Calculation of Landscape Development Intensity Index (LDI) Values

1. SCOPE AND APPLICATION

1.1. This procedure details the calculation of the Land Development Intensity (LDI) values using ArcMap and Microsoft Excel.

1.2. This SOP assumes a working knowledge of terminology and data manipulation in ArcMap 10.2 and Microsoft Excel 2013. Older versions of ArcMap and Excel may be used, but the specific steps may differ.

2. SUMMARY OF METHOD

2.1. Biology staff obtains an Excel file with a list of samples with geographic coordinates for which LDI values need to be calculated.

2.2. ArcMap is used to correlate a sampling site to the watershed in which it was sampled. The water body (lake, stream, river) associated with a site is selected and a 100 meter buffer is created around it using either the Buffer Tool or the LDI Stream Buffer Tool in ArcMap.

2.3. The LDI should only be calculated using the buffer area and should not include the water body itself. The LDI is calculated using ERAtools in ArcMap, which uses the most current land use layer. The buffer area is selected and the ERAtools Select Tool is used to link the buffered area to the LDI layer. The resulting LDI score is displayed in an Excel file, which is saved to be entered into the Statewide Biological Database (SBIO).

2.4. If the site was sampled in the past, an older land use layer may be more appropriate, and the LDI should be calculated manually by clipping the buffered area to the appropriate Water Management District (WMD) land use layer. The resulting table should be converted to U.S. Acres and exported to Excel. The Excel file is manipulated to calculate the total LDI for the buffered area. The Excel file is saved and the LDI value entered into SBIO.

3. SOFTWARE AND FILES

3.1. ArcMap 10.2

3.2. Excel 2013

3.3. LDI_final.era \\Fldep1\dear\Labs\Lab5\Biology\AppliedBiology\LDI stuff\SBIO LDIs

3.4. LDI_lookup.xlsx \\Fldep1\dear\Labs\Lab5\Biology\AppliedBiology\LDI stuff\SBIO LDIs

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4. PROCEDURE

4.1. In ArcMap, open the FDEP **Dataminer** 5.0 ( ) tool and locate the map "Florida NHD" by searching the Water Base Maps and add the layer to the data frame. The **NHD 24** layer will be used in this method.

Note: ArcMap should be operating as ArcInfo (administrator) to ensure all of the required tools and capabilities are available.

4.2. An Excel file with the geographic coordinates (Latitude and Longitude) for the stations that require LDI values is generated in advance. Select **File/Add Data/Add XY Data**. Find the Excel file and select it as the table to be added to the map. Ensure "Longitude" is in the **X Field** and "Latitude" is in the **Y Field** (these will be populated with the coordinates from the Excel file), and **Edit** the Geographic System so that it is the North American 1983 HARN Geographic Coordinate System. The data sheet is now located in the Table of Contents (TOC).

Note: If only a few sites are being worked on, each site can be located separately by selecting the **Go to XY** tool and entering the latitude and longitude of the site. If this is the case, continue to 4.4. This method, however, will not work with the LDI Stream Buffer Tool method.

4.3. In the TOC, use the mouse to right-click on the data sheet layer created in 4.2. Select **Data/Export Data**. **Export** "All features," **Use the same coordinate system as** "the data frame," and ensure the **Output feature class** is set to the designated folder. When asked to export the data as a layer click **Yes**. Remove the original layer from the TOC by right-clicking on it and selecting **Remove**. Using the **Select Features by Rectangle** ( ) tool, select the desired sampling point; zoom to it by right-clicking on the point and selecting **Zoom to Selected Features**.

Note: If the sheets in the Excel file (Step 4.2) were not named, the original layer will be named "Sheet1$ Events." If the sheet was named, the layer will have the name of the sheet.

Note: Whether to delete a layer or deselect it is a preference. The data sheet layer can be deleted because it is no longer useful. However, in future steps it may be wise to simply deselect layers by un-checking the box in the TOC as steps are completed, and not delete them from the TOC, in order to show the progress in case of an error.

4.4. **For Lake LDI Calculations:** (For Stream and River calculations, proceed to step 4.5.)

4.4.1. Use the **Select Features by Rectangle** ( ) tool and select the lake that corresponds to the sampling point.

Note: It may be necessary to use an aerial imagery layer in order to verify whether a polygon is a lake or marsh.

Note: Streams flowing into lakes are not included as it was determined that the contribution to the lake system was not significant.

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4.4.2. Right-click on the Florida NHD/NHD 24/ NHDWaterbody layer in the TOC, select **Data/Export Data**. Choose to **Export** "Selected features," **Use the same coordinate system as** "this layer's source data," and ensure the **Output feature class** is set to the designated folder and the layer is named appropriately. Click **OK**. When asked to export the data as a layer click **Yes**.

4.4.3. Uncheck all other layers in the TOC so that only the layer created in 4.4.2 is visible. Open ArcToolbox ( ), select **Analysis Tools/Proximity**, and double-click **Buffer**. Set the **Input Features** as the layer exported in 4.4.2, ensure the **Output feature class** is set to the designated folder, set the **Distance** to a **Linear unit** of 100 **Meters**, and click **OK** to complete buffer.

Note: If an Internet Explorer error message pops up this is a problem with the internet options (not ArcMap) and can be fixed by opening an **Internet Explorer** window selecting **Tools/Internet Options**, navigate to the **Security** tab, select **Trusted sites**, click the **Sites** button and deselect the box next to "Require server verification (https:) for all sites in this zone." Add the network drive to the trusted sites (ex: file://Lab5).

4.4.4. In ArcToolbox ( ), select **Analysis Tools/ Overlay**, and double-click **Erase**. With the buffer created in 4.4.3 as the **Input Features** and the exported layer from step 4.4.2 as the **Erase Features**, ensure the **Output feature class** is set to the designated folder and click **OK** to erase. Deselect any selected features. Continue to 4.6.

Note: Natural waterbodies have an LDI of 1.00, so including the water in the calculation will artificially lower the LDI and give an erroneous value.

4.5. **For Stream and River LDI calculations:**

4.5.1. **LDI Stream Buffer Tool**

For sites with flow direction established for all connected upstream flowlines, use the **LDI Stream Buffer Tool** as described below. If flow direction is not established for all upstream connected flowlines (i.e. canals), refer to manual buffer creation as described in 4.5.2.

Note: In order for the **LDI Stream Buffer Tool** to work, you must first create an Excel file with the geographic coordinates of the sites you are calculating values for as described in 4.2 and 4.3.

Note: If the **LDI Stream Buffer Tool** has not yet been added to your **ArcToolbox** in ArcMap, open **ArcToolbox** and right click the **ArcToolbox** folder at the top of the window. Select **Add Toolbox** and navigate to the "**\\FLDEP1\giscloud\LDI_Tool**" folder. Select the **LDI Stream Buffer Tool** toolbox (.tbx) to add it to your **ArcToolbox**. Save this toolbox to your **ArcToolbox** by right clicking the **ArcToolbox** folder at the top of the window and selecting **Save Settings** and **To Default**.

4.5.1.1. Open up the attribute table of the exported site coordinates created in 4.2 and 4.3.

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4.5.1.2. Zoom to the desired site by double-clicking the far-left column of the row in the attribute table. This will also **select** the site.

4.5.1.3. The site must be snapped directly to the flowline of the stream or river in order for the tool to run. To do this, right click on the exported site coordinates layer in the **TOC** and select **Edit Features → Start Editing**.

4.5.1.4. If not already selected, **select** the desired site and drag it to the flowline of the appropriate stream or river using the **Edit Tool** ( ) until it snaps to the feature.

Note: The above step will only work if you have **snapping** enabled. If **snapping** has been disabled, select the **Editor** drop-down from the toolbar. Scroll down to **Snapping** and turn on the **Snapping Toolbar**. In the **Snapping Toolbar,** click on the **Snapping** drop-down and select **Use Snapping**.

4.5.1.5. Select **Stop Editing** from the **Editor Toolbar**. When asked if you want to save your edits, select **Yes**.

4.5.1.6. If not already selected, **select** the site. Make sure nothing else is selected.

4.5.1.7. In **ArcToolbox**, select the **LDI Stream Buffer Tool** and open the **Stream Buffer Model**.

4.5.1.8. In the **Input Point Feature** drop-down field, select the exported site coordinates layer that the site is in.

4.5.1.9. In the **Output Buffer Location and Name** field, select the appropriate destination folder and name for the buffer being created.

4.5.1.10. In the **NHD_24K_Area** drop-down field, select the NHD 24K Area layer (Florida NHD → NHD 24K → NHD 24K Area)

4.5.1.11. In the **NHD_24K_Waterbody** drop-down field, select the NHD 24K Waterbody layer (Florida NHD → NHD 24K → NHD 24K Waterbody).

4.5.1.12. Select **OK** to run the model. Make sure the resulting buffer covers all connected upstream flowlines. Also, make sure that any natural waterbodies have been erased from the buffer. Reservoirs should be left in the buffer.

Note: Natural waterbodies have an LDI of 1.00, so including the water in the calculation will artificially lower the LDI and give an erroneous value. Reservoirs, however, have an LDI of 4.09 and therefore must be included in the calculation.

4.5.1.13. If the buffer covers all of the necessary waterbodies, right-click the newly created buffer layer in the **TOC** and use the **Edit Features** option to **Start Editing**. Use the **Cut Polygons Tool** to cut the

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downstream portion of the buffer perpendicular to the flowline. **Select** the downstream piece separated by the **Cut Polygons Tool** and delete it. Continue to 4.6 for buffer calculation. If the buffer failed to cover all of the necessary waterbodies, the remaining waterbodies can be buffered manually and appended to the initial buffer using the following steps.

Note: If the site falls within the NHD 24K Area layer, the buffer will extend for the entire length of the feature regardless of upstream/downstream orientation. In this case, cut off the downstream portion using the same method described above.

4.5.1.14. Using one of the **Select Features** tools (), select the remaining features that need to be buffered from the Florida NHD layer. Within the Florida NHD layer, the NHD 24K Flowline, NHD 24K Area, and NHD 24K Waterbody features will need to be buffered separately. Once the desired feature is selected, open the **Buffer** tool. Set the **Input Features** field to NHD 24K Flowline, NHD 24K Area, or NHD 24K Waterbody (depending on which layer the feature is in). In the **Output Buffer Location and Name** field, select the appropriate destination folder and name for the buffer being created. Set **Distance** to **Linear unit**; entering 100 **Meters** into the field. Change **Dissolve Type** to "ALL", and click **OK** to create the buffer. If the feature was an NHD 24K Area or NHD 24K Waterbody feature, the water area must be erased from the buffer (unless it is a reservoir). To do this, open the **Erase** tool and set the **Input Features** field to the newly created buffer. Set the **Erase Features** field to either NHD 24K Area or NHD 24K (depending on which layer the feature came from). In the **Output Buffer Location and Name** field, select the appropriate destination folder and name for the new buffer being created.

4.5.1.15. Open the **Append** tool and set the **Input Datasets** field to the buffer created in 4.5.1.14. Set the **Target Dataset** to the buffer created by the **LDI Stream Buffer Tool** in 4.5.1.12. Change the **Schema Type** to "NO_TEST" and click **OK**. This step may need to be performed more than once, depending on how many features were buffered in 4.5.1.14.

4.5.1.16. Open the **Dissolve** tool and set the **Input Datasets** field to the buffer created in 4.5.1.15. In the **Output Feature Class** field, select the appropriate destination folder and name for the buffer being created. With the final buffer created, proceed to 4.6 for buffer calculation.

4.5.2. Manual Buffer Creation

This method should be used when flow direction is not established for all upstream connected flowlines or when the **LDI Stream Buffer Tool** fails to buffer correctly.

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4.5.2.1. Draw a circle from the sampling point. While the mouse button is depressed and the circle is still being drawn, type "r" before releasing the mouse button to bring up a text field in which to set the radius of the circle. Fill in "10000" to set the radius of the circle to 10,000 m and hit enter. Right-click on the circle and select **Properties**. Under the **Symbol** tab, change the **Fill Color** to "No color" and the **Outline Color** to black or some other noticeable color. The **Outline Width** can also be adjusted to make it more noticeable.

Note: Ensure units are displayed as meters (**View/Data Frame Properties**).

4.5.2.2. Zoom in so that all NHDFlowline, NHDArea, and NHDWaterbody features that are **upstream, connected, and within the circle** are in the view extent. Using the mouse, right-click on the Florida NHD/NHD 24 layer in the TOC for each feature type (one at a time), select **Data/Export Data.** Choose to **Export** "All features In View Extent," **Use the same coordinate system as** "this layer's source data," and ensure the **Output feature class** is set to the designated folder and each layer is named appropriately (ex:SiteArea, SiteFlow, etc.). Click **OK**. When asked to export the data as a layer click **Yes**.

Note: When multiple feature types are present they must be exported separately.

Note: When there are fewer features to select, *i.e.*, it is clear that upstream connections of the LDI site are contained in an obvious subsection of the view extent, employ the **Select Features by Rectangle** () or **Select Features by Lasso** () tool to make selections. For each feature type selected by this method, Choose to **Export** "Selected features".

4.5.2.3. Uncheck all other layers in the TOC so that only the layers created in 4.5.2.2 are visible and select **Editor/Start Editing**, and when the window pops up select the source that has the layer(s) from 4.5.2.2 in it. Using the **Edit Tool** arrow, select features (multiple features can be selected at the same time by clicking and dragging a box around the features to be selected) that will not be included in the final buffered layer (i.e. not connected and upstream of the sampling point) and press **Delete**. When finished, select **Editor/Stop Editing** and when asked to save edits click **Yes**.

Note: It helps to turn off unnecessary layers to ensure that it is clear what is being selected.

Note: If there is doubt as to what is upstream and connected a topography layer and flow arrows can be used as a guide to determine the flow pattern and an aerial imagery layer can be used to

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verify connection. Make the topography layer unselectable so that editing the layer(s) from 4.5.2.2 is not interrupted by accidentally selecting topography lines. In the TOC, choose **List by Selection** ( ) and locate the Topography layer. Click the colored button **Click to toggle selectable ( )**.

Note: **All features** that are upstream, connected and within the circle should be included in the final buffered layer. This includes features that are within the circle and flow back outside of the circle, as long as they ultimately return to the inside of the circle.

4.5.2.4. Open ArcToolbox ( ), select **Analysis Tools/Proximity**, and double-click **Buffer**. Set the **Input Feature** as the layer(s) exported in 4.5.2.2, ensure the **Output Feature Class** is set to the designated folder, set the **Distance** to a **Linear unit** of 100 **Meters** and change the **Dissolve Type** to "ALL", and click **OK** to complete buffer. Uncheck the Flowline, Area, and Waterbody features in the TOC so that only the buffer layers are visible.

Note: Flowline, Area and Waterbody features need to be buffered separately.

4.5.2.5. If there are no Area and Waterbody features, proceed to Step 4.5.2.12.

4.5.2.6. If there are Area or Waterbody features, combine all of the buffer polygons. In ArcToolbox ( ), select **Data Management Tools/ General** and double-click **Append**. Select the Waterbody and Area Buffer features created in 4.5.2.4 as the **Input Datasets**, select the Flowline Buffer as the **Target Dataset**, and click **OK** to append all polygons together.

4.5.2.7. In ArcToolbox ( ), select **Data Management Tools/Generalization** and double-click **Dissolve**. Set the **Input Features** as the Flowline Buffer, ensure the **Output Feature Class** is set to the designated folder, and click **OK** to dissolve.

4.5.2.8. Natural Waterbodies and Areas connected to the flowline must be erased from the dissolved buffer layer created in Step 4.5.2.7.

If there are only unnatural Waterbodies (reservoirs) and no Areas, proceed to step 4.5.2.12.

Note: Natural waterbodies have an LDI of 1.00, so including the water in the calculation will artificially lower the LDI and give an erroneous value. Reservoirs, however, have an LDI of 4.09 and therefore must be included in the calculation.

4.5.2.9. If there are only natural waterbodies, proceed to step 4.2.5.11.

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4.5.2.10. If there are natural and/or unnatural waterbodies (reservoirs), the reservoirs must be deleted from the waterbody features layer before it is erased from the final buffer layer in step 4.5.2.11.

Select **Editor/Start Editing.** Open the attribute table of the Waterbody features layer. Select by attributes to select reservoirs ("FTYPE" = 436).

Delete reservoirs (hit delete key while they are selected) from the waterbody features layer.

Note: If the waterbody features are all reservoirs, you can instead choose not to erase the waterbody features from the final buffer layer in step 4.5.2.11.

4.5.2.11. In **ArcToolbox** ( ), select **Analysis Tools/ Overlay**, and double-click **Erase**. With the Flowline_Buffer_Dissolve created in 4.5.2.7 as the **Input Features**, select the Waterbody or Area feature as the **Erase Features**, ensure the **Output Feature Class** is set to the designated folder, and click **OK** to erase. Repeat this step for the remaining Waterbody or Area feature. If there is only one of the two, then this step is only done for that one feature.

Note: It is important to name the exported, buffered, and dissolved files meaningful names as it is easy to get the layers confused, especially if there are multiple types of features (i.e. flowline, area, and waterbody).

4.5.2.12. If there is a segment that extends downstream of the sampling point or beyond the circle's radius, the buffer needs to be cut to remove those segments. Uncheck all features in the TOC except for the Flowline_Buffer (or, if needed, the Buffer_Dissolve layer created in 4.5.2.7). Select **Editor/Start Editing**, and when the window pops up select the **Source** that has the buffered layer (s) from 4.5.2.7 (or 4.5.2.11) in it. Select the buffer using the **Edit Tool** arrow. In the Editor toolbar, select the Cut Polygons Tool ( ),zoom to the area where the excess buffer is to be cut off, draw a line perpendicular to the stream from one side of the buffer to the other and double-click to end the line. Select the portion to be deleted with the **Select Features by Rectangle** ( ) tool and delete it. When finished, select **Editor/Stop Editing** and when asked to save edits click **Yes**.

Note: Single-click as needed to cut the buffer following the contour of the circle. The line will not stop drawing until you double-click.

Note: Add-ins tools like this Cut Polygons With Circle Tool hosted on the ArcGIS website can make this process less cumbersome for experienced users.

4.6. Buffer Calculation Using ERATools

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For older sampling dates for which manual calculation of the LDI may be required, proceed to Step 4.7.

For recent sampling dates, deselect any selected features and uncheck all features in the TOC except for the final buffer layer (dissolved and erased as needed). Select the buffer. From ERATools toolbar, select **ERAtools Select Tool**. Set the **Analysis Definition File** as LDI_final.era, **Select Output Format** as "Excel," **Enter Buffer Size** as "0," **Save To** the designated folder, and create an appropriate name and title. Click **Run Report**. Proceed to step 4.8.

4.7. For older sampling dates:

4.7.1. Select the Buffer.

4.7.2. Add the correct Water Management District (WMD) land use layer to the data frame using the Boundaries **Base Maps** in FDEP **Dataminer** 5.0 ( ).

Note: The WMD will be one of these five: NWFWMD, SFWMD, SJRWMD, SRWMD, or SWFWMD and the year created. The year that is closest to the sampling date should be used. If the sampling data falls between the years of two WMD layers, compare the two to determine if there is a difference then use best judgment on which to use.

4.7.3. Open **ArcToolbox** ( ), select **Analysis Tools/Extract**, and double-click **Clip**. Choose the WMD land use layer for the **Input Features**, choose the final buffer layer (dissolved and erased as needed) for the **Clip Features**, ensure the **Output Feature Class** is set to the designated folder, and click **OK**.

4.7.4. Right-click on the clipped layer created in 4.7.3 in the TOC and select **Open Attribute Table**. Select the **SHAPE_AREA** column and right-click to select **Calculate Geometry**, if asked if you wish to continue click **YES**. Ensure the **Property** is "Area" and the **Units** are "Acres US [ac]" and click **OK**.

4.7.5. Select **Table Options/Export**, ensure "All records" is selected from the **Export** drop down menu, and ensure that the **Output table** is saved as a text file in the designated folder. Click **OK.** When asked if you want to add the new table to the map, click **No**.

4.7.6. Open the text file in Excel. In the Text Import Wizard, make sure the "Delimited" radio button is selected under **Original data type** and click **Next**. Under **Delimiters** check the box next to "Comma" and click **Next** then **Finish**.

4.7.7. With the file open, select **Insert/PivotTable**. With all data selected, click **OK**.

4.7.8. From the **Pivot Table Field List** on the right, drag "LEVEL_3" or "LUCODE" into the **Row Labels** area; drag "SHAPE_AREA" into the **Values** area. Copy and paste the data in the pivot table "as values" into another area of the existing sheet or a new sheet.

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4.7.9. For each row, divide the SHAPE_AREA by the Grand Total area to get a proportion of the area associated with each land use.

4.7.10. Using the file LDI_lookup.xlsx, match the Row Labels (land use codes) in the table to the FLUCC column in LDI_lookup to get the value in the LDI column of the LDI_lookup. Multiply the proportions generated in step 4.7.9 by their associated LDI value from LDI_lookup. Sum all the proportioned LDIs to get the total LDI for the 100 m buffer.

4.7.11. Note: It's easiest to do the match statements if you move a copy of the LDI_lookup sheet into the working file.

4.7.12. Note: The LDI calculated once all the proportions are summed should be between 1 and 10 (1 being the best).

4.8. Save the LDI value that is generated, rounded to two decimal places in an Excel file. The file is saved to be entered in SBIO. A .jpeg copy of the map with buffer showing which features were selected should be saved in the designated folder for quality control.

5. QUALITY CONTROL AND DOCUMENTATION

5.1. Files are kept for quality control. Required files:

5.1.1. Electronic file with SBIO site info, final LDI, land use layer used, person calculating LDI, date calculated.

5.1.2. Exported .jpg map showing site and buffer used to generate LDI.

5.1.3. The proportional landuse calculation file, if used.

5.2. It is recommended that those calculating LDIs participate in an LDI proficiency test. Sites previously calculated by experienced analysts are chosen and re-calculated, using the same station and land use layer as before, and the scores are compared to determine proficiency.

APPENDIX OF CHANGES

11/23/2010	Document Creation following SOP LB-001.
06/08/2012	Changed ERAtools item to select in 4.6.
06/08/2012	Changed author from Cheryl Swanson to Loretta Wolfe.
05/19/2014	Updated instructions for adding data points from an Excel file.
06/01/2015	Updated to include LDI Stream Buffer Tool method, reservoir inclusion in buffers, and inclusion of features that flow out of circle perimeter and back in.

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