USING WILDFIRE MODELS FROM ISU'S GIS TREC

This document describes the general process you can use to successfully develop a wildfire susceptibility, wildfire hazard, and/or wildfire risk model for your area of interest (AOI). First, understand that each of these types of models (susceptibility, hazard, and risk) build upon one another with the base or core model being the wildfire susceptibility model. You must create a susceptibility model to create a hazard model, and the resulting hazard model is then used to create a risk model.

Second, understand the difference between each model and use the correct terminology[1] to communicate the results of each model.

Before jumping into the development of wildfire models for *your* AOI, spend some time getting to know the models we have developed. Each model contains an ArcGIS Pro Toolbox file (*.atbx) and two folders. One is a `RiskModelInputs` folder and the other a `RiskModelOutput` folder. The model inputs folder will contain the data layers necessary to re-create the wildfire models for Bannock County, Idaho. You will need similar layers to create wildfire models for your AOI.

Let's take some time to get acquainted with these models:

1. For simplicity, I suggest creating a new ArcGIS Pro project for your wildfire modeling efforts. Alternatively, you could integrate these models into an existing project.
    a. Copy the entire contents of our wildfire model into the project folder of your ArcGIS Pro project. This includes the model input folder and its data, the model output folder, along with the model's toolbox file (*.atbx)
    b. From ArcGIS Pro, use the Catalog pane to verify these files exist. Your project folder should look similar to the figure below.

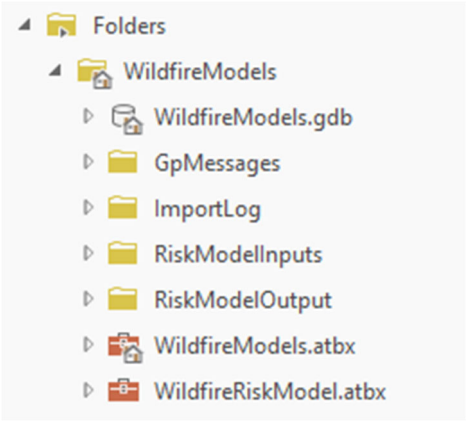


Figure 1. An ArcGIS Pro project was created and named WildfireModels. After copying the wildfire susceptibility model data into the project folder (WildfireModels), the project will contain two new sub-folders and a new toolbox.

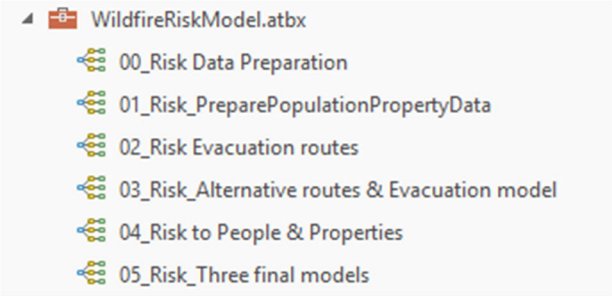
2. Open the risk model inputs folder.
3. Notice it contains one raster layer and numerous feature classes (n = 5) within the geodatabase named `Risk`.

[1] Cf. https://giscenter.isu.edu/pdf/PDF_NASA_SPARC/WildFireTerminologyReview.pdf

To create a wildfire risk model for *your* AOI you the same layers as those provided in the inputs folder. These layers do not need to be stored within a geodatabase but they do need to be topologically correct.

The structure layer can be derived in a number of ways. For this study, we used Artificial Intelligence Deep Learning tools in ArcGIS Pro to extract structure footprints (polygons) from current aerial imagery (e.g., National Agricultural Imagery Program (NAIP)) and then, after good clean up and verification, along with manual editing we arrived at the final structures layer included in this geodatabase.

4. Add each of the layers to the current map in ArcGIS Pro. Explore these layers to familiarize yourself with these data, their spatial resolution, spatial reference system, range in numeric values, and attributes.
5. Next, return to the Catalog pane and expand the model toolbox. It should look like the figure below.



6. Before running any of the models, take a few minutes to become acquainted with the model and its overall workflow. To do this, iteratively open each model by right-clicking the model and selecting Edit from the fly-out menu.

   Do not make any changes to the model, just review it so you are familiar with how each model functions. When finished, close each model.

7. It is important to run the toolbox models in the order indicated by the model's name. In other words, run model 00 first, then model 01, etc. This is important as some models use the output from a previous model.

SOME VERY IMPORTANT AND SPECIFIC NOTES ARE GIVEN BELOW.

RUNNING MODEL 00

8. Open the `00_Risk Data Preparation` model from the `WildfireRiskModel` toolbox
   a. Specify the processing extent using the `EXAMPLE_AOI` layer
   b. Click Run.
9. When the model completes, add the resulting `CensusBlockGroups_AOI` polygon feature class to the current map. This layer will be found at `.\RiskModelOutputs\RiskModelOutputs.gdb`

a. Before running the next model, you will need to use the `Enrich` geoprocessing tool in ArcGIS Pro to add the necessary demographic fields to the CBG layer.
Data enrichment requires the use of credits from ArcGIS Online (AGOL) and cannot be easily incorporated into model builder tools.

   To avoid having to consume credits to complete the example model, I have provided you with the output data for the Bannock County AOI. Add the `EXAMPLE_CensusBlockGroups_AOI_Enriched` layer from the `RiskModelOutputs.gdb` to the current map.

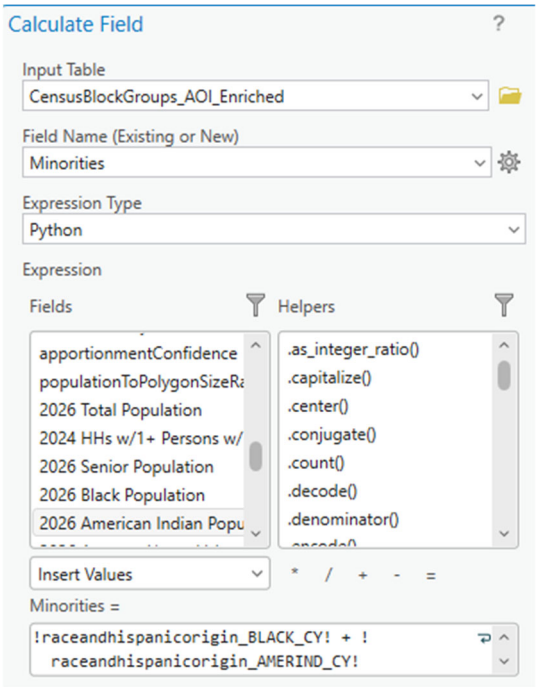
   When you run the `Enrich` tool for your AOI, be sure to add current (or as current as possible) fields describing:
   - Number of elderly people
   - Number of disabled people
   - Number of Native American people
   - Number of African American people
   - Number of households living at or below the poverty level

   NOTE: You may also want to add the mean (average) home value and/or median home value if you do not have access to parcel level data for your AOI.

   These fields are used as previous wildfire risk studies have found these specific populations experience elevated risk to wildfire[2].

b. If you have not already done so, add the enriched example layer to the current map.
c. When creating the Enriched layer for your AOI, you will also need to add a `Minorities` field. This field will sum the population of all minorities included in the demographics you chose to use for your AOI. Use the `Add Field` tool to accomplish this and make the Data type Double.
d. Populate the new `Minorities` field using the `Calculate Field` tool as shown below.

[2] Cf. https://giscenter-sl.isu.edu/AOC/AOC_Research/SPARC/LiteratureReview%20Wildfire%20Risk%20Demographics.pdf



e. Click OK to complete the calculation.

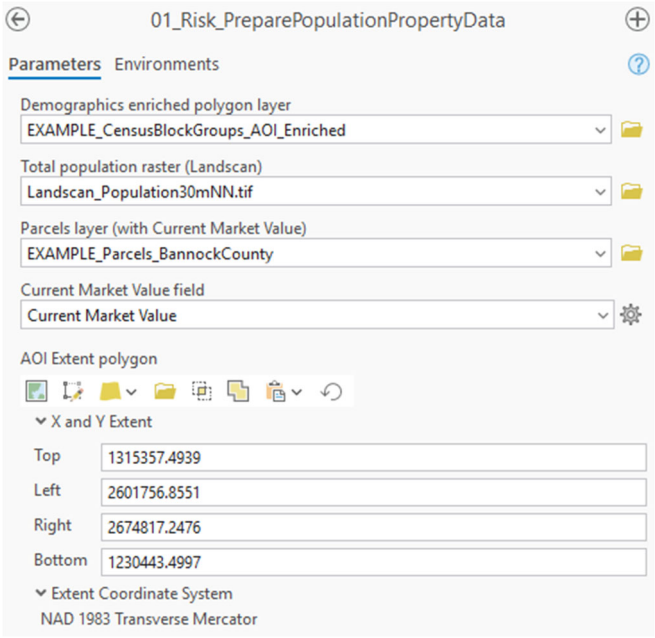
10. Another part of the risk model involves wildfire risk to property. This component model is calculated using a parcels layer. Add the `EXAMPLE_Parcels_BannockCounty` layer to the current map.
    a. Open its attribute table
    b. The parcels layer needs to have a `Current Market Value` field (or a field with another name but the same type of data) populated for all parcels. Locate this field in the example attribute table and familiarize yourself with its data type. NOTE: Null values are not allowed.

       If null values exist in the parcels layer it is recommended to make a copy of the parcels layer for this model and change all null values to zero (0).

    c. If you cannot access a parcels layer for your AOI, you can use the enriched demographics data prepared earlier. You will need to create a numeric `Current Market Value` field and populate it with the mean (or median) home values. This is an acceptable alternative but will not result in the same level of granularity in the final risk model.

RUNNING MODEL 01

11. Double-click the `01_Risk_PreparePopulationPropertyData` model to open it.
    a. Complete the tool dialog as shown below using input data found in the `RiskModelInput` folder.



b. Click Run.
c. The model should complete in just a few minutes resulting in the creation of three sub-component models, namely: `TEMP_FireRisk_VulnerablePopulations.tif`, `TEMP_FireRisk_Populations.tif`, and `TEMP_FireRisk_ParcelProperties.tif`

RUNNING MODEL 02

12. Running the `02_Risk Evacuation Routes` model will also require some data preparation on your part.

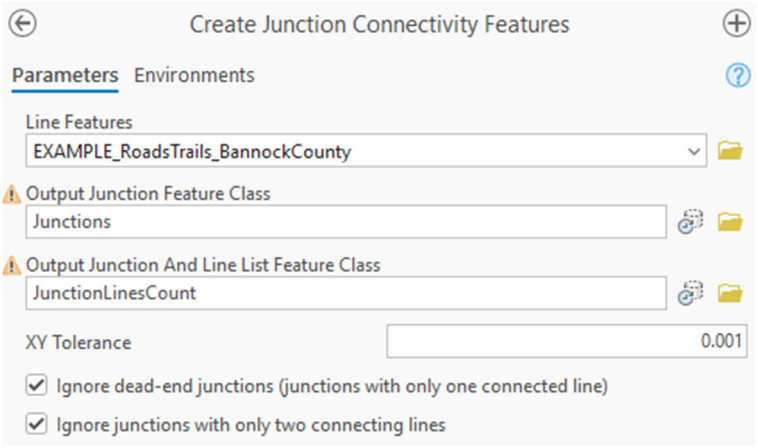
    While the example layer (`EXAMPLE_RoadsTrails_BannockCounty`) provided in the `Risk.gdb` (cf., `RiskModelInputs` folder) is ready for use, when running this model for *your* AOI, you will need a current and comprehensive roads layer with a reliable traffic volume capacity field like the vehicle per hour (`VPH`) field found in the example.

13. Open the `02_Risk Evacuation Routes` model.
    a. Complete the tool dialog as shown below using input layers found in the `RiskModelInputs` folder (NOTE: the frequent use of the AOI polygon to set the processing extent).
    b. Click Run.
    c. This model will take some time to process but you can expect it to finish in approximately 10 minutes. One sub-component model is created name `TEMP_FireEvacuation.tif`

14. Next, we need to model intersections and alternative evacuation routes. Before running the third model you will need to prepare the intersections data using the roads layer. Visit https://www.arcgis.com/home/item.html?id=3fa41b1f8b764879be8f21b4e7ffbabd#overview

And learn about the `Line and Junction Connectivity` tool.

a. Download the tool
b. Extract the tool from the Zip file
c. Copy the toolbox to your wildfire modeling project folder.
d. From ArcGIS Pro, find the `Line and Junction Connectivity Tools` toolbox in the Catalog pane.
e. Running the tool is very similar to any other geoprocessing tool. Expand the toolbox from the Catalog pane and double-click the `Create Junction Connectivity Features` python script.
f. Complete the tool dialog like that shown below.



g. **Be sure to place a check mark in both of the optional settings**; Ignore dead-end junctions and Ignore junctions with only two connecting lines.
h. Click Run
i. This tool completes quickly and normally is finished in well under one minute. The Junctions layer will be used in the next step of the model.

RUNNING MODEL 03

15. Double-click the `03_Risk_Alternative routes & Evacuation model`
    a. Select the `Junctions` layer created in the previous step (NOTE: do NOT use the `JunctionLinesCount` layer). The `Junctions` layer will be found in the `Risk.gdb` within the `RiskModelInputs` folder.
    b. Specify the processing extent using the `EXAMPLE_AOI` layer.
    c. Click Run.
    d. Model 03 will complete in about one minute and will produce one new raster layer, `FireRisk_EvacuationRisk.tif`. Notice this layer is not prefixed with TEMP because it may be of use by itself to emergency managers and decision makers.

RUNNING MODEL 04

16. Open model `01_Risk to People & Properties`. This model combines the output from some of our previous models into two component model layers, namely `FireRisk_People.tif` and `FireRisk_Properties.tif`.

17. When processing completes, view both layers in the current map. Notice again, these layers are not prefixed with TEMP as each may be of use to emergency managers and decision makers.

    The range of numeric values for each layer must fall between 0 and 1000. However, each layer does not need to fully reach the minimum and maximum values (0 and 1000, respectively).

RUNNING MODEL 05

18. Double-click `05_Risk_Three final models` from the `WildfireRiskModel` toolbox.
    a. There is only one input needed and that is the wildfire hazard raster created previously. You will need to locate this layer and provide it as input to the final wildfire risk models.
    b. Click Run.
19. When the final model builder tool completes, you will have three wildfire risk models for Bannock County, Idaho (when running these same tools for your AOI, you will have three wildfire risk models for your AOI as well). These raster models are:
    - `WildfireRisk_People.tif`
    - `WildfireRisk_Properties.tif`
    - `WildfireRisk_People+Properties.tif`

FINAL PREPARATIONS

20. You may wish to clip these layers to more precisely fit the AOI.
21. It is recommended that you transform these data into *Actionable Information*. Specifically, consider what information an Emergency Manager will need from our spatial data to arrive at a well-informed decision regarding future wildfire mitigation. In other words, our model needs to inform him/her about those areas where a pre-fire treatment could be used to reduce the effect of a future wildfire. To do this we will take a quantitative approach using statistics; *The Language of Science*.
    a. Create a histogram chart for each of the final clipped wildfire risk models.
    b. Make note of each model's mean and standard deviation (SD)values using the table below.

	Mean value	SD value
WildfireRisk_People		
WildfireRisk_Properties		
WildfireRisk_People+Properties		

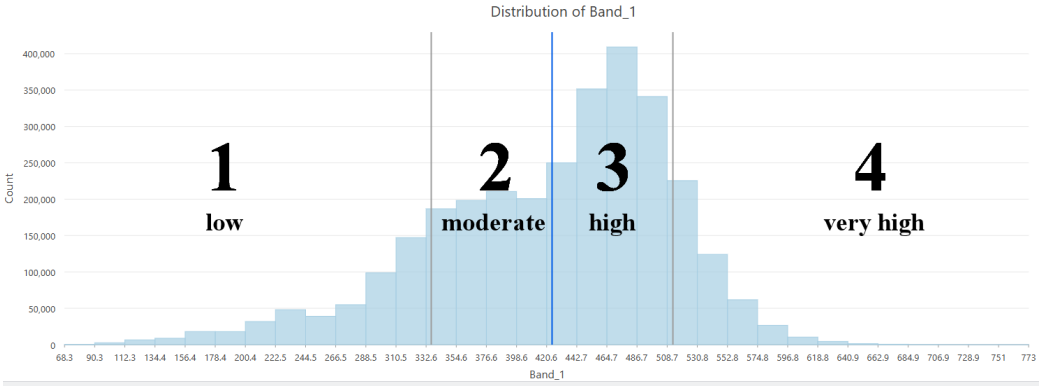
    c. Calculate the 95% confidence interval value about the mean (95 CI is the mean +/- 1.96 SD). Note the values for each model in the table below.
        Mean – 1.96 SD (lower bound)
        Mean + 1.96 SD (upper bound)

	Lower bound	Upper bound
WildfireRisk_People		
WildfireRisk_Properties		
WildfireRisk_People+Properties		

22. Use these data to write an ASCII reclass file for use in ArcGIS Pro. Minimize ArcGIS Pro and open notepad or other ASCII text file editor. To do this correctly, carefully follow the steps outlined below.
    a. The first line is for your own use. It is optional but very handy. It describes what this reclass file is intended to do. Type something like:
    `# Remap wildfire risk values into four categories or classes.`
    NOTE: the hashtag (#) must be used to denote this is a comment and not an instruction to ArcGIS Pro.

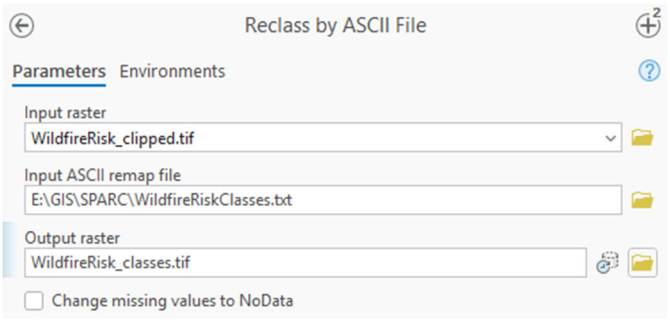
    b. The next four lines will identify the minimum and maximum risk values for each risk class followed by a colon (:) and then the numeric value for that class.
    ```
    0 338.3 : 1
    338.3 426.6 : 2
    426.6 514.9 : 3
    514.9 1000 : 4
    ```
    NOTE: there is a space between each value and around the colon

    The four classes will equate to low (1), moderate (2), high (3), and very high (4) risk. The histogram below will help you visualize the class breakdown.



    c. Save the text file into your ArcGIS Pro project folder, naming it similar to `WildfireRiskClasses.txt`

23. Return to ArcGIS Pro
24. Open the `Reclass by ASCII File` geoprocessing tool.
25. Complete the tool dialog as shown below and click Run (NOTE: You will need to repeat these steps for each of the three risk models).



26. Once processing completes, add the new layer to the current map.
    a. Apply meaningful symbology and label names to the symbology legend (i.e., low, moderate, high, and very high).
    b. Save this as a Layer file (*.lyrx)

Explore each of the three models and prepare yourself to discuss these with local emergency managers and decision makers. Pre-fire mitigation plans can be informed using these data and for your specific AOI and local communities, one of the risk models may be deemed better than the others.

If you encounter errors while running any of the models, please let us know by emailing giscenter@isu.edu

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