Designing a Workflow to Identify Optimal Locations for New Childcare Centers

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Task: Identify optimal locations for new childcare centers in Toronto.

Analysis Criteria:

- Within **800 metres of a subway station <u>or</u> 500 metres of a bus stop AND**
- Within **1km of a main road AND**
- In an area with **population growth of more than 2%** (from 2016 to 2021)

Data Preparation

Step 1: Import the data files into your project geodatabase.

- In the catalog pane, add a new folder collection to the data folder containing the census tract boundaries, transit locations and road network files.
    - Alternatively, you may move the extracted data file directly into the project folder to forgo the process of creating a folder connection.
- Open the geodatabase in the catalog pane, right click and select "import" and select "feature classes". Input your census tract boundaries, transit locations and road network data files and select Run.
- Add the newly important .shp files to your map by dragging them onto the map. The new feature class layers will now show up in the contents pane.

Step 2: Ensure the map and layers have a common coordinate system

- Since we are focused on Toronto in this analysis, the NAD 1983 UTM Zone 17 N is the best suited coordinate system for this task. Change the CRS of the map to the NAD 1983 UTM Zone 17 N CRS by right clicking on the map tab in the Contents pane and selecting "Properties." Select the Coordinate systems tab and enter NAD 1983 UTM Zone 17N in the search bar. Select it and make it the new CRS for the map.
    - **EXPLANATION**: The UTM is a transverse Mercator projection that is conformal (preserves local shapes and angles) and minimizes distortion near the central meridians. The central meridian of Zone 17N is located at 81°W, which is close to Toronto's longitude of 79.4°W, allowing for minimal

distortion. It is also standard practice for government agencies and other analysts to use NAD 1983 and UTM Zone 17N in their maps of the GTA.

- The transit locations and road network files are already formatted in the UTM CRS, but the census tract boundaries data files are not. Use the Project Data Management tool to change the CRS of the census tract boundaries shapefile. Open the Analysis Toolbox and search for the Project Data Management tool. Open the tool and then input the census tract boundaries feature class. Make the output feature class name "CensusTract_NAD1983_Projection." Set the output coordinate system to NAD 1983 UTM Zone 17 and select Run.

Step 3: Calculate the population growth between 2016 and 2021

- Open the attribute table of the Census tract boundaries feature class. Add a new field and name it "POP_GROWTH" with the alias "Popn_Growth." Set the data type to "double."
    - **EXPLANATION**: Population growth calculations may produce growth rates that are below the value of 1 and/or contain decimal values. Therefore, they should not be rounded up or down to ensure that the values calculated are precise and accurate. For this reason, it is best to set the data type for the POP_GROWTH field as "double," since that allows for decimal places. Press the save button under the fields section of the menu ribbon.
- Right click on the new Popn_Growth field and select "Calculate Field". Enter the following formula into the Expression box to get the rate of population growth for each census tract in a decimal value:
    - ((!Pop2021! - !Pop2016!) / !Pop2016!)

Step 4: Delete irrelevant data in the census tract boundaries feature class

- To do so, open the Select by Attribute tool. Select the "POP_GROWTH" field and choose "New Selection." Select Add Clause and input the following query in the drop down boxes:
    - Where: POP_GROWTH is less than 0.02.
        - For consistency, we will use the value 0.02 instead of a percentage since the growth percentages in the table are represented as rates of change instead of percentages.
- **EXPLANATION**: We can delete census tract boundary data that has a growth rate below 2% because it is then irrelevant to the outlined criteria for our analysis of potential new childcare center locations.

Spatial Analysis

Step 5: Create buffers for the transit locations and the road networks.

EXPLANATION: Buffers create a new feature class of polygons that delineate an offset of distance around an input feature (i.e. lines, points, polygons). This tool will allow us to observe the areas of overlap between the census tract boundaries, transit locations and road networks within the specified distances outlined in the criteria for the analysis. Buffers can be dissolved where they overlap with other buffers in the same layer and they can also be created for a field that has varying values, such as the buffer distances field that will be created in this step.

1. Open the attribute table of the Transit locations feature class. Add a new field titled “BUFF_DIST” with the alias “Buffer_distance.” Make the data type double.
2. Next, assign the buffer distance values to the transit station locations. Open the Select by Attributes tool and enter the *“Transit_locations”* feature class as the input rows. The selection type will be “New Selection.” Input the following statement into the expression boxes:
    a. Type is equal to “bus”
    b. Apply the query.
3. With the rows containing “bus” selected, right click the “BUFF_DIST” field and select Calculate Field.
    a. Enter the value “500” in the expression box. Select Apply. Once applied, clear the selection.
4. **Repeat steps 1 through 3** with the other text value, “subway,” and use the numeric distance value of “800” when assigning the buffer distance value to the selected rows. Ensure to verify the accuracy of results by double checking the values of each record upon its completion.
5. **Verify the Coordinate system of the map and the points layer** to ensure the field values are interpreted in the unit of measure, meters. Right click the point transit location layer, select properties and review the Spatial reference. Ensure the coordinate system is a Projected Coordinate system (NAD 1983 UTM Zone 17 N) and that the linear unit is in meters. Reproject the layer if necessary using the Project tool located in the Geoprocessing pane.
    a. **Explanation**: Verifying the unit of measure is important for creating a variable buffer because you cannot clarify the unit type when you enter a field in the distance section of the Buffer tool.
6. Once the unit of measure (meters) has been verified, open the Buffer analysis tool found in the analysis toolbox. Select “Transit_locations” as the input features. For the Output feature class, write the name “Transit_Location_Var_Buffers.” For the distance, select “field” and open the drop down menu to select the

"BUFF_DIST" field. Doing so will create a variable buffer, where buffer values will vary depending on the distance value specified in the BUFF_DIST field. Select Dissolve as the dissolve type. Select Planar as the method, since we are measuring distances at a smaller, local, city level. Select Run and the new variable buffer layer will appear in the contents pane.

   a. **EXPLANATION**: Since the new locations are required to be within 800 m of a subway station OR 500 m of a bus stop, dissolving the buffer variables would be practical since these are not mutually exclusive conditions and should be treated as one buffer since either condition must be met.
   b. **EXPLANATION**: Using a variable buffer for the Transit_location feature class is practical because the BUFF_DIST field contains varying distance values. Creating a variable buffer is more efficient than creating two separate buffer feature classes for the same data layer and later merging them.

7. Create a buffer for the road networks layer. Open the Buffer analysis tool, and select the "Road_networks" feature class as your input feature. In the output feature class box, write "Road_net_buffer." In the distance section, write a distance of 1000 meters. Select Planar as the method. Select dissolve as the dissolve type. Select Run, and the new buffer feature class will appear as a layer in the contents pane.
   a. **EXPLANATION**: a distance of 1000 meters is used since the projection system of the map interprets distances as meters, and 1000 meters is one kilometer, which is the buffer distance we are measuring for this feature class. Dissolving is also advisable since we are looking for the optimal area in which to place the new childcare centers and will not treat overlapping areas within this feature class as mutually exclusive when factoring them into our later analysis of the overlaps between layers.
8. Merge the "Transit_Location_Var_Buffers" and "Road_net_buffers" layers. Open the Merge tool in the analysis toolbox. Select "Transit_Location_Var_Buffers" and "Road_net_buffers" as the input dataset. Specify the name of the output feature class as "Transit_road_buffers" and run the tool.
   a. Merging the two buffer layers will ensure that the attributes for all features are intact and simplify later analysis where the merged buffer layer will be used to clip the overlap in area between the buffers and the census tract polygons. As one buffer layer, the "Transit_road_buffers" will minimize the steps required to identify and clip the areas of spatial overlap.

Step 6: Use a Spatial Query to find the census tract boundaries that overlap the “Transit_road_buffers”

- Open the Select by Location tool found in the menu ribbon. Input the “census tract boundaries” as the input features and use “Overlap” as the spatial relationship. Select “Transit_road_buffers” as the selecting features. Ensure the selection type is set to “New selection” and press apply.
    - **EXPLANATION**: A spatial query retrieves spatial data based on its location and spatial relationship with other data. We will use the **overlap** spatial relationship in this context because it describes a spatial relationship where some, but not all features of feature class A overlap with feature class B. In the case of contains and within, all of feature class A has to be contained by or within feature class B, which will not be the case for this analysis and provide inaccurate results. Not all areas of the buffer will overlap with the census tract boundary, but the areas that do will be relevant to the purposes of our analysis and should not be missed with an ill-suited spatial relationship that would miss these spatial locations that are not entirely encompassed by the other feature class.

Step 7: Clip the overlap between the census tract boundaries and the “Transit_road_buffer” layer.

- Open the Clip tool, which can be found through the toolbox in the analysis tab. Select the “Transit_road_buffer” as the input features and select the “census_tract_boundaries” polygon layer as the Clip Features. Name the Output Feature Class as “Optimal_location_area.” Run the clip tool to create a new polygon layer representing the overlapping area between the two layers.
    - **EXPLANATION**: The clip tool only retains the spatial area where the input layer (the buffer layer) overlaps with the clip layer (the census tract boundaries layer) and produces a new layer of the clipped spatial area. I am making the choice to make the Transit_road_buffer layer the clipped layer since the preserved polygon features of the different, overlapping buffers (bus stops + subway stations and the road networks) would be beneficial to preserve for communicating the areas in which the distances outlined in our analysis criteria are located, thus adding important visual information relevant to the decision making purpose of this analysis.
- **Conduct a spatial join** between the Census tract boundaries layer and the new Optimal_Locations_area layer. Doing so will add the population growth attribute data to the new layer “Optimal_location_area” layer. Open the spatial join tool located within the analysis toolbox. Select the “Optimal_location_area” as the target feature. Select the census_tract_boundaries layer as the join features.

Specify the name of the new feature class as “Optimal_location_complete.” Select one-to-many as the join operation, since many census tract boundaries may overlap with one area identified within the buffer layer. Select overlap as your spatial relationship. Run the tool to create the new feature class in your map.

Step 8: Create a centroid of the newly clipped census tract layer.

- Open the feature to point tool located in () and input the “Optimal_location_complete” layer in the input features box. Title the output feature class “Optimal_location_centroid.” Run the tool and then turn off all other map layers, except the new “Optimal_location_centroid” layer.
    - **EXPLANATION of using centroids to identify the OPTIMAL LOCATION**: Creating a centroid will position a childcare center locations at the very center of an area where all the criterion for our analysis have been met (i.e. within 1 km of a road network, within 500 meters of a bus stop or 800 meters of a subway station, within an area that has a population growth that is greater than 2%).

Export

Step 8: Apply appropriate symbology for the new centroid points and update the appearance of other map features/geometries for clarity and presentation purposes.

- Aim for clarity in communicating the results of your analysis. Ensure that the symbology of the centroid point features are visible and contrast in color and size from the colors of the buffer polygons.

Step 9: Finalize the map layout to export for presenting the results of your analysis

- Ensure the data sources, extent bar, title bar, your name, data legend and north arrow are included on your map layout. Use the Title Bar Letter Landscape as the layout for your final map layout. Ensure that the only map layers that are showing are the “Optimal_location_centroid” point layer and the “Optimal_location_complete” polygon layer that had been joined with the census tract population growth attribute data.
- **Title the map “Optimal new locations for Childcare Centres in Toronto”.** In the legend, include information that details the range of population growth rates within the map areas. Also include information that specifies what buffer

polygons are representing the road networks and what buffer polygons are representing the transit locations.

- Use the print map tool to export a PDF of the map for presentation of your results.