2021

Treatment Planner (BETA)

A conservation strategy tool designed to help prioritize forest management actions by connecting ArcGIS, FVS, and EEMS within a 4-Box decision making framework.

User Manual Version 0.0.1

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Table of Contents

The Treatment Planner is currently in the early stages of development. If you have questions, comments, or encounter any problems, please contact the Conservation Biology Institute at geospatial@consbio.org.

I. INTRODUCTION

1.1 Purpose and Contents

The purpose of this document is to provide instruction and guidance on the use of the Treatment Planner – A conservation strategy tool designed to help users prioritize forest management actions by connecting ArcGIS, FVS, and EEMS within a 4-Box decision making framework.

Upon successful completion of this document, readers should be able to:

1. Understand the relationship between the 4-Box model and the Treatment Planner.
2. Effectively use the Treatment Planner to help inform their forest management decisions.

How this document is organized

Section I provides an introduction, as well as a list of the software, technical, and data requirements needed in order to get started with the Treatment Planner. Section II provides an overview of the 4-Box model, the Treatment Planner, and the relationship between the two. Section III provides a step-by-step tutorial on how to use the Treatment Planner. And finally, Section IV provides information on how users can add their own EEMS models to the Treatment Planner.

1.2 Software Requirements

The Treatment Planner is not a stand-alone desktop application. Rather it forms a bridge between three different software packages. Consequently, users will first need to ensure that they meet the software requirements listed below and have downloaded/installed any remaining programs that haven't already been installed.

1. **Microsoft Windows 7 or Windows 10**

2. **ArcGIS Desktop 10.6.1 or greater**
   While earlier versions of ArcGIS may work, they have not been tested. ArcGIS Pro is currently not supported.

3. **MPilot**
   MPilot is a plugin-based environmental modeling framework written in python. It is required in order to run EEMS Models developed using EEMS for ArcGIS.

   To install MPilot, follow the instructions below:

   a. Open a command prompt (in Windows 10, you can do this by typing "cmd" into the Search box in the bottom left hand corner of your screen).
   b. Type in "cd C:\Python27\ArcGIS10.X\Scripts", replacing "X" with the version of ArcGIS Desktop you have installed.
   c. Type in "pip install mpilot".
   d. Restart ArcCatalog & ArcMap.

   For more information regarding MPilot, visit the MPilot repository on GitHub: https://github.com/consbio/mpilot

4. **Forest Vegetation Simulator (FVS)**
   *FVS (*Seymour, Robert. (2013) *is a US Forest Service tool designed to simulate forest vegetation change in response to natural succession, disturbances, and management actions. You can download FVS at the URL below:*
   https://www.fs.fed.us/fvs

5. **Microsoft Access 2010 or greater**
   Microsoft Access is a relational database management system (RDBMS). It comes bundled with Microsoft Office Professional.

6. **The Treatment Planner**
   The Treatment Planner is a Python Toolbox and does not need to be installed. The latest version can be downloaded from GitHub:

   <Insert GitHub repository>

7. **EEMS for ArcGIS**
   EEMS is a fuzzy logic modeling system written in Python. The EEMS for ArcGIS toolbox is included with the Treatment Planner within the EEMS/EEMS3.1.0_ArcGIS folder. Since it is included, it does not need to be downloaded separately. Since it is a python toolbox, no installation is required. It is listed here solely for completeness. More information about EEMS can be found at the following URL:

   https://consbio.org/products/tools/environmental-evaluation-modeling-system-eems

1.3 Data Requirements

1. **An FVS Database**
   The Treatment Planner requires an existing FVS database to describe the current forest conditions. A sample database is included for use in the tutorial, but in order to use the Treatment Planner in a real-world setting, you will need an FVS database containing data for your study area. The FVS database must include, at a bare minimum, an FVS_StandInit table and an FVS_TreeInit table.

2. **A "Stands" Feature Class**
   In addition to the FVS database, you will also need a shapefile or geodatabase feature class representing the stands in your FVS database. This feature class must have a STAND_ID field that can be linked to the STAND_ID field in the FVS database. A sample stands feature class is included with the Treatment Planner for use in the tutorial.

1.4 Recommended Training & Experience

1. In addition to the software and data requirements listed above, users should have formal GIS training and experience with ArcGIS Desktop and ArcGIS Model Builder.

2. Experience with EEMS and building EEMS models is also highly recommended as this will allow you to develop and connect your own EEMS models to the Treatment Planner.

3. Experience with Microsoft Access is recommended in order to be able to examine the FVS databases, but it is not required.

II. OVERVIEW

2.1 What is the 4-Box Model?

The 4-Box model is a conceptual representation of a process designed to help predict future landscape conditions based on simulated management actions and change over time (figure 1). It was originally conceived of by Tim Sheehan, Ph. D., an ecological modeler and the original developer of EEMS (Sheehan, T. and Gough, M. (2016)). As illustrated below, the 4-Box model describes an iterative process whereby the land manager first examines the current conditions of the landscape through the lens of a particular question or management objective (e.g., *where are areas that need protection or restoration*?). They then engage in an exploratory process involving several "what-if" questions in order to examine the predicted effects of various simulated management alternatives. For example, if we were to perform one or more treatments on a forest stand (e.g., *thin from above, or thin from below*), how would that affect the stand structure over time (*e.g., how would it affect the stand density, basal area, and average DBH*)? And how would those new conditions then affect a particular phenomenon of interest (e.g., *severe fire risk, or wildlife habitat suitability*)? This process is then repeated under a different set of treatment options (scenarios) in order to help develop an effective management strategy to implement in the real world.

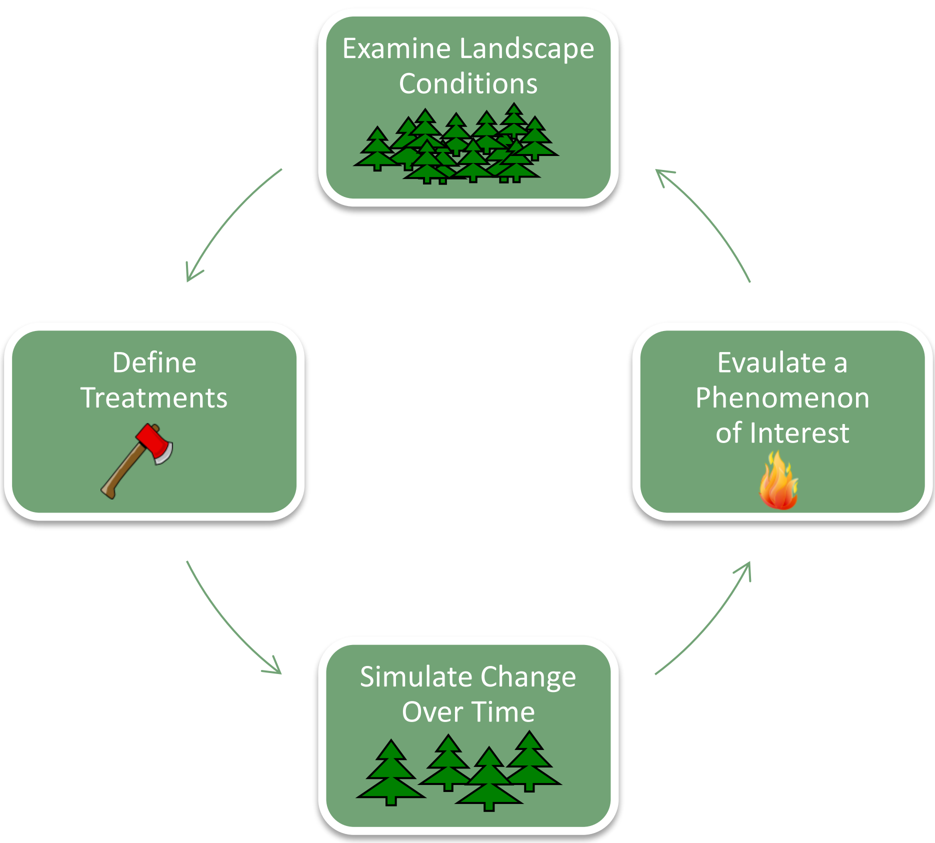


Figure 1. The 4-Box model represents a process for evaluating future conditions based on simulated treatments and change over time.

2.2 What is the Treatment Planner?

The 4-Box model is more of a conceptual framework than a software specific one. That is, it describes a process that could be implemented using a variety of different software packages and analytical techniques; and the Treatment Planner is just that – a software specific implementation of the 4-Box model. It is perhaps unique, however, in that it brings together all the components of the 4-Box model into a single tool with a user-friendly interface.

More specifically, the Treatment Planner is an ArcGIS script tool within a Python Toolbox. To run the tool, the user specifies several input parameters, which include:

1. The path to an existing FVS database which is used to define the current conditions of the landscape (*top box in the 4-Box model*).
2. A treatment or set of treatments to perform (*left box*).
3. The number of years to simulate forest growth/change (*bottom box*).
4. The phenomenon of interest to model based on the simulated future conditions (*right box*).

These input parameters are then handed off to the Forest Vegetation Simulator (FVS) to perform the specified treatment(s) and to simulate change over time. The outputs from FVS (e.g., trees per acre, basal area, etc.) are then handed off to the Environmental Evaluation Modeling System (EEMS) to model the phenomenon of interest (e.g., severe fire risk) based on these future conditions.

While a discussion of FVS and EEMS is beyond the scope of this document, users are encouraged to learn more about these applications at the URLs below:

FVS: https://www.fs.fed.us/fvs
EEMS: https://consbio.org/products/tools/environmental-evaluation-modeling-system-eems

The Treatment Planner comes with two EEMS Models built-in which are designed to calculate the following phenomena of interest:

1. **Severe Fire Risk** – A simple model designed to evaluate the risk of severe fire occurrence under future conditions based on three terrain variables (Slope, Solar Insulation, and Southwestness) as well as four FVS generated forest stand structure variables (Basal Area, Trees Per Acre, Stand Density Index, and Crown Competition).

2. **Thinning Assessment** – A simple model to identify stands to prioritize for thinning treatments based on stand density, avoidance of old growth, and economic value.

These models can be used as-is, or tailored for a specific region or purpose. Additional EEMS models can be developed and added to the Treatment Planner by the user – the only requirement is that they are configured to make use of one or more of the outputs fields generated by FVS. A more thorough discussion of this topic is presented in section V (Adding Custom EEMS Models).

III GETTING STARTED

The Treatment Planner is distributed in a zip file that contains several files and folders (see Figure 2 below). To get started using the Treatment Planner, first extract the content of the zip file to a folder on your local hard drive. The items within the extracted folder must be maintained in their current locations within the existing directory structure. Moving these items around has the potential to cause problems.

3.1 The Treatment Planner Contents

1. A Data folder containing subfolders for Inputs, Intermediate, and Outputs.
2. A Docs folder containing this user manual
3. An EEMS folder containing EEMS as well as a set of sample EEMS Models (EEMS_Models.tbx)
4. An MXD folder for storing map documents (MXDs)
5. The Treatment Planner Toolbox (Treatment_Planner.pyt)

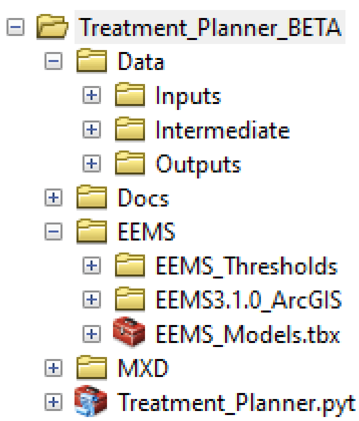


Figure 2. The Contents and directory structure of the Treatment Planner Download

3.2 The Treatment Planner Toolbox

The Treatment Planner Toolbox (Treatment_Planner.pyt) currently contains a single tool called "Run Simulation" (pictured below) which performs all the functions of the 4-Box model. Additional tools may be added in future versions.

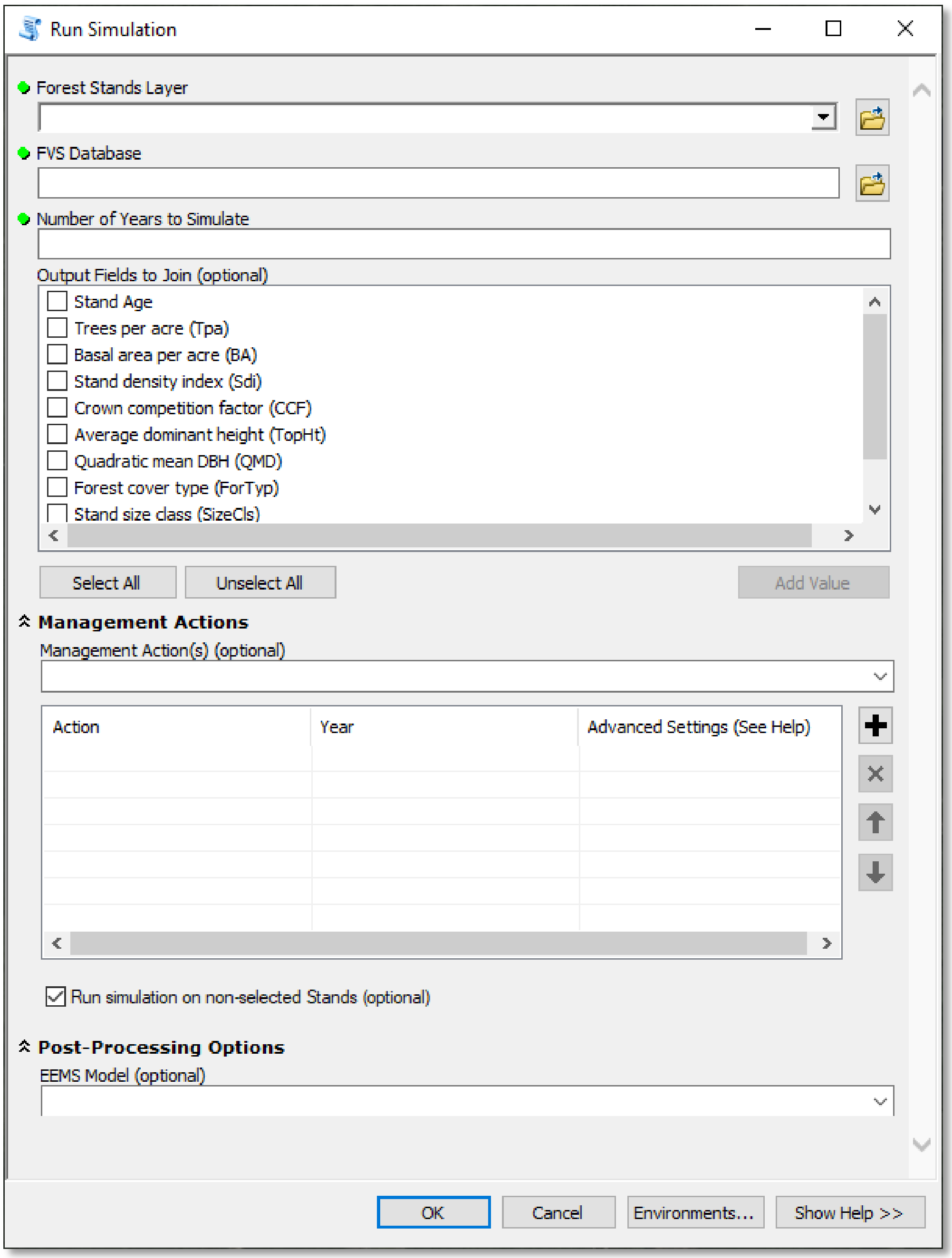


Figure 3. The Treatment Planner/Run Simulation Tool Interface

The tool input parameters are described in the table below. Note that these descriptions can also be accessed within the tool itself by simply placing your cursor in one of the input parameter fields and clicking the “Show Help” button.

Input Parameter	Description
Forest Stands Layer	The ArcGIS layer or feature class representing the stands in the FVS database. Must have a field called STAND_ID containing values that match those in the STAND_ID field of FVS_StandInit table.
FVS Database	The path to an FVS-ready database representing the forest stands and individual trees.
Number of Years to Simulate	The number of years to simulate forest vegetation growth/change into the future. A minimum of 1 year is required.
Output Fields to Join	The FVS outputs to join to the output stands feature class. Note that if you are running an EEMS model, you must check the boxes corresponding to those required by the READ commands in the EEMS model. **Trees per acre (Tpa)** is a count of the number of trees per acre. **Basal area per acre (BA)** describes the average amount of an acre (measured in square feet) occupied by the cross section of tree stems. **Stand Density Index (Sdi)** is a relative measure of stand density that is based on the number of trees per unit area and diameter at breast height (DBH) of the tree of average basal area (source: wikipedia). **Crown competition factor (CCF)** (Krajicek and others 1961) is a relative measurement of stand density that is also based on tree diameters. Tree values of CCF estimate the percentage of an acre that would be covered by the tree’s crown if the tree were open grown. Stand CCF is the summation of individual tree (CCFi) values. A value of 100 theoretically indicates that tree crowns will just touch in an unthinned, evenly spaced stand (source: FVS manual). **Average dominant height (TopHt)** is the average height of the 40 largest diameter trees (source: FVS Manual). **Quadratic mean DBH (QMD)** is the DBH of the tree of average basal area (source: FVS manual). **Forest Cover Type (ForTyp)** is a code representing the dominant forest type (lookup table here: https://www.fs.fed.us/fmsc/ftp/fvs/docs/bulletins/ForTyp_Codes.pdf) **Stand size class (SizeCls)** A code representing the following classes (FVS manual): 1 = Large (sawtimber)

	2 = Medium (poletimber) 3 = Small (seedling-sapling) 4 = Chaparral/Woodland 5 = Nonstocked **Merchantable cuft volume (MCuFt)** represents the volume of merchantable timber in cubic feet.
Treatment(s)/Management Action(s)	The treatments/management actions to perform on the selected stands. Select a management action from the dropdown menu, then enter in a year (starting at year 0) on which to perform that action, and (optionally) a CSV list for the *Advanced Settings* entered in the order specified below. If no stands are selected, the management action will be applied to all the stands. Note that the year field uses a 0 index starting value (so entering in a value of 0 would perform the treatment on the inventory year associated with the stand(s) in the FVS database). **Thin from Above** - (also known as French or crown thinning) the removal of trees from the dominant or codominant crown classes to favor the best trees of those same crown classes (source: FVS Tutorial). **Advanced Settings:** 1. Trees per acre 2. Proportion of trees left 3. Diameter lower limits 4. Diameter upper limits 5. Height lower limits 6. Height upper limits **Thin from Below** - (also known as ordinary, German, or low thinning) the removal of trees from the lower crown classes to favor those in the upper crown classes (source: FVS Tutorial). **Advanced Settings:** 1. Trees per acre 2. Proportion of trees left 3. Diameter lower limits 4. Diameter upper limits 5. Height lower limits 6. Height upper limits **Clearcut -** the cutting of essentially all trees, producing a fully exposed microclimate for the development of a new age class (source: FVS Tutorial).

	Advanced Settings: 1. Diameter of smallest tree cut 2. Number of legacy trees per acre 3. Minimum diameter of legacy trees **Prescribed Burn** - A wildfire set intentionally for purposes of forest management, farming, prairie restoration or greenhouse gas abatement (source: Wikipedia). **Advanced Settings:** 1. Wind speed (mph) at 20 feet above the vegetation 2. Moisture level (1=Very Dry, 2=Dry, 3=Moist, 4=Wet) 3. Temperature (F) 4. Mortality Code (0=Turn off FFE mortality, 1= FFE estimates mortality 5. Percentage of stand area burned (%) 6. Season of fire (1=Early spring, 2=Before greenup, 3=After greenup (before fall), 4=Fall)
Run simulation on non-selected Stands	Checking this box runs the simulation on all of the stands in the input feature class, not just the selected ones.
EEMS Model	A list of available EEMS models to run on the output values generated by FVS. The output values from the last year of the simulation will be used in the EEMS model. Note that you must be sure to check the “Output Fields To Join” boxes corresponding to the inputs fields used by the READ commands in the EEMS model. Two sample EEMS models are available by default. Additional EEMS models can be developed and added to the Treatment Planner. The only requirement is that they are configured to make use of one or more of the “Output Fields to Join” variables generated by FVS.

Table 1. The input parameters available in the Run Simulation tool.

IV. TREATMENT PLANNER TUTORIAL

4.1 Overview

The tutorial below will demonstrate how to run the Treatment Planner using four stands located just outside the community of Shaver Lake California in the mixed conifer forest of the Southern Sierra Nevada Mountains. In this example, we will play the role of a forest manager interested in determining what the severe fire risk in this area will be in 10 years under two different management alternatives:

1. No Action Alternative (no treatments/management actions)
2. Thinning Treatment (A management plan that involves thinning a high risk stand on year 5)

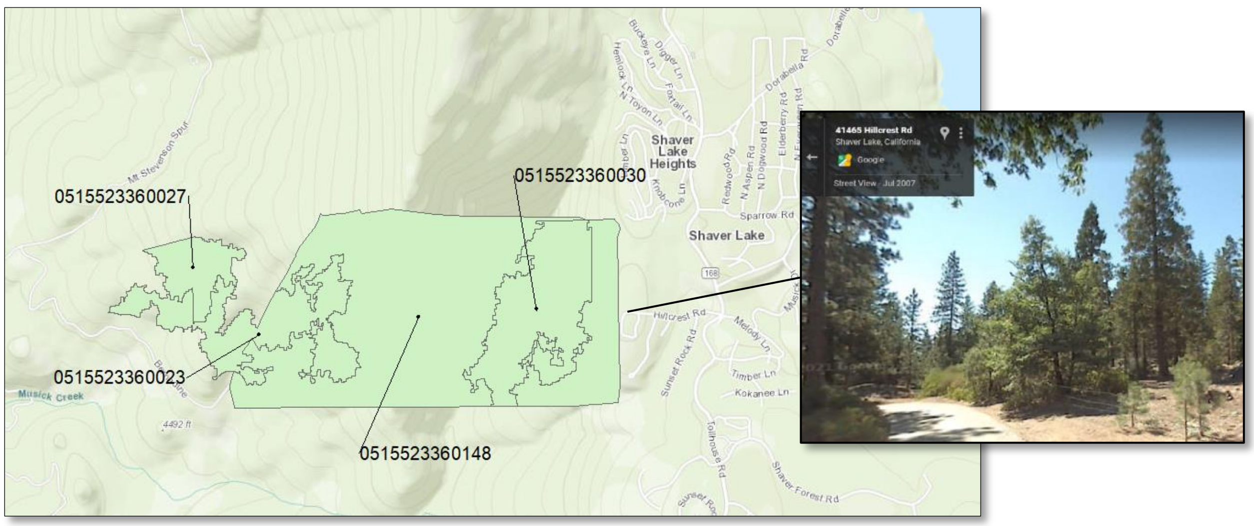
After each simulation, we will examine the predicted effects of each of these management alternatives in order to help us select a management strategy that will be most effective in reducing the severe fire risk in this area.

4.2 Disclaimer

The data and models used in this tutorial are intended for demonstration purposes only and have not been vetted for accuracy. Consequently, the outputs generated from the simulations performed in this tutorial will not necessarily reflect real-world conditions and should not be used for purposes other than testing and training.

4.3 Preparation

1. If you haven't already, extract the contents of the Treatment_Planner_BETA.zip file to a desired location on your local hard drive.
2. Open the demo MXD located in the MXD folder.
3. Each of the four stands in the Shaver Lake Forest Stands layer (shown below) has a corresponding record in the FVS_StandInit table in the ShaverLake.accdb FVS database. The values in the STAND_ID field (shown as labels below) are what allows the Treatment Planner to associate each of these polygons with a record in the FVS_StandInit table. The FVS_TreeInit table in the FVS database contains all the information about the trees located within each of these stands.



While we will only be examining four stands in this tutorial, the FVS_StandInit table contains records for several additional stands present in this area. Some of these stands also have corresponding polygons, which can be found in the Shaver_Lake_Forest_Stands_All feature class.

4. **Optional:** Open up the sample FVS database in Microsoft Access and examine the FVS_StandInit table and the FVS_TreeInit table. The FVS_TreeInit table contains a record for each tree (or collection of similar trees) located within each of the stands in the FVS_StandInit table. The STAND_ID field indicates which stand each of these trees is located within. Other fields in the FVS_TreeInit table include the species code, DBH, height, and crown ratio. Additional information regarding the data in the FVS_TreeInit table can be found in the FVS Documentation.

5. Close Microsoft Access if it is open.

6. **Optional:** Open up and examine the Severe Fire Risk EEMS model in the EEMS_Models toolbox. This is the model that the Treatment Planner will use to predict the severe fire risk in each of our stands x years into the future.

There are two main branches to this model (show below in Figure 4):

The left hand branch (Topography is conducive to Fire) is based on topographic properties that don't change over time (Southwestness, Solar Insulation, and Slope). These values have been pre-calculated in the input stands feature class we'll be using in the tutorial. These are not values that the Treatment Planner will generate, so if you intend to run this model on your own stands, these values would first need to be calculated.

The right hand branch (Structure is Conducive to Fire) is based on the outputs generated by FVS x years into the future (Basal Area, Tree Density, Stand Density Index, and Crown Competition).

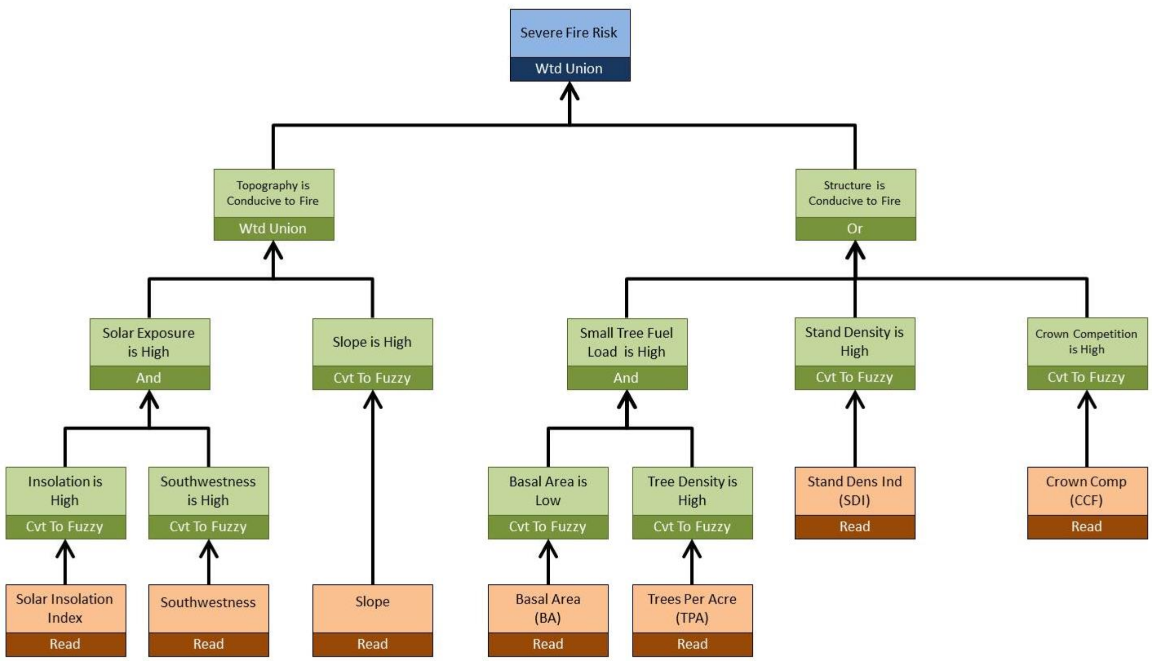


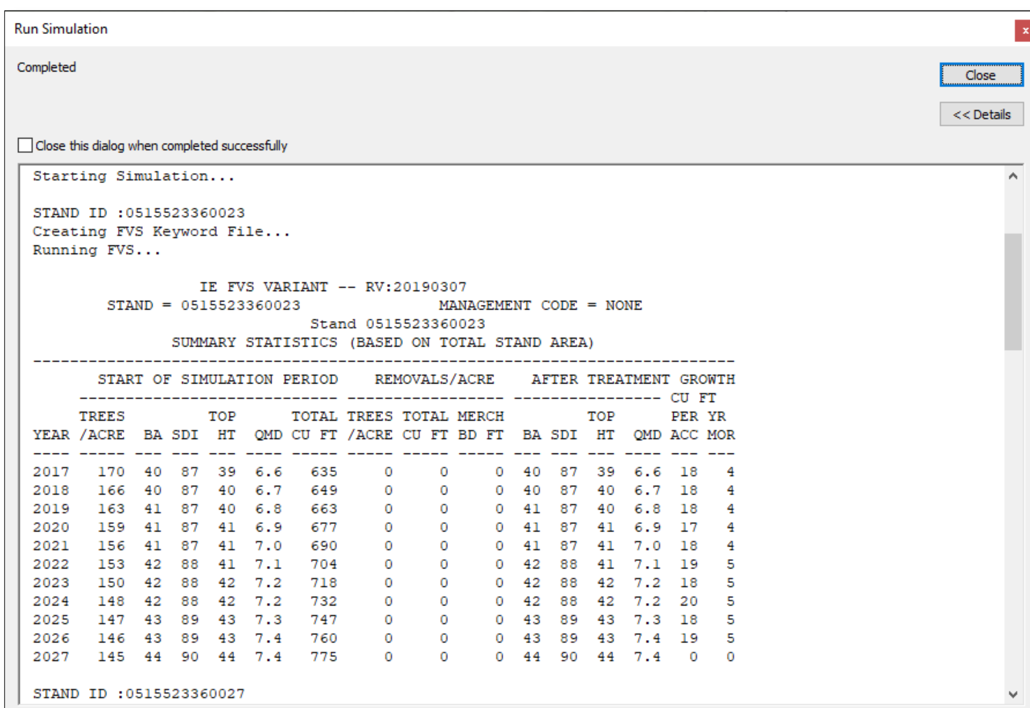
Figure 4. A graphical representation of The Severe Fire Risk Model included with the Treatment Planner

Please refer to section V of this document for information on how to include your own EEMS models in the Treatment Planner.

4.4 Scenario 1: No Action Alternative

Once the preparation steps above have been completed, you can proceed with the simulation below which will determine what the severe fire risk will be in 10 years, for each stand, under the no action alternative (i.e., if no treatments are performed).

1. In the Catalog Window in ArcMap, locate the Treatment Planner Toobox, and double click the Run Simulation tool contained within it.
2. Drag the **Shaver Lake Forest Stands** layer over to the **Forest Stands Layer** input field.
3. Browse to the following **FVS Database** if the path isn't already entered in: <Local Treatment Planner Path>\Data\Inputs\FVS_Databases\ShaverLake.accdb
4. Enter in 10 for the **Number of Years to Simulate**.
5. For the checkbox items in the **Output Fields to Join** list, click **Select All**. For each output field that is selected, the final value for the last year of the simulation will be joined to the output feature class.
6. Since we are simulating a no action alternative, we will leave the **Management Actions** options blank.
7. Under **Post-Processing Options** -> select **Severe Fire Risk** from the list of EEMS Models that appear dropdown menu.
8. Click Ok.
9. After the tool runs through an initialization process, you'll notice that the tool dialog box will display the output data generated by FVS for each stand in the stands layer:



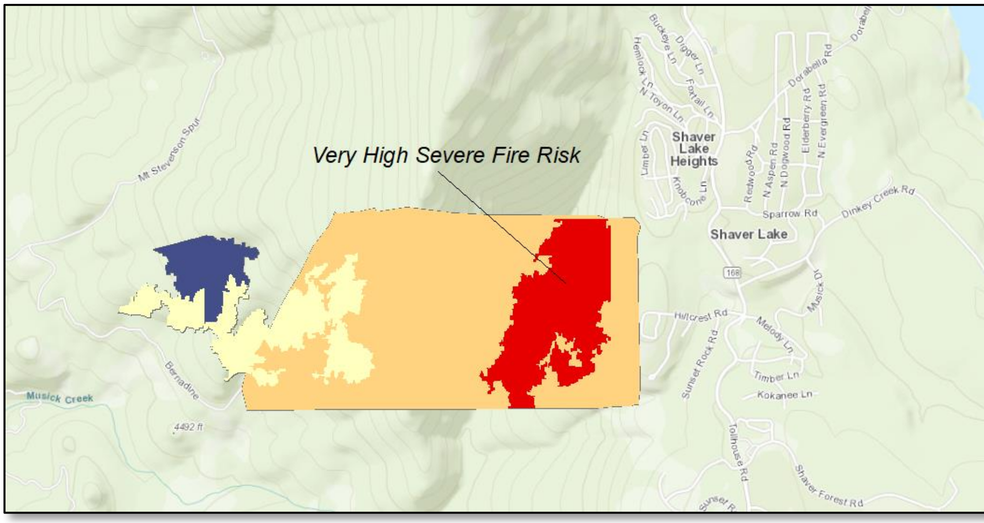
```
Run Simulation
Completed
Close
<< Details
Close this dialog when completed successfully

Starting Simulation...

STAND ID :0515523360023
Creating FVS Keyword File...
Running FVS...

              IE FVS VARIANT -- RV:20190307
        STAND = 0515523360023                MANAGEMENT CODE = NONE
                              Stand 0515523360023
                SUMMARY STATISTICS (BASED ON TOTAL STAND AREA)
----------------------------------------------------------------------------
       START OF SIMULATION PERIOD    REMOVALS/ACRE    AFTER TREATMENT GROWTH
     ---------------------------- ----------------- ---------------- CU FT
     TREES         TOP       TOTAL TREES TOTAL MERCH         TOP      PER YR
YEAR /ACRE  BA SDI  HT  QMD CU FT /ACRE CU FT BD FT  BA SDI  HT  QMD ACC MOR
---- ----- --- --- --- ---- ----- ----- ----- ----- --- --- --- ---- --- ---
2017   170  40  87  39  6.6   635     0     0     0  40  87  39  6.6  18   4
2018   166  40  87  40  6.7   649     0     0     0  40  87  40  6.7  18   4
2019   163  41  87  40  6.8   663     0     0     0  41  87  40  6.8  18   4
2020   159  41  87  41  6.9   677     0     0     0  41  87  41  6.9  17   4
2021   156  41  87  41  7.0   690     0     0     0  41  87  41  7.0  18   4
2022   153  42  88  41  7.1   704     0     0     0  42  88  41  7.1  19   5
2023   150  42  88  42  7.2   718     0     0     0  42  88  42  7.2  18   5
2024   148  42  88  42  7.2   732     0     0     0  42  88  42  7.2  20   5
2025   147  43  89  43  7.3   747     0     0     0  43  89  43  7.3  18   5
2026   146  43  89  43  7.4   760     0     0     0  43  89  43  7.4  19   5
2027   145  44  90  44  7.4   775     0     0     0  44  90  44  7.4   0   0

STAND ID :0515523360027
```

What this is showing is change in forest conditions over time, within each stand, starting on year 0 (2017), and continuing through to year 10 (2027). The table below describes what each of these columns represents.

Column	Description
START OF SIMULATION PERIOD	
YEAR	**The simulation year**
TREES/ACRE	**Trees per acre (Tpa)** is a count of the number of trees per acre.
BA	**Basal area per acre (BA)** describes the average amount of an acre (measured in square feet) occupied by the cross section of tree stems
SDI	**Stand Density Index (Sdi)** is a relative measure of stand density that is based on the number of trees per unit area and diameter at breast height (DBH) of the tree of average basal area (source: wikipedia).
TOP HT	**Average dominant height (TopHt)** is the average height of the 40 largest diameter trees (source: FVS Manual).
QMD	**Quadratic mean DBH (QMD)** is the DBH of the tree of average basal area (source: FVS manual).
TOTAL CU FT	**Total cuft volume (CuFt)** represents the volume of timber in cubic feet.
REMOVALS/ACRE	
TREES/ACRE	**Trees per acre (Tpa)** removed based on any management actions specified.
TOTAL CU FT	**Total cuft volume (CuFt)** removed based on any management actions specified.
MERCH BD FT	**Merchantable cuft volume (CuFt)** removed based on any management actions specified.
AFTER TREATMENT GROWTH	
BA	**Basal area per acre (BA)** growth following any management actions specified.
SDI	**Stand Density Index (Sdi)** growth following any management actions specified.
TOP HT	**Average dominant height (TopHt)** following any management actions specified.
QMD	**Quadratic mean DBH (QMD)** following any management actions specified.
CUBIC FT PER YR	
ACC	Cubic Feet of Timber accumulated per year
MOR	Cubic Feet of Timber removed via mortality per year

10. After you've had a chance to examine the output of the tool dialog, click close and examine the output layer that was automatically added to the table of contents. You'll notice that the EEMS Model has determined that one of the stands (0515523360030) is

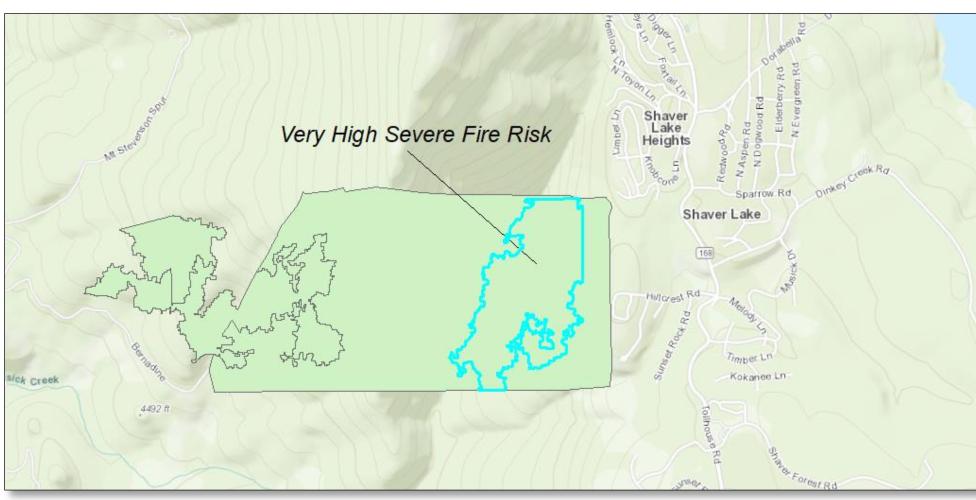
expected to have a **VERY HIGH** risk of a severe fire in 10 years if no treatments are performed. If you look in the attribute table of the output, you'll notice that the value in the **High_Severe_Fire_Risk_Fz** field is 0.79 on a scale of -1 to +1. Moreover, it is surrounded by stands that are expected to have a **MODERATELY HIGH** severe fire risk.



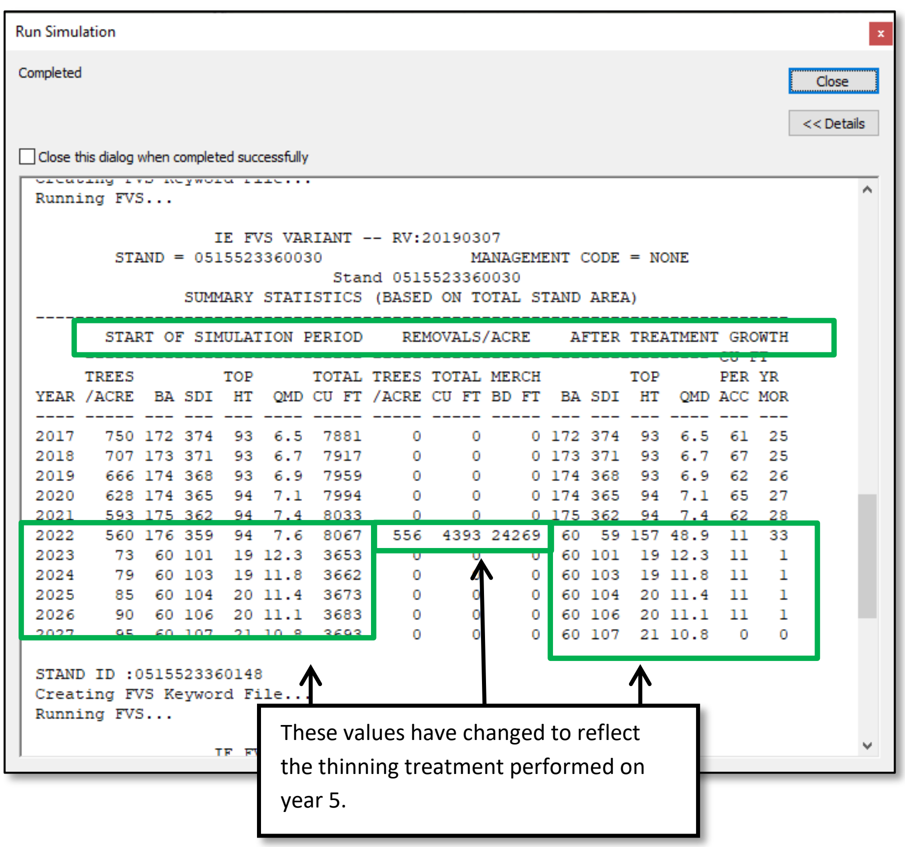
4.5 Scenario 2: Single Thinning Treatment

In this example, we will conduct the same the analysis as above, except we will now perform a single thinning treatment on the stand that was determined to be at high risk under the no action alternative.

1. In ArcMap, uncheck the EEMS Output in the Table of Contents, and select the high risk stand in the original stands layer using the **Select Features** arrow (as shown below). Note that it is possible to select multiple stands for treatment if desired. For this tutorial, however, we are only interested in applying a treatment to this single stand.



2. Click Geoprocessing → Results → Current Session → Run Simulation. This is a shortcut that will open up the tool with the same parameters used in the last simulation.
3. Leave everything the same, but under Management Actions, select **Thin From Below**.
4. In the Year column, enter in **5** to specify that we would like to perform the treatment on the 5th year. Note that this parameter uses a 0 index starting value (so entering in a value of 0 would perform the treatment on the inventory year associated with the stand(s) in the FVS database).
5. Leave the “Run simulation on non-selected Stands” checked. This will force the simulation to run on all the stands, not just the stand(s) selected for treatment. However often for testing purposes, and/or when dealing with large FVS databases and evaluating multiple scenarios, it is quicker and more efficient to uncheck this box.
6. Expand the Post-Processing options to confirm that the **Severe Fire Risk** model is still selected.
7. Click Ok.
8. As the simulation is performed, the dialog box will again show the outputs generated by FVS. As it does this, notice what happens to the values under “REMOVALS/ACRES” field on year 5 in the stand that you selected for treatment (0515523360030). Because we specified a thinning treatment on year 5, these fields will now indicate the number of trees per acre removed, the total cubic board feet removed, and the total merchantable board feet removed by this treatment. The values under the START OF SIMULATION PERIOD have also changed in response to the thinning treatment. There are now fewer trees per acre, the basal area has decreased, the trees are now smaller on average, etc.



Note some of the changes that occurred following the treatment on year 5:

a. There are now fewer trees per acre (TREES/ACRE).
b. The Basal Area per acre (BA) has decreased.
c. The Stand Density Index (SDI) has decreased.
d. The average height of the 40 largest diameter trees (TOP HT) has decreased.
e. The total cubic feet has decreased.

9. After you've had a chance to examine the output in the tool dialog, click close and examine the output layer that was automatically added to the table of contents. You'll notice that the stand that previously had a high fire risk in 10 years under the no action alternative now has a **MODERATELY LOW** severe fire risk because of the treatment we performed. If you examine the attribute table, you'll see that the value in the **High_Severe_Fire_Risk_Fz** field for this stand has dropped significantly from 0.79 to -0.36.

4.6 Conclusion

In this tutorial, we have demonstrated how the Treatment Planner can be used to help land managers evaluate the effects of different management alternatives on a forested landscape. We tested two alternatives and discovered that under the No Action Alternative, one of the stands just outside the community of Shaver Lake would have a VERY HIGH risk for a high severity fire in 10 years. We then repeated the simulation with a thinning treatment performed on year 5 and discovered that this reduced the Severe Fire Risk of this stand from VERY HIGH (0.79) to MODERATELY LOW (-0.36), suggesting that this would be the preferred management strategy to implement on the ground.

At this point it is important to note that the output risk value will be highly sensitive to the TRUE and FALSE thresholds used in the Severe Fire Risk EEMS model. Most of the thresholds in this model were set at 1STD from the mean (based on the output from an initial simulation using all the stands in the Shaver_Lake_Forest_Stands_All feature class. Users wanting to run this model in a different study area may want to adjust these thresholds.

This concludes the tutorial. At this point you are encouraged to experiment with different scenarios. For example, try performing the treatment on a different year. If the stand in question currently has a high fire risk, it might make more sense to perform the treatment during the current year (year 0) if feasible. How does that affect the severe fire risk in this stand in 10 years? Try experimenting with different management actions, and perhaps multiple management actions on different years. Also notice that each management action has an "Advanced Settings" parameter that will allow you to fine tune each management action.

Finally, remember it is important to look not only at the classified output (High, Very High, etc.), but also at the continuous values generated in the **High_Severe_Fire_Risk_Fz** field.

V. ADDING CUSTOM EEMS MODELS

**Note: This section assumes that users are already familiar with EEMS and have experience building EEMS models. This manual does not provide instructions on how to create EEMS models. To learn more about EEMS and the process of building EEMS models, please refer to the EEMS Manual.*

The Treatment Planner comes pre-packaged with two sample EEMS models. If you completed the tutorial in the previous section, you are already familiar with the Severe Fire Risk model. In this section, we will see how advanced users can develop and include their own EEMS models in the Treatment Planner. These models could be designed to calculate any variable of interest (e.g., *fisher habitat quality* or *bark beetle infestation predictions*). They just need to be added to the EEMS_Models toolbox, configured to make use of one or more of the outputs variables generated by FVS (shown below), and added to the Run Simulation tool.

Output variables generated by FVS

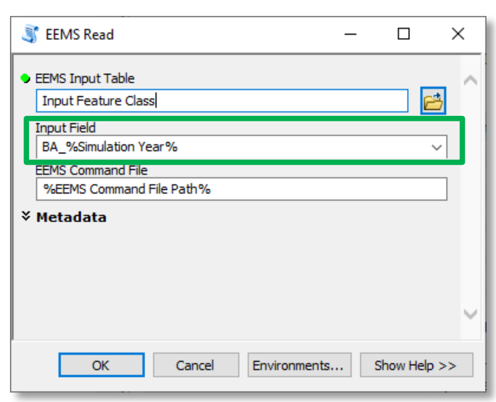
I. Age (Stand Age)
II. Tpa (Trees per acre)
III. BA (Basal area per acre)
IV. Sdi (Stand Density Index)
V. CCF (Crown competition factor)
VI. TopHt (Average dominant height)
VII. QMD (Quadratic mean DBH)
VIII. MCuFt (Merchantable cuft volume)
IX. ForTyp (Forest Cover Type)
X. SizeCls (Stand Size Class)

To use the variables above in a custom EEMS model, you simply need to add them to an **EEMS Read** command using the following form:

<FVS_Variable_Name>_%Simulation Year%

For example, if you would like your EEMS model to use the **BA** variable generated by FVS (Basal area per acre), you would enter the following into the Input Field of the EEMS Read command:

BA_%Simulation Year%



%Simulation Year% is a variable that will be populated automatically using the final year of the simulation (e.g., 2020).

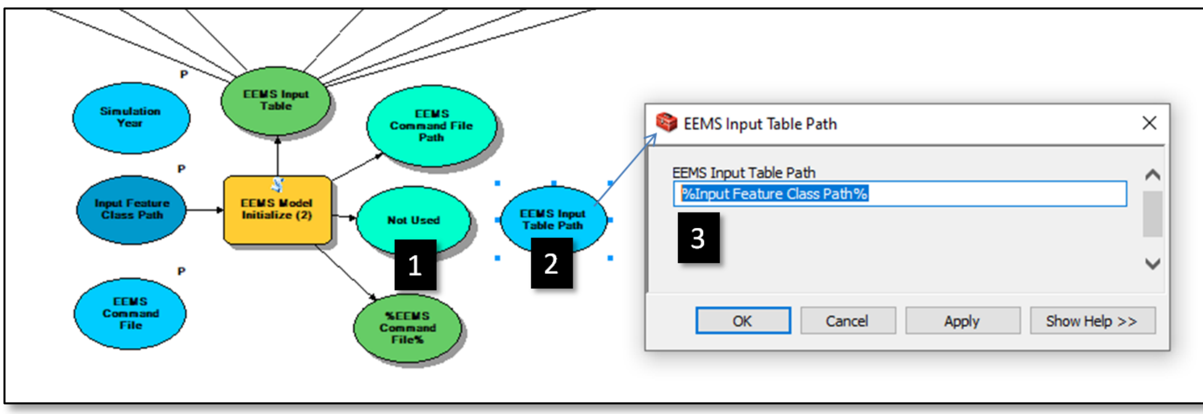
In addition to the FVS variables, your EEMS model can also make use of static variables that do not change with each simulated timestep (for example slope, or elevation). These fields just need to be pre-calculated and included in the input stands feature class, and can then be used in an EEMS Read command as they normally would.

Before developing your own EEMS models for use in the Treatment Planner, it is recommended that you first open up and examine one of the sample EEMS models to use as a reference. In particular, examine the EEMS Read commands to see how they conform to the rules described above.

Making Your Models Transportable

In order to ensure that the models you develop for the Treatment Planner are transportable – i.e., that they can be used if/when the Treatment Planner folder is moved to a new location within your file structure (or provided to another user) – it is recommended that you perform the following steps:

1. Rename the "EEMS Input Table Path" Bubble to something else (e.g., "**Not Used**")
2. Create a new string variable called **EEMS Input Table Path.**
3. Double click the **EEMS Input Table Path** variable you created above and enter in the name that appears in the bubble associated with your input feature class, between percentage signs. For example, if the name on your input feature class bubble is the default "Input Feature Class Path", then you would simply enter in **%Input Feature Class Path%,** as shown below.



If you don't perform the steps above, you will just to need to make sure that you right click and run the "**EEMS Model Initialize**" tool in your model anytime the Treatment Planner folder is moved to a new location. Failure to perform at least one of these options will likely generate the following traceback error:

```
Traceback (most recent call last):
  File "<string>", line 450, in execute
  File "C:\temp\tp\5\Treatment_Planner_BETA\EEMS\EEMS_Models.tbx", line 26, in
SevereFireRisk
    šC_9Ñ_œ$ExecuteError: Failed to execute. Parameters are not valid.

Traceback (most recent call last):
  File "<string>", line 492, in updateParameters
  File "c:\program files (x86)\arcgis\desktop10.6\arcpy\arcpy\__init__.py", line 1138, in
ListFields
    return gp.listFields(dataset, wild_card, field_type)
  File "c:\program files (x86)\arcgis\desktop10.6\arcpy\arcpy\geoprocessing\_base.py", line
346, in listFields
    self._gp.ListFields(*gp_fixargs(args, True)))
IOError: "%EEMS Input Table Path%" does not exist
```

Adding Your Custom EEMS model To the Treatment Planner

After you have developed an EEMS model for use in the Treatment Planner (within the **EEMS_Models** toolbox), right click on your model and select **Properties**. On the **General** tab, give your model a **Name**. The model **Name** may be different from the model **Label** which is what you see in the catalog window. You will need to reference the model **Name** in the steps below.

Before performing the steps below, it is highly recommended that you make a backup copy of the **Treatment_Planner.tbx** toolbox as you will need to make edits to it.

1. After you have developed your model following the guidelines above, open up the Treatment Planner Toolbox (Treatment_Planner.pyt) in a text editor or a Python IDE so that we can add the model to the Run Simulation Tool.

2. First, you will need to indicate the name you would like to appear when selecting your custom EEMS model from the model dropdown list. To do this, add a name to the **param6** filter list, replacing `<new model dropdown name>` with a name of your choosing. You can use any name here you like – it does not have to correspond to the actual name of the model.

```
param6.filter.list = ["Severe Fire Risk", "Thinning Assessment", "<new model dropdown
name>"]]
```

3. Next, add the block of code below to the **EEMS Models** section of the Treatment_Planner.pyt file (located at the bottom of the file), replacing `<new model dropdown name>` with the dropdown name you decided on above, and replacing `<EEMS model name>` with the name that appears in the **Name** field on the General Tab of your EEMS Model. As an optional step, if you have a layer file (.lyr) that you have created ahead of time that is configured to symbolize your model output based on the final output field, you can put that layer file in the **Data\Outputs\lyr** folder and add the third line, replacing `<layer file name>` with the name of your layer file.

```
if eems_model == "<new model dropdown name>":
    arcpy.<EEMS model name>_EEMSModels(last_year, input_stands_path, eems_command_file)
    eems_lyr_file = eems_lyr_dir + "<layer file name>.lyr" #optional line
```

4. Finally, save the Treatment_Planner.pyt file, and Right Click -> Refresh the Treatment_Planner.pyt file in the Catalog Window. When you double click the Run Simulation tool, you should now see your EEMS Model listed in the EEMS Model dropdown.

REFERENCES CITED

Seymour, Robert. (2013). User's Guide to the Forest Vegetation Simulator (FVS) and Suppose Interface.

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