

Tree Planting Priority Areas - Analysis Methodology

GOAL:

To create a GIS data layer that will aid Hennepin County Environment & Energy staff in determining where to plant new trees from the county's tree nursery to help ensure continued and expanded tree canopy coverage within the county.

A weighted scoring analysis model was created so that areas with impervious surfaces, open water, or existing tree canopy cover would receive the lowest combined filter scores, while areas in need of and/or a good candidate for expanded tree cover would receive the highest scores.

ANALYSIS PROCESS REVIEW:

Before undertaking this project a peer review was done via the internet to determine if any other similar projects/studies had been completed. There were three such projects that were identified and reviewed prior to the undertaking of this project: Cities of New York, Baltimore, and Austin.

As a result of this peer review and an available data review, seven filter groupings covering both the physical and social landscapes were identified; Environmental, Population, Income, Employment, Education, Housing, and Health. Hennepin County GIS Office and Environment & Energy staff met to select and create a scoring system for the GIS data layers that would make up each filter group. In total, 18 difference GIS data layers were used in the seven filter groupings.

The following analysis filter datasets were selected:

Analysis Filter	Filter Layers	GIS Data Sets	Score Range	Minimum Score	Maximum Score	Data Type
Environmental						
	Tree Canopy Cover - Current	2015 UofM Land Cover - Tree cover classes	-50 or 10	-50	10	Raster
	Impervious Surfaces	2015 UofM Land Cover - Impervious Class	-200 or 10	-200	10	Raster
		Minneapolis/St. Paul Airport Area	-100 or 0	-50	0	Vector
	Urban Heat Island	MetCouncil Heat Vulnerability data	0,10,20	0	20	Raster
	Water Quality	FEMA Floodplain data	20,10,0	0	20	Vector
		DNR Buffer Law Protected Areas	0 or 20	0	20	Vector
		2015 UofM Land Cover - Lakes/Ponds & Rivers classes	-200 or 0	-200	0	Raster
	Air Quality	MetC Criteria Pollutants - 2005	0,5,10,15,20	0	20	Vector
		MetC Criteria Pollutants (PMs) - 2015	0,5,10,15,20	0	20	Vector
Population						
	Population Density	American Community Survey data 2011-2015 averages	0,5,10,15,20	0	20	Raster
	Population - Under 18	American Community Survey data 2011-2015 averages	0,5,10,15,20	0	20	Vector
	Population - Over 65	American Community Survey data 2011-2015 averages	0,5,10,15,20	0	20	Vector
Income						
	Median Income per Household	American Community Survey data 2011-2015 averages	20,15,10,5,0	0	20	Vector
	Poverty - Concentrated	American Community Survey data 2011-2015 averages	0 or 20	0	20	Vector
Employment						
	Employed Population	American Community Survey data 2011-2015 averages	20,15,10,5,0	0	20	Vector
Education						
	Adults - did not complete High School	American Community Survey data 2011-2015 averages	0,5,10,15,20	0	20	Vector
Housing						
	Home Ownership	American Community Survey data 2011-2015 averages	20,15,10,5,0	0	20	Vector
Health						
	Asthma Hospitalizations	MN Dept of Health - data by zip code 2009-2013	0,5,10,15,20	0	20	Vector
		Totals:		-500	300	

1) **ENVIRONMENTAL Filter:**

Tree Canopy Cover (raster) – Original GIS data was created by the University of Minnesota Land Cover project from 2015. Data had twelve classes of land cover identified, however, two classes correspond to existing tree cover.

Filter Layer Purpose: Plant trees where there currently is not tree canopy cover.

Data Prep: GIS data is distributed as a Metro-wide (7 County) Tiff image.

- Data had to be converted from Tiff image to an ESRI Grid raster data set (*Data Export*).
- Hennepin County portion was extracted out (*Extract by Polygon, Extract by Mask*).
- GIS Data was reclassified (*Reclassify*) to make a single tree canopy cover layer by combining the two tree cover classes into a single classification.
- Final filter data layer was created by reclassifying (*Reclassify*) data to create a weighted score layer.
 - Existing tree canopy (-50); No existing tree canopy (10); No Data cells (No Data)

Impervious Surfaces – Roads & Buildings (raster) – Original GIS data was created by the University of Minnesota Land Cover project from 2015. Data had twelve classes of land cover identified, however, two classes correspond to impervious classes; buildings and roads.

Filter Layer Purpose: Trees will not be planted in impervious surface areas.

Data Prep:

- GIS Data was reclassified (*Reclassify*) to make an impervious surfaces layer by combining the two impervious land classes into a single classification.
- Final filter data layer was created by reclassifying (*Reclassify*) data to create a weighted score layer.
 - Existing road & buildings (-100); No existing road & buildings (10); No Data cells (No Data)

Impervious Surfaces – Roads & Buildings (raster) – Original GIS data was taken from the Hennepin County Municipal Boundaries dataset.

Filter Layer Purpose: Trees will not be planted in the area of the Minneapolis/St. Paul Airport.

Data Prep:

- Exported (*Data Export*) a version of the municipal data for use as a scored filter layer.
- Added field (*Add Field*) - Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Used *Select by Attribute* [BufferDist] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Scoring is as follows: in airport area (-50); not in airport area (0)
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

Urban Heat Island (raster) – GIS Data is from the Metropolitan Council’s Climate Vulnerability Assessment project. Heat Vulnerability Data is in degrees Fahrenheit. GIS Data created from Landsat data image taken on July 22, 2016, with a mean temperature of 86°F for that day.

Filter Layer Purpose: Planting trees in areas susceptible to heat island issues can provide cooling from tree shade.

Data Prep:

- Hennepin County portion was extracted out (*Extract by Polygon, Extract by Mask*).
- Reclassed (*Reclassify*) data to create a weighted score data layer using a 3 class Natural Breaks (Jenks) classification.
 - Group breaks: 86.3059; 93.5104; 122.5182
 - Group scores: 0, 10, 20

Water Quality – Information comprised of three GIS data sets: FEMA Floodplains, DNR Buffer Law Protected Waterways and Open Water – Lakes/Ponds & Rivers.

FEMA Floodplains (vector) – Federal Emergency Management Agency’s Floodplain GIS data, which has two classes; 100 year floodplain and 500 year floodplain.

Filter Layer Purpose: Planting trees in floodplain areas can help with water absorption and stabilize ground during a flooding event.

Data Prep:

- Exported (*Data Export*) a version of the floodplain data for use as a scored filter layer.
- GIS data only includes floodplain areas; combined it (*Union*) with Hennepin County Boundary data to fill in the missing areas within the county.
- Added scoring field (*Add Field*) - Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Used *Select by Attribute* [FLOODPLAIN] and *Calculate Field* tools to group and populate the weighted score field [TP_Score].
 - Scoring is as follows: 100 year floodplain (20); 500 year floodplain (10); Non-floodplain (0)
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI’s Spatial Analyst extension.

DNR Buffer Law Protected Waterway Areas (vector) – GIS data comes from the work done for compliance with the DNR Buffer Law that protects waterways within a specified buffer distance. Data set covers areas outside of the Hennepin County boundary.

Filter Layer Purpose: Planting trees within this buffer area will help to filter water runoff and improve water quality.

Data Prep:

- Exported (*Data Export*) a version of the DNR buffer data for use as a scored filter layer.
- GIS data only includes buffer area; combined it (*Union*) with Hennepin County Boundary data to fill in the missing areas within the county.
- Added scoring field (*Add Field*) - Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Used *Select by Attribute* [BufferDist] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Scoring is as follows: in buffer area (20); not in buffer area (0)
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.
- Hennepin County portion was then extracted out (*Extract by Polygon, Extract by Mask*).

Open Water - Lakes/Ponds & Rivers – Original GIS data (raster) was created by the University of Minnesota Land Cover project from 2015. The data includes a Lakes/Ponds and a Rivers classification.

Filter Layer Purpose: Trees will not be planted within open water areas.

Data Prep:

- GIS Data was reclassified (*Reclassify*) to make an open water layer by combining the two water land classes into a single classification.
- Final filter data layer was created by reclassifying (*Reclassify*) data to create a weighted score layer.
 - Existing lakes/ponds & rivers (-100); all other areas (0)

Air Quality –

MPCA Criteria Pollutants (PMs) 2005 (vector) – Historic air pollution data is from the Minnesota Pollution Control Agency circa 2005. Data includes a set of fields for particulate matter emissions (PM, PM10, PM2_%_PRIM).

Filter Layer Purpose: Trees planted in areas of higher air pollution can help to filter the air and reduce air pollution.

Data Prep:

- Added field (*Add Field*) - Field Name: Total_PMs, alias: none, Double
- Turned off all attribute table fields except; OBJECTID, PM, PM10, PM2_5_PRIM, Total_PMs (*Layer Properties – Fields Tab*)
- Performed a *Spatial Join* with the 2010 Census Block-group geographies to convert point data to a polygon based data set.
 - Use the *Field Map of Join Features* to set the *Merge Rule* to Sum for the PM, PM10, PM2_5_PRIM, Total_PMs fields.
- Added field (*Add Field*) - Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Used *Select by Attribute* to select all NULL values in the [Total_PMs] field.
 - Converted the NULL values in the [Total_PMs] field to 0 using the *Field Calculator*.
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [Total_PMs] with the Natural Breaks (Jenks) classification being used to find data break points.

- Used *Select by Attribute* [Total_PMs] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 26,450.005; 80,034.037; 161,426.646; 264,153.407; 1,073,219.800
 - Group Scores: Scoring numbers (low to high) 0, 5, 10, 15, 20
 - The higher the amount of particulates in the air the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

MPCA Criteria Pollutants (PMs) 2015 (vector) – Historic air pollution data is from the Minnesota Pollution Control Agency circa 2015. Data set includes data points for particulate matter emissions (PM-PRI, PM10-PRI, PM25-PRI).

Filter Layer Purpose: Trees planted in areas of higher air pollution can help to filter the air and reduce air pollution.

Data Prep:

- A definition query was imposed on data set to select only data points for particulate matter emissions (PM-PRI, PM10-PRI, PM25-PRI) and for year (2015).
- Data was then exported (*Data Export*) out to a new feature class of just particulate matter data points.
- Performed a *Spatial Join* with the 2010 Census Block-group geographies to convert point data to a polygon based data set.
 - Use the *Field Map of Join Features* to set the *Merge Rule* to Sum for the Emissions_LB and Emissions_Ton fields.
- Added field (*Add Field*) - Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Used *Select by Attribute* to select all NULL values in the [Emissions_LB] field.
 - Converted the NULL values in the [Emissions_LB] field to 0 using the *Field Calculator*.
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [Emissions_LB] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [Emissions_LB] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 11,179.600; 57,199.475; 137,350.236; 239,897.379; 628,356.350
 - Group Scores: Scoring numbers (low to high) 0, 5, 10, 15, 20
 - The higher the amount of particulates in the air the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

2) **POPULATION Filter:** using 2010 Census Block-group level geography with the 2011-2015 ACS demographic estimates.

Population – Under 18 (vector) – data is normalized by population total for each block group to yield percentages. [AGEUNDER18 / POPTOTAL]

Filter Layer Purpose: Goal is to plant more trees where there are larger populations of children.

Data Prep:

- Exported (*Data Export*) a version of the Population – Under 18 data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: PCT_Under18, alias: Percent Under 18, Float
 - Used the *Calculate Field* tool to calculate values for this field- [AGEUNDER18 / POPTOTAL]
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [PCT_Under18] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [PCT_Under18] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 0.1038; 0.1842; 0.2545; 0.3301; 0.5026
 - Group Scores: Scoring numbers (low to high): 0, 5, 10, 15, 20
 - The higher the percentage of children the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

Population – Over 65 (vector) – data is normalized by population total for each block group to yield percentages. [AGE65UP / POPTOTAL]

Filter Layer Purpose: Goal is to plant more trees where there are larger populations of elderly.

Data Prep:

- Exported (*Data Export*) a version of the Population – Over 65 data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: PCT_Over65, alias: Percent Over 65, Float
 - Used the *Calculate Field* tool to calculate values for this field- [AGE65UP / POPTOTAL]
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [PCT_Over65] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [PCT_Over65] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 0.08343; 0.1542; 0.2415, 0.3938; 0.6574
 - Group Scores: Scoring numbers (low to high): 0, 5, 10, 15, 20
 - The higher the percentage of elderly the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

Population Density-Total (vector) – data is normalized by the square mile area of each block group to yield population per square mile. [POPTOTAL / TOT_SQML]

Filter Layer Purpose: Goal is to plant more trees where there are larger, more densely packed populations.

Data Prep:

- Exported (*Data Export*) a version of the Population Density data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: Pop_Density, alias: Population Density, Float

- Used the *Calculate Field* tool to calculate values for this field- [POPTOTAL / TOT_SQML]
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [Pop_Density] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [Pop_Density] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 4,018.221; 8,368.834; 15,393.102; 36,035.813; 117,734.117
 - Group Scores: Scoring numbers (low to high): 0, 5, 10, 15, 20
 - The higher the population density (per Square Mile) the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

3) **INCOME Filter:** using 2010 Census Block-group level geography with the 2011-2015 ACS demographic estimates.

Median Income per Household (vector) –

Filter Layer Purpose: Goal is to plant more trees where the median income is lower.

Data Prep:

- Exported (*Data Export*) a version of the Median Income per Household data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [MEDIANHHI] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [MEDIANHHI] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 44,028.0; 69,940.0; 99,844.0; 143,125.0; 250,001.0
 - Group Scores: Scoring numbers (high to low): 20, 15, 10, 5, 0
 - **ISSUE: 15 block-groups currently have a NULL value for the MEDIANHHI field. ** (assigned a 0 for score)**
 - The lower the median income the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

Poverty Concentrated (vector) – using 2010 Census Tract level geography with the 2011-2015 ACS demographic estimates. Data shows areas with 40% or More in poverty.

Filter Layer Purpose: Goal is to plant more trees where there are more people in poverty.

Data Prep:

- Data was for Twin Cities Metro area, so Hennepin County portion was extracted out (*Clip*).
- GIS data only includes poverty areas; combined it (*Union*) with Hennepin County Boundary data to fill in the missing areas within the county.

- Added field (Add Field) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Used *Select by Attribute* [ACP] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Scoring is as follows: in concentrated poverty area (20); not in concentrated poverty area (0)
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

4) **EMPLOYMENT Filter:** using 2010 Census Tract level geography with the 2011-2015 ACS demographic estimates.

Employed Population (vector) – data is normalized by population over 16 (working age) for each tract to yield percentages. [WORKDENOM / POPOVER16]

Filter Layer Purpose: Goal is to plant more trees where there are more unemployed people.

Data Prep:

- Exported (*Data Export*) a version of the Employed Population data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: Empl_Pop_PCT, alias: Employed Population - Percent, Float
 - Used the *Calculate Field* tool to calculate values for this field – [WORKDENOM / POPOVER16]
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [Empl_Pop_PCT] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [Empl_Pop_PCT] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 0.5335; 0.6204; 0.6858; 0.7460; 0.8489
 - Group Scores: Scoring numbers (high to low): 20, 15, 10, 5, 0
 - The lower the percentage of employed people the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

5) **EDUCATION Filter:** using 2010 Census Block-group level geography with the 2011-2015 ACS demographic estimates.

Adults – Did not Complete High School (vector) - data is normalized by population over 18 for each block group to yield percentages. [LESSHS / POPOVER18]

Filter Layer Purpose: Goal is to plant more trees where there are more people who did not graduate high school.

Data Prep:

- Exported (*Data Export*) a version of the Adults – Did not Complete High School data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: Adults_DnC_HS, alias: Adults - Did not Complete HS - Percent, Float
 - Used the *Calculate Field* tool to calculate values for this field – [LESSHS / POPOVER18]
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [Adults_DnC_HS] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [Adults_DnC_HS] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 0.03742; 0.09476; 0.1711; 0.2784; 0.6267
 - Group Scores: Scoring numbers (low to high): 0, 5, 10, 15, 20
 - The higher the percentage of people that did not complete high school the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

6) **HOUSING Filter:** using 2010 Census Block-group level geography with the 2011-2015 ACS demographic estimates.

Home Ownership (vector) – GIS Data has home ownership as a percentage [field: HOMEOWNPCT] for each block group.

Filter Layer Purpose: Goal is to plant more trees where there percentage of home ownership is lower.

Data Prep:

- Exported (*Data Export*) a version of the Home Ownership data for use as a scored filter layer.
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [HOMEOWNPCT] with the Natural Breaks (Jenks) classification being used to find data break points.
- Used *Select by Attribute* [HOMEOWNPCT] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: 0.2290; 0.4620; 0.6840; 0.8670; 1.0000
 - Group Scores: Scoring numbers (high to low): 20, 15, 10, 5, 0
 - The lower the percentage of home ownership the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

7) **HEALTH Filter:**

Asthma Hospitalizations (vector) – Data source is the Asthma Hospitalizations from the MN Dept. of Health for 2009-2013 (Metro-wide). GIS data is aggregated by zip code areas, and is categorized by Age-Adjusted Rate per 10,000.

Filter Layer Purpose: Goal is to plant more trees where there are higher levels of asthma hospitalizations.

Data Prep:

- Exported (*Data Export*) a version of the Asthma Hospitalizations data for use as a scored filter layer.
- Data was for Twin Cities Metro area, so Hennepin County portion was extracted out (*Clip*).
- Added field (*Add Field*) – Field Name: TP_Score, alias: Tree Planting – Score, Short Integer
- Categorized (*Quantiles – Graduated colors*) the data set using 5 categories [AgeAdjustRate] with the categories being the same as the ones used by MN Dept. of Health.
- Used *Select by Attribute* [AgeAdjustRate] and *Calculate Field* tools to populate the weighted score field [TP_Score].
 - Group Breaks: Null; 2.3-6.1; 6.2-11.1; 11.2-19.1; 19.2+
 - Group Scores: Scoring numbers (low to high): 0, 5, 10, 15, 20
 - The lower the number of asthma hospitalizations the higher the score.
- Data set was then rasterized (*Polygon to Raster*) for use as an analysis filter in ESRI's Spatial Analyst extension.

GIS OVERLAY ANALYSIS:

Once all the raster scored filter layers were created, they were run through the *Weighted Sum* tool in the ESRI Spatial Analyst extension to create the final raster output layer.

All layers were given the same weight in the *Weighted Sum* tool, except for the Impervious Surfaces and Open Water filter layers, which were given twice the weight of the other layers.