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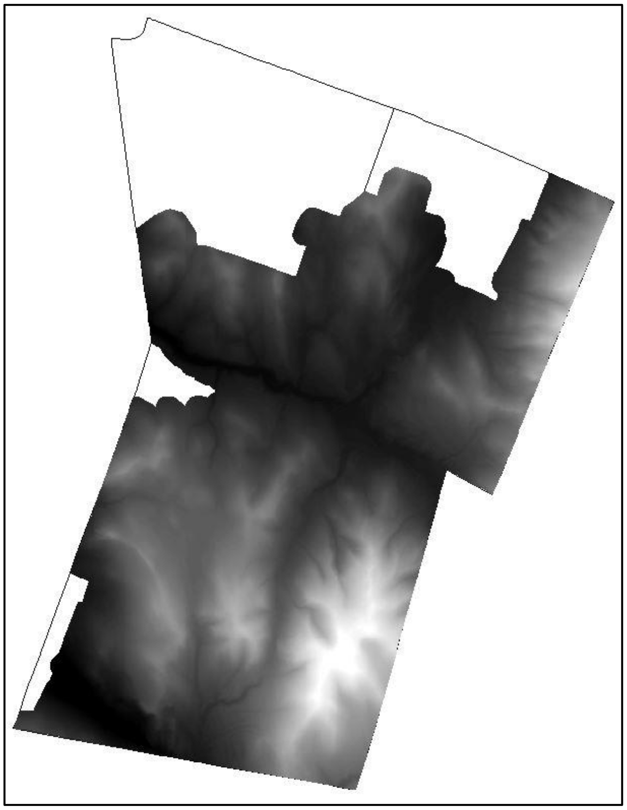
# EXERCISE 1

# Extract Sinks and Generate Contours



## Introduction

This exercise is the first in a three series set of exercises that provides step-by-step instructions for performing a remote sensing workflow that identifies potential vernal pools (PVP) in the New Hampshire portion of the White Mountain National Forest. Once researchers and land managers have a dataset that represents PVPs, they can go out into the field and verify whether a PVP contains appropriate vernal pool indicator species. This workflow relies on the "Contour Tree Tools Public" ArcToolbox, which was designed by Qiusheng Wu, a Geographer at Binghamton University. The toolbox contains two separate tools that are used in a two-step process to first identify topographic depressions in a DEM and then to create contours within those depressions. In this exercise, you will first "smooth" the lidar derived DEM, then you will run the Extract Sink tool, the output of which feeds into the Identify Depression Hierarchy tool.

## Objectives

- Process lidar-derived digital elevation model (DEM)
- Use Contour Tree toolbox to identify sinks
- Set parameters that exclude sinks below a certain depth and size threshold

## Required Data

- **DEM.tif**—Lidar derived DEM with 1-meter spatial resolution
- **StudyArea.shp—**A shapefile that defines the study area for this workflow. The study area is composed of the boundaries for three New Hampshire towns. The DEM covers the majority of the study area, but not all of it.

## Prerequisites

- **Install Esri ArcMap on computer and have basic understanding of how to use the software.**
- **Download VernalPools.zip**

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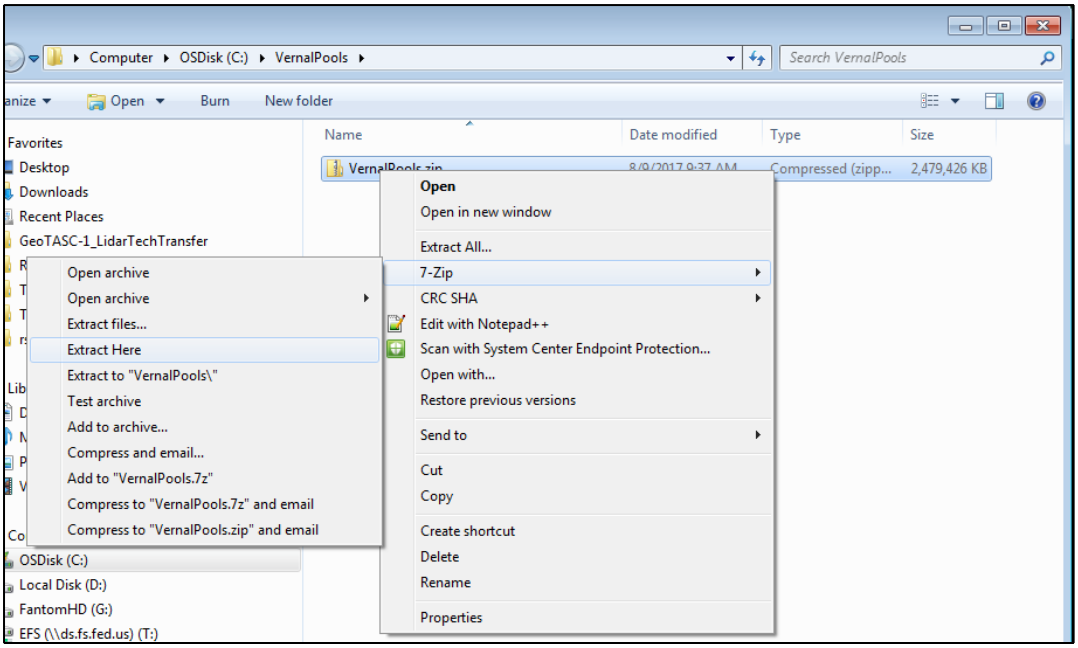
# Part 1: Set up ArcMap

## A. Download and Extract Data

1. All of the data required for this and subsequent exercises is included in the **VernalPools.zip** folder. To access and load this data, you will need to unzip the folder.
2. Once you have downloaded the VernalPool.zip folder, create a **new folder** on your C drive named **VernalPools**. Alternatively, if you are working on Citrix, created a folder on the T drive (T:\DataCenter\Citrix).
3. Next, **copy and paste** the **VernalPools.zip** folder in to the **VernalPools** folder on the **C drive** (C:\VernalPools) or T drive (T:\DataCenter\Citrix)**.**

***Note:*** *The images in this and the following exercises display the process of saving data on the C drive, but if you are working on Citrix, the process should be the same except for the drive location shown.*

4. Right click **VernalPools.zip**, hover over **7-zip** and click **Extract Here** (see below).

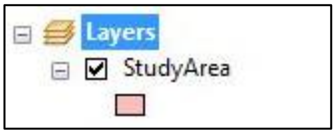



## B. Open ArcMap and Load Data

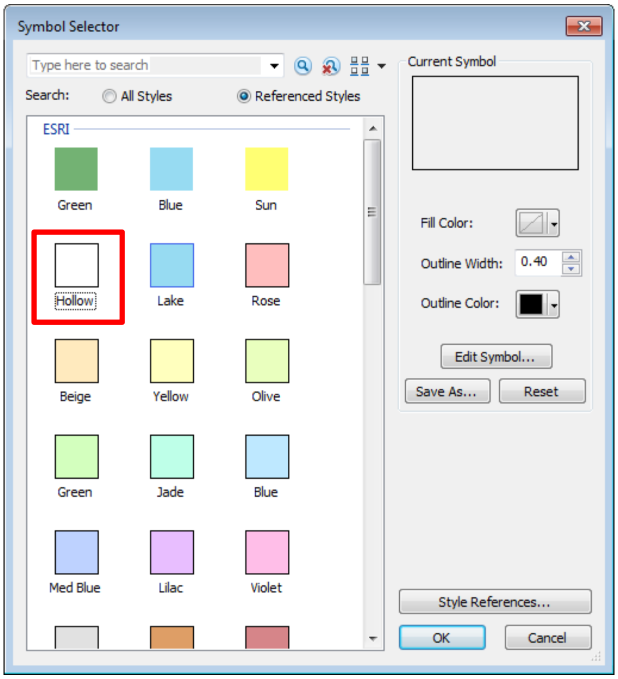
1. Launch ArcMap from the start menu by clicking **Start, Programs, ArcGIS, ArcMap 10.x**.
2. Click the **Add Data** button and navigate to the **VernalPools** folder (C:\VernalPools or T:\DataCenter\Citrix\VernalPools).
3. In the **Data** subfolder, select **DEM.tif** from the **DEM** (C:\VernalPools\Data\DEM) folder and click **Add**.

***Note:*** *If you are working in Citrix, then DEM.tif may be too large for you to process due to limitations associated with Citrix. Instead, you should use **DEM_clip.tif** (C:\VernalPools\Data\DEM), which is identical to the DEM you would get as a result of Part 2-A. If you intend to implement this workflow in a* *different area and need to clip the DEM to a different study area shapefile, you may need to clip the data on a desktop version of ArcMap.*

4. Then repeat the above steps and navigate to the the **StudyArea** folder and add **StudyArea.shp**.
5. To visualize the raster within the study area shapefile, click the symbol below **StudyArea** in the TOC (see below).

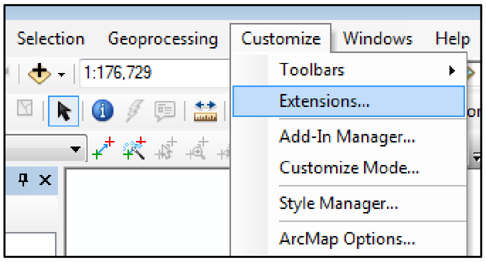



6. In the **Symbol Selector** window that opens, select **Hollow** and click **OK** (see below).

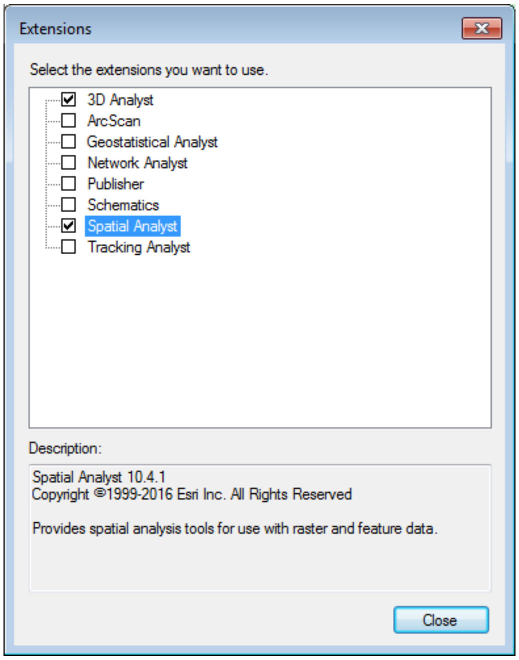



## C. Turn on Spatial Analyst Extension

1. Click the **Customize** drop down menu and select **Extensions** (see below).



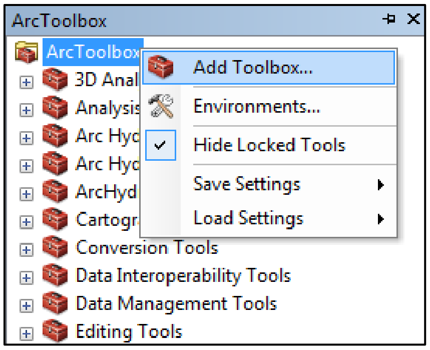

2. Check the box next to **Spatial Analyst** by clicking it, then click **Close**.



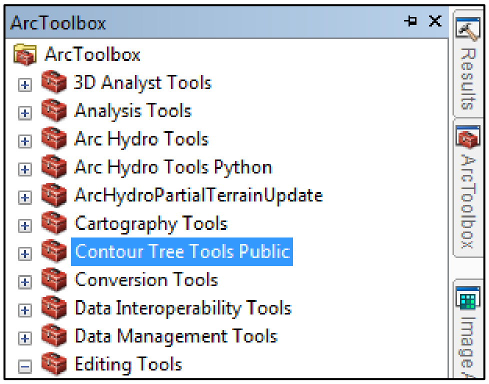

## D. Add Contour Tree Tools Public ArcToolbox

1. Open the **ArcToolbox** tab on the right side of your screen. If it not docked to the side of your ArcMap window, click the Arc Toolbox icon (see below) at the top of the window.
   i. Drag the toolbox to the right side of the screen and dock it if it isn't already.

2. With the ArcToolbox window open, right click the ArcToolbox icon at the top of the tab (see below) and click **Add Toolbox**.




3. Within the Add Toolbox window, navigate to the location of your course data and the **Contour Tree Tolls Public.tbx**. Select the tool and click **Open**.
4. It will take several seconds for the toolbox to load into your ArcMap session. When it is done, you will notice it is added (alphabetically) to the list of available tools (see below).




# Part 2: Clip & Smooth DEM

In addition to clipping the DEM, this part will show you how to smooth a DEM using the focal statistics tool in ArcMap. Smoothing a DEM is a common preprocessing step when working with rasters, as it helps reduce noise without distorting the elevation data.

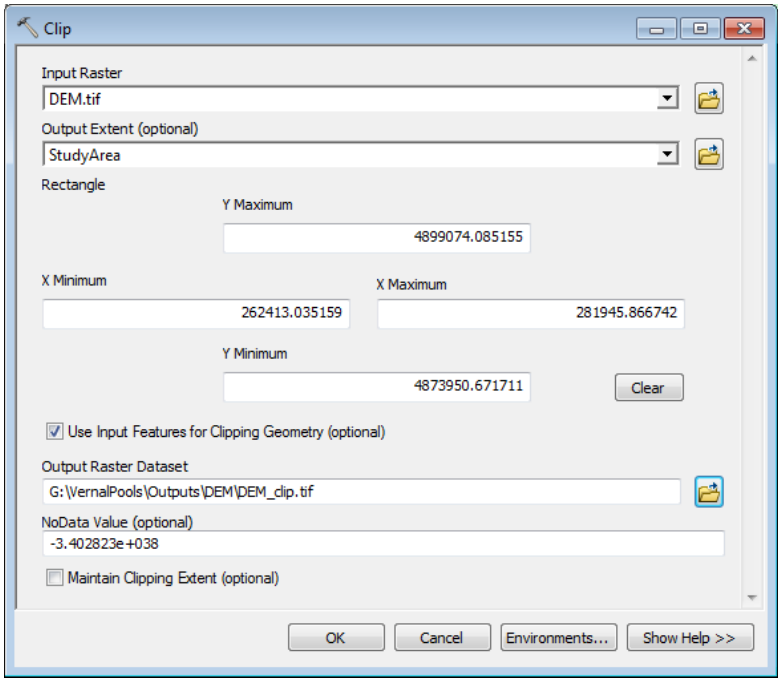
> ***Note:*** *If you are working and Citrix and using* ***DEM_clip.tif****, skip to Part 2-B. Citrix will crash if you try to clip the provided DEM.tif (3.51 GB) to the study area.*

## A. Clip DEM to Study Area

1. Navigate to and open the **Clip** (raster) tool, which can be found by expanding **Data Management Tools**, **Raster, and Raster Processing**.

> ***Note:*** *This is not the standard Clip tool for vector data, though it has the same name.*

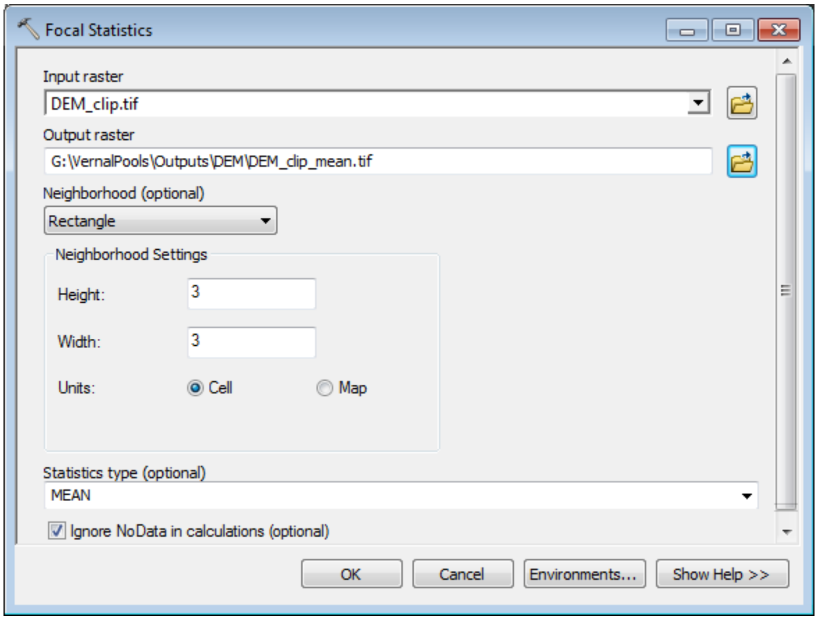
2. For the Input Raster parameter, select **DEM.tif**.
3. Select **StudyArea** for the Output Extent parameter**.**
4. Click the box next to **Use Input Features for Clipping Geometry**. This will ensure that the output clips to the specific shape of the shapefile, not just the Min/Max X, Y values.
5. Click the folder icon next to the **Output Raster Dataset** parameter and navigate to the DEM output folder. Name your output **DEM_clip.tif** and then click **save.**
6. Click **OK** to run the clip tool (see below).




## B. Use Focal Statistics to “Smooth” the Clipped DEM

> ***Note**: Check the Source tab in the DEM properties to see whether or not the Pixel Type of the raster is floating point or integer. If your raster is an integer, then you can use any of the available options within the statistic types dropdown. However, floating point rasters can only generate mean, minimum, range, sum and standard deviation statistics.*

1. Open the ArcToolbox and navigate to and open the **Focal Statistics** tool, which can be found by expanding the **Spatial Analyst Tools** and **Neighborhood**.
2. Select **DEM_clip.tif** as your Input Raster.
3. Click the folder icon next to **Output raster** and navigate to your **output DEM** folder.
4. Name the output **DEM_clip_mean.tif** and click save.
5. In the neighborhood settings parameters, set the neighborhood to **Rectangle,** set both the **height** and **width** to **3** and ensure that the units are set to **Cell**.
6. Select **Mean** as the **Statistics type** and leave the box next to **Ignore NoData in calculations** checked.
7. Click **OK** to run the Focal Statistics tool (see image below).




8. To clean up your Table of Contents (TOC), right click **DEM_clip.tif** and **DEM.tif**, and click **remove**.

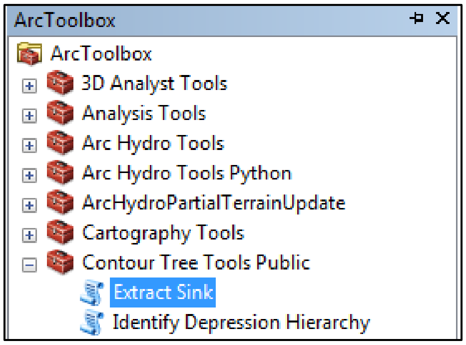
# Part 3: Extract Sinks

The first step of the sink identification process draws on the Extract Sinks tool, which produces several outputs detailing topographic depressions— or sinks— that satisfy user-specified parameters.

***Note:*** *When running this tool in Citrix, you may receive messages alerting you that you surpassed a quota threshold. However, the tool should still run successfully and generate the correct outputs.*

## A. Open the Extract Sink Tool

1. Open ArcToolbox, expand **Contour Trees Tool Public** by clicking the plus sign next to it and double click **Extract Sink** (see below).



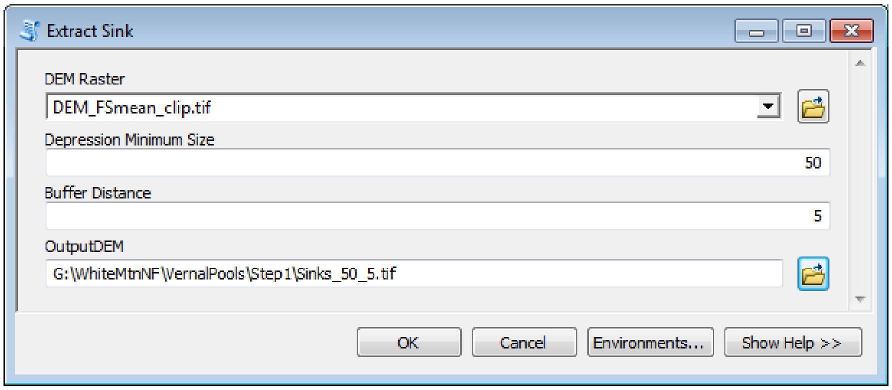

2. Select **DEM_clip_mean.tif** as the DEM raster.
3. Set the **Depression Minimum Size** as **50**.
    i. This parameter sets the minimum area threshold in square meters.
4. The **buffer distance** can be left at its default value of **5**.

i. This adds a buffer to the identified sinks. The point of this is to ensure that the sink boundaries are not underestimated. A value of 3 to 5 is what is recommended for 1-meter DEMs.

5. Click the folder icon next to the **OutputDEM** field and navigate to the output **Step1** folder
6. Name the output **Sinks_50_5.tif** and click **Save**.

   i. This naming convention will help you keep track of the parameters you set for this output.

7. Click **OK** to run the Extract Sink tool (see below).




   i. The tool can take some time, so be patient. It may take upwards of 35 minutes with this dataset (1.65 GB raster) depending on your computer.

## B. Examine the Outputs

1. When the tool finishes, **Sinks_50_5.tif** will be added to your ArcMap table of contents. Other outputs are added to the Step1 folder.
2. Open **ArcCatalog 10.X** (Start Menu, All Programs, ArcGIS) and navigate to the **VernalPools** folder.
3. The outputs added to the Step1 output folder include the following files:

   i. Sinks_50_5.tif

      (a) Raster file containing detected sinks with specified buffer.

   ii. Dem_final.tif (default)

      (a) A copy of the input DEM

   iii. Sink_depth.tif (default)

      (a) Raster file that provides depth values of detected sinks

   iv. Sink_no_buffer.tif (default)

      (a) Raster file displaying sinks without the buffer distance specified in the tool parameters

   v. Sink_poly.shp (default)

      (a) Polygon file of the detected sinks without the buffer

***IMPORTANT****: If you plan on generating multiple outputs (i.e. run the tool multiple times), you need to create a new output folder for each iteration because there are four default files (see above) that are output and will be overridden by subsequent uses of the tool if not saved in a different folder. You cannot specify the names of the four default outputs, so the best way to keep track of these is saving them in a* *new folder with a name that describes the parameters of the outputs within. Since you are only generating one set of outputs in this exercise, it is okay to use simple names like Step 1 and Step 2.*

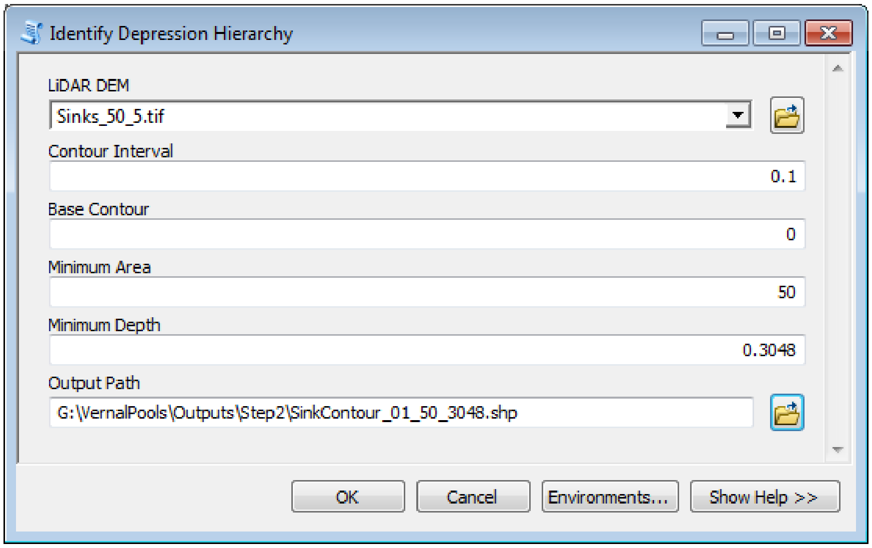
vi. The only output that is necessary for Step 2 of this process is **Sinks_50_5.tif**. This will be the raster input used to generate the final polygon outputs.

# Part 4: Identify Depression Hierarchy

Now that you have successfully run the Extract Sinks tool, you are ready for step 2. This step will take the primary output from step 1 and generate a shapefile that creates contours within the sinks that meet the user-specified parameters (contour interval, area, and depth). The resulting shapefile will contain various types of geometric statistics of the output sinks, but the primary importance of this tool is the ability to set a depth threshold.

## A. Open the Identify Depression Hierarchy Tool

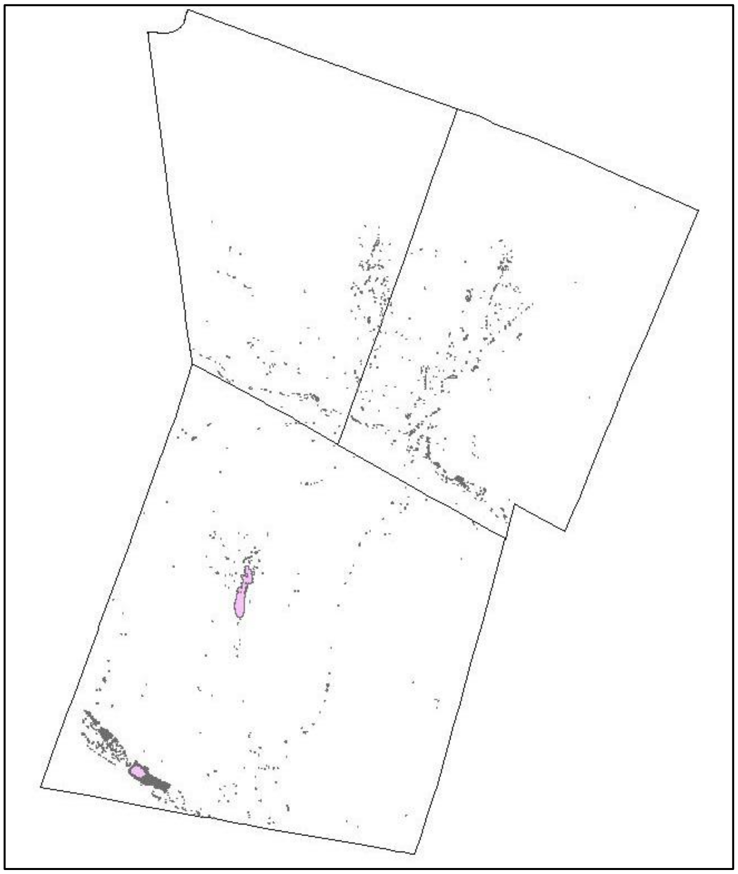
1. Double-click the **Identify Depression Hierarchy** tool, which can be found in the **Contour Tree Tool (Public**) ArcToolbox.
2. Select **Sinks_50_5.tif** as the Lidar DEM raster.
3. Set the **Contour Interval** to **0.1** and leave the **Base Contour** as **0**.
    i. This sets the interval (in meters) that will be used to generate contours within each sink. If you set it higher, the tool will run faster, but some contours will be excluded from the outputs that you want. To avoid this, you'll use a very small interval.
4. Set the **Minimum Area** to **50**.
5. Set the **Minimum Depth** to .**3048**.
    i. This sets the minimum depth of a detected sink to 1 foot (converted from meters).
6. Click the folder next to **Output Path** and navigate to the **Step2** output folder.
7. Name the output **SinkContour_01_50_3048.shp** and click **Save**
    i. Note: Inserting decimal points into a file or folder name can cause issues, so they were not included in the output name.
8. Click **Ok** to run the Identify Depression Hierarchy tool**.**




i. This can take upwards of 50 minutes to finish processing.

## B. Examine Outputs

1. Once the tool is done running, open **ArcCatalog** and navigate to your output Step 2 folder.
2. You will see the output file with the name you gave it along with two other folders titled "**Contains**" and "**Single**."
   i. The **Single** folder has shapefiles for each individual contour interval in a depression.
   ii. The **Contains** folder combines the single shapefiles based on the contain level # (e.g. Contain_L2 combines Single_L1 & L2, Contain_L3 combines Single_L1, L2, & L3).
3. Compare **SinkContour_01_50_3048.shp** with your Step 1 output.
4. Click the step 1 raster on and off to see how many areas did not satisfy the depth parameter set in Step 2. The step 2 output should look like the below image.



5. Open the **SinkContour_01_50_3048.shp** attribute table and examine its contents. There are 3042 polygons in this shapefile, but this includes all contours within a single sink and therefore does not represent the actual count of sinks at this stage of the workflow.

## C. Save ArcMap Session

1. Save your ArcMap session by clicking **File**, then **Save As**.
2. In the Save As window, navigate to the **VernalPools** folder and name the map **VernalPools.mxd**.
3. Click **Save**.

**Congratulations!** You have successfully completed this exercise. You now know how to prepare the DEM for the workflow and how to use the Contour Tree Tools to identify sinks that meet user specified parameters. Now that you have identified sinks that fit your criteria, it is time to draw on the ancillary datasets to eliminate sinks that fall in areas where we do not expect vernal pools to be.