Urban Planning

GIS can be used to support the planning and development or redevelopment of urban areas. Regional or urban landscape development has historically been a hotbed for the use of GIS. Weighted (or sum) overlays are one way to combine layers for GIS planning. However, in weighted overlays, each cell is either in a class or not; there is no way to include a probability of membership. A different way to perform overlays is to use fuzzy logic, which based not on clear-cut boundaries but rather the imprecision of class boundaries

Urban planners have embraced the use of GIS to assist them and involve the public in decision making. They have identified parameters of a potential development scenario for the expansion of the urban area. Four main goals of development are taking into consideration: Proximity to existing development and infrastructure; Protection established parks and a desire to incorporate aesthetically pleasing views into the landscape.

The planners request a landscape assessment in Okanagan Valley to help and support the urban development decision. You are required to provide analysis results for the purpose

You first need to create distance maps and then convert these maps into fuzzy overlays that can be combined. This analysis would give the planners a clear indication of suitable locations surrounding Okanagan Valley for expanding the urban area. The following questions may help you better understand the problem and break the problem down to smaller ones. Record your answers.

> *Q. What geographic area are your studying?*
> *Q. What decisions do you need to make?*
> *Q. What information would help you make the decisions?*

Examine the data

Thoroughly investigate the data layers to understand how they will help you address the problem. The spatial coordinate system, the resolution of the data, and the attribute data are all important pieces of information about a feature class.

Data Location: L:\geog413\data\okanagan

boundary	Study boundary
highways	Highway
lakes	Lakes
rivers	Rivers
urban	Urban area
parks	Parks
elevation	Elevation

- Open a new ArcMap file and add data ***elevation, urban, parks, lakes, highways*** and ***boundary***
- Change the name of the data frame to Okanagan.

Set the environments by clicking Geoprocessing -> Environments

Current/Scratch Workspace:	your local folder
Output Coordinate System:	Same as ***boundary***
Processing Extend:	Same as ***boundary***
Raster Analysis Cell Size:	Same as ***elevation***
Raster Analysis Mask:	***boundary***

- Right-click the data frame and go to Properties. Go to Coordinate System tab and set the coordinate system same as ***boundary.*** Save the map file as **Okanagan_base.mxd**

Analysis

The followings are the urban planners' decision parameters. They had four main goals for the new urban development:

1. Proximity to existing urban areas
2. Proximity to highways
3. Proximity to lakes
4. Protection of parks
5. Aesthetically pleasing views of landscape. Middle-range elevations provide the most aesthetically pleasing views

Step 1: Create a basemap of Okanagan Valley

- Create a basemap of Okanagan Valley with *lakes, highways, urban, parks, boundary*
- Symbolize and label the layers appropriately based cartographic conventions
- Save the map as **okanagan_base.mxd** and save the map file again as **okanagan_distance.mxd**

Step 2: Calculate Euclidean distance around Urban, Parks, Highways and Lakes

Euclidean distance is defined as distance that you would measure with a ruler in a straight line. The Euclidean Distance tool used in this analysis calculates straight-line distance from the polygon features and converts the results internally into a raster.

- Open **okanagan_distance.mxd** and rename the data frame to "Urban Distance".
- Copy this data frame and paste it three times. Rename the new data frames to "Parks Distance" and "Highway Distance" and Lakes Distance respectively

Reminder: To make a data frame active, right-click the name and select Activate

A. Euclidean distance around Urban

- Activate Urban Distance data frame. In the Urban Distance data frame, remove *parks* and *highways*
- Generate a Euclidean distance using *urban* as the feature source data
- Save the output as *dist_urban*
- Symbolize *dist_urban* to 5 classes using appropriate break values such as 5000; 15000; 25000; 40000 and the highest value given.

B. Euclidean distance around Parks

- Activate Parks Distance data frame and remove *urban* and *highways.*
- Generate a Euclidean distance map to *parks* and save the output as *dist_parks*
- Symbolize *dist_parks* in 5 classes using appropriate break values such as 5000; 10000; 15000; 25000 and the highest value given.

C. Euclidean distance around Highway

- Activate Highway Distance data frame and remove *parks* and *urgban*
- Generate a Euclidean distance map to *highways* and save the output as *dist_hwys*
- Symbolize *dist_hwys* in 5 classes appropriate break values such as 2000; 5000; 10000; 15000 and the highest value given.

D. Euclidean distance around Lakes

- Activate LakeDistance data frame and remove *parks, highway* and *urgban*
- Generate a Euclidean distance map to *lakes* and save the output as *dist_lakes*
- Symbolize *dist_lakes* in 5 classes

Step 3: Display elevation with reasonable elevation highlighted

- Copy Highways Distance data frame and paste it. Rename it as "Optional Elevation".
- In the Optional Elevation data frame, remove ***highways*** and ***dist_hwys*** and add ***elevation***

Note down the following

a. The lowest and highest elevations and which shades of gray represent them
b. Which shades of gray represent the elevations between 500 -700? This elevation range provide beautiful lake view especially for residential development.

- Classify ***elevation*** into ten classes with suggested break value 300; 500; 800; 1000; 1200; 1500; 1800; 2000; 2200 and the highest value for last class. Highlight the elevations of approximately 500 -800
- Create a presentation layout showing all four data frames. Use proper cartographic principles
  Save the map file as **okanagan_distance.mxd**

Step 4: Use the Fuzzy Membership tool

In standard weighted overlays, each pixel in a raster contributes to a calculation complexly or not all; that is, it has a value of either 1 or 0. This means that you have criteria that let you say with certainty that a particular location counts or it does not. However, since real situations are not black or white, there is often some probability that a particular location should count. Fuzzy logic offers us a way to include this variation in our calculations.

In this part of the exercise we will use the Fuzzy Membership tool to scale the input raster data sets so that each pixel has a value ranging from 0 to 1, indicating the strength of the raster as a part of a set. (Think of this like probability). A value of one means the raster is a full member of the fuzzy set (and would have 100 percent weight in a calculation), and the value can decrease to 0, meaning that pixel is not a member of the fuzzy set and has a 0 percent weight in a calculation.

The Fuzzy member tool has various membership functions. You can decide which function to use based on which best describes the situation, depending on the phenomenon being modeled.

The **Fuzzy Small** transformation function is used when the smaller input values are more likely to be a member of the set (distance closer to both urban and highways)

The **Fuzzy Large** transformation function is used when the larger input values are more likely to be a member of the set (distance from parks).

The **Fuzzy Near** transformation function is most useful if membership is near a specific value. The functions is defined by a midpoint defining the center of the set, identifying definite membership, and therefore being assigned a 1. As values move from the midpoint, in both the positive and negative directions, membership decrease until it reaches 0, indicating no membership. The spread defines the width and character of the transition zone.
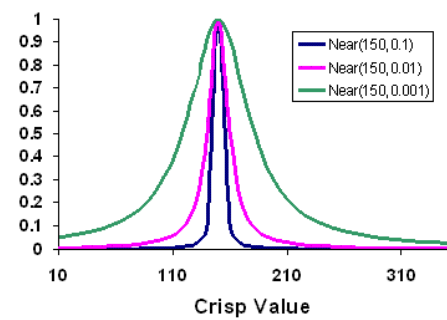
Fuzzy Near and Fuzzy Gaussian can be similar, depending on the specified parameters. The Fuzzy Near function generally decrease at a faster rate, with a more narrow spread, than the Fuzzy Gaussian function and is therefore used when the values very near the midpoint are more likely to be a member of the set. Following graphs show how the membership is assigned. Crisp Value here is the raster value from input
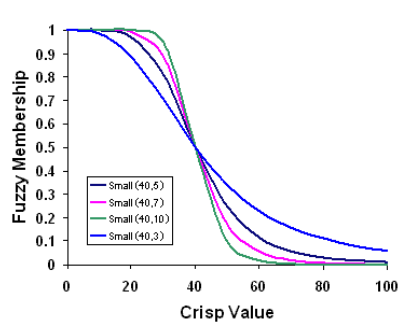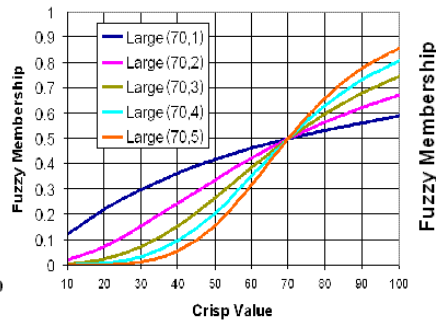
Fuzzy SMALL   Fuzzy Large   Fuzzy NEAR

A. Fuzzy Membership SMALL for Urban Distance (using Small membership favors the goal of "closeness to existing development")

- Open **okanagan_distance.mxd** and activate the Urban Distance data frame. Rename the data frame to "Fuzzy Small Urban"
- Use the Fuzzy Membership tool with ***dist_urban*** as the input raster and ***fuzzySM_urban*** as output raster

ArcToolbox->Spatial Analyst Tools-> Overlay->Fuzzy Membership
Input raster:	***dist_urban***
Output raster:	***fuzSM_urban***
Membership type:	Small
Midpoint:	15000 (15 km)
Spread:	5

- Remove ***dist_urban***
- Using the Identify tool, verify that geographic areas closer to the ***urban*** area have a larger value (closer to 1) than geographic areas away from the urban area (values closer to 0)

B. Fuzzy Membership SMALL for Highway Distance (using Small membership tool favors the goal of "closeness to existing infrastructure")

- Activate the Highways Distance frame. Rename the data frame to "Fuzzy Small Highway"
- In the same way as you did for ***dist_urban*** create a fuzzy membership raster with ***dist_hwys*** as the input, set Midpoint to 10000 and save the input raster and ***fuzSM_hwys*** as output raster
- Remove ***dist_hwys***
- Using the Identify tool, verify that geographic areas closer to the ***highways*** have a larger value (closer to 1) than geographic areas away from the highways (values closer to 0)

C. Fuzzy Membership SMALL for Lakes Distance (using Small membership tool favors the goal of "closeness to existing infrastructure")

- Activate the Lakes Distance frame. Rename the data frame to "Fuzzy Small Lakes"
- In the same way as you did for ***dist_urban*** create a fuzzy membership raster with ***dist_lakes*** as the input, set Midpoint to 5000 and save the input raster and ***fuzSM_lakes*** as output raster
- Using the Identify tool, verify that geographic areas closer to the ***lakes*** have a larger value (closer to 1) than geographic areas away from the highways (values closer to 0)

D. Fuzzy Membership LARGE for Parks (using the Large membership favors the goal of "protection of open areas and parks")

- Activate the Parks Distance data frame. Rename the data frame to "Fuzzy Large Parks"
- Use the Fuzzy Membership tool with ***dist_parks*** as the input raster
- Set Membership type to Large, Midpoint to 5000 and Spread to 5

- Save the output as *fuz_LG_parks*
- Remove *dist_parks*
- Using the Identify tool, verify that geographic areas closer to the *parks* have a lower value (closer to 0) than geographic areas away from the parks (values closer to 1)

E. Fuzzy Membership NEAR for Elevation (using Near membership favors the selection of middle elevation values, which satisfies the goal of incorporating aesthetically pleasing views)

- Activate the Optional Elevation data frame. Rename the data frame to "Fuzzy Near Elevation"
- Use the Fuzzy Membership tool with *elevation* as the input raster
- Set Midpoint value to 600 and Spread value to 0.0001
- Save the output raster as *fuzNR_elev*
- Using the Identify tool, verify that geographic areas having midrange elevations have higher values (closer to 1) and areas with high or low elevations have lower values (closer to 0)
- Create a presentation layout showing all four data frames. Use proper cartographic principles
- Save the map file as **okanagan_fuzzy.mxd**

Step 5: Fuzzy Overlay AND with model

Now that you have created the fuzzy layers the decision criteria, you need to combine them into a single overlay that will highlight the best areas for additional development

Combine fuzzy memberships using Fuzzy Overlay AND

- Open **okanagan_fuzzy.mxd** and rename the "Fuzzy Small Urban" data frame to "Fuzzy Overlay"
- Copy *fuzSM_hwys* from the Fuzzy "Large Parks" data frame and paste it in the "Fuzzy Overlay" data frame.
- Copy *fuzLG_parks* from the "Fuzzy Small Highways" data frame and paste it in the "Fuzzy Overlay" data frame.
- Copy *fuzNR_elev* from the "Fuzzy Near Elevation" data frame and paste it in the "Fuzzy Overlay" data frame.
- Delete data frames: Fuzzy Small Highways, Fuzzy Large Parks, Fuzzy Near Elevation
- Use Fuzzy Overlay tool to combine the fuzzy membership rasters. Select AND for the Overlay type.

  > **ArcToolbox->Spatial Analyst Tools-> Overlay->Fuzzy Overlay**
  > Input rasters: *fuzNR_elev*, *fuzLG_parks*, *fuzSM_hwys*, *fuzSM_urban, fuzSM_lakes*
  > Output raster: *overand*
  > Overlay type: AND

- Symbolize *overand* to 5 classes with break value at 0.1, 0.3, 0.6, 0.8 and the highest value for the last class.

*Examine the city of Okanagan area (**urban** - UANAME field), which area are good for urban development?*

- Save the map file as **okanagan_fuzzy_overlay.mxd**

- Construct a graphic representation of the process you have used to be include on your layout or as stand-alone representation of your workflow. You may use ModelBuilder or a stand-alone graphics or presentation program to do this step. To use ModelBuilder:
  - The model can be exported and added to the layer as a graphic or can be used as stand-alone diagram of your workflow.
- Save the map file as **okanagan_fuzzy_overlay.mxd**

~~~~~~~~The End ~~~~~~~