Health Care Gravity Models Documentation (Preliminary Draft)

One-Step (1SHGM) and Two-Step (G-2SFCA)
Python (GeoPandas and tkinter), QGIS (PyQGIS and PyQT), and ArcGIS Pro (ArcPy)
Larry Spear, GISP – May 2, 2019

Background:

This documentation describes the development of both the one-step (1SHGM) and two-step (G-2SFCA) varieties (methods) of gravity models that are useful for evaluating geographic accessibility to health care providers and facilities. The one-step models are based on previous developments of a 1SHGM by the Division of Government Research, UNM. The 1SHGM (hybrid-zonal) was previously developed using SAS and ArcGIS Desktop (ArcPy). There are several varieties of the two-step 2SFCA methods that have been pioneered by other researchers. The generalized G-2SFCA method developed using ArcGIS Desktop (ArcPy) by Professor Fahui Wang at LSU serves as the basis for this development. This documentation describes the development of a Python version with GeoPandas and a tkinter GUI, plus a QGIS Version 3.x (PyQGIS and PyQT) version all open-source software facilities. In addition, another version using ArcGIS Pro (ArcPy and the ArcGIS API for Python) commercial software from Esri is also being developed and tested.

Once completed, the resulting scripts will be made available to other users who need to statistically evaluate the results of both a 1SHGM and 2SFCA gravity models using various distance decay parameters (exponential, power, and Gaussian). These scripts will help in selecting the most appropriate method. Options to employ a hybrid-zonal technique or not will also be available.

Note: Updates to this documentation will be made available as progress is made!
The initial development for the Python (GeoPandas) and QGIS (PyQGIS) versions is being performed using Ubuntu Linux for now and a Windows and Mac versions will eventually be developed. Microsoft Windows is being used for the ArcGIS Pro version. – There is also a SAS version of the G-2SFCA that was previously developed. It is being used to compare results and it will be added to this documentation once a SAS Macro version is prepared.

More Background Information:

- Geographic Access to NM Healthcare Providers and Facilities
- DGR Poster from 2002 Esri SWUG
- 1SHGM (PyQGIS) Documentation
- Profesor Fahui Wang, LSU (Quantitative Methods and Socio-Economic Applications in GIS)

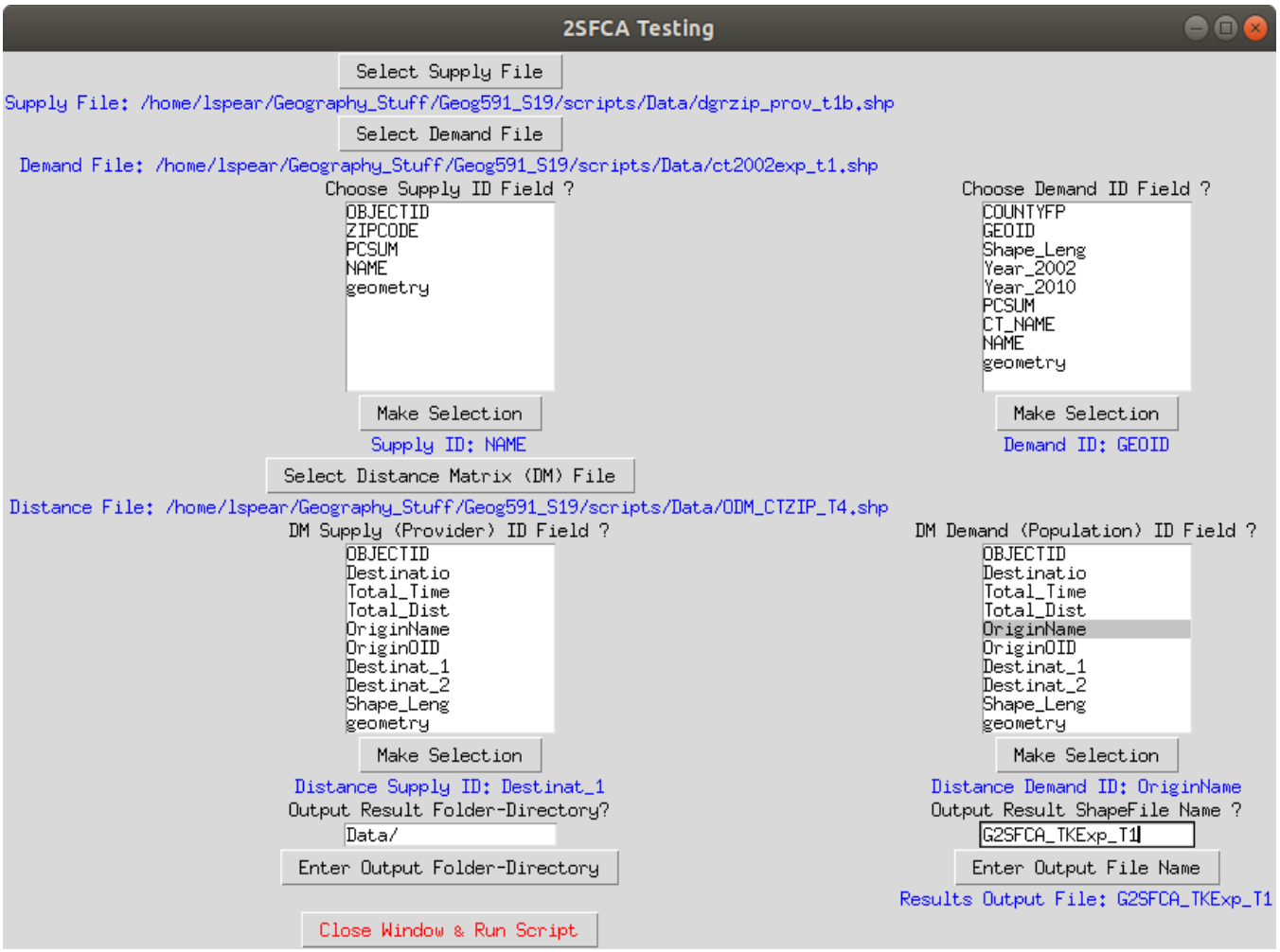
Python Version (Preliminary Testing):

The following are some screen shots of the preliminary testing version with a developing tkinter GUI. It is based on a previous version developed using Jupyter Notebook. It is now being developed using PyCharm and Python (3.7.1) with GeoPandas (also tkinter, pysal, numpy, and matplotlib) on Ubuntu Linux. It currently produces summary statistics, histogram, boxplot, and rather crude point plot and a choropleth map intended to foster the statistical evaluation of results. Currently only the G-2SFCA (hybrid-zonal) version with exponential distance decay is being used for development testing. Subsequent versions will allow the user to choose either a 1SHGM or G-2SFCA models with various

distance decay (exponential, power, or Gaussian) parameters and either a standard or hybrid-zonal method. Also, improved statistical options using the statsmodels library and hopefully the ability to perform a spatial ANOVA will be available.

Note: The results are saved as a Shapefile that can be opened and enhanced in a GIS like ArcGIS or QGIS (an example choropleth map from QGIS is shown below).

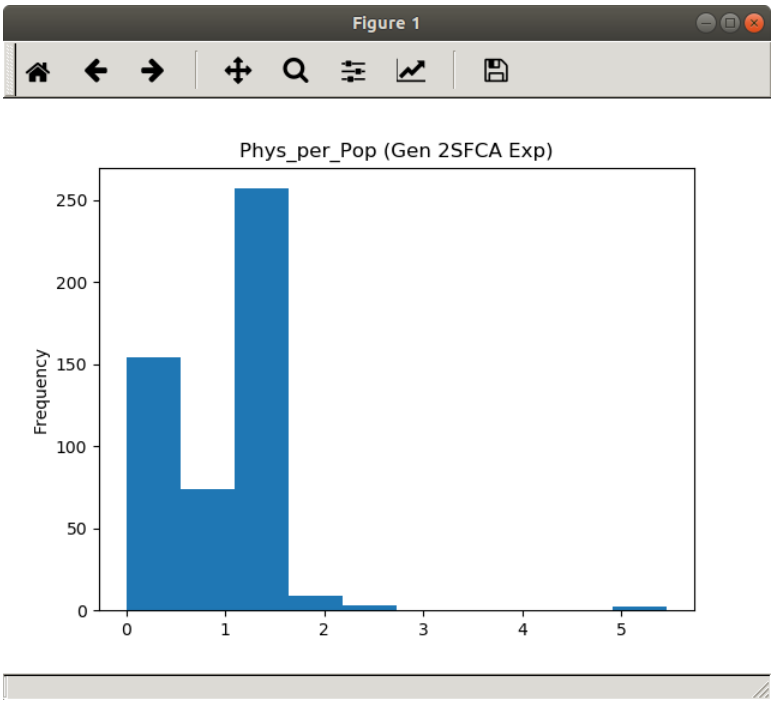
The following is an example of the tkinter GUI and output from a 2SFCA (hybrid-zonal) version with exponential distance decay:

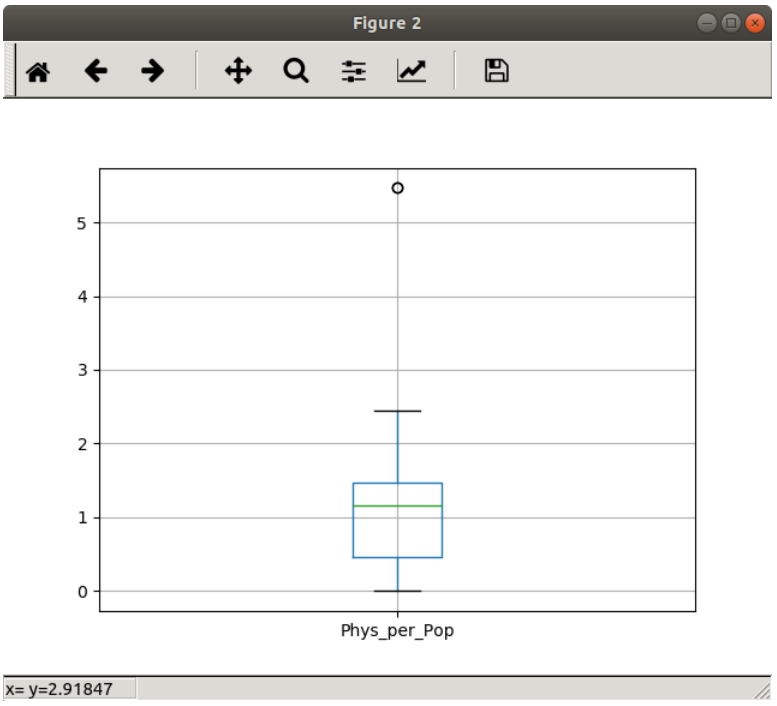


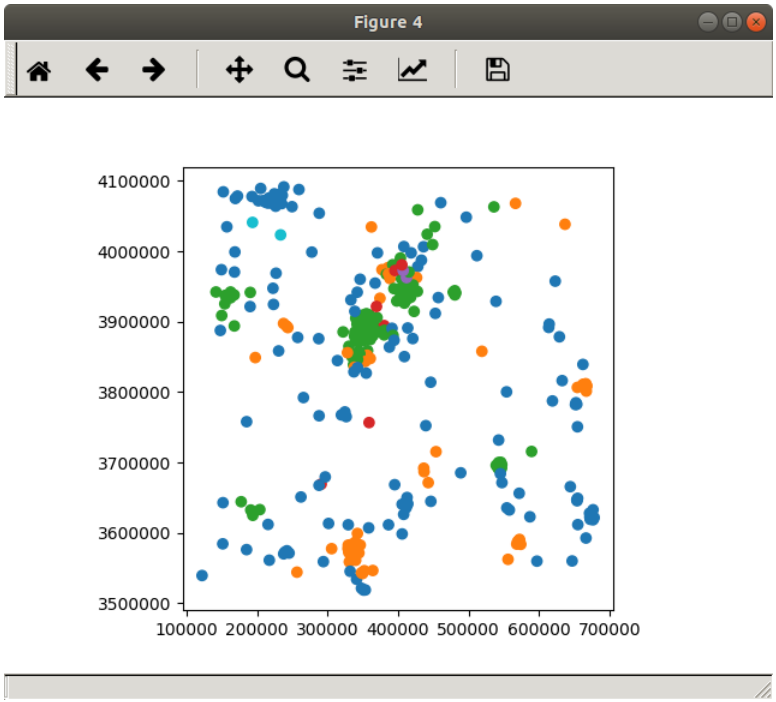
These are an example of the descriptive statistics that are produced:

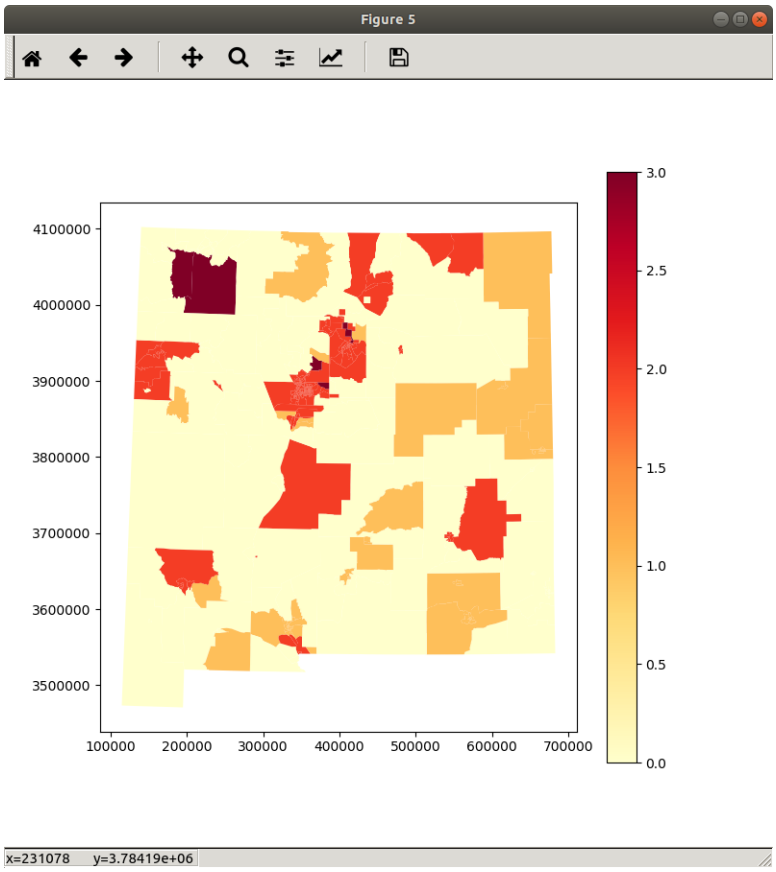
```
****** Descriptive Statistics ******
              RATIO         OName      ...       Phys_per_Pop  Pop_per_Phys
count   499.000000  4.990000e+02      ...         499.000000  4.990000e+02
mean      1.010023  3.502372e+10      ...           1.010023  2.880129e+06
std       0.642107  2.071603e+07      ...           0.642107  4.325795e+07
min       0.000001  3.500100e+10      ...           0.000001  1.820000e+02
25%       0.464789  3.500100e+10      ...           0.464789  6.815000e+02
50%       1.164413  3.501796e+10      ...           1.164413  8.580000e+02
75%       1.466572  3.504500e+10      ...           1.466572  2.151000e+03
max       5.466023  3.506197e+10      ...           5.466023  8.836463e+08
```

These are examples of the other graphs, plots, and map that are currently produced:

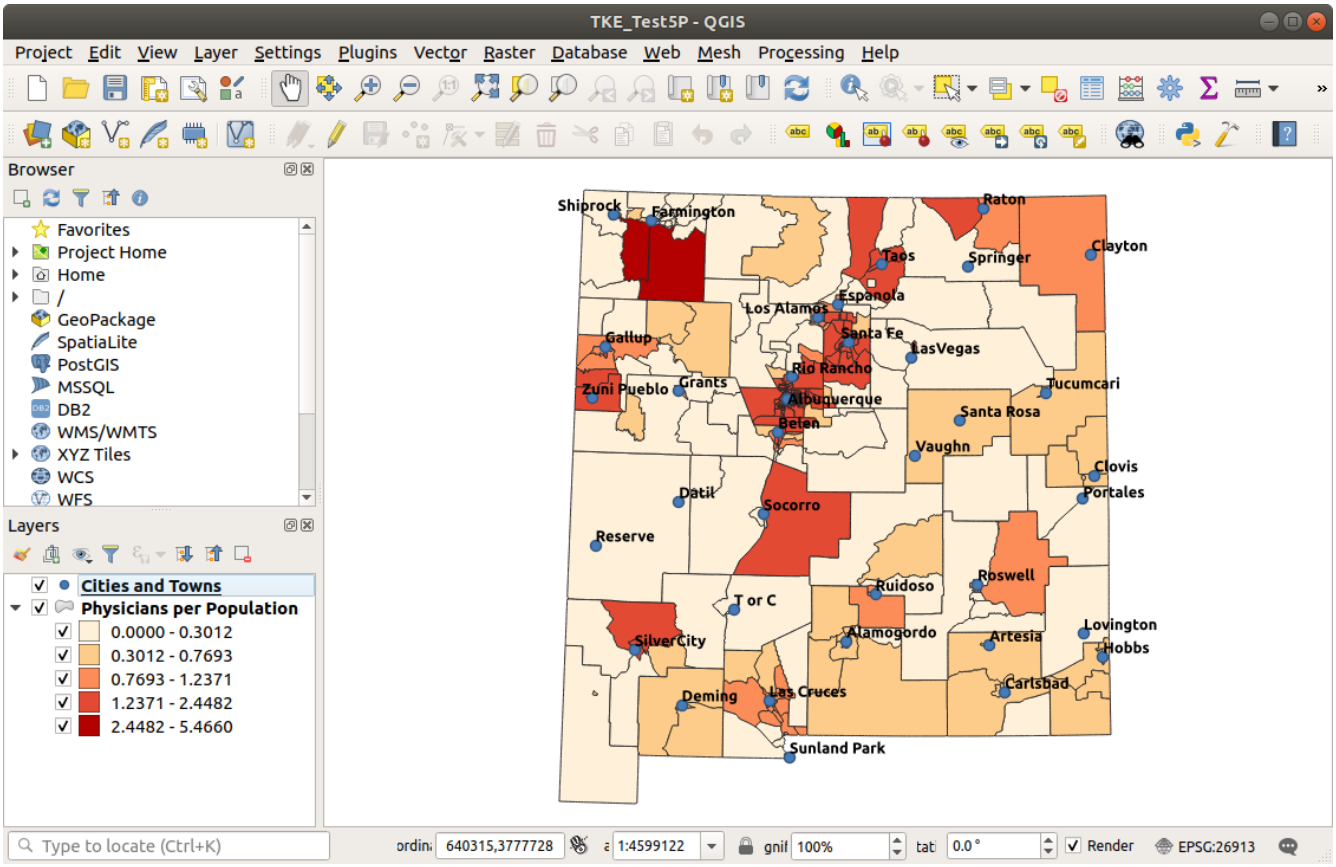








An example of a resulting shapefile displayed in QGIS:



QGIS Version (Being Developed)

I am currently researching if GeoPandas can be used in combination with PyQGIS version 3.x without any dependency problems with other supporting Python packages. If possible, I hope to first develop an internal script and plugin (using the Script Runner and iPython Console plugins), and eventually a standalone script. All will be based on the previous Python 3 with GeoPandas code with necessary PYQGIS and PyQT GUI code.

Note: I had previously developed a PyQGIS version 2.x plugin for the 1SHGM which can be migrated to version 3.x but it does not use GeoPandas. However, I would prefer to develop a PyQGIS version 3.x standalone scripts using GeoPandas. It was only recently that a PyQGIS version 3.x for Linux became available from conda-forge. I will use this to create a separate development environment in PyCharm. I hope to make progress here shortly.

ArcGIS Pro Version (Being Developed)

Also given recent developments in Esri's ArcGIS Pro and the ArcGIS API for Python it is now possible to develop a version of the G-2SFCA using the new Spatially Enabled Data Frame (SEDF) built from

Pandas. This has worked very similarly to GeoPandas. After creating a clone of the ArcGIS Pro environment (can't modify default environment and cloning suported in version 2.3.2 – environment only accessible from Anaconda Navigator) I was able to use Jupyter Notebook (pre-installed with version 2.3.2) and the ArcGIS API for Python (version 1.5.1 also pre-installed). The results are the same as with the Python version (see above) except I was having a problem producing a test map using the map widget. I recently learned that a clone of the arcgispro-py3 environment can be made more directly from the Anaconda Prompt (Conda install ArcPy) than from within ArcGIS Pro (only accessible from Anaconda Navigator) and I will see if this resolves some problems in the future.

SAS Version (Being Developed)

I have previously developed a SAS (University Edition) version of both the 1SHGM and G-2SFCA. I have been using SAS to compare results for accuracy with the Python based versions and to perform some exploratory data analysis. Eventually, I will create a SAS Macro user interface and perhaps include the SAS Bridge for Esri. As I make progress it will also be documented here.

R Version (Being Developed)

I had previously developed a version of the 1SHGM for R. I will eventually do more work here for the G-2SFCA to take advantage of the R ArcGIS Bridge and other statistical libraries that may be useful in performing a spatial ANOVA.