

## 2016 MGIS Geog564 – Lab 4 - Evaluation models

Assigned date: 1/22/2016

Due date: 2/3/2016 – yep, a Wednesday with some help along the way. One of the biggest challenges of this assignment is steps 1 and 2 where you are asked to prepare six criteria for MCE normalization and WST analysis. You are strongly encouraged to choose which data layers you want to use and strategize how you plan to produce a single measure that supports each criterion. There is a rapid review and feedback window January 25 – 28 where you may share your ideas with Gene so he can offer suggestions and alternatives. A summary of these exchanges will be part of Thursday's applied Canvas session on January 28.

### Introduction – creating an Evaluation model

The core purpose of this lab is to create and run an Evaluation model for the Levee Offset geodesign study in WRIA9 lowlands. The Evaluation Model will be formalized as a Multi-Criteria Evaluation (MCE) model using a weighted linear combination decision rule (See RUGIS 7.3). This Evaluation model uses as its input the Criteria with supporting data you developed in Lab02. In this lab six (or more) of those criteria data fields will be transformed into formal Multi-Criteria Evaluation (MCE) Criteria for each parcel polygon. Each MCE Criterion will be weighted by a weight whose value reflect the relative weight of that criterion from a stakeholder group's perspective. The weighted scores are then summed to generate a weighted score total (WST) that is the Evaluation score for the parcel. A map of the polygons based on that Evaluation Score will show what parts of the study area are functioning well in terms of the weighted Values of your stakeholders.

On completing this lab, you will have completed the Assessment half of the Steinitz Framework, an important milestone. The MCE criteria, weights and tools will be reused in Lab06, the Decision Model.

### Topics –

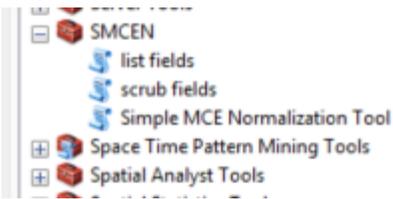
- How do we transform data to MCE Criteria?
- How do we incorporate stakeholder values in an Evaluation of the study area?
- How do we evaluate how well different parts of the study area are performing with respect to those values?
- How do we incorporate different shareholder perspectives into an evaluation of the study area?

## 2 Techniques and Tools

There is a new Arc toolbox that supports Simple Multi Criteria Evaluation Model Normalization (SMCEN.tbx) and the Weight Sum Total tool WST\_2016.py distributed in SMCEN.zip [\[\[link here\]\]](#). Upon extract you should find these contents:

Name	Date modified	Type	Size
 list_fields.py	1/18/2016 2:22 PM	Python File	2 KB
 scrub_fields.py	1/18/2016 2:54 PM	Python File	2 KB
 smcen.py	1/21/2016 12:42 AM	Python File	5 KB
 SMCEN.tbx	1/21/2016 1:05 AM	ArcGIS Toolbox	24 KB
 WST_2016.py	1/21/2016 12:25 AM	Python File	5 KB

Load the toolbox as you would any other, open each of the tools and read the documentation. The tools in ArcToolBox should look like:



WST\_2016.py is a stand-alone script used to complete Step 4 you can run by double-click or open it in a python editor like IDLE (Python GUI). Right-click on the tool in Windows Explorer and choose the option to open the file in IDLE. Running WST\_2016.py in IDLE has the advantage of copying and pasting the messaging/comments into a word document as metadata for your work.

Before you begin, make sure you set ArcMap to 'Overwrite the outputs of geoprocessing operations' in the Geoprocessing >> Geoprocessing options dialog.

The following table summarizes the steps in the workflow to follow in executing Lab04. More detail on some of the steps, *and use of the tools*, is provided in an appendix below. Please bear in mind the deliverables described in the Deliverables section below and note that those deliverables appear in the table in purple. You are invited to take advantage of the two demonstration data layers described during the practical session on January 16. You can find a compressed archive of these data and workflow documents named Lab\_4\_demo.zip on the [Course Google Drive site](#).

	Step	Task	Inputs	Methods/[tools]	Output
<b>Repeat Steps 0-3 for each criterion</b>	Step1a Raw measure: preprocessing (if necessary)	Select and describe six criteria input for MCE and WST. If multiple data inputs are supporting a single criterion, process them now to generate a single raw measure	Data attribute(s) for one criteria from starting Data Table (=Values Table + data fields per criterion from Lab02	Manual data processing.	<b>Raw single measure</b> that supports the six criterion (can be anti-correlated with objective); <b>Starting Data Table</b>
	Step 1b: Raw Measure: QA/Cleanup	Examine raw metric for outliers	Raw Single measure from step 1a	Through histograms and/or statistics remove outliers	<b>Useful single measure</b> that supports criterion (can be anti-correlated with objective); <b>brief summary of outlier removal logic</b>
	Step2 Criterion Metric completion	Transform data supporting each criterion in to a metric for that criteria; most metrics will be driven by values in/out of active flood zone from Lab03.	Six useful single measures; ); Active Flood Zone Boundary (Lab03)	Use manual processing to transform useful single measure into a metric that supports the logic of the criterion	<b>Complete Metric Rules Tables for each criterion; Parcel layer with Criterion metric attribute; Active Flood</b>

		<i>Remember: you are invited to share your ideas to complete this step during the rapid review window.</i>			<b>Zone; Data workflow document for each criteria.</b>
Step3 Metric Normalization	Create an MCE Criterion by normalizing the criterion metric	Criterion metric	Transform criterion metric to a value between 0 and 1 using [list fields], [scrub fields], [Simple MCE Normalization] tools	Parcel layer copy with an <b>MCE Criterion</b> for each Value Table criterion you carried forward	
Step 4 Equal Weighted Score Total	Enter equal weights for all criteria, multiply MCE Criterion value by weights, and sum to weighted score total	All MCE Criteria, equal weights	using the [WST_2016.py] tool	Parcel layer copy with a <b>weighted MCE score</b> for each Value Table criterion and an overall WST value	
Step 5a WST Analysis: Generate equal weights WST map	Create an informative map of WTS, look for spatial patterns	Parcel layer copy with overall WST value attribute	Overlay with river, cities, ... in ArcMap	<b>Map of equal weight WST; written discussion</b>	
Step 5b WST Analysis: weighted MCE Criteria Scores	Compare highest/median/lowest scoring sets of 5 parcels, discuss what drivers are apparent	Parcel layer copy with a <b>weighted MCE score</b> for each Value Table criterion	Copy the 15 parcels with PIN, [PROP_Name] and weighted MCE scores to Excel, generate stacked horizontal bar chart	<b>Excel Horizontal stacked Barchart; written discussion</b>	
Step 6a WSTs for three perspectives	Repeat step but with weights from 3 stakeholders' perspectives	All MCE Criteria, 3 stakeholder's weights	Create a set of weights that might reflect a stakeholders perspective; use the [WST.py] tool x 3 perspectives	Parcel layer copy with a <b>weighted MCE score</b> for each Value Table criterion and an overall WST value; <b>weights table</b>	
Step 6b WSTs Maps for three perspectives	Repeat 5a for 3 weights set, create 2x2 image array of equal weights + 3 perspectives	Parcel layer copy with a <b>weighted MCE score</b> for each Value Table criterion and an overall WST value for each perspective	Overlay with river, cities, ... in ArcMap; create 2x2 matrix of WST map images	<b>Image containing 2x2 WST Maps of study area for equal and 3 perspective weights sets;</b>	

					written discussion

### 3 Deliverables

- Step 1 Metric Prep
  - Starting Data Table = Values Table + data field mapping from Lab02, possibly modified after feedback
  - Brief written summary of outlier removal/attribute value setting logic employed
  - Bring through at least 6 criteria, with at least one in each of economic, social and environmental.
  - Data workflow document describing your work to create each of the criterion metrics. See example workflow documents in Lab\_4\_demo.zip on the [Course Google Drive site](#).
  - All together about (< 2 pages, apart from the workflow documents)
- Step 2 Criterion Metric Completion
  - Map of Active Flood Zone Boundary from Lab03, possibly modified after feedback from Lab03
  - Complete Metric Rules Tables for each criterion you are bringing through (see appendix)
- Step 5a WST Analysis
  - Image of Evaluation Map of informative equal weight WST for study area and written discussion of findings (~ 1 page)
  - Excel Horizontal stacked horizontal Barchart of 15 parcels (5 top, 5 near median, 5 bottom by WST) showing the weighted MCE Criterion score for each parcel – use [Prop\_Name] as identifier; written discussion analyzing drivers observed from barchart: (~ 1 page)
- Steb 6b
  - Image containing 2x2 Evaluation (WST) Maps of study area for equal weights and 3 shareholder perspective weights sets; written discussion of findings (~ 1 page)

### 4 Expectations and grading –

Performance	Credit	Description
No deliverable	0 points (0%)	No deliverable
Minimal engagement	15 points (60%)	Less than four criteria successfully processed through all steps OR Less than three shareholder perspectives OR Any criteria addressed lack a workflow document (Step 2) OR Any criteria missing an outlier evaluation/action discussion OR Missing WST map and discussion OR Missing weights table OR Missing Excel table from Step 5a
Incomplete	20 points (80%)	Less than six criteria successfully processed OR Any criteria addressed lack a workflow document (Step 2) OR Any criteria missing an outlier evaluation/action discussion OR

		Missing WST map and discussion OR Missing weights table OR Missing Excel table from Step 5a
Complete	25 points (100%)	All deliverables described in the deliverables section.
Beyond complete	25 points (100%) with up to five future points	More than 6 criteria brought through; use of a criterion that does not use flood in/out, yet is valid – e.g wetlands connected to river; exploration of how top 5 parcels ranks vary from different perspectives

## Appendix: Notes on Important Steps in the Workflow

Here are notes that may guide you for some key steps in the workflow.

### Step1 Metric Prep:

Addressing the triplicate of Values dimensions: Economic, Social and Environmental

In Lab02 you created a Data Table (= Values Table + Data Fields column) which includes a list of Criteria and a database field(s) that will support that criterion. Lets call that database field (or if you had multiple fields that you planned to combine, the data field that is outcome of your processing) the metric for the criterion. You will need to specify an orientation for that metric - do higher values coincide with higher scores for the criterion, or the reverse.) For this lab the metric needs to be numeric, so if you have an ordinal scale – say poor, OK, Great – you’ll need to transform each scale item to a numeric ratio scale – e.g interpret poor as 0, OK as 40 and Great 100.

This lab requires that you bring forward at least 6 criteria from Lab02 (of source you can augment your own Data Table with rows from a collective table that Gene will produce from all Lab02 submissions). In terms of breadth of coverage for your original values table, this lab requires that you have at least one criteria supporting at least one Value each in the Values dimensions of Economic, Social and Environmental.

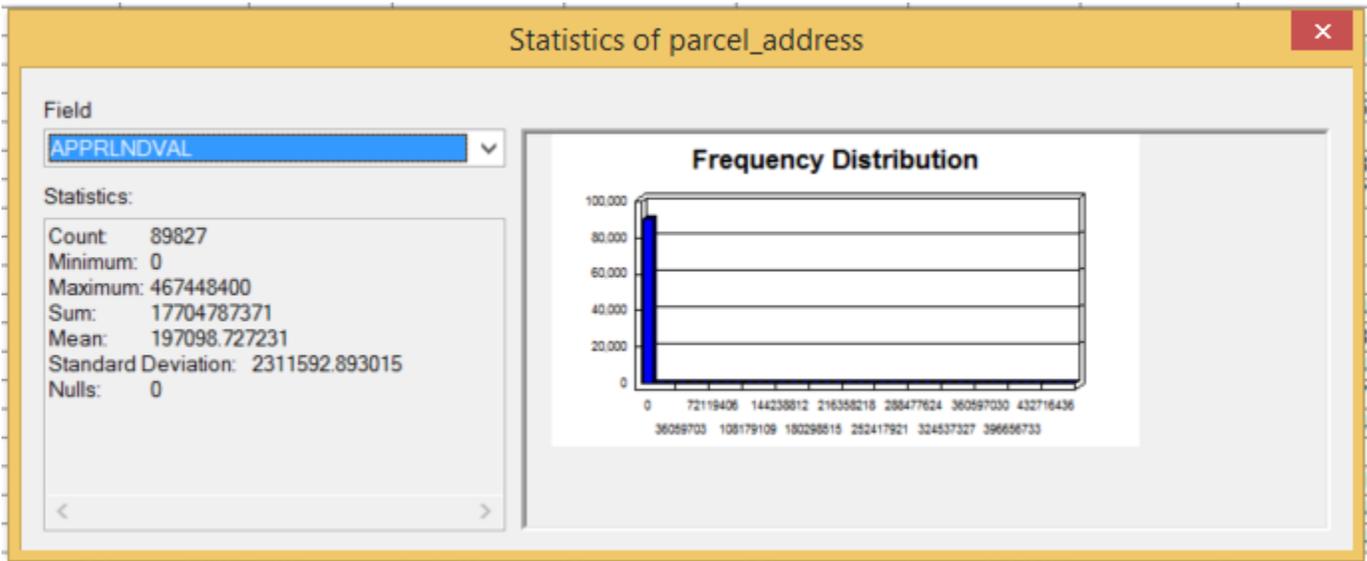
### Step 1b Raw Metric QA/Cleanup: Histograms of Metric values – clean out outliers

With 89,827 parcels, there are going to be some data anomalies. You need to make sure that such anomalies do not render your metric useless.

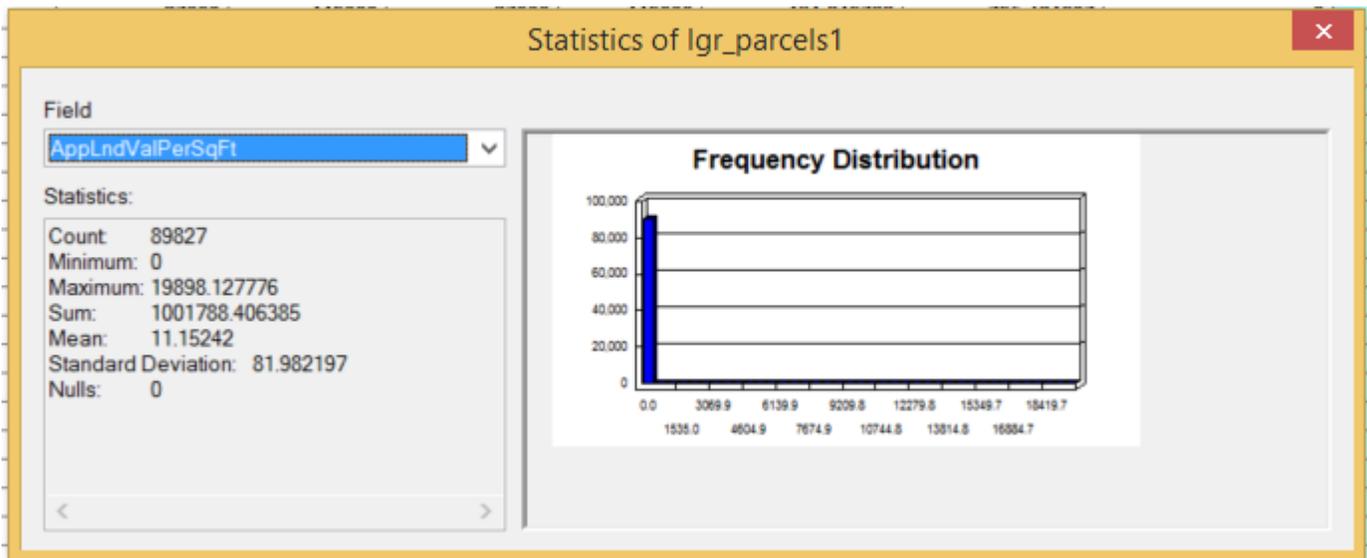
To see if you have an issue, create a histogram of the values of each metric (input data field) you intend to use. Do they provide suitable metrics to help decide which parcels are the systems you care about or working well? We’ll be creating MSE Criteria from your measure based on linear transformations, and min/max values will be mapped to 0/1 or 1/0 by the Simple MSE Normalization tool that Gene created for you. So if there are a few outlying parcels with values orders of magnitude larger than the other 89,000, the vast majority of your parcels will be mapped to either 0 or 1. Generally, a useful MSE Criterion has reasonable percentages of parcels distributed throughout the 0-1 range.

Think carefully about the value in your input data field –if its value is likely highly correlated with parcel size, you will likely want to divide by parcel area.

For example, suppose the Appraised Land Value attribute [APPRLNDVAL] in the [parcel\_address] layer was one you wanted to use as a metric for a criterion. Its raw histogram looks like (obtained by right clicking the header of the column and selecting Statistics):



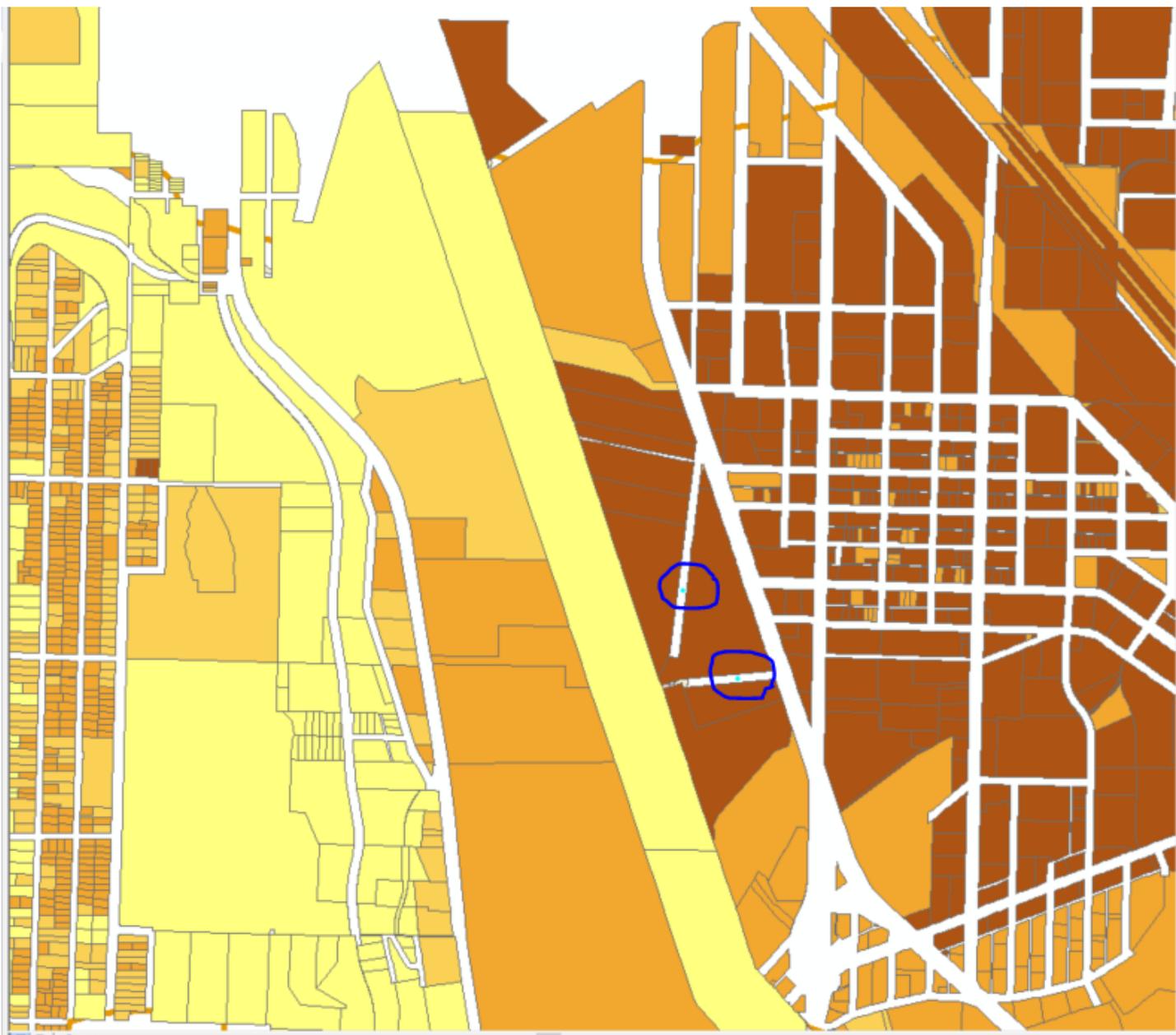
Clearly it has a few very high values, and all the rest are much smaller (there are about 89,000 in the first bin and the standard deviation is about 20 times the mean). But when it comes to \$\$ valuation, it is likely that the larger the parcel the greater its appraised value. So you might create a new field  $[AppLndValPerSqFt] = [APPRLNDVAL] / [Shape\_Area]$



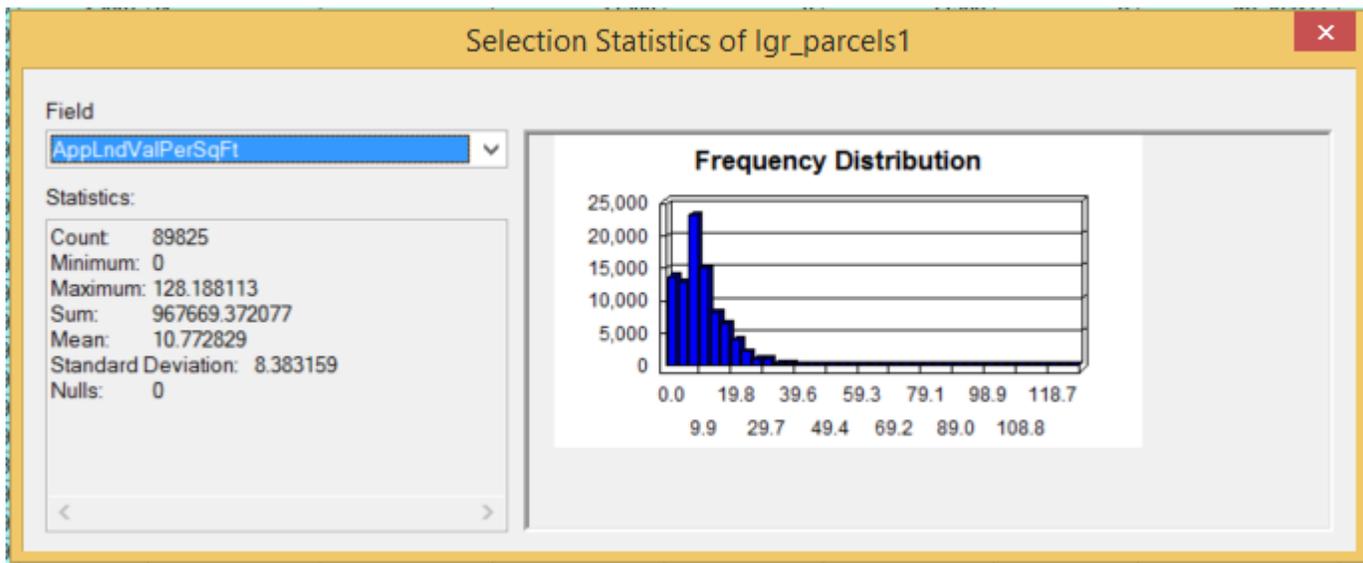
Better – the stdev is about 8 times the mean, but there are still 89,000 in the first bin. Sort the parcels by decreasing  $[AppLndValPerSqFt]$

SITETYPE	PRESENTUSE	LOTSQFT	NEW_CONSTR	TAXVAL_RSN	APPRLNDVAL	APPR_IMPR	TAX_LNDVAL	TAX_IMPR	Shape_Length	Shape_Area	MCE_APPRLNDVAL	AppLndValPerSqFt
		332	51000	N	EX	1581000	0	0	31.725215	79.454711	0	19898.127776
		332	36450	N	EX	1129900	0	0	31.724979	79.453444	0	14220.906531
R2		29	590	N		76000	77000	76000	122.576808	592.878685	0	128.188113
DV		29	796	N		87000	119000	87000	131.819788	795.481607	0	109.367708
		316	2614	N	OP	47000	0	0	155.109068	438.828907	0	107.103245
		309	23087	N		11500	0	11500	46.369277	109.235588	0	105.277046
R2		29	815	N		82000	87000	82000	113.967217	809.494131	0	101.297831
R2		29	815	N		82000	87000	82000	114.318212	814.726861	0	100.647228
R2		29	1386	N		137000	38000	137000	169.998066	1385.974463	0	98.84742
R2		29	1386	N		137000	38000	137000	169.999084	1385.985785	0	98.846613
R2		29	1386	N		137000	38000	137000	170.026078	1386.28209	0	98.825485
R2		29	1387	N		137000	38000	137000	170.13494	1387.435749	0	98.743311
R2		29	969	N		93000	132000	93000	149.542024	968.747926	0	96.000206

You see that there are two (2) parcels whose  $[AppLndValPerSqFt]$  value is 100 times larger than the rest (which all lie within 2 sigma of the mean). Selecting and zooming in on these two, small 80 square feet (!) spots, they are near the harbor:



Looking them up, these two properties seem to be some weird Seattle DOT artifacts with associated street use permits. They seem artificial. If I remove them and rerun the statistics, I get the following histogram:



While it still has a few high values, any criterion based on a linear multiple of this measure of Appraised Land Value / Area will show useful variation over the parcels. Which is what I expect in a study area that has important industrial areas, cities and residential areas.

To make the culling of these two outliers official, you might a) delete them from your parcel feature class copies or b) manually set the value of [AppLndValPerSqFt] to 128, the new Max or 0 the new Min value, depending on how your criterion will interpret the values of this measure.

You need to repeat this examination for all your candidate metrics. Remove or overwrite the attribute values of outliers until you get a histogram like the above with a good spread in values, and NOT one where 99% of the parcels values fall into the first bin, remove outliers. But note where they are and record your reasoning for excluding them.

**Step2 Criterion Metric completion**

Most of the criteria will require you to understand whether the parcel whose attribute is providing the raw metric is inside or outside or intersected by the flood zone boundary. If your objective is protect 90% of all valuable built infrastructure, and my raw attribute gives me a measure of value, I need to proceed to transform this field to get field values that represent your criterion - to measure how well the valuable built infrastructure in a parcel is protected. Hopefully your definitions for Objective and Criterion were clear enough for this to be straight forward.

A Metric Rule table is a useful way to lay this out.

Subject fc: parcel	Spatial relation: intersection with flood zone	Metric value: Appraised land value per square foot	Reasoning
Metric field value: AppLndValPerSqFt	Parcel fully in flood zone	0	None of the parcel's value is protected
	Parcel fully out of flood zone	AppLndValPerSqFt	All the value is protected
	Parcel partially in of flood zone	AppLndValPerSqFt * (area of parcel in flood zone/area of parcel)	Assume the parcel's value is spread evenly across parcel

Look at Gene's examples for population and transportation Lab\_4\_demo.zip on the [Course Google Drive site](#) to see how you might calculate the in/out numbers you will need to complete the transformation of raw measures to criteria.

Note that Lab\_4\_demo.zip has two examples of workflow documentation. Rules/purpose of making a workflow document is very basic: Take a screenshot of each tool you use and paste it into a word document as you do the work. Provide sufficient description of your tool choices and decisions so you can recount your work and someone else can appreciate the logic of your work.

On completing Step 2 you will have generated the metric field that your Values Table prescribed for the Criterion. This Criterion metric typically has unit dimensions (acres, \$\$, households, people, linear miles (e.g. roads, streams)) and is defined for all analysis units in the study area.

### Step3 Metric Normalization

SMCEN.tbx has the tools that will help you perform the metric normalization. The key to doing this smoothly is starting with feature classes and tables that are easy to manage and an output feature class to receive the output. A persistent challenge working with parcel data and any other data with excessive fields that are unnecessary for your needs. 'list fields' and 'scrub fields' are made to help cleanly discard fields you don't need. 'list fields' does just that, the fields for the input feature class are reported in the analysis report dialog as a python list of field name strings.

Example:

```
['OBJECTID', 'Shape', 'KC_FAC_FID', 'KCPARKFID', 'SITENAME', 'SITETYPE', 'OWNER', 'OWNERTYPE', 'MANAGER', 'MANAGETYPE', 'MAINTD_BY', 'MAINTTYPE', 'Shape_Length', 'Shape_Area']
```

Copy this text and paste it into a text editor and delete the fields you want to discard keeping the fields you want to carry into a new feature class.

Example:

```
['OBJECTID', 'Shape', 'PIN', 'SITETYPE', 'Shape_Area']
```

Enter the feature class and the field list and an output feature class in 'scrub fields' to discard the fields not included in the list.

While this can be a convenience working with unwieldy tables, the procedure to discard unwanted fields is critical for use of the 'Simple MCE Normalization tool'. The purpose of this tool is to iteratively create an output feature class that holds the normalized criteria fields. Toward this end you need to create the base output feature class that will receive the normalized fields before you begin. Run the 'list fields' and 'scrub fields' pair and discard all fields except for ['FID', 'Shape', 'OBJECTID', 'PIN']. Name the output something appropriate like 'MCE\_FC'.

To normalize your criteria metrics open the Simple MCE Normalization tool and review the tool help to appreciate the input/output fields. The tool will evaluate the input field from the input feature class to determine the minimum and maximum values to calculate the normalization. Then the input feature class is joined with the output feature class where a new output field is created. This output field is named the same as the input field with a "MCE\_" prefix. The normalized values are calculated and written into the new output field in the output feature class. Lastly, the input and output feature classes' join is removed. Open the table for the output feature class and explore the results.

You want to do this for each of the criteria in your MCE. You don't need to scrub fields from your input feature classes as you already have a scrubbed output feature class that will hold just the MCE fields. Important note: You need to pay attention to all the fields you want to bring together in the MCE\_FC output feature class to insure there are no conflicts. Two fields named 'Shape\_length' and 'Shape\_area' produce the same output field name 'MCE\_Shape\_' once the "MCE\_" prefix is added and the result is right truncated to fit into the output table structure. Carefully review your input field names to prevent having output field being dropped or overwritten.

### - Handling Absences

One final consideration before you formally normalize your criterion to generate an MCE Criterion - how to interpret the absence of the subject feature(s) of your Criterion? If protecting farmlands from flood is your objective, how does your criterion deal with parcels that have no farmland?

Rule Table for MCE Criterion for “Protect all Farmlands from Flooding” Objectives

Subject FC: Farmland	Spatial relation: parcel contains farmland	Spatial relation: parcel contains farmland and intersects with floodzone	MCE Criterion Value: : reasoning
	Yes	No	1 : functions well, all farmland protected
	Yes	Yes	(area of farmland in parcel outside flood zone)/(area of farmland in parcel)
	No	No	1 : absence, no farmland needs protecting

With the [Simple MCE Normalization tool] we have made available you’ll find a field named ‘default output value’. This value is written into the output normalization field before the normalization values are calculated. Any records that don’t receive a normalized value retains this default output value.

A (Complete) Metric Rule table (that handles Absence) for objective “protect all farmlands from flooding”:

Subject FC: Farmland	Spatial relation: parcel contains farmland		Metric value: acres protected in sqft	MCE Criterion Value: : reasoning
	Yes	No	Parcel area (sqft)	all farmland protected
	Yes	Yes	Area of intersection of parcel with Flood zone (acres)	Assuming parcel is all farmland
	No	No	Parcel area (sqft)	absence, no farmland needs protecting, but need full area to trick normalization tool

Yes, having to jump back to your measure attribute and hack its value so that the MCE Normalization comes out right is irritating. But it is harder than you might think to create a general MCE Normalization tool that can support the user in designing Absence rules for all situations.

**Step 4 WST with WST\_2016.py:** Another tool distributed in SMCEN.zip is WST\_2016.py. You can locate the file in Windows Explorer and double-click to launch it, a short description of how to use the tool will show in the DOS executable window. A better choice is to open a Python editor like IDLE commonly installed in this location ..\Python27\ArcGIS10.3\Lib\idlelib\idle.pyw. If you right-click on the tool you should be given the option to open the file in IDLE. The advantage to use of an interpreter is you can retain the process record messages echoed to the command line while the tool is running.

This tool expects to find fields in the input table with ‘MCE\_’ prefixes. This is the way the tool knows which fields to include in the WST calculation. The help message displayed when the tool runs looks like this:

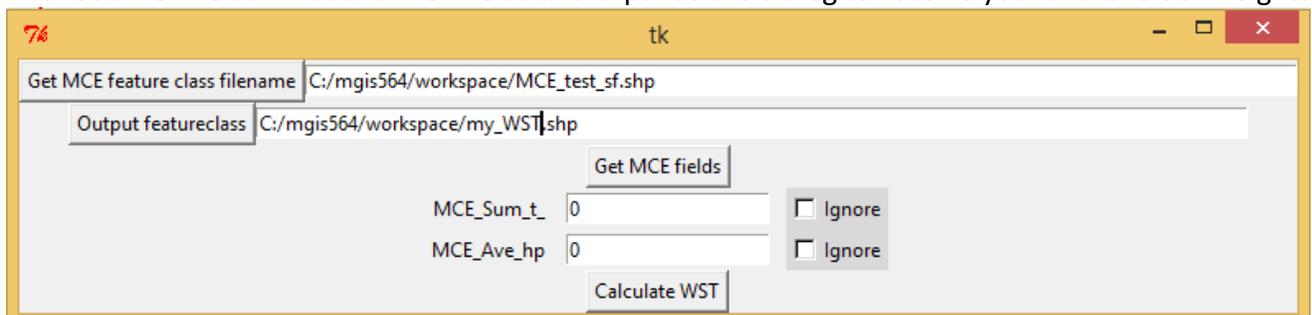
Weight sum total (WST) tool

1. Select the MCE feature class (MCE\_FC) or type the full filename
2. Select the output WST feature class (WST\_FC) or type the full filename.
3. Click 'Get MCE fields' to read the MCE\_FC fields that begin with 'MCE'.
4. The MCE fields will present for weighting.
5. Enter weights. Check 'Ignore' to exclude fields.
6. Click 'Calculate WST' to create the WST\_FC with the weight fields and WST.
7. Change the WST\_FC and reuse

Once arc finishes loading this dialog is shown that handles items 1 – 3.



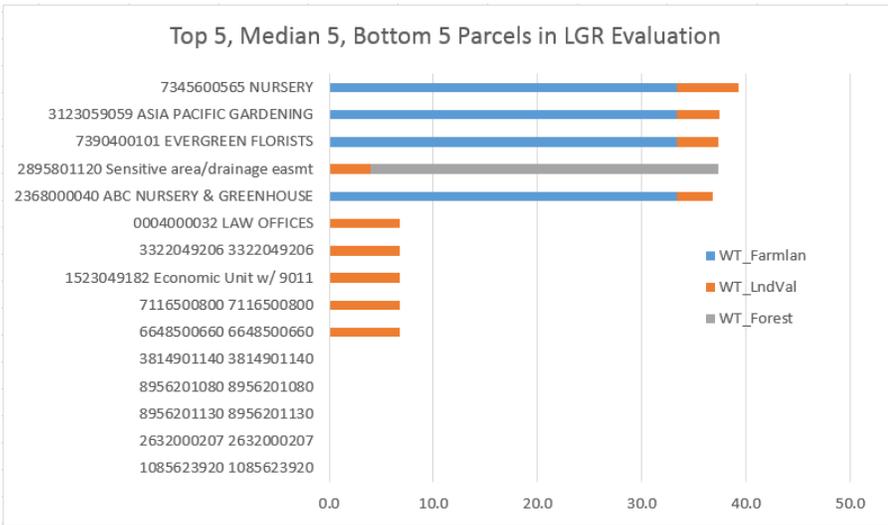
1. Type in the filename for the MCE\_FC feature class you created above that carries those normalized fields with "MCE\_" prefix.
2. The output WST feature class (WST\_FC) should be another bare bones feature class product like MCE\_FC from 'scrub fields'. Again, the join/key field is critical to connecting the record/fields among these tables.
3. The 'Get MCE fields' finds the MCE fields and expands the dialog to receive your shareholder weights.



4. Expect to find the (six) normalized fields you've created listed here.
5. Enter the weights for the MCE fields and check the 'ignore' option if you don't want to calculate. A weight of 0 is still a valid weight.
6. When you calculate WST the input feature class is copied to create the output feature class. New weight fields corresponding to each MCE field are created. These weight fields are named the same as the MCE input fields except the 'MCE\_' prefix is replaced with 'WT\_'. Finally a field named WST is created that is the final WST calculation.

### Step 5b WST Analysis:

For equal weights, take the 5 parcels with the highest WST values, the 5 parcels with the lowest (but >0) and 5 parcels near the median (when sorted by WST). Create a map showing the river, the DEM and the WST layer and indicate where the parcels are on it. Add any other layers you feel might be informative. Use the Select by Attribute method in the Attribute Table to select the 15 and export them to a dbf. Open in Excel and with their PIN numbers as identifiers and [Prop\_Name] as labels, create a stacked horizontal bar chart based on their weighted criteria ("WST\_x") values.



Note – I only have 3 criterion in this bar graph – you should have at least six.

What can you say about what makes for a well performing parcel versus a median versus a poorly performing parcel? Are there any obvious spatial patterns in the WST map? Does what you see make logical sense?

**Step 6a WSTs for three perspectives**

When you first run the WST Calculator, do it with equal weights, and generate the Evaluation map based on equal weights for all criteria. Then do so again with weights sets from three different roles, roles you should choose to be as different as possible. Record the 3 weights sets in a table. Create a display with the 4 maps together in a quad image. Do you see any differences? Any pattern to those differences? How might those differences be explained?