State-and-Transition Simulation Modeling of Landscape Dynamics using ST-Sim

Self-Directed Training Course
Part 1

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Preparing for the Course

The suite of exercises provided in this document represent Part 1 (i.e. Exercises 1&2) of the self-directed training course. By the end of these exercises you should be able to build and run your own simple model using ST-Sim. When done you can optionally continue on to Part 2 of the course, which covers additional advanced features.

1. Download and install SyncroSim for Windows

ST-Sim is an open-source plug-in "package" that runs within the SyncroSim software. As a result you will need to download and install the SyncroSim software on your local computer. **For this introductory course we will be using version 2.2.27 of SyncroSim for Windows**, which is the version that was available at the time this course was originally developed in January 2021.

Using your web browser, navigate to: https://syncrosim.com/download-id/syncrosim-for-windows-version-2-2-27/ to download and install SyncroSim version 2.2.27.

Note: if you have a more recent version of SyncroSim already installed you will need to uninstall it first in order to install and run SyncroSim version 2.2.27. Alternatively you can proceed with the course by using the *latest version of SyncroSim*, in which case some of the course instructions may be slightly out-of-date. **After you have completed the course you should always upgrade to the latest version**.

2. Complete the online homework *(optional)*

Before you begin working through the course, you will benefit by reviewing the online Overview of SyncroSim and completing the 30-minute Quickstart Tutorial for SyncroSim.

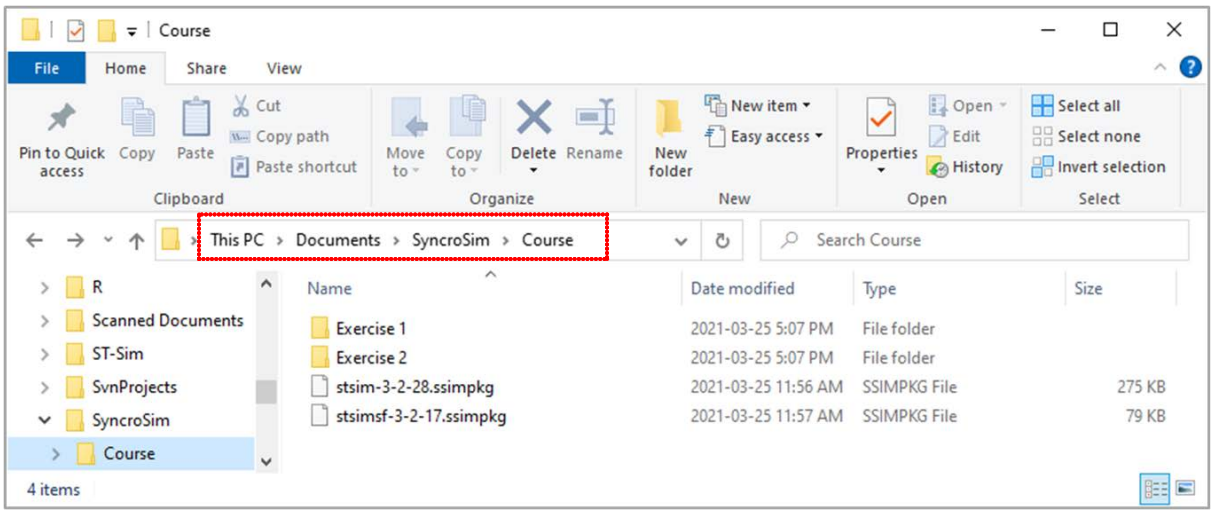
3. Download and install course files

1. Download the zip file https://apexrms.com/download/stsim-course-files-part-1/

2. Create a new folder for the course files on your computer. We recommend you create a folder called "Course" under the existing folder **Documents\SyncroSim**.

3. Unzip the contents of the downloaded file to this new folder (i.e., right-click on the zip file, select **Extract All**, set **Documents\SyncroSim\Course** as the destination for extracted files, then click on **Extract**).

4. A series of subfolders should now appear in your **Course** folder as shown below. Note that only files for Exercises 1 and 2 are included in Part 1; files for Part 2 of the course (i.e., Exercises 3 to 8) are available from https://apexrms.com/training.



4. Follow the online course material and exercises

In this self-directed course you will listen to a recording of a live 2-day course (delivered in Australia in January 2021), pausing the recording periodically to do exercises at your own pace.

- The video playlist for the original live course has been divided into the following 11 segments:

  Course Overview
  Introduction
  Exercise 1: Getting started
  Exercise 2: Spatial model
  Exercise 3: Landscape stratification
  Exercise 4: Temporal variability
  Exercise 5: Spatial variability
  Exercise 6: Attributes
  Exercise 7: Stocks and flows
  Exercise 8: Command line & R
  Other Advanced Features

- A video recording of the entire course can be viewed as a YouTube playlist at: https://youtube.com/playlist?list=PL57N-QiM8Rikg1ih5ieogJDv9Wa9TMA67
- To avoid a blurry presentation, ***make sure your YouTube Quality is set to 1080p*** (under the Settings icon at the bottom right of the YouTube window)
- Specific instructions for each of the exercises can be found in the remainder of this document.

5. Ask questions and provide feedback

We encourage you to ask questions and provide feedback both during and after the course through the ST-Sim Self-Directed Course Forum; you can also purchase additional hourly support at any time.

6. Continue with Part 2 of the course

To continue on with Part 2 (Exercises 3-8) of this course, see the instructions at https://apexrms.com/training.

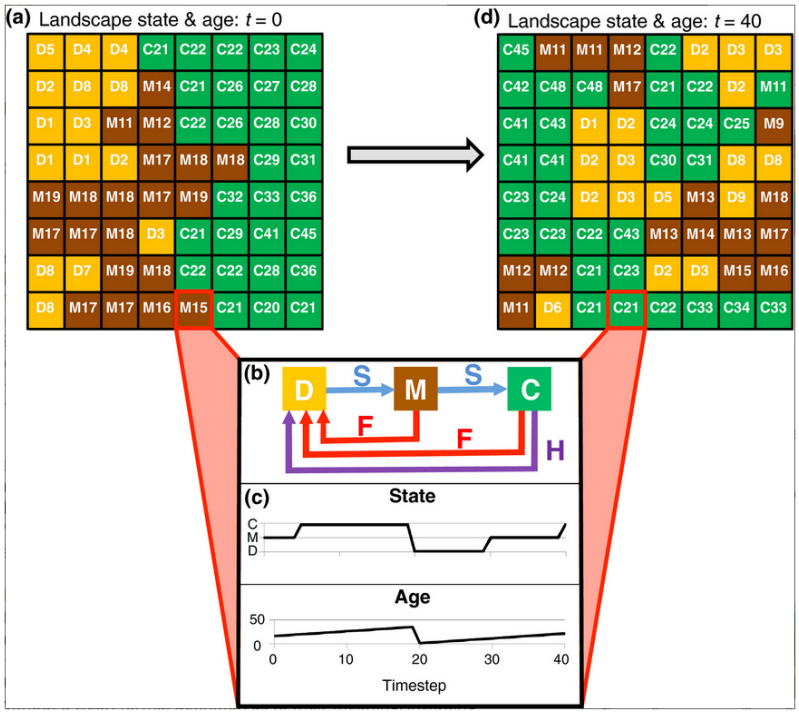
Exercise 1: Getting started with ST-Sim

Objectives

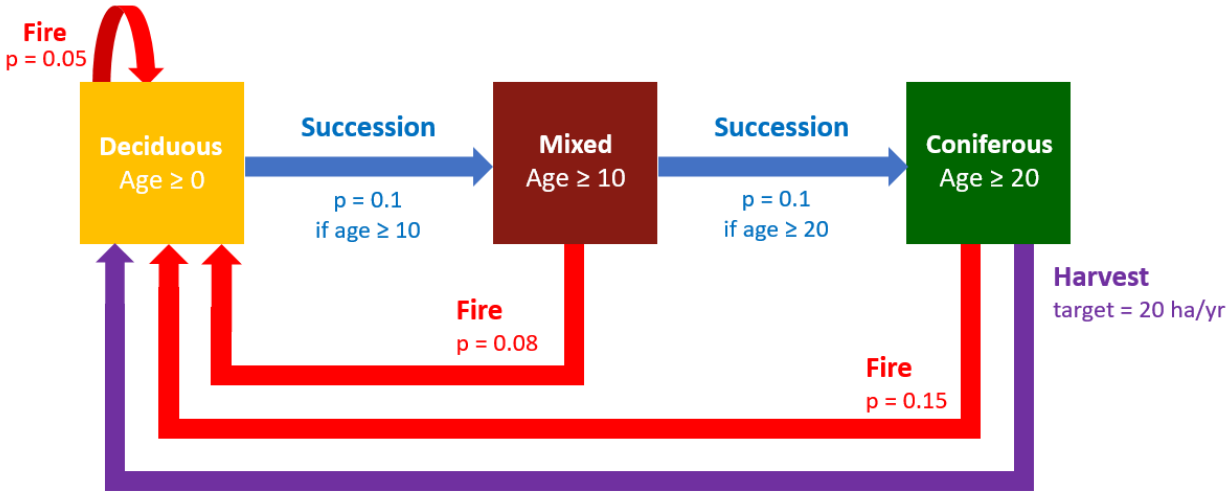
- Build and run a simple, non-spatial state-and-transition simulation model
- View graphs of results
- Compare alternative future scenarios

In this exercise, you will create a simple state-and-transition simulation model that forecasts the fate of a forested landscape 40 years into the future, based on the example first presented in Daniel et al. (2016). Conceptually, each spatial cell in this landscape today has been classified into one of three possible states (D = Deciduous, M = Mixed, C = Coniferous). The age of each cell today has also been recorded. Based on a pathway diagram specifying the transition probabilities between states (panel b below), your model will then stochastically forecast the future composition of this landscape in response to transitions due to Succession (S), Fire (F) and Harvest (H).

Note that the model you will create in this exercise will be *non-spatial* – that is, the model will be initialized using landscape totals for the area in each state and age, rather than cell-by-cell (i.e., mapped) values; future exercises will show you how to make your model fully spatial.



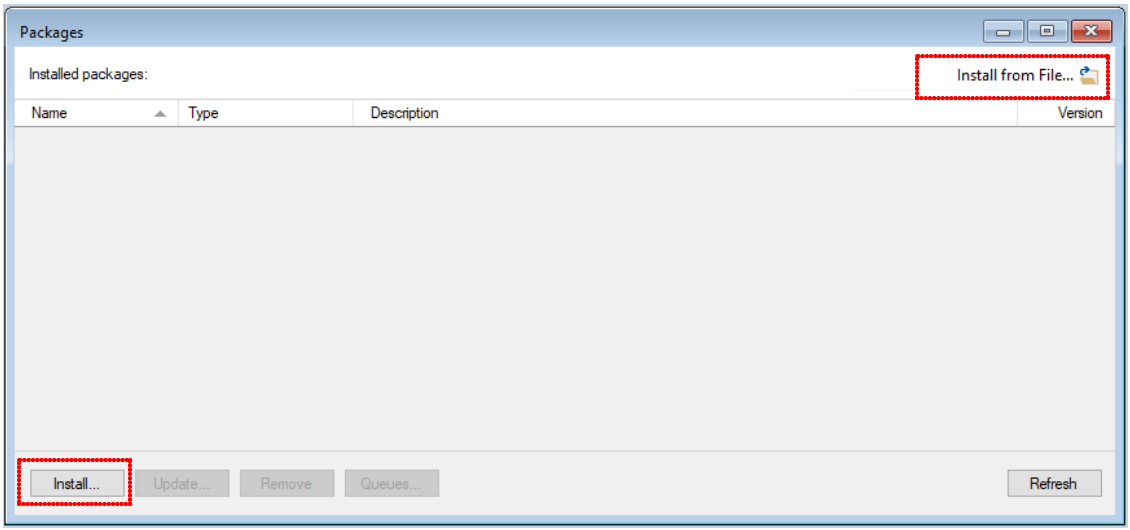
Below are the numeric details of the pathway diagram we will use for this exercise. Note that Succession and Fire transitions are expressed as annual transition probabilities (with Succession transitions also conditional on age), while Harvest uses a target for the total area to transition each year.



Task 1 – Create a new ST-Sim library

We will start by downloading the *stsim* package required for this course and create a new, empty ST-Sim Library. A Library is simply a file (with extension.*ssim*) for storing all of your model inputs and outputs.

1. Open SyncroSim. Under the **File** menu, select *Packages*. This will open the **Packages** window displaying a list of all the installed packages. If you have not installed any packages prior to this exercise, this list will be blank.



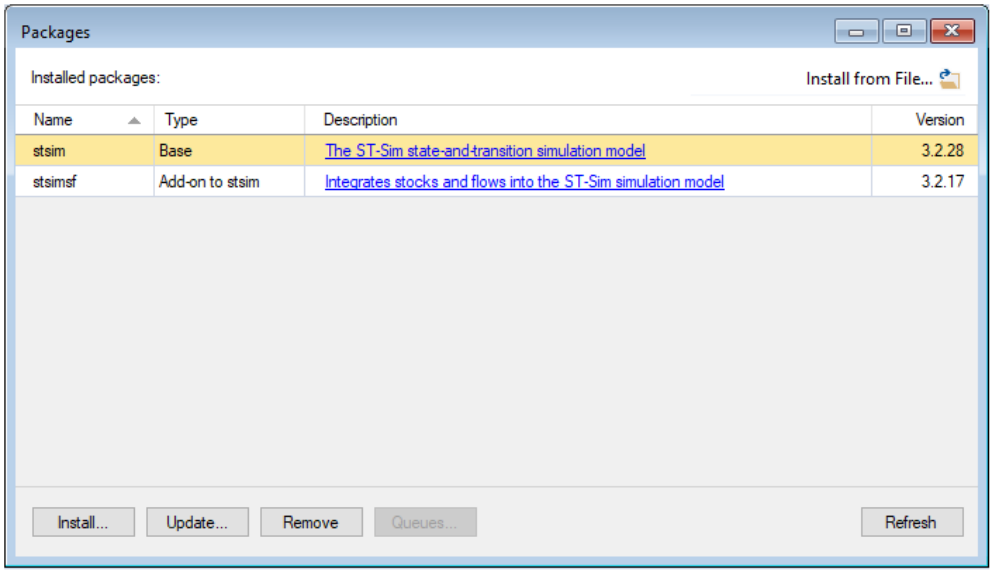
2. *If you are running the version of SyncroSim recommended for the cours*e (i.e. version 2.2.27 – you can check this under the **Help | About SyncroSim** menu):

   Click on **Install from File** in the upper right corner of the **Packages** window. Navigate to your **Course** folder, select the file called “stsim-3-2-28.ssimpkg”, and click **Open** to install the package. Repeat for the file called “stsimsf-3-2-17.ssimpkg”. These are the versions of each package used in the original live course.

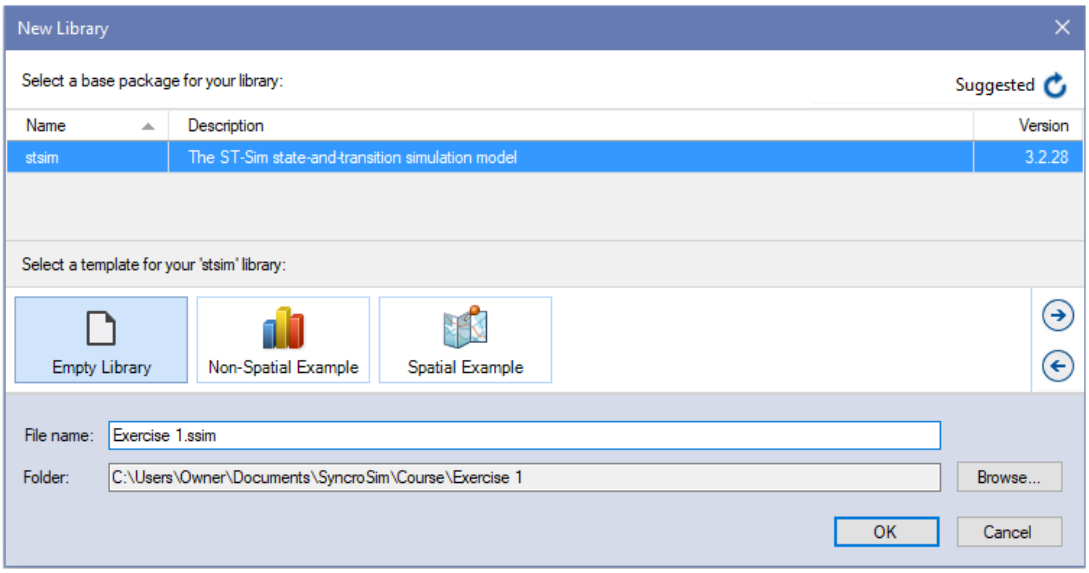
3. *If you are running the latest version of SyncroSim* (i.e. greater than version 2.2.27):

   Click on the **Install** button in the lower left corner of the **Packages** window to go to the SyncroSim Package Server. Select the packages called “stsim” and “stsmsf” and click **Ok**. These are the latest versions of each package.

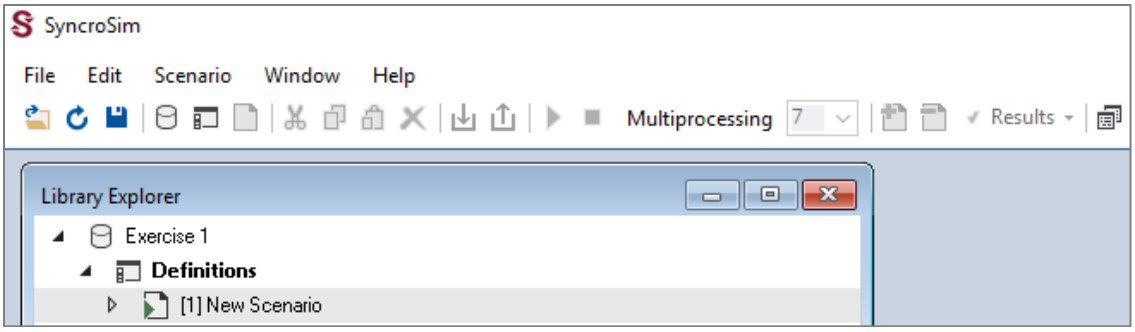
4. You should see both packages now listed in the **Packages** window. **Close** the **Packages** window.



5. Navigate to the **File** menu, and select *New Library*. In the upper pane of the **New Library** window, click on the **stsim** package to select it. Click on the **Empty Library** template. In the **File name** field at the bottom of the **New Library** window, rename the file to “Exercise 1.ssim”. Click on the **Browse** button and navigate to the **Course \ Exercise 1** folder. Click **OK**.

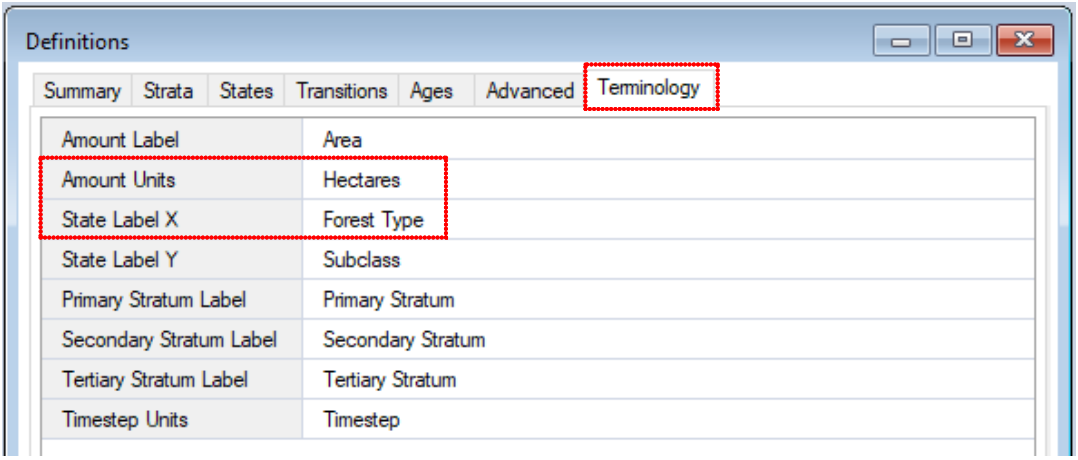


6. Your new Library will open in the SyncroSim **Library Explorer**. When creating a new Library, one empty scenario called **New Scenario** will be automatically created for you. Scenarios provide a clear and organized template for entering and storing values for your model’s required inputs.

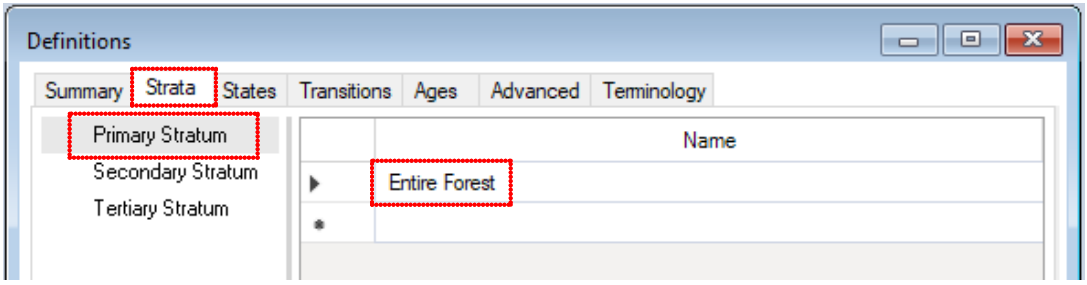


Now that you have created a new empty Library, you are ready to begin setting up various basic *definitions* for it. These definitions are generally terms that you specify in order to customize the model to your specific landscape. Note that definitions will be shared by all scenarios in your Library.

7. To set model definitions, right-click on **Definitions** and select *Properties*. Navigate to the **Terminology** tab where you will define the terminology to be used for your particular model. Set **Amount Units** to *Hectares*, and set **State Label X** to *Forest Type*.

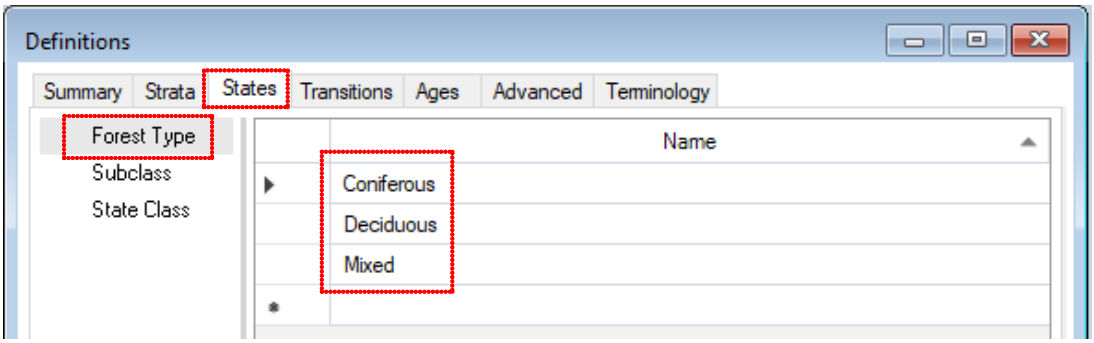


8. Switch to the **Strata** tab. In ST-Sim, a landscape can be stratified spatially according to up to three possible dimensions (more on this in later exercises). For this simple model, we will keep the entire landscape in a single stratum – to do this we will define a single **Primary Stratum** and call it *Entire Forest*.

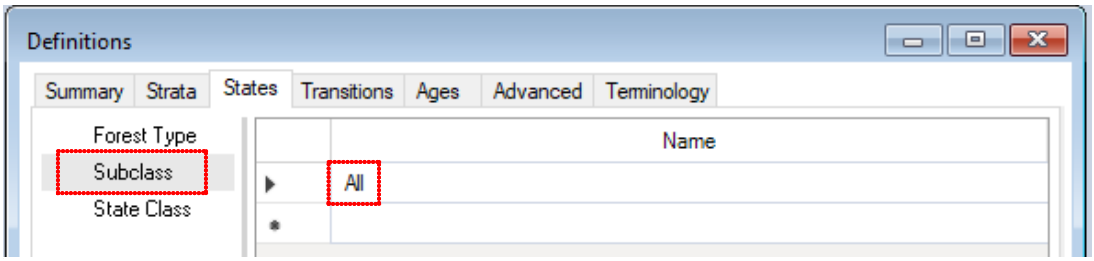


9. Switch to the **States** tab to define the state classes for your model. Each unique State Class is identified according to its **Class** and **Subclass**. Earlier we told ST-Sim (in the Library's **Terminology** settings) to refer to the *class* as a Forest Type, which we will define now. Create

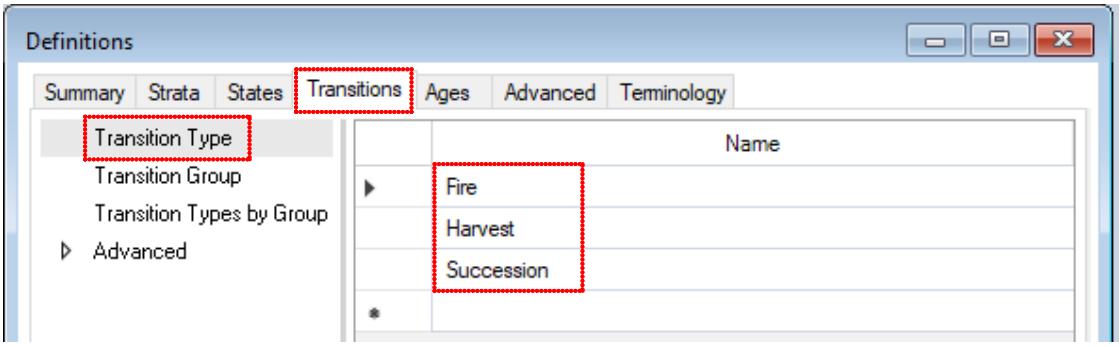
the following three forest types: *Deciduous*, *Mixed* and *Coniferous*.



10. Still on the **States** tab, click on **Subclass** on the left sidebar. As we will not be defining any subclasses for this model, we add a single **Subclass** called *All*.



11. Switch to the **Transitions** tab. For our model, there are three transitions: *Succession*, *Fire* and *Harvest*. Click on **Transition Type** on the left sidebar and enter these three transitions into the table.



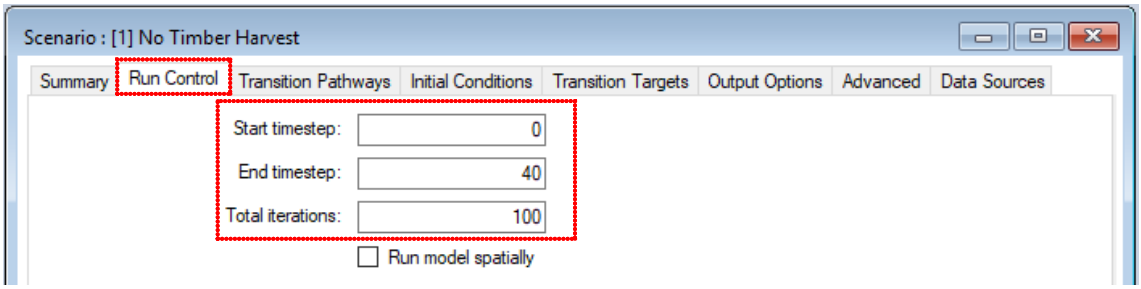
12. Close the **Definitions** window and save your model by clicking the **Save All** icon on the main toolbar.

Task 2 – Configure a scenario

Now that you have completed your model definitions, you can create your first simulation scenario. This scenario will hold the input values for your model. As you develop scenarios in SyncroSim, all of the data associated with each scenario are stored automatically in your SyncroSim Library.

1. Your new Library opened with a single empty scenario (called **New Scenario**) in it. Right-click on this **New Scenario** and select *Properties*. Rename the scenario "No Timber Harvest". You may choose to enter your name as the **Owner** of the scenario, and enter a brief **Description**, e.g., "Simple model of a forested landscape with no timber harvest".

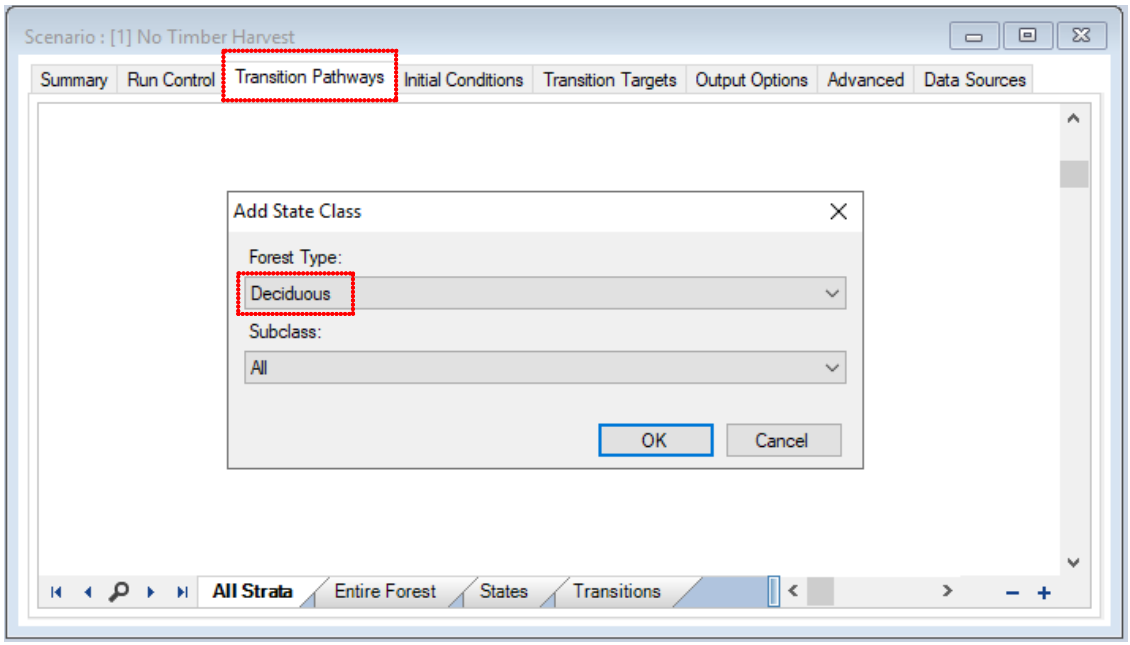
2. Switch to the **Run Control** tab. Here you will define the timeframe and number of Monte Carlo iterations you wish to run. Set the **Start timestep** to *0* and the **End timestep** to *40* (40 years), and **Total iterations** to *100*.This model is non-spatial, so leave the checkbox unchecked.

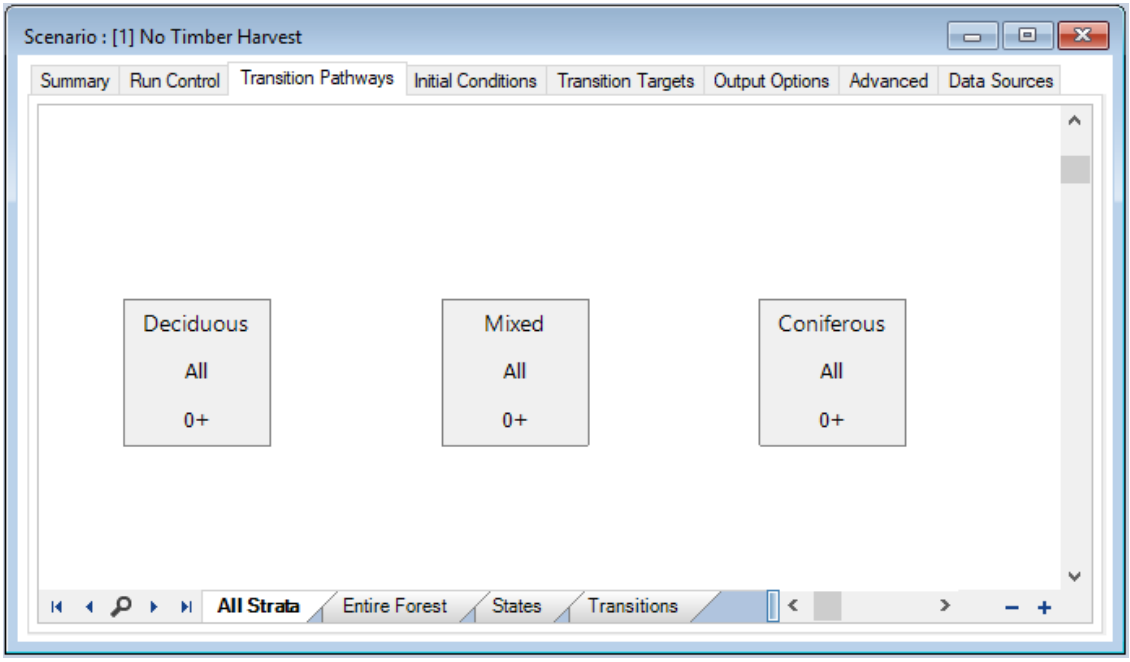


3. Switch to the **Transition Pathways** tab. Here you will define your model's pathway diagram, including probabilities and age limits for the various transitions that can occur.

   Remember that this is a three-state model, where the State Class of each cell can be one of three possible forest types (Deciduous, Mixed or Coniferous).The pathway diagram for the model then specifies three possible transition types (Succession, Fire and Harvest) that can move a cell from one State Class to another over time (as defined in Step 9 of Task 1 above). A table summarizing the transitions you will enter into the model is shown at the end of Step 8.

4. To add a State Class (box) to your pathway diagram, right-click anywhere on the white space of the **Transition Pathways** window, and select *Add State Class* from the context menu. In the **Add State Class** window, open the **Forest Type** drop-down list, select *Deciduous* and click **OK** to add the first State Class to your diagram. Repeat this step, but select *Mixed* as the Forest Type. Repeat one more time and select *Coniferous*.

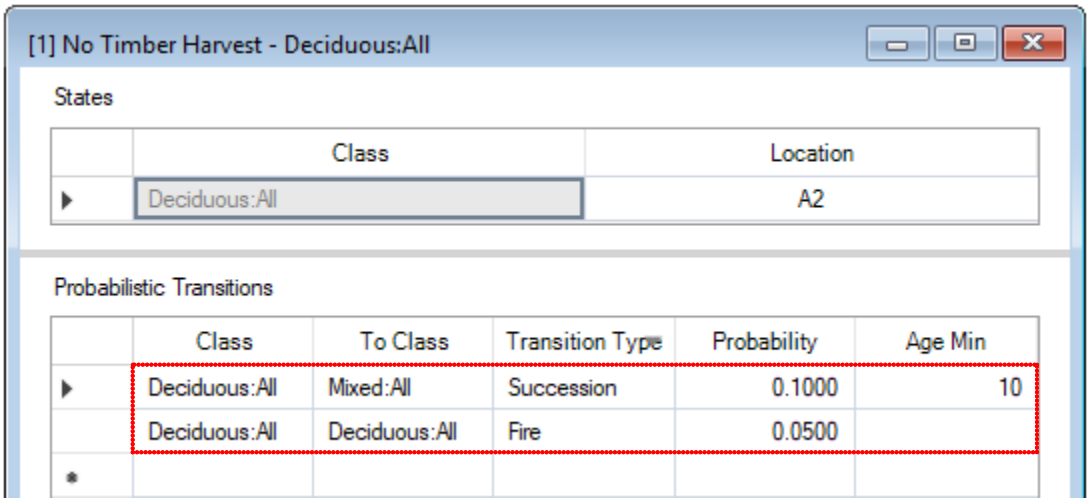




5. Double-click (or right-click) on the Deciduous State Class box to open it. There are two transitions that can occur for this forest type: Succession and Fire. In the **Probabilistic Transitions** pane, add a row where you tell ST-Sim that the *Deciduous* **Class** will transition to the *Mixed* **To Class** according to a **Transition Type** of *Succession* with an annual **Probability** of *0.1* (see image below). To specify that this transition should only occur once a cell is 10 years old or more, right-click on the table and toggle the **Age Min** option to make this column visible. Set the value for **Age Min** to *10* years.

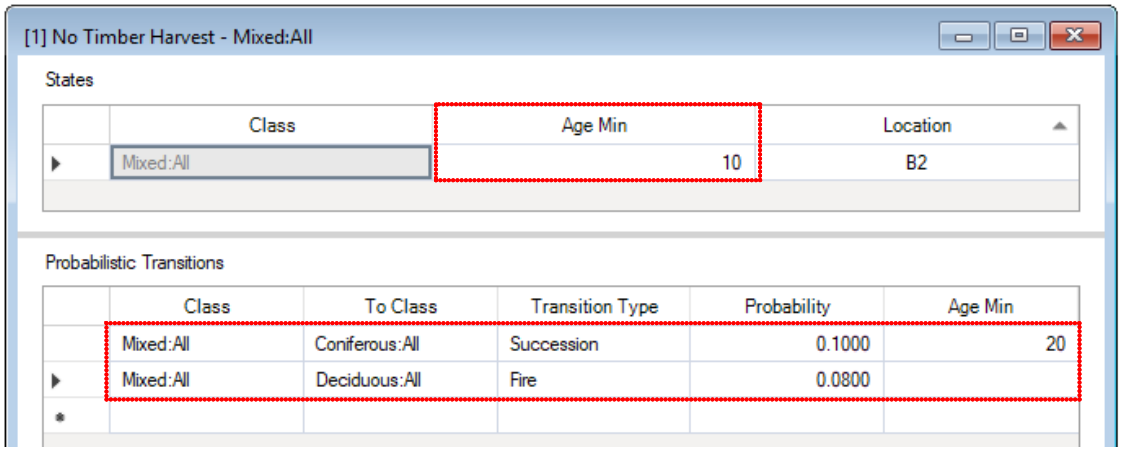
6. In the second row of the table, set the Deciduous State Class to transition back to itself (i.e., both **Class** and **To Class** should be *Deciduous*) via *Fire* with an annual probability of *0.05* (i.e., Fire

occurring on the landscape about every 20 years).

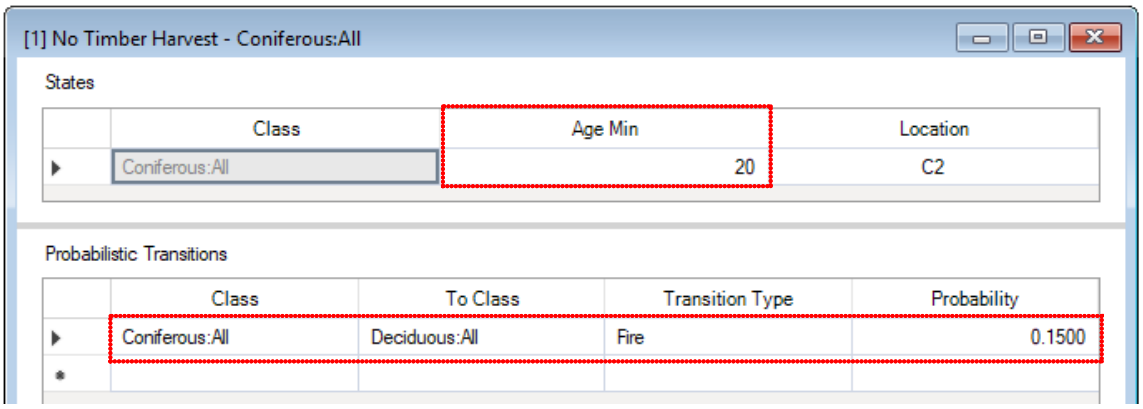


When you close the window, you will see the two transitions you just defined for the Deciduous State Class on the pathway diagram.

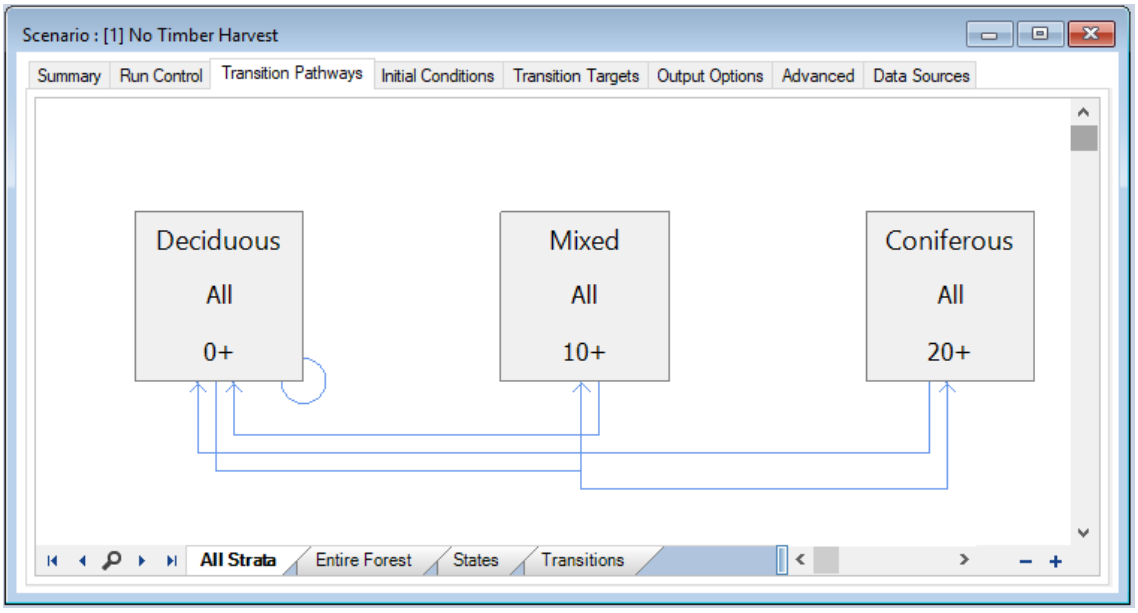
7. Next, open the Mixed State Class box(right-click or double-click). Recall that for a cell to be classified as Mixed it must be at least 10 years old. To set this property for the Mixed State Class, right-click on the **States** pane to add the **Min Age** field, and enter *10*. In the **Probabilistic Transitions** pane, set the *Mixed* class to transition to *Coniferous* via *Succession*, with a **Probability** of *0.1* and a **Min Age** of *20*. In the second row of the table, set the *Mixed* State Class to transition to *Deciduous* via *Fire* with a **Probability** of *0.08* (or 8% annually). Close the window.



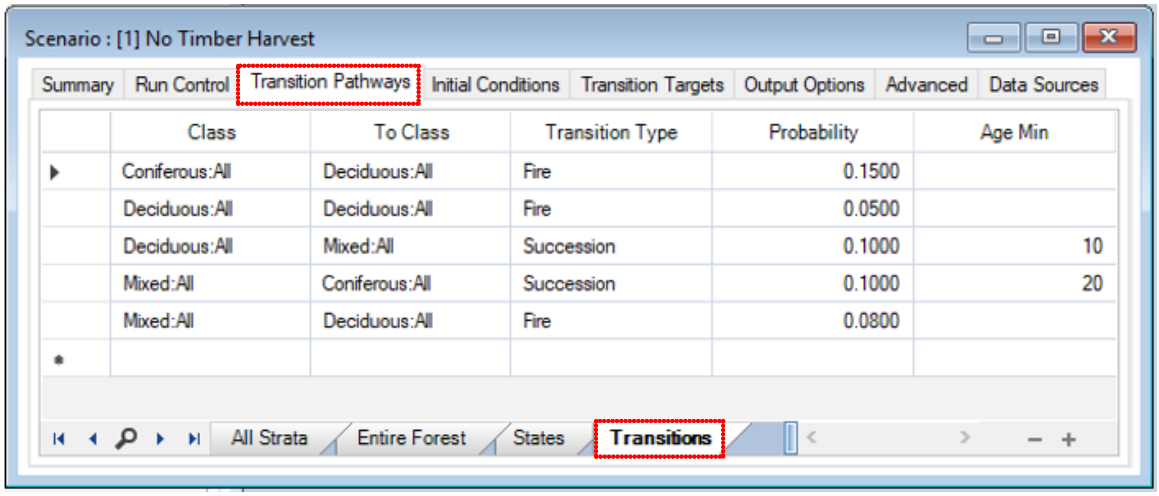
8. Open the Coniferous State Class. In the **States** pane, set the **Min Age** for the Coniferous forest type to be *20* years. In the **Probabilistic Transitions** pane, set *Coniferous* to transition to *Deciduous* via *Fire* with a **Probability** of *0.15*.



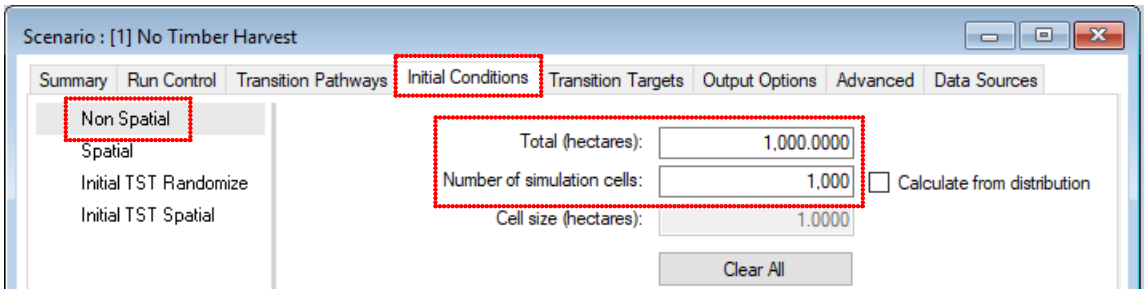
You now have a basic pathway diagram in ST-Sim that represents the model presented at the beginning of this exercise (without Harvest). Your pathway diagram should look similar to the image below.



To see a complete list of all the transitions you just entered, on the **Transition Pathways** tab for your scenario, click on **Transitions** near the bottom of the window to bring up a worksheet containing the transition pathways table. To see all transitions, you will need to add the optional **To Class** and **Min Age** fields from the context menu.

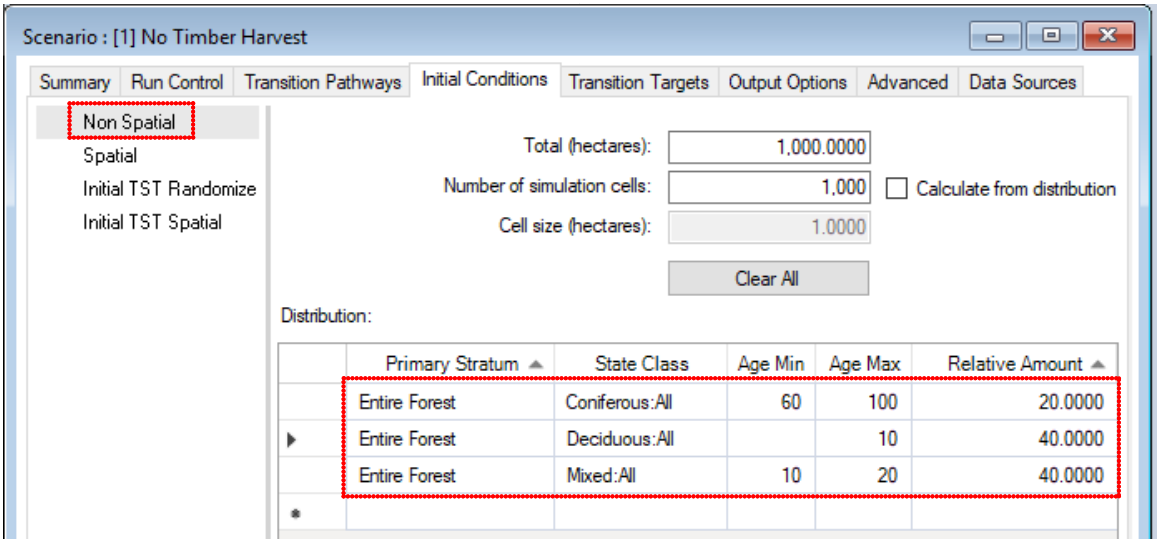


9. The next step in configuring your scenario is defining the size and resolution of your forested landscape. To do this, switch to the **Initial Conditions** tab and click on **Non Spatial** on the left sidebar. Set **Total (hectares)** to *1,000* and **Number of simulation cells** to *1,000*. This means that the total size of the hypothetical landscape in this model is 1,000 hectares and each simulation cell, or parcel of land, is one hectare in size.



10. Because you are creating a non-spatial model (as opposed to working with map inputs), you must specify the proportion of the landscape that is in each State Class (i.e., forest type) at the start of the simulation (later on, we will touch upon how to specify initial conditions using raster maps). Still on the **Initial Conditions** tab, right-click on the **Distribution** table and add the **Age Min** and **Age Max** optional fields. For each of the entries below, the **Primary Stratum** will be *Entire Forest*.
    a) For the *Deciduous* State Class, set **Age Max** to *10* years, and set **Relative Amount** to *40%* of the landscape.
    b) For the *Mixed* State Class, set the age range to be 10-20 years (**Age Min** = *10*, **Age Max** = *20*), and set **Relative Amount** to *40%* of the landscape.
    c) For the *Coniferous* State Class, set the age range to be *60-100* years, and set **Relative Amount** to*20%* of the landscape.

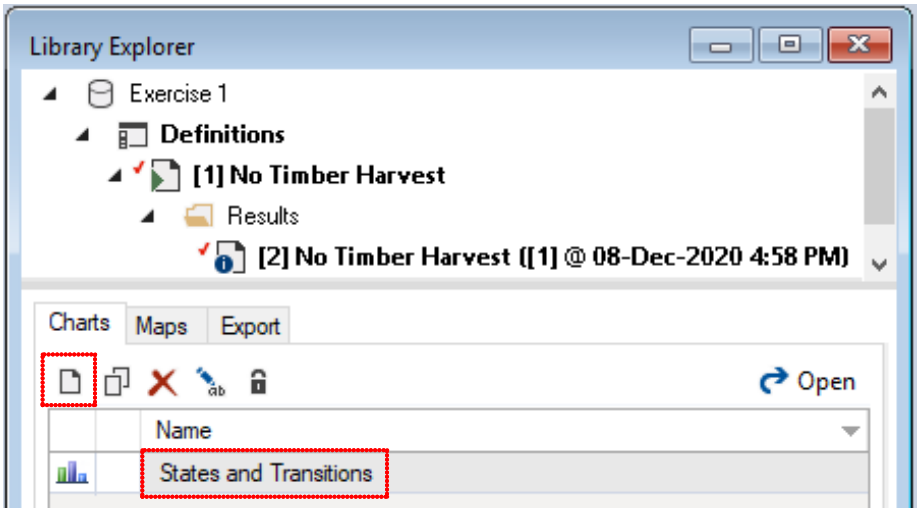
    Note that the **Relative Amount** values do not have to add to 100; they could be expressed as hectares or proportions of the landscape and the model will re-normalize at the start of the simulation. Close the **Scenario** window and **Save** your work.



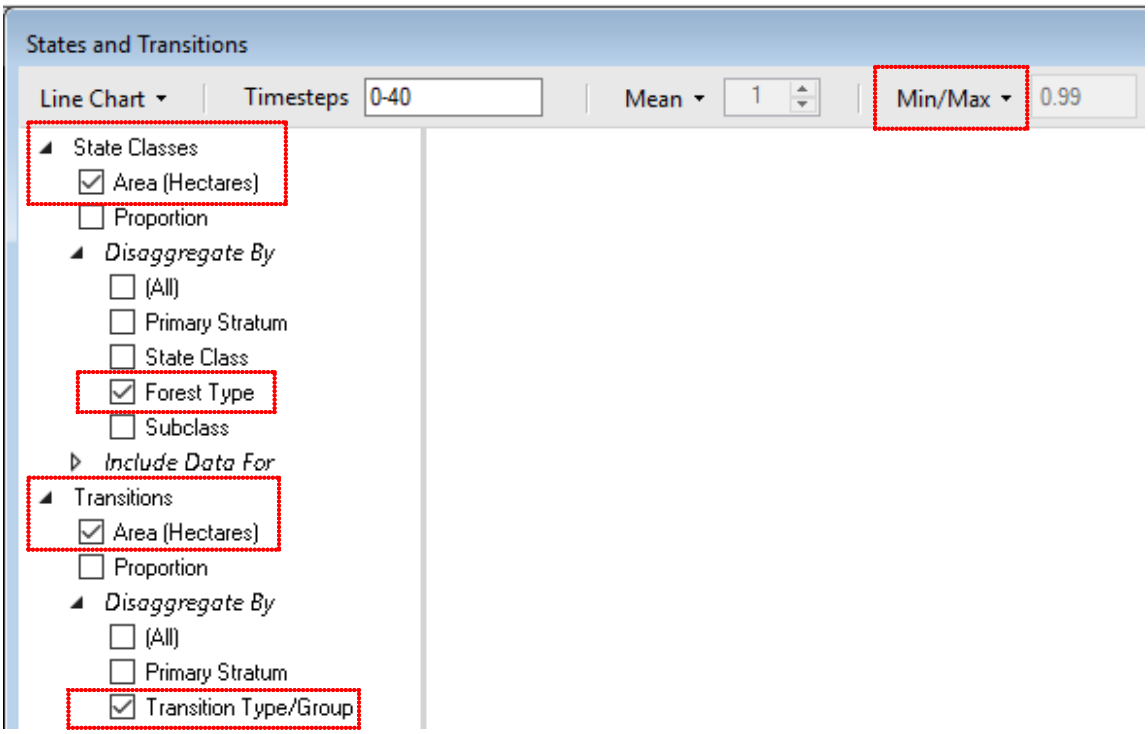
Task 3 – Run the scenario and view results

1. The next step is to run your scenario. To do this, either right-click on the scenario in the **Library Explorer** pane and select *Run* from the context menu, or click on the **Run Scenario** icon on the toolbar at the top of your screen. The **Run Monitor** will track the progress of your run and notify you of any issues encountered. When the run is done, close the **Run Monitor**.

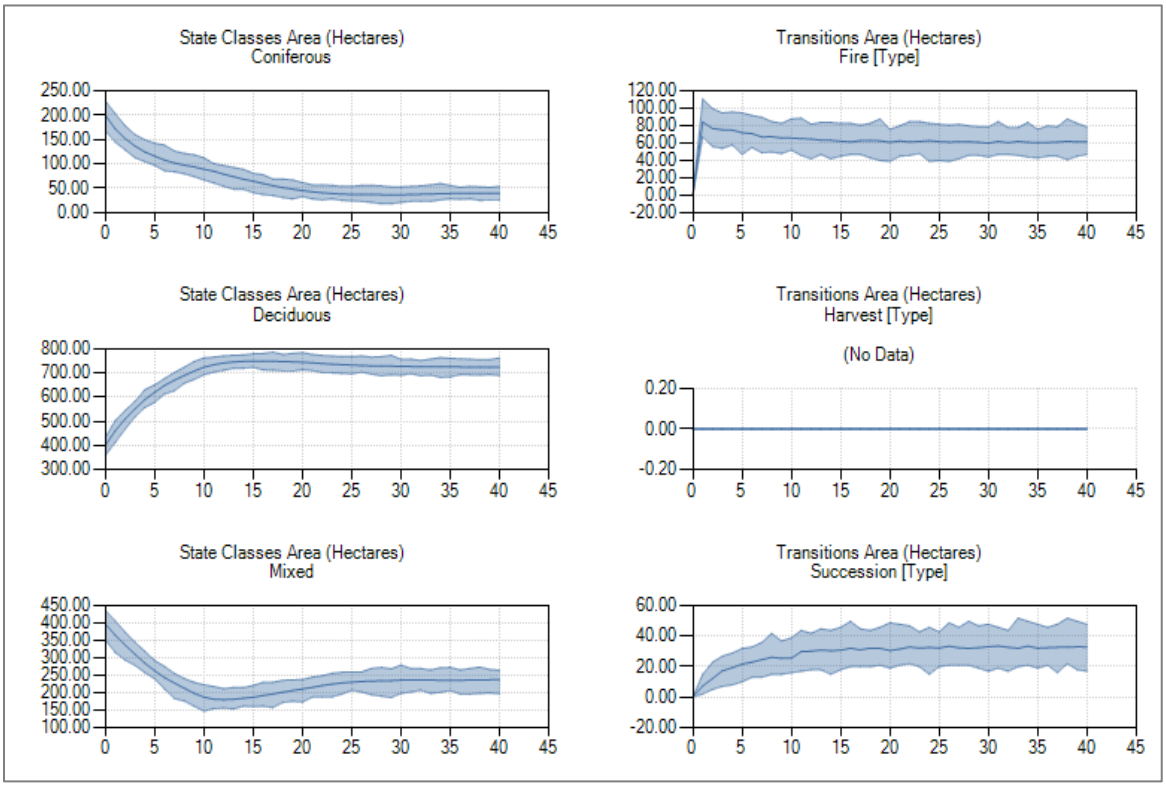
2. You are now ready to analyse your results. In the **Library Explorer**, expand the node for the **No Timber Harvest** scenario you just ran. You will see a **Results** folder containing a Results Scenario. This Results Scenario contains your model outputs and will have a red checkmark beside it indicating that it has been added to the **Results Viewer**. The **Results Viewer** is a pane situated below the **Library Explorer** with three tabs for viewing and exporting results. On the **Charts** tab, click on the **New** icon to open a **New Chart** window. Name the new chart "States and Transitions" and click **OK** to close the **New Chart** window.



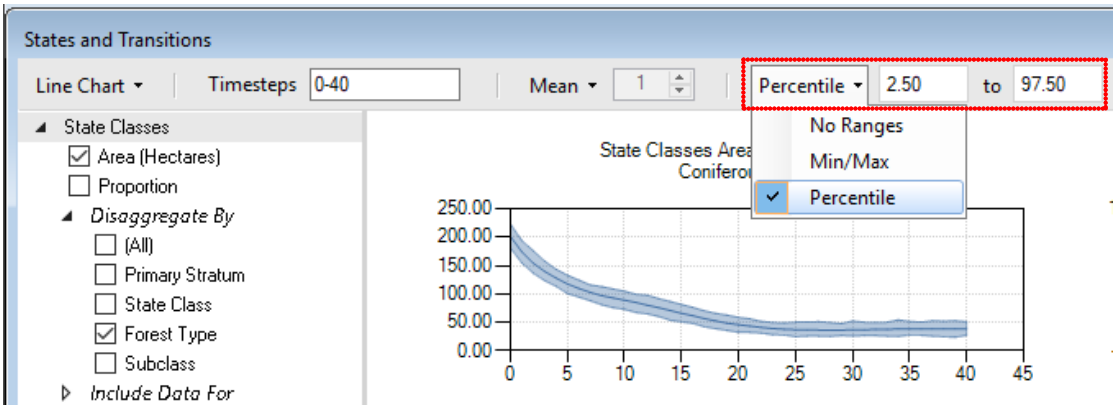
3. The left sidebar of your **States and Transitions** charting window lists the variables that you can chart over the course of the simulation. You can create charts showing the average amount of area in each of the three forest types, and the average amount of area undergoing each of the three types of transitions.
    a) To generate charts of transitions over time, expand the **Transitions** node to see the available variables and select *Area (Hectares)*. Under **Disaggregate By**, select *Transition Type/Group*. This will create a separate chart for each of your three transition types (Succession, Fire, and Harvest).
    b) To generate charts of forest types over time, expand the **State Classes** node to see the available variables, and select *Area (Hectares)*. Under **Disaggregate By**, select *Forest Type*. This will create a separate chart for each of your three forest types (Deciduous, Mixed, and Coniferous).
    c) To display model uncertainty on your charts, modify the error bar type by clicking on *No Ranges* near the top of the window and selecting *Min/Max* from the **Error Bar Type** drop-down menu.
    d) Click **Apply** (upper right corner of the charting window) to display your charts.



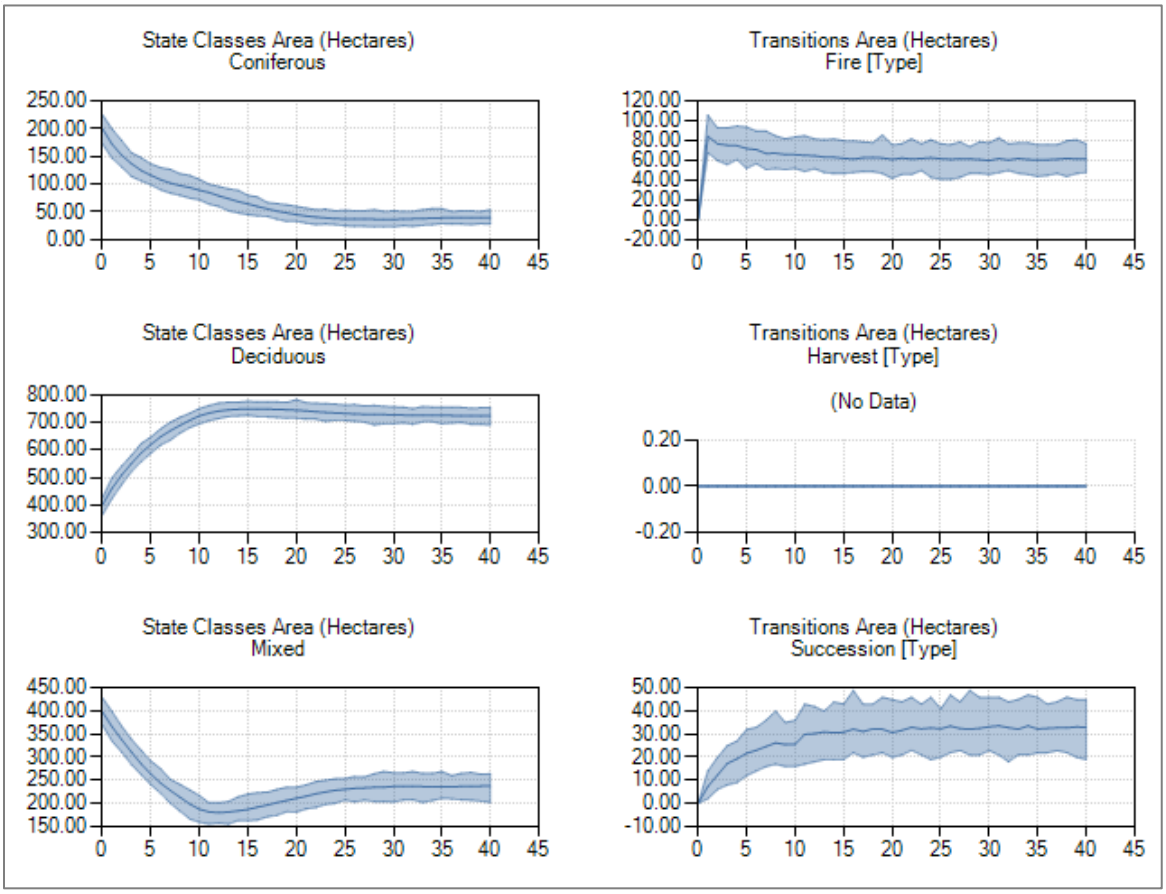
Your charts should look something like this:



4. Because your simulation ran many Monte Carlo iterations, you can get a sense of the variability across all iterations. To do this, change the **Error Bar Type** to *Percentile* (see image below). Set the range as *2.5* to *97.5*. This represents a 95% Monte Carlo confidence interval. Click **Apply**.



The variability is represented by the shaded area around each line.

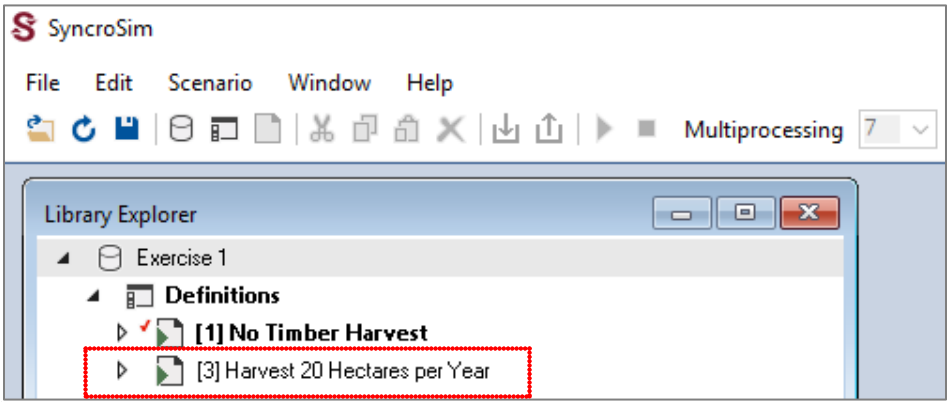


The charts show the average area for Coniferous and Mixed forest types decreasing over time, while the area of Deciduous forest type increases over time. Both Fire and Succession are occurring on the landscape, but timber Harvest is not. Close your charting window.

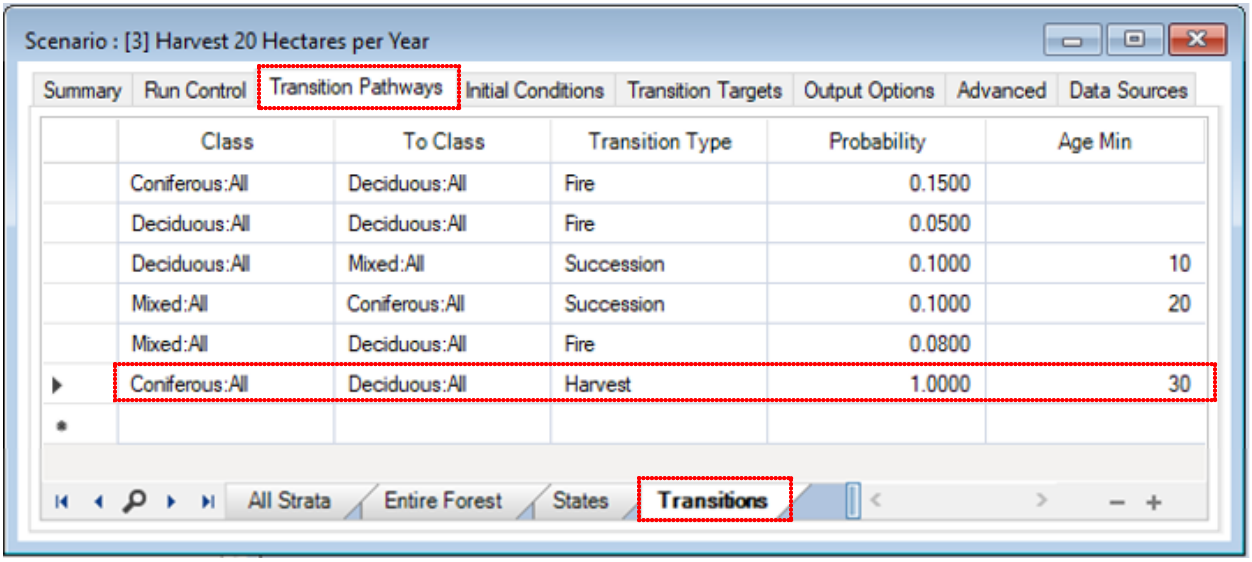
Task 4 – Create a second scenario and compare results

The final task for this exercise will be to create a scenario in which some timber harvest occurs and compare this scenario to the previous one where no timber harvest occurs on the landscape.

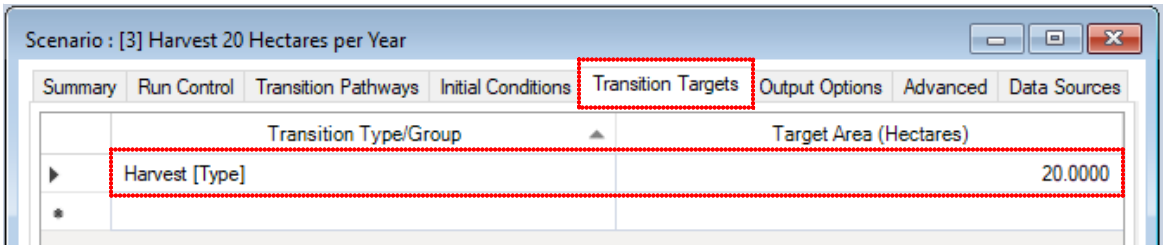
1. In the **Library Explorer**, right-click on the **No Timber Harvest** scenario and select *Copy*. Right-click on **Definitions** and select *Paste*. Double-click on the copied scenario to open it. On the **Summary** tab, rename the copy to "Harvest 20 Hectares per Year*"*, and edit the **Description** to indicate that some harvest will be occurring.



2. To add Harvest dynamics to your model, switch to the **Transition Pathways** tab and click on **Transitions** at the bottom of the window. In the table, enter a new row (i.e., transition pathway) in which a cell in the *Coniferous* State Class transitions to *Deciduous* via *Harvest* when the age of the cell is greater than *30* years. Unlike Fire and Succession transitions which occur stochastically in the model to reflect real-life variability, a Harvest transition can be specified as a target or absolute amount of area within the landscape. Here we have specified that Harvest only occurs in Coniferous stands (i.e., cells) that are at least 30 years old. Because you will specify the level of Harvest as a target rather than a probability, set the **Probability** of Harvest to *1*.



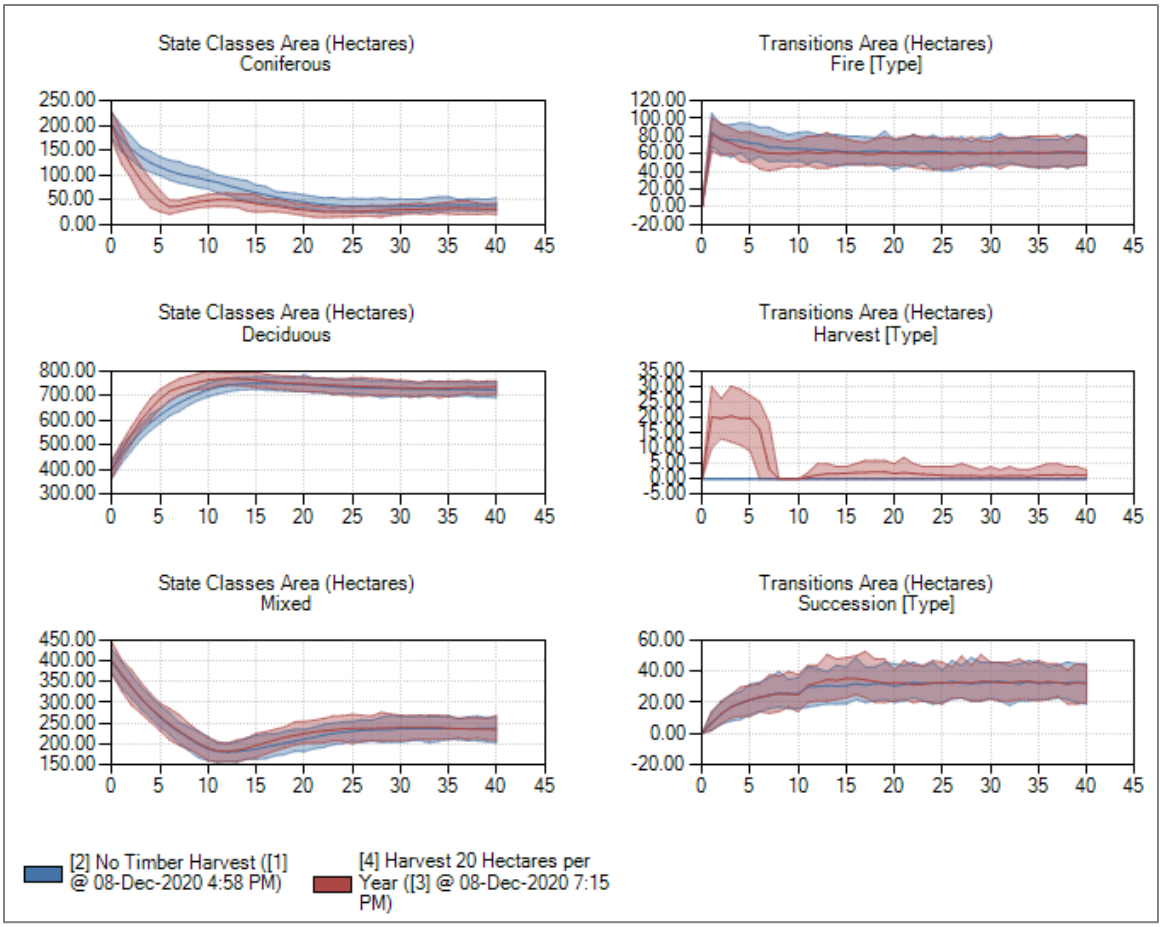
3. To define a Harvest transition target, click on the **Transition Targets** tab for your scenario. Set the **Target Area** for the *Harvest* transition to *20* hectares per year. Close the **Scenario** window and **Save** your work.



4. **Run** the new scenario (either right-click and select *Run*, or click on the **Run Scenario** icon on the toolbar).

5. When the run is complete, the results will show up immediately in the **States and Transitions** chart that you created based on the **No Timber Harvest** scenario.

   Your charts should look something like this:



What is the effect on the composition of the landscape of adding timber harvest? Why does the amount of timber harvest change over the course of the simulation?

Bonus Question: *Try running a scenario in which you assume that fire suppression is able to double the fire return interval for the landscape (Hint: probability = 1 / return interval). What effect does the model say this management action would have on the future composition of the landscape? And how would harvest be affected by this change?*

6. When you are done, **Save** your work (**File | Save All**) and then **Close** your Library (**File | Close All**).

7. Finally, to check your work, select the **File | Open Library** menu, navigate to the Exercise 1 folder and open the SyncroSim library file called “Exercise 1 Solution.ssim”. This contains all the of library settings as they should appear once you have completed the exercise. At the end of this manual you will also find answers to the written questions throughout each exercise.

Exercise 2: Running a model spatially

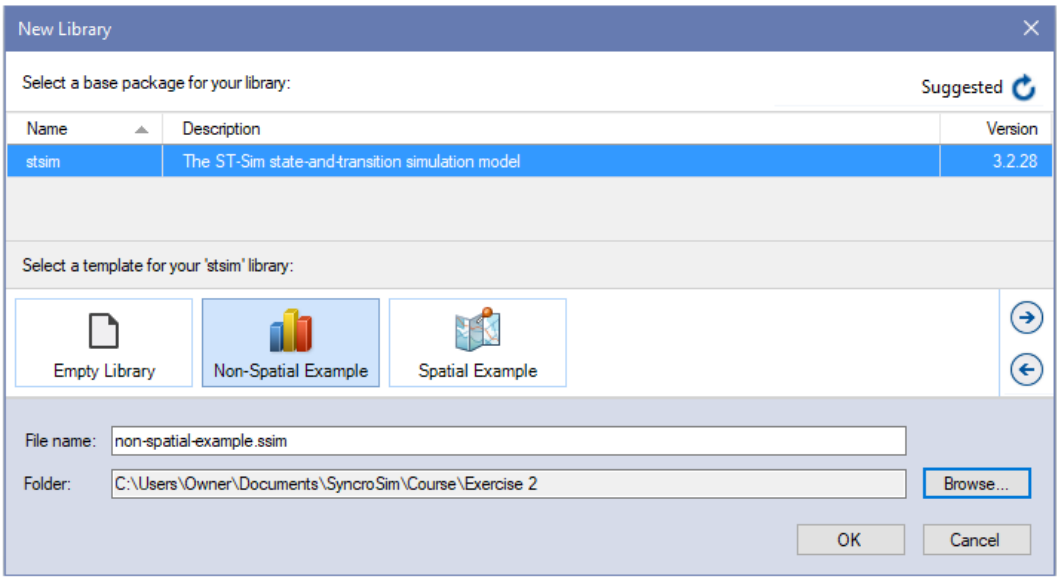
Objectives

- Learn about working with templates and folders
- Set up definitions for spatial simulations
- Load input maps and run spatial simulations
- Create size distributions to simulate transition events

In this exercise you will learn how to use and edit *templates* that come with SyncroSim. SyncroSim Templates are Libraries that contain pre-configured scenarios with model inputs. You will begin with a Template, called “Non-spatial Example” that contains the exact model inputs you used in Exercise 1, and edit this non-spatial Template into one that can be used in a spatial simulation.

Task 1 – Create a new library using templates

1. From the **File** menu, select *New Library*. Left-click to select the **stsim** package and choose the **Non-Spatial Example** template. Set the folder path to the file destination **Course\Exercise 2**. Click **OK**.



2. When the Library opens, you’ll see the two scenarios and the charts that were created in Exercise 1. Right-click on the **Non-Spatial Example** Library and rename it “Exercise 2”.

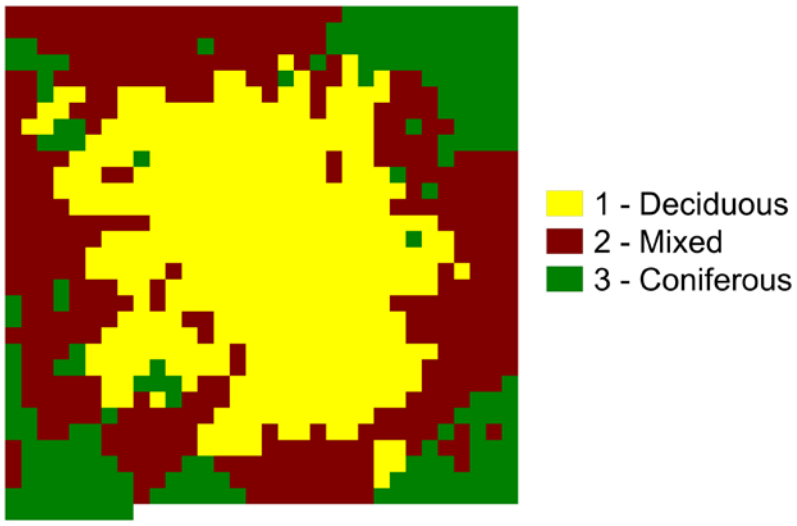
3. For this exercise, you will only be working with the harvest scenario, so you can delete the **No Timber Harvest** scenario from your **Exercise 2** Library. To do this, right-click on the scenario name and select *Delete* from the context menu. Click **Yes** when prompted for confirmation.

Task 2 – Set up definitions for spatial simulations

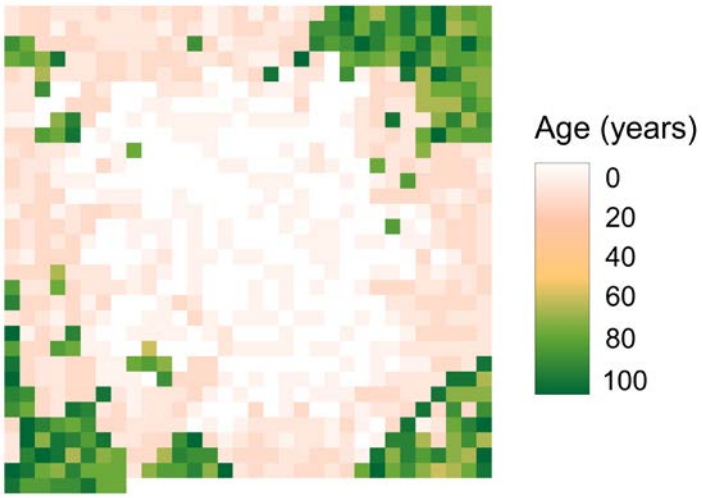
In this exercise we will be specifying our initial conditions using raster maps. In this task we will look at each of these maps and then set up our Library definitions to be able to correctly interpret each of them.

All raster files in this exercise are provided in GeoTIFF format. The first raster file (called **initial-stratum.tif**) defines the spatial bounds of the entire study area for our simulation. As displayed below, this raster defines a landscape that is almost square, is 1,000 hectares in size, and has 1,000 cells. Every cell in the raster is also assigned a value of 1. We will eventually use this raster to define our **Primary Stratum** in ST-Sim (recall that we previously defined a single Primary Stratum called *Entire Forest* to represent the entire study area).

A second input raster file (called **initial-age.tif**) of exactly the same size and shape as the previous raster, specifies the initial forest type of each cell in our landscape (see below). In this raster a value of 1 represents Deciduous, 2 represents Mixed, and 3 represents Coniferous. Note that the proportion of cells in each forest type in this raster exactly matches the landscape totals provided in the previous non-spatial exercise (i.e., 40% Deciduous, 40% Mixed, and 20% Coniferous).

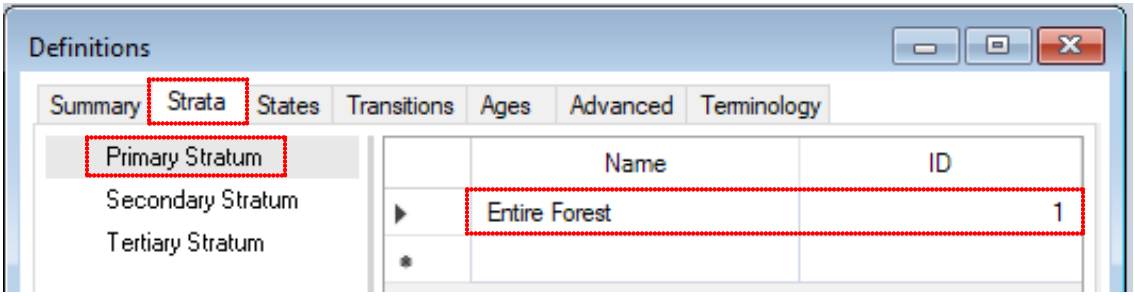


The last input raster file (called **initial-age.tif**) specifies the age of each cell (again with the same size and number of cells as the previous raster). This age raster also matches the landscape totals in the previous non-spatial exercise (i.e., 40% age 0-9, 40% age 10-19, and 20% age 60-100).

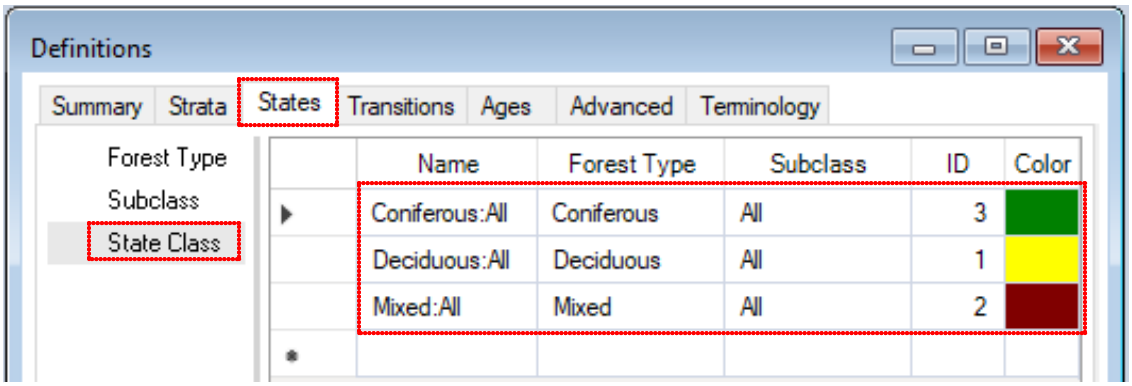


In order to use these maps to specify our initial conditions spatially in ST-Sim, we first need to modify a few of our previous model definitions. The next few steps will be telling ST-Sim how to interpret the values in each of these rasters.

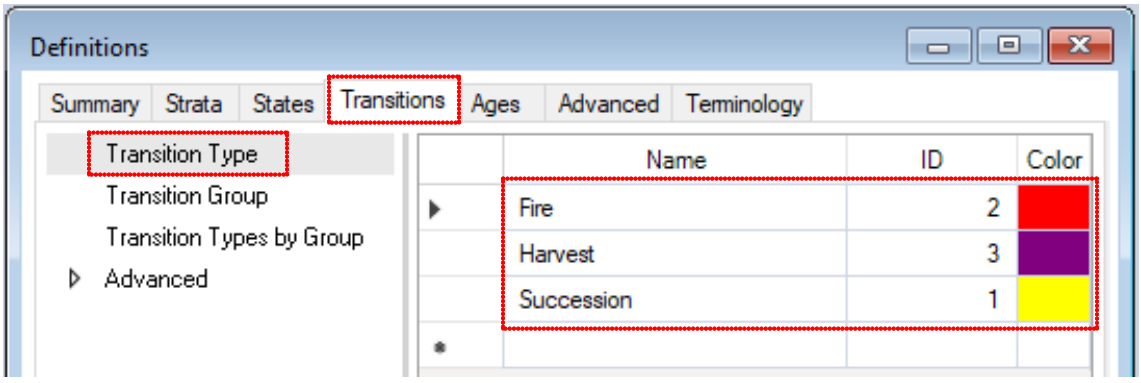
1. Double-click on **Definitions** for your **Exercise 2** Library**.** In the **Definitions** window, navigate to the **Strata** tab and click on **Primary Stratum** on the left sidebar. Right-click on the table and add an **ID** column**.** Set the ID of *Entire Forest* to *1*. This tells ST-Sim that a value of 1 on the Primary Stratum raster represents the cells that are within the study area.



2. Switch to the **States** tab and click on **State Class** on the left sidebar. Right-click on the table and add an **ID** and **Color** column. For *Coniferous*, set the ID to *3* and the color to *green* (double-click to open the color palate). For *Mixed*, set the ID to *2* and the color to *burgundy*. For *Deciduous*, set the ID to *1* and the color to *yellow*. Now when you load your State Class map, every cell that has a value of 3, for example, will get initialized to the Coniferous forest type.



3. Switch to the **Transitions** tab and click on **Transition Type** on the left sidebar. While there are no input maps of transitions, we will eventually be generating output rasters for each transition type. Here we will be associating a value and color to display for each transition. Right-click on the table and add an **ID** and **Color** column. For *Fire*, set the ID to *2* and the color to *red*. For *Harvest*, set the ID to *3* and the color to *purple*. For *Succession*, set the ID to *1* and the color to *yellow*. Close the **Definitions** window and **Save** your work.



Task 3 – Create a new spatial scenario

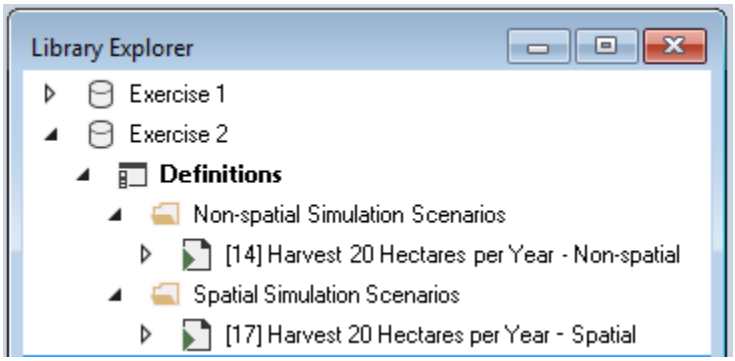
You will now import the raster data so you can run the model spatially. The simplest way to do this is to edit a copy of the existing non-spatial harvest scenario.

1. To start we will create a new folder within our Library in which to store the existing non-spatial scenario for safe-keeping. Right-click on **Definitions**, select *New* | *Folder* and name it "Non-spatial Simulation Scenarios". Click **OK**.

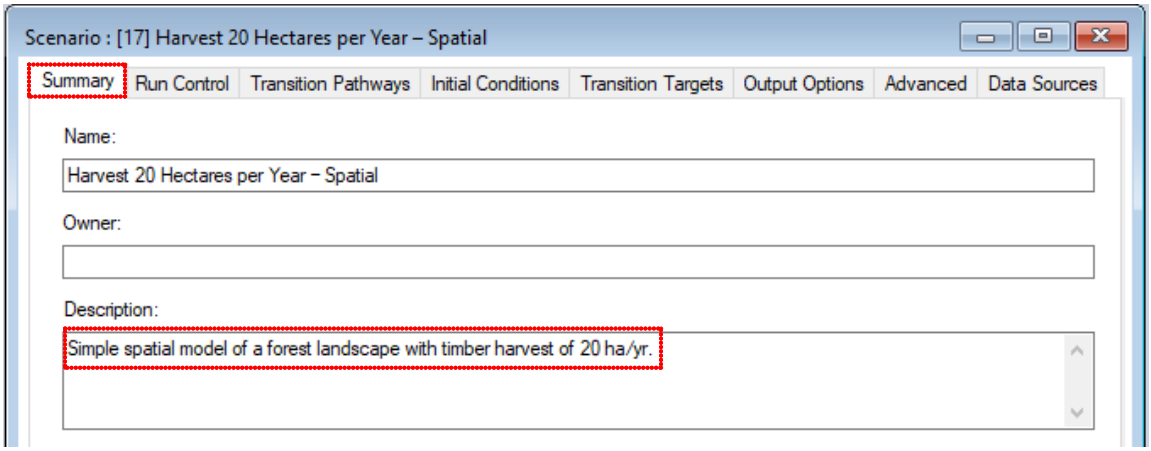
2. Rename the existing harvest scenario to "Harvest 20 Hectares per Year - Non-spatial" (right-click, *Rename*, add "Non-spatial" to the end, then click **OK**). To move this scenario into the folder you just created, click and hold the left mouse button and drag the scenario into the folder.

3. Next create another new folder (right-click on **Definitions** as you did in Step 1) and call it "Spatial Simulation Scenarios".

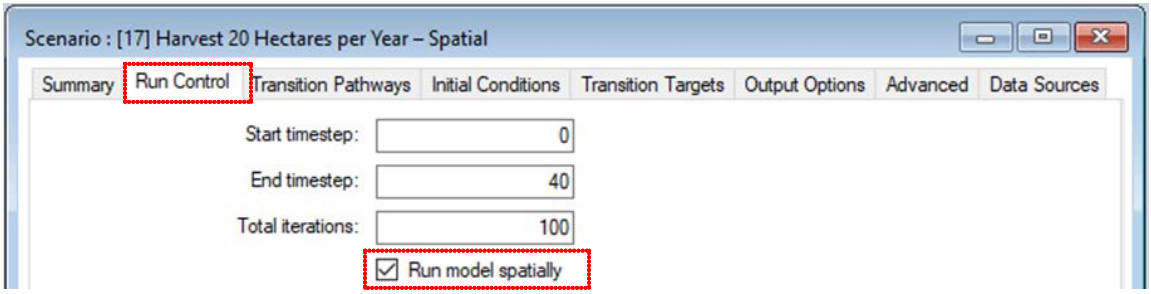
4. Expand the **Non-spatial Simulation Scenarios** folder to show the previous non-spatial scenario inside it. Right-click on the scenario name and select *Copy* from the context menu. Right-click on the **Spatial Simulation Scenarios** folder and select *Paste* to put a copy of the non-spatial scenario into the folder. Before making any modifications to this scenario, *Rename* the copy to "Harvest 20 Hectares per Year – Spatial" (i.e., change "Non-spatial" to "Spatial").



5. We will now edit this new scenario to make it spatial. Right-click on the scenario **Harvest 20 Hectares per Year – Spatial** and select *Properties*. On the **Summary** tab, modify the **Description** to indicate that the scenario is spatial and that there will be some harvest.

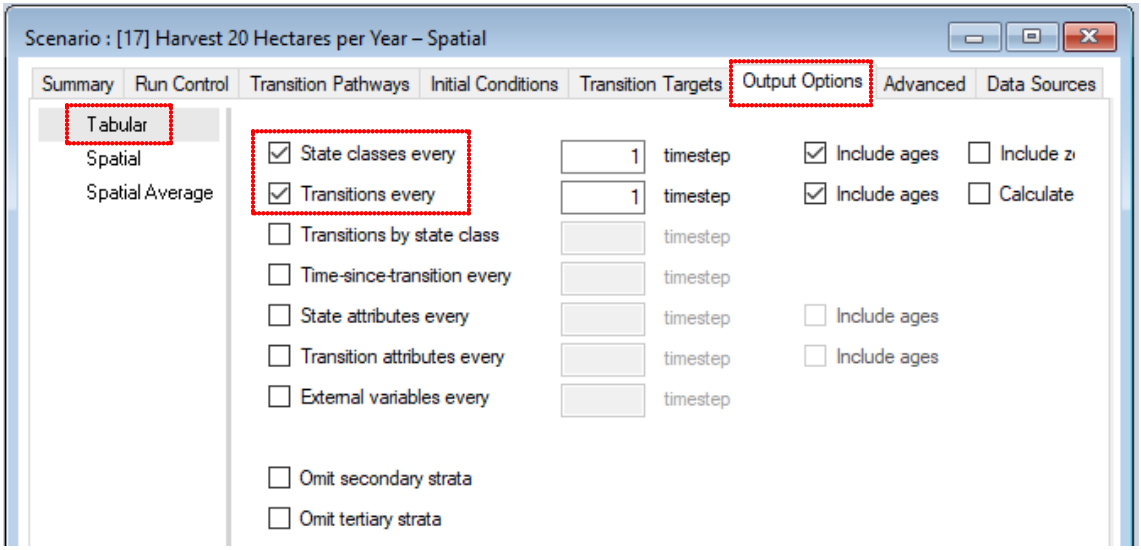


6. Switch to the **Run Control** tab and select to run the model spatially by checking the **Run model spatially** box.

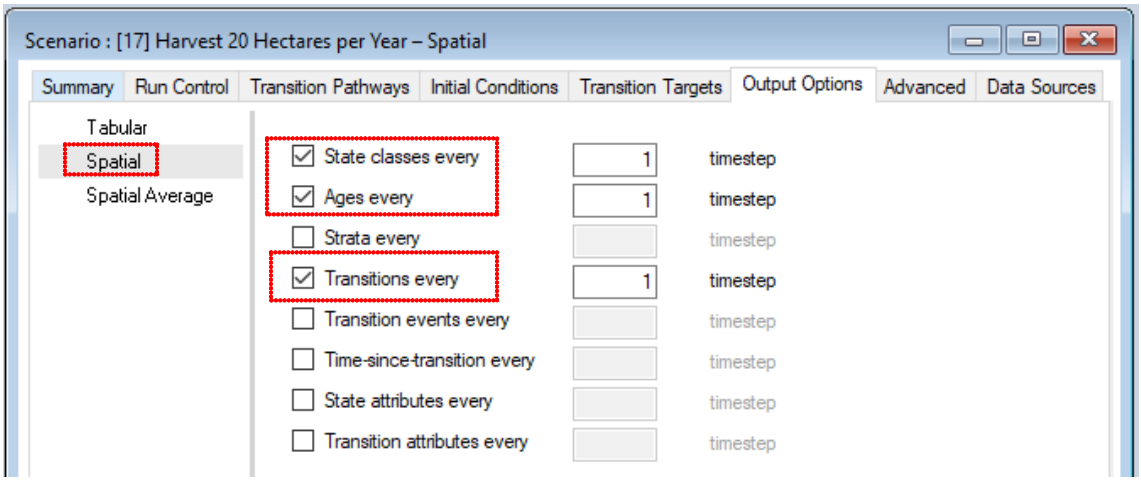


7. When we ran this model non-spatially in the previous exercise, we specified the initial distribution of each of the three forest types (and ages) across the landscape (using the **Initial Conditions** tab). Take a moment to review these values (we will modify them in the next Task).

8. Switch to the **Output Options** tab. For the non-spatial run in the last exercise, we did not explicitly define what model outputs we wanted over time. For our spatial run, we want to see a **Tabular** output for *State classes every* timestep and *Transitions every* timestep. Note that the *Include ages* boxes get checked automatically.



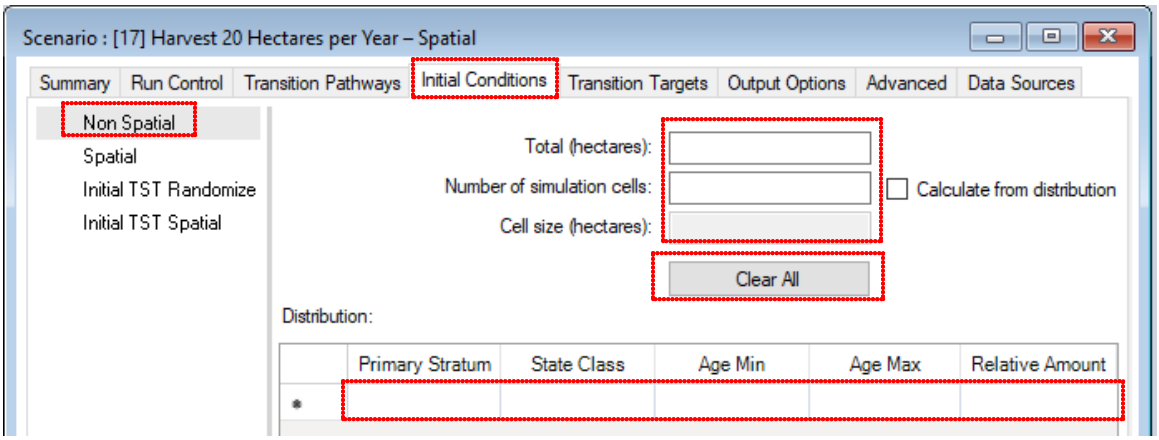
9. Switch to the **Spatial** node on the left sidebar. In the checklist, select outputs for *State classes every* timestep, *Ages every* timestep, and *Transitions every* timestep. Close the **Scenario** window and **Save** your work.



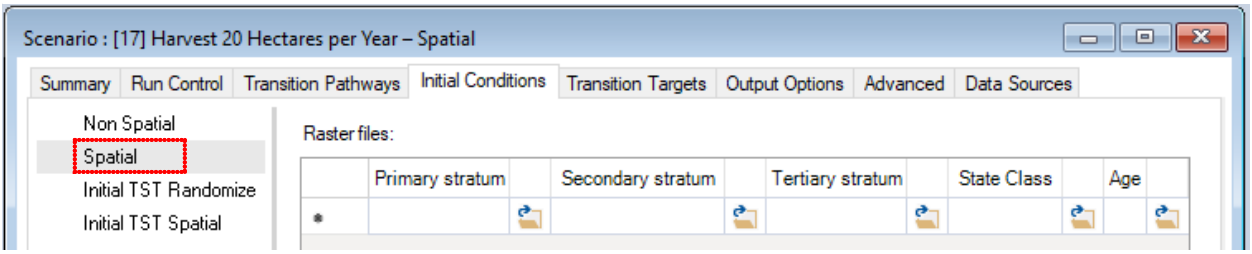
Task 4 – Define initial conditions using maps

The last change we need to make to our new spatial scenario is to the way the initial conditions are specified.

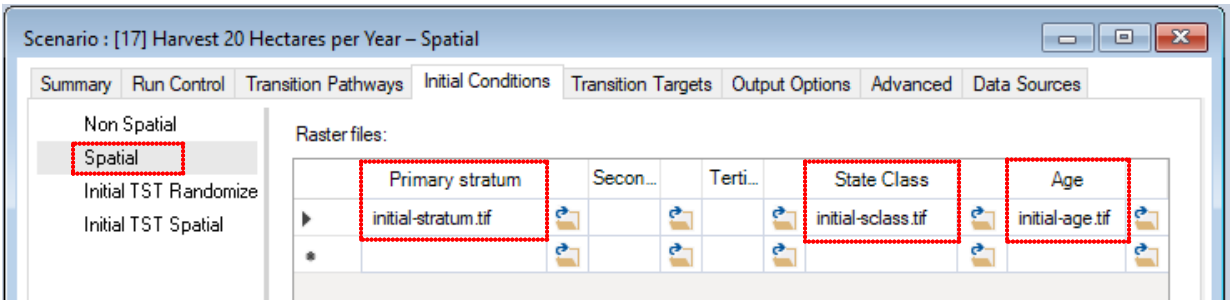
1. Open the scenario **Harvest 20 Hectares per Year – Spatial** again, and click on the **Initial Conditions** tab. In the last exercise, you used the **Non Spatial** node on the left sidebar to initialize your landscape to be 1,000 hectares in size, with 1,000 simulation cells, and a specific distribution of forest types. As you will be using maps to initialize your landscape in this exercise, you may delete the existing information in this tab. First, right-click on any one of the cells in the **Distribution** table and select *Delete All*. Next, click the **Clear All** button above the table to remove the information on landscape and cell size.



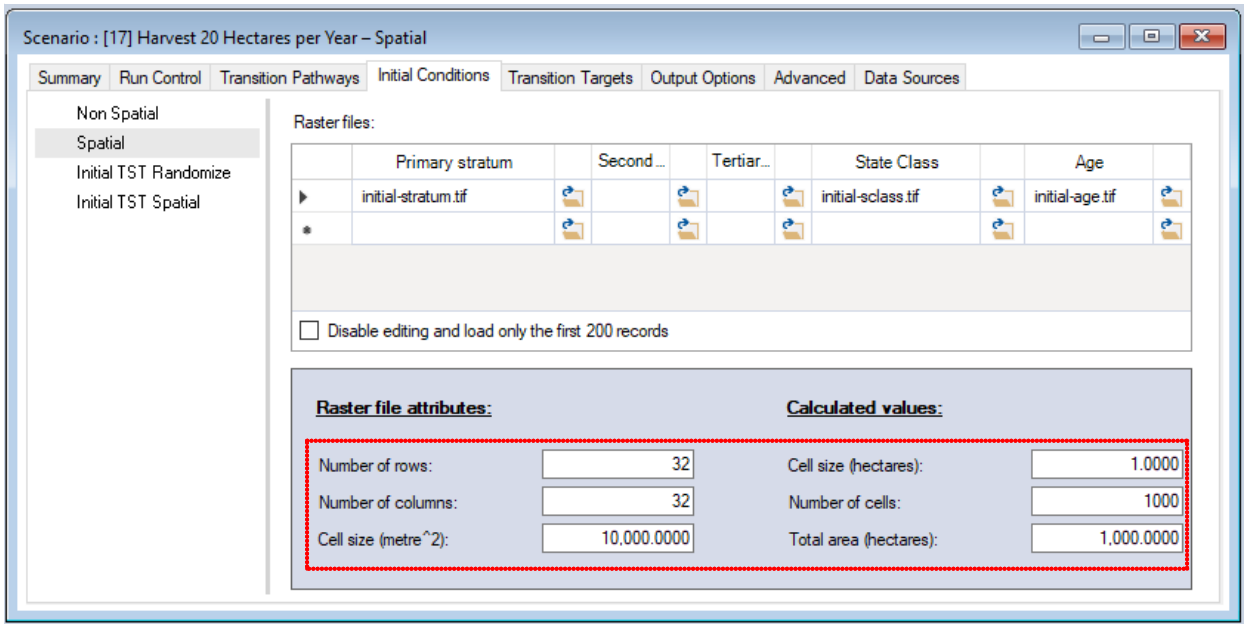
2. On the left sidebar of the **Initial Conditions** tab, now click on the **Spatial** node; this is where you can navigate to the different raster files that you need to load. Note that you do not need to have raster files for every field in this table (only the Primary Stratum and State Class rasters are required). For this exercise, you will load raster files for Primary Stratum, State Class and Age.



3. The next step is to load these files into your model. On the **Spatial** node of the **Initial Conditions** tab, click on the folder icon beside **Primary stratum** in the table. Navigate to your **Course\Exercise 02 \Files** folder and select the **initial-stratum.tif** file. Click **Open** to load the file. Repeat this process for the **State Class** and **Age** raster files.



4. Click in any cell in the bottom pane of the window to automatically populate the fields there according to the information in the raster files just loaded.



5. Close the **Scenario** window and **Save** your work.

Task 5 – Run the model and view results

1. Before running your current spatial model, first run the **Harvest 20 Hectares per Year – Non-spatial** scenario. The results generated will automatically be added to your **States and Transitions** chart.

2. Right-click on the scenario called **Harvest 20 Hectares per Year – Spatial** and select *Run*. When done, close the **Run Monitor**. The results for this scenario run will be shown immediately on the **States and Transitions** chart, along with the results for the first scenario.

   Your charts should look something like this:

Note that both scenarios look almost identical to each other. This makes sense as both scenarios begin with the same initial conditions at timestep zero.

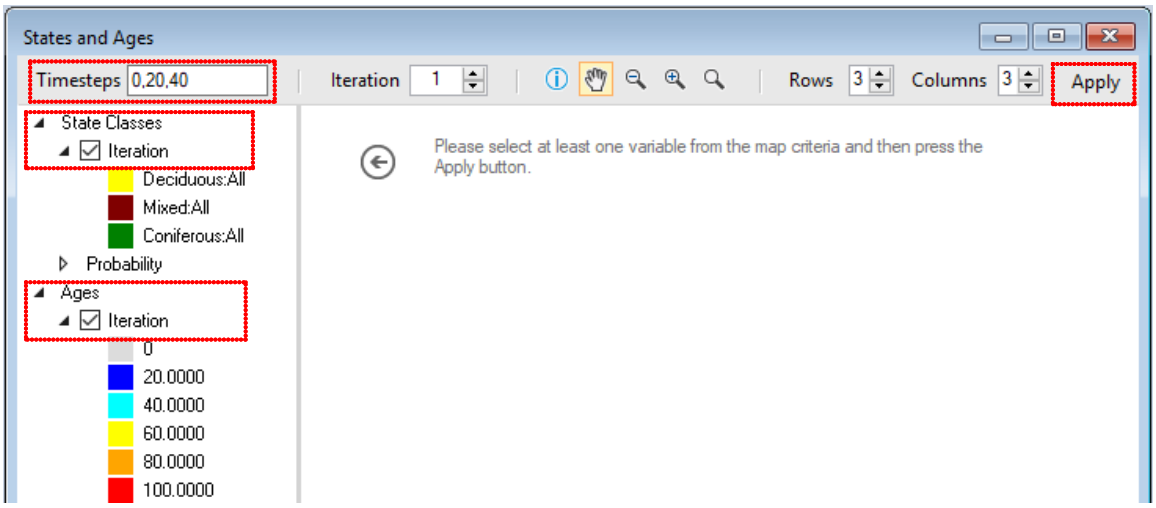
What do you notice about the Harvest Transition Area graph? Is the 20 hectare per year harvest target sustainable over 40 years?

Looking at the Coniferous, Deciduous, and Mixed State Class graphs, what trends do you notice between these three forest types?

Close the **States and Transitions** chart window. Right-click on the non-spatial results again and select *Remove from Results*. Note that this action does not delete these results; it simply removes them from the output charts/maps.

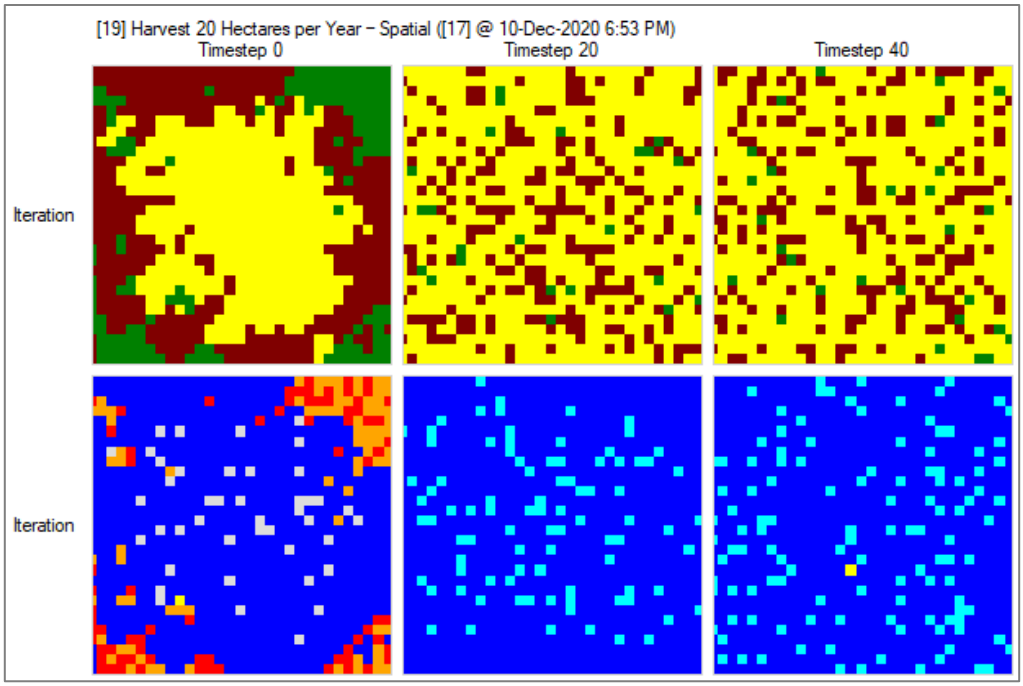
3. To view maps generated from your spatial simulation, click on the **Maps** tab and create a new map (by clicking on the icon) and call it “States and Ages”. Click **OK**.

4. In the left sidebar of the **States and Ages** map window, expand the **State Classes** node and click on the *Iteration* checkbox. Expand the **Ages** node and click on the *Iteration* checkbox. To see these values change over time, in the **Timestep** field at the top of the window enter *0,20,40* where 0 represents our initial conditions, 20 is half-way through the simulation, and 40 is the end of the simulation. Click **Apply**.



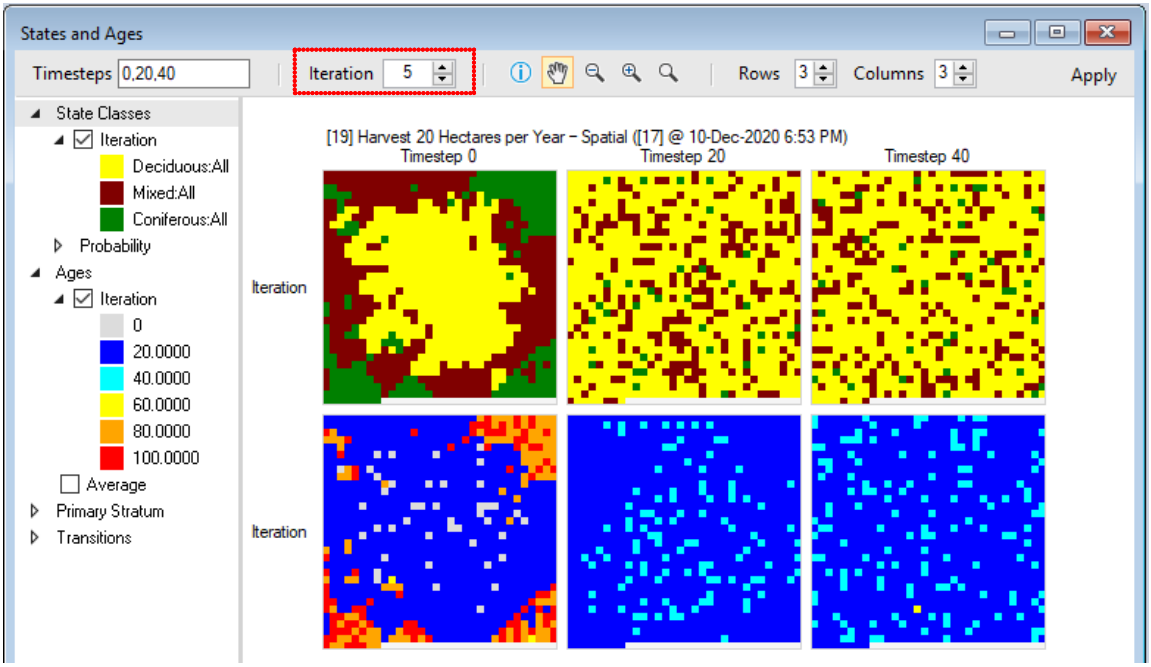
5. The maps that appear represent the results from the spatial scenario that used input maps to initialize the landscape. The first row shows maps of **State Class** for each simulation cell and the bottom row shows maps of forest **Age**. The legend on the left sidebar shows the different colors used by the model to represent the state classes and ages in the maps.

   Your maps should look something like this:

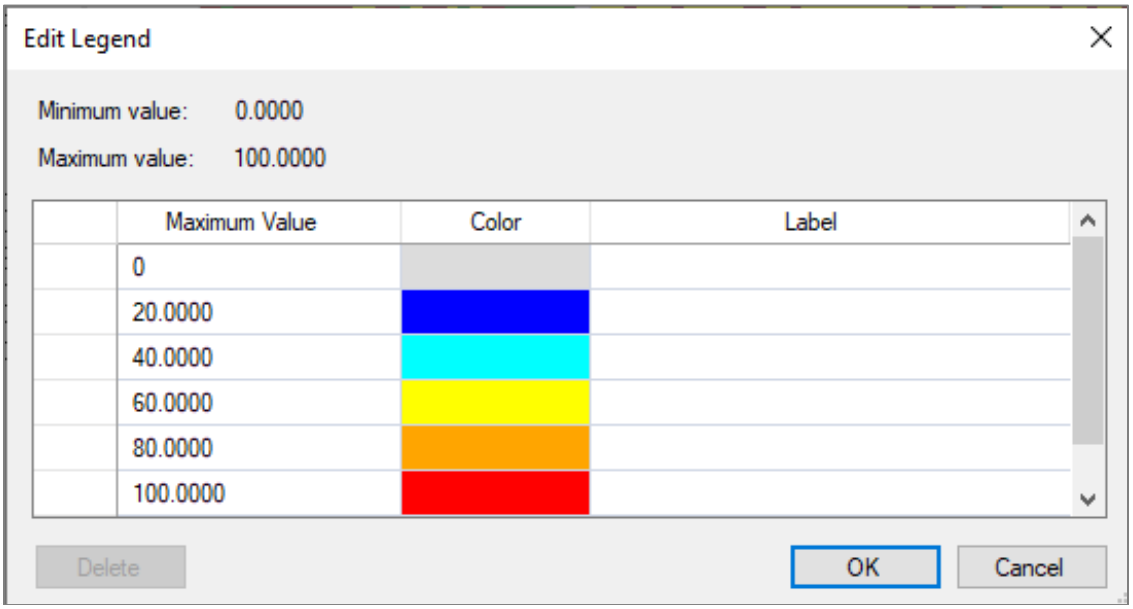


How would you describe the State Class and Age distribution patterns on your landscape in Timestep 0? How do these patterns differ from Timestep 20 and Timestep 40?

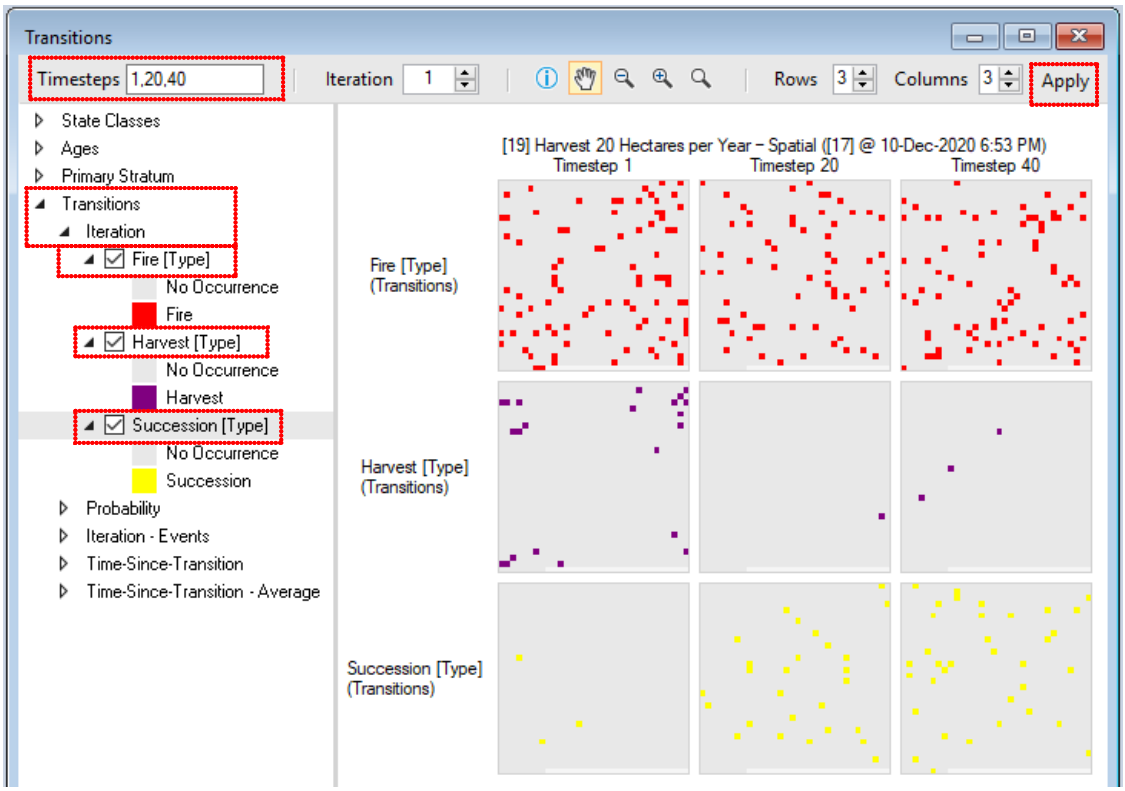
These maps are presently showing just the first Monte Carlo realization for the simulation. You can scroll through the Monte Carlos using the up and down arrows beside the **Iteration** field at the top of the map.



6. You may choose to change the colors used in the maps by editing the Legend. To do this, double-click on one of the colors in the **Ages** node to open the **Edit Legend** window. Double-click on the color you wish to change, e.g., 20 (years), and select a color from the color palate. Click **OK** to close the palate and close the **Edit Legend** window. Back on the map, click **Apply** to update the Legend to use the new color.



7. Close the **States and Ages** map. The next map that we want to create is one that will show the transitions that occur over time. On the **Maps** tab, create a new map called **Transitions**. In the left sidebar of the map window, expand the **Transitions** node, then the *Iteration* node, and select all three transitions (*Fire*, *Harvest*, and *Succession*). Set the **Timesteps**to*1*, *20* and *40*. Click **Apply**.



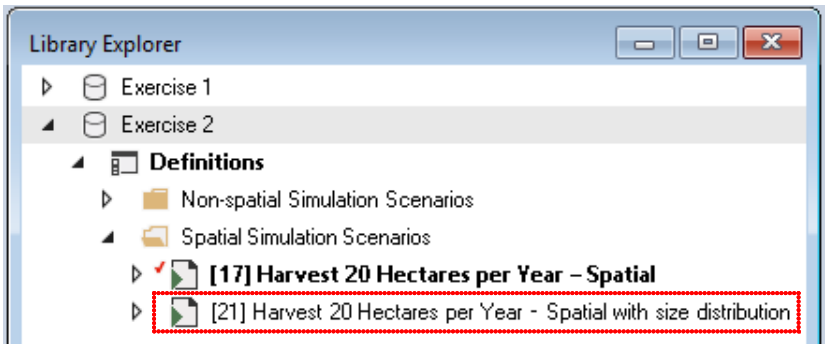
Your map will show cells that transition according to Fire in the top row, Harvest in the second row, and Succession in the third row for Timesteps 1, 20 and 40. Like the **States and Ages** maps, you can scroll through different iterations in the **Transitions** maps and edit the Legend.

How would you describe the patterns for Fire, Harvest, and Succession transitions across the landscape?

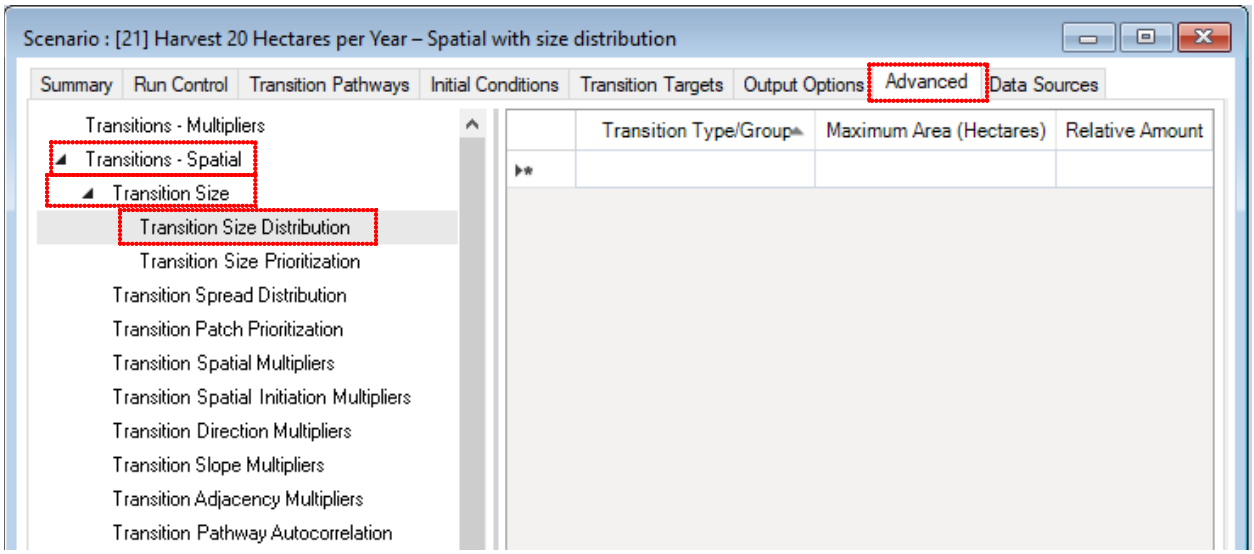
Task 6 – Define transition size distributions

The random pattern for Fire transition produced by the last simulation is unrealistic, as a fire event typically starts with an ignition point and then spreads to neighboring cells. In this task you will learn how to specify spatial patterns for how transitions occur within a simulation. Keep the **Transitions** map window open and click **Arrange All** on the SyncroSim toolbar ( ).

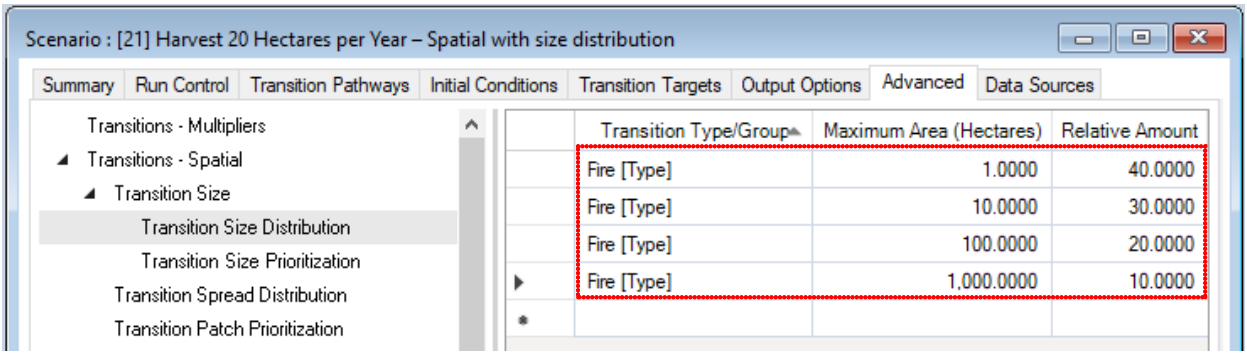
1. Start by making a copy of the scenario **Harvest 20 Hectares per Year – Spatial** and pasting it into the same folder (**Spatial Simulation Scenarios**). Open (double-click) the scenario and rename it “Harvest 20 Hectares per Year – Spatial with size distribution”.



2. Switch to the **Advanced** tab. Expand the **Transitions – Spatial** node, expand the **Transition Size** node, and click on **Transition Size Distribution**.

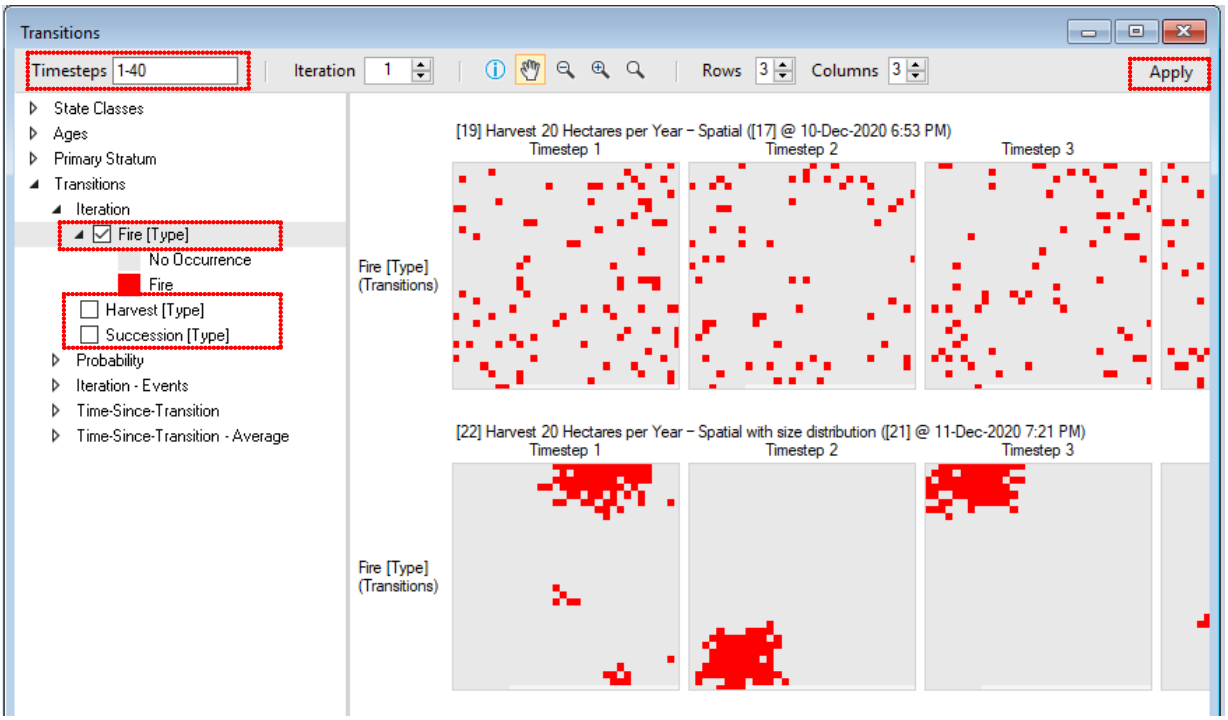


3. In the table on the right, define a frequency distribution for the size of fire events on the landscape. In the **Transition Type/Group** field, select *Fire*. Enter *1* for **Maximum Area (Hectares)** and *40* for **Relative Amount**. This means that 40% of fire events on the landscape will be between 0 and 1 hectare in size. In the next three rows of the table, enter values so that*30%* of fires on the landscape will be from *1 to 10* hectares in size, *20%* of fires will be from *10 to 100* hectares in size, and *10%* of fires will be from *10 to 1,000* hectares in size.



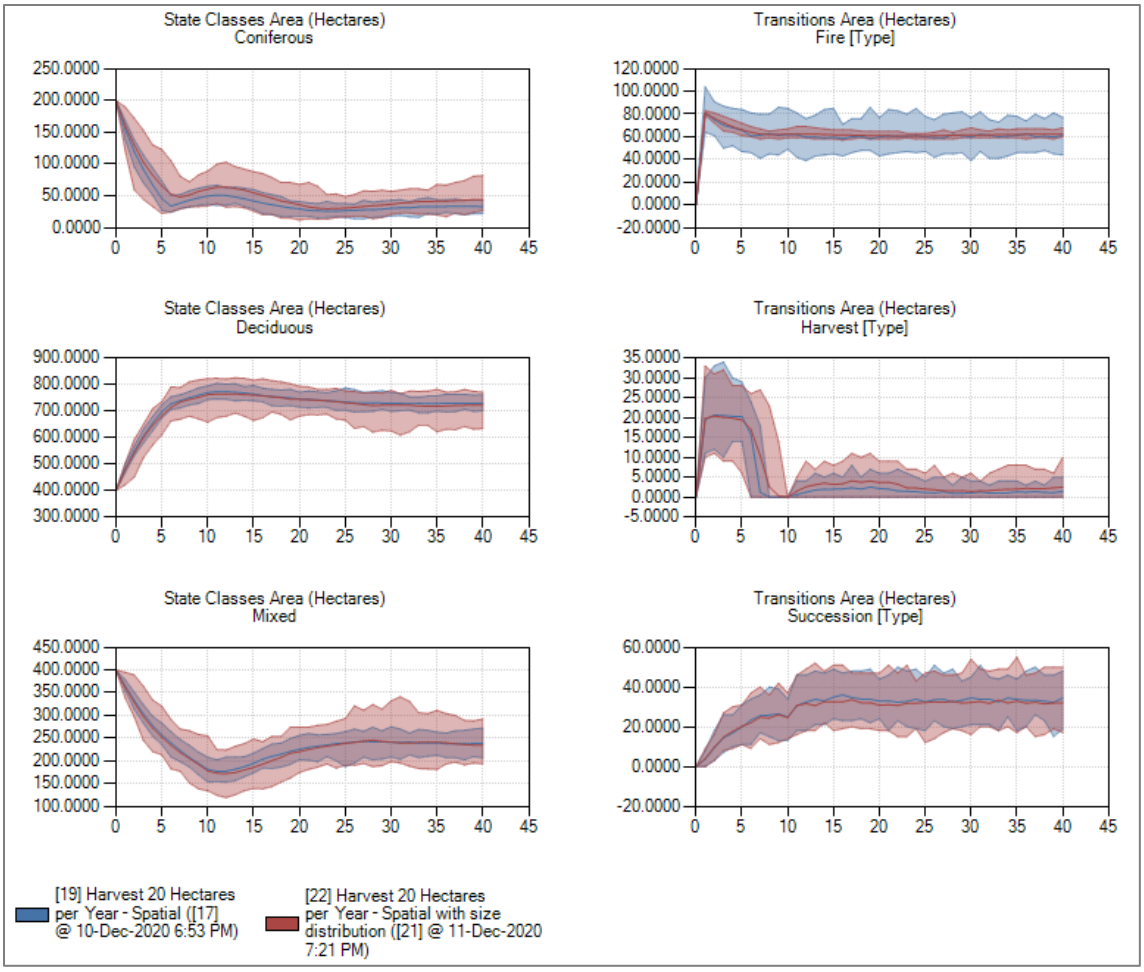
4. Close the **Scenario** window. **Save** your work and **Run** the scenario. When the run is done, close the **Run Monitor**.

5. As before, the results of the latest run immediately populate the map that is presently open. This time, we want to focus on the Fire transition, so start by turning off the Harvest and Succession transitions. Set the **Timesteps** to *1-40*. Click **Apply**. By comparing the two scenarios in this map, you can see that the scenario with a defined fire size distribution shows fire events rather than individual cells transitioning.



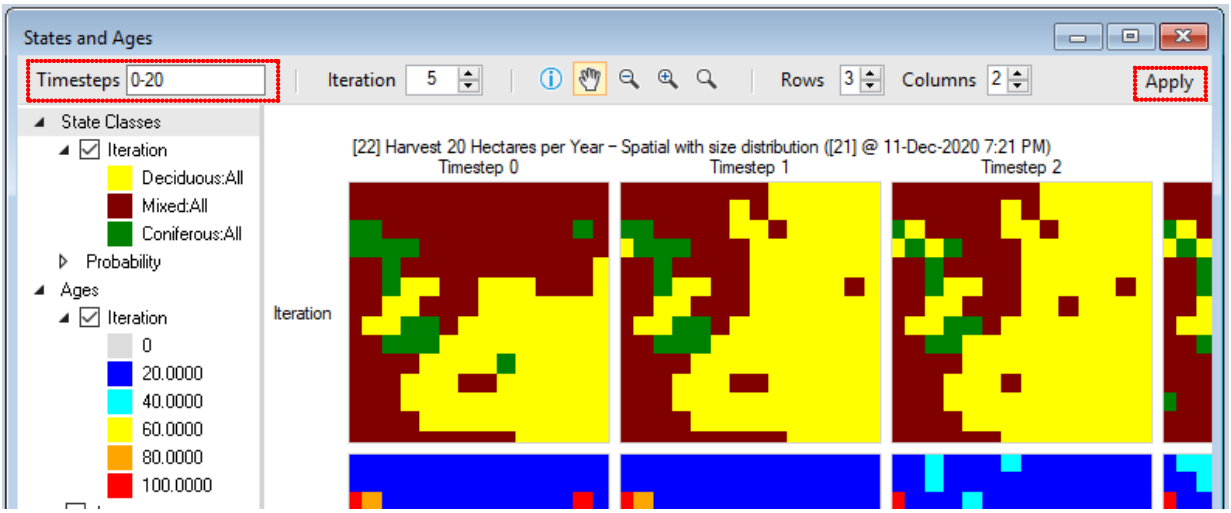
6. Close the **Transitions** map and **Save** your work. Click on the **Charts** tab and open the **States and Transitions** chart. Click on **Arrange All**.

   What differences do you notice between the two spatial runs?



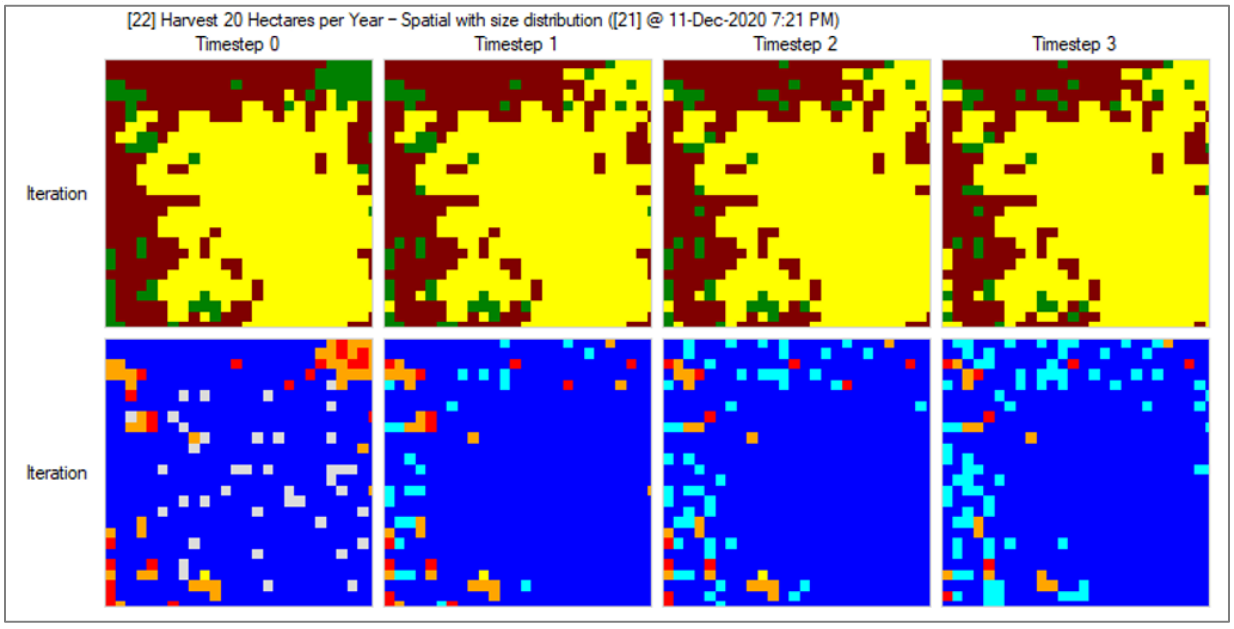
7. Close the **States and Transitions** chart window. Before opening the **States and Ages** map one last time, remove the results for the first spatial scenario (**Harvest 20 Hectares per Year – Spatial**).

8. Open the **States and Ages** map and click **Arrange All**. Show only the first 20 timesteps of the simulation by entering*0-20* in the **Timesteps** field and click **Apply**.



9. Slide the scroll bar at the bottom of the window back and forth to view all timesteps from 0-20.

   What changes do you notice across the landscape?



10. **Save** your work and close the Library (**File | Close All**).

Answers to Questions

Exercise 1: Task 4

What is the effect on the composition of the landscape of adding timber harvest? Why does the amount of timber harvest change over the course of the simulation?
Adding harvest reduces the amount of conifer forest on the landscape in the early years (i.e. up to about year 15), with a corresponding increase in the amount of deciduous forest for this same period. By year 15, however, the composition of the landscape is very similar for both scenarios. This is because the target level of 20 ha/yr of harvest, which occurs only in older conifer forests, leads to a transition from conifer to deciduous. However by year 7 there is no older conifer left on the landscape (due to the previous years' harvest) so the harvest drops to zero, and thus the two scenarios act similarly from this point onwards.

Bonus Question: Try running a scenario in which you assume that fire suppression is able to double the fire return interval for the landscape (Hint: probability = 1 / return interval). What effect does the model say this management action would have on the future composition of the landscape? How would harvest be affected by this change?
We can represent doubling the fire return interval in the model by halving the fire transition probabilities. If we do this we see that there is far more conifer and mixed forest left on the landscape, with a corresponding reduction in the amount of deciduous forest. The amount of harvest is thus able to increase due to the increase in available older conifer forest that is no longer disturbed by fire.

Exercise 2: Task 5

What do you notice about the Harvest Transition Area graph? Is the 20 hectare per year harvest target sustainable over 40 years?
The level of harvest drops from its target of 20 ha/yr to zero around Timestep 7. It then rises again to a level of less than 5 ha/yr for the remainder of the simulation. This suggests that a harvest of 20 ha/yr is not sustainable for this landscape.

Looking at the Coniferous, Deciduous, and Mixed State Class graphs, what trends do you notice between these three forest types?
The stability of the state class area in the last 15 Timesteps of the simulation suggest that the landscape reaches an equilibrium by the end of the 40 Timestep simulation corresponding to the transition probabilities for Succession and Fire, combined with an equilibrium Harvest level of approximately 2 ha/yr.

How would you describe the State Class and Age distribution patterns on your landscape in Timestep 0? How do these patterns differ from Timestep 20 and Timestep 40?
In Timestep 0 the State Class and Age raster maps both show strong spatial-autocorrelation (i.e. clumpiness) in their distribution, as one would expect in the boreal forest. However by Timestep 20 and 40 the spatial autocorrelation disappears (i.e. the raster maps show a speckled distribution).

How would you describe the patterns for Fire, Harvest, and Succession transitions across the landscape?
The maps of projected transitions also show no spatial autocorrelation (i.e. they are speckled), which for Fire and Harvest does not seem appropriate.

Exercise 2: Task 6

What differences do you notice between the two spatial runs?
The original spatial simulation (with no size distribution specified for Fire) shows no spatial autocorrelation – i.e. the cells burned appear to have been selected randomly. In contrast, the simulation with a size distribution shows strong spatial autocorrelation in the distribution of burned cells across the landscape.

What changes do you notice across the landscape?
The landscape becomes increasingly Deciduous and younger as the simulation progresses.