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Software: ArcGIS version 10, Windows Explorer, Notepad, Microsoft Excel and Maxent 3.3.3e.

Lesson 7: How to Detect Tamarisk with Maxent Modeling

Background

This tutorial will walk you through the process of taking generated random points of known invasive tamarisk stands and using them to map the species' distribution. This process involves inputting several environmental layers that the model will use to predict the tamarisk distribution. Only a single month will be run through the model at a time. The environmental layers you will use within Maxent will 7 bands of Landsat data as well as calculated NDVI, SAVI, and three tasseled cap transformation rasters. This process will include preparing the Landsat data, random point data, and Maxent modeling processes. Sections of this process are also found within other tutorials and may contain similar steps. Throughout this project, you will be using *ArcGIS version 10 (ArcCatalog and ArcMap)*, *Windows Explorer*, *Notepad*, *Microsoft Excel* and *Maxent 3.3.3e*. There may be several steps that this tutorial covers that you may have already completed if following previous tutorials simply skip these sections and move on. All screenshots shown utilize the La Junta, CO region which lies within the Landsat data row 32, column 34.

Preparing Data

Landsat Data

Please refer to the section *Preparing Data Scenes for Mosaicking* within the previous tutorial "How to Bring Landsat Data into ArcGIS, Mosaic and Clip Scenes." You are not interested in the mosaicking portion of this tutorial, but this tutorial does walk you through the steps to get rid of "No Data" areas within Landsat Scenes. Next, please refer to Grant's tutorial titled "Calculating Vegetation Indices from Landsat 5 TM and Landsat 7 ETM+ Data" in order to calculate NDVI, SAVI, and Tasseled Cap transformations from Landsat bands 1-5, and 7. All of these need to be prepared prior to importing them into the Maxent model.

Maxent Input

The Maxent model requires CSV files for the input samples. The CSV file you will create will come from the random points file created in the tutorial "How to Create 200 Random Points Using Hawth's Tools."

Open a blank template in *ArcMap* and use the **Add Data**  icon and add the shapefile previously created named **random_points.shp**.

After the data points have been added, you need to create X and Y coordinates for your random points. They have a spatial reference, but do not contain attribute fields that represent that spatial reference.

In order to create X and Y coordinates, navigate to the **toolbox** and select **Add X,Y Coordinates**. It can be found under **Data Management Tools → Features**.

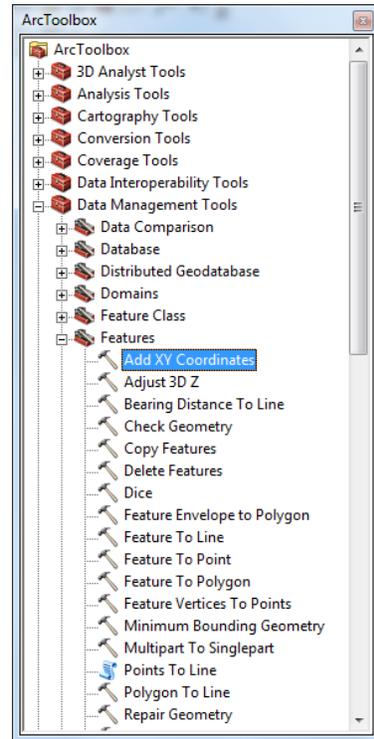
Under **Input Features** select the layer **random_points** from the drop down or browse to the source file using the browse icon.

Click **Ok**.

After the tool finishes running, right click on the **random_points** layer in the table of contents and select **Open Attribute Table**.

Check to make sure that a **Point_X** and **Point_Y** field was added to the attribute table.

Open up the workspace where the **random_points.shp** file is located using Windows Explorer.

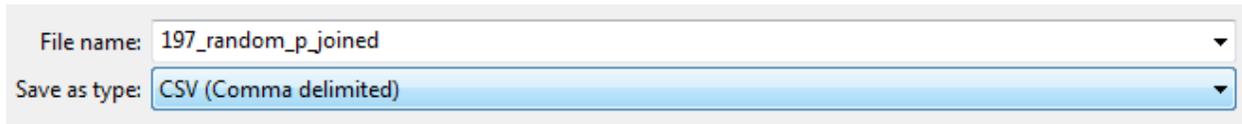
A screenshot of a Microsoft Excel spreadsheet titled '197_random_p_joined'. The spreadsheet has three columns: 'Species', 'Easting', and 'Northing'. The 'Species' column contains the text 'Invasive Tamarisk' for all 31 rows. The 'Easting' and 'Northing' columns contain numerical values representing coordinates. The data is as follows:

Species	Easting	Northing
Invasive Tamarisk	711105.839	4168431.802
Invasive Tamarisk	712092.8213	4169194.023
Invasive Tamarisk	711510.3969	4168766.91
Invasive Tamarisk	711234.8803	4168372.709
Invasive Tamarisk	711711.5087	4169542.096
Invasive Tamarisk	711692.9075	4169637.342
Invasive Tamarisk	711222.0904	4168638.751
Invasive Tamarisk	604285.4536	4184738.755
Invasive Tamarisk	546073.6871	4234725.84
Invasive Tamarisk	545792.3591	4234160.844
Invasive Tamarisk	545736.5554	4234446.583
Invasive Tamarisk	545938.8344	4234614.137
Invasive Tamarisk	545884.198	4234292.244
Invasive Tamarisk	638541.7769	4179198.796
Invasive Tamarisk	639006.8571	4170399.725
Invasive Tamarisk	682242.1814	4214346.016
Invasive Tamarisk	553961.375	4245077.038
Invasive Tamarisk	553514.9457	4247362.951
Invasive Tamarisk	554003.2464	4242456.017
Invasive Tamarisk	553892.8063	4242419.863
Invasive Tamarisk	533351.4198	4174725.082
Invasive Tamarisk	532964.2958	4174902.359
Invasive Tamarisk	533128.2051	4175868.038
Invasive Tamarisk	533472.3153	4175710.458
Invasive Tamarisk	532846.8772	4175303.042
Invasive Tamarisk	532374.8929	4174912.083
Invasive Tamarisk	532167.9698	4173966.101
Invasive Tamarisk	533153.7849	4175335.955
Invasive Tamarisk	533452.5469	4176413.337
Invasive Tamarisk	532909.6594	4174580.466

Open the file **random_points.dbf** using *Microsoft Excel* and delete all fields except for the **Point_X** and **Point_Y** fields.

Also designate one column to name what is located at this known point (Invasive Tamarisk). The Excel spreadsheet should look like this when finished:

Save the spreadsheet as some memorable file name (in this example it is named **197_random_p_joined**) in a **CSV** format. Select this from the **Save As** drop-down selection.



Close *Microsoft Excel* making sure to not save the file back into the .dbf format.

Environmental Layers

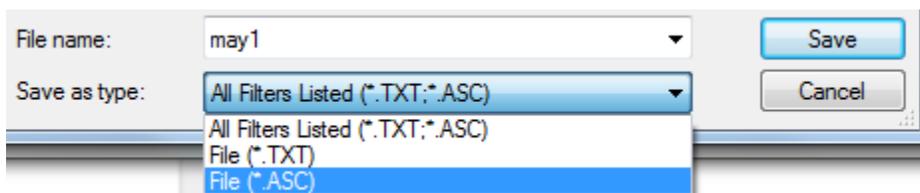
All environmental layers that are input into the Maxent model must be in the ASCII format. The Landsat data previously acquired and clipped are in a GRID format. This goes for the indices like the NDVI, SAVI and three tasseled cap transformations (brightness, greenness, and wetness).

To convert these files, you will use a tool within *ArcCatalog*. This will be the most time consuming portion of the tutorial aside from running the model.

Open *ArcCatalog* and open the **toolbox**  and navigate to the conversion tool from **Raster to ASCII**. It can be found by following **Conversion Tools → From Raster → Raster to ASCII**.

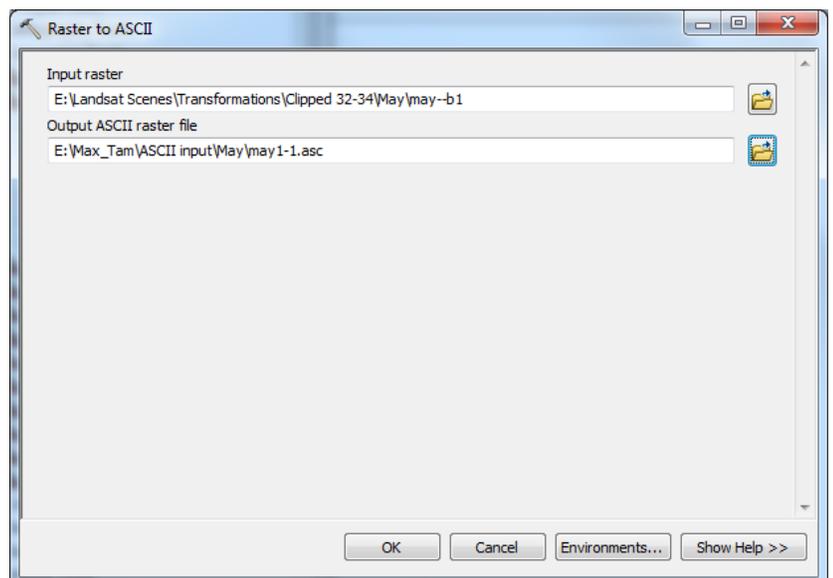
For the **Input raster** navigate to the specific band you would like to convert first using the browse icon .

For the **Output ASCII raster file** browse to your workspace and create a new directory with the  icon and name it **ASCII_Inputs**. Save the file there under a memorable name. **IMPORTANT:** under the **Save as Type** drop-down choose **ASC**. Click **Save**.



Before allowing the tool to run, make sure that the file path in **Output ASCII raster file** ends in **.asc** (You may have to change it from a .txt to a **.asc**). The window should look like the one to the right.

Click **Ok**.

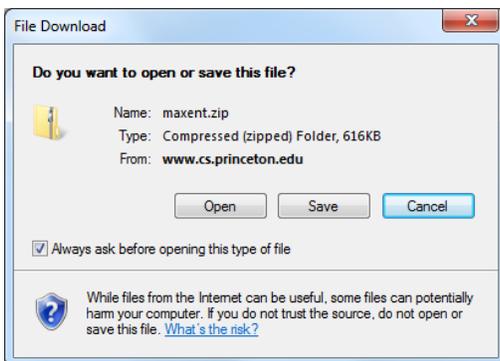


Repeat these steps using the **Raster to ASCII** tool for all 7 bands and the 5 vegetation transformations (NDVI, SAVI, and three tasseled cap).

Downloading Maxent

To begin, go to the website <http://www.cs.princeton.edu/~schapire/maxent/> to download the Maxent software. On this page, you will find links to two papers that may help inform you more on mathematical and theoretical aspects of how the Maxent model works. Further down the page under **Terms of Use**, you will see where to enter your *Name*, *Institution*, and *Email* address. Fill in the requested information, and select **version 3.3.3e** (or latest available version).

When you are finished, click the **Accept terms and download** button.



A new page should come up that explains how to download the software. You can download each of the Maxent's three files separately (i.e. maxent.jar, maxent.bat, readme.txt) or you can download all of them in .zip file.

Save the .zip folder to whatever workspace you are working off of.

Once your download is completed, you should see the three Maxent files in your directory.

To open the Maxent model, go to this folder and click on the **maxent.bat** file.

Setting up a run

Before starting Maxent, navigate to your workspace folder and create a new directory labeled **Outputs_(Month)**. This will be the directory where the outputs created by Maxent will be stored.

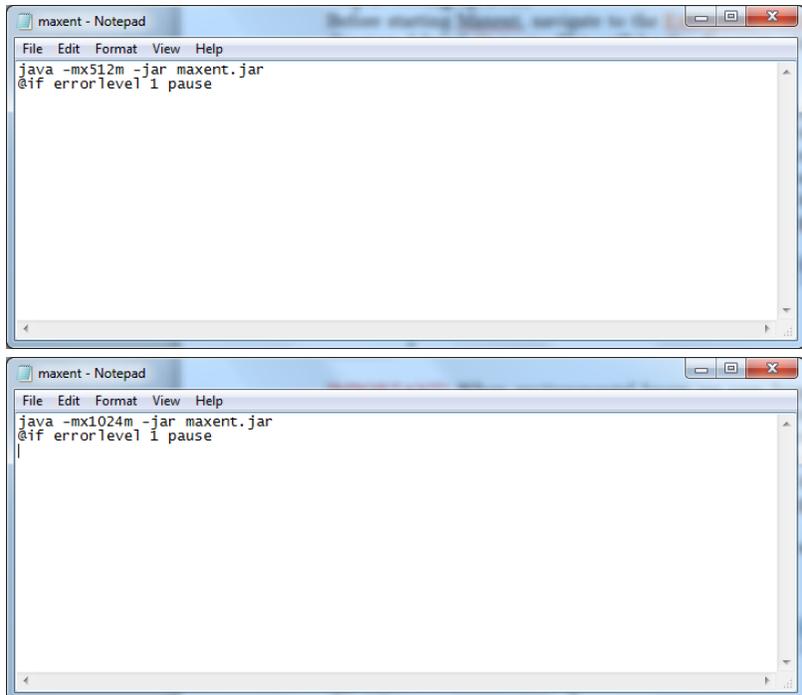
IMPORTANT! When environmental layers are very large, you may get an “out of memory” error when you run the program. The best way to fix this problem is to give Maxent access to more memory. To do this, you will edit the **maxent.bat** file and increase the memory from 512 to 1024 (or multiples of 512 such as 512x2, 512x3, 512x4 depending on your computer's RAM). Memory size of 512 indicates the 512mb of your computer's total RAM will be allocated for running Maxent model.

To do this, first right click on the **maxent.bat** file in your working directory and select **Edit**.

A Notepad window should appear like the one shown on the right.

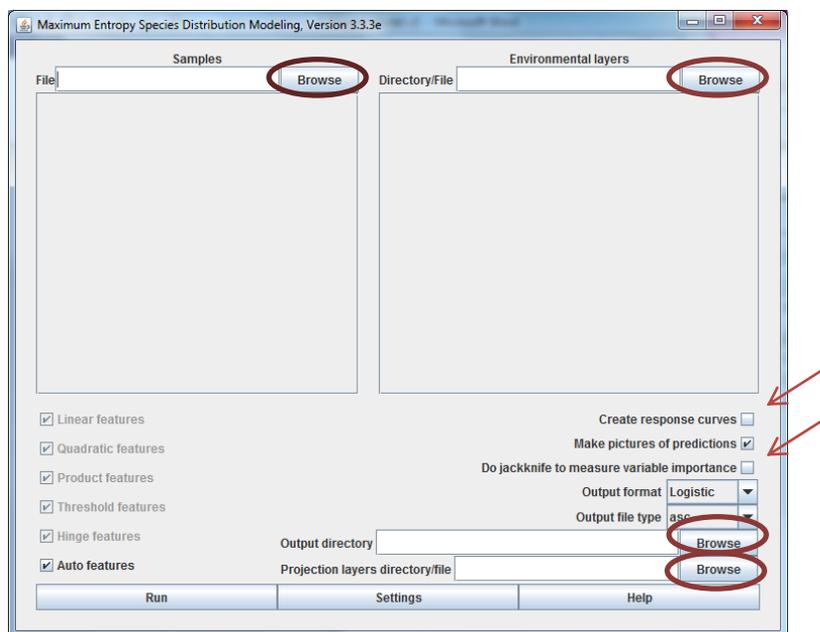
You can change the amount of memory that Maxent uses by simply changing 512 to 1024. This is how the window should look.

Once you have changed the memory, click **File** and **Save** and close the window.



Step 3: Opening Maxent and Running Model

To open Maxent, click on the [maxent.bat](#) file. A window should open that looks like this:



To begin, you must provide a **Samples** file. This file is the presence localities in .csv format created previously (the example used earlier was [197_random_p_joined.csv](#)). Navigate to this file by clicking the **Browse** button next to **Samples**, or you can type in the file path.

Next you have to provide the **Environmental Layers** used for the model. This will be the directory that contains all your environmental layers in ASCII format (they must have an .asc file extension) with the same geographic bounds, cell size, and projection system. In our case, the directory containing our layers is found in the **ASCII_Inputs** directory. Navigate to this directory by clicking the **Browse** button next to **Environmental Layers**, or type in the file path. **IMPORTANT:** Navigate to the directory as a whole, not the individual ASCII files.

Notice how you can change the environmental layers to either continuous or categorical. If any of the layers you include in your environmental layers are categorical (none for the tamarisk), make sure you change them by clicking on the down arrow and choosing categorical.

An **Output** directory also needs to be selected. This will be the directory where all the Maxent outputs will be stored. Navigate to your workspace using the **Browse** button next to **Output Directory**.

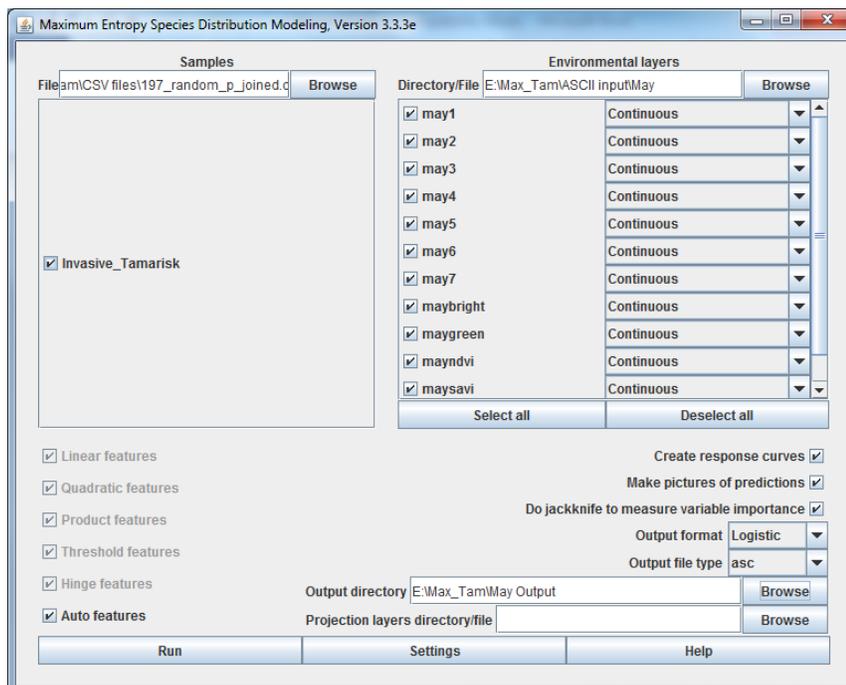
Create a new directory using the  icon in the upper right-hand corner of the browse window. Name the directory **Outputs**. Highlight the directory using the cursor and click Open.

You can leave the **Projection Layers Directory/File** window blank if you do not intend on producing future scenarios, which is the case in terms of tamarisk. This process is only designed to detect tamarisk.

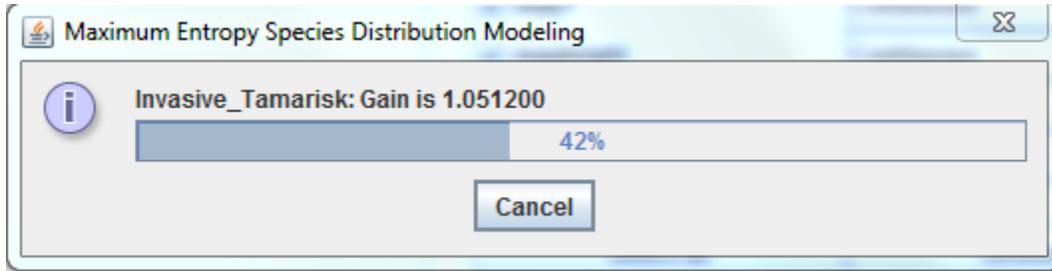
Make sure that the **Create Response Curves**, **Make Pictures of Predictions**, and **Do jackknife to Measure Variable Importance** boxes are all checked.

Keep the **Auto Features** box checked and leave the **Output Format** as **Logistic** and the **Output file type** as **.asc**

Now, the Maxent GUI (graphic user interface) should look like this:



Now that everything has been entered into the Maxent program, simply press the **Run** button to begin modeling. A progress window will appear describing the modeling process.



You will also be able to see the gain for each environmental variable while the model is running. The gain is similar to a measure of goodness of fit. Specifically, the gain is a measure of the closeness of the model concentration around the presence samples. So a gain value of 2, would translate to the average likelihood of the presence samples is $\exp(2)$ or about 7.5 times higher than that of a random background pixel.

Once the Maxent model has completed its run, the progress window will disappear. You will be able to find all the outputs created by Maxent in the **Output** directory you created earlier.

Congratulations! You have now completed a Maxent model and can start interpreting the outputs. Output interpretation can be found in tutorial "A Maxent Model v3."