# National Forests Trail Rating Application Procedures

## Data Collection

Goal: Collect line features of trails inside the National Forests and National Forest boundary polygon features. Also collect detailed digital elevation model (DEM) and slope raster of contiguous United States.

1. Download National Forest trails geodatabase from the Forest Service's FSGeodata Clearinghouse website. On the home page click the link reading "Downloadable Data." The URL to that page is https://data.fs.usda.gov/geodata/edw/datasets.php for reference.
2. Once on this page, find the feature classes titled "Administrative Forest Boundaries" and "National Forest System Trails." It is important to download these as ESRI geodatabases and not shapefiles. Geodatabases allow for better data compression and for longer field names, which will be vital when defining difficulty classes.
3. Download DEM and slope rasters of contiguous United States. The best source to use is the EDNA dataset found on the USGS Earth Explorer web utility (https://earthexplorer.usgs.gov/).
    a) Because the files that will be used are extremely large (around 60GB each once unzipped), USGS requires that an account be set up first for the site. They do this to better monitor where their large data sets are going and what they're being used for. To do this, click the "Register" link in the right hand corner of the Earth Explorer page and follow the instructions.
    b) Once the account is created and the user is at the web utility, click the "Data Sets" tab, open the drop down menu labeled "Digital Elevation," select "EDNA" from subsequent list, and click "Results". (See Figure 1). In the resulting "Results" tab, advance to page three, and select the layer names "ORIG_DEM" and "SLOPE" from the list by clicking the footprint-shaped icon (See Figure 2). Then, click the "Download Options" icon (circled in Figure 2) and download.
4. Unzip all downloaded datasets.

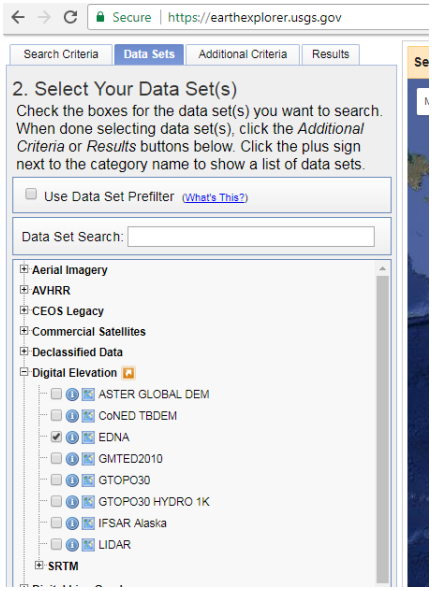


**Figure 1**

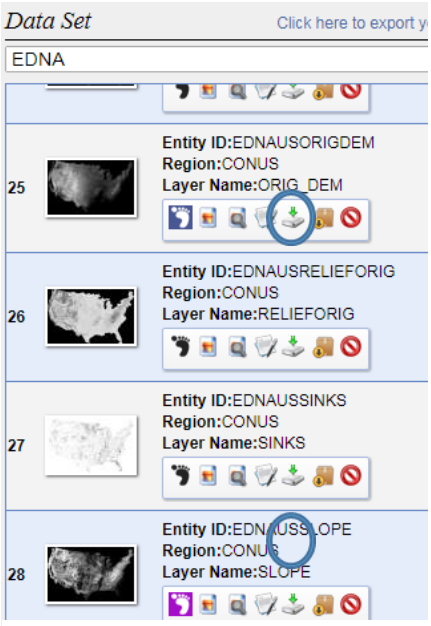


**Figure 2**

Notes on Data Collection:

- ENDA was chosen for three reasons: (1) it is a complete DEM of the contiguous United States, which eases the elevation data extraction process, (2) the data set is detailed, with each pixel being 30x30 meters; (3) it had a slope raster as well, which eliminated the need for one to be calculated.

Data Splitting and Extraction

Goal: Create segments of each trail within the United States National Forests that include a field describing elevation and slope.

1. Open ArcCatalog and new ArcMap document.
2. In ArcCatalog, create new file geodatabase in appropriate folder. Name it something fitting, such as "TrailProject," because this will be the geodatabase that will hold all trail feature classes during processing.
3. Close ArcCatalog.
4. In ArcMap, add the feature classes downloaded from the FSGeodata Clearinghouse. These will be titled "TrailsNFS_Publish" and "AdministrativeForest."
5. Open ArcToolbox, click the "Data Management Tools," then "Features," then select the "Copy Features" geoprocess. Choose "TrailsNFS_Publish" as the Input Features and save the Output Feature Class in the "TrailProject" geodatabase. Name the output feature class "TrailsFull" and click "OK" to run the geoprocess. This will ensure the original "TrailNFS_Publish" feature class remains unchanged and can be used as a backup if needed.
6. Repeat Step 5, only copy the "AdministrativeForest" polygon features instead of "TrailsNFS_Publish." Name the output feature class "ForestFull" and run the geoprocess.
7. Remove the "TrailsNFS_Publish" and "AdministrativeForest" layers from the Table of Contents.
8. Because the EDNA dataset has elevation and slope data only for the contiguous United States, the trails and National Forests outside the contiguous United States will be deleted from their feature classes. Using the "Select Features" tool on the Tools toolbar, select the line and polygon features outside of the lower 48 states. The resulting selection will resemble Figure 3.

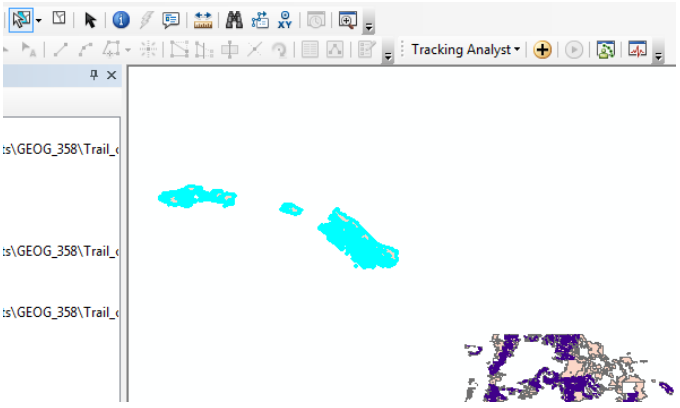


**Figure 3**

9. Open the "Delete Features" tool within ArcToolbox, and run for "TrailsFull" and "ForestFull."
10. To create the segments needed of each trail, open the "Dice" geoprocess from ArcToolbox. Set the Input Features to be "TrailsFull" and set the Output Features to "TrailsDice" within "TrailProject." The option "Vertex Limit" for the tool determines where each line will be diced. For this application, set the Vertex Limit at 20.
11. Open the "Feature Vertices to Points" geoprocess in ArcToolbox. Select the input features to "TrailsDice," set the output feature class to "TrailsPts" in the "TrailProject" geodatabase, and set point type to "MID" (See Figure 4). Setting the point type to MID is essential because this will create a point at the midpoint of each line segment, giving a better approximation of the elevation and slope of each segment than creating a point at the start or end of each line.

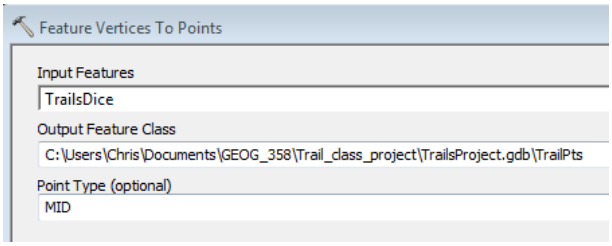


**Figure 4**

12. Using the Add Data tool, add the EDNA elevation and slope rasters to ArcMap.
13. Inside the Spatial Analyst Tools within ArcToolbox open the “Extract Values to Points” in the Extraction submenu.
14. In the geoprocess window, select “TrailsPts” as the input point features, either slope or elevation as the input raster, and name the output point features “TrailsExtract1” within the same “TrailsProject” geodatabase.
15. Click “OK” to begin the geoprocess. Warning that depending on the computational power of the computer being used, this process could take up to a few hours to run. Plan accordingly.
16. With this geoprocess complete, the extracted values are under the field named “RASTERVALU” in attributes table of “TrailExtract1.” Unless this is changed, when the geoprocess is ran again an error will appear saying there is a field with the same name as the field the tool is trying to create. To prevent this, open the “Alter Fields” tool under “Fields” within the “Data Management Tools” of ArcToolbox. In the window, select “TrailsExtract1” as the input table, “RASTERVALU” as the field name, and either “Elevation_meters” (the ENDA DEM is listed in meters), or slope, depending on which raster was used first (See Figure 5).

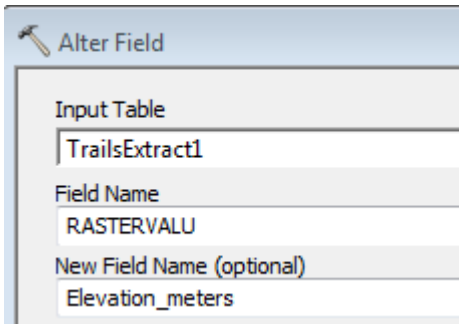


**Figure 5**

17. Repeat steps 13 thru 16, except with the unused raster and “TrailsExtract1” as the input points feature and alter the field name to data that was extracted from the raster.
18. Open the “Spatial Join” tool within the “Analyst Tools” of ArcToolbox. Select the “TrailsDice” as the target features and “TrailsExtract2” as the join features. Then set the output to be named “TrailsJoin” and saved within the same “TrailsProject” geodatabase.
19. The “Spatial Join” tool looks to join together attributes that share a specified spatial relationship. In this particular case there are two matching sets of attributes except for the slope and elevation attributes. This means if the tool runs without specifying to not join every single attribute, there will be two of each attribute in the output feature class of this geoprocess. In “Field Map of Join Features (optional)” box in the tool window, there is a list of each attribute that will be added to the output class. Fields can be either added or deleted from this list. Scroll down this list and notice that the fields begin to repeat themselves, except they end with “_1.” For example, there will be a field titled “TRAIL_NAME” and “TRAIL_NAME_1.” To delete all the duplicate fields, scroll to the first field that ends in a “_1” (it should be “TRAIL_NO_1”), click to select it, and click the “x” to the right of the list (See figure 6). Repeat this until all the redundant fields are deleted. Then ensure the “Match Option” is

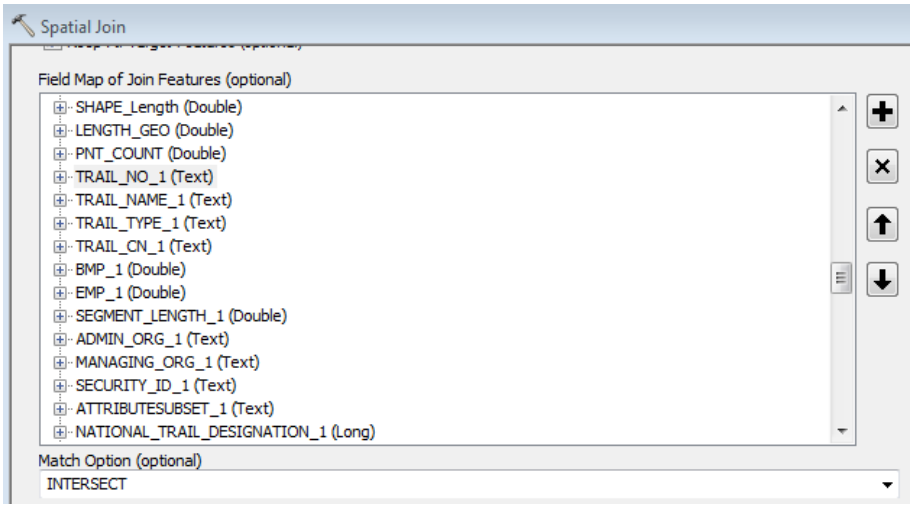


**Figure 6 – Select “TRAIL_NO_1” and click the “x” to remove the field from the resulting output. Repeat until all redundant fields are removed.**

set the “Intersect” (the default), and run the tool.

Notes on Data Splitting and Extraction:

- The number for the vertex limit is very important because it will determine the length of each segment, and subsequently the detail of the difficulty rating. The goal is to make the ratings as accurate and detailed as necessary; to have a reasonable combination of segment length and detail. But depending on the computational power of the machine being used, computation time might also be a factor when deciding on a vertex limit. With trial and error the machine that this was completed on could handle 20 as the vertex limit, although the computations took a significant amount of time.

<u>Difficulty Calculations</u>

Goal: Create fields that describe the difficulty of each segment of trail based on a numeric rating system.

1. Open the “Add Field” tool within the Fields submenu of ArcToolbox’s “Data Management Tools.”
2. Set the input table to be “TrailsJoin” and set the new field name as “Elevation_feet.” This new field will contain the elevation values collected, just converted from meters to feet. The values in this field will be integers, so to eliminate the decimal figures from this field the field type option will need to be changed to “SHORT” (See Figure 7).
3. Repeat the “Add Field” tool four additional times, creating the following fields:

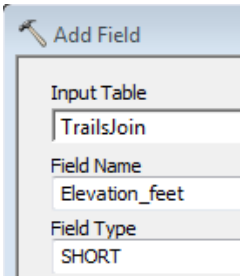

**Figure 7**

   - “Elevation_diff” for elevation difficulty.
   - “Slope_diff” slope difficulty.
   - “Total_diff” for the total numeric difficulty of the trail.
   - “Diff_rating” for the designated trail difficulty (e.g. Easy, Moderate, Hard).

   All these fields should also have their field type set to “SHORT” except for “Diff_rating” which will have the field type “TEXT” because the field will contain text strings.
4. Open the attributes table of “TrailsJoin” and scroll to the far right edge of the table to view the newly created fields. Each cell of the fields at this point should be filled with <Null>.
5. Right click the “Elevation_feet” field and select the “Field Calculator” option. A message will flash warning that you are about to edit outside of an editing session. Click “Yes” to continue to the field calculator tool.
6. To calculate the elevation of each point in feet, select “Python” as the “Parser” (all field calculations will be done in Python), scroll to the bottom of the list of fields, and select “Elevation_meters.” The name of the field will then appear in the text box below with exclamation points at the beginning and end of the string. Multiply this field name by the conversion factor from meters to feet (1 meter = 3.28084 feet), and click “OK” to begin the calculation

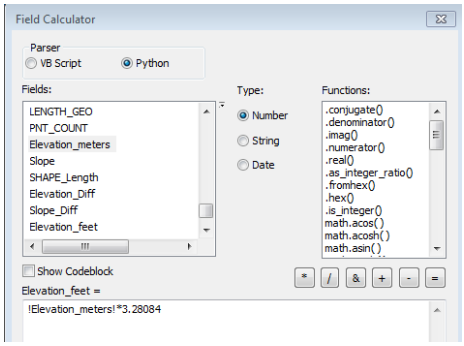

**Figure 8**

```
def eleDiffCalc(ele):
    if ele >= 0 and ele < 7000:
        return 0
    elif ele >= 7000 and ele < 8500:
        return 1
    elif ele >= 8500 and ele < 11000:
        return 2
    elif ele >= 11000 and ele < 12500:
        return 3
    elif ele >= 12500 and ele < 20000:
        return 4
```

**Figure 9**

(See Figure 8). Once the field calculation is complete there should be numbers without decimal figures within the “Elevation_feet” field.

7. To calculate the difficulty rating for elevation, a Python conditional statement within the codeblock must be used. Right click the “Elevation_diff” field and open the Field Calculator, clicking “Yes” to the warning as before. Select the “Show Codeblock” box inside the field calculator window and an additional textbox will appear.
8. Write a Python conditional statement that will return an integer for a value within a specified range elevation values (See Figure 9). This is written as a Python function titled “EleDiffCalc”, and will go within the codeblock textbox. These difficulty ranges are not based on anything particular at this point, just arbitrary numbers increasing in value with higher elevation figures. Once the function is written, type the function name “EleDiffCalc” into the lower textbox, and type in “!Elevation_feet!” within parenthesis next to the function name, being sure to include the exclamation points. Click “OK” to run the calculation (See Figure 10).
9. Calculate the difficulty based on slope, by repeating the same process described in steps 7-8, replacing the function found in the “Pre-Logic Script Code” box with the function “slopeDiffCalc” shown in Figure 11. Then, type the function name “slopeDiffCalc” into the lower textbox with “!Slope!” in the function handle before running the calculation (See Figure 12).
10. Now calculate the overall difficulty number of the trail segments. This will be done by simply adding “Elevation_diff” and “Slope_diff.” Within Field Calculator for “Total_diff,” run an addition function adding the two difficulty field just calculated (See Figure 13).
11. The final difficulty calculation will be to add a difficulty title to a set range of difficulty values. Open Field Calculator for “Diff_rating” and enter the conditional statement shown in Figure 14 into the “Pre-Logic Script Code” textbox. Enter the function name into the lower textbox, type “!Total_diff!” in the function handle, and run the calculation (See Figure 15). These will be used in the web application to make deciphering trail difficulties more intuitive.

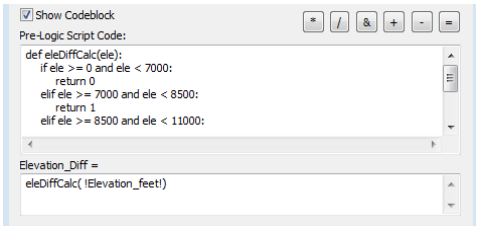


**Figure 10 – Note the function in Figure 9 is written in the “Pre-Logic Script Code” textbox.**

```
def slopeDiffCalc(slope):
    if slope >= 0 and slope < 2.86:
        return 1
    elif slope >= 2.86 and slope < 5.71:
        return 2
    elif slope>= 5.71 and slope < 8.53:
        return 3
    elif slope >= 8.53 and slope < 11.31:
        return 4
    elif slope >= 11.31 and slope < 20:
        return 5
    elif slope >= 20 and slope < 90:
        return 6
```

**Figure 11**

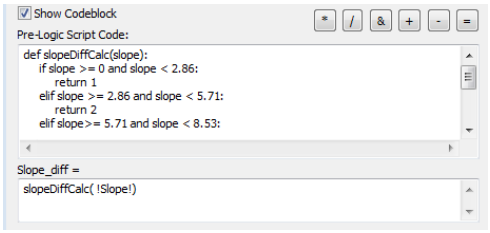


**Figure 12**

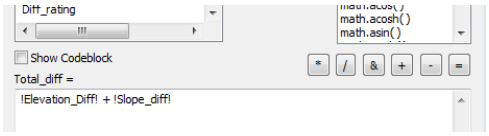


**Figure 13 – Note the addition operation does not happen in the “Pre-Logic Script Code.”**

```
def totalDiffCalc(num):
    if num >= 0 and num < 3:
        return 'Easy'
    elif num >= 3 and num < 6:
        return 'Moderate'
    elif num >= 6 and num < 8:
        return 'Hard'
    elif num >= 8 and num < 11:
        return 'Very Hard'
```

**Figure 14**

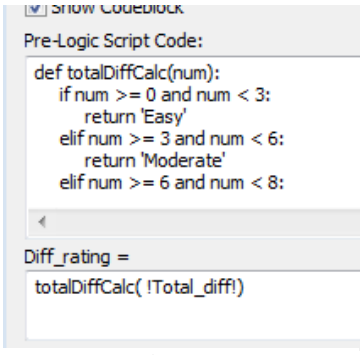


**Figure 15**

Data Preparation for Web Publishing

Goal: To prepare the completed data for publishing on ArcGIS Online. This includes eliminating unnecessary fields, selecting only trails designated for hiking, and organizing files for successful upload to ArcGIS Online.

1. Open ArcCatalog.
2. Go to the folder location of the "TrailsProject" geodatabase.
3. Right click within the folder window, click "New," and select "File Geodatabase."
4. Rename the new geodatabase "TrailsHiking." ArcGIS Online requires that data uploaded to their servers be in certain data formats, the most commonly of those being the file geodatabase and the shapefile. For this application, the geodatabase is the better option because the length of field names can be much longer than a shapefile's. The long strings used to name these fields would be cut short in a shapefile, and vital information about the difficulty fields would be lost.
5. Repeat to create another new file geodatabase, this one titled "NationalForests." This geodatabase will contain the National Forest polygons from "ForestFull."
6. Open ArcToolbox within ArcCatalog, and open the "Copy Features" tool.
7. Clicking on the folder icon and select "ForestFull" as the input feature, and save the outputs as "NationalForests" within the new "NationalForests" geodatabase. Click "OK" and run the tool.
8. Back in ArcMap, open the attributes table for "TrailsJoin."
9. Look at the attributes table, it is easy to see there are many fields (75 to be exact). To save space on the ArcGIS Online server, the unnecessary fields will be removed.
10. Open "Delete Field" in ArcToolbox.
11. Select "TrailsJoin" as the input table.
12. Click the "Select All" option below the "Drop Field" box. The fields that are going to be kept will be unselected from this list, this way is faster.
13. In the "Drop Field" box, unselect the following fields by clicking the square next to the field name, removing the check.
    - TRAIL_NAME
    - TRAIL_TYPE
    - ATTRIBUTESUBSET
    - TERRA_MOTORIZED
    - ALLOWED_TERRA_USE
    - Elevation_meters
    - Slope
    - Elevation_feet
    - Elevation_diff
    - Slope_diff
    - Total_diff
    - Diff_rating
14. Within this file of trails there are trails not only for hiking, but for horseback riding, all-terrain vehicle (ATV) use, 4x4 vehicle use, and even snowshoe use. The final web application is intended for use by hikers, so only these trails designated as hiking trails will be uploaded. Open the "Select by Attribute" under the "Selection" tab of the main menu bar.
15. For safety reasons, the trails that will be

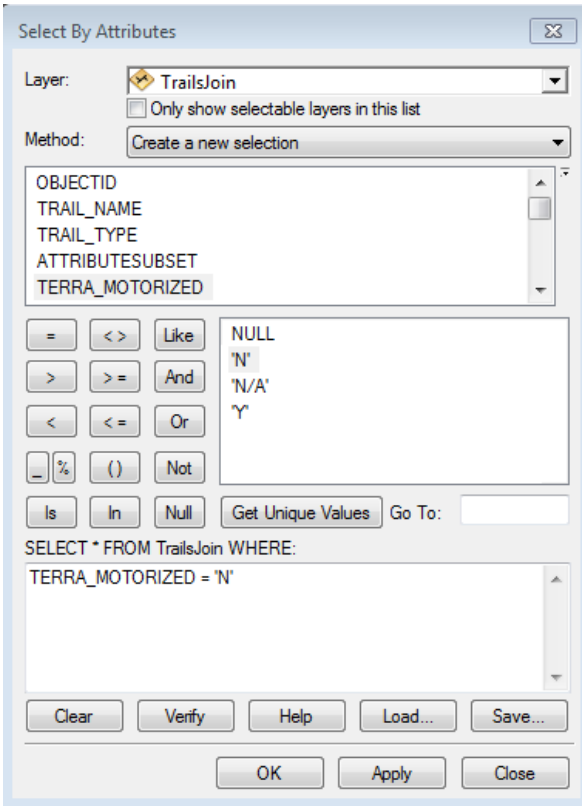


**Figure 16**

uploaded are only those that do not allow motorized vehicle use. The field "TERRA_MOTORIZED" describes this attribute of the trail. If the field is populated with a "Y," the trail allows motor vehicle use during the year, if it is populated with an "N," the trail doesn't allow motor vehicle use, and some trails are listed as "N/A" because that particular National Forest decided not to release that information with this data set. So for this application, only the trails that have their "TERRA_MOTORIZED" field populated with "Y" will be uploaded to ArcGIS Online.

16. In the "Select by Attribute" window, select "TrailJoin" from the list of selectable features.
17. Double click "TERRA_MOTORIZED" from the list of fields. It will appear in the textbox below.
18. In this textbox, add an equals sign and 'N' after "TERRA_MOTORIZED." Click verify to ensure that there were no errors in the setup of the statement. If it returns "The expression was successfully verified," click "Apply" to select all the features that match this condition (See Figure 16).
19. Once the selections have been made, open the "Copy Features" geoprocess within ArcToolbox.
20. Select "TrailsJoin" as the input features, and save the output as "TrailsHiking" within the new geodatabase with the same name.
21. Open Windows Explorer.
22. Go to the folder location of "TrailsHiking" and "NationalForests" then compress the folders into individual .zip folders.
23. The geodatabases "TrailsHiking" and "NationalForests" are now ready to be uploaded to ArcGIS Online and incorporated into a web application using ArcGIS JavaScript API.