Presence then Loss
5	499966	1 | 1 | 2 Stable Absence and then Gain
6	46115	2 | 1 | 2 Loss then Gain
7	609209	1 | 2 | 2 Gain then Stable Presence
8	606971	2 | 2 | 2 Stable Presence and Stable Presence



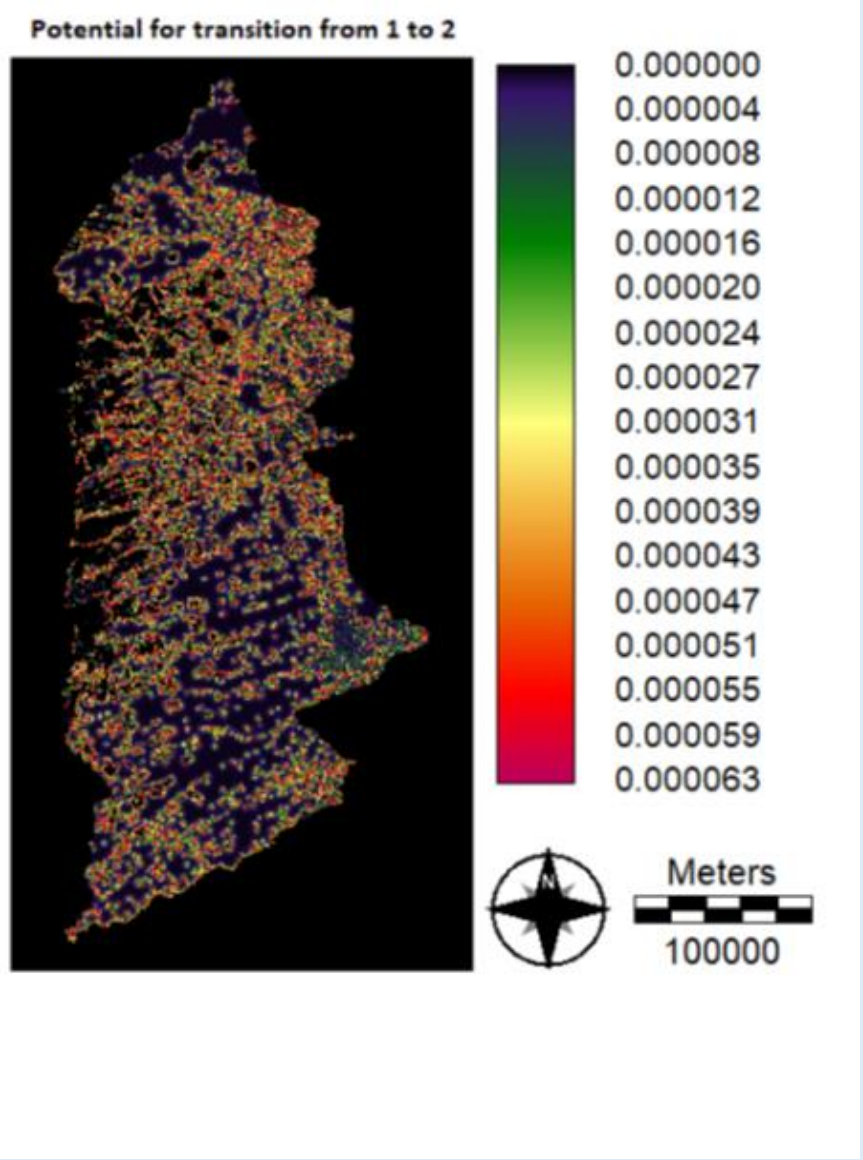
Loss (2,3,4) : 148,462
Gain (5,6,7): 1,155,290

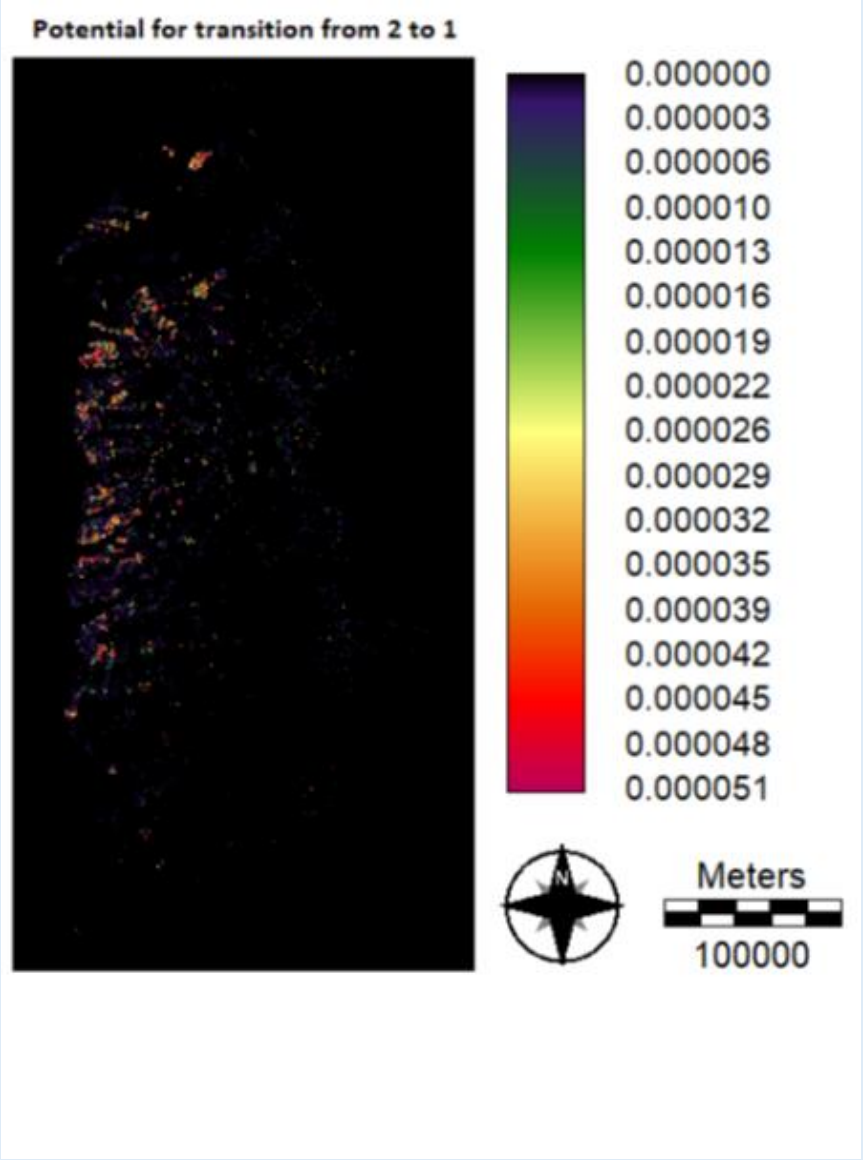
Absence of Alternation in Simulation:
1 | 2 | 1 Gain then Loss
2 | 1 | 2 Loss then Gain

Run3: DTC (dynamic)

One variable

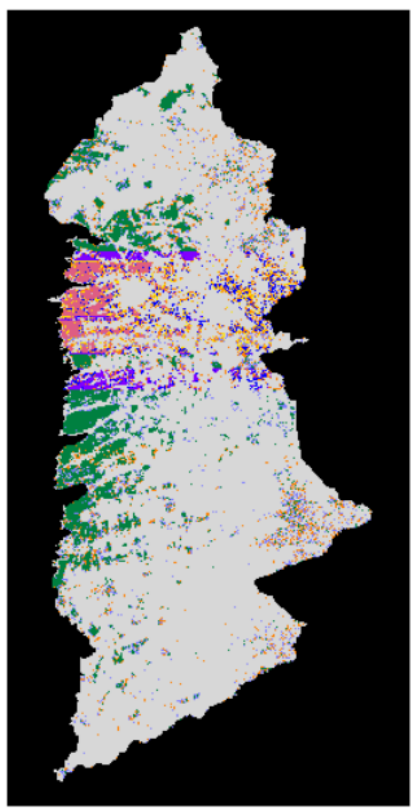
Transition Potential Maps for 2 stages for DTC as Dynamic Variable





CROSSTAB – DTC (dynamic)

2000 | 2010 Simulation | 2020 Simulation

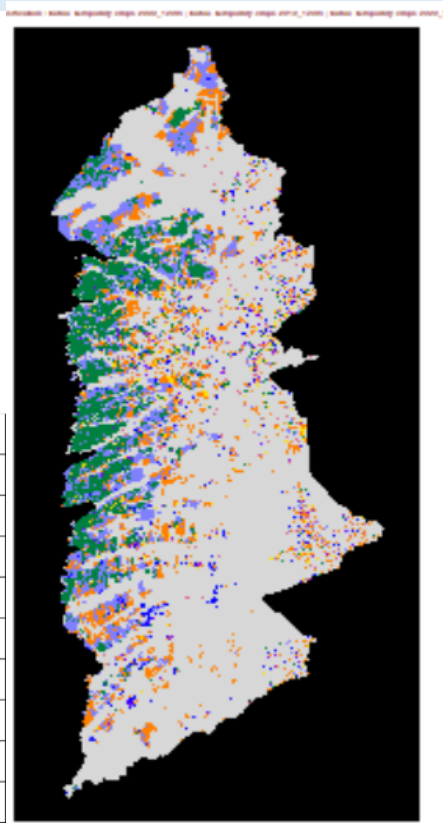


1 | 1 | 1 Stable Absence then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence then Stable Presence

Meters
100000

Category	Cells	Legend
0	7381141	
1	4401077	1 | 1 | 1 Stable Absence then Stable Absence
2	114438	2 | 1 | 1 Loss then Stable Absence
3	102614	1 | 2 | 1 Gain then Loss
4	73351	2 | 2 | 1 Stable Presence then Loss
5	267863	1 | 1 | 2 Stable Absence then Gain
6	61527	2 | 1 | 2 Loss then Gain
7	226776	1 | 2 | 2 Gain then Stable Presence
8	478413	2 | 2 | 2 Stable Presence then Stable Presence

Reference Change 2000 | 2010 | 2020



1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence and then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Meters
100000

Category	Cells	Legend
0	7381141	
1	3815336	1 | 1 | 1 Stable Absence and then Stable Absence
2	45143	2 | 1 | 1 Loss then Stable Absence
3	73819	1 | 2 | 1 Gain then Loss
4	29500	2 | 2 | 1 Stable Presence then Loss
5	499966	1 | 1 | 2 Stable Absence and then Gain
6	46115	2 | 1 | 2 Loss then Gain
7	609209	1 | 2 | 2 Gain then Stable Presence
8	606971	2 | 2 | 2 Stable Presence and Stable Presence

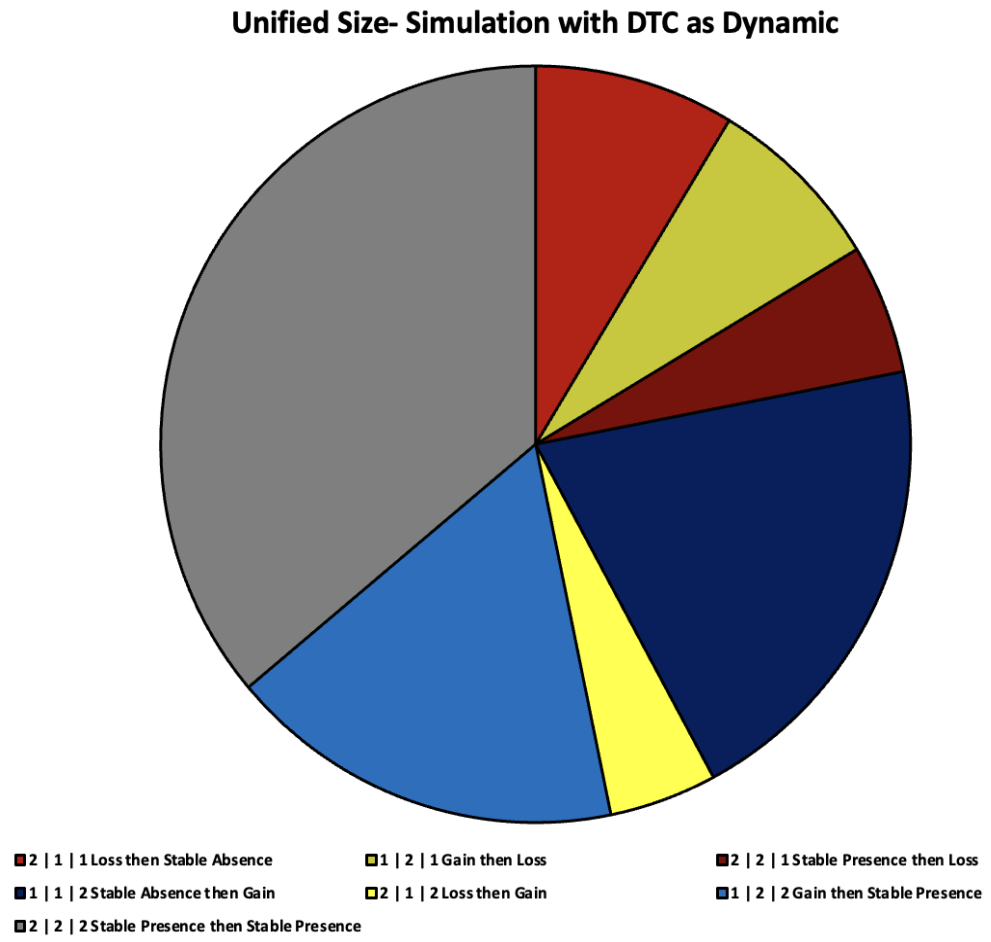
All 8 categories are present however, there is noticeable banding in the simulation image- specifically in Loss then Stable Absence(2|1|1) and Gain then Stable Presence (1|2|2)

Loss (3,4,5) : 290,403
Gain (6,7,8) : 556,166

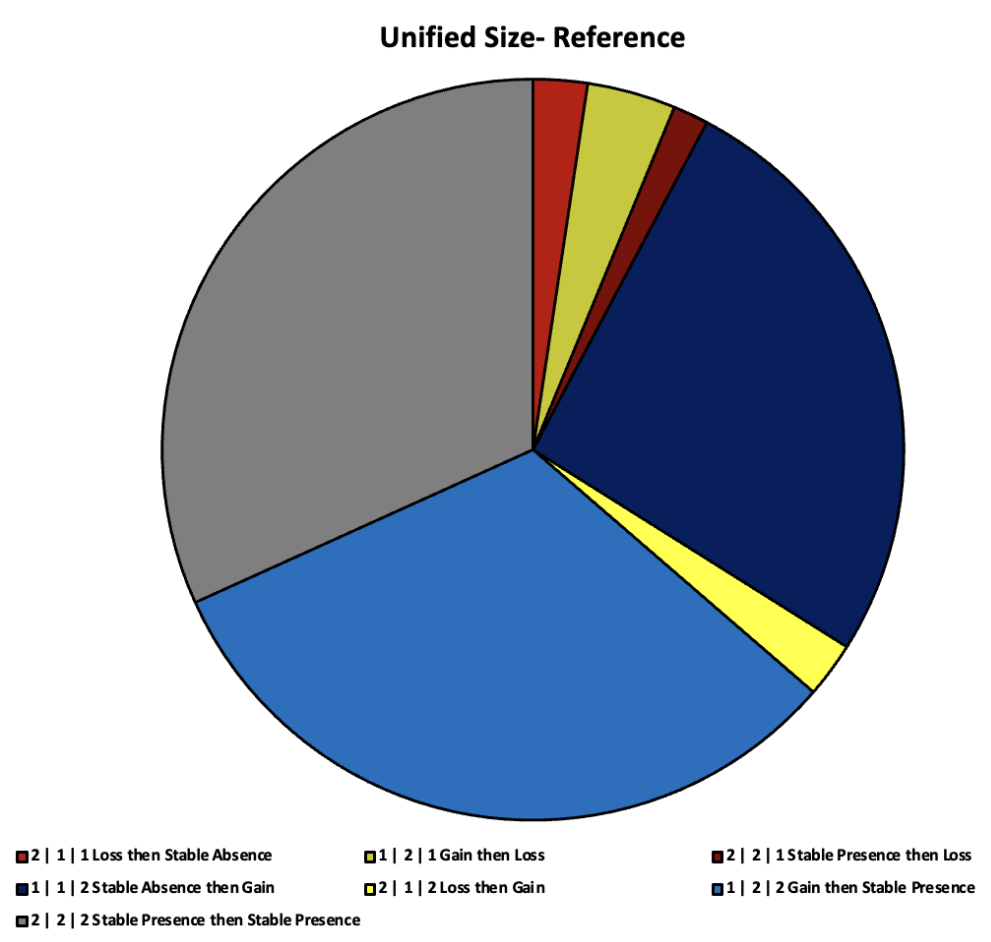
Loss (2,3,4) : 148,462
Gain (5,6,7): 1,155,290

Trajectory of change with DTC as Dynamic (2000-2010-2020)

Unified Size - Simulation

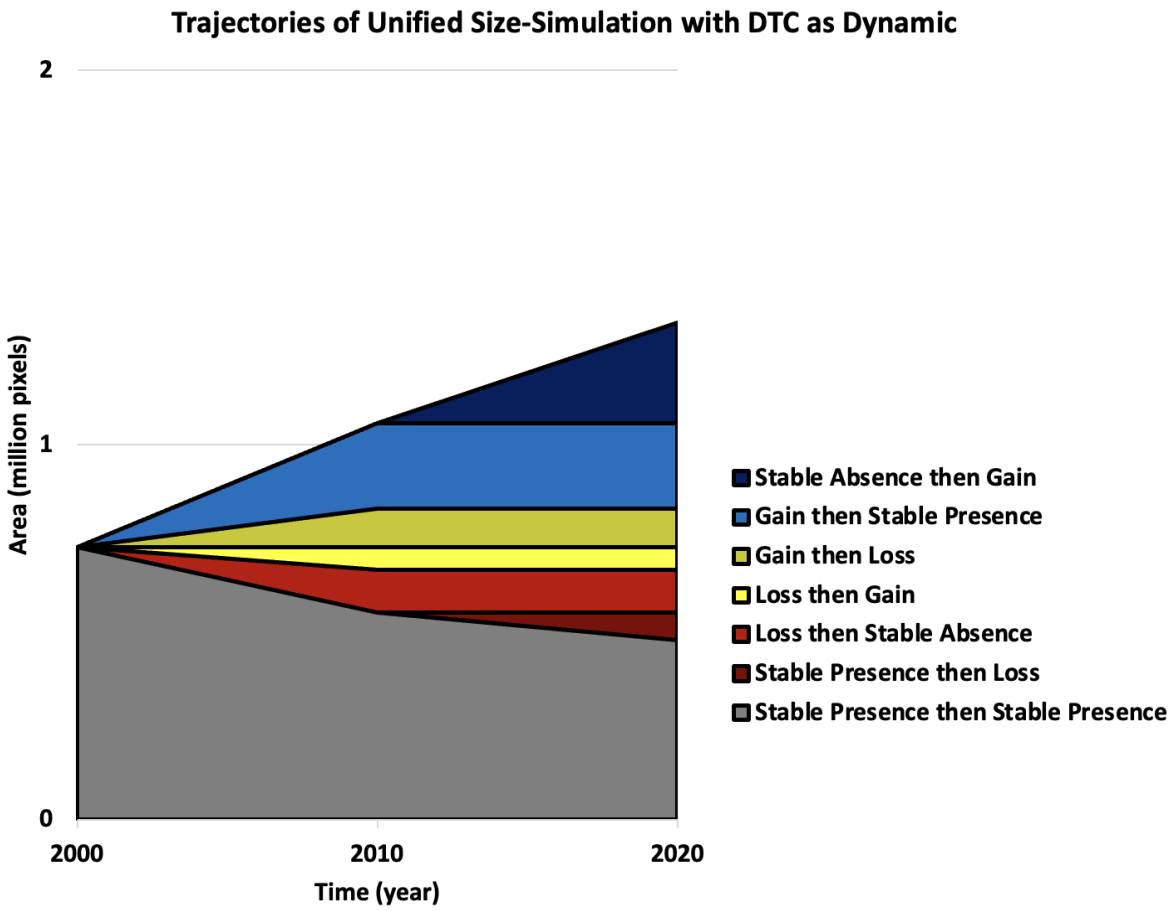


Unified Size - Reference

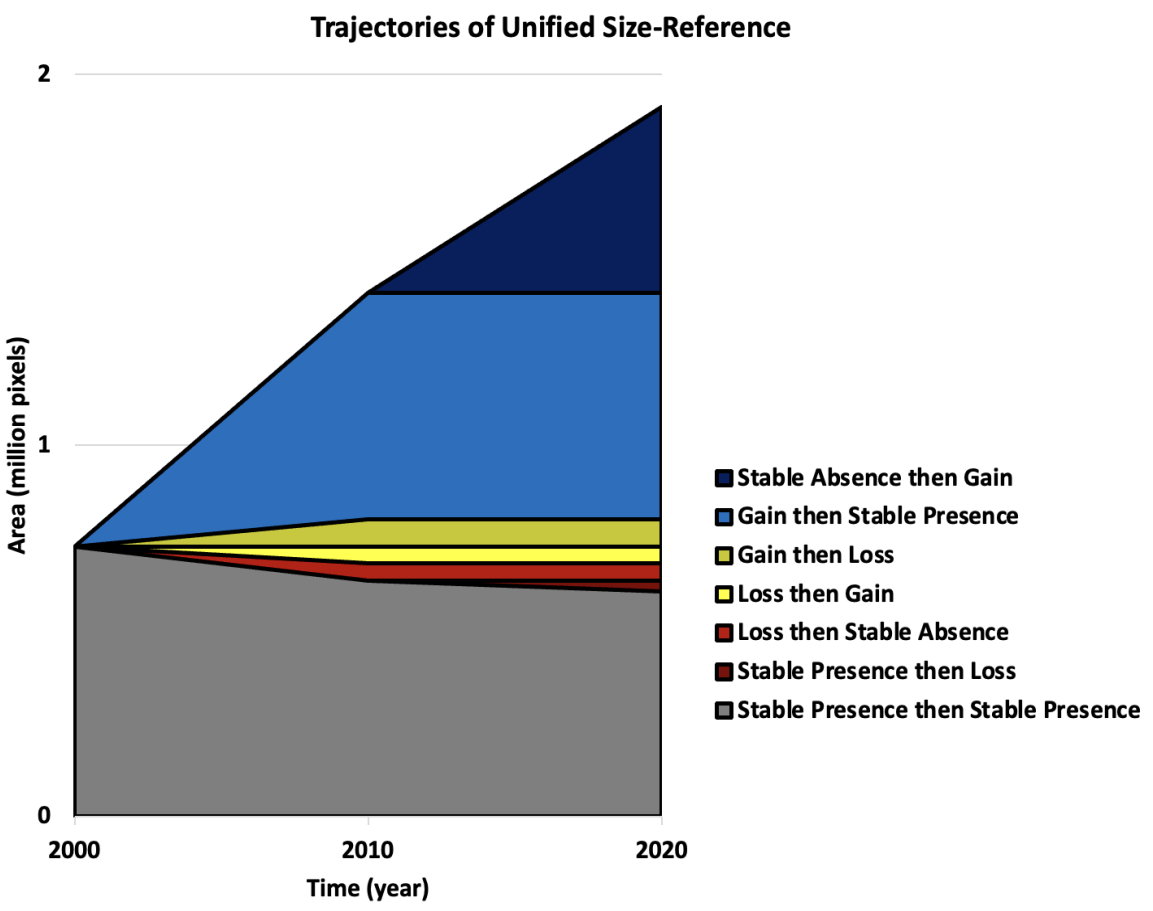


Trajectories of Unified Size (2000-2010-2020)

Simulation



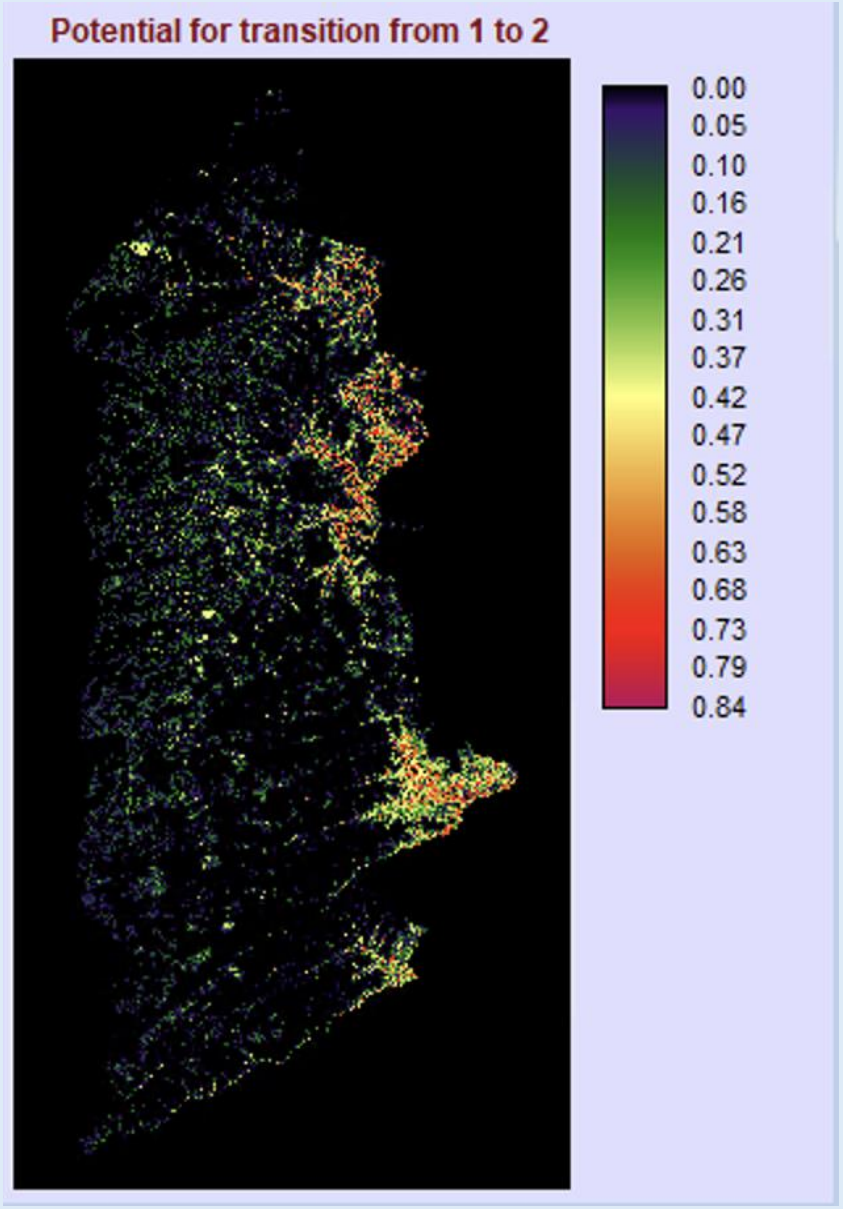
Reference

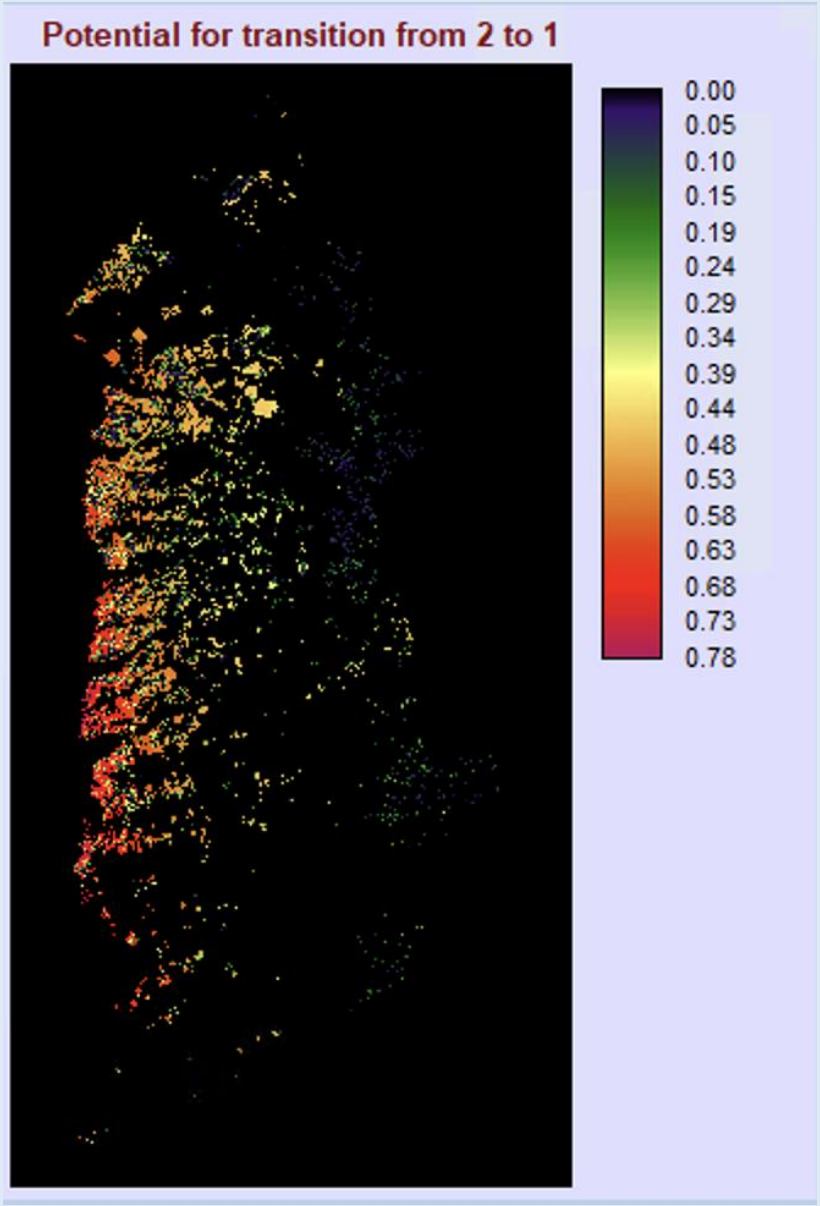


Run4: DTC (dynamic) and Elevation (static)

Two Variables

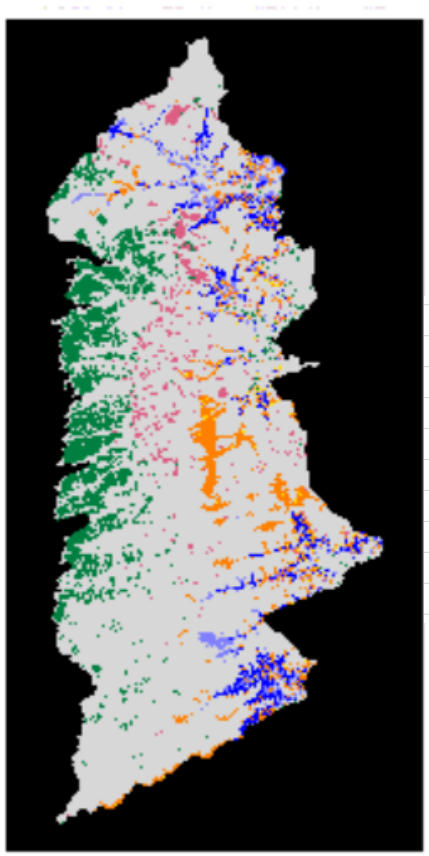
Transition Potential Maps for 2 stages for the 2 Variable run (DTC, elevation)





CROSSTAB – Two variables DTC (dynamic) & elevation

Simulate Change 2000 | 2010 | 2020



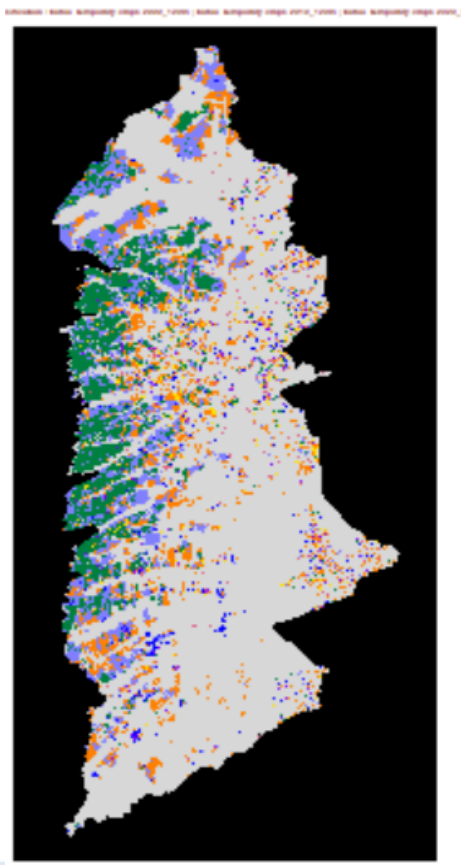
1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
1 | 1 | 2 Stable Absence and then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Category	Cells	Legend
0	7381141	
1	4365606	1 | 1 | 1 Stable Absence and then Stable Absence
2	149909	2 | 1 | 1 Loss then Stable Absence
3	175965	1 | 2 | 1 Gain then Loss
4	0	2 | 2 | 1 Stable Presence then Loss
5	303334	1 | 1 | 2 Stable Absence and then Gain
6	26056	2 | 1 | 2 Loss then Gain
7	153425	1 | 2 | 2 Gain then Stable Presence
8	551764	2 | 2 | 2 Stable Presence and Stable Presence

Meters
100000

Loss (2,3,4) : 325,874
Gain (5,6,7): 482,815

Reference Change 2000 | 2010 | 2020



1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence and then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Category	Cells	Legend
0	7381141	
1	3815336	1 | 1 | 1 Stable Absence and then Stable Absence
2	45143	2 | 1 | 1 Loss then Stable Absence
3	73819	1 | 2 | 1 Gain then Loss
4	29500	2 | 2 | 1 Stable Presence then Loss
5	499966	1 | 1 | 2 Stable Absence and then Gain
6	46115	2 | 1 | 2 Loss then Gain
7	609209	1 | 2 | 2 Gain then Stable Presence
8	606971	2 | 2 | 2 Stable Presence and Stable Presence

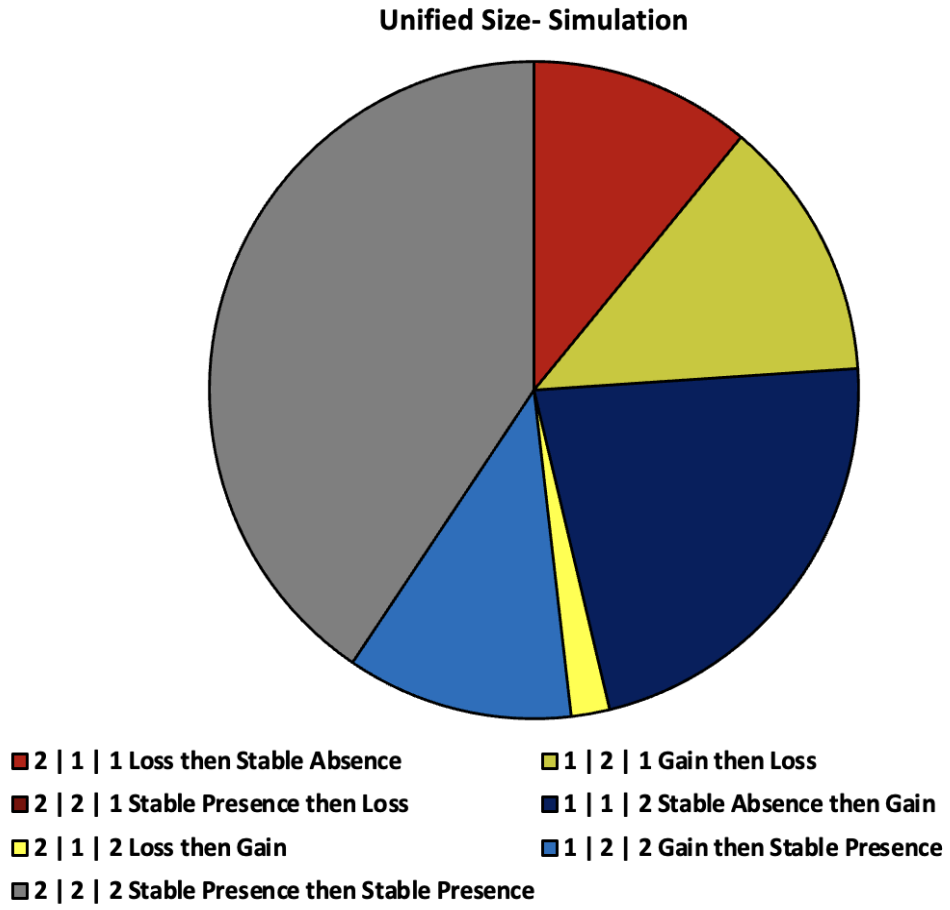
Meters
100000

Loss (2,3,4) : 148,462
Gain (5,6,7): 1,155,290

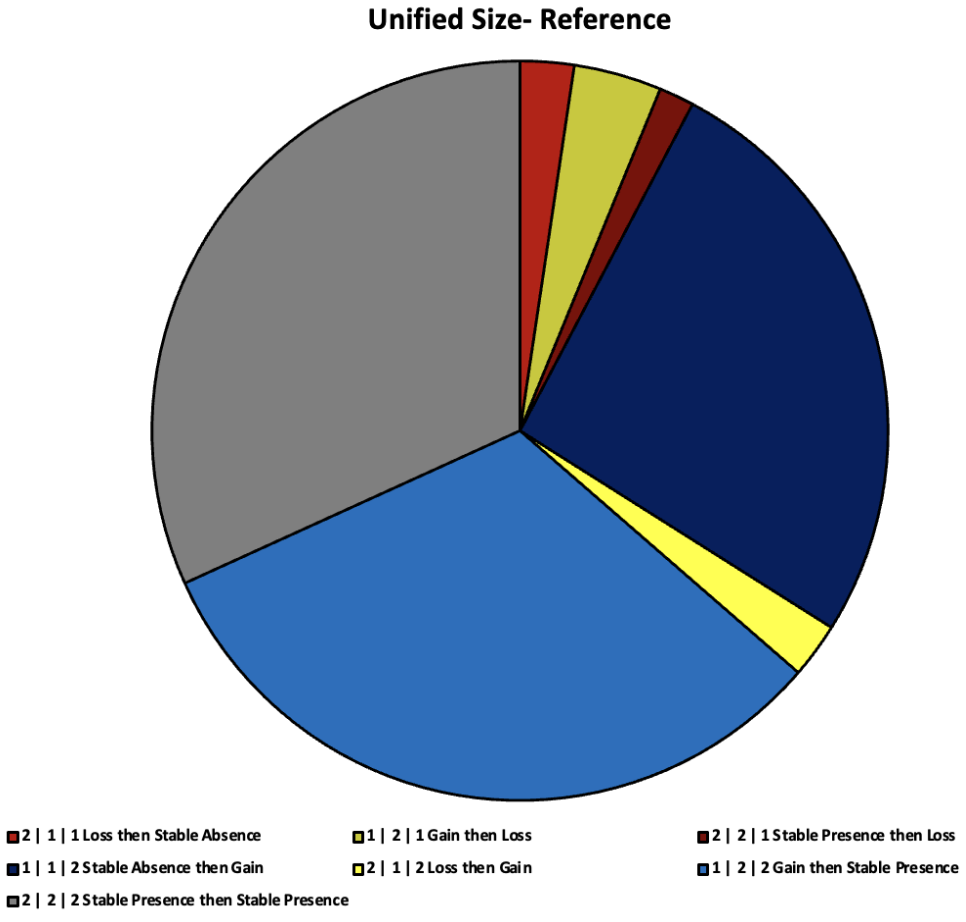
Absence of Alternation in Simulation:
2 | 2 | 1 Stable Presence then Loss

Trajectory of simulated change with 2 variables (2000-2010-2020)

Unified Size - Simulation

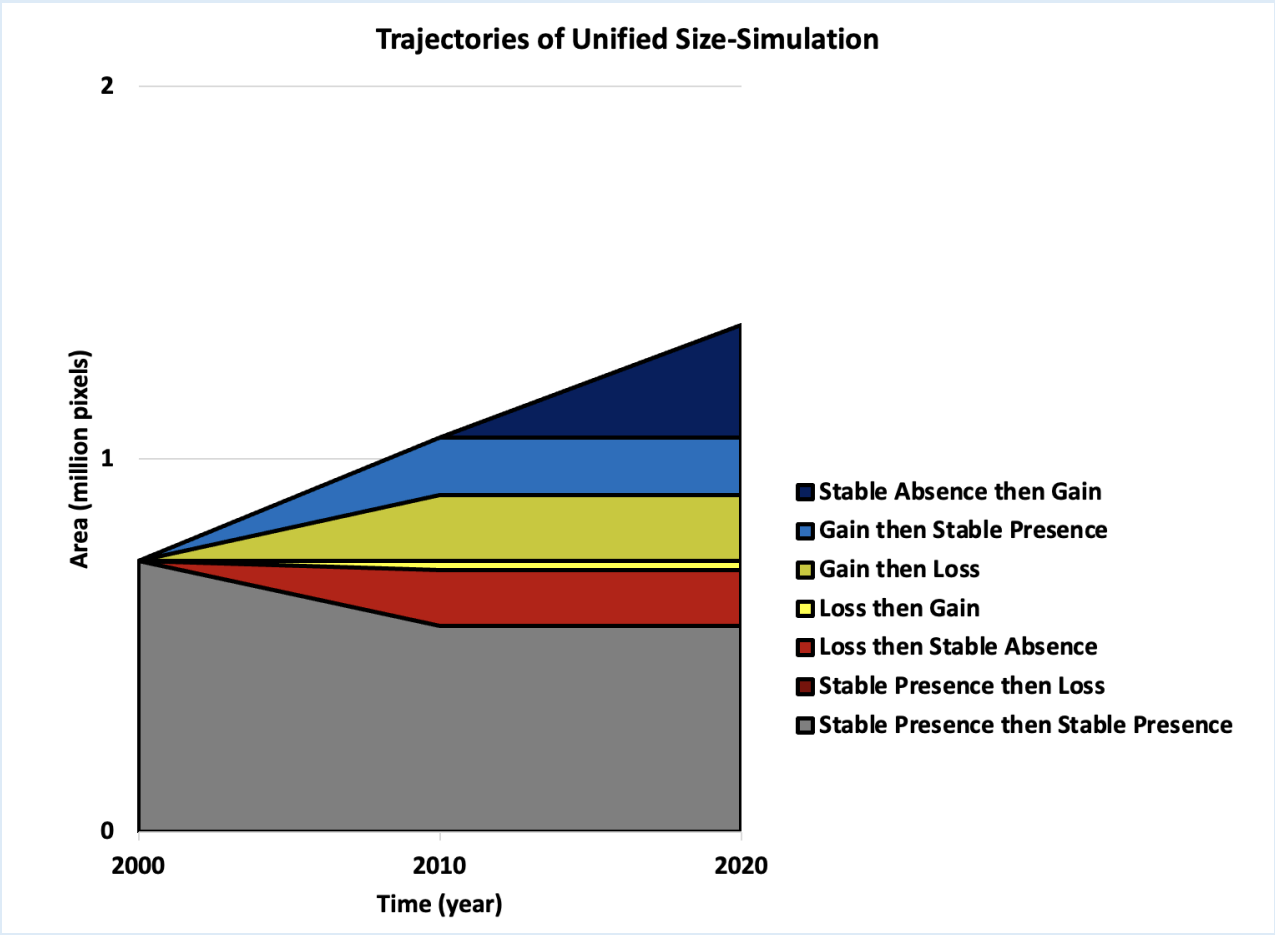


Unified Size - Reference

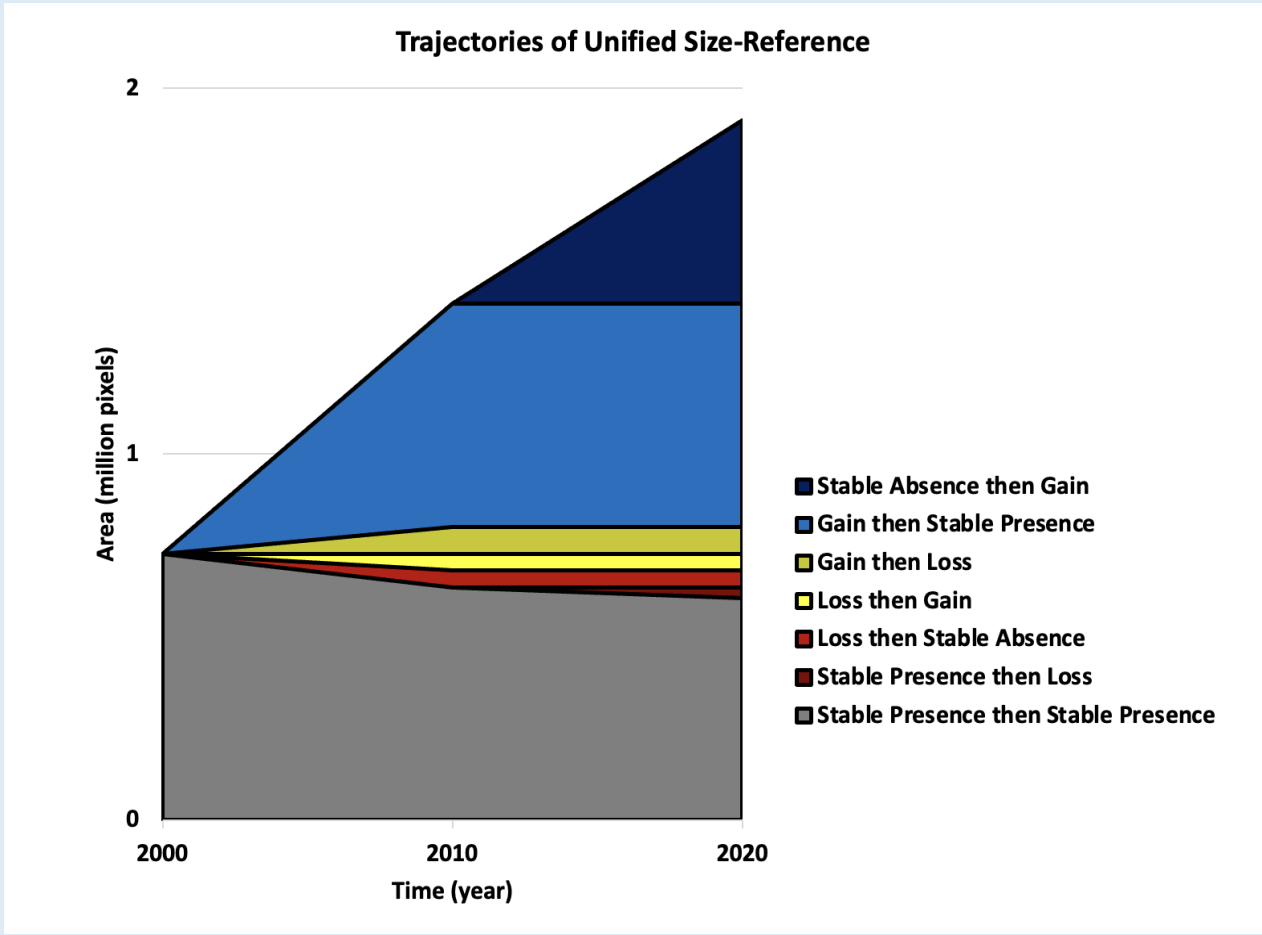


Trajectory of Unified Size (2000-2010-2020)

Simulation



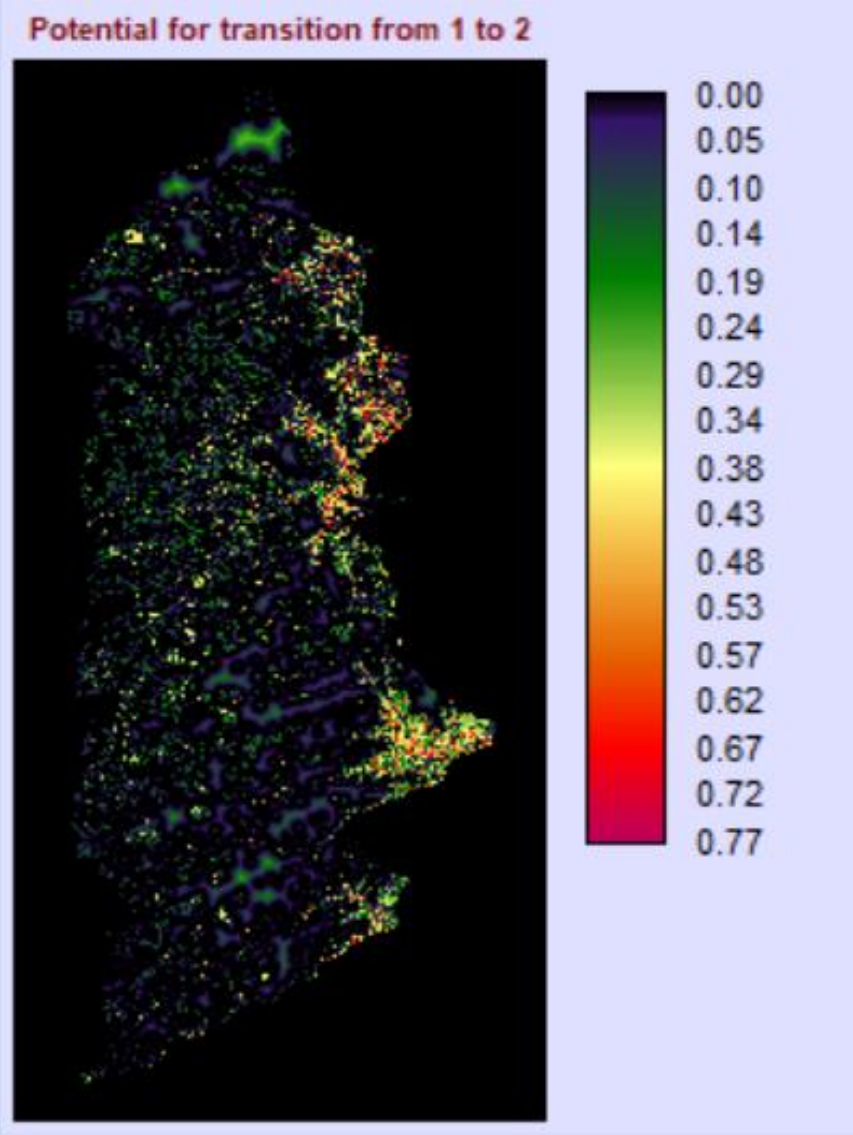
Reference

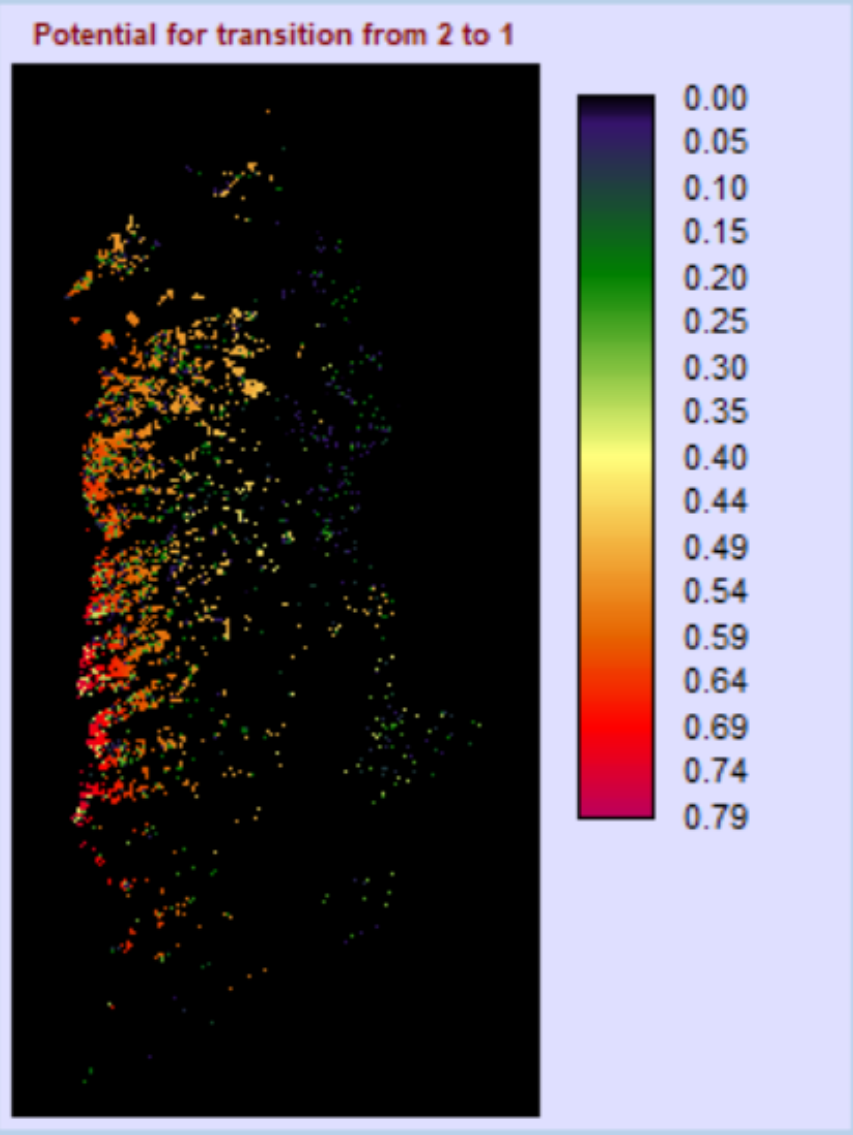


Run5: DTC (dynamic), Elevation (static), and Slope (static)

Three Variables

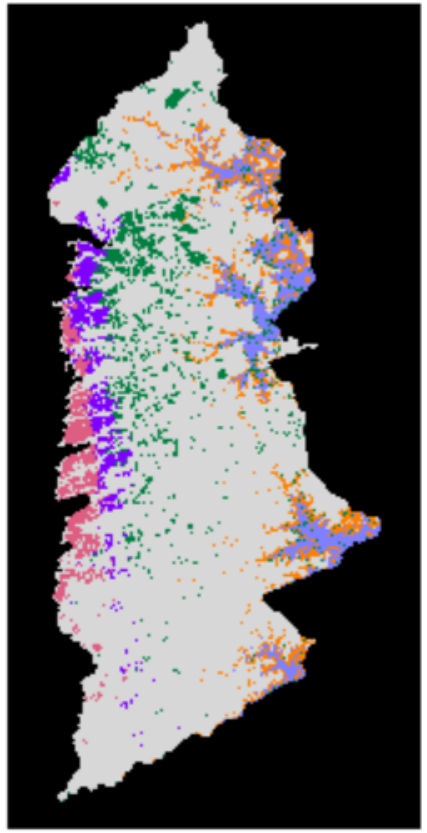
Transition Potential Maps for 2 stages for the 3 Variable run (DTC, slope, elevation)





CROSSTAB of 3 variables - DTC (dynamic), Slope, Elevation

MLP Trajectory of Simulate Change 2000 | 2010 | 2020



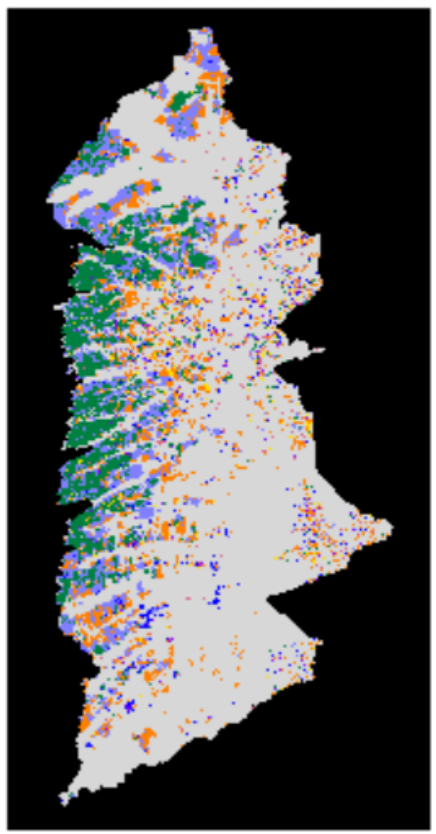
1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence then Stable Presence

Category	Cells	Legend
0	7381141	
1	4339626	1 | 1 | 1 Stable Absence and then Stable Absence
2	175956	2 | 1 | 1 Loss then Stable Absence
3	0	1 |2 |1 Gain then loss
4	175956	2 | 2 | 1 Stable Presence then Gain
5	329352	1 | 1 | 2 Stable Absence then Gain
6	0	2 | 1 | 2 Loss then Gain
7	329352	1 | 2 | 2 Gain then Stable Presence
8	375817	2 | 2 | 2 Stable Presence then Stable Presence

Meters
100000

Loss (2,3,4) : 351,912
Gain (5,6,7): 658,704

Reference Change 2000 | 2010 | 2020



1 | 1 | 1 Stable Absence and then Stable Absence
2 | 1 | 1 Loss then Stable Absence
1 | 2 | 1 Gain then Loss
2 | 2 | 1 Stable Presence then Loss
1 | 1 | 2 Stable Absence and then Gain
2 | 1 | 2 Loss then Gain
1 | 2 | 2 Gain then Stable Presence
2 | 2 | 2 Stable Presence and Stable Presence

Category	Cells	Legend
0	7381141	
1	3815336	1 | 1 | 1 Stable Absence and then Stable Absence
2	45143	2 | 1 | 1 Loss then Stable Absence
3	73819	1 | 2 | 1 Gain then Loss
4	29500	2 | 2 | 1 Stable Presence then Loss
5	499966	1 | 1 | 2 Stable Absence and then Gain
6	46115	2 | 1 | 2 Loss then Gain
7	609209	1 | 2 | 2 Gain then Stable Presence
8	606971	2 | 2 | 2 Stable Presence and Stable Presence

Meters
100000

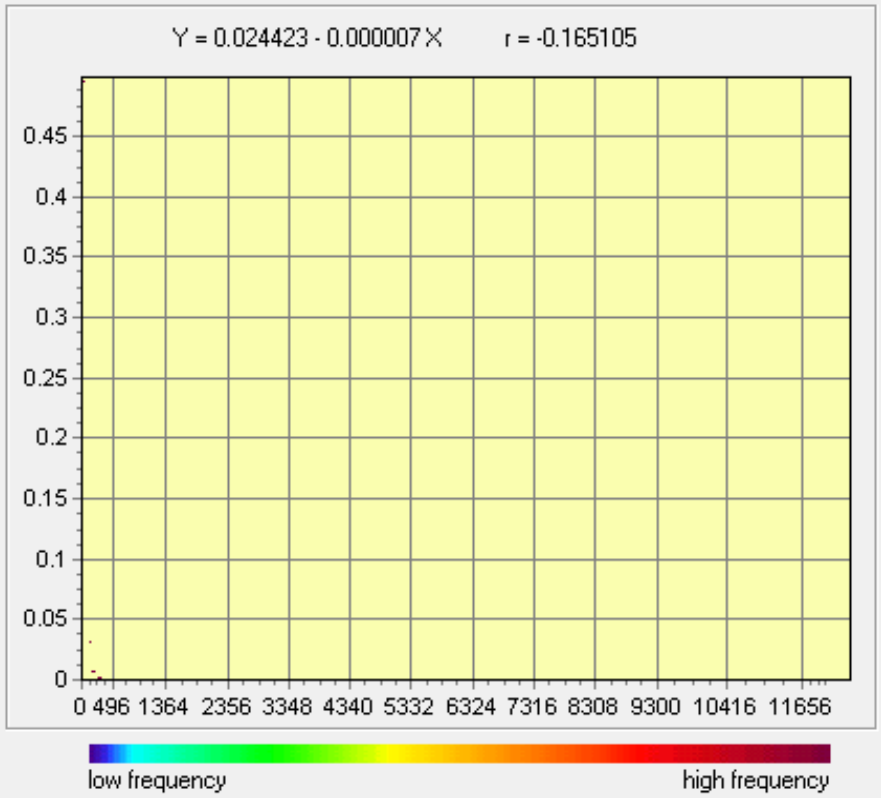
Loss (2,3,4) : 148,462
Gain (5,6,7): 1,155,290

Absence of Alternation in Simulation:
1 | 2 | 1 Gain then Loss
2 | 1 | 2 Loss then Gain

REGRESS

- We created a regress plot for each variable of each run to see how adding variables would impact the allocation of pixels.
- We compared each variable to the transition potential map from 1(absence) to 2(presence).

Run1: 1 variable(Independent) vs Transition Potential from 1 to 2(Dependent)

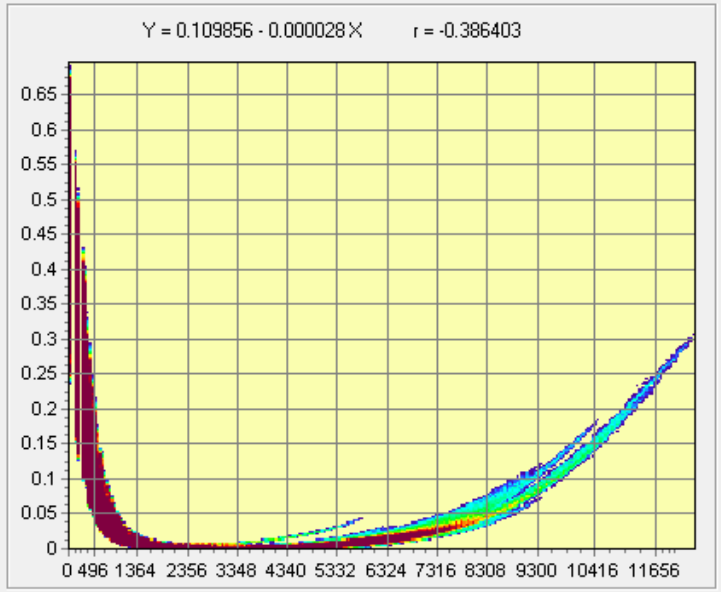



```
Regression Parameters:

X axis: change_distance_masked
Y axis: mlp_dtc_s_transition_potential

Coeff. of Det.          =       2.73 %
Std. Dev. of X          =  1648.913227
Std. Dev. of Y          =     0.073210
S.E. of Estimate        =     0.072205
Std. Error of Beta      =     0.000000
t Stat for r or Beta    =  -400.579840
t Stat for Beta <> 1    =     1.000000
Sample Size (n)         =      5726059
Apparent df             =      5726057
```

Distance to Change (static)

- There are very few pixels visible in this regress plot.
  - This is potentially because the transition potential values are so low that they blend into the x-axis.
- The few pixels visible are around 500m or less from change and have higher transition potential values than those further away- (although the values are still very low) it is hard to definitively state the relationship with so few pixels visible.

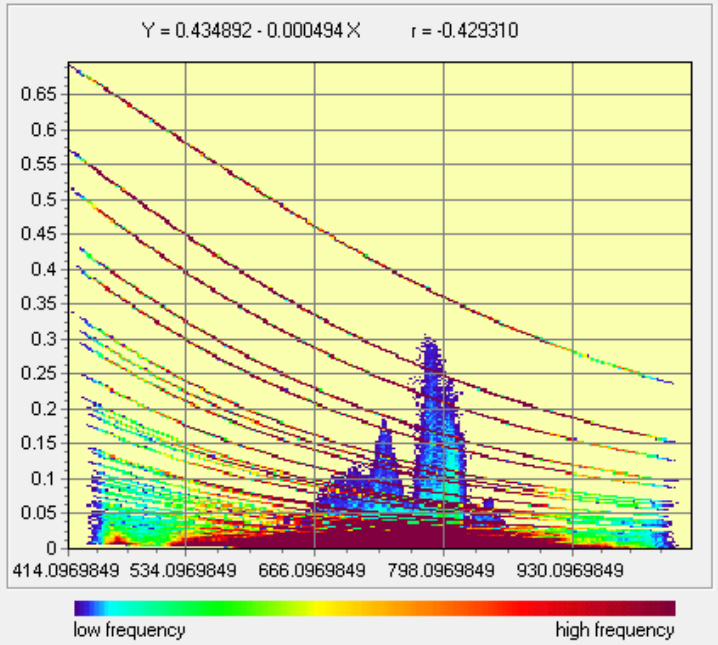
Run2: 2 variable(Independent) vs Transition Potential from 1 to 2(Dependent)




```
Regression Parameters:

X axis: change_distance_masked
Y axis: masked_run_transition_potentia

Coeff. of Det.          =      14.93 %
Std. Dev. of X          =  1648.913227
Std. Dev. of Y          =     0.120424
S.E. of Estimate        =     0.111071
Std. Error of Beta      =     0.000000
t Stat for r or Beta    = -1002.493431
t Stat for Beta <> 1    =     1.000000
Sample Size (n)         =      5726059
Apparent df             =      5726057
```

Distance to Change (static)

- Areas closer to change have the highest transition potentials. There is a steep decline in transition potentials until around 1000m, followed by a period of nearly 0 transition potentials before a gradual increase around 5000m. This is likely due to the additional of elevation as a variable.

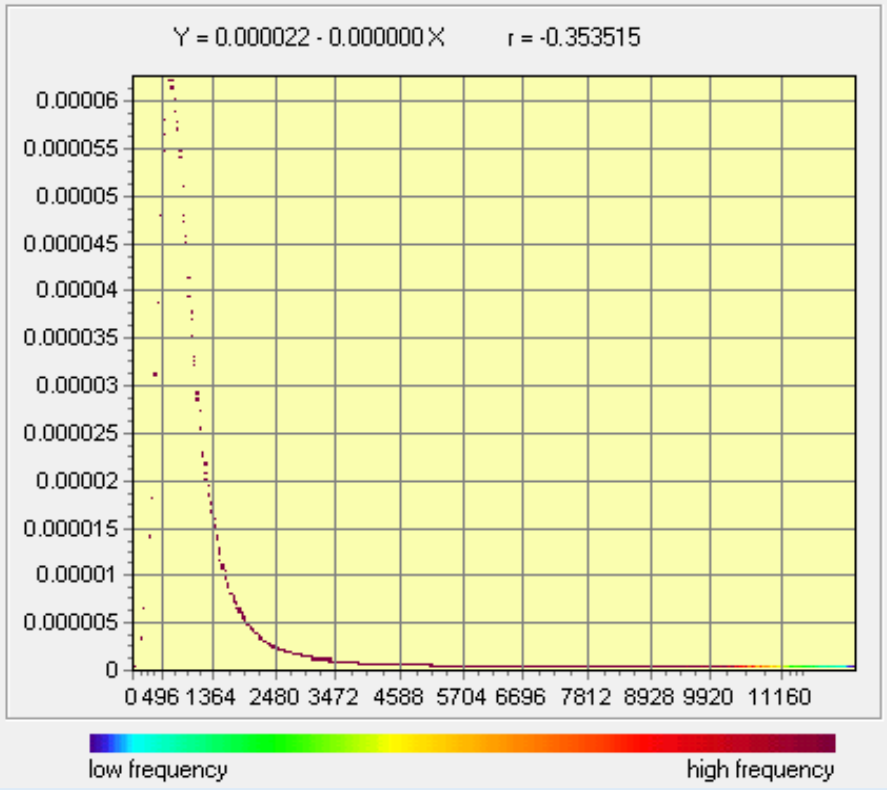



```
Regression Parameters:

X axis: elevation_masked
Y axis: masked_run_transition_potentia

Coeff. of Det.          =      18.43 %
Std. Dev. of X          =   104.726574
Std. Dev. of Y          =     0.120424
S.E. of Estimate        =     0.108762
Std. Error of Beta      =     0.000000
t Stat for r or Beta    = -1137.458214
t Stat for Beta <> 1    =     1.000000
Sample Size (n)         =      5726059
Apparent df             =      5726057
```

Elevation

- There are a large number of pixels that have transition potential values that are less that 0.05.
- There are a couple of peaks in transition potentials, the largest being at around 780 m**.** The majority of the pixels have low transition potential values around 0.5 or less.

Run3: DTC(dynamic) as Independent vs Transition Potentials as Dependent

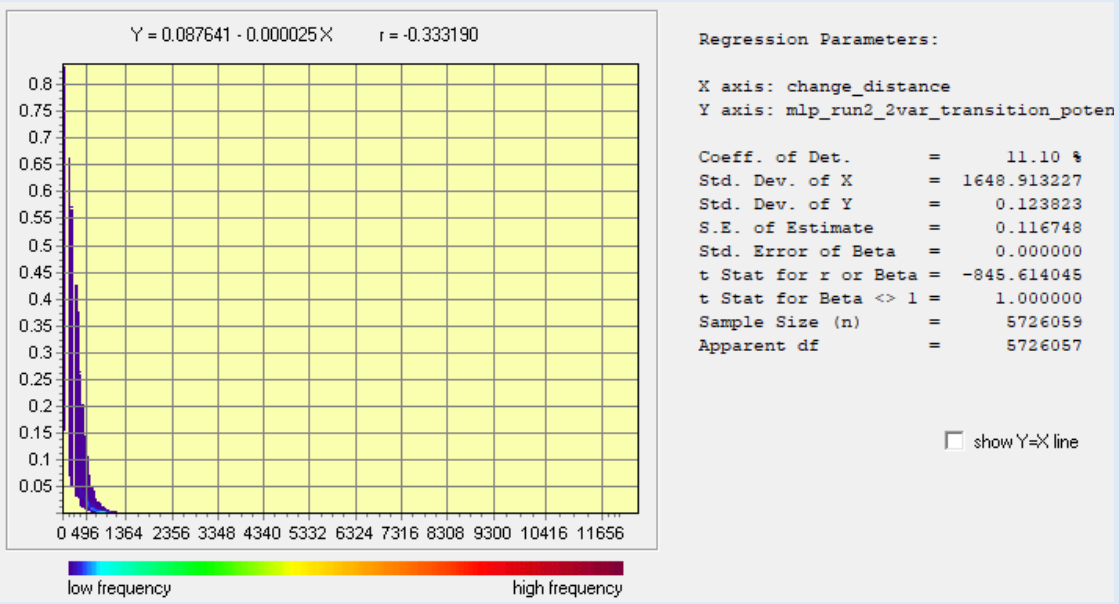



```
Regression Parameters:

X axis: change_distance_masked
Y axis: mlp(distchangedynamic)_transit

Coeff. of Det.          =      12.50 %
Std. Dev. of X          =  1648.913227
Std. Dev. of Y          =     0.000020
S.E. of Estimate        =     0.000019
Std. Error of Beta      =     0.000000
t Stat for r or Beta    =  -904.325070
t Stat for Beta <> 1    =     1.000000
Sample Size (n)         =      5726059
Apparent df             =      5726057
```

DTC (dynamic)

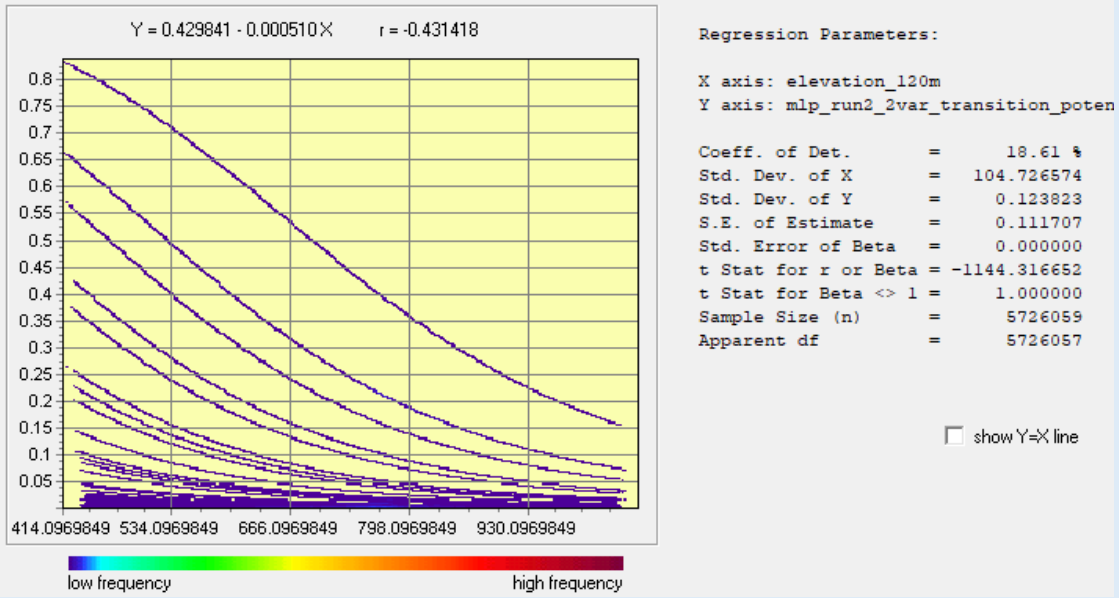
- All the pixels in this plot have very low transition potential values—note that the y-axis ranges from 0.000005 to 0.00006.
- Areas where DTC is closest to 0 appear to have very low transition potential values, but as DTC increases, the transition potential values increase rapidly and peak at about 500m before decreasing rapidly and remaining low.

Run4: 2 Variables(Independent) vs Transition Potential from 1 to 2(Dependent)



Distance to Change (dynamic)

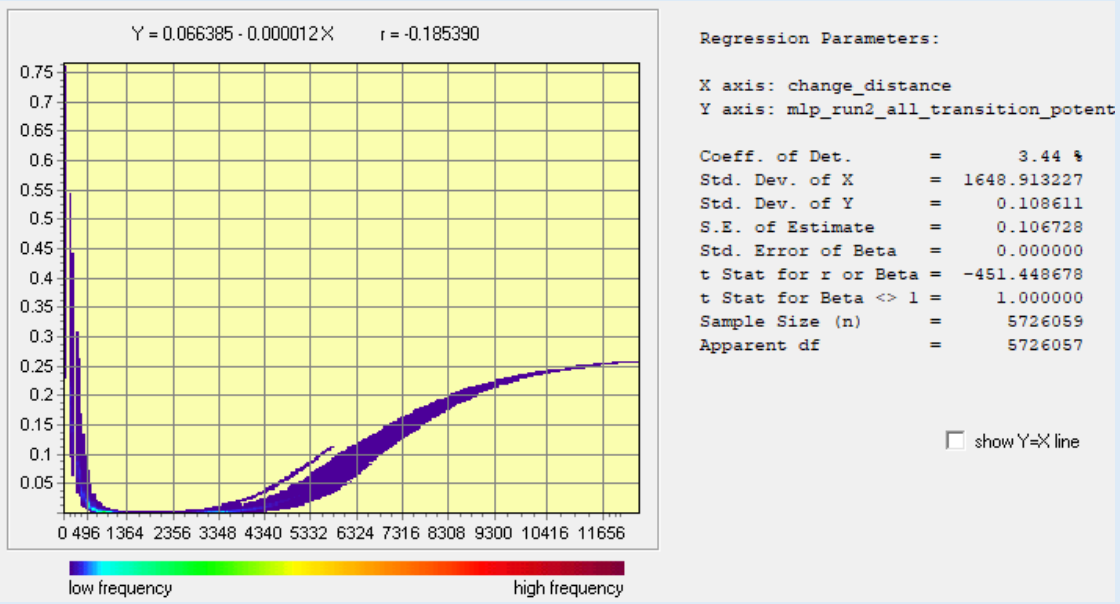
- Areas closer to change tend to have higher transition potential values than those further away from change.
- At around 500m the transition potential values approach 0.



Elevation

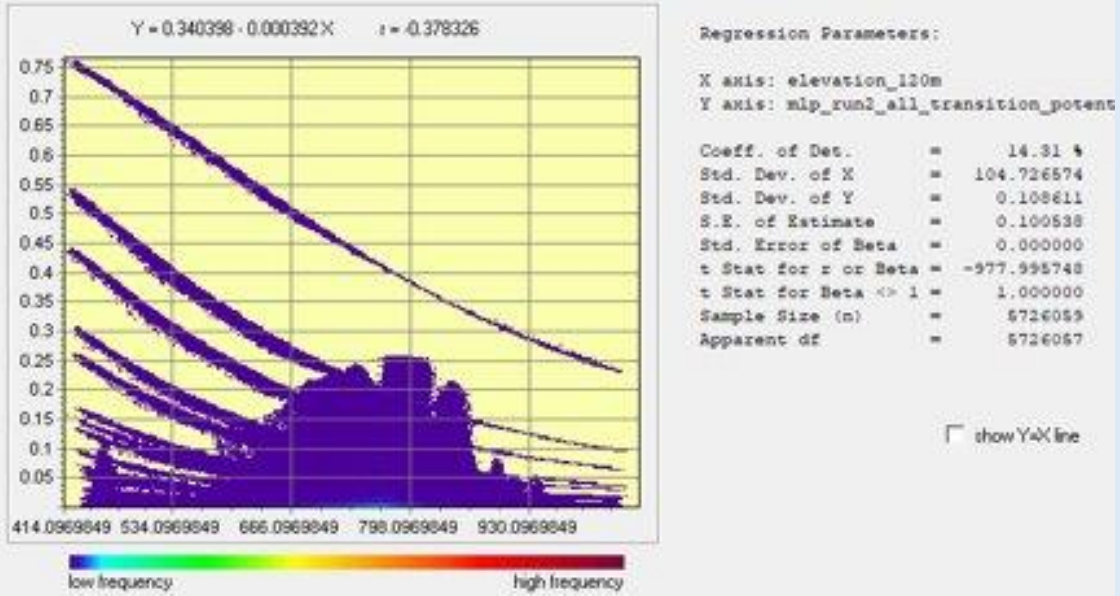
- The transition potential values are higher at lower elevations and then decrease as elevation increases.

Run5: 3 Variables(Independent) vs Transition Potential from 1 to 2(Dependent)



Distance to Change(dynamic)

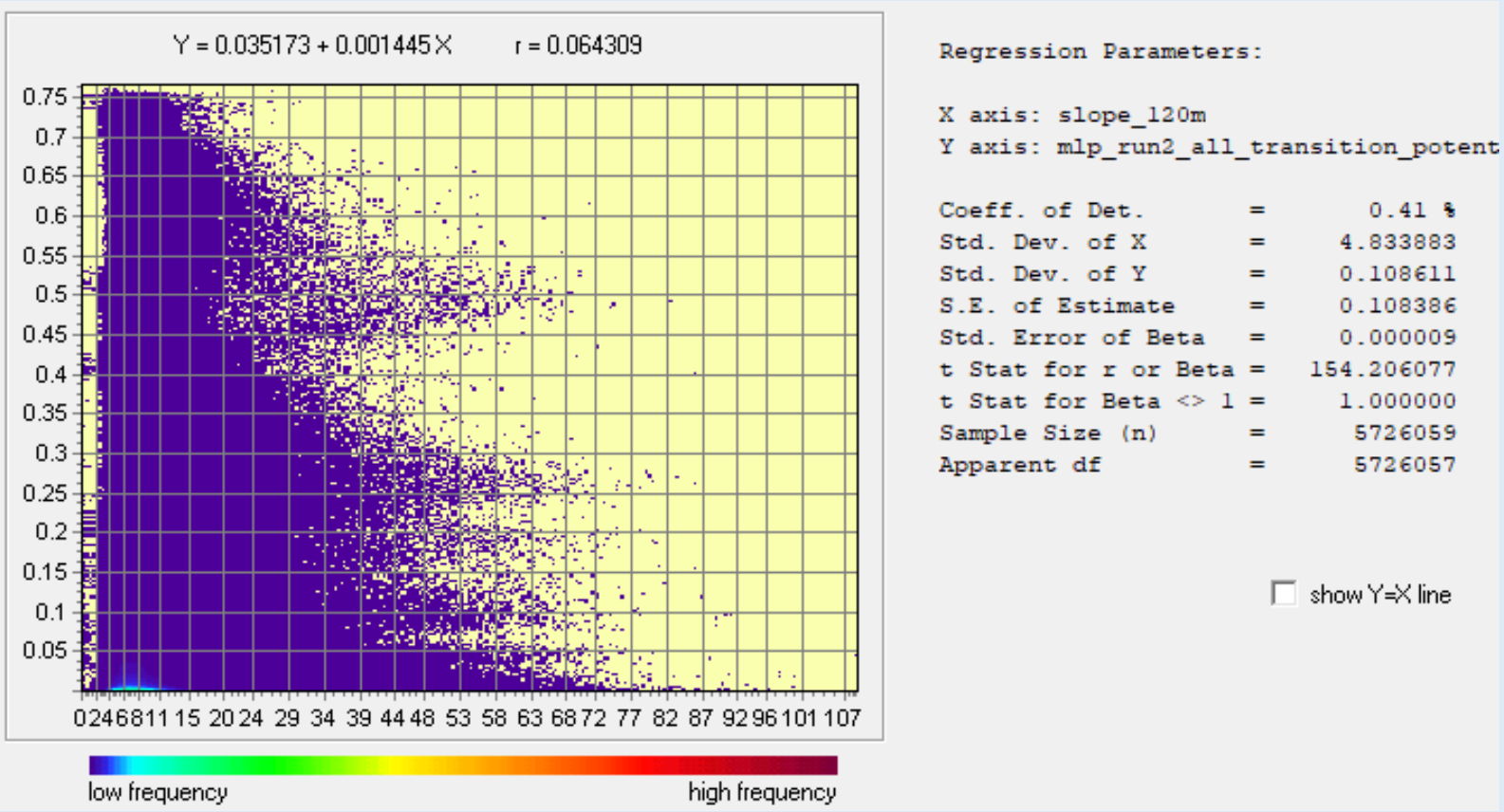
- Closer areas, around <1364m to change have higher transition potential values. Around 4000m the transition potential values begin to steadily increase.
- The steady increase in transition potential values after approximately 4000 meters is likely due to the addition of the slope variable.



Elevation

- The transition potential values decrease as elevation increases.
- The highest transition potentials occurred at lower elevations.
- We believe the "blob" in the middle of the graph is likely due to the addition of elevation as a variable.

Run5: 3 Variables(Independent) vs Transition Potential from 1 to 2 (Dependent)

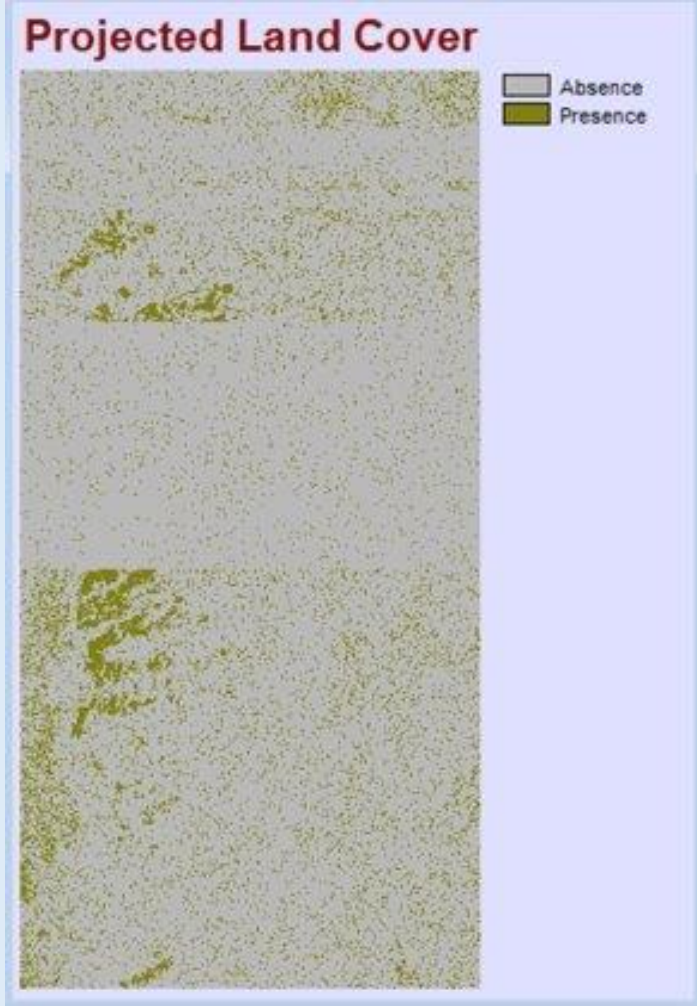


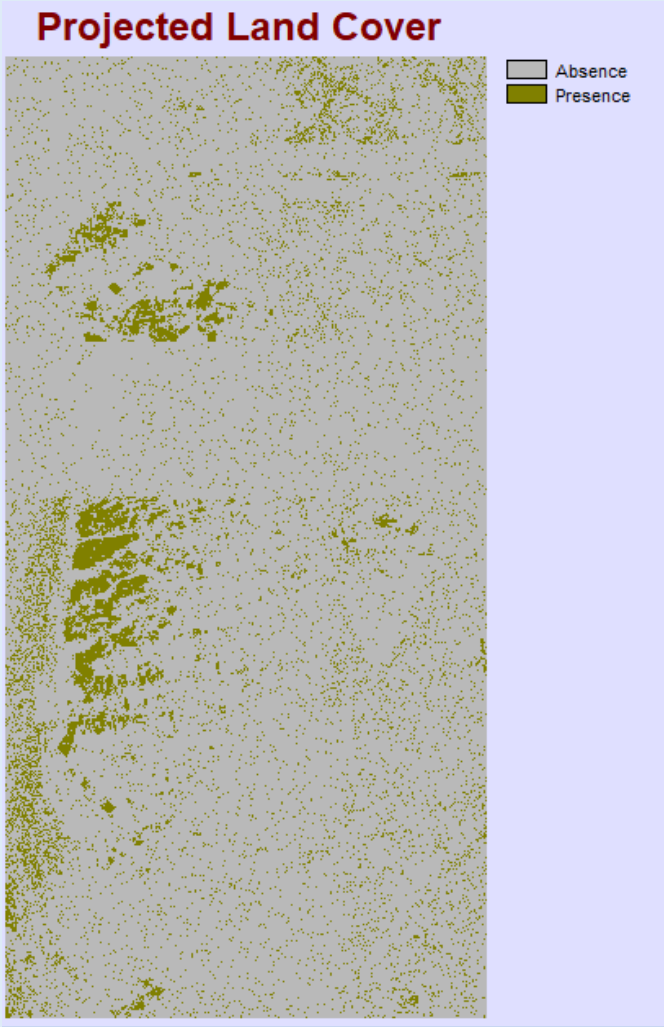
Slope

- Predicted change is allocated to high transitions between 4-10m.
- There is less of a defined relationship between elevation and the transition potential map, so likely this variable has the least influence on the allocation of pixels.

Challenges

Striping

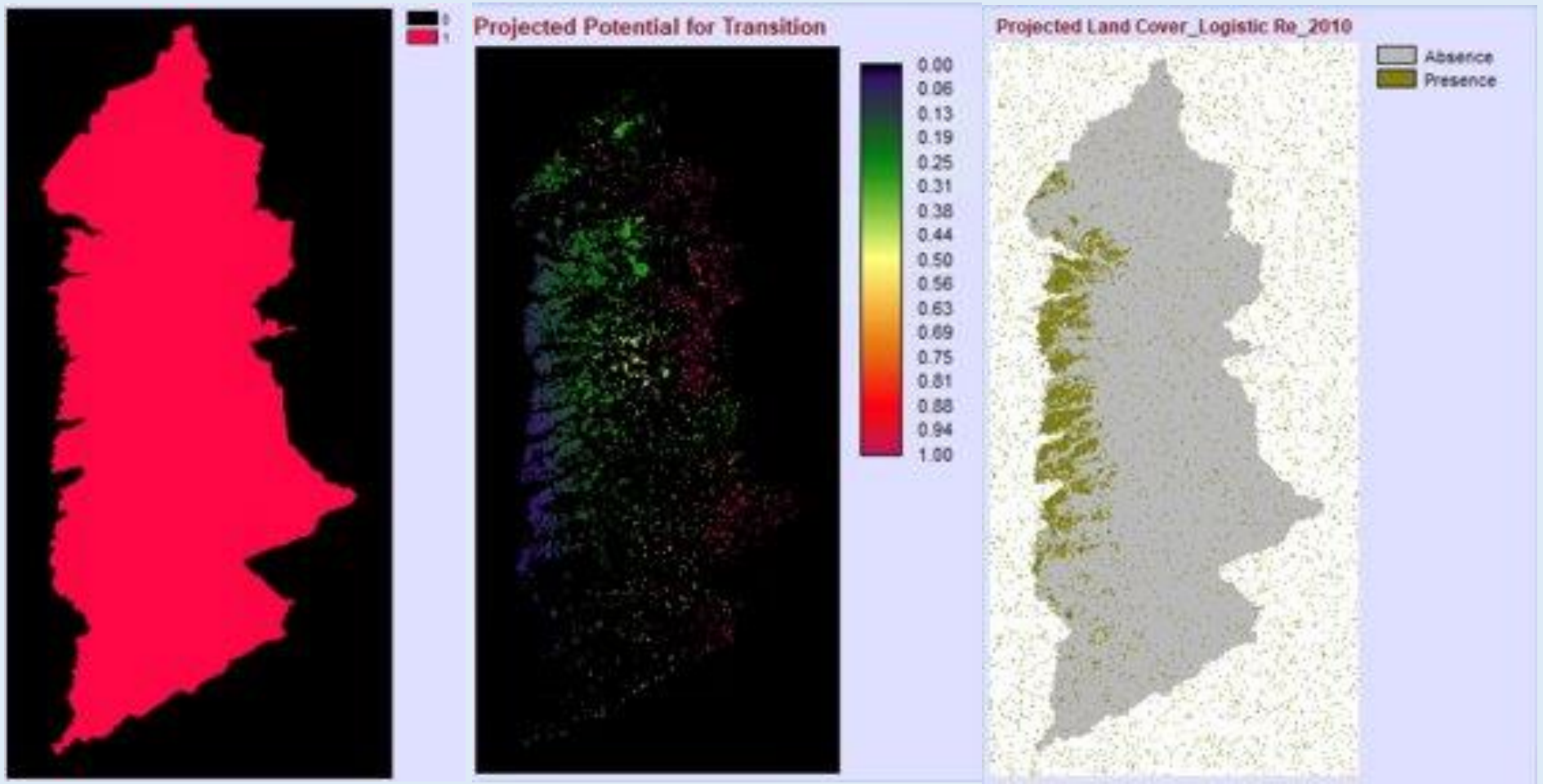




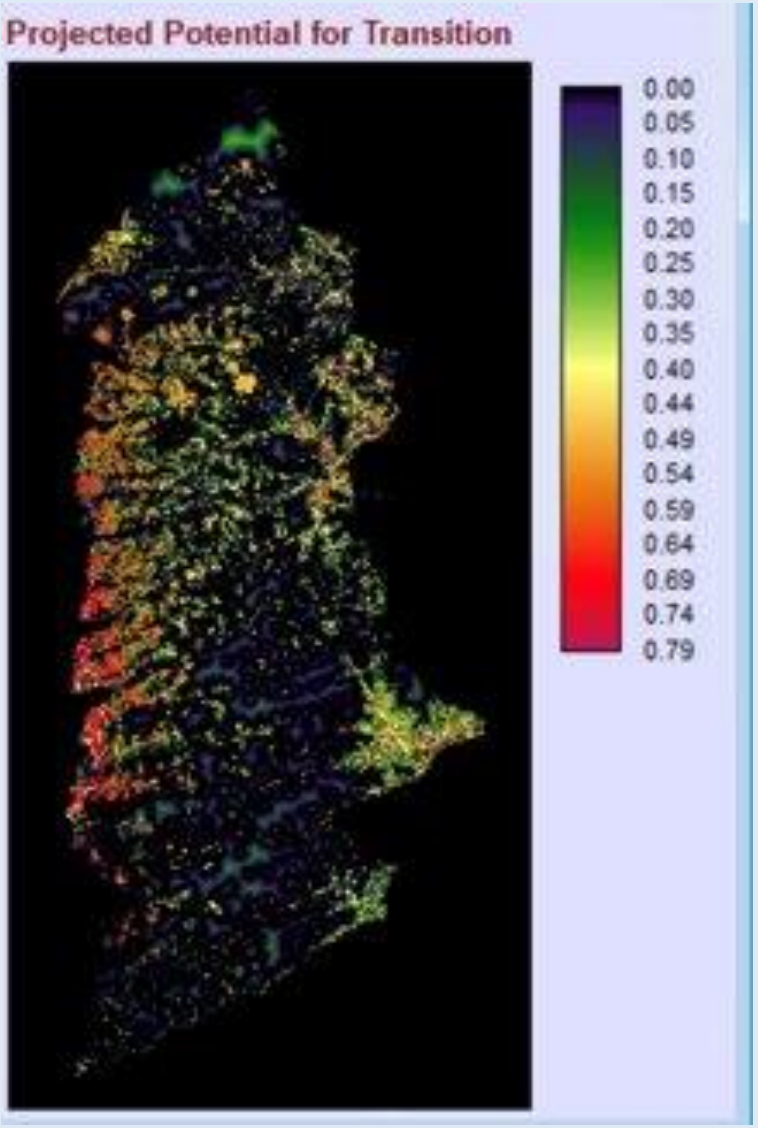
- We initially ran logistic regression in LCM with only one variable: DTC as dynamic variable**.** This resulted in striping in prediction maps
- In an email with Professor Pontius, he explained that this issue was caused by "the number of pixels of simulated change [being] fewer than the number of pixels that have the same transition potential value" and recommended that we add more variables.
- This led us to adding two additional variables, elevation and slope, to our next runs.

Simulated change in mask (Logistic Regression)

- We added the three variables (DTC, slope, elevation), and added a mask of the area outside of the 9 municipalities as a constraint.
- Despite the constraint however, the model was predicting change with no apparent pattern outside the study area – we are not sure why this is happening



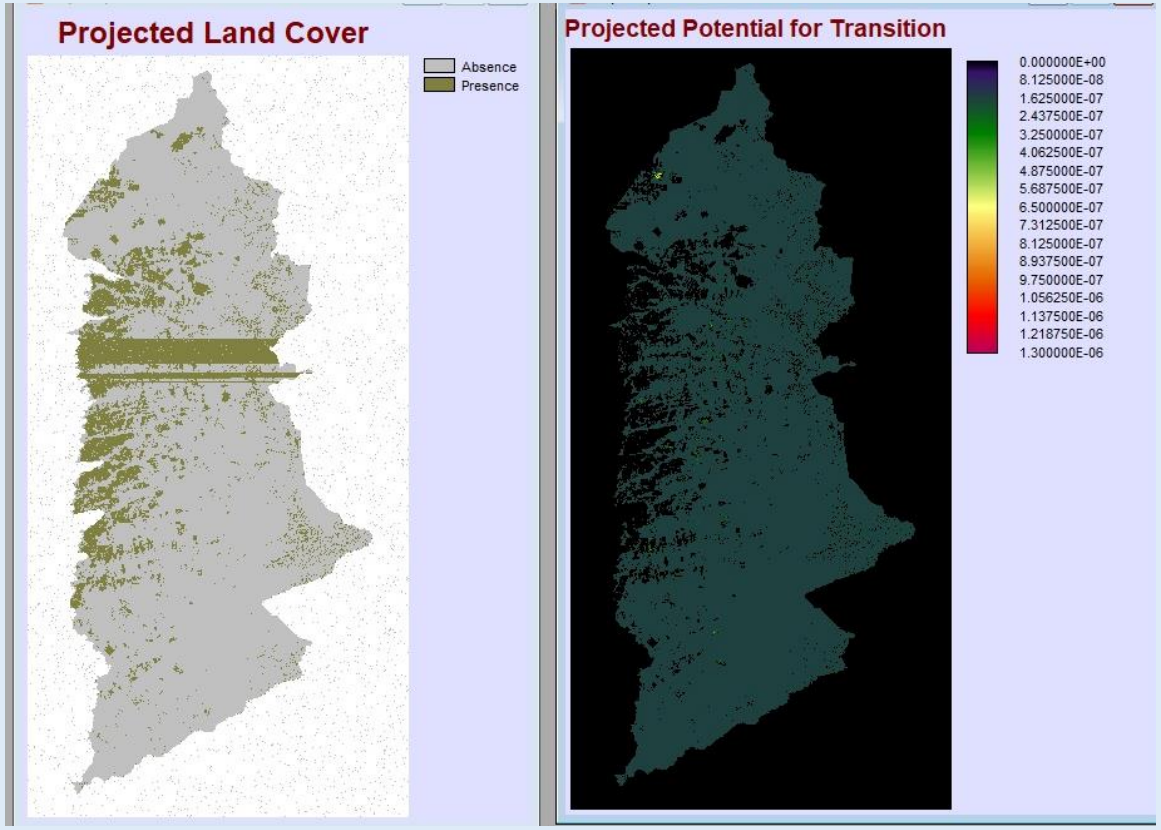
Logistic Regression



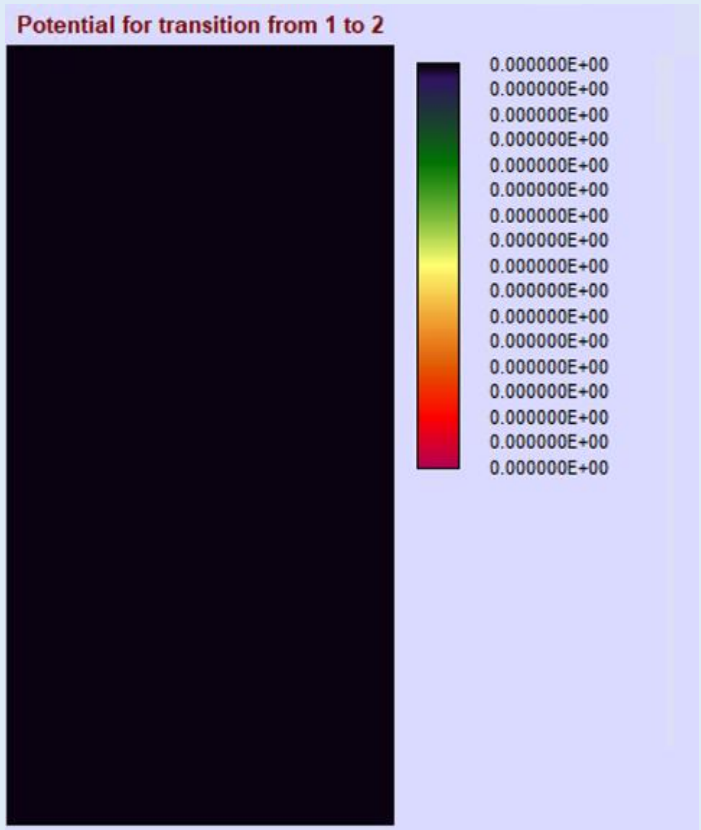
We initially tried the methodology with Logistic regression but due to the reasoning in the two previous slides – the striping and the prediction outside of the study area – we decided to do the subsequent runs using MLP and use those results instead.

MLP

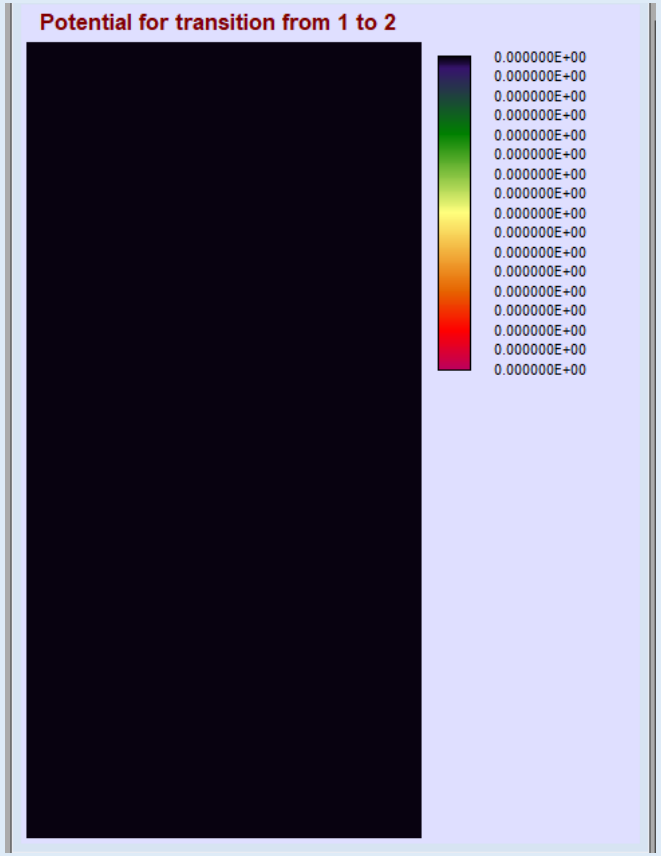
Striping – Distance to Absence and Distance to Presence as Dynamic

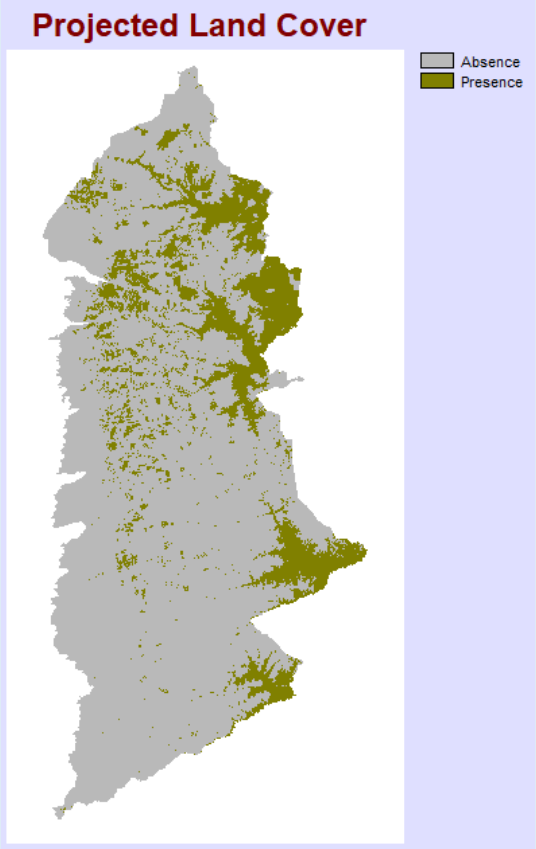


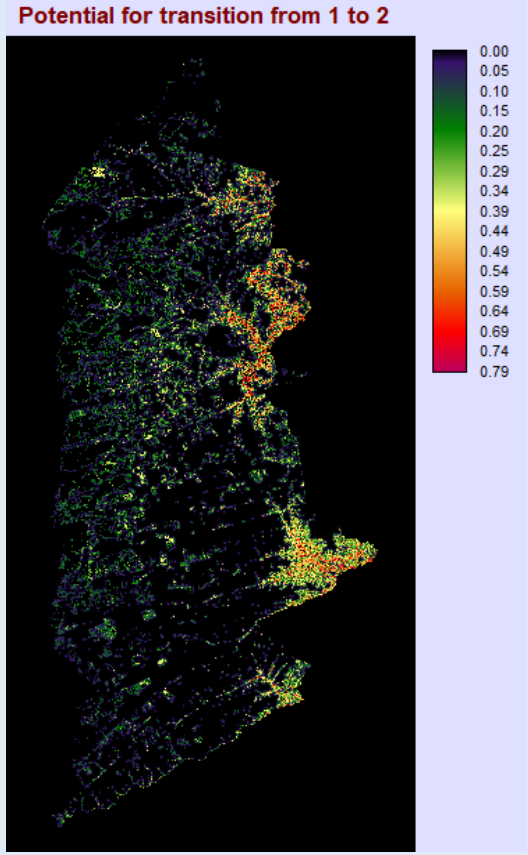
Change in mask – Distance as Static, Distance to Absence, and Distance to Presence as Dynamic



Unexpected Error (DTC as Dynamic, Slope, Elevation)

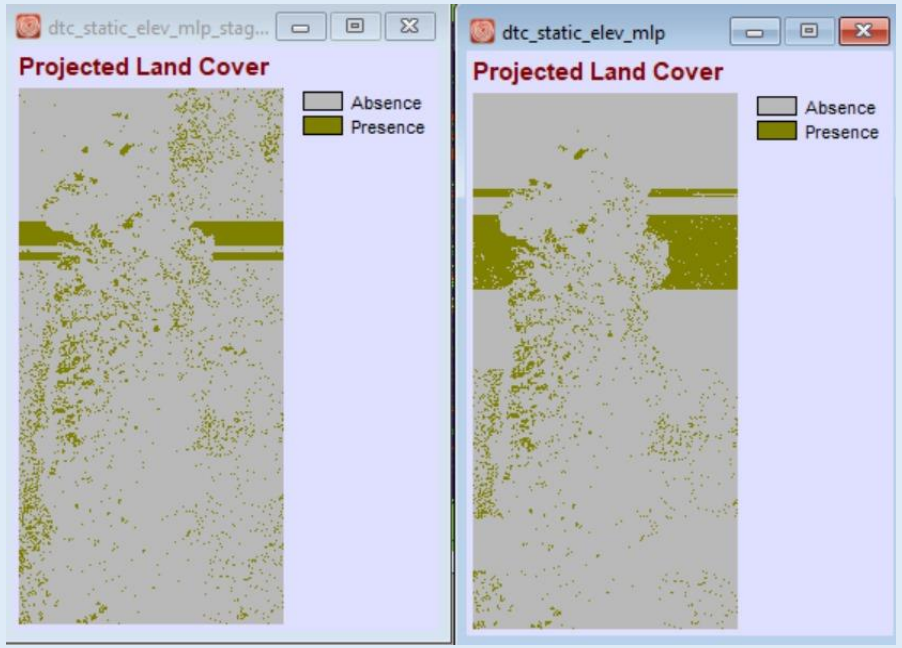


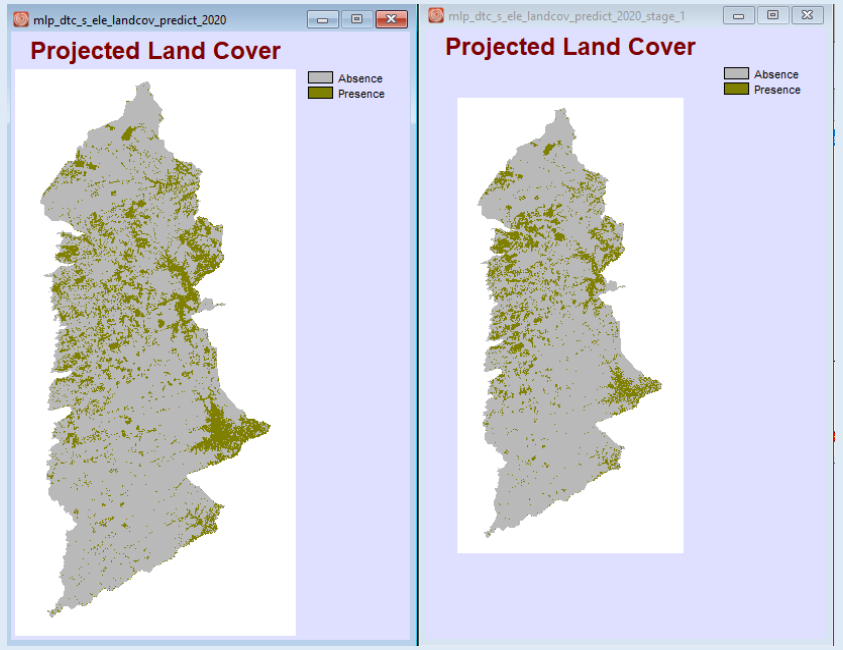


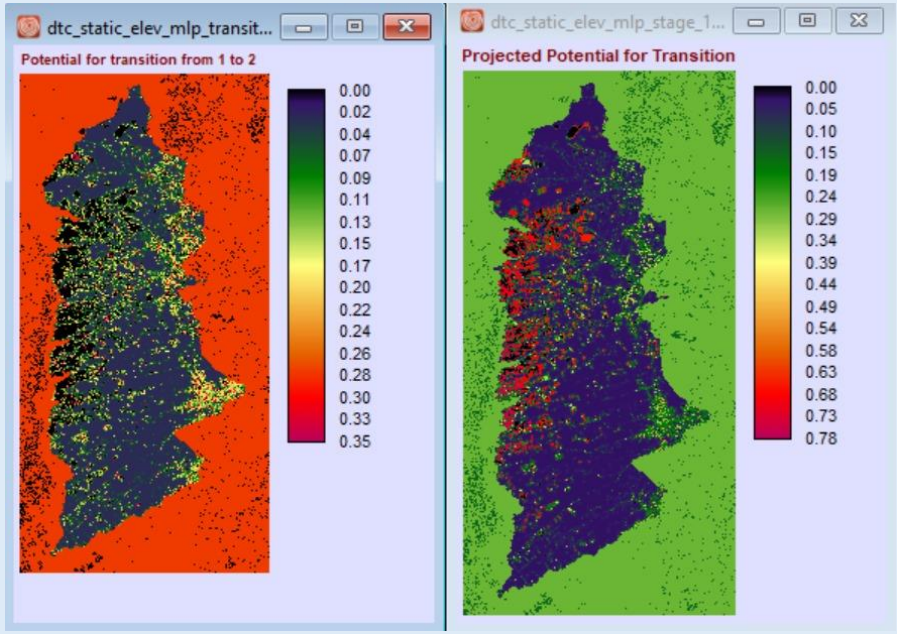


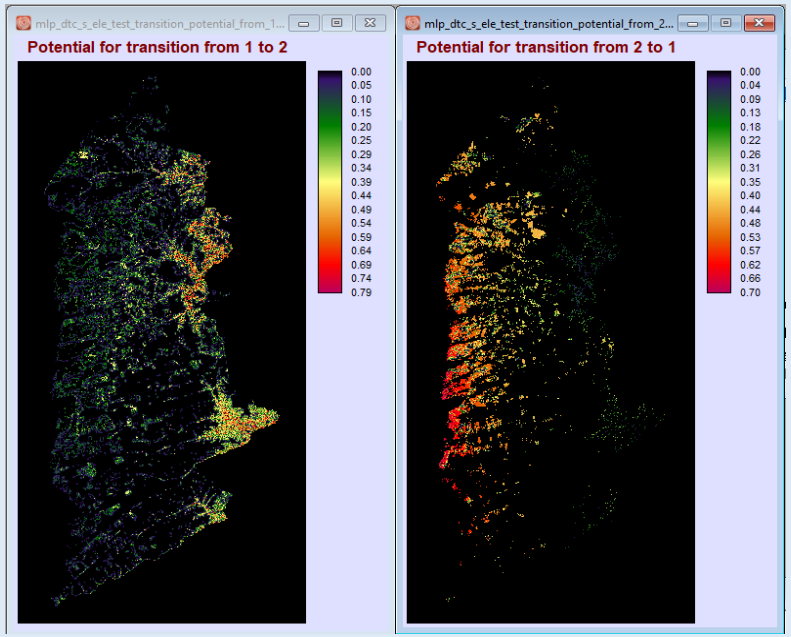
Unexpected errors occurred when we tried different runs with the same variable in MLP. The result on the left we ran with DTC as Dynamic, Slope, and Elevation, which is Run5, but the results got pixels allocation out of the study area; after we restarted Terrest and ran again, the problem was solved.

Unexpected Error (DTC as Static, Elevation)









Conclusion

Summary of Findings

- Runs with static variables will not result in alternation.
- In the dynamic runs (Runs 3,4,5), with each added variable, a category is lost.
  - In Run 4, we lost 2 | 2 | 1 Stable Presence then Loss (although this was not an alternation category).
  - In Run 5 we lost both alternation categories, 1 | 2 | 1 Gain then Loss and 2 | 1 | 2 Loss then Gain
- Our most successful run was Run 3 (DTC Dynamic) which was our only run that simulated alternation, however, it did exhibit banding issues.
- TerrSet's LCM has some software issues that result in banding and pixel allocation error as seen in our challenges section of this PowerPoint.

Next Steps

- We will compile a report on the issues we discovered during the analysis and send it to Tammy Woodard from Clark Labs - which will include striping and pixel allocation outside of the study area.
- Although this goes beyond the scope of our project, it would be interesting to see if alternation can be achieved without the striping issue seen in Run3 (1 variable, DTC dynamic) using LCM.

Thank you!