Introduction to State-and-Transition Simulation Modeling of Landscape Vegetation Dynamics

Pre-Course Homework Exercises

Prepared by

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Before you begin…

Before you begin these homework exercises you will need to first download and install SyncroSim for Windows **version 2.0.42**. SyncroSim can be downloaded from: http://www.apexrms.com/syncrosim-sys-req/

Note that **SyncroSim** is a generalized framework for scenario-based stochastic simulations over space and time which supports plug-in models. **ST-Sim** is a SyncroSim plug-in for spatially-explicit, stochastic state-and-transition simulation models (STSMs). When you first install SyncroSim, ST-Sim (version 3.1.42) is automatically included in the installation.

After installing SyncroSim you will also need to download the homework files from: http://www.apexrms.com/download/6084/

Extract the contents of this zip file to a local drive on your computer. For example we recommend that you use the following directory: **Documents\SyncroSim\Homework**

Finally, before beginning the exercises you should watch this video on the basics of state-and-transition simulation models:
https://www.youtube.com/watch?v=ORoyBqogZFs

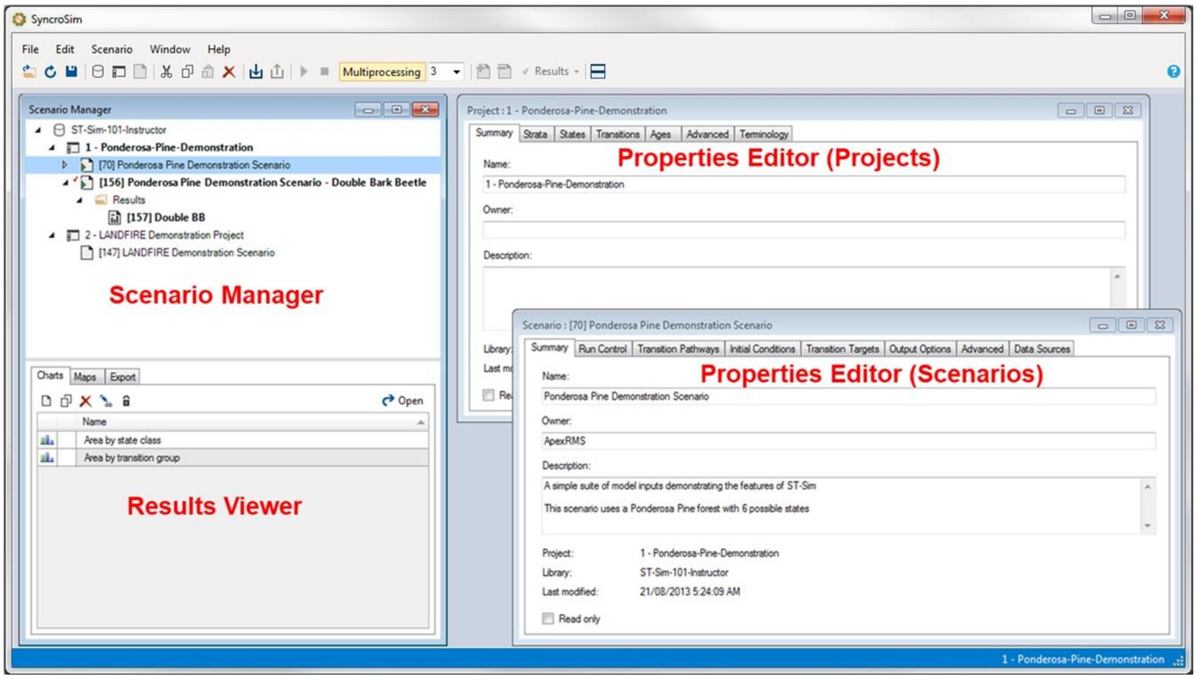
Exercise 1: Viewing and Running a Model

Objective

In this exercise you will learn how to open, edit and run an existing state-and-transition model in ST-Sim. You will also learn how to view graphs of simulation results.

Background

Libraries, projects and scenarios



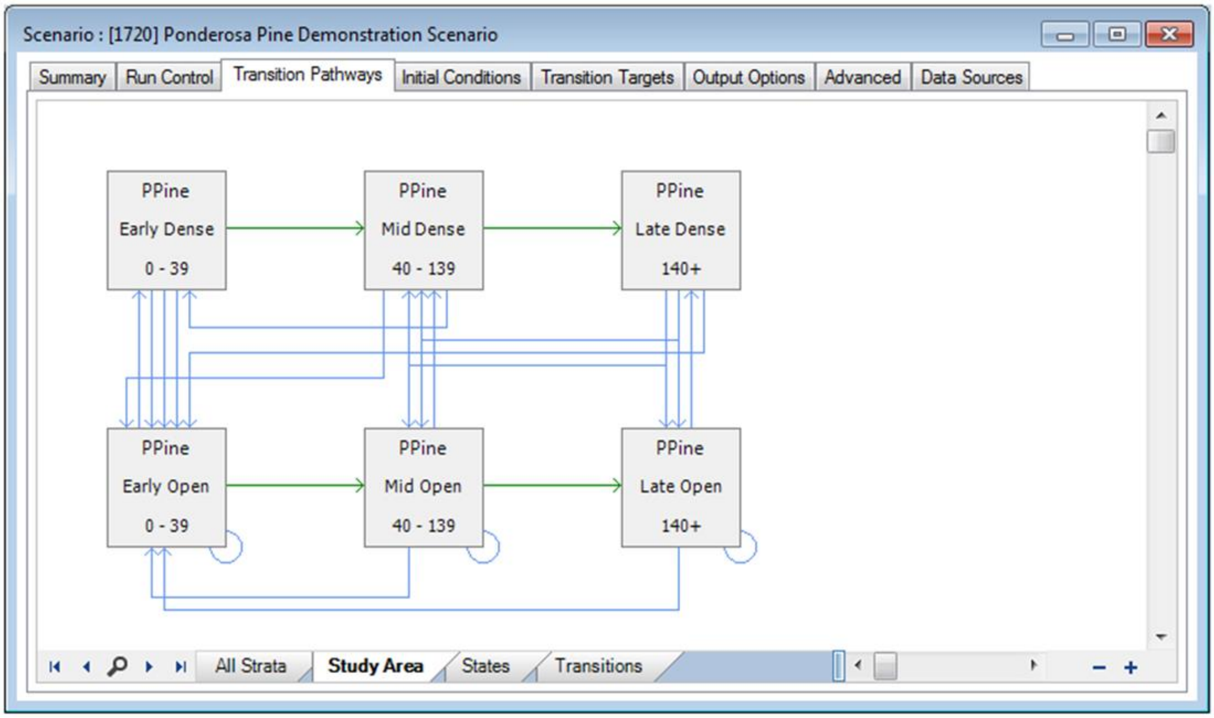
A ***library*** in SyncroSim is a SQLite database file with an **.ssim** extension containing all of your model inputs and outputs. A library can be opened using the **File** menu. The contents of a library can be viewed using the **Scenario Manager** window.

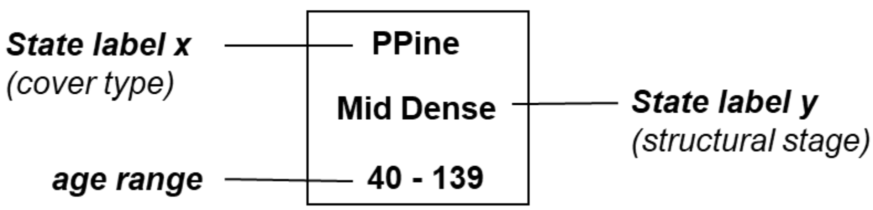
A ***scenario*** is a suite of user-defined model inputs; it can also optionally contain model outputs if the scenario has been run through the ST-Sim model. These inputs and outputs can be defined in the **Properties Editor** window for the scenario.

A ***project*** in SyncroSim is a container within a library that allows users to group scenarios together. Each project has a number of **properties** – these properties are model inputs (often referred to as **definitions**) that are shared across all of the project's scenarios. Typically users have one project for each landscape they are simulating. All of the project properties are defined in the **Properties Editor** window for the project.

Editing Transition Pathways

In this exercise we will be working with transition pathways, which are one of the inputs for ST-Sim.

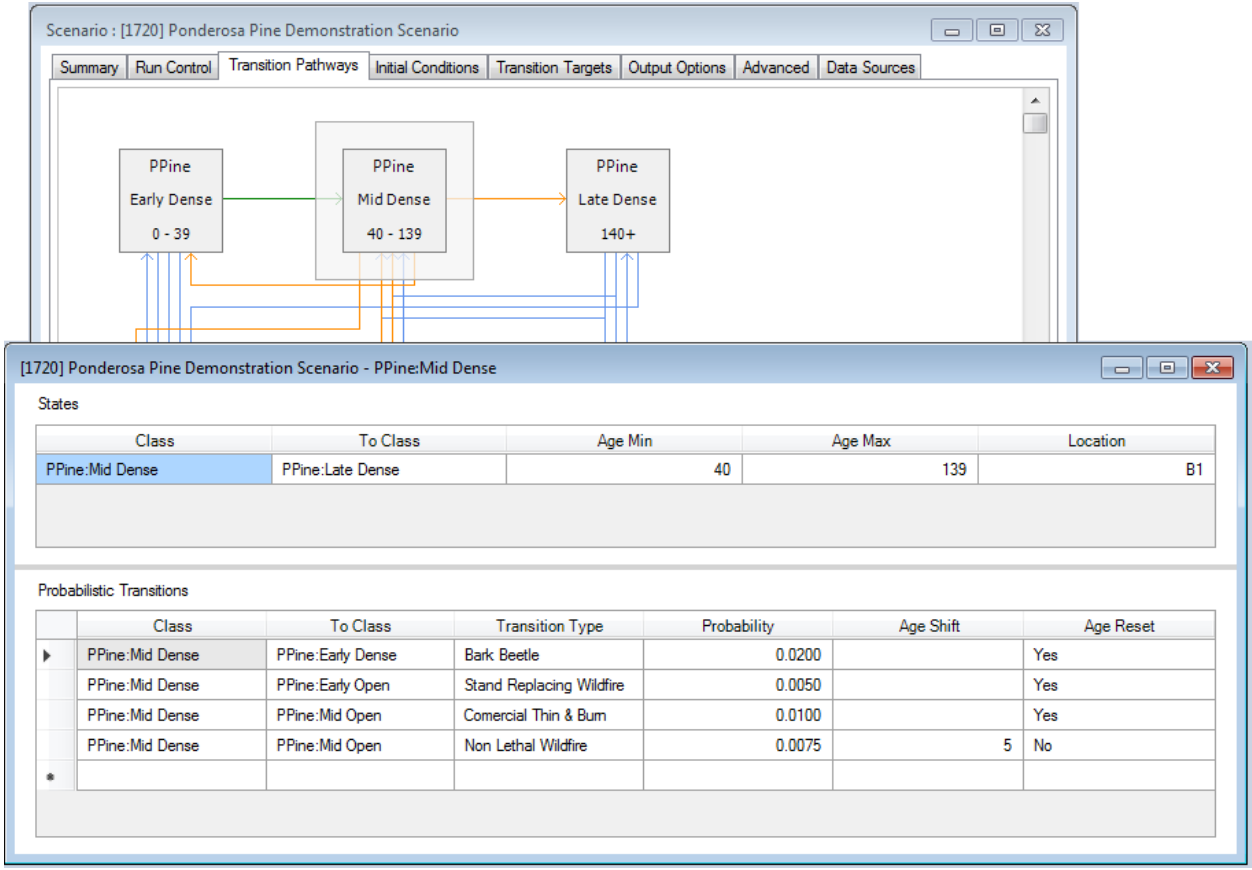




The **Transition Pathways** tab of the **Properties Editor** window in ST-Sim displays states and transitions in pathway diagrams. The boxes in each pathway diagram represent state classes, while the lines represent transition pathways (green lines are deterministic and blue lines are probabilistic).

A state class in ST-Sim is identified as a unique combination of two labels, which by default are referred to as the **state label x** and **state label y**. Typically the **state label x** is used for the predominant vegetation associated with the class, while the **state label y** is used for the age structure of the class. Each state class also has an age range, with the minimum and maximum age displayed for each class on the pathway diagram.

State Class Details



When you select and open one or more state classes (by double clicking on its box or right-clicking and selecting **Open**), the **State Class Details** window launches and displays the details of the **states** and **probabilistic transitions** for the selected classes.

At the top of the **State Class Details** window is a grid displaying the **deterministic transitions** associated with the state classes selected. By default the grid displays the deterministic transitions FROM the source state class selected (in the Class field) TO any other destination state classes (the To Class field); right-clicking on the grid will open a context menu providing additional display options. The Age Min field is the minimum age of the source state class; the Age Max field is the maximum age of the source state class.

At the bottom of the **State Class Details** window is a second grid displaying the **probabilistic transitions** associated with the state class selected. By default the grid displays all of the probabilistic transitions FROM the state class (Class field) selected TO any other classes (To Class field). The type of probabilistic transition is identified in the Transition Type field, and the probability of that transition occurring is shown in the Probability field.

Procedure

Task 1 – Explore pathways and state class properties

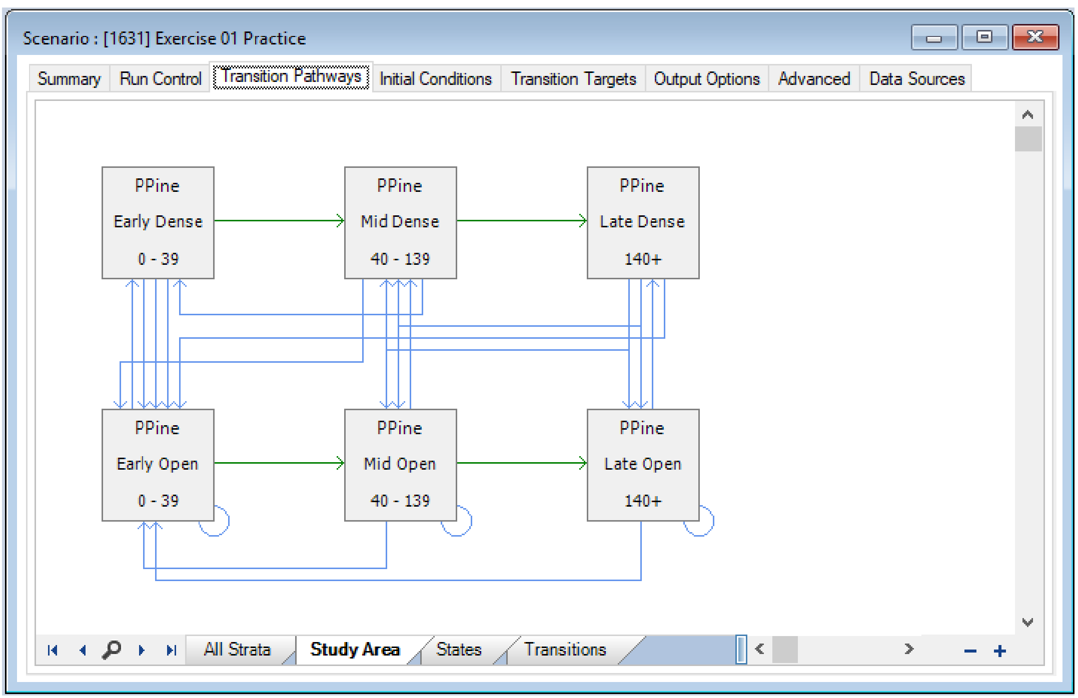
1. Launch SyncroSim (**Start | Programs | SyncroSim**). If there is a sample library open in the main window, close it (**File | Close All**).

2. From the **File** menu, select **Open Library….** Navigate to the folder where you extracted the homework files (i.e., **C:\Users\[*Username*]\Documents\SyncroSim\Homework**) and select the homework library called **ST-Sim-Homework-Exercises.ssim**. Click **Open**.

3. In ST-Sim's **Scenario Manager** window, left-click on the open arrow beside the project **Exercise 01** to expand its contents and show the single scenario called **Exercise 01 Begin**. Right-click on the scenario name, and select **Copy** from the context menu. Right-click again and select **Paste** from the context menu.

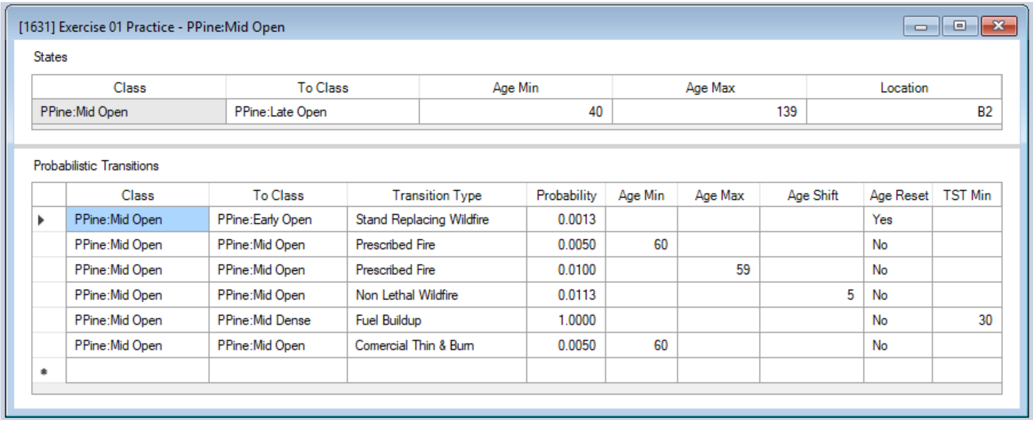
4. Right-click on the copied scenario, and select **Rename**. Name the new scenario "Exercise 01 Practice". Save your project (**File | Save All**).

5. Open the new scenario in the **Properties Editor**, either by right-clicking and selecting **Properties**, or by double-clicking. In the **Properties Editor**, go to the **Transition Pathways** tab to see the pathway diagram for the project. Right-click anywhere on the diagram and select **Filter Transitions** from the context menu. Use this dialog to show in turn:
   - only deterministic pathways
   - only the **Stand Replacing Wildfire** probabilistic transitions
   - all transitions



6. Hover your mouse pointer over the box labeled **PPine Mid Dense.** What are the full names for the **Cover Type** and **Structural Stage** associated with this state class? (Tip: If you don't see a tooltip (i.e. a pop-up window with labels) when you hover over the box, click on the header bar for the window to make sure it has the focus and try again.)

7. Open the state class called **PPine Mid Open** by right-clicking on it and choosing **Open** from the context menu (or by double-clicking). This action opens a **State Class Details** window that shows the properties of the state class you opened.



Class	To Class	Age Min	Age Max	Location
PPine:Mid Open	PPine:Late Open	40	139	B2

Class	To Class	Transition Type	Probability	Age Min	Age Max	Age Shift	Age Reset	TST Min
PPine:Mid Open	PPine:Early Open	Stand Replacing Wildfire	0.0013				Yes	
PPine:Mid Open	PPine:Mid Open	Prescribed Fire	0.0050	60			No	
PPine:Mid Open	PPine:Mid Open	Prescribed Fire	0.0100		59		No	
PPine:Mid Open	PPine:Mid Open	Non Lethal Wildfire	0.0113			5	No	
PPine:Mid Open	PPine:Mid Dense	Fuel Buildup	1.0000				No	30
PPine:Mid Open	PPine:Mid Open	Comercial Thin & Burn	0.0050	60			No	

What is the annual probability of **Stand Replacing Wildfire** occurring? What does this translate to in terms of a fire return interval?

If **Stand Replacing Wildfire** occurs, to which class will the pathway lead afterwards?

8. Close the **State Class Details** window, but keep the **Properties Editor** window open for the next task.

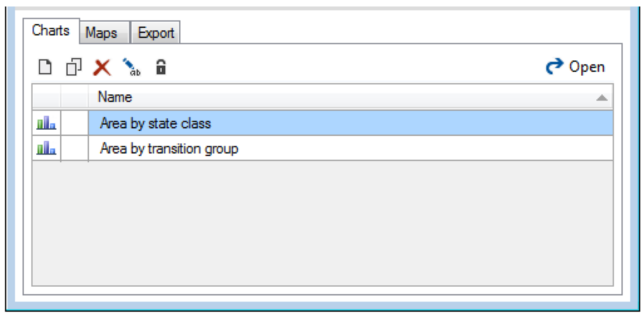
Task 2 – Run the model and generate results

1. On the **Properties Editor** window, click on the **Run Control** tab. Set the model to run from **Start Timestep** 0 to **End Timestep** 300 for 5 **Iterations**.
2. Click on the **Initial Conditions** tab and set the **Total** area modeled to 40,000 acres. Change the **Number of simulation cells** to 650. Note that the **Cell size** field gets automatically refreshed when you enter these new values.

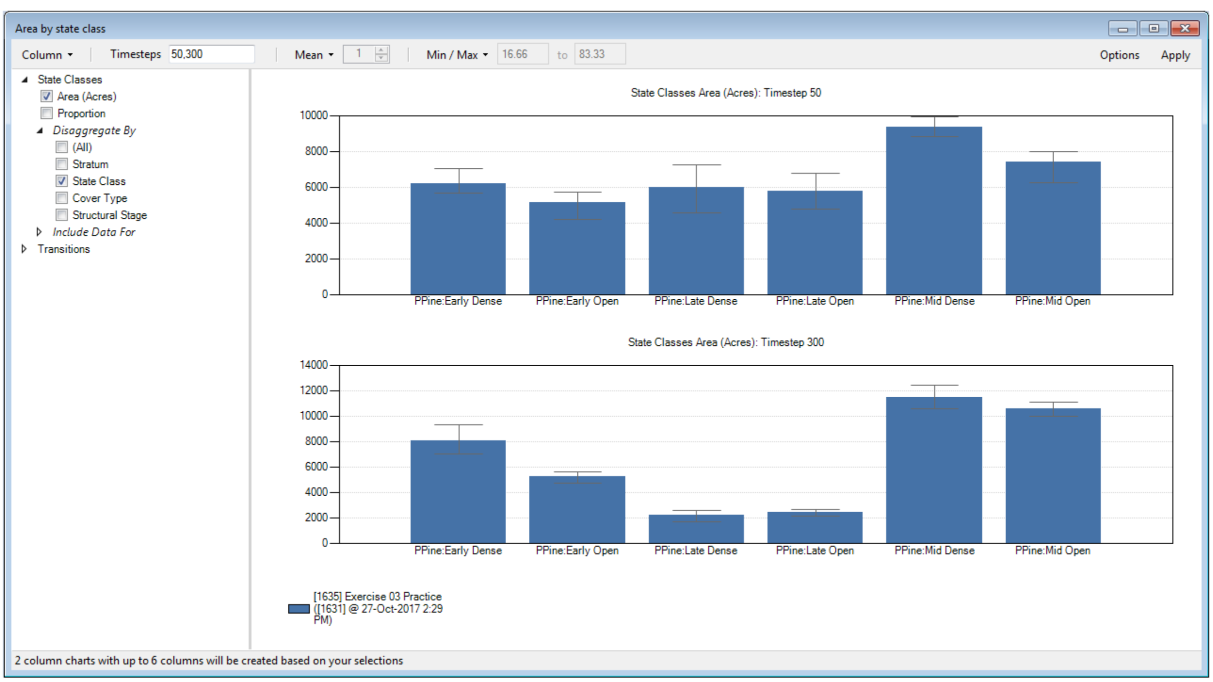
   What resolution will the model run for the area and number of cells specified (it can be a non-integer value)?

   Can you figure out how the model calculated the number of simulation cells to run for the specified area and resolution?

3. Click on the **Output Options** tab. In the **Tabular output** frame, check **State classes every** and **Transitions every** to set them to output every 1 **Timestep**.
4. Close the **Properties Editor** window and save your project (**File | Save All**).
5. Right-click on scenario **Exercise 01 Practice** in the **Scenario Manager** window, and select **Run** (or select **Run** from the **Scenario** menu). A **Run Monitor** window will open, showing the progress of the run.
6. When the run is completed, close the **Run Monitor**. In the **Scenario Manager**, click on the open arrow to expand **Exercise 01 Practice** and then expand the Results folder so you can see your results listed. The data from your run will automatically populate the charts listed in the **Results Viewer** window below the **Scenario Manager**.
7. View charts of your results by opening each of the charts in turn. In the lower pane of the window, there are three tabs that provide access to ST-Sim's reporting features: **Charts, Maps** and **Export**.

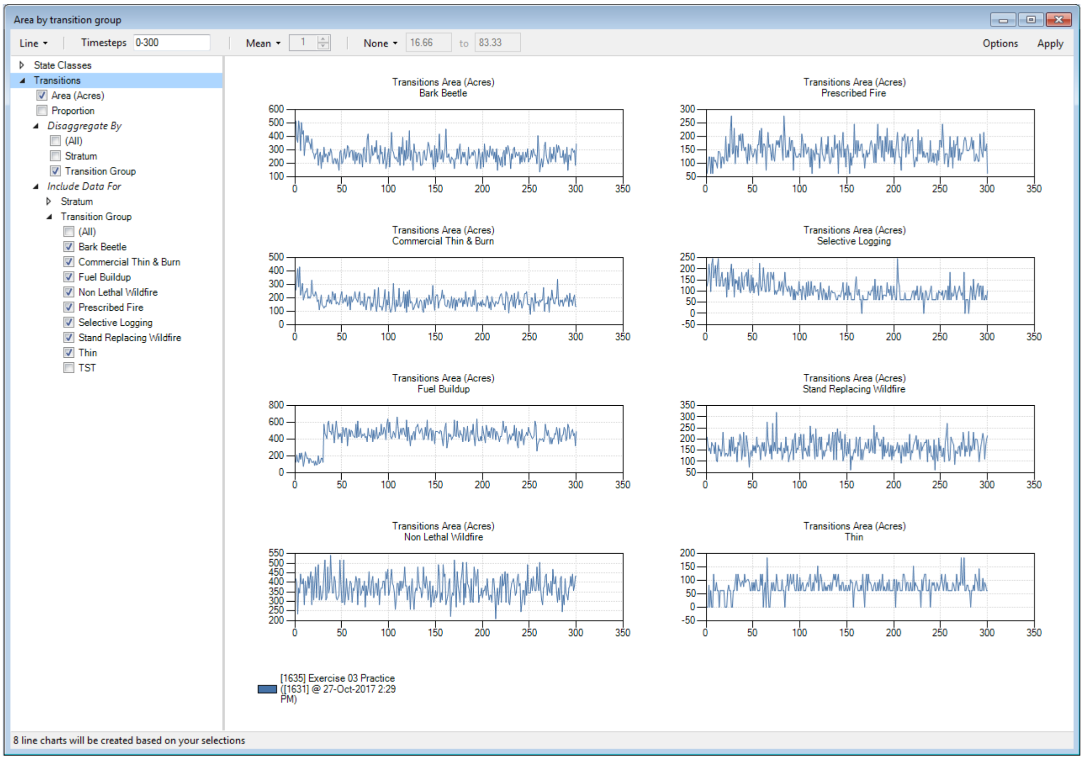


8. With the **Charts** tab active, and the **Area by state class** graph panel selected, click on the **Open** button at the right of the window. Line graphs of area by state class will open in a separate window.
9. At the top of the chart window on the left, open the drop-down menu and change the selection from **Line** to **Column**. Change the timesteps to display by typing the string "50,300" (without quotations) into the **Timesteps** text box.
10. Click on the **Apply** button in the upper right corner of the window to view the column graphs of the area in each state class for timesteps 50 and 300.



What is the approximate area in state class **PPine Late Dense** for timestep 300?

11. Next, generate a time graph of transitions. To do this, close your **Area by state class** chart. Back in the **Results Viewer** window, select the **Area by transition group** chart and click **Open**. Change the timesteps to display by typing the string “0-300” (without quotations) into the **Timesteps** text box. Check all the transitions you want to display on the left-hand menu under **Transition Group** (Bark Beetle, Commercial Thin & Burn, Fuel Buildup, Non Lethal Wildfire, Prescribed Fire, Selective Logging, Stand Replacing Wildfire, and Thin). Click on the **Apply** button in the upper right corner of the window.



Scanning the **Stand Replacing Wildfire** graph by eye, what is your estimate of the average area burned per year over the entire landscape?

What percentage of the entire landscape area is this each year?

What does this represent in terms of an average return interval?

12. Close all open windows except the **Scenario Manager** window.

Task 3 – Compare Initial Conditions settings

1. In the **Scenario Manager** window, copy the scenario **Exercise 01 Practice** and name it “Exercise 01 Practice – Equal Initial Conditions”.
2. Open **Exercise 01 Practice – Equal Initial Conditions**, and switch to the **Initial Conditions** tab. Make the area for each state class equal (Relative Amount = 0.1666). When done, close the **Properties Editor** window and save your project.
3. In the **Scenario Manager**, right-click on the **Exercise 01 Practice – Equal Initial Conditions** scenario, and select **Run** from the context menu. When the run completes, close the **Run Monitor** window. The run results will be added, as an overlay, to the charts in the **Results Viewer**.
4. Open the **Area by state class** chart.

Is there much of a difference in the results of the two scenarios (i.e. **Exercise 01 Practice** [blue] and **Exercise 01 Practice – Equal Initial Conditions** [red]) for state class area in year 50? In year 300?

5. Display line graphs that show area by state class results for both scenarios.

   What effect do the new initial conditions have on the model's predictions for distribution of area between state classes in year 300?

   How many years does it take before the initial conditions no longer influence the model predictions?

6. **Close** the Area by state class. Save your work (**File | Save All**).

BONUS: When you looked at the run results for **Exercise 01 Practice** in Task 2, you were asked to estimate the average area burned per year by **Stand Replacing Wildfire** by looking at a graph of transition area. Can you figure out how to get the exact average area burned by **Stand Replacing Wildfire** using an Excel output report?

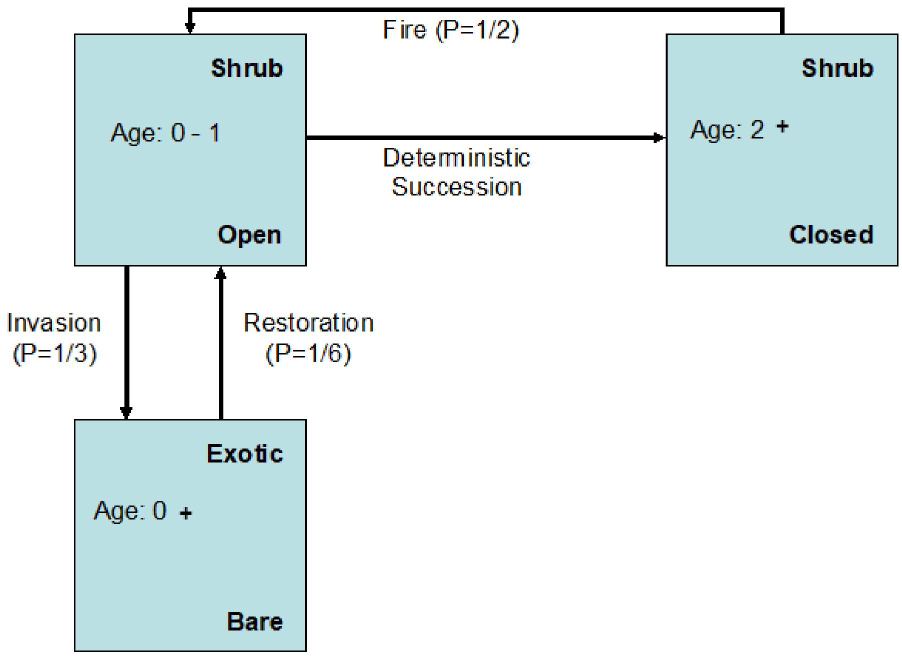
When done, leave ST-Sim open for the next exercise. Note that you can compare your work against the scenarios in the project called **Exercise 01 Solution**.

Remove all the results for the Exercise 01. You will see a small red check mark next to the name of a scenario which has results added to the results window for charting purposes. To remove results, right-click on **Exercise 01 Practice** and select **Remove from Results** from the context menu; this action does not delete the results, it just removes them from the charts in the Results View. Also remove results for **Exercise 01 Practice – Equal Initial Conditions** in this way.

Exercise 2: Creating a Model from Scratch

Objective

Learn how to create a ST-Sim model from scratch, including adding definitions and pathways, and setting run parameters.



Background

In this homework exercise we will be creating a simple model of a fictitious ecosystem to illustrate how to build a model from scratch. During the course we will replicate this model using a simple set of instructions that involves rolling dice without the ST-Sim software. The purpose of that exercise will be to illustrate how the ST-Sim algorithm works. Here we provide a bit of background on the made up ecosystem that we are using for these two exercises.

This is a simple model of a **shrub community** that has three state classes:
(1) **Open** – consisting of mainly herbaceous species and a high proportion of bare ground
(2) **Closed** – consisting of both herbaceous and woody species
(3) **Exotic** – consisting mainly of exotic herbaceous species

Open state

- The **open** state lasts 2 years and represents a site that has been severely disturbed within this time period.
- After 2 years elapse with no disturbance, there is a deterministic transition to the **closed** state.
- Because of the high proportion of bare ground in the **open** state it is vulnerable to invasion by exotic species. While a parcel of land is in the **open** state, there is a 1/3 (0.33) probability that it will experience an invasion transition during the span of 1 year.

Closed state

- The **closed** state has a high density of fuel so it is vulnerable to replacement fire; for every year in the **closed** state, there is a 1/2 (0.5) probability of a fire resulting in a transition back to age zero at the **open** state.

Exotic state

- Budgets are tight, so **exotic** states are rarely restored back to the **open** state, with a probability of 1/6 (0.167) every year.

Current conditions

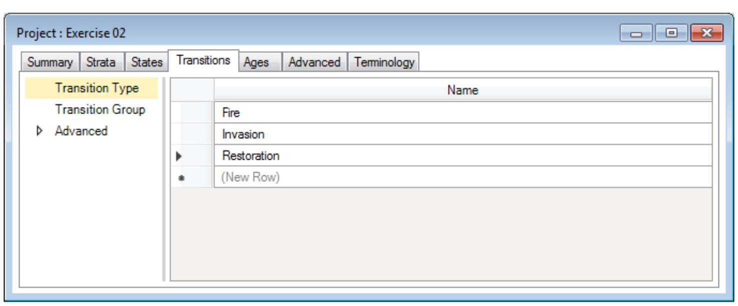
- Assume that the entire landscape to be simulated has been burned within the last 2 years - as a result we will assume that it is all in the **open** class, with 50% of the landscape burned this year (i.e., currently age 0) and 50% burned the previous year (i.e., currently age 1).

Procedure

Before doing this exercise, make sure you watch this video on creating a simple ST-Sim model beginning with the creation of a new library: https://youtu.be/k0UeCCIGuf4. The video reviews some of the material covered in the previous exercise and demonstrates how to create a new model.

Task 1 – Create project definitions

1. If it is not already open, launch SyncroSim (**Start | Programs | SyncroSim**).
2. Your ST-Sim-Homework-Exercises library should be open from the previous exercise but if it is not, from the **File** menu, select **Open Library…**. Navigate to the folder where you extracted the homework files (i.e., **C:\Users\[*Username*]\Documents\SyncroSim\Homework**) and select the training library called **ST-Sim-Homework-Exercises.ssim**. Click **Open**.
3. To create a new project, right-click anywhere in the **Scenario Manager** and select **New | Project** from the context menu. Name the new project "Exercise 02".
4. Right-click on the new project and select **Open** from the context menu (or double-click) to open it in the **Properties Editor**.
5. Go to the **Terminology** tab to look at the default labels for the states and transitions you will be defining. Rename **State Label X** to "Cover Type", and rename **State Label Y** to "Structural Stage".
6. Edit the definitions to match the states and transitions used in the model illustrated above. To do this:
    a. On the **Strata** tab, create a single primary stratum for your landscape and call it **My Vegetation Type**.
    b. Add the following definitions to match the model diagram, using the **States** tab and the **Transitions** tab:
        i. Cover Types: Shrub, Exotic
        ii. Structural Stages: Bare, Open, Closed
        iii. State Classes: Exotic, Bare; Shrub, Closed; Shrub, Open
        iv. Transition Types: Fire, Invasion, Restoration



    c. Close the **Properties Editor** window and save your work using **File | Save All**.

Task 2 – Create a new scenario

1. In the **Scenario Manager** window, right-click on the **Exercise 02** project and select **New | Scenario** to create a new scenario. Name this new scenario "Class Dice Example**"**. Click **OK** and close the **New Scenario** window.

Task 3 – Create classes and transitions

1. Add state classes to your new scenario. To do this, open the **Class Dice Example** scenario in the **Properties Editor** window by right-clicking on it and selecting **Properties** (or double-clicking).
2. Switch to the **Transition Pathways** tab**.** At the bottom of the window, there are four tabs. Select the tab labeled **My Vegetation Type**. Right-click anywhere on the blank editor window and select **Add State Class**. One at a time, add the following three classes to your scenario:

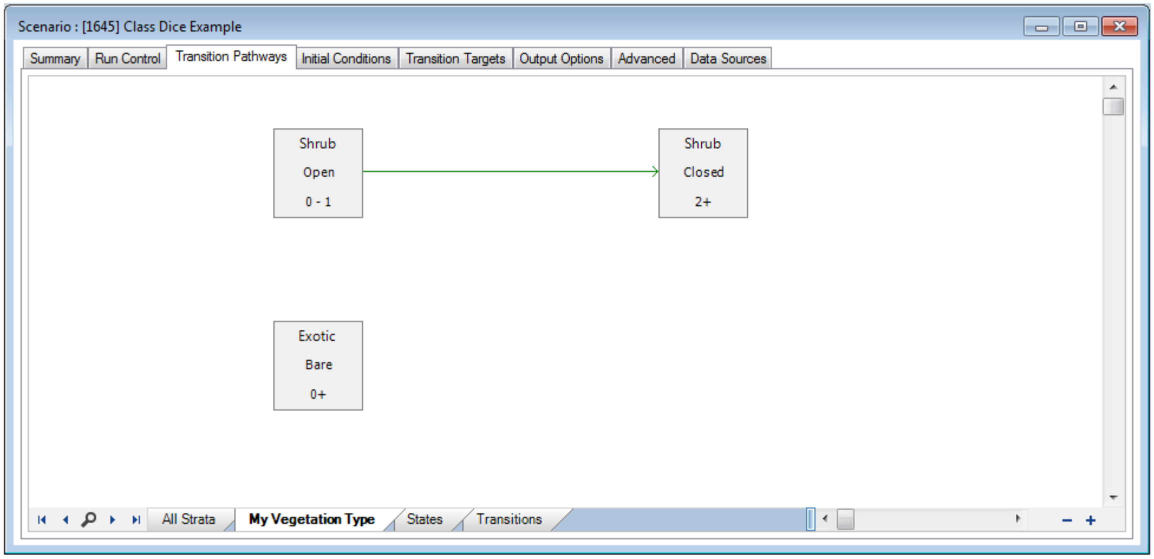
Cover Type	**Structural Stage**
Shrub	Open
Shrub	Closed
Exotic	Bare

3. Set the locations of your state classes by selecting and dragging them, one at a time, into the positions shown in the figure at the beginning of this exercise.
4. Add **Age Ranges** and **Deterministic Pathways**. Open each state class in turn (double-click or right-click and select **Open** from the menu), and edit the deterministic transition for each class using the following information. Note: to add this information you will need to right-click anywhere in the **States** table to add the appropriate columns.

Class	**Age Range** (in years)	**Deterministic Transition**
Shrub:Open	0-1	Shrub:Closed
Shrub:Closed	2-[blank]	(none – leave as going back to same class)
Exotic:Bare	0-[blank]	(none – leave as going back to same class)

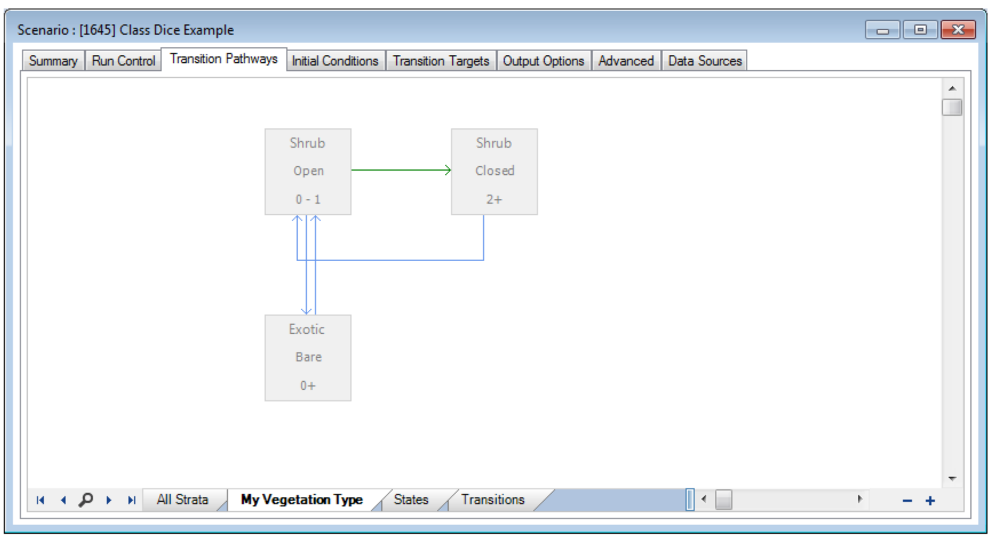
   a. Use the values in the **Age Range** column above for **Start Age** and **End Age**.
   b. The class listed in the **Deterministic Transition** column above is the destination class for the deterministic pathway; select the appropriate class from the **To Class** drop-down list.

When done, your transition pathway diagram should look like this:



5. Add **Probabilistic Pathways**. Open each state class in turn and add the probabilistic pathways according to the diagram for the model at the beginning of this exercise. Right-click anywhere in the **Probabilistic Transitions** table to add the required columns.

   When done, your transition pathway diagram should look like this:



6. Save your work (**File | Save All**).

Task 4 – Run the model

1. To replicate the dice exercise, set the following properties for the **Class Dice Example** scenario:
   - **Run Control** tab:
     - Start timestep = 2015
     - End timestep = 2025
     - Total Iterations = only 1 for this task, but later we will try 100 iterations

- **Initial Conditions** tab:
  - Total area = 100 acres
  - Number of simulation cells = 10
  - Relative Amount = Create a single row entry in the **Distribution** table that assigns all of the area of **Shrub:Open** to 1. This assigns all of the area initially to this state class.

2. Close the **Properties Editor** window and **Save** your project.
3. Select the scenario in the **Scenario Manager** and run the model. Note that when the run is completed, there will be an **Information** icon beside the run **Status** field. Click on the **Run log** to see more details. Why is additional information associated with the run status this time?

Task 5 – View results

1. Once the run is complete, you will be able to view your results in the **Results Viewer** window.
2. On the **Charts** tab, click on the paper icon to create a new chart panel. Name the chart "My Favorite Chart". Click **OK**. A blank chart panel will open in a charts window.
3. To display graphs of the area in each state class, click to add **State Classes | Area (Acres)** from the list of variables. Expand the **Disaggregate By** list, and click to select **State Class**. Click on the **Apply** button at the top right of the window to display your graphs.

   What is the approximate average area in each class at the end of year 2025?

   Without closing the chart, run your model again by right clicking on the scenario "Class Dice Example" and selecting **Run**. How does the area predicted in each class according to the second simulation compare to the area predicted by the first? Why might the results be different?

4. Close all open windows except the **Scenario Manager**.

Task 6 – Compare scenarios

1. Make a copy of the **Class Dice Example** scenario, and name it "Class Dice Example - 100 Iterations".
2. Open the scenario in the **Properties Editor** window. On the **Run Control** tab, change the value in the **Iterations** field to 100.
3. Close the **Properties Editor;** run the model to add results for the new scenario to the chart you created in the **Results Viewer** window.
4. From the **Results Viewer** window, open the **My Favorite Chart** panel you created.

5. You should see 3 lines on each graph—one for each scenario (i.e., 2 for the first scenario, and 1 for the scenario with 100 iterations). Right-click on the chart area and select **Show Data Points**. Then hover your mouse over the blue, red, and green lines to see a tooltip that displays the actual values for each point on the line graphs.

   How do the graphs compare for these 3 runs of the model (two with 1 iteration, and one with 100 iterations)?

   On the top of the charts window, change the range from **None** to **Min/Max** and click on **Apply**. This represents the minimum and maximum for each iteration. With how much confidence can you predict the outcome of any one iteration?

6. Add **Transitions | Area (Acres)** from the **Variables** list to your graphs; also add **Transition Type/Group** from under the **Disaggregate By** list. Click on **Apply** to refresh the graphs to display the area transitioned each year.

   For the 100 iterations run, what is the area that burned in year 2020?

   For the 100 iterations run, what is the total area that is eligible to burn in the previous year? (Hint: look at your state-and-transition model diagram to figure out which state classes are eligible to burn.)

   What proportion of the area eligible to burn in year 2020 did the model predict would burn? How does this compare to the fire probability entered for the model?

7. Close all open windows except the **Scenario Manager**.

For this exercise the landscape area has been very small (100 ac). Let's now run this same model over a larger landscape. Before beginning, remove the results for the **Exercise 02 Class Dice Example** scenario from the output by right-clicking on the scenario name and selecting **Remove from Results** from the context menu; this action does not delete the results, it just removes them from the charts and maps in the result viewer. Also remove results for **Exercise 02 Class Dice Example – 100 Iterations**.

8. Make a copy of the scenario **Class Dice Example - 100 Iterations**, and name the new scenario "Class Dice Example - Larger Landscape".
9. For this new scenario, change the total area for the simulation to 10,000 acres and the number of simulation cells to 1,000. **Save All**.
10. Create another scenario (as a copy of the "Larger Landscape" scenario) in which you double the proportion of area we restore each year (from 1/6 to 1/3). Name the new scenario "Class Dice Example - Larger Landscape - Double Restoration Probability". **Save All**.

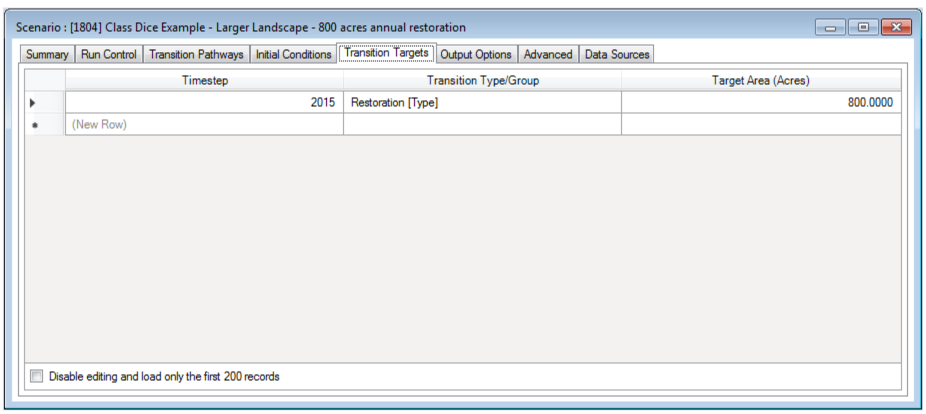
11. Run both “Larger Landscape” scenarios at once by selecting them both in the **Scenario Manager** (Ctrl left-click), right-clicking, then selecting **Run**.

    What is the prediction for area in the exotic class at the end of year 2025 for each of these 2 restoration options?

    We doubled the probability of restoration — did the area restored also double? Explain.

    Has the area burned changed between restoration options? Can you explain why?

12. Close all windows except the **Scenario Manager** window.
13. Finally, make a copy of the original “Larger Landscape” scenario and name it “Class Dice Example - Larger Landscape - 800 acres annual restoration”.
14. Open the new scenario in the **Properties Editor**, go to the **Transition Targets** tab, and set the scenario such that:
    - There is a target of 800 acres per year of restoration.
    - This target begins in year 2015 (and continues every year thereafter).



15. Close the **Properties Editor** window and save your work.
16. Run and compare the results of this scenario to the previous “Larger Landscape” scenarios.

    What area is restored under this latest scenario in years 2015 and 2025? Does this match the target we set for the area to be restored each year?

    BONUS: If you have time, try to determine the minimum area that must be restored each year in order to keep the area of exotics to less than 25% of the landscape.

17. Remove Exercise 02 results from the chart. Close all windows except the **Scenario Manager** window.

Exercise 3: Spatially Explicit Models

Objective

To convert the model developed in Exercise 02 from a non-spatial to a spatially explicit model. In doing so you will learn about:

1. Editing definition fields needed for spatially explicit models
2. Loading input raster files required for spatially explicit models
3. Creating and viewing output maps
4. Editing spatially explicit scenario properties including:
   - Transition Size Distribution
   - Transition Spread Distribution
   - Transition Patch Prioritization properties

Procedure

In this exercise, we will work with the model developed as part of Exercise 02 to learn about setting up and running spatially explicit models in ST-Sim.

Before doing this exercise you should watch the following videos on spatial models in ST-Sim:

1. Spatial models in ST-Sim: https://youtu.be/xHku6jltFeA
2. Adding spatial dynamics to ST-Sim: https://youtu.be/IQbGIMompps

Begin by re-familiarizing yourself with the model. In the **Scenario Manager**, open the scenario called **Modified Class Dice Example** listed under the project **Exercise 03**. Look at the **Transition Pathways** tab in the **Properties Editor** and note that the ages of the **Shrub:Open** and **Shrub:Closed** state classes have been modified so that the “Closed” state does not begin until age 5. What impact do you think this change would have on the invasion dynamics of the landscape?

Now look at the **Probabilistic Transitions** for each state class, and note that the probabilities have been modified. They have been reduced to 0.01 for **Restoration**, 0.1 for **Fire** and 0.001 for **Invasion.** In the first exercise we used probabilities that can be replicated with dice as we will use dice to replicate that model during the course. For this exercise we are no longer constrained to working with probabilities that can be simulated with dice and these values are better suited for illustrating the spatially explicit functionalities of ST-Sim.

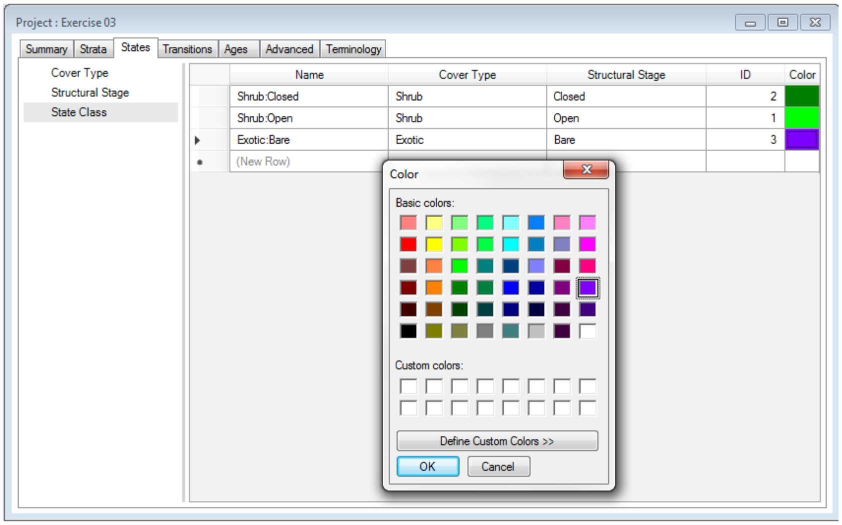
Close the **Properties Editor**, make a copy of the Modified Class Dice Example scenario and name it “Exercise 03 Spatial”.

Task 1 – Edit definition fields needed for spatially explicit models

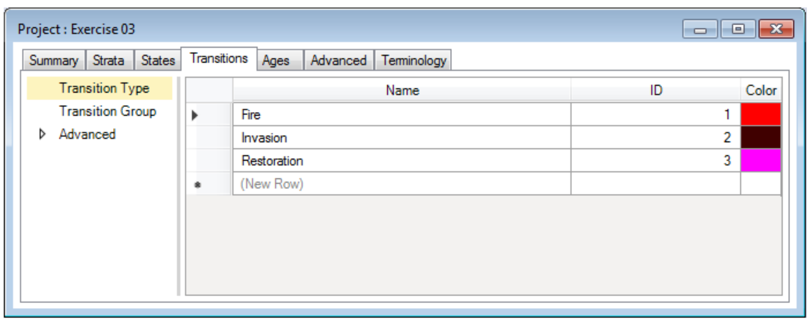
1. In the **Scenario Manager**, right-click on the project called **Exercise 03** and select **Open** from the context menu (or double-click to open).
2. Click on the **Strata** tab and note that this model has only a single **Stratum** called **My Vegetation Type**. Select the **Vegetation Type** node on the tree to the left, then right-click on the table and select **ID** from the context menu to add the field to the table. This field tells ST-Sim what integer value will be used to uniquely identify the stratum associated with each grid cell in an input raster. In this example, there is only a single stratum, so all raster grid cells will be assigned to the same integer value. We have chosen to represent this stratum with an ID of 1 in the raster, so specify a value of 1 for the **ID**.

3. On the **States** tab click on the **State Class** node on the tree to the left. The **ID** and **Color** fields have been added by right-clicking on the table and selecting them from the list of additional fields. As with the **Vegetation Type,** the **ID** field is used to denote the integer value to uniquely identify the state class associated with each grid cell in an input raster. The **ID** values have been set to 1 for **Shrub:Open**, 2 for **Shrub:Closed** and 3 for **Exotic:Bare**. The **Color** field will be used to define the legend for maps displaying state classes directly in the ST-Sim Map Window.

4. The **Color** for the **Shrub:Open** state class has been set to light green; for **Shrub:Closed** to dark green; and for **Exotic:Bare** to purple. Colors can be changed by double-clicking on the color field.



5. In the **Transitions** tab, the **ID** and **Color** fields for **Transition Type** have been set according to the image below. These will be used for displaying rasters of transitions occurring during the simulations. Colors can be changed by double-clicking on the color field.



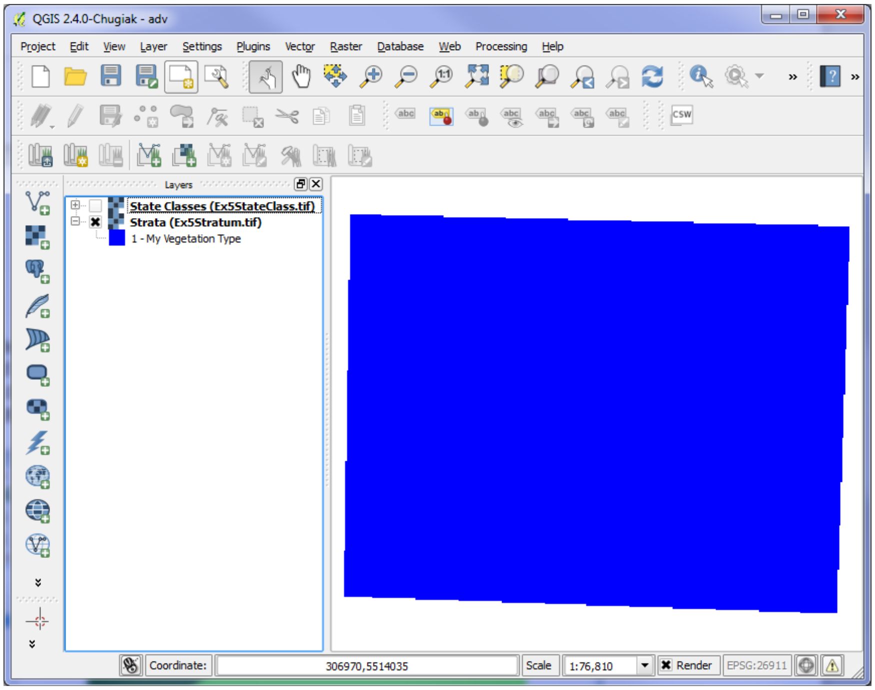
Close the **Definitions** window and save your changes.

Task 2 – Load input rasters, run the model and view results

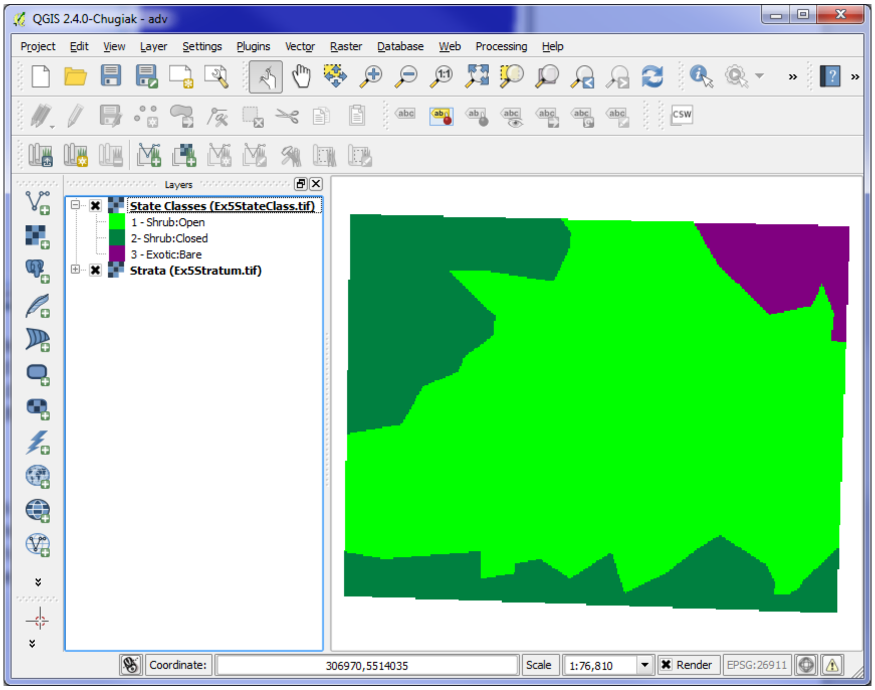
1. Open the **Exercise 03 Spatial** scenario and navigate to the **Initial Conditions** tab. Select the **Non Spatial** node on the tree to the left and note that non-spatial initial conditions have not been defined for this scenario. Select the **Spatial** node from the tree on the left to specify the initial conditions spatially instead.

2. In the **Raster files** table, click on the browse button for **Vegetation Type**, and navigate to your course folder (**C:\Users\[*Username*]\Documents\SyncroSim\Homework\Maps**). From the **Maps**

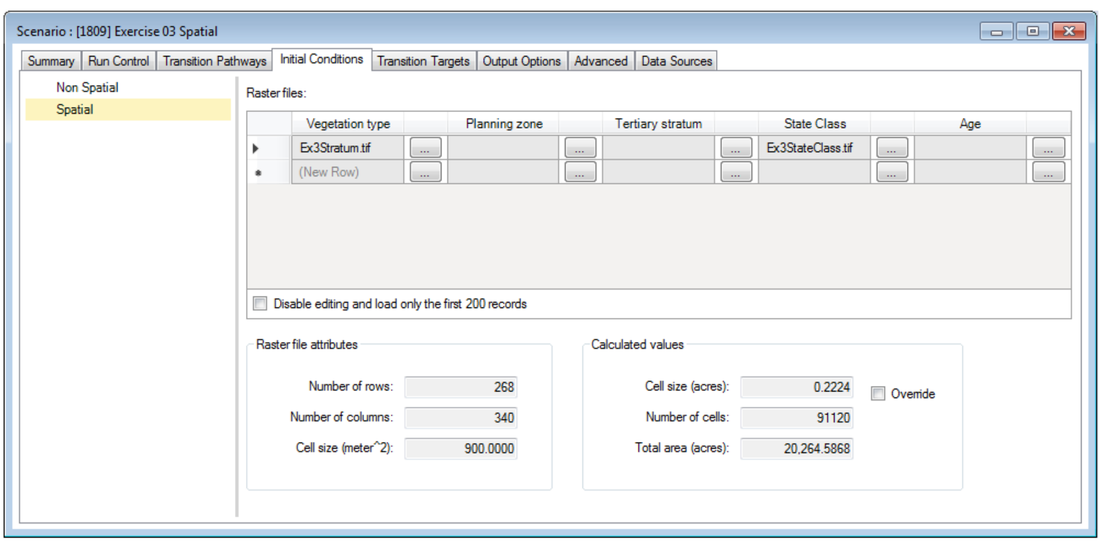
folder, select the file called **Ex3Stratum.tif**. This is a single band GeoTIFF file denoting the stratum ID associated with each grid cell for the landscape we are simulating in this exercise (in this example it is a raster of all 1s). Click **Open** in the file dialog and the file will be imported to your ST-Sim library for this scenario. Below is an image of what this file looks like. Note that here it is rendered using the free GIS software QGIS, but it could be rendered in any other software that allows you to display raster files.



3. Next specify the initial state class of each grid cell. We do this by loading a raster grid denoting the state class ID associated with each grid cell at the start of the simulation. To do this, repeat Step 2 above for the **State Class** file and select the GeoTIFF file called **Ex3StateClass.tif**. Below is an image of this file.



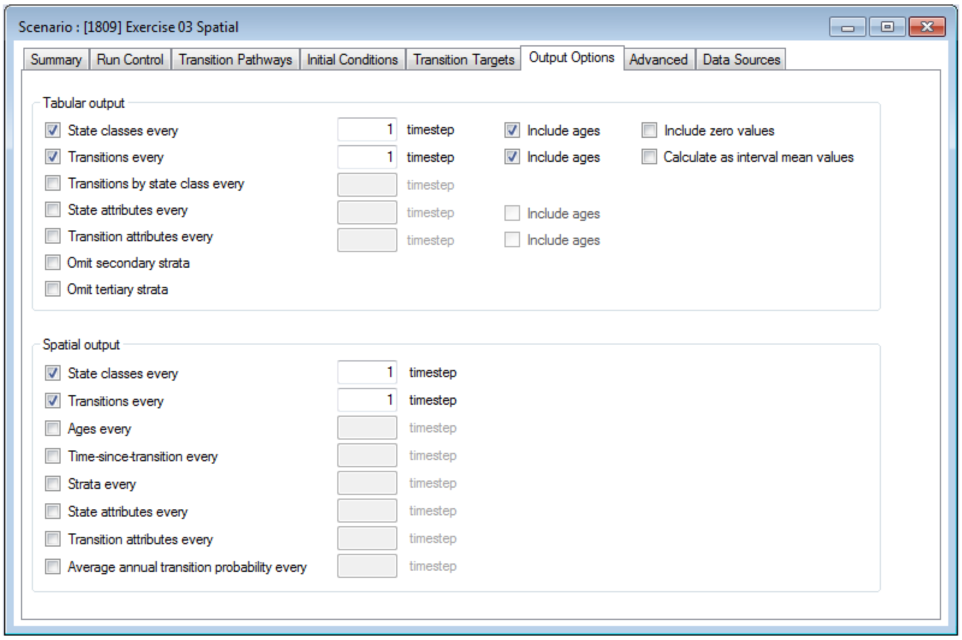
Note that all the raster files you import for a scenario must be identical with respect to the number of rows and columns. The metadata for things such as cell size, spatial reference system, lower left corner, and extent are derived from the stratum raster. Cells must be square. Once your raster files are loaded, click outside the **Raster files** table to populate the **Raster file attributes** and **Calculated values** fields below. Note the cell size, number of cells and total area.



Note that we are not loading an initial **Planning zone** file, which is a more advanced feature for further stratifying the landscape. We have also decided not to load an optional **Age** file specifying the initial age of each grid cell.

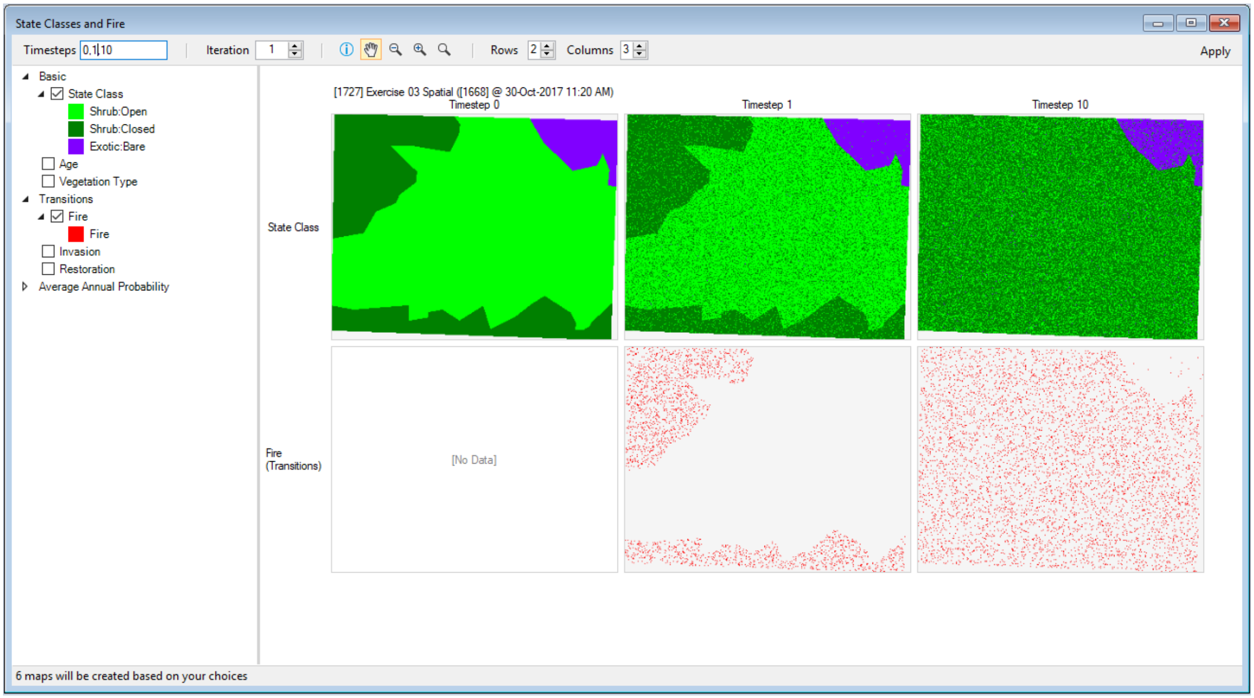
How do you anticipate ST-Sim will initialize the ages of each simulation cell for this simulation?

4. Navigate to the **Output Options** tab of the **Properties Editor**. Select **Tabular output** for state classes and transitions every 1 timestep and **Spatial output** for state classes and transitions every 1 timestep.



5. Switch to the **Run Control** tab and check the **Run model spatially** checkbox. Set the model to run for 10 timesteps and 1 iteration.
6. **Run** the **Exercise 03 Spatial** scenario.
7. Create charts that show graphs of state class and transition type/group area over time. Describe the trends that you see in this simulation.

8. Switch to the **Maps** tab in the **Results Viewer** window and click on the **New Map** button. Call this map “State Classes and Fire”. From the list of **Variables** on the left, select **State Class** and **Fire** (under **Basic** and **Transitions** respectively). In the **Timesteps** field at the top of the window, type the string “0,1,10” (without the quotes). Click the **Apply** button.



How would you describe the pattern that you see in the output maps? What is difference between the initial conditions and the resulting output timesteps? Why are these results so unrealistic?

Task 3 – Define spatially explicit inputs for transition sizes and spread

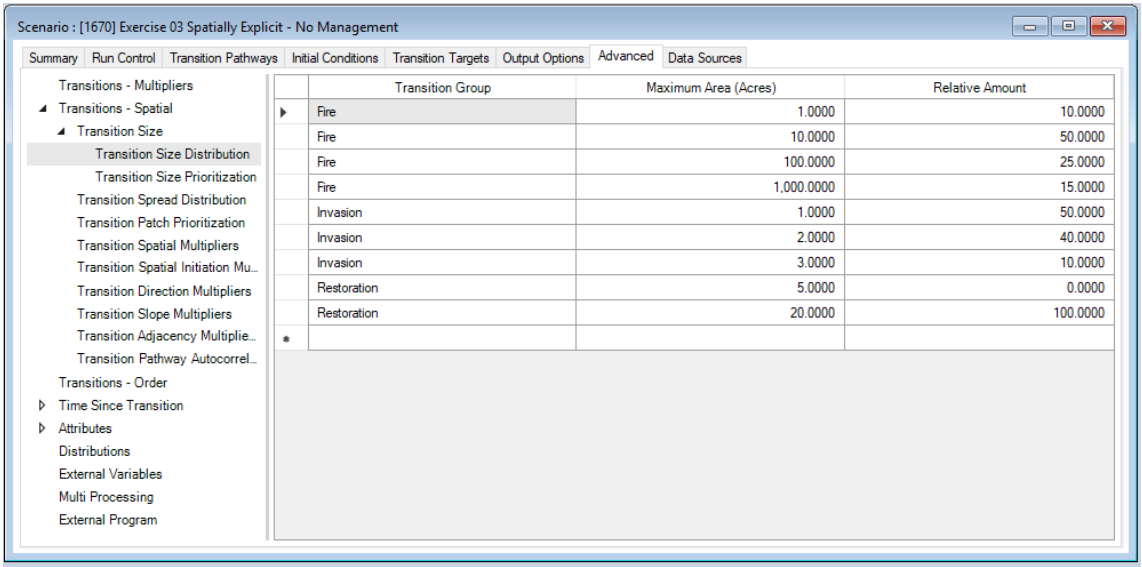
The unrealistic output so far can be explained as follows:

- The initial conditions show large contiguous areas with the same state classes.
- Subsequent timesteps show a very speckled pattern of transitions and resulting state classes. The model is still not spatially-explicit, as the cells are transitioning independently from each other. This is unrealistic because fire events and other transitions will tend to spread across the landscape as contiguous patches.

We will now define additional inputs to make the simulation spatially explicit.

1. Create a copy of the "Exercise 03 Spatial" scenario, and name it "Exercise 03 Spatially Explicit - No Management".
2. Open the new scenario in the **Properties Editor**.
3. On the **Transition Targets** tab, check to make sure that no management has been specified (i.e. the table is blank or there are 0 acres specified for the **Restoration** transition).
4. Switch to the **Advanced** tab. Part of the problem with the model we ran for **Task 2** is that we did not define how events such as fire, which spread within a timestep, should occur across the landscape. To do this you must define a **Transition Size Distribution**. In the frame at the left side of the window, click on the open arrow beside **Transitions – Spatial** to expand its contents. Expand **Transition Size**, and select **Transition Size Distribution**. This input defines the frequency distribution for

transition sizes to be used by the model. Right-click on the empty table and select **Import** from the context menu. Navigate to your homework file folder (**C:\Users\[Username]\Documents\SyncroSim\Homework**) and select the file called **Ex3 Transition Size Distribution.xlsx**. Click **Open.**

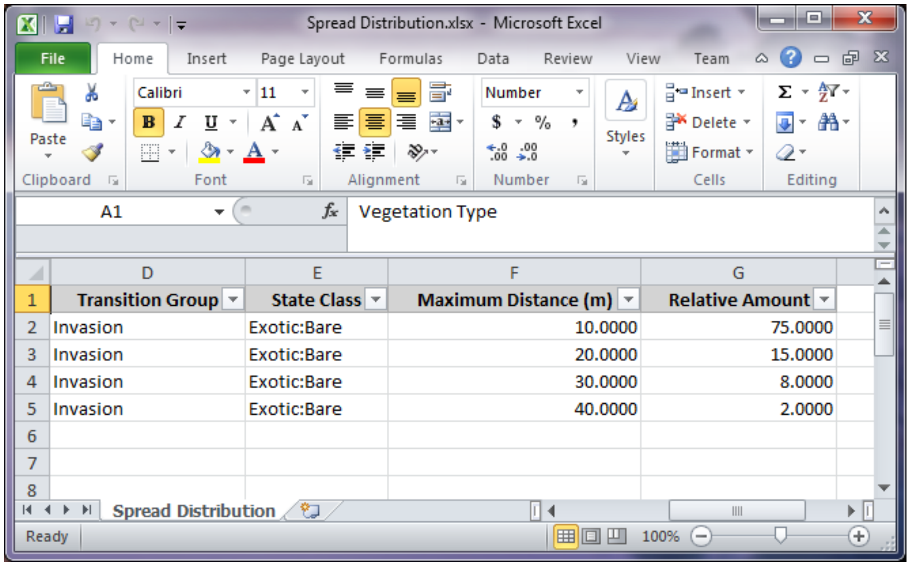


Based on these inputs:

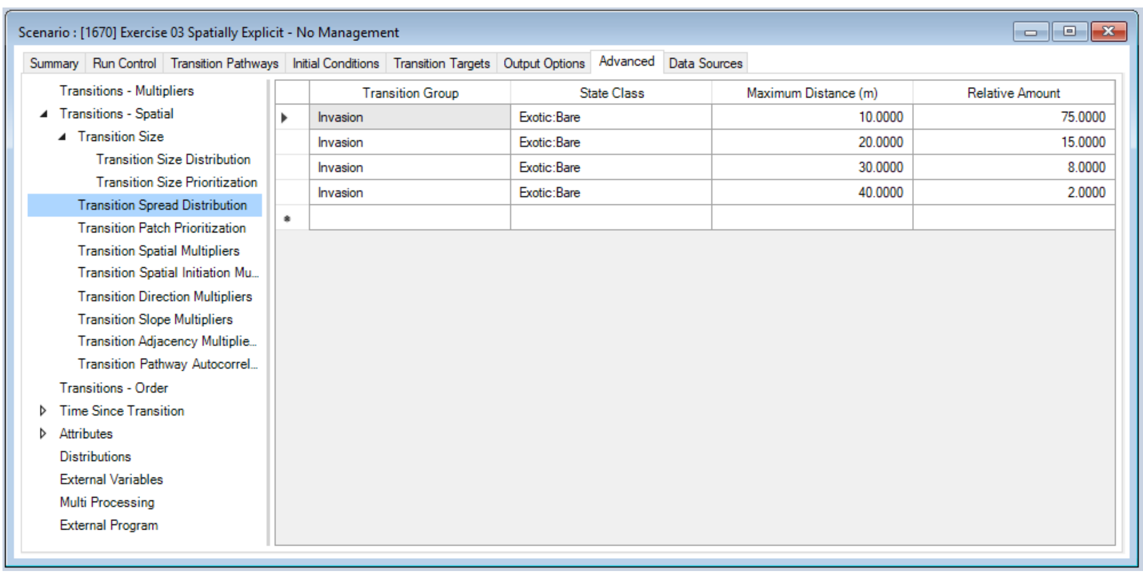
- **Restoration:** 100% of restoration events will be between 5 and 20 acres in size.
- **Invasion:** 50% of invasion events will be between 0 and 1 acre; 40% of invasion events will be between 1 and 2 acres; and 10% of invasion events will be between 2 and 3 acres.
- **Fire:** Fire events will target a size distribution where 10% of events will be less than 1 acre; 50% of events will be between 1 and 10 acres; 25% of events will be between 10 and 100 acres and 15% of events will be between 100 and 1000 acres.

When simulating these events the model initializes an event by randomly selecting an eligible cell and then spreads the event to eligible cells until reaching a target size. Cells with higher probabilities for the event are more likely to be selected for initiation and spread from neighbors than cells with lower probabilities. The target size for each event is selected from the **Transition Size Distribution**.

5. Another problem with the model we ran for **Task 2** is the way exotic spread was modeled. While it is possible that new exotic invasions coming from outside of the landscape are improbable, once there are cells that are invaded, it is likely that they will be a source of spread to neighboring cells in subsequent timesteps. To define how certain transition groups spread from cells in a specified state class to their neighbors you must define a **Transition Spread Distribution**. In the **Advanced** tab, switch to the **Transition Spread Distribution** node. Right-click on the empty table and select **Export All** from the context menu. Excel will create a file in your participant files folder called **Transition Spread Distribution.xlsx** and open it (check the taskbar). This file contains the fields required for transition spread data, ready for data entry. Enter the values shown below, save and close the Excel file.



Return to **Transition Spread Distribution** table in ST-Sim and right-click anywhere on it. Select **Import** and navigate to the file that you just modified. Click **Open**.

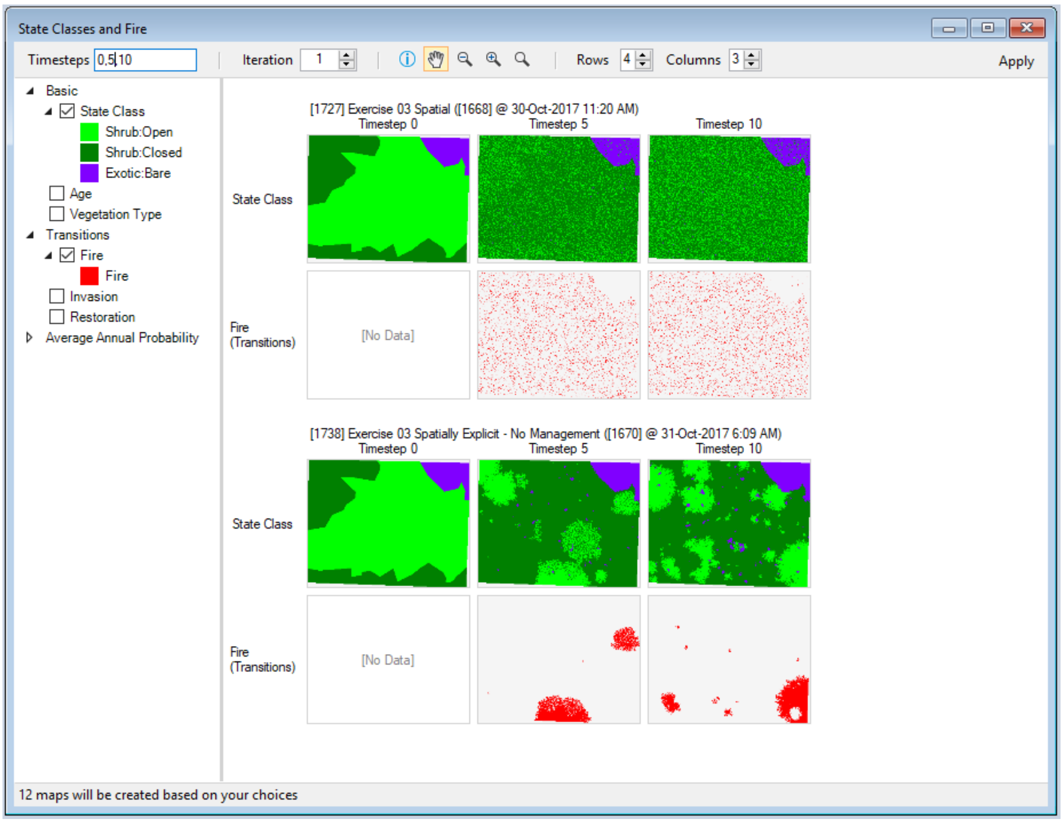


Based on these inputs the **Exotic:Bare** state class is contagious for the **Invasion** transition group. This distribution states that 75% of annual spread events will be between zero and 10 meters, 15% will be between 10 and 20 meters, 8% will be between 20 and 30 meters and 2% will be between 30 and 40 meters.

6. Close the **Properties Editor** and run the model.

7. Look at the state class area over time and explain the difference between scenarios in how much area is in the **Exotic:Bare** state class.

8. Open the **State Classes and Fire** map and set the timesteps to 0, 5 and 10. At the top of the map window, change the number of rows to 4 so you can see all of the maps without the need to scroll down. Describe the difference in the spatial outputs between scenarios.



Task 4 – Add Restoration and Transition Patch Prioritization

In this task we will add restoration and explore alternative ways of allocating restoration resources in space using the **Transition Patch Prioritization** property.

1. Create a copy of the **Exercise 03 Spatially Explicit - No Management** scenario, and name it “Exercise 03 Spatially Explicit - 100 ac Restoration”.
2. For this scenario, in the **Transition Targets** tab, set the area for the transition type/group **Restoration** to 100 acres per year and **Run** the model. Look at charts and maps of state class area for this and the previous scenario (remove the results for the **Exercise 03 Spatial** scenario from the output by right-clicking on the scenario name and selecting **Remove from Results** from the context menu; this action does not delete the results, it just removes them from the charts and maps in the Results View).

How effective does applying 100 ac of restoration to the landscape appear to be in reducing the amount of exotic invasion? Why do you think this is the case?

3. A common strategy used when managing invasive plants is to focus restoration efforts on the edges of large patches in order to reduce the spread of the invasive front. We will now define a scenario that uses this strategy to control exotics on the landscape. Make a copy of the scenario you just ran and rename it “Exercise 03 Spatially Explicit - 100 ac Restoration – Large Patch Edges”.
4. Open up this scenario with the **Properties Editor** and go to the **Advanced** tab. On the tree to the left select **Transitions - Spatial | Transition Patch Prioritization**.
5. Create a single record where you set the patch prioritization to “Largest (transition edges only)” for the **Restoration** transition type/group.
6. Close the **Properties Editor** and **Run** the model. View your results in the **Area by state class** chart and in the **State Classes and Fire** map. Also create a map of restoration transitions, and compare to the previous scenario with no prioritization. Does prioritizing the edges of the largest patches increase the effectiveness of restoration?

7. Finally, we will explore one last strategy. The literature suggests that focusing treatments on new foci of invasion may be most effective. However this strategy is more expensive because these foci require more effort to detect than large patches so less area can be treated overall. To simulate this strategy, make a copy of the previous scenario and rename it “Exercise 03 Spatially Explicit - 80 ac Restoration – Small Patches”.
8. Open up this scenario with the **Properties Editor** and go to the **Advanced** tab. On the tree to the left select **Transitions - Spatial | Transition Patch Prioritization**.
9. Set the patch prioritization to “Smallest” for the **Restoration** transition type/group. Under the **Transition Targets** tab reduce the target area for restoration to 80 acres.
10. Close the **Properties Editor** and **Run** the model for this newest scenario. View your results in the **Area by state class** chart and in the **State Classes and Fire** map. Also look at your map of restoration transitions, and compare to the previous scenario with large patch edge prioritization. Does reducing the area treated and prioritizing the smallest patches increase the effectiveness of restoration?

11. When done, close your project and exit ST-Sim.