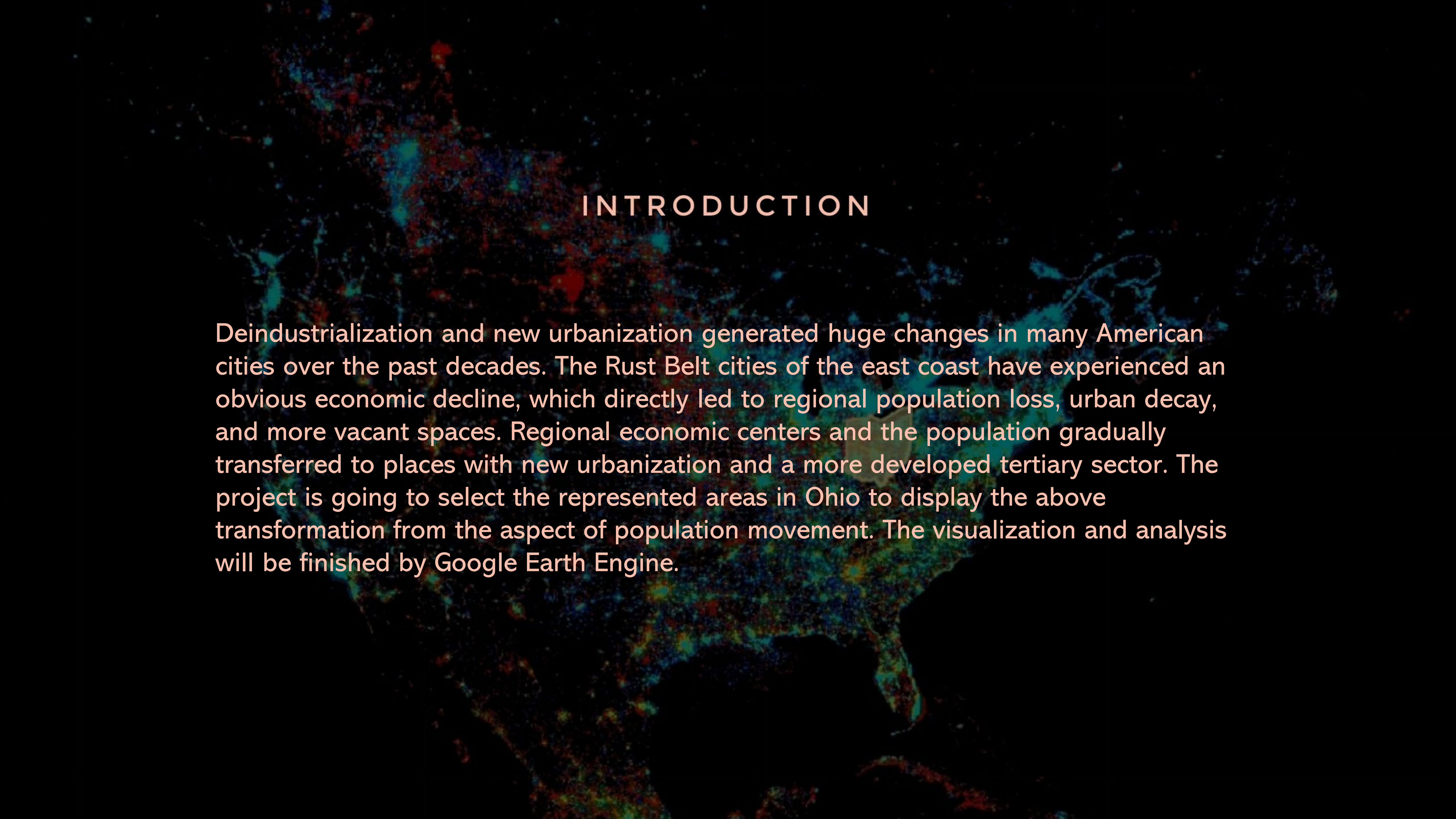
Population Movements in the Major Cities of Ohio

XIAORAN WANG

LARP 743



INTRODUCTION

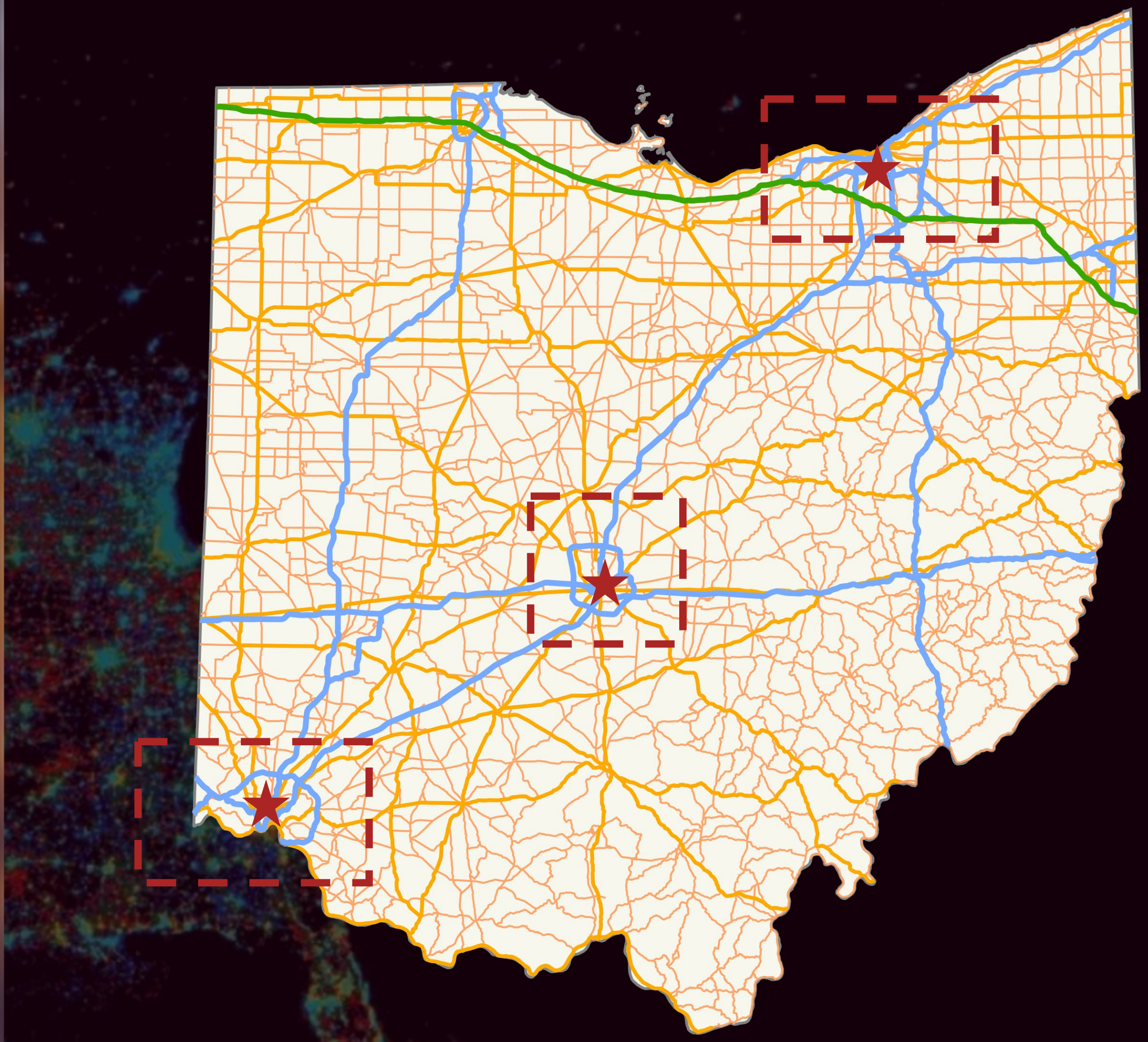
Deindustrialization and new urbanization generated huge changes in many American cities over the past decades. The Rust Belt cities of the east coast have experienced an obvious economic decline, which directly led to regional population loss, urban decay, and more vacant spaces. Regional economic centers and the population gradually transferred to places with new urbanization and a more developed tertiary sector. The project is going to select the represented areas in Ohio to display the above transformation from the aspect of population movement. The visualization and analysis will be finished by Google Earth Engine.

STUDY AREA

The study area of the project is Ohio, and it mainly focus on the region around the three major cities: Columbus, Cleveland and Cincinnati. These cities correspond to the three local economic centers of Ohio:

- Columbus → Central Ohio
- Cleveland → Central and Western Lake Erie Area
- Cincinnati → Southwest Ohio

Cleveland is a typical Rust-belt city; Columbus and Cincinnati also experienced a slight effect of deindustrialization. The project will depict the pattern of population movement around each city and make evaluations on the dynamics of urbanization in the three metropolitan regions in Ohio.



DATA

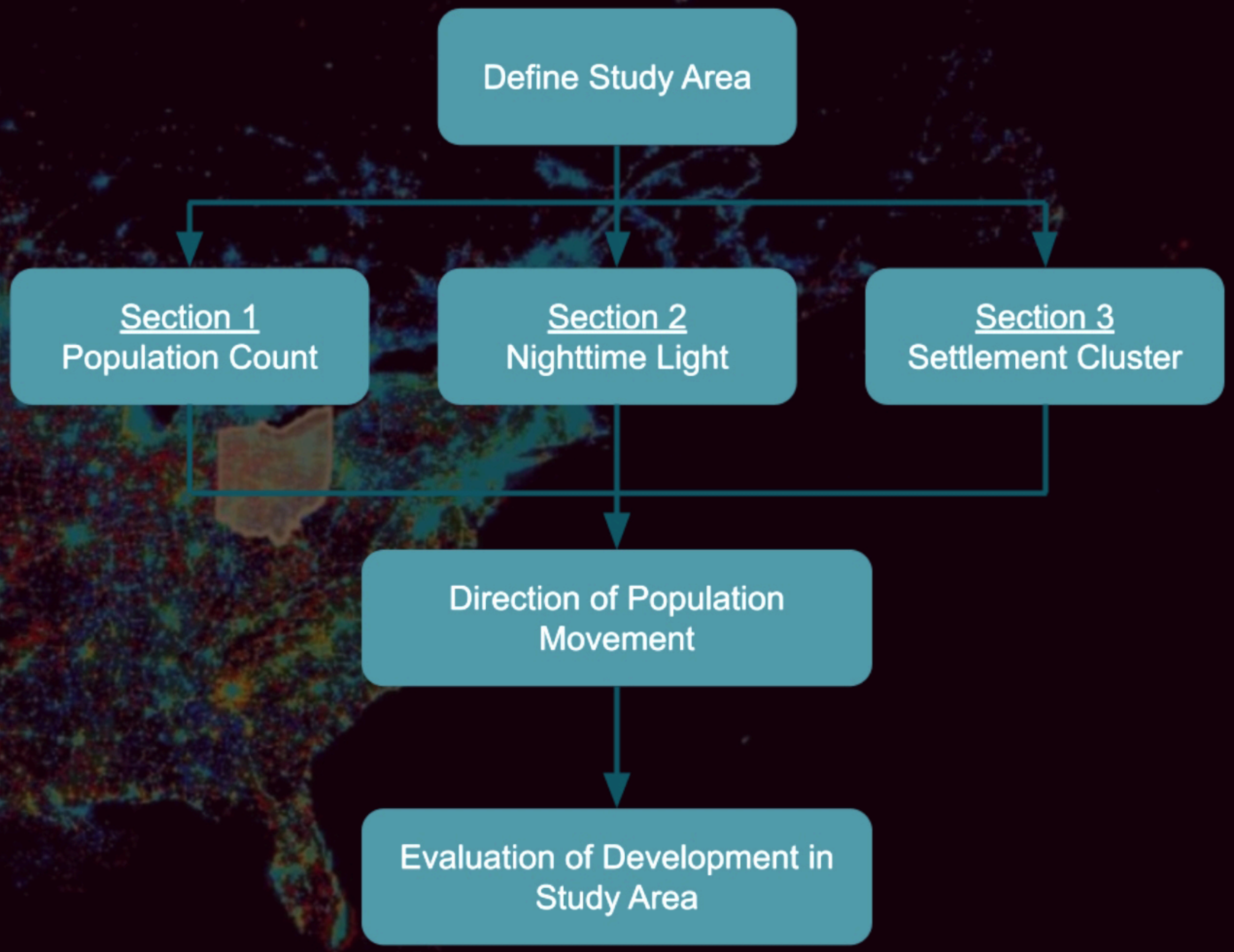
TIGER: US Census States 2016

DMSP OLS: Nighttime Lights Time Series Version 4, Defense Meteorological Program Operational Linescan System

Population Density (Gridded Population of the World Version 4.11)

GHSL-Global Human Settlement Layer Grid 1975-2015

FRAMEWORK



Define Study Area

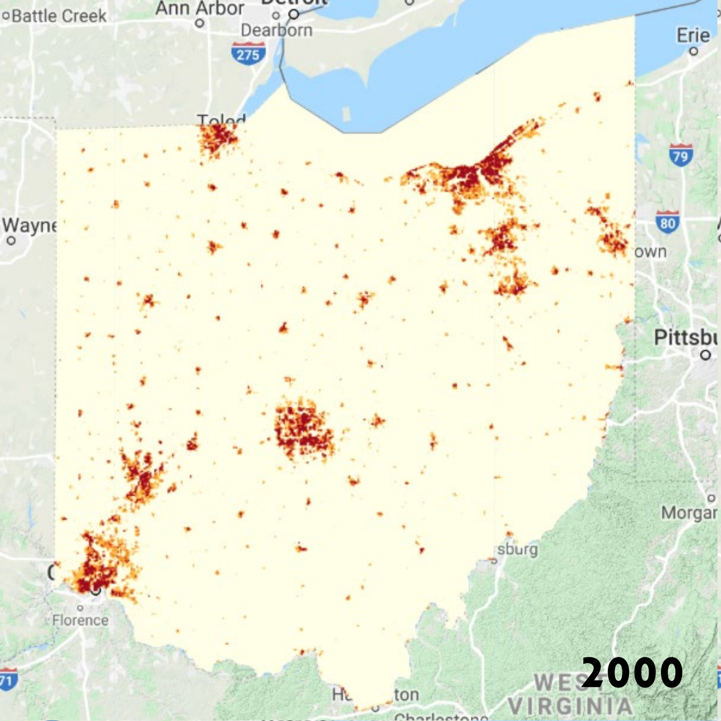
Section 1
Population Count

Section 2
Nighttime Light

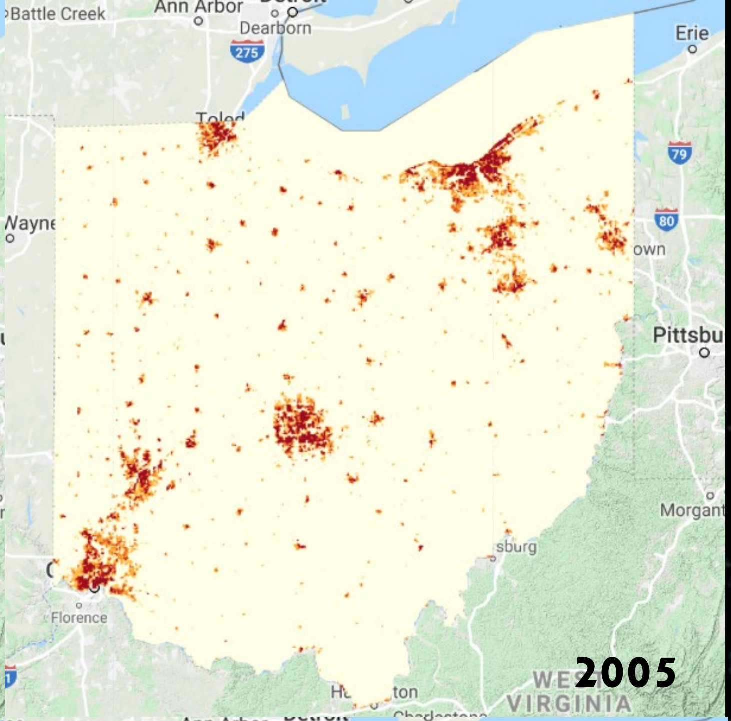
Section 3
Settlement Cluster

Direction of Population Movement

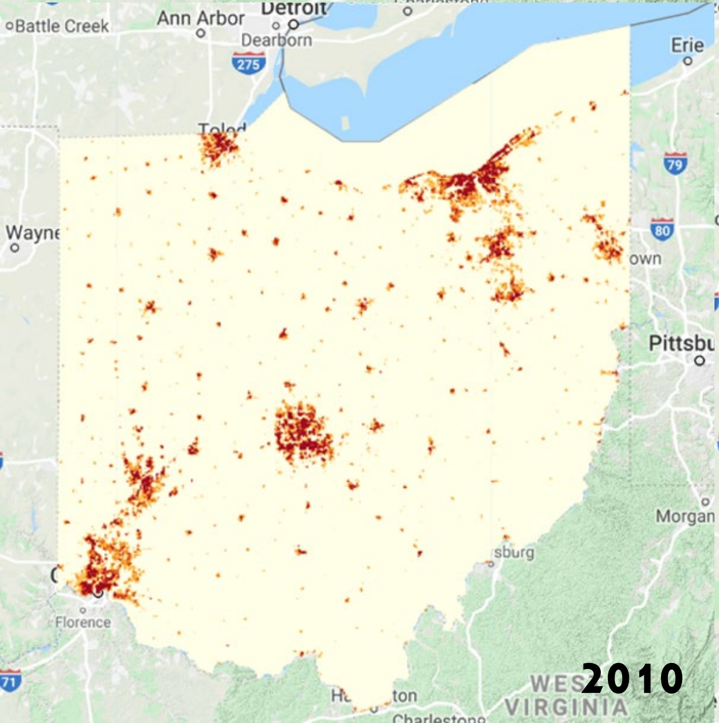
Evaluation of Development in Study Area



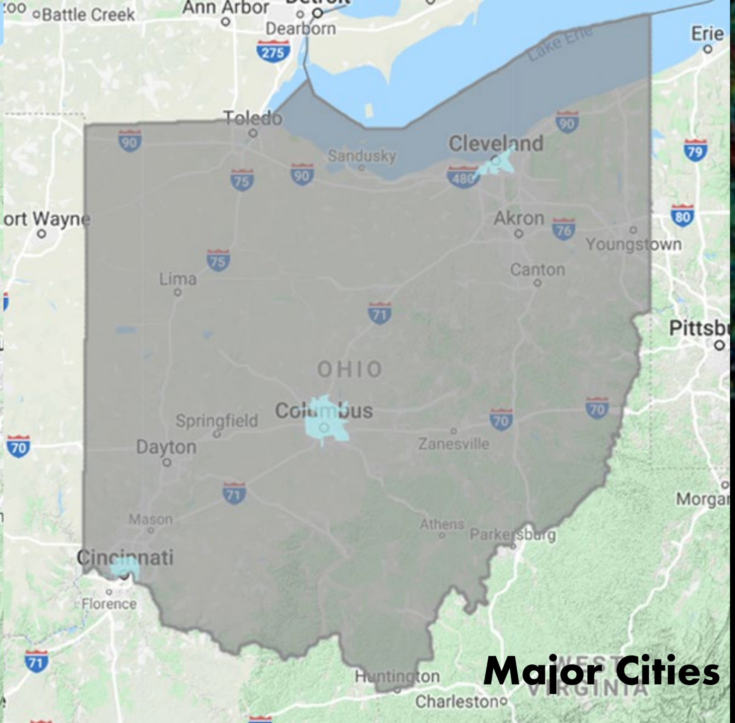
2000



2005

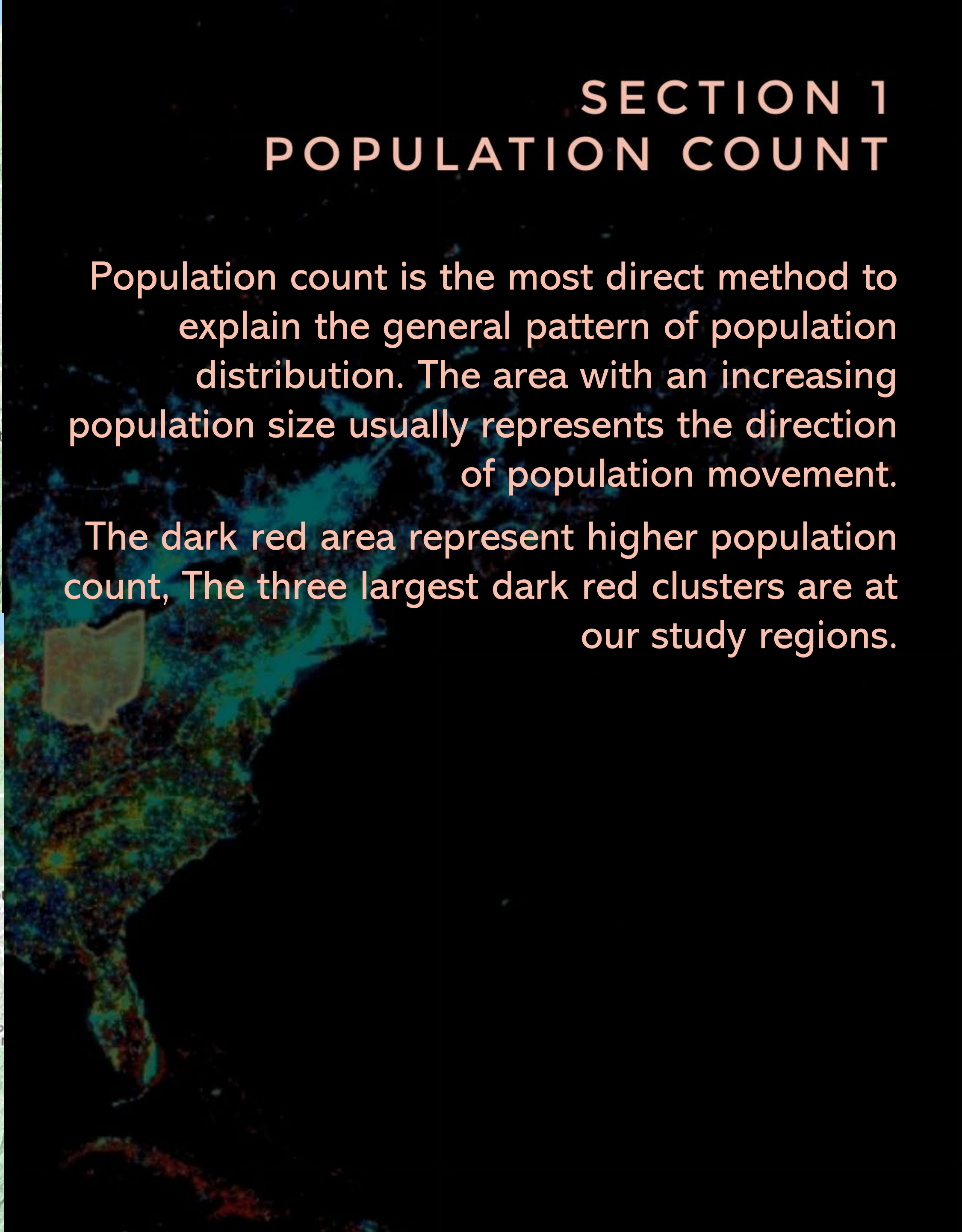


2010



Major Cities

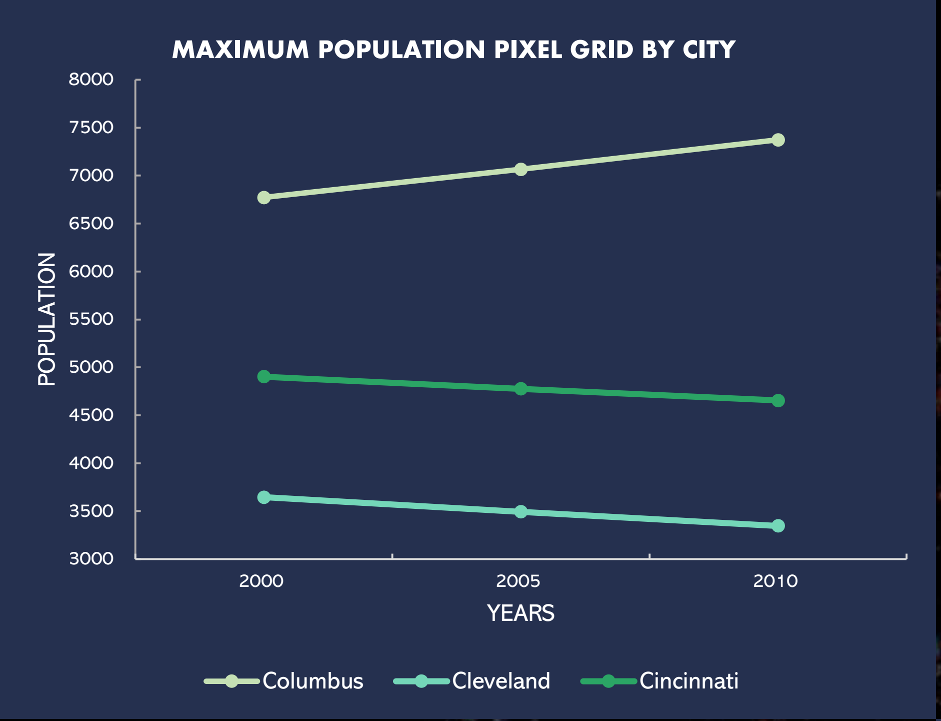
SECTION 1
POPULATION COUNT

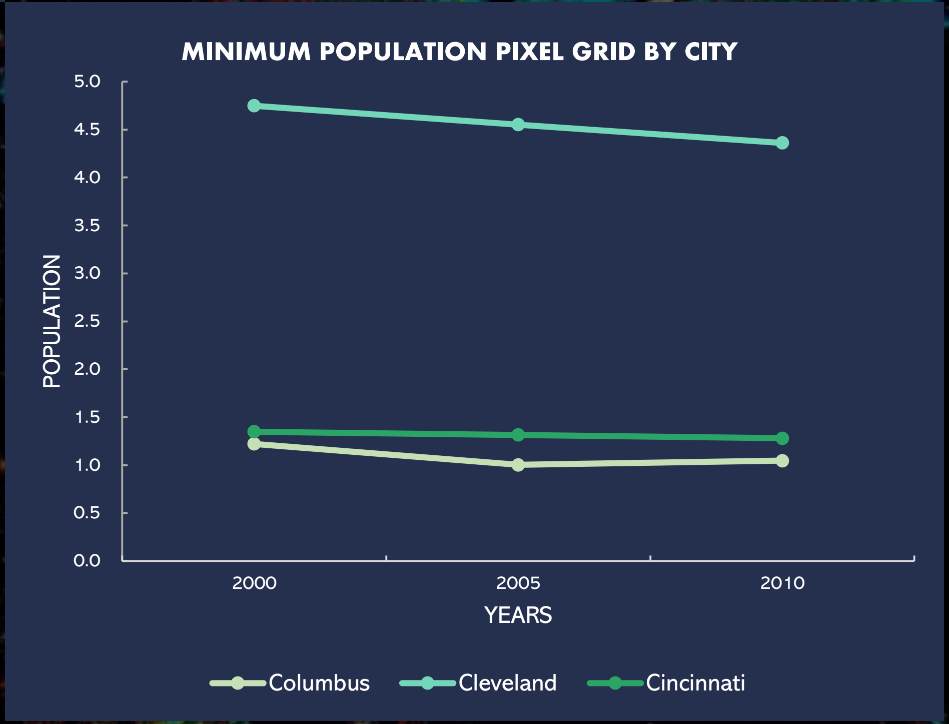


Population count is the most direct method to explain the general pattern of population distribution. The area with an increasing population size usually represents the direction of population movement.

The dark red area represent higher population count, The three largest dark red clusters are at our study regions.

SECTION 1
POPULATION COUNT

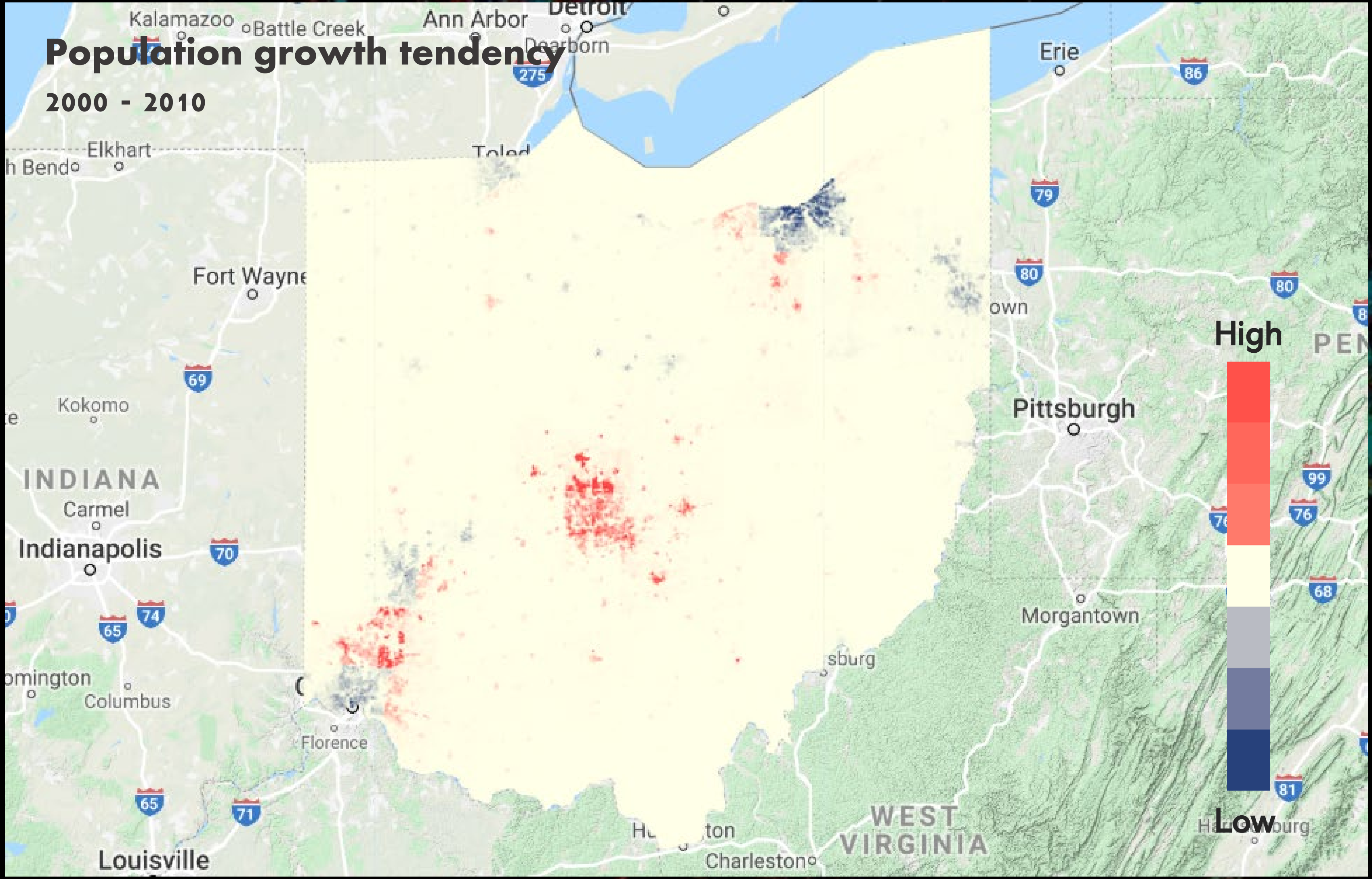




The pixel grids with the largest and smallest population counts represent the ground and celling of population size in each city. The lowest population counts in Columbus and Cincinnati are quite close, but for Cleveland, each grid has at least 4 population. The total differences between maximum and minimum values in Cleveland is also smaller than that of other two cities.

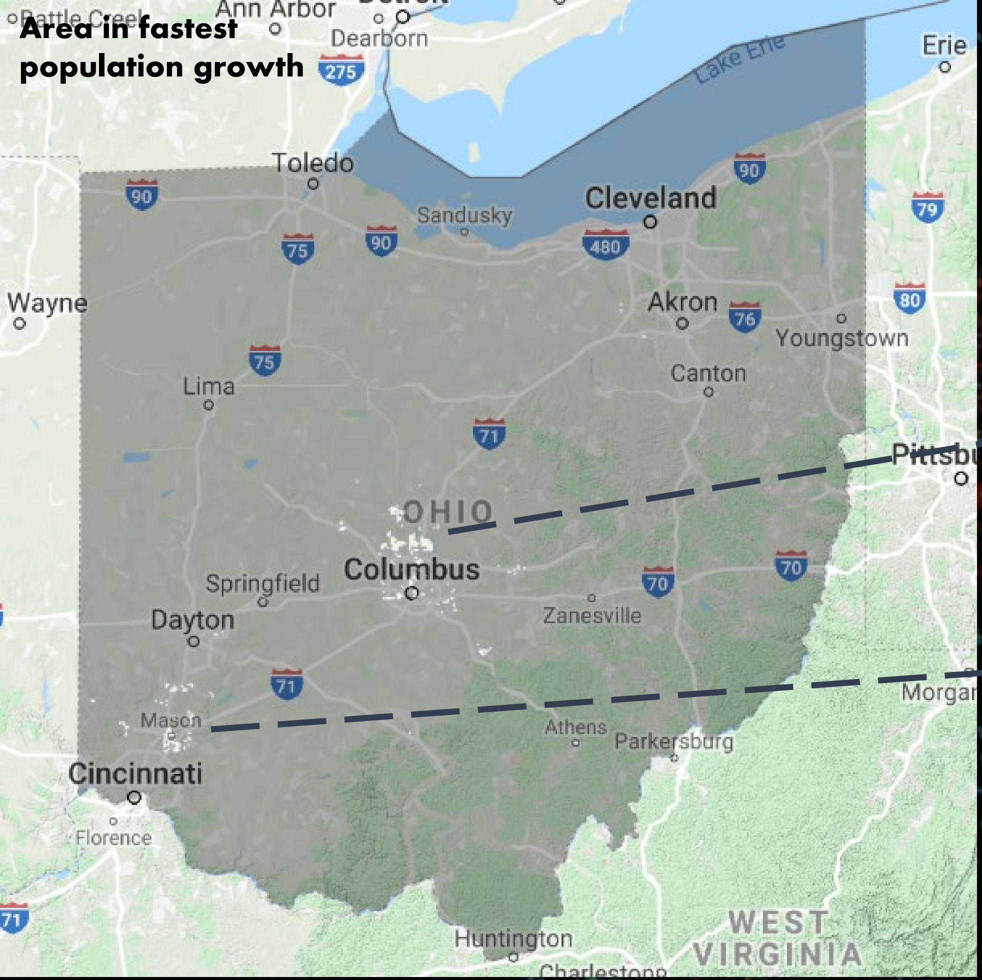
Therefore, Columbus has the greatest population differences, and population is more eventually distributed in Cleveland.

SECTION 1
POPULATION COUNT



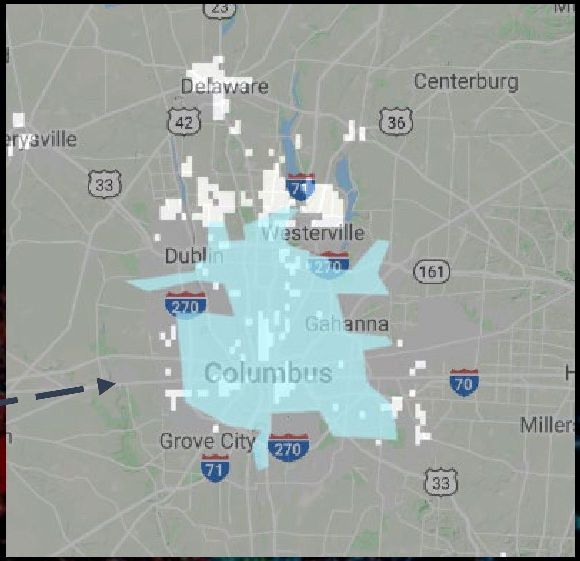
The linear fit shows the trends of population growth from 2000 to 2010. The dark red indicates the areas were in a higher growth rate, and the blue indicates the area was in negative growth, or in other words, experienced population loss.

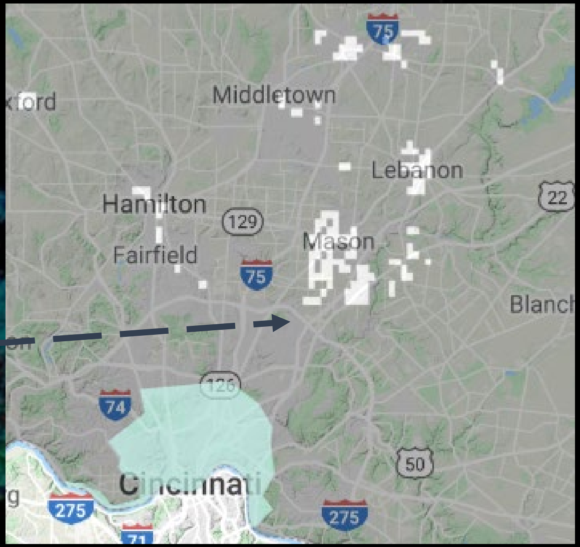
SECTION 1
POPULATION COUNT



Area in fastest population growth

Fastest Growth: Area with more than 15 growth rate





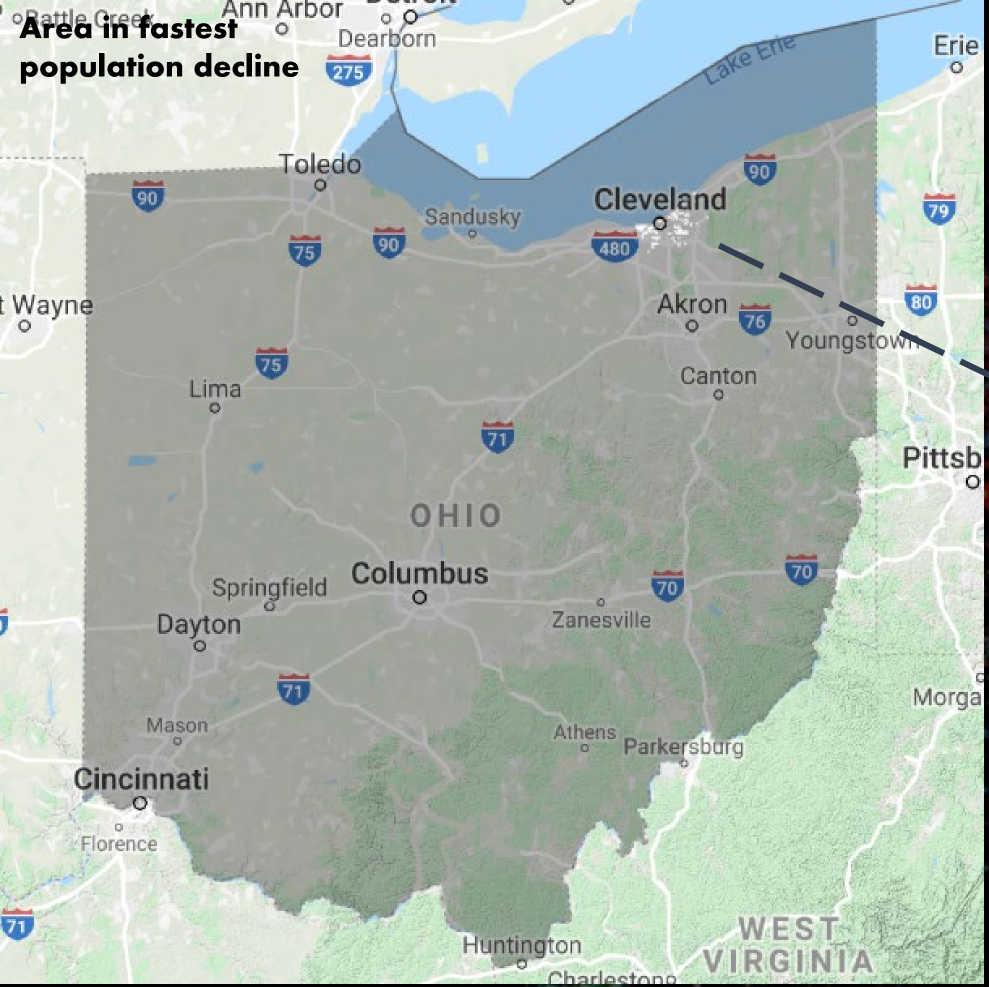
Central Ohio

The northern and central parts gain the highest growth rates. Dublin and Westerville, the two suburbs of Columbus, are more remarkable due to the great economic developments over the past years.

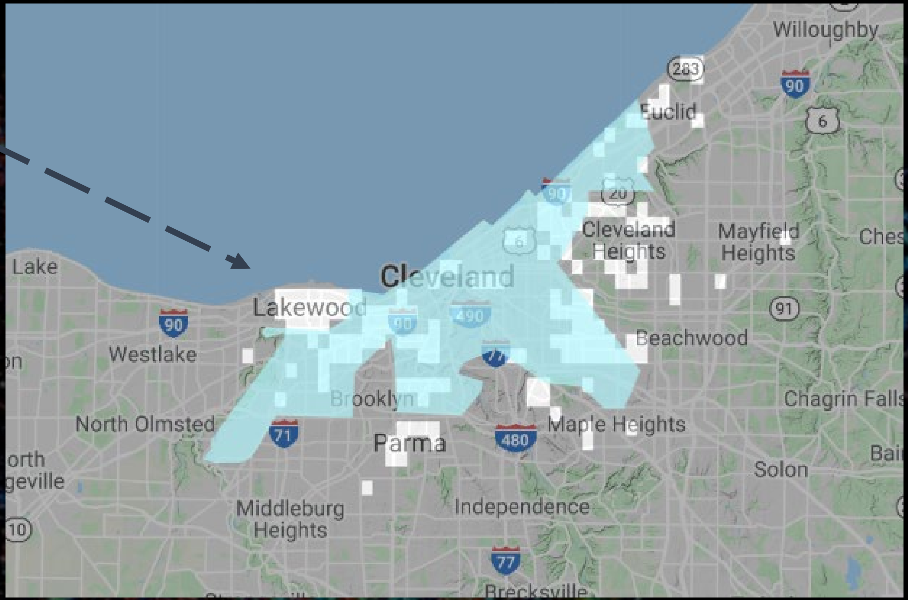
Southwest Ohio

The outskirts experienced small-scale population growth, but the distribution is fragmented. The growth is around the city Mason. The Kings Island amusement park and the world's largest tennis center effectively promote the local developments and indirectly raise the local population.

SECTION 1
POPULATION COUNT



Fastest Decline: Area with less than -15 growth rate

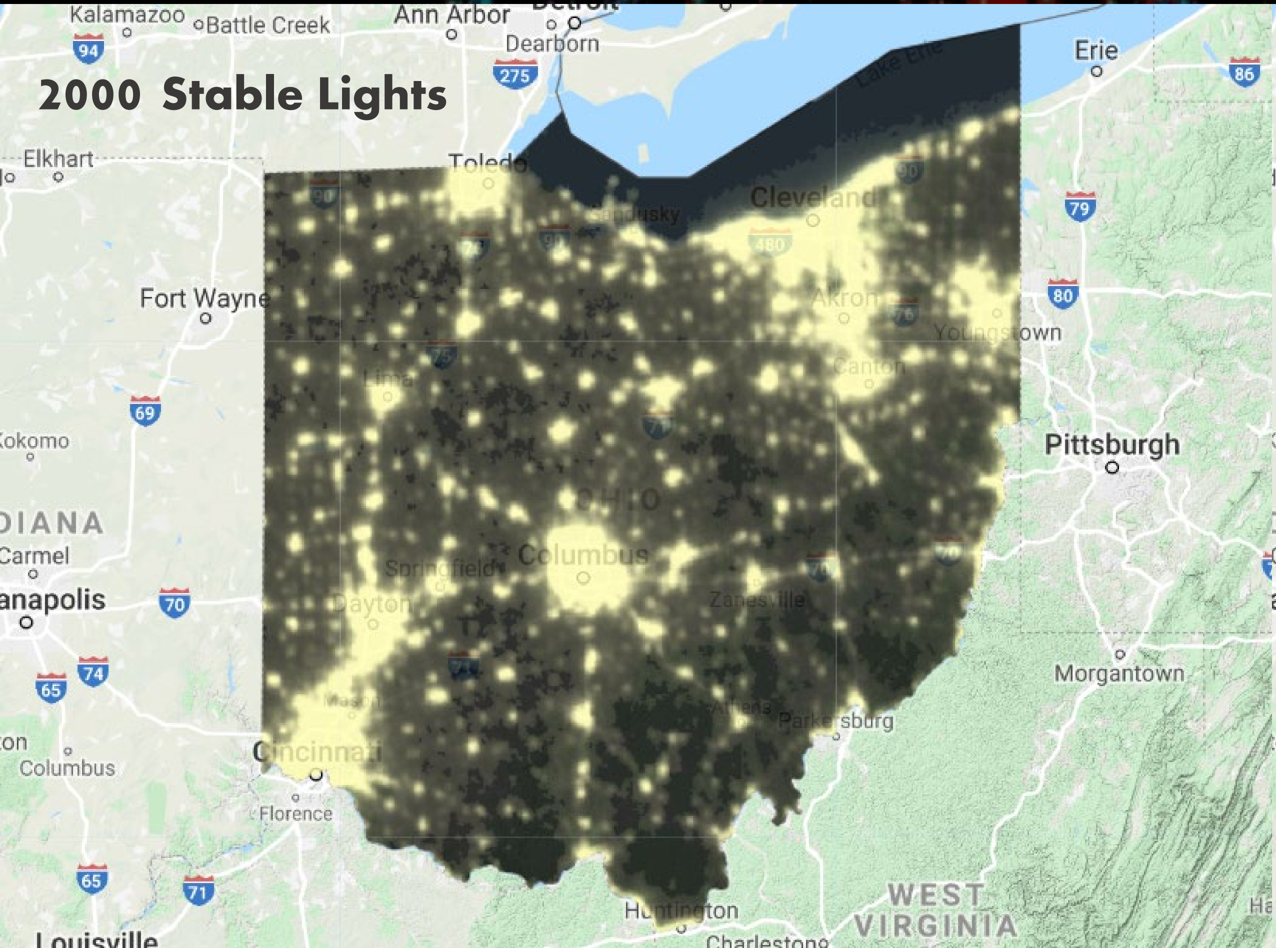


Central and Western Lake Erie Area

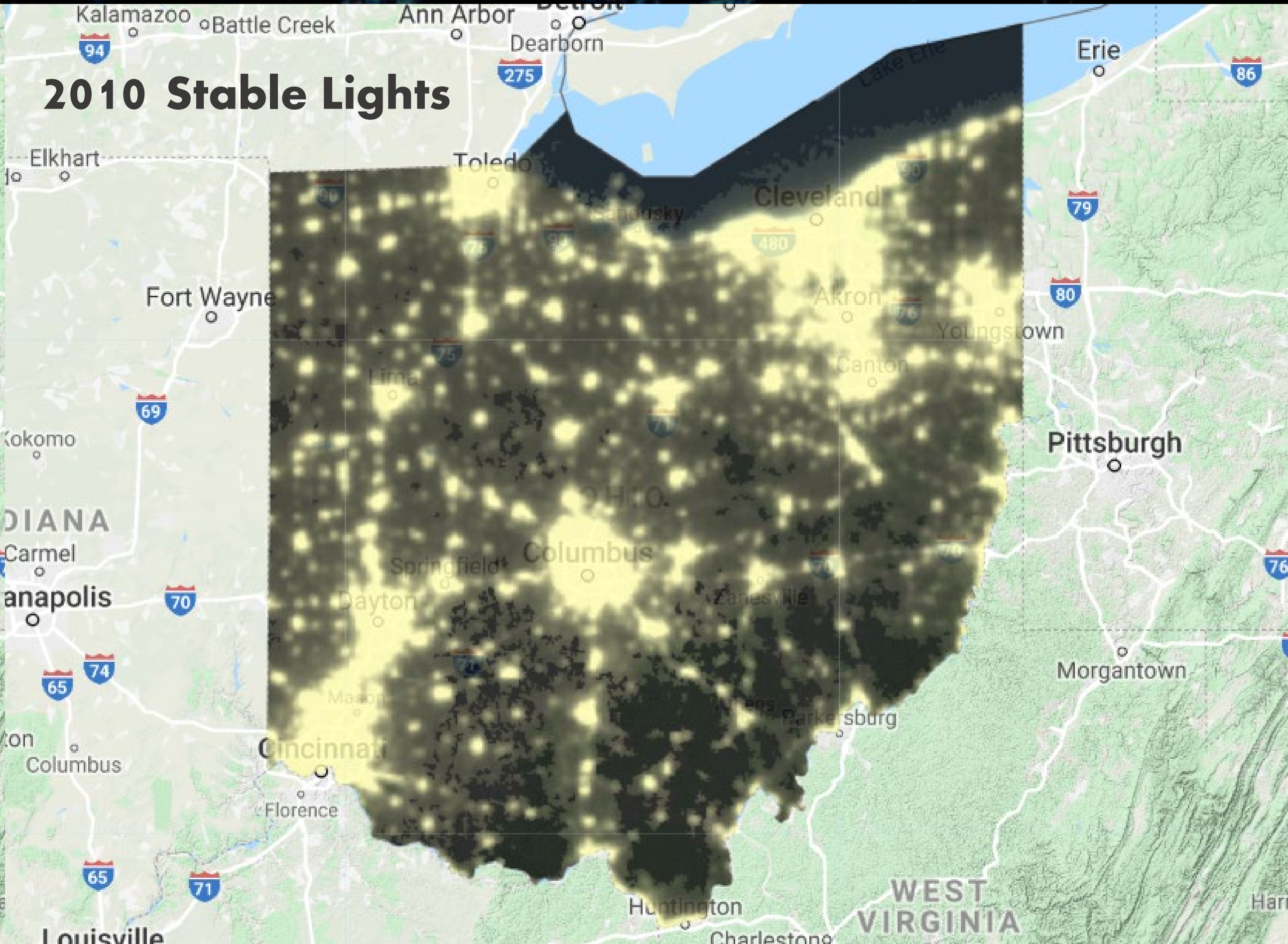
It is the only region experienced pure population loss, and all the remarkable changes took place at or around Cleveland. The city surrounding areas also experienced a certain degree of population loss, but not as significant as the loss in the city.

SECTION 2
NIGHTTIME LIGHTS

Stable nighttime lights identify the distribution of built-up areas, people's settlements and regional dynamic.

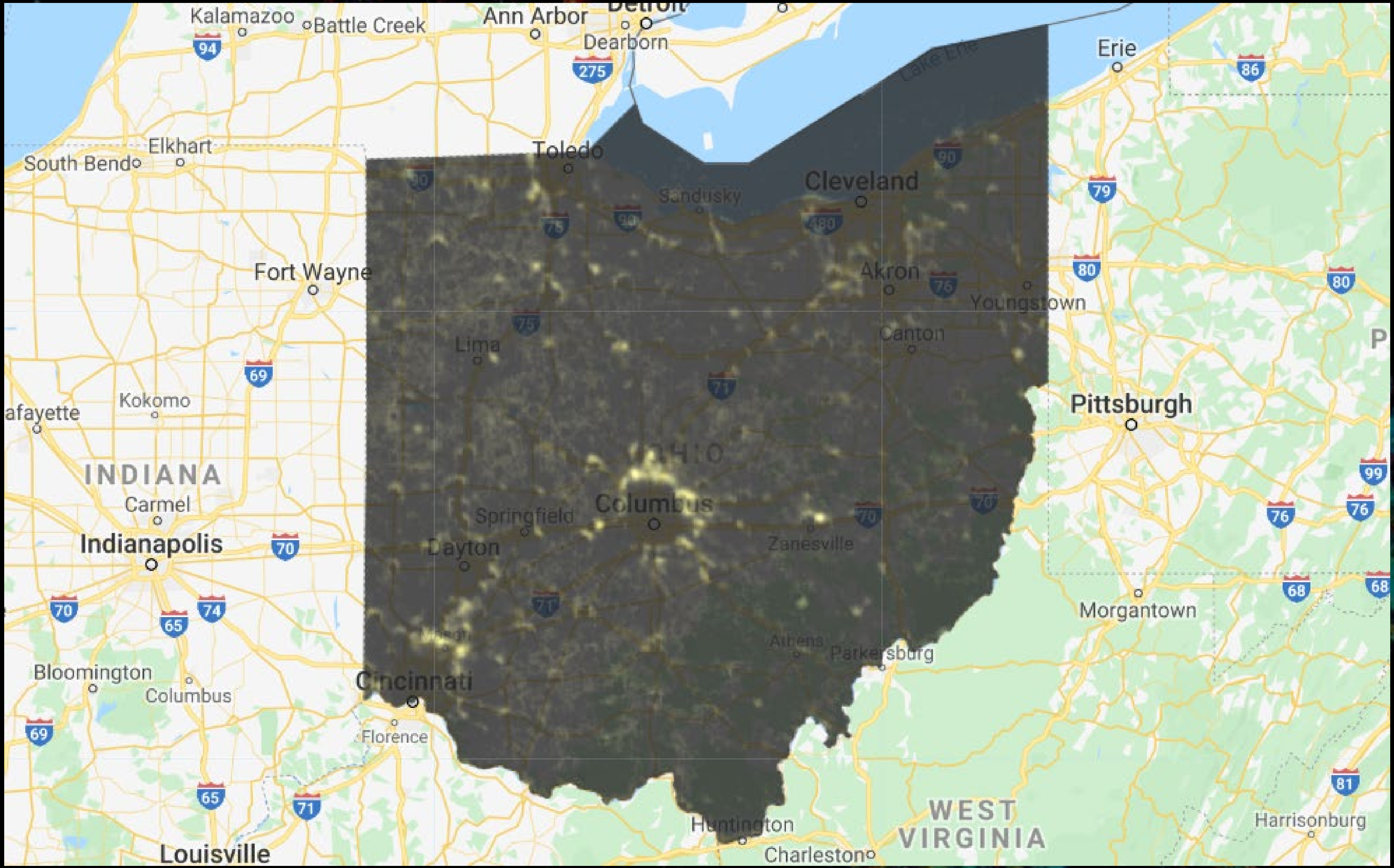


2000 Stable Lights



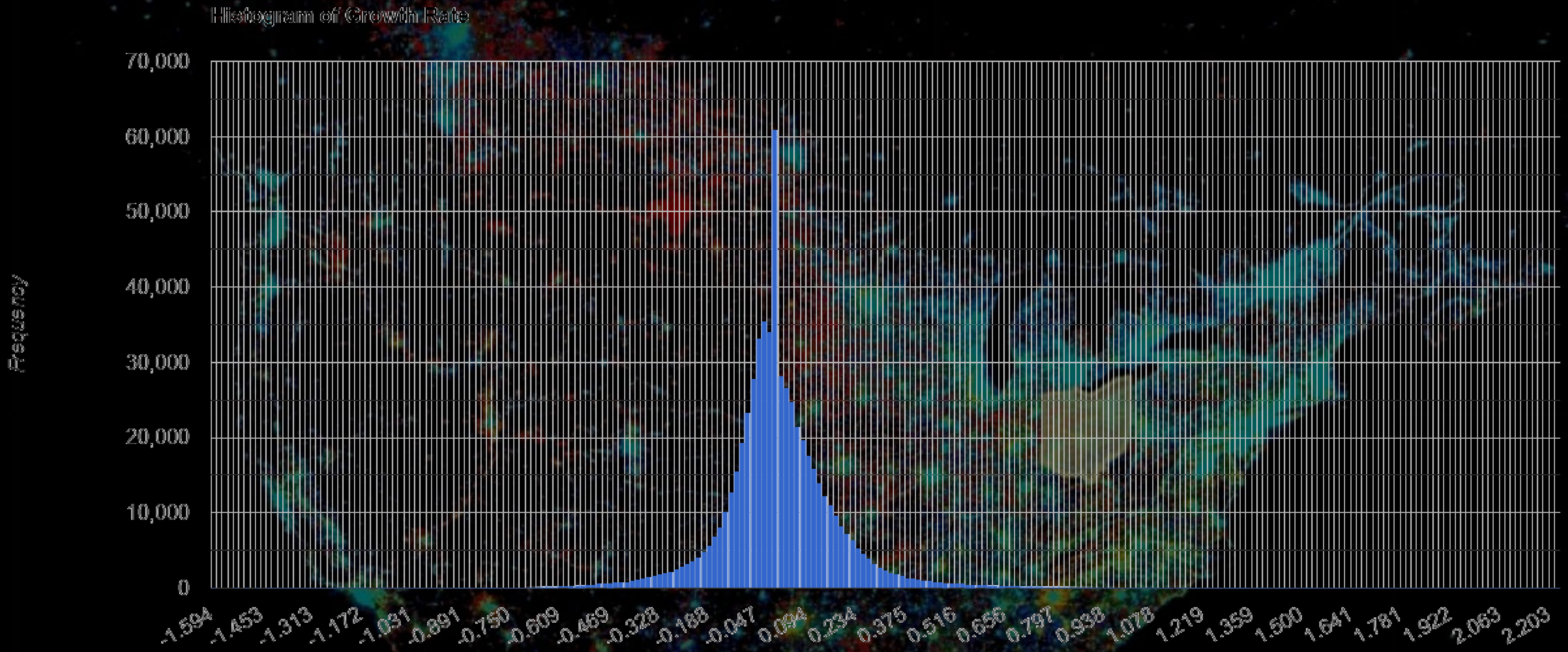
2010 Stable Lights

SECTION 2
NIGHTTIME LIGHTS



The areas experienced the growth of stable lights from 2000 to 2010 are highlighted, and one can observe that mostly the highlights are surrounding the major urban areas. The highlights indicates the new urban expansion, and it shows the urban outskirts at Central Ohio region experienced more expansion.

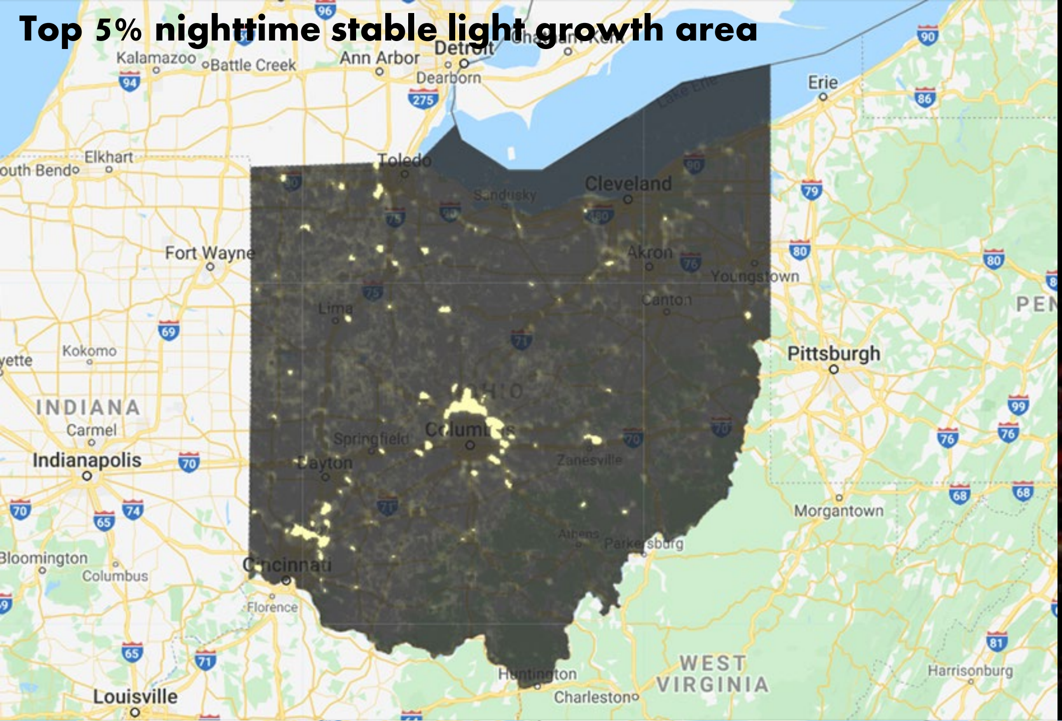
SECTION 2
NIGHTTIME LIGHTS

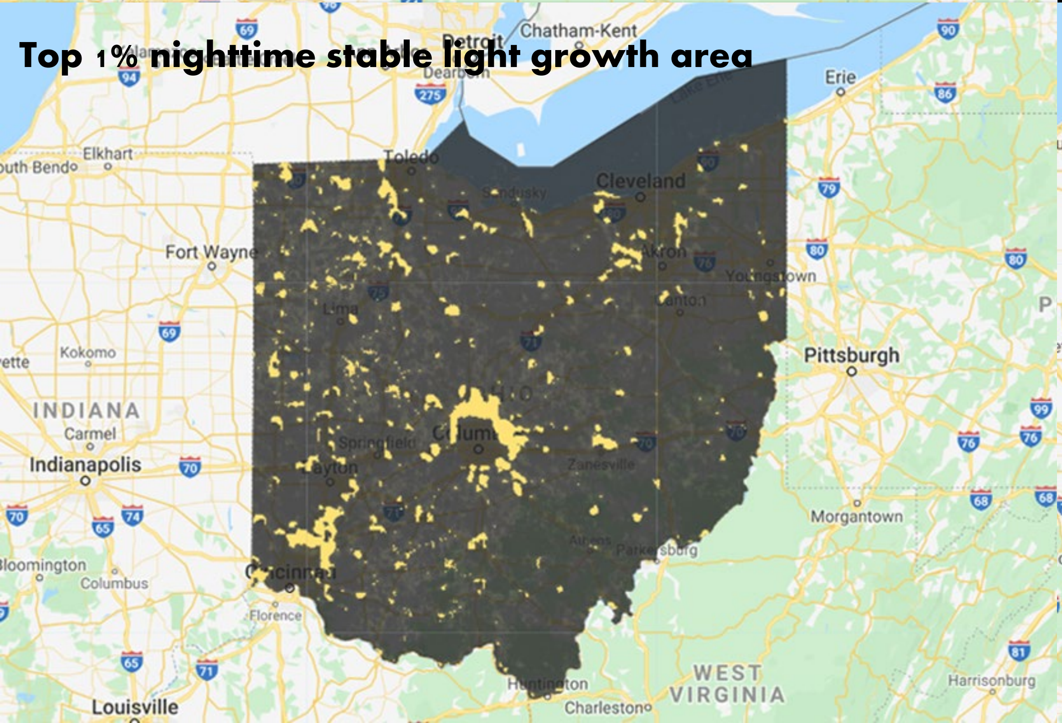


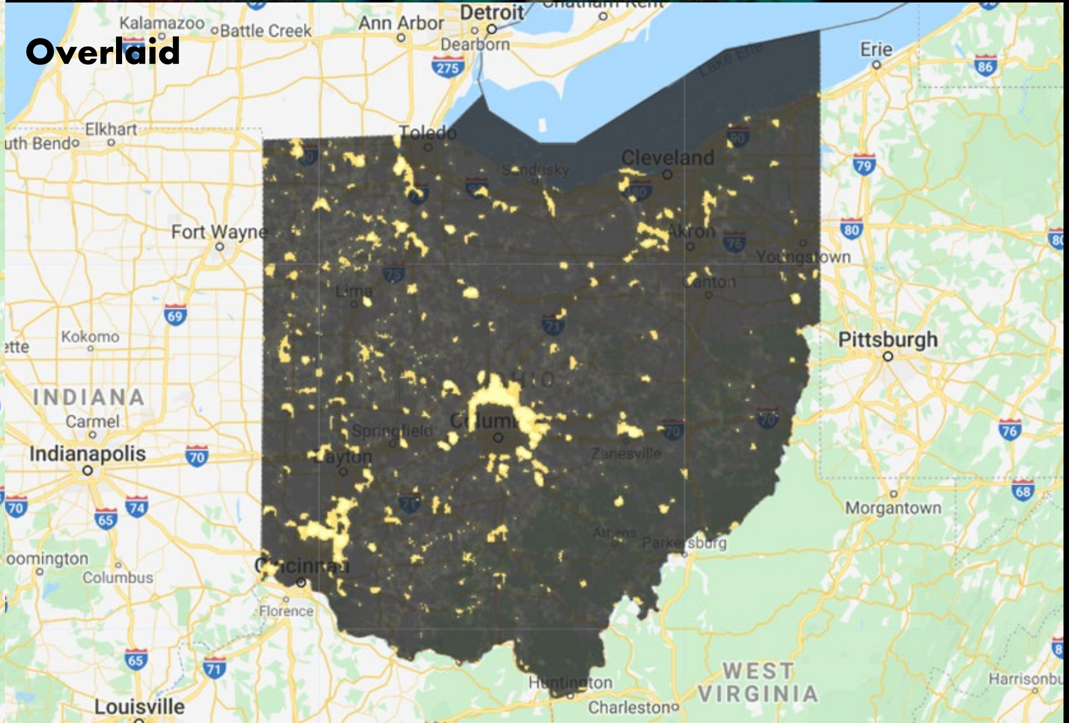
The plot shows the distribution of stable nighttime light growth rates, and it helps to decide the cut-off of choosing the area with the highest growth rate. According to the plot, it seems like more areas experienced negative stable light growth.

SECTION 2
NIGHTTIME LIGHTS

Most of the top 5% growth area is overlapped with the highlighted area in the map of the overall growth, but in the map of the top 1% growth area, the highlighted areas are more concentrated around the Columbus. The comparison indicates that the surroundings of Columbus experienced the highest degree of urbanization over the 10 years.


Top 5% nighttime stable light growth area


Top 1% nighttime stable light growth area


Overlaid

SECTION 3
SETTLEMENTS

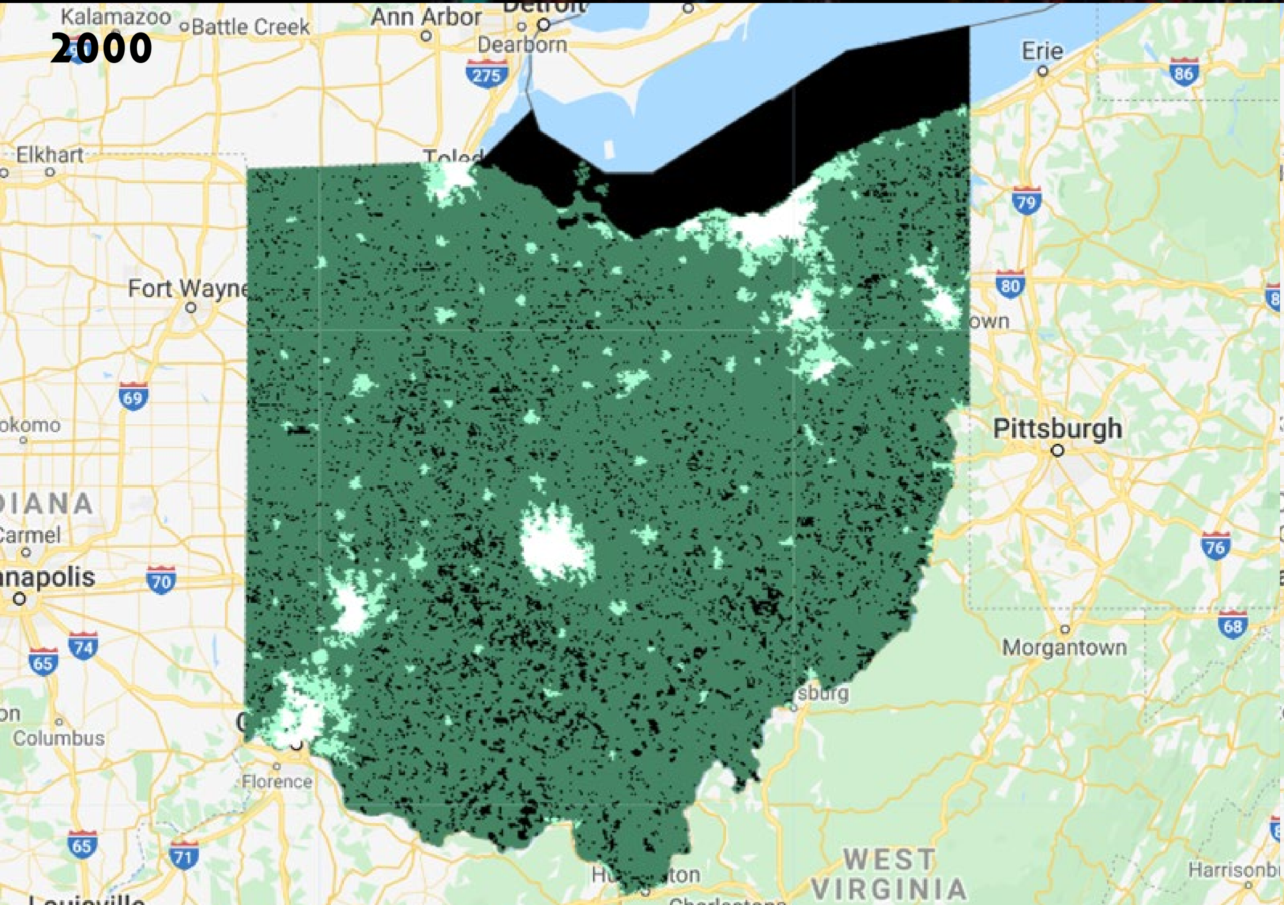
Finally, we want to see whether the high populated and more urbanized regions correspond to the area with dense settlements. Due to the limitation of the dataset, this section we use the human settlements data in 2000 and 2015. Data in 2015 is not able to fully explain the fact of 2010, so it is just a reference for the overall population movements.

⬜ HDC (high density clusters)

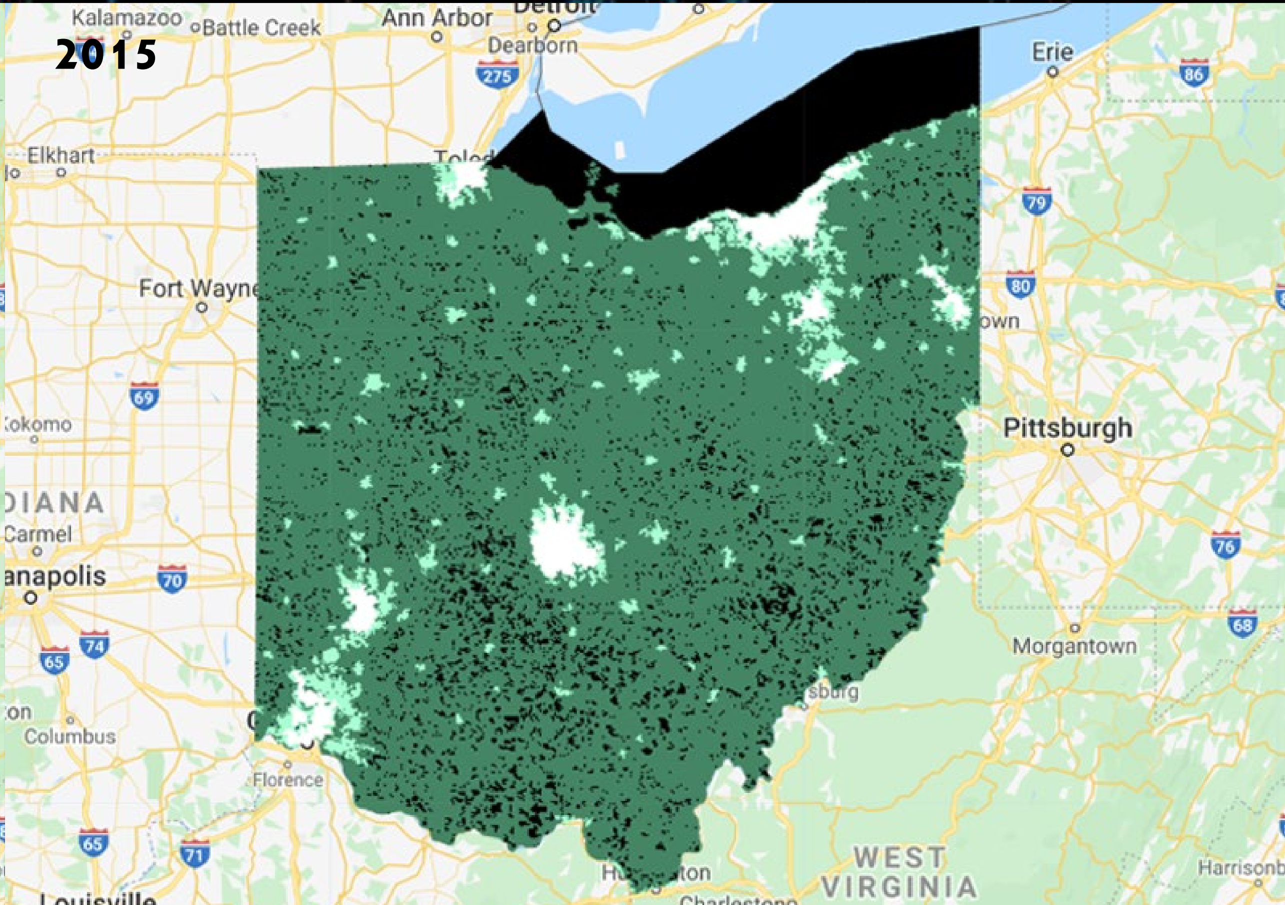
🟩 LDC (low density clusters)

🟩 Rural Areas

⬛ Inhabited Areas

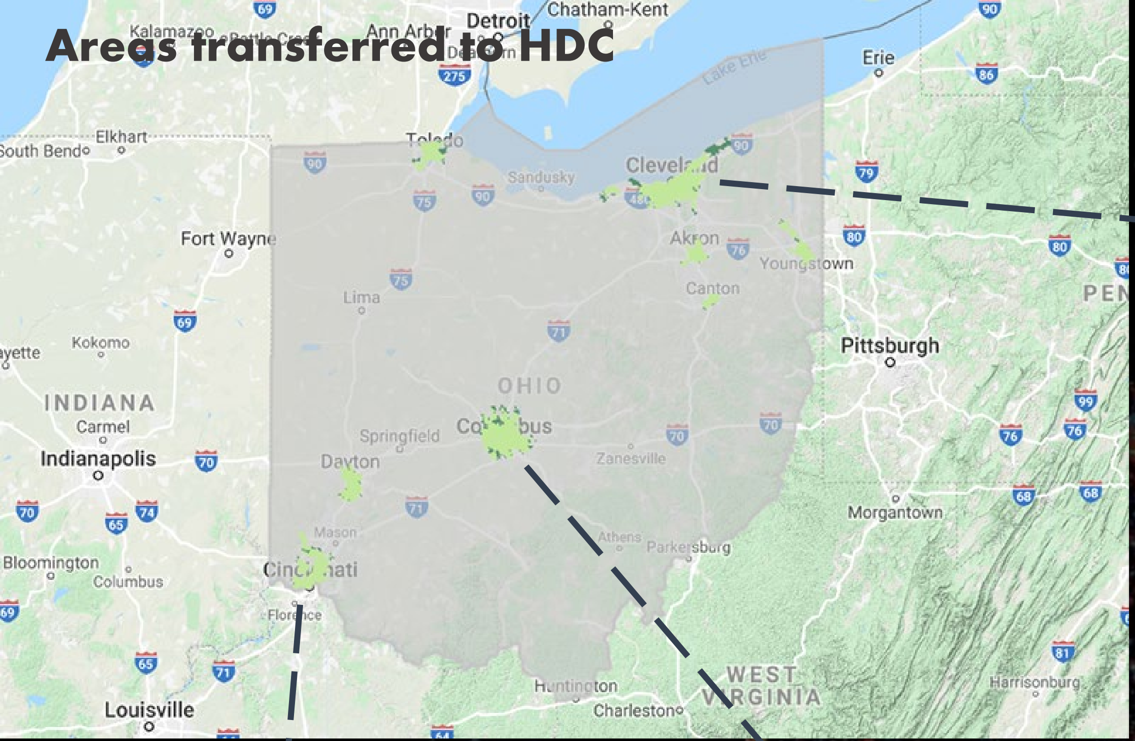


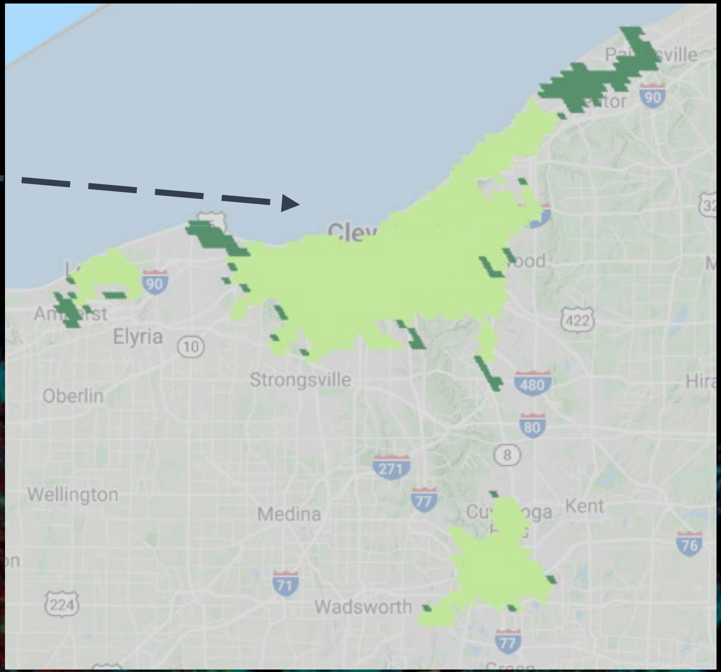
2000

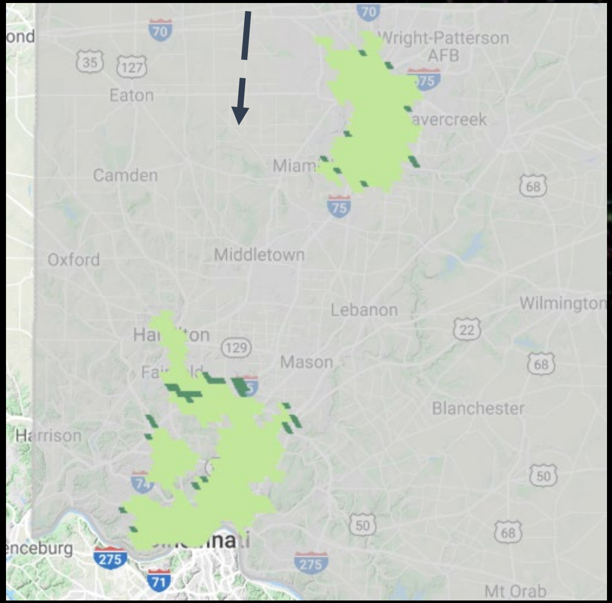


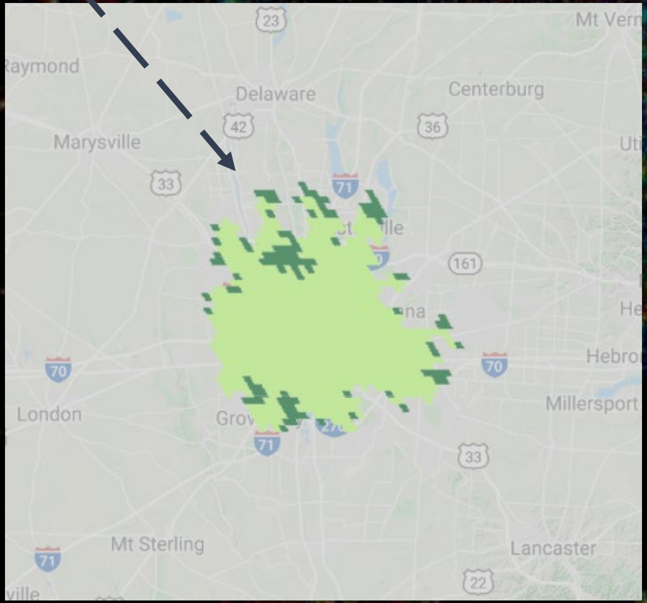
SECTION 3 SETTLEMENTS

Areas transferred to HDC









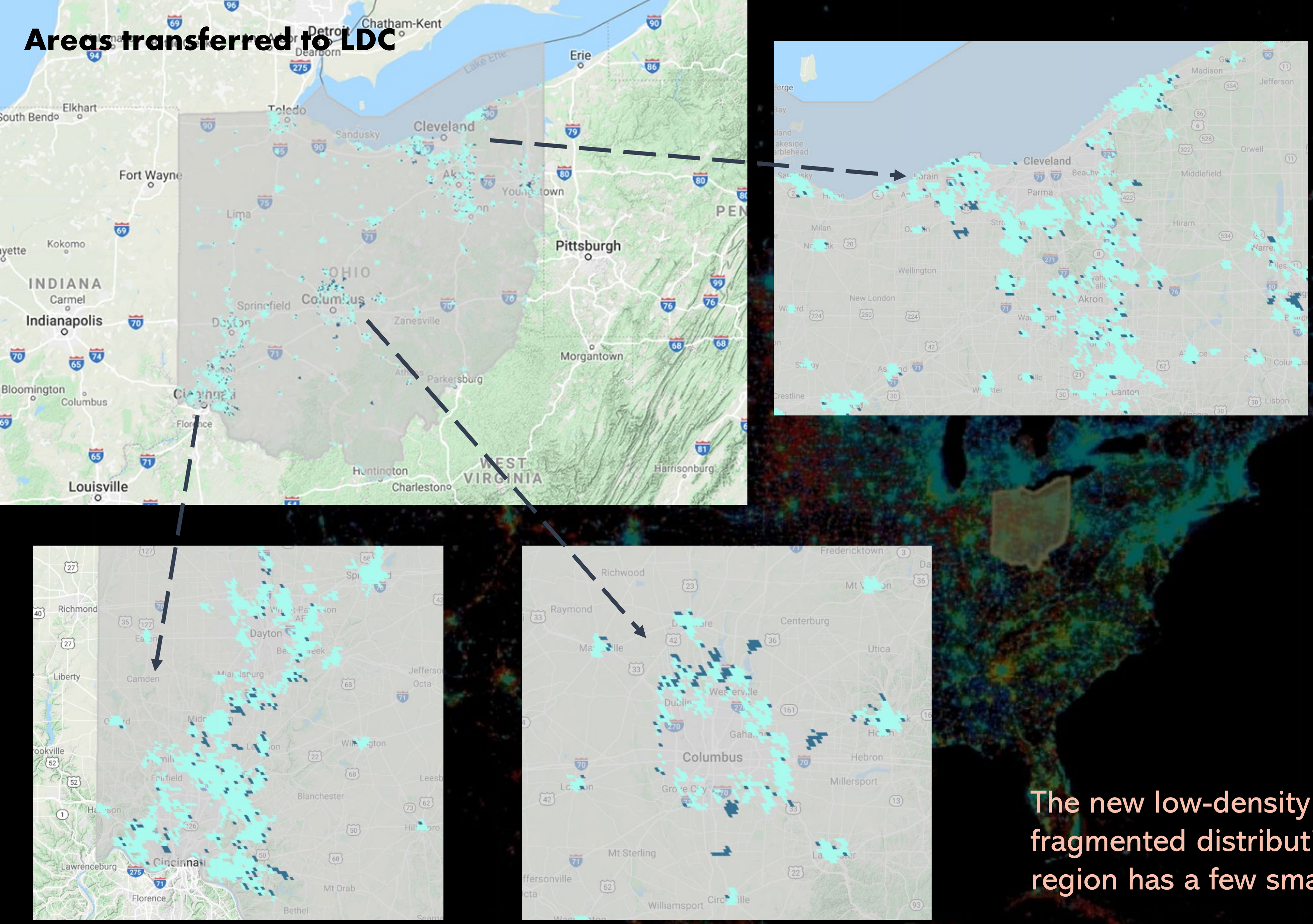
🟩 HDC 2000

🟩 New LDC 2015

The high-density settlements are in an outward expansion. Southwest Ohio has the smallest changes.

SECTION 3
SETTLEMENTS

Areas transferred to LDC

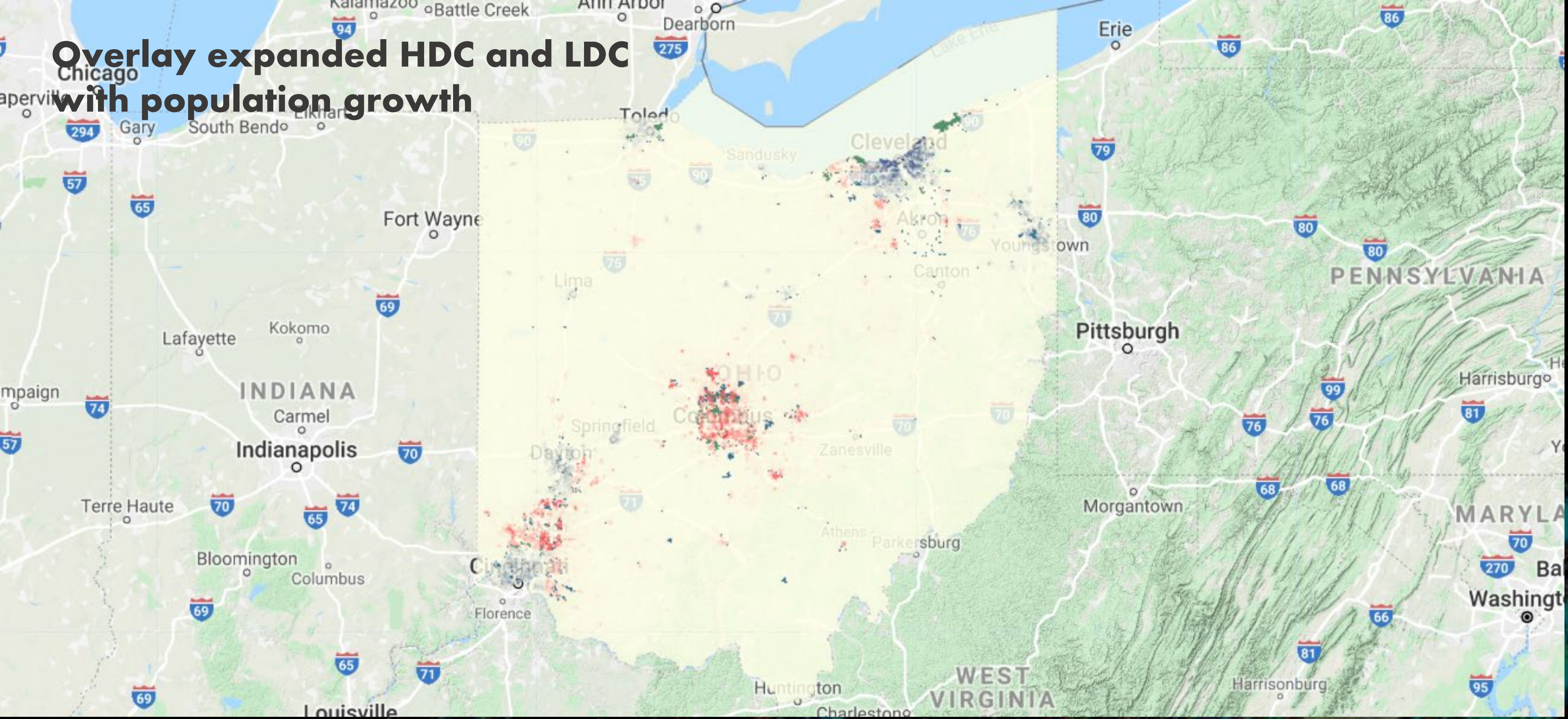


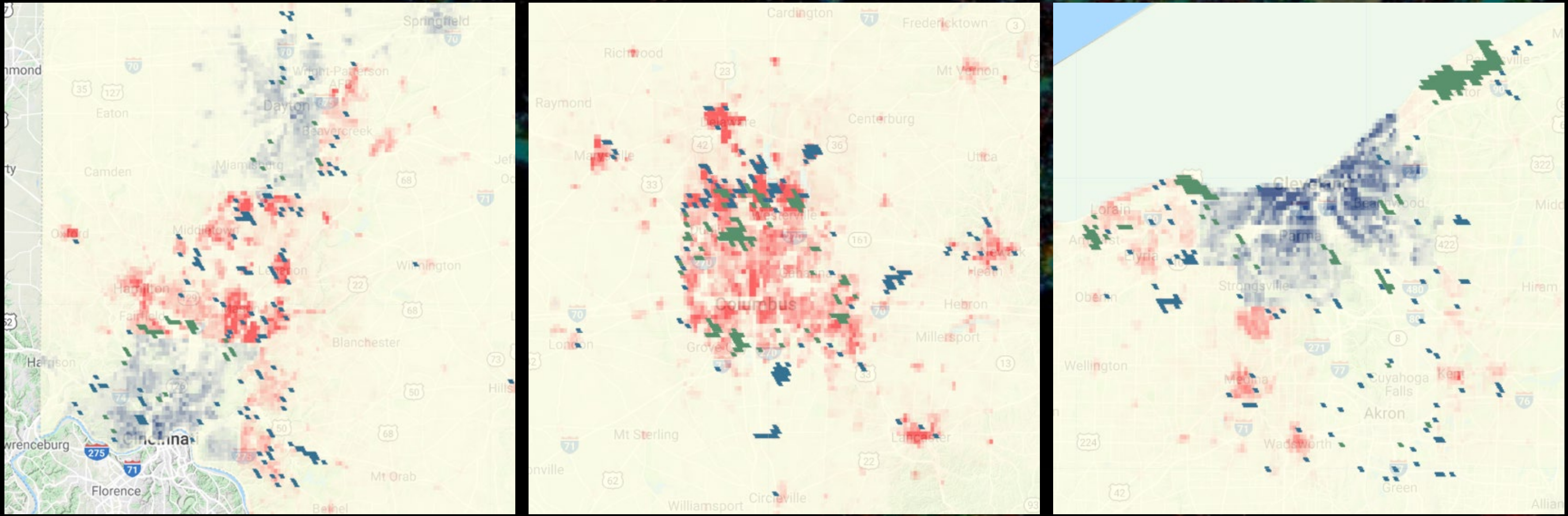
■ LDC 2000

■ New LDC 2015

The new low-density settlements are in a fragmented distribution. Central Ohio region has a few small clusters pattern.

Overlay expanded HDC and LDC with population growth



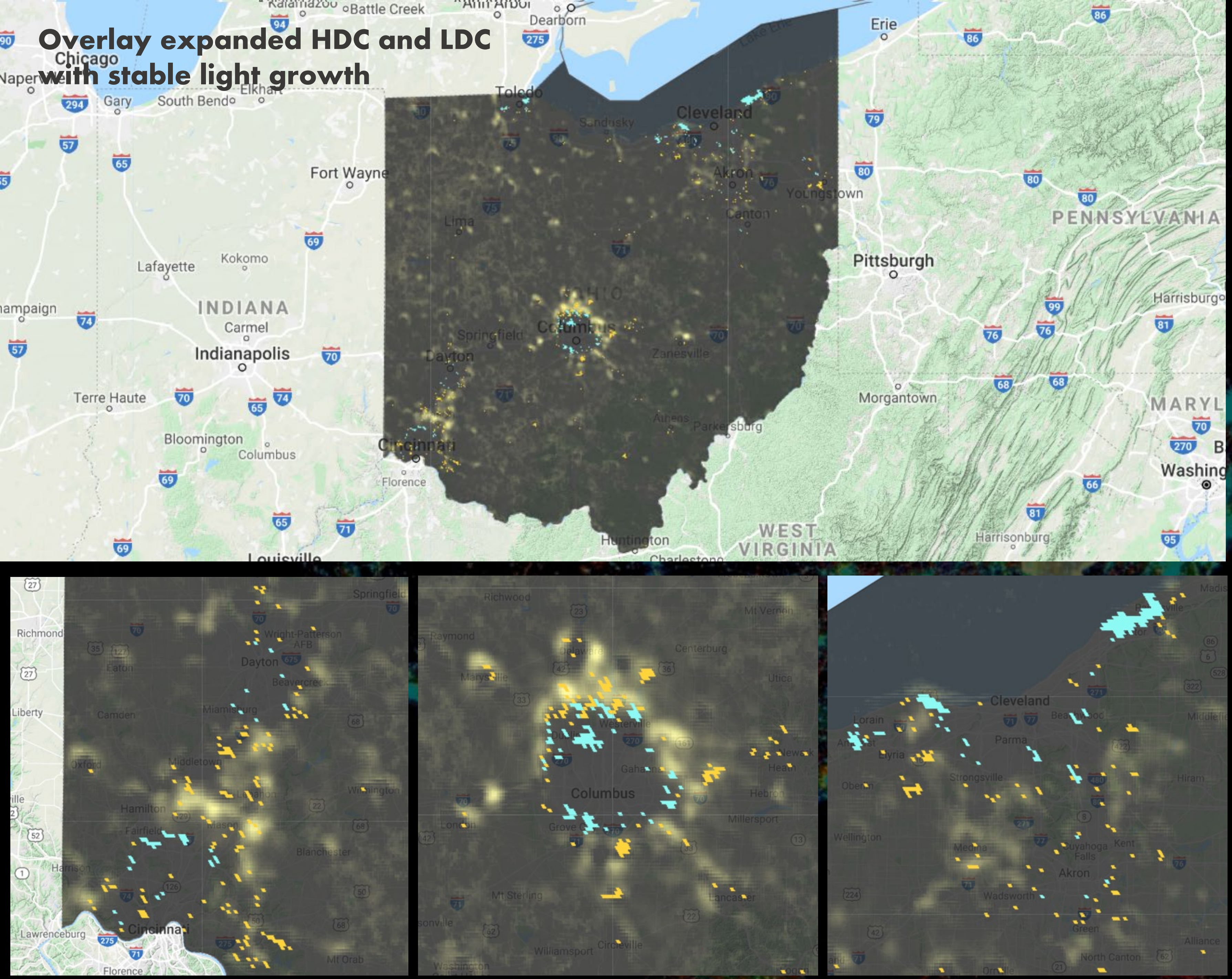


Generally, the areas in the high population growth rate are covered by the newly emerged settlement clusters. The overlaid pattern in Southwest Ohio and Central Ohio is more significant.

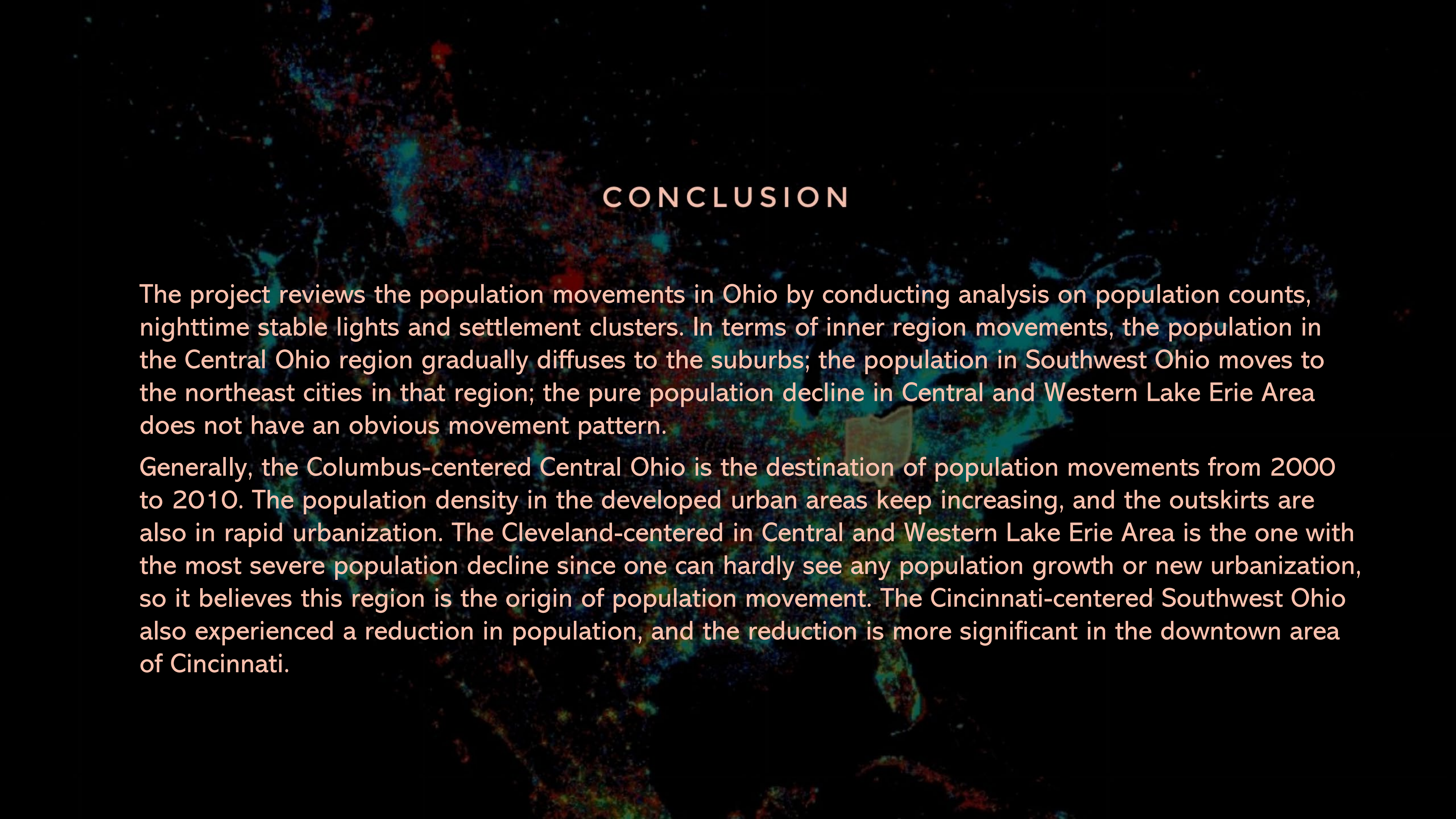
The population growth rate in Central and Western Lake Erie Area does not fully correspond to the new emerged clusters.

SECTION 3 SETTLEMENTS

Overlay expanded HDC and LDC with stable light growth



Areas in increasing stable lights do not have a strong relationship with newly emerged settlement clusters. Instead, many new clusters appear in the region with brighter stable lights. It indicates that more people move to the existed urban constructed areas. The population density is in an increasing tendency.



CONCLUSION

The project reviews the population movements in Ohio by conducting analysis on population counts, nighttime stable lights and settlement clusters. In terms of inner region movements, the population in the Central Ohio region gradually diffuses to the suburbs; the population in Southwest Ohio moves to the northeast cities in that region; the pure population decline in Central and Western Lake Erie Area does not have an obvious movement pattern.

Generally, the Columbus-centered Central Ohio is the destination of population movements from 2000 to 2010. The population density in the developed urban areas keep increasing, and the outskirts are also in rapid urbanization. The Cleveland-centered in Central and Western Lake Erie Area is the one with the most severe population decline since one can hardly see any population growth or new urbanization, so it believes this region is the origin of population movement. The Cincinnati-centered Southwest Ohio also experienced a reduction in population, and the reduction is more significant in the downtown area of Cincinnati.

REFERENCE

Center of Family and Demographic Research. (2006). Ohio Population News: Migration in Ohio. *Bowling Green State University.*

Pham, H. M., Yamaguchi, Y., & Bui, T. Q. (2011). A case study on the relation between city planning and urban growth using remote sensing and spatial metrics. *Landscape and Urban Planning*, *100*(3), 223-230.

Muller, E. K. (1977). Regional urbanization and the selective growth of towns in North American regions. *Journal of Historical Geography*, *3*(1), 21-39.

Previous Project of LARP 743:
Qu, Ge. The Evolution of Megaretions in China.
Lin, Lufeng. US Urbanization Expanding & Shrinking.

GEE SCRIPTS

https://code.earthengine.google.com/e521d82e9c81b7a92585759d45e77e4e

```
// define state boundary, and three major cities
var USstates = ee.FeatureCollection('TIGER/2016/States');
var Ohio = USstates.filter(ee.Filter.eq('NAME','Ohio’));
// *(!!!!!need to import geometry code from the last page!!!!!!)
var Columbus = /* color: #69b3ff */geometry,
    Cleveland = /* color: #c331ff */geometry2,
    Cincinnati = /* color: #1202ff */geometry3;
Map.centerObject(Ohio, 7);
Map.addLayer(Ohio, {color:'C6C5C5'}, "Ohio");

// SECTION 1 Population Count

// https://developers.google.com/earth-engine/datasets/catalog/CIESIN_GPWv411_GPW_Population_Count
var popCount = ee.ImageCollection("CIESIN/GPWv411/GPW_Population_Count");
//Convert the image collection to a list and get the images for 2000 2005, and 2010
var popList = popCount.toList(5,0);
var pop2000 = ee.Image(popList.get(0)).clip(Ohio);
var pop2005 = ee.Image(popList.get(1)).clip(Ohio);
var pop2010 = ee.Image(popList.get(2)).clip(Ohio);
```

```
var densityVis = {max:1000,
                  palette:
["ffffe7","FFc869","ffac1d","e17735","f2552c","9f0c21"],
                  min: 200};

Map.addLayer(pop2000, densityVis, "popCount2000");
Map.addLayer(pop2005, densityVis, "popCount2005");
Map.addLayer(pop2010, densityVis, "popCount2010");

// find the max and min population of each year
var maxReducer = ee.Reducer.max();
var minReducer = ee.Reducer.min();

var filter_2000 = pop2000.gt(1);
var no_zero_2000 = pop2000.mask(filter_2000);

var filter_2005 = pop2005.gt(1);
var no_zero_2005 = pop2005.mask(filter_2005);

var filter_2010 = pop2010.gt(1);
var no_zero_2010 = pop2010.mask(filter_2010);

var col_Max_2000 = pop2000.reduceRegion(maxReducer, Columbus);
var col_Min_2000 = no_zero_2000.reduceRegion(minReducer, Columbus);
var col_Max_2005 = pop2005.reduceRegion(maxReducer, Columbus);
var col_Min_2005 = no_zero_2005.reduceRegion(minReducer, Columbus);
```

GEE SCRIPTS

```
var col_Max_2010 = pop2010.reduceRegion(maxReducer,
Columbus);
var col_Min_2010 = no_zero_2010.reduceRegion(minReducer,
Columbus);

print('Columbus 2000 Max', col_Max_2000, 'Columbus 2000 Min',
col_Min_2000,
      'Columbus 2005 Max', col_Max_2005, 'Columbus 2005 Min',
col_Min_2005,
      'Columbus 2010 Max', col_Max_2010, 'Columbus 2010 Min',
col_Min_2010);

var cle_Max_2000 = pop2000.reduceRegion(maxReducer,
Cleveland);
var cle_Min_2000 = no_zero_2000.reduceRegion(minReducer,
Cleveland);
var cle_Max_2005 = pop2005.reduceRegion(maxReducer,
Cleveland);
var cle_Min_2005 = no_zero_2005.reduceRegion(minReducer,
Cleveland);
var cle_Max_2010 = pop2010.reduceRegion(maxReducer,
Cleveland);
var cle_Min_2010 = no_zero_2010.reduceRegion(minReducer,
Cleveland);
```

```
print('Cleveland 2000 Max', cle_Max_2000, 'Cleveland 2000 Min',
cle_Min_2000,
      'Cleveland 2005 Max', cle_Max_2005, 'Cleveland 2005 Min',
cle_Min_2005,
      'Cleveland 2010 Max', cle_Max_2010, 'Cleveland 2010 Min',
cle_Min_2010);

var cin_Max_2000 = pop2000.reduceRegion(maxReducer, Cincinnati);
var cin_Min_2000 = no_zero_2000.reduceRegion(minReducer,
Cincinnati);
var cin_Max_2005 = pop2005.reduceRegion(maxReducer, Cincinnati);
var cin_Min_2005 = no_zero_2005.reduceRegion(minReducer,
Cincinnati);
var cin_Max_2010 = pop2010.reduceRegion(maxReducer, Cincinnati);
var cin_Min_2010 = no_zero_2010.reduceRegion(minReducer,
Cincinnati);
print('Cincinnati 2000 Max', cin_Max_2000, 'Cincinnati 2000 Min',
cin_Min_2000,
      'Cincinnati 2005 Max', cin_Max_2005, 'Cincinnati 2005 Min',
cin_Min_2005,
      'Cincinnati 2010 Max', cin_Max_2010, 'Cincinnati 2010 Min',
cin_Min_2010);

// general population growth pattern in Ohio State
function createTimeBand(img) {
  var year = img.date().difference(ee.Date('2000-01-01'), 'year');
  return ee.Image(year).float().addBands(img);
}
```

GEE SCRIPTS

```
// Map out the area by growth rate
Map.addLayer(pop_fit,
            {min: -20, max: 20, bands: ['scale'],palette: ['27417b',
'ffffe7', 'ff4343']},
            'population growth trend');

// Select top population growth area and the least growth area
(population loss area)
var top_growth_area = pop_fit.select(['scale']).gte(15);
var least_growth = pop_fit.select(['scale']).lte(-15);
Map.addLayer(top_growth_area,{opacity:0.3}, "top_growth");
Map.addLayer(least_growth,{opacity:0.3}, "least_growth");


// SECTION 2 Nighttime Lights

var NightLight = ee.ImageCollection('NOAA/DMSP-
OLS/NIGHTTIME_LIGHTS');
//Convert the image collection to a list and get the images for
2000 and 2010
var lightsList = NightLight.toList(35,0);
var light2000 = ee.Image(lightsList.get(12));
var light2010 = ee.Image(lightsList.get(31));
```

```
// select stable light
var stable_2000 = light2000.select(['stable_lights'],
['2000StableLight']).clip(Ohio);
var stable_2010 = light2010.select(['stable_lights'],
['2010StableLight']).clip(Ohio);

//Map.centerObject(Ohio, 7);
Map.addLayer(stable_2000, {min:0, max:55, palette: ["000000",
"fffcac"], opacity:0.8}, "stableLight2000");
Map.addLayer(stable_2010, {min:0, max:55, palette: ["000000",
"fffcac"], opacity:0.8},  "stableLight2010");

function createTimeBand(img) {
  var year = img.date().difference(ee.Date('2000-01-01'), 'year');
  return ee.Image(year).float().addBands(img);
}

// Fit a linear trend to the nighttime lights collection.
var light_collection = ee.ImageCollection('NOAA/DMSP-
OLS/NIGHTTIME_LIGHTS')
    .select('stable_lights')
    .map(createTimeBand);
var light_fit =
light_collection.reduce(ee.Reducer.linearFit()).select(["scale"],["Growth
Rate"]).clip(Ohio);
```

GEE SCRIPTS

```
// Map out the area by stable light growth rate
Map.addLayer(light_fit.select(["Growth Rate"]), {min:0, max:2,
palette: ["262626", "FFFB95"], opacity:0.8},
            'stable lights trend');

// firstly we need to find out the distirbution of growth rate
var lightgrowth_chart = ui.Chart.image.histogram(light_fit, Ohio,
500);
print("lightgrowth_chart", lightgrowth_chart);

// the top 5%
var percentileReducer_5 = ee.Reducer.percentile([95]);
var RatePercentile_5 =
light_fit.reduceRegion( percentileReducer_5, Ohio, 500, null, null,
true );
var theCutOff_5= ee.Number(RatePercentile_5.get("Growth
Rate"));
print('RatePercentile',RatePercentile_5);
//Mask out the rest 95% pixels
var top_5 = light_fit.mask(light_fit.gt(theCutOff_5));
//Map out the areas experienced top 1% fastest growth in
intensity of economic activities.
Map.addLayer(top_5, {palette: ["FFE276"]}, "top5%");

// the top 1%
var percentileReducer_1 = ee.Reducer.percentile([99]);
```

```
var RatePercentile_1 = light_fit.reduceRegion( percentileReducer_1,
Ohio, 500, null, null, true );
var theCutOff_1= ee.Number(RatePercentile_1.get("Growth Rate"));
print('RatePercentile',RatePercentile_1);
//Mask out the rest 99% pixels
var top_1 = light_fit.mask(light_fit.gt(theCutOff_1));
//Map out the areas experienced top 1% fastest growth in intensity of
economic activities.
Map.addLayer(top_1, {palette: ["FEFEB9"]}, "top1%");


// SECTION 3 Human Settlements

// https://developers.google.com/earth-
engine/datasets/catalog/JRC_GHSL_P2016_SMOD_POP_GLOBE_V1
var settlements =
ee.ImageCollection('JRC/GHSL/P2016/SMOD_POP_GLOBE_V1');

// Since the settlements data does not have feature list for 2010, here
we use filterDate
var s2000 = settlements.filterDate ('2000-01-01','2000-12-31');
var s2015 = settlements.filterDate ('2015-01-01','2015-12-31');

var settlements_2000 = ee.Image(s2000.first()).clip(Ohio);
var settlements_2015 = ee.Image(s2015.first()).clip(Ohio);

var visParams = {
  min: 0.0, max: 3.0,
  palette: ['000000', '448564', 'a8fed2', 'ffffff'] };
```

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```
Map.addLayer(settlements_2000, visParams, '2005');
Map.addLayer(settlements_2015, visParams, '2015');

// only select high density cluster
var HDC_find_2000 = settlements_2000.eq(3);
var HDC_2000 = HDC_find_2000.mask(HDC_find_2000);

var HDC_find_2015 = settlements_2015.eq(3);
var HDC_2015 = HDC_find_2015.mask(HDC_find_2015);
Map.addLayer(HDC_2000, {palette:['C2E79B']}, 'HDC 2000');
Map.addLayer(HDC_2015, {palette:['00ff00']}, 'HDC 2015’);

// More HDC
var extra_HDC = HDC_2000.mask(HDC_2015);
var growth_HDC = extra_HDC.mask(extra_HDC.eq(0));
Map.addLayer(growth_HDC, {palette:['58916D']}, 'more HDC');

// only select low density cluster
var LDC_find_2000 = settlements_2000.eq(2);
var LDC_2000 = LDC_find_2000.mask(LDC_find_2000);
Map.addLayer(LDC_2000, {palette:['A9FBEF']}, 'LDC_2000');

var LDC_find_2015 = settlements_2015.eq(2);
var LDC_2015 = LDC_find_2015.mask(LDC_find_2015);
Map.addLayer(LDC_2015, {palette:['ff0000', 'a8fed2']}, 'LDC_2015');
```

```
// More LDC
var extra_LDC = LDC_2000.mask(LDC_2015);
var growth_LDC = extra_LDC.mask(extra_LDC.eq(0));
Map.addLayer(growth_LDC, {palette:['357192']}, 'more LDC’);

var geometry = /* color: #69b3ff */ee.Geometry.Polygon(
        [[[-82.93512772628208, 40.103901520103875],
          [-82.9639668376102, 40.11020362488072],
          [-82.97357987471958, 40.11808043477897],
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GEE SCRIPTS

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  geometry2 = /* color: #c331ff */ee.Geometry.Polygon(
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GEE SCRIPTS

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geometry3 = /* color: #1202ff */ee.Geometry.Polygon(
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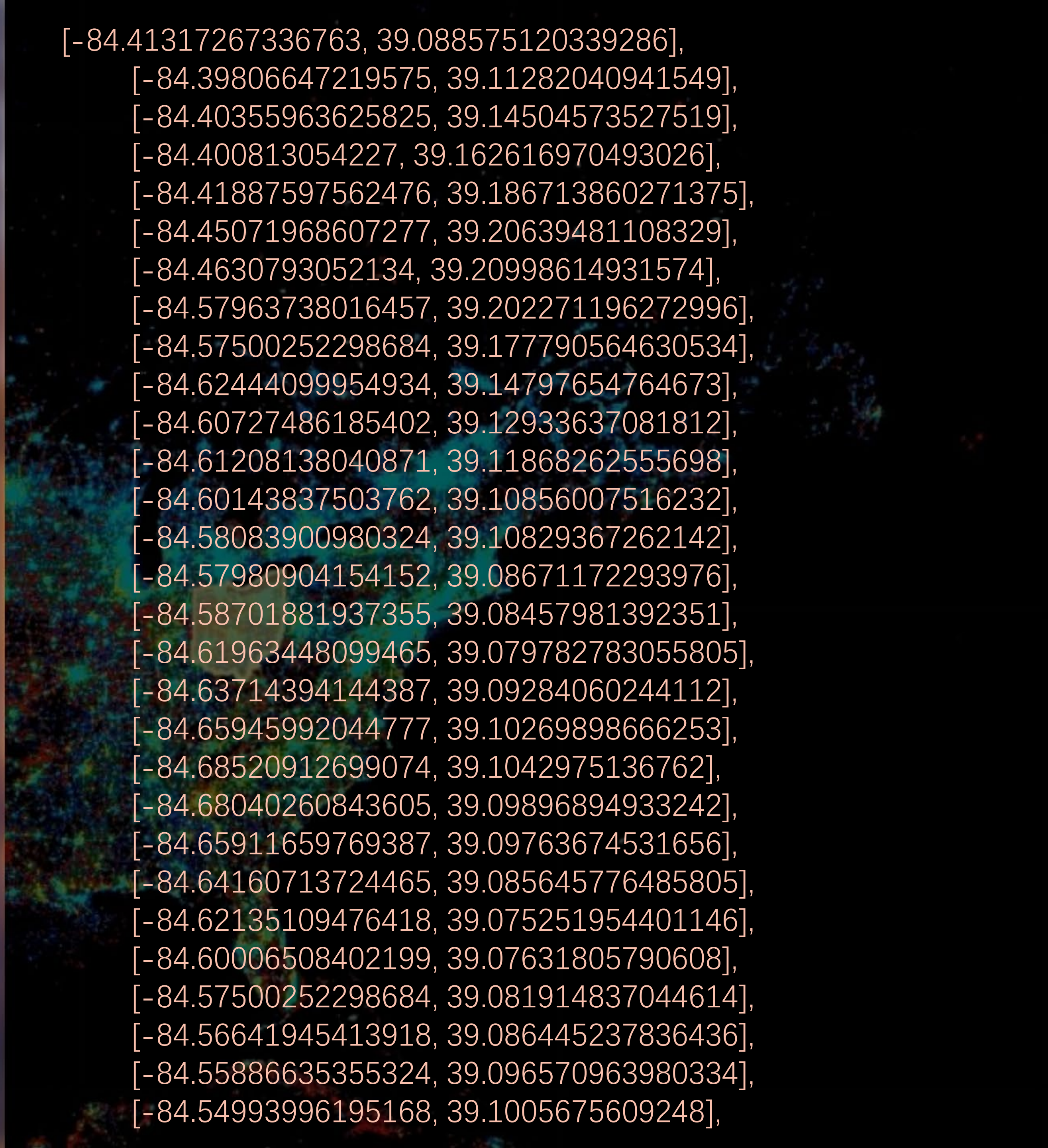

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```