LEAM 2021

University of Illinois

Dept of Landscape Architecture

Land Use Evolution and Impact Assessment Laboratory

Overview

Leam 2021 is a numerical modeling system that uses a variety of raster, vector, network, and point data inputs to create accessibility-based attraction and probability maps and make projections about land use change.

The LEAM 2021 processes and algorithms seek to:

- Expand the user's control over the input data
- Leverage the latest technologies
- Maximize the potential accuracy of the results
- Do so in a lossless manner preserving the level of detail of the original input data

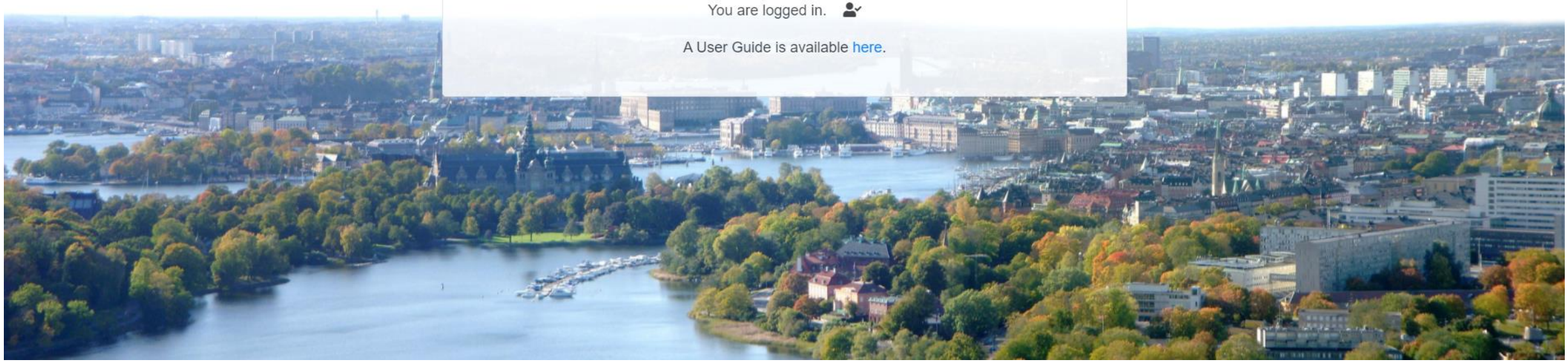
LEAM | Stockholm

Home | Run Models | Import Files | View Data | View Maps | View Results

Välkommen / Welcome
to LEAM | Stockholm

You are logged in.

A User Guide is available here.



Running Models

The internal processes that drive the Leam 2021 models generally fall into four steps:

- Preparation of networks and attractors
- Accessibility-based network and raster analysis of attractors to build sets of attraction maps
- Regression analysis of attraction maps and land use maps to produce sets of probability maps
- Combining the probability maps with scenarios that represent economic pressures to various sectors in order to build a map representing projections of land use change

Each process is a stand-alone that produces its own set of outputs which are useful in their own right and may then be used, re-used, and mixed and matched as inputs to subsequent processes.

Run Models

Process 1a - Build Network Analysis Attraction Maps

Produce attraction maps using network models of the transportation systems and point data such as population, employment, etc.

+ More Run this process if:

Process 1b - Build Economic Sector Attraction Maps

Create land use and attraction maps for various econmic sectors using definitions of the qualifying businesses for each sector.

+ More Run this process if:

Process 2 - Build Probability Maps

The final output is a set of probability maps built using attraction maps (from processes 1a and 1b), economic projections, and land use by economic sector

+ More Run this process if:

Process 3 - Model Land Use Change

The final output is a set of land use change maps built using probability maps (from process 2) and economic projections

+ More Run this process if:

Attraction Maps

Attraction maps offer a way to measure the impact across the study area of various user-defined locational attractors according to the accessibility to these attractors from any point in the study area.

Attractors can be either point locations or areal features (polygons or raster areas) and usually have some sort of weighting. Common categories of attractors might include such things as:

- Employment sources
- Population
- Healthcare locations
- Parks and green spaces
- Social media data
- Points of Interest

Accessibility to these attractors is measured based on travel times by a number of modes of transportation resulting in a distribution of attraction values across the study area.

Methodology

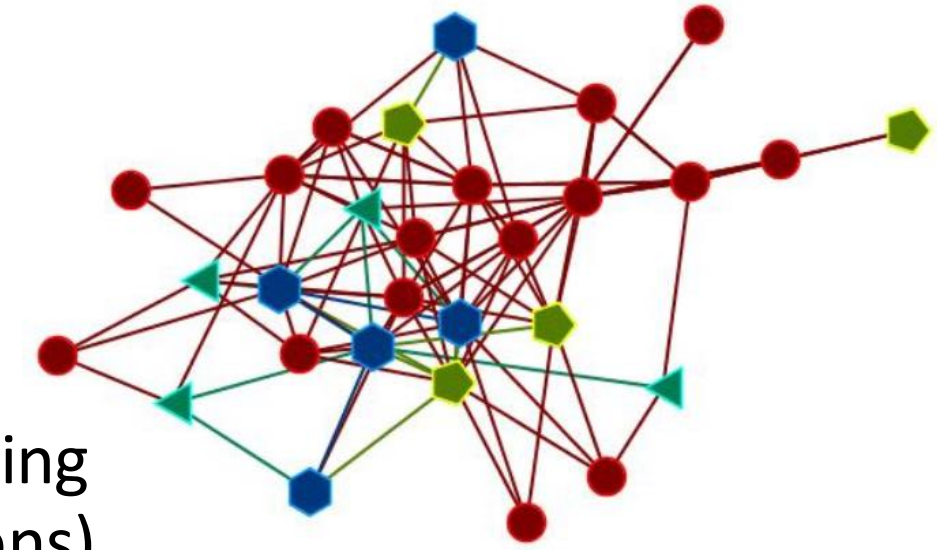
The processes used to create attraction maps fall into two primary categories:

- Raster analysis
- Network-based analysis.

In most cases, some combination of both is employed during the modeling process.

Note: A significant difference between the network and raster analyses is that the network analysis considers the influence of all attractors and distances to them whereas raster analysis, while considering all attractors, preserves the value from only the most influential (i. e. the one with the higher weighted accessibility). Given that the two different styles of analysis are also used quite differently, this isn't necessarily a short-coming.

Network Analysis



Our network analysis involves converting geographic data into non-locational abstract representations of the various transportation networks consisting only of nodes (points) and edges (connections).

Each edge contains data about distance, travel speed, and direction of travel between the nodes it connects.

The available networks include:

- Driving
- Biking
- Walking
- Bus
- Rail
- Ferry

Travel can move between the selected networks

Process

Individual travel time distributions (a network version of an isochron map) are created – one for every single data point (attractor).

These distributions are converted to attraction values based on each point's weight and the travel time from that point to each node of the network.

These sets of attraction values from each point are then aggregated to get the total attraction value for every node and edge in the network.

The attraction values in the network model are then mapped back to the geographical objects that they represent.

Advantages

Network analysis allows us to produce attraction distributions that have several advantages:

- Highly accurate
- Able to take into account directionality of travel such as;
  - on and off ramps
  - expressways
  - one-way streets
- Can handle limited access travel such as expressways and railways
- Properly handle overlapping, but non-intersecting, travelways such as road-crossing bridges, tunnels, and viaducts in manner not possible in ordinary 2-D analysis

Raster Analysis

The raster-based attraction analysis is used to disseminate the values of the various user-selected attractors across the study area on a cell-by-cell basis.

Process

For a cell with a known value, new values are calculated for each of the eight neighboring cells according to the cost of traversing each cell. In this case, the cost is estimated travel time.

The estimated traversal time is based on the network travel speed at that location if the cell lies on some sort of network or on the type of land cover otherwise.

Where a cell already has a value, either from another attractor or from the same attractor by a different route, the value representing the greater influence wins. This makes the assumption that a traveller would have chosen the more efficient route, but also that he or she has is concerned only with travel to the attractor that is most attractive from that location.

The process is repeated a predetermined number times filling the map with attraction values within a certain radius of each attractor. The number of repetitions varies depending on the situation but should repeat enough times that the attraction values will have decayed to the point of insignificance before the analysis stops.

Advantages

Though network analysis is generally more detailed and accurate, raster analysis also has several advantages in certain situations.

- Speed
- Able to handle very large numbers of attractors
- Able to handle non-point attractors such as:
  - Polygons
  - Raster areas

In the Interface

The building of attraction maps occurs in two different processes:

Process 1a - Build Network Analysis Attraction Maps

This method is primarily network-based but after the network analysis, a raster analysis is run to calculate attraction values for all of the cells that lie off of the travel networks.

Process 1b - Build Economic Sector Attraction Maps

This method is used to create a set of new land use maps. This process allows the user to group detailed land use categories into economic sectors and then produces sets of land use and attraction maps based on those definitions. Optionally, this process will also build an additional set of land use attraction maps (*New).

Inputs for Run Models / Process 1a

Required:

- Network model source file – Use system default
- Attractors – The user selects a previously created data file of attractors or uploads a new one
- Network types – The user selects which network types to include in the analysis (driving, biking, walking, bus, rail, and/or ferry)

Optional:

- (*New) Travel speed scenario – The user may use default travel speeds, select an existing travel speed scenario, or create a new travel speed scenario using simple lambda expressions

LEAM 2021 Interface / Run Models / Process 1a – Build Network Analysis Attraction Maps

Process 1a - Build Network Analysis Attraction Maps

Produce attraction maps using network models of the transportation systems and point data such as population, employment, etc.

+ More

Run this process if:

Network Models File:

Network Graphs with Speeds - Created by admin on Sunday Oct. 11, 2020 - 7:07 p.m.

Edit / Add

Point Data GDF:

Stockholm Hospitals 2 - Created by admin on Wednesday Oct. 20, 2021 - 4:29 p.m.

Edit / Add

Networks to Include in the Model:

☐ Drive ☐ All Rail ☐ Bus ☐ Ferry ☐ Bike ☐ Walk

Travel Speeds Scenario:

Rush hour 2 - Created by admin on Wednesday June 2, 2021 - 6:37 a.m.

Edit / Add

Give a reference name for this run:

Run 123, Build Network Attr Maps

Run

Inputs for Runs Model / Process 1b

Required:

- OSM Query - This is the feature that enables the user to create his or her own land use categories (*New) which the system then builds by querying OpenStreetMap. The user may select an existing OSM query or build a new one through the query builder interface (*New).

Options:

- Create additional "buildings only" versions of the land use and attraction maps (*New). This allows later processes to distinguish between used land and built upon land for each category.
- Build a set of additional localized attraction maps based on the land use maps (*New). This has been shown to greatly improve the subsequent probability maps.

LEAM 2021 / Run Models / Process 1b - Build Economic Sector Attraction Maps

Process 1b - Build Economic Sector Attraction Maps

Create land use and attraction maps for various econmic sectors using definitions of the qualifying businesses for each sector.

+ More

Run this process if:

OSM Query:

OSM Land Cover 5 - Created by admin on Sunday Oct. 24, 2021 - 6:42 p.m.

Edit / Add

☐ Include an additional buildings-only layer for each sector

☑ Create a full set of localized sector attraction maps from the land use maps

Give a reference name for this run:

Run 123, Build Sector Attr Maps

Run

*New – Land Use Queries

OSM Query Builder

Define and build queries that will pull data directly from OpenStreetMap

The easiest way to create these definitions is to start with an all-encompassing file that has all the right words and tag pairs th
don't want.

Edit to create a new OSM query:

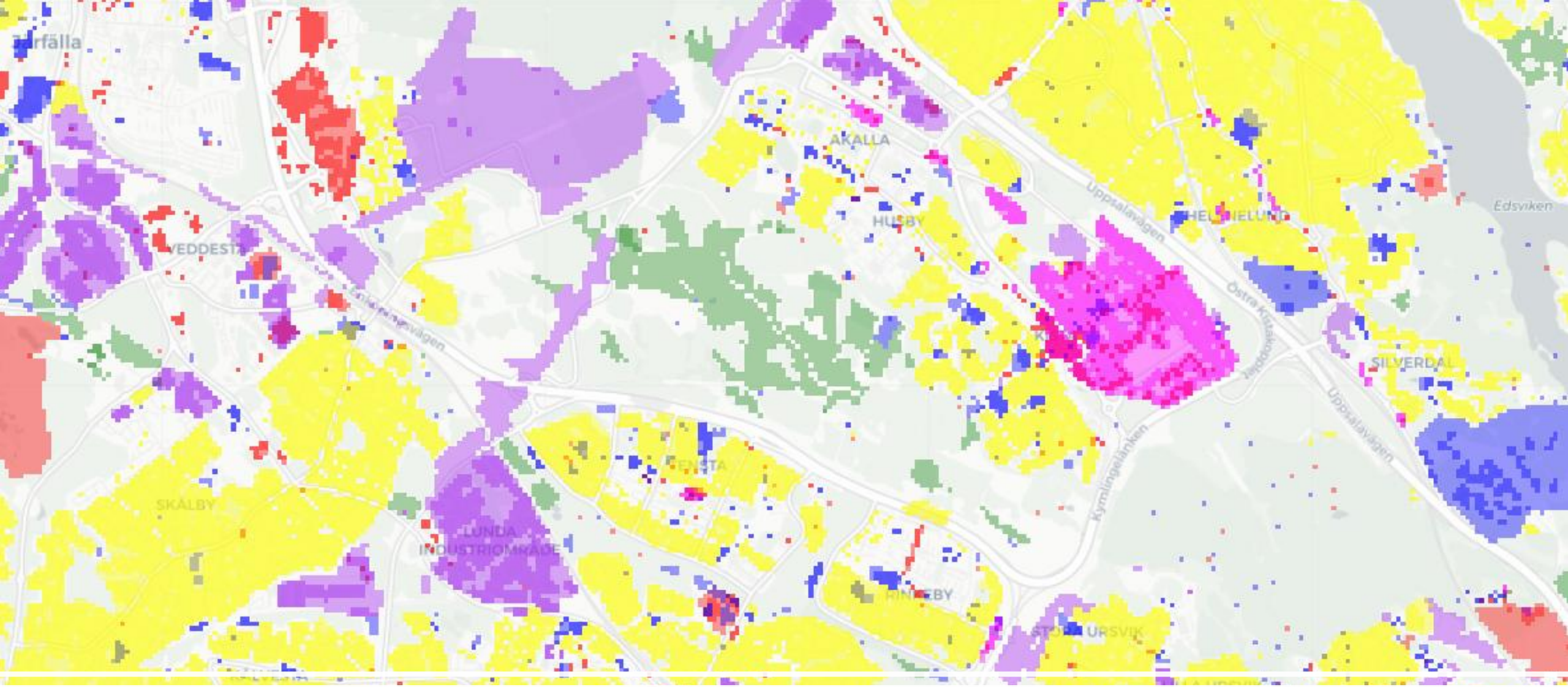
```
agriculture:
  color: green
  query:
    building:
    - farm
    - barn
    - conservatory
    - cowshed
    - farm_auxilary
    - greenhouse
    - stable
    - sty
    landuse:
    - orchard
    - vineyard
    - allotments
    - farmland
    - farmyard
  value: 6
commercial:
```

```
commercial:
  color: red
  query:
    building:
    - hotel
    - commercial
    - retail
    - supermarket
    - hanger
    description:
    - boat_storage
    - boat storage
    landuse:
    - retail
    leisure:
    - adult_gaming_centre
    - amusement_arcade
    - beach_resort
    - bowling_alley
    - dance
    - disc_golf_course
    - escape_game
    - fishing
    - fitness_centre
    - fitness_station
    - golf_course
    - horse_riding
    - ice_rink
    - marina
    ...
```

*New – Building-Aware Land Use Categories

This new feature distinguishes between land that has buildings on it and land that doesn't within all land use categories and gives the user the option to build a second set of buildings-only land use maps and LU attraction maps.

- These can be used as input for the regressions that build the probability maps.
- They are also used to construct a much more nuanced Growth Classification Map than previously used in which unbuilt land is more available for development than its built-upon counterpart. The Growth Classification Map itself was already a more nuanced version of a traditional No-Growth map allowing for degrees of availability for growth.



New Building-Aware Land Use Categories: Standard (lighter), With Buildings (darker)

Probability Maps

Having created land use and attraction maps, the next major step would be to use them to create a set of probability maps.

Regression analysis is performed using a user-selected set of the attraction maps and land use maps as the input. A series of regressions are run using all but one of the input maps as the independent variables and the other as the dependent variable. The system currently uses a Tikhonov (ridge) regression to address problems that can arise from some degree of multicollinearity of the independent variables.

As previously shown, the regressions were found to be greatly improved as a result of preprocessing the inputs by converting what had been standard land use maps into localized attraction maps prior to running the regressions.

Inputs for Run Models / Process 2

Required:

- A set of attraction and land use maps to serve as inputs to the regression. This is normally a set land use maps along with attraction maps repesenting accessibility by various means to/from population and employment centers and potentially other attractors.
  - Note: If the resulting probability maps are to be used to produce land use change maps, then a land use or land use attraction map must be included for each of the economic sectors (commercial, office, community, industrial, agriculture).

LEAM 2021 / Run Models / Process 2 - Build Probability Maps

Process 2 - Build Probability Maps

The final output is a set of probability maps built using attraction maps (from processes 1a and 1b), economic projections, and land use by economic sector

+ More

Run this process if:

Attraction and Land Use Maps:

Please select a set of attraction and land use maps...

Give a reference name for this run:

Run 133, Build Prob Maps

Run

Land Use Change Maps

- The final process takes output from the Economic I/O Interface and combines it with a set of corresponding probability maps to make predictions about land use change.
- The Economic I/O Interface outputs numbers representing scenarios for economic growth in predefined sectors. The Econ I/O scenario dictates the amount of expected growth in each sector and the probability maps are used to determine where that growth is likely to occur given the competing interests of the sectors. Obviously, the probability maps will need to correspond to the predefined sectors.

(*New) Once the files are selected, the system will automatically match the probability files to their corresponding sector.

Inputs for Run Models / Process 3

Required:

- A set of probability maps that correspond to the economic sectors from the Econ I/O Interface **(commercial, office, community, industrial, agriculture).**
- Output from the Economic I/O Interface. The user may either select an existing scenario from the drop-down list or create a new scenario in the Econ I/O Interface and save it.

LEAM 2021 / Run Models / Process 3 – Model Land Use Change

Process 3 - Model Land Use Change

The final output is a set of land use change maps built using probability maps (from process 2) and economic projections

+ More

Run this process if:

Probability Maps:

Please select a set of probability maps...

Economic IO File:

Econ IO - High Growth Scenario - Created by admin on Friday June 11, 2021 - 3:26 a.m.

Edit / Add

Give a reference name for this run:

Run 133, Build LUC Maps

Run

LEAM 2021 / Run Models / Process 3 – Model Land Use Change / Econ I/O Interface

Export Results:

Output_File.txt | Create file

Input/output multipler calculation

Future Employment Projection

	Current Full-time Employment ** in 2015	Shock*	Future Employment in 2040 in Baseline Model	Change of Full-time Employment after Shock	Future Full-time Employment in 2040 after Shock
11 Ag, Forestry, Fish & Hunting	1,123.00	0	314.45	0.22	314.67
21 Mining	1,378.15	30	2,136.45	124.80	2,261.25
22 Utilities	301.00	80	345.94	66.09	412.03
23 Construction	5,447.00	0	5,479.29	22.31	5,501.60
31-33 Manufacturing	3,178.00	0	926.39	0.88	927.27
42 Wholesale Trade	4,149.00	0	4,226.64	54.14	4,280.78
48-49 Transportation & Warehousing	2,225.00	0	2,165.50	32.39	2,197.89
44-45 Retail trade	14,814.00	0	16,326.43	374.85	16,701.28

Note: A new scenario must be saved here and then imported into LEAM 2021 to become avaiable to the system

Import Files

This utility is provided only as a means to import external files such as older LEAM files (attraction maps, probability maps, etc.), LEAM files that were created outside this LEAM 2021 system, and files created in the Economic I/O Interface.

This is not for files loaded as part of the ordinary course of running models, such as point data files for attractors. They are uploaded as part of the appropriate Run Models process.

Import File

This is a general purpose file importer for loading saved Econ IO scenarios, files generated in previous LEAM systems, or other externally created files. Files imported here will become visible to others.

Select file to import:

Choose File No file chosen

File type:

Please select a file type...

Reference name:

A reference name for the uploaded file...

Description (optional):

Upload

View Data

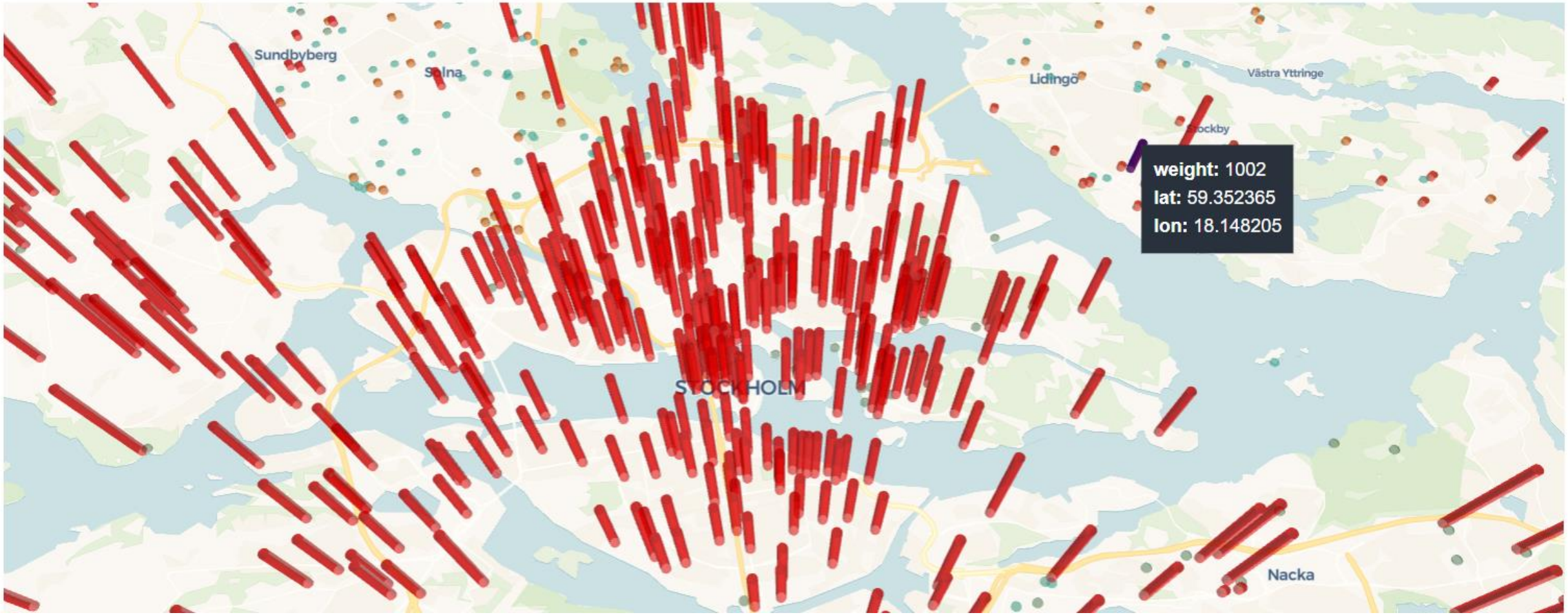
The View Data screen provides an interactive 3-D viewer (*New) for files in the system that represent point data such as sets of attractors. The data is displayed as pillars at each location with a height proportional to the the weighting or magnitude of attractor. Details about the attractor are available by clicking on any pillar.

View Data

Select file to view:

Job data / (point-data-gdf__job-data_seF0d.feather); Created by admin on Friday July 2, 2021 - 6:37 a.m.

View



View Maps

This screen provides access to viewing any mappable data in the system. The user may choose whatever files and as many files as he or she wants. An overlay is built from each file and they are all displayed together in the OpenStreetMap-driven map viewer (*New).

The files that may be display include:

- Land use maps
- Attraction maps
- Probability maps
- Land use change maps
- Point data files (displayed as circle markers and as a heat maps)

Inputs for View Maps

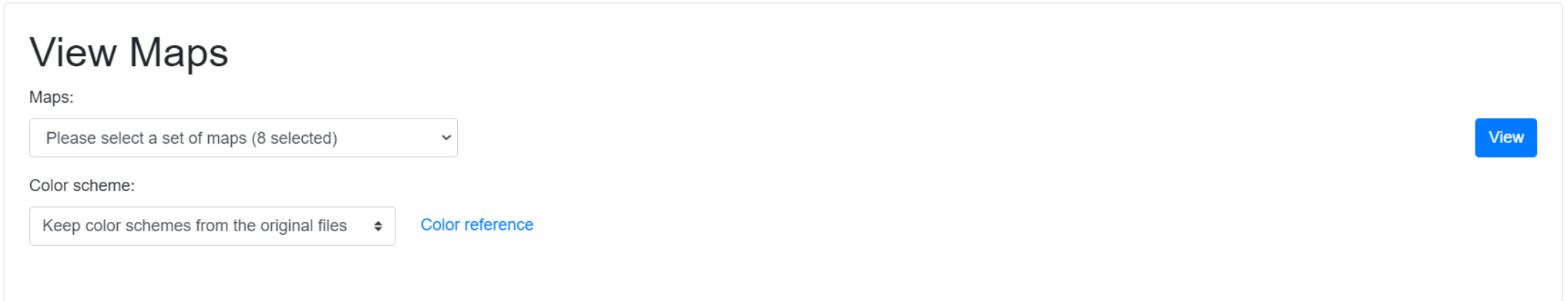
Required:

- The files to be included as overlays

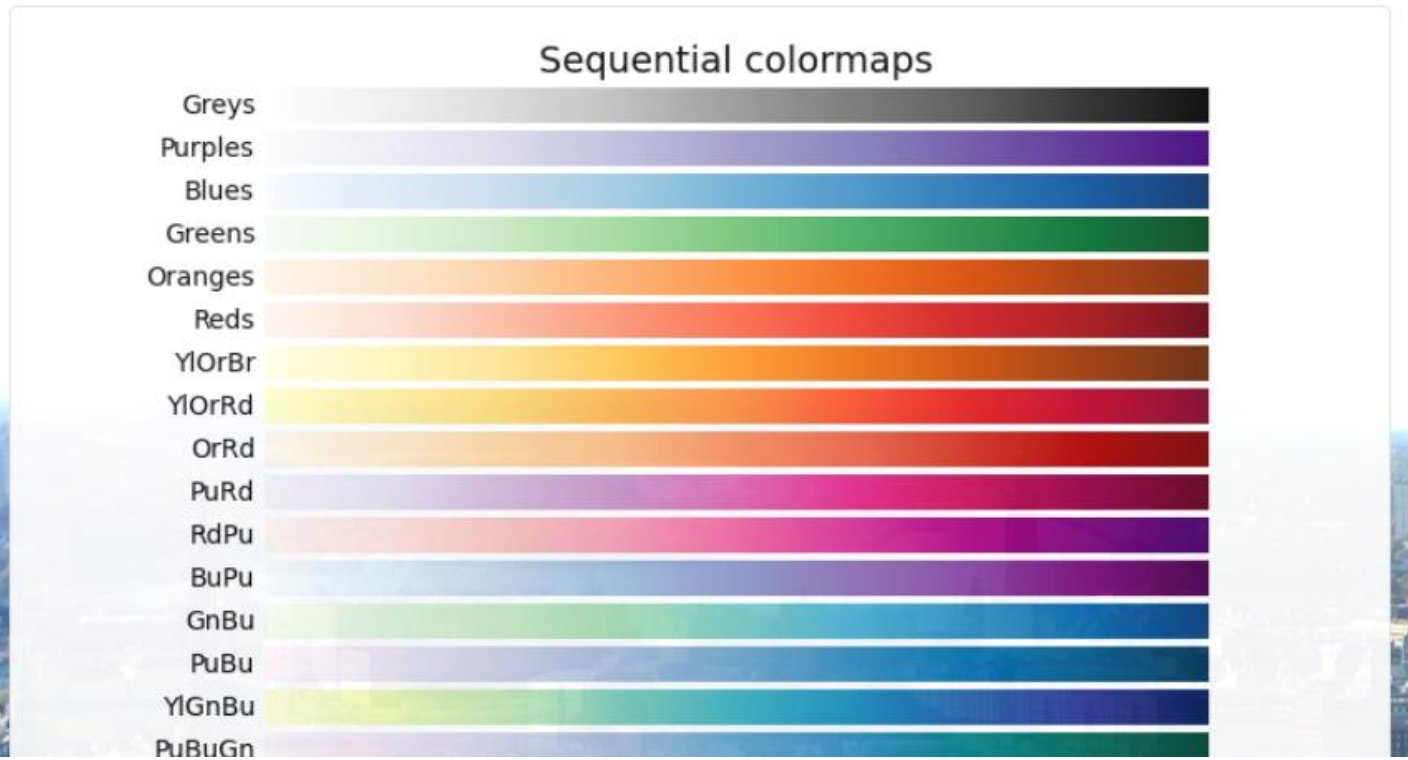
Optional:

- (*New) Apply a different color scheme to the data than the one in the original file. This takes some extra time to load because the newly colorized files must be built on the fly.

LEAM 2021 / View Maps



Color Reference



(*New) OpenStreetMap Viewer

The New OSM map viewer has several new features worth mentioning:

- No Google license required
- Multiple background modes
- Layer grouping (on/off by group)
- Full screen mode
- Geo-locater search tool
- Measuring tool
- Opacity slider

View Results

Very similar to the View Maps screen in many ways, the main difference here is that the user selects a single model run and the system compiles all the associated files along with other information about the model run.

Along with the results files, the user has the option to include the input files as layers also.

In addition to the map, details regarding the selected model run are also displayed.

Inputs for View Results

Required:

- The model run to view

Optional:

- (*New) Whether or not to include input files as overlays
- A new color scheme different from the one in the original file. This takes some extra time to load because the newly colorized files must be built on the fly.

LEAM 2021 / View Results

View Results

Model Runs:

Please select a model run (0 selected)

View

Include input files as map layers for comparison

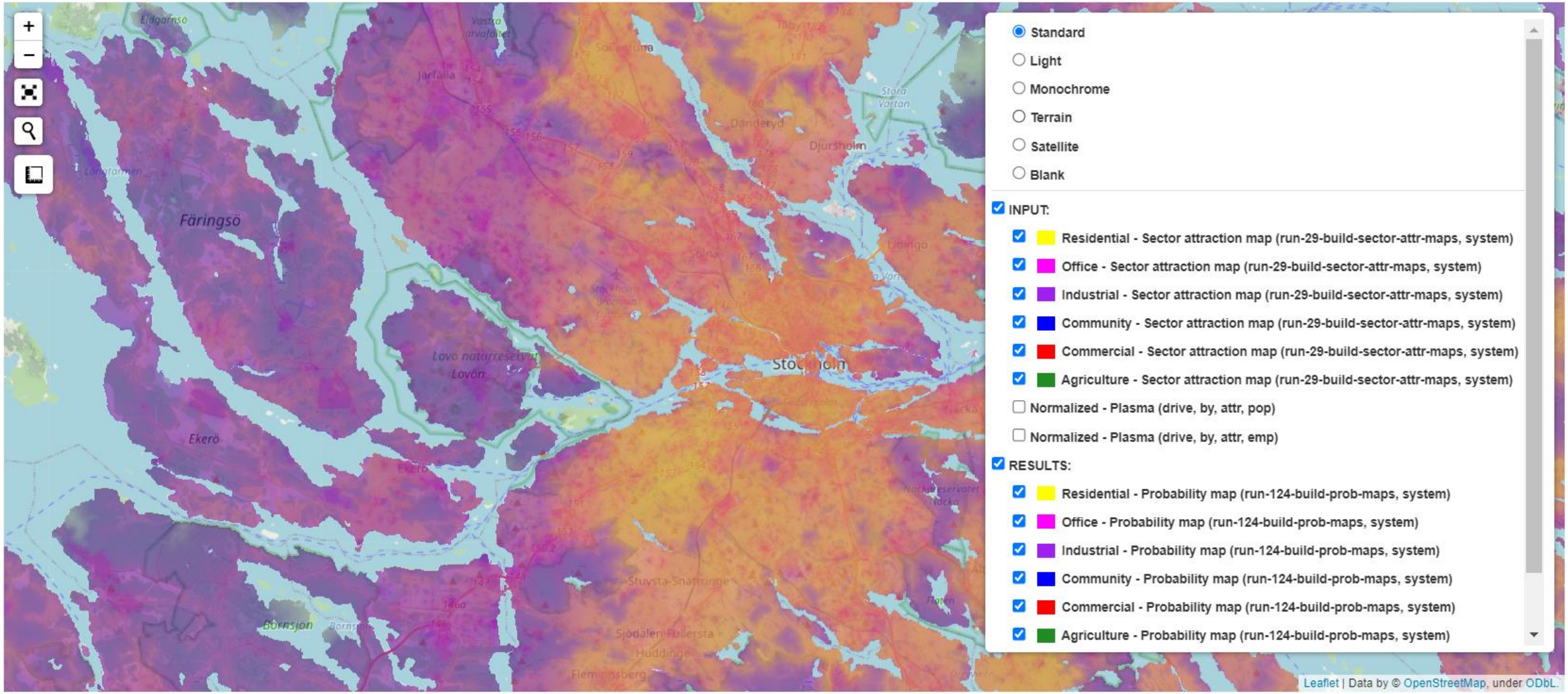
Color scheme:

Keep color schemes from the original files

Color reference

Run 124, Build Prob Maps

Run by admin on 2021-10-26



Opacity: 0.3

Downloads

Download fully interactive map

Inputs:

- system_run-29-build-sector-attr-maps_sector-attraction-map_residential
- system_run-29-build-sector-attr-maps_sector-attraction-map_office
- system_run-29-build-sector-attr-maps_sector-attraction-map_industrial
- system_run-29-build-sector-attr-maps_sector-attraction-map_community
- system_run-29-build-sector-attr-maps_sector-attraction-map_commercial
- system_run-29-build-sector-attr-maps_sector-attraction-map_agriculture
- pop_attr_by_drive_plasma_normalized
- emp_attr_by_drive_plasma_normalized

Results:

- system_run-124-build-prob-maps_probability-map_residential
- system_run-124-build-prob-maps_probability-map_office
- system_run-124-build-prob-maps_probability-map_industrial
- system_run-124-build-prob-maps_probability-map_community
- system_run-124-build-prob-maps_probability-map_commercial
- system_run-124-build-prob-maps_probability-map_agriculture
- system_run-124-build-prob-maps_probability-map_population-drive
- system_run-124-build-prob-maps_probability-map_employment-drive

Run details:

Regression parameters:

residential: [0, 0.06459348622953646, -0.08610505181930424, 0.48848461597021914, 0.02967360073138265, -0.03636455717745883, 0.4924335757782721, -0.049350416804400124, 0.632625110157985]

office: [0.0034578717901503396, 0, 0.08179569790830703, 0.11482446670283476, 0.11360553494934761, -0.015577337621384944, -0.021397315617902087, 0.05407123867029422, -0.3424713441303774]

industrial: [-0.020111248217027592, 0.35687875521299467, 0, 0.06534606369292961, 0.10099140244217948, -0.00559398785769094, 0.1032828306039782, -0.019269606435810004, 0.1316152323306352]

community: [0.07531893415202069, 0.33072540034377795, 0.043138229077092964, 0, 0.16260011692668552, 0.0011868653369971028, 0.0438337207676088, 0.05778204334669556, 0.050565152966878024]

commercial: [0.007140646763440348, 0.5106773898940523, 0.10404981418841228, 0.25376684409059996, 0, -0.002446138527117951, 0.056813660024518584, 0.017007902877921706, 0.3782175342287575]

agriculture: [-0.06408950419820321, -0.51283975065662, -0.042210425895957145, 0.013566155082866687, -0.01791522871507325, 0, 0.5751290886434121, -0.23398131878843764, 5.50011928047498]

population_drive: [0.04321913747742328, -0.03508064492921033, 0.03881022643886134, 0.024950744078418557, 0.020721152539901755, 0.02864080126568506, 0, 0.9747043701633075, 0.9537773523657798]

employment_drive: [-0.004146483968130368, 0.08486630978888647, -0.006931889304427952, 0.03148681851493784, 0.00593844342409215, -0.01115479871221103, 0.9331117033940237, 0, -0.3862603398940401]

	Dependent variables							
	residential	office	industrial	community	commercial	agriculture	population drive	employment drive
residential	0.000000	0.003458	-0.020111	0.075319	0.007141	-0.064090	0.043219	-0.004146
office	0.064593	0.000000	0.356879	0.330725	0.510677	-0.512840	-0.035081	0.084866
industrial	-0.086105	0.081796	0.000000	0.043138	0.104050	-0.042210	0.038810	-0.006932
community	0.488485	0.114824	0.065346	0.000000	0.253767	0.013566	0.024951	0.031487
commercial	0.029674	0.113606	0.100991	0.162600	0.000000	-0.017915	0.020721	0.005938
agriculture	-0.036365	-0.015577	-0.005594	0.001187	-0.002446	0.000000	0.028641	-0.011155
population_drive	0.492434	-0.021397	0.103283	0.043834	0.056814	0.575129	0.000000	0.933112
employment_drive	-0.049350	0.054071	-0.019270	0.057782	0.017008	-0.233981	0.974704	0.000000

LEAM 2021 / View Results - page4

Scores:

- residential:
  - Alpha: 0.7
  - R2: 0.4003123248659767
  - MSE: 640.7052965374563
  - RMSE: 25.312157089775187
  - NRMSE: 0.12656078544887595
  - CV(RMSE): 2.749023782166695
- office:
  - Alpha: 0.7
  - R2: 0.33433144539391424
  - MSE: 34.13915546095413
  - RMSE: 5.842872192762232
  - NRMSE: 0.029214360963811158
  - CV(RMSE): 6.544978610357895
- industrial:
  - Alpha: 0.7
  - R2: 0.19443216941709318
  - MSE: 149.67906522681645
  - RMSE: 12.234339590955306
  - NRMSE: 0.06117169795477653
  - CV(RMSE): 5.685280988856617
- community:
  - Alpha: 0.7
  - R2: 0.43365138494963573
  - MSE: 98.82846123980735
  - RMSE: 9.941250486724865
  - NRMSE: 0.04970625243362432
  - CV(RMSE): 3.061362624816091
- commercial:
  - Alpha: 0.7

Här är slutet