
HEC-EFMSim Workshop

Simulation of Stationary and Mobile Communities

Objective

In this workshop, you will use EFMSim to investigate spatial and temporal aspects of stationary and mobile ecological communities.

Background

EFMSim is a new software tool that uses spatial and temporal data layers to predict changes in ecological communities. It allows modelers to test the effects of land management practices, water management decisions, water quality concerns, and any other spatial and temporal variable of interest.

Simulating ecosystems in time and space is complicated. The following steps are needed to apply EFMSim: define study area, create layouts by splitting study area into collections of elements, import data, create variables based on data, define communities, create rules to govern communities, and, finally, simulate and view results. In the interest of time, several of these steps have been done for you.

This workshop focuses on four ecological communities of interest: Cottonwood trees - a key tree species for western riparian forests, Delta smelt - an endangered species of fish that inhabits a stretch of river being considered for restoration, and a prey-predator simulation showing the interaction of rabbits and grass.

Part 1 of this workshop focuses on cottonwood recruitment. Part 2 investigates delta smelt movement. Part 3 involves two communities – grass and rabbits.

Part 1: Simulating Stationary Ecological Communities

In this part of the workshop, you will define the communities to be simulated, the rules that govern their behavior, run the simulation and analyze results. The define study area, layout setup, data import and variable creation steps have already been completed.

Getting Started

Open the project and review the information that has already been entered.

- Open HEC-EFMSim.



- Use the **"File | Open Project"** menu option to open an HEC-EFMSim project named **Cottonwood_2020.prj**. It is located at **C:\Workshops\EFMSim\Cottonwood_2020** (or in a location determined by the workshop facilitator).

- ☑ To open the layout interface...
 - Click the **Layouts** button on the left hand side of the interface (or select the **"Windows | Layouts | All"** menu option if the button is not visible).
 - The outline of the Study Area should be visible. In the **Layout Map** tab, navigate to the **"Layouts | Open"** menu option.
 - Select **Layout1** and click **OK**.
 - Use the **Zoom** tool to get a better look at the Study Area (left click and drag a window to zoom in and right click to zoom out).

Note: The river riparian zone is parsed into a grid of 45'x45', while the more upland terrestrial area has a 90'x90' grid.



- ☑ Data interfaces are comprised of: **Data Import** tables, **Data Controls**, and **Create Variables**...
 - Click on the yellow-green **Data** button on the **Control Panel** (usually on the left-hand side of main interface).
 - Review the contents of the **Data Import** tables...
 - "Elevation" is a constant data set of topography for the study area.
 - "WSE_today" and "WSE_yesterday" are regular data sets comprised of daily simulated water surface elevations produced by an unsteady river hydraulics model.

Note: **Data Import** tables allow users to import the spatial and temporal data to be used in simulations. EFMSim can import data sets that do not change with time (i.e., "constant"), change sporadically with time (i.e., "irregular"), or are available at each time step (i.e., "regular").

- Review settings in the **Data Controls** tab...
- A data controls set named "Centroid" has been created with the centroid option selected for both raster and feature class data.

Note: **Data Controls** determines how imported data are snapped to elements in the model layout. For example, the centroid option assigns values to elements based on the data

value that occurs at the centroid of each element. The interface also allows users to specify different methods for individual data sets via exceptions.

- Review settings in the **Create Variables** tab...
- The "depth_today" and "depth_yesterday" variables have been created using the variable calculator and will be explained in the following sections.

Note: **Create Variables** allows modelers to make variables based on imported data sets. These variables are then available when defining rules for communities. This is useful when community dynamics are indirectly related to imported data (eg, a species of plant may need to be inundated for more than one day before it is stressed or experiences mortality).

With layouts and data tasks complete, we are ready to begin entering ecological info. This is actually an important transition during EFMSim applications. It marks the point at which it makes sense to tell the software to "Prepare for Simulation". When this command is issued, the software will populate its database with the values needed for simulation. Processing time is proportional to the number of elements in each layout as well as the amount of data imported and variables created. For the purposes of this workshop, the project has already been prepared for simulation.

Making Communities and Using Rules

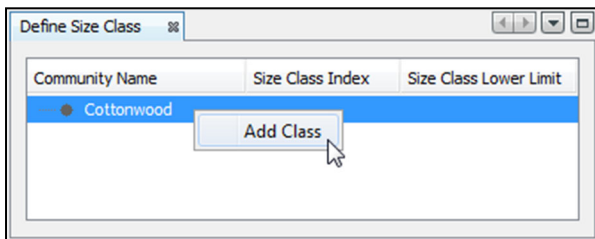
Next, use the Community interfaces to create the Cottonwood community and size classes and then use the Logic interfaces to define recruitment and growth rules for Cottonwoods. In riparian areas, cottonwood seedlings begin to grow in areas of newly exposed river substrate. We will use this information to define a recruitment rule that initiates seedlings in areas that were wet yesterday and are dry today.

- To define the Cottonwood community...
 - Click on the green **Communities** button on the left...
 - Select the **Communities** tab.
 - Input the following information into the Communities table.
 - **Name:** Cottonwood
 - Level: 0
 - Size Variable: height
 - Size Units: feet

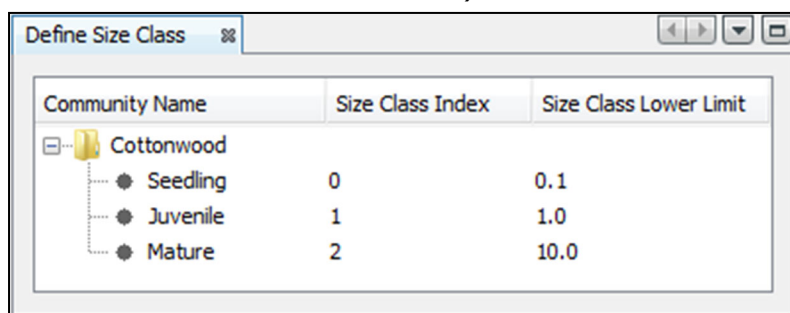
Communities ☒			
Name	Level	Size Variable	Size Units
Cottonwood	0	height	feet

- Click on the **Define Size Class** tab.




- Next, define three cottonwood size classes by first left-clicking to highlight the *Cottonwood* community name then right-clicking and selecting **Add Class**.

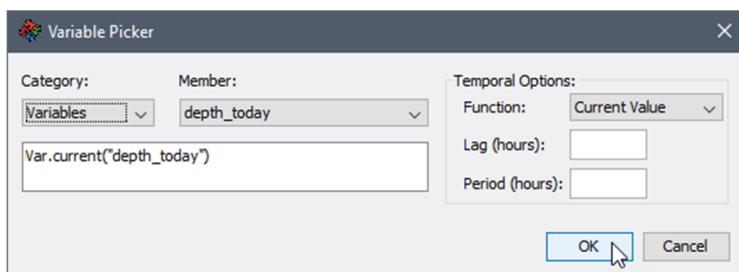


- Add three size classes: **Seedling**, **Juvenile** and **Mature** with size class lower limits of **0.1**, **1.0**, and **10.0**, respectively. (Hint: Double-click the added class to rename and enter the lower limits).



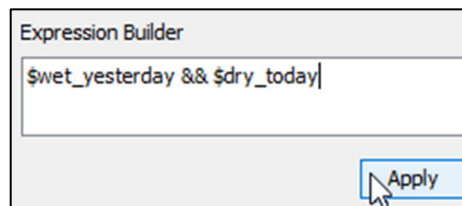
To define rules for the communities...

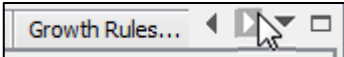

- Click the green **Logic** button on the left...
- Select the **Recruitment Rules** tab.
 - Create a new recruitment rule named **Recruit_Cottonwood** by clicking the **Add Rule**  button.
 - Assign the **Cottonwood** community by selecting it from the dropdown list.
 - The recruitment season should start on **05Jan** and end on **27Jan**.
 - In the **Data/Variables: Rasters** table, input the following data. In the second column click the cell to use the **Variable Picker**  (or double-click the cell) to select the variables "depth_today" and "depth_yesterday". Use the  button to add another line of input.

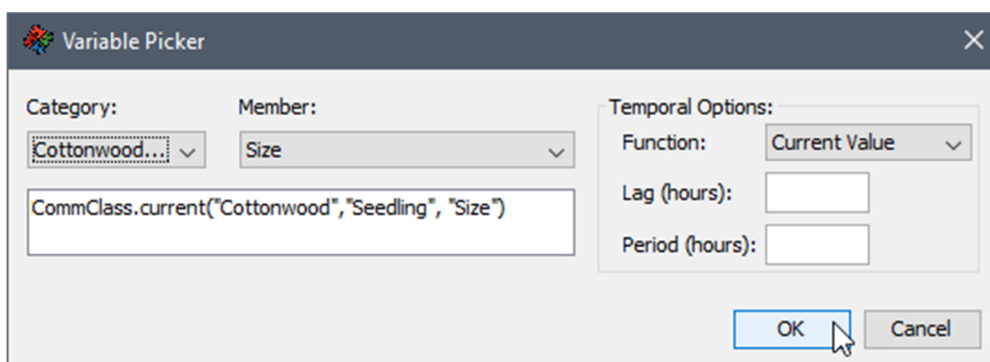
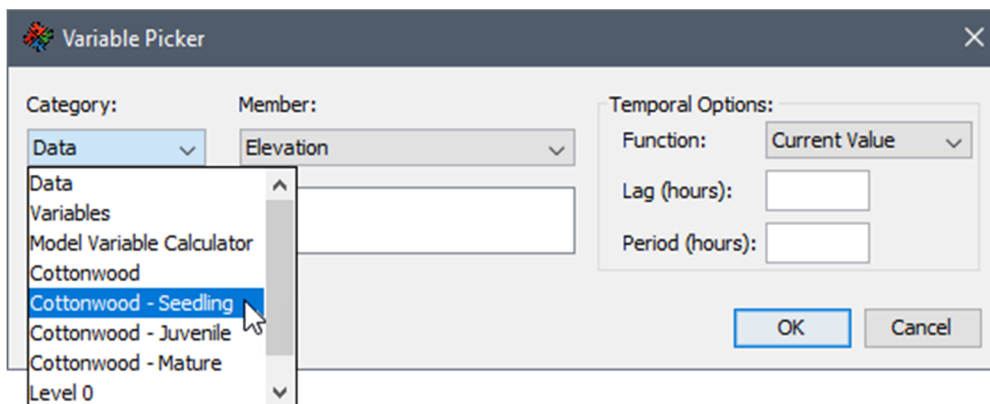


Data/Variables: Rasters					
dry_today	Var.current("depth_today")	<		0.0	- +
wet_yesterday	Var.current("depth_yesterday")	>		0.0	- +

- Under the **Expression Builder**, input the following equation.
Type carefully...
there is **a space** on each side of the double "&&". Variables and syntax must match exactly.



- Finally, click the **Apply** button on the bottom right hand side of the frame.
- Select the **Growth Rules** tab (may need to scroll ).
 - To create a new growth rule, named **Grow_Cottonwood**, click **Add Rule** .
 - Choose the **Cottonwood** community from the drop-down list.
 - Next, right-click in the empty space below the **Seedling** tab and select **Insert Row(s)...** and select **1** and click **OK**.
 - Use **07Jan** to **28Jan** for the timeframe.
 - Name the rule **Grow_Seedling**.
 - Select the **Equation** radio button and use the buttons to the right to input **CommClass.current("Cottonwood","Seedling","Size")+0.1**. The **VAR** button will allow you to pick a variable to insert. Click on the **VAR** button. Select **Cottonwood - Seedling** from the **Category** drop-down menu and select **Size** from the **Member** drop-down menu. Then click **OK**. Then use the buttons to enter "+0.1" in the **Equation** window. *Note: Please be sure to include the "0" in "0.1".*



- Click the **Set Value** button to assign the equation you just entered into the Value field.

Seasons

Seedling Juvenile Mature

From	To	Name	Value
07Jan	28Jan	Grow_Seedling	CommClass.current("Cottonwood", "Seedling", "Size")+0.1

Rate

Equation

CommClass.current("Cottonwood", "Seedling", "Size")+0.1

7 8 9 / ^
4 5 6 * (
1 2 3 -)
0 +/- . + VAR

Repeat these steps for the Juvenile and Mature size classes using similar names and values of:

CommClass.current("Cottonwood", "Juvenile", "Size")+0.5 and
CommClass.current("Cottonwood", "Mature", "Size")+1.0.

- Select the **Apply** button when you are finished.

Creating Alternatives and Simulations

With the rules complete, the next step is to build the alternative and simulation to be performed.

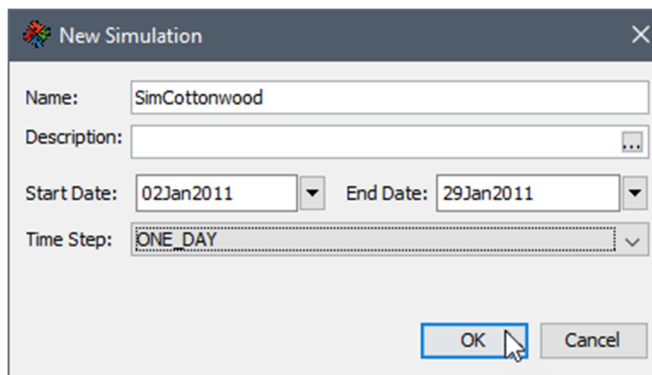
- Use the pink **Scenario Builder** button on the left to access the **Alternatives** tab.
- Make an alternative named **AltCottonwood**, choose the Cottonwood community (click **Edit** to open the **Select Communities** window) and select the layout and data control set discussed earlier.

Name:	Community	Boundary Condition	Layout	Data Control	Data Type	Hatchery Plan
AltCottonwood	Cottonwood		Layout1	Centroid		-

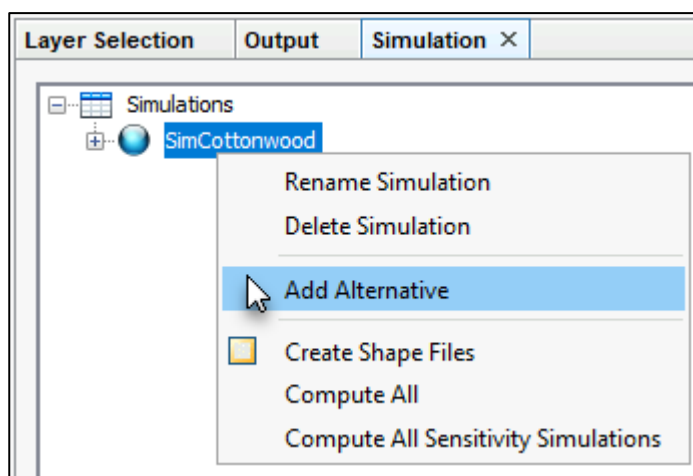
Now you are ready to simulate...

- Select the **"View | Simulation"** menu option from the top menu bar.

- Right-click on the Simulations tree, select **New Simulation**, and create a new simulation named **SimCottonwood** with a start date of **02Jan2011**, an end date of **29Jan2011** and a **ONE_DAY** time step. Click **OK**.



- Expand the Simulations tree, right-click on **SimCottonwood**.
 - Uncheck the **Create Shape Files** option, and select **Add Alternative**, highlight **AltCottonwood**, and click **OK**.



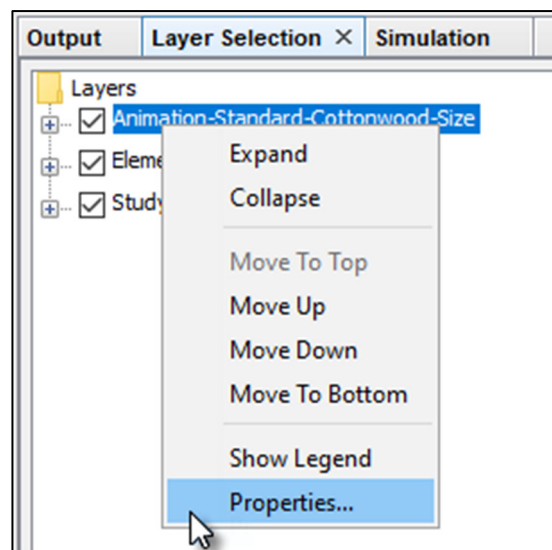
- To compute, right-click the **SimCottonwood** simulation and select **Compute All**.

- To view the progress of the simulation, click on the **Simulation** tab in the **Output** tab at the bottom of the screen. If the **Output** tab is not visible, navigate to **View | IDE Log** and it should appear at the bottom of the screen.

- Once the simulation is done, we must make the alternative active to view the results. To make the **AltCottonwood** alternative active, right-click on it and select **Set Map**. A red dot should appear next to the active alternative.

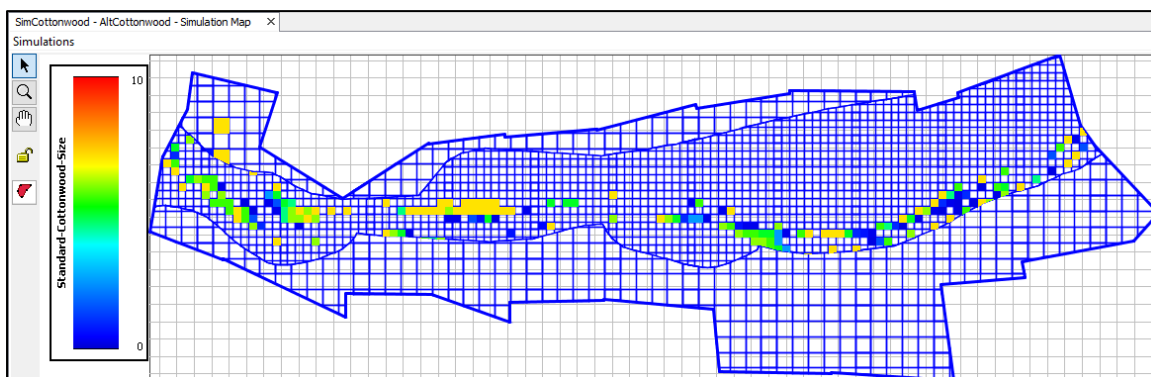
- Click the **View Animation** button (located at the bottom of the **Simulation** tab) to access the Animation Controls window.

- From the **Layer Selection** tab, right-click on the **Animation-Standard-Cottonwood-Size** layer and click **Properties** from the shortcut menu.

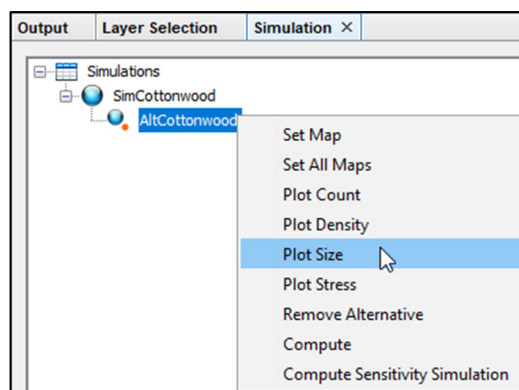


- From the **Properties** dialog from the **Properties** tab, in the **Contour Limits** panel uncheck the "System Specified Min/Max Values" option. Enter a Maximum of **10.0** and keep the Minimum at 0.1. Click **OK**.

- ☑ Hit the play button and watch your Cottonwoods recruit and grow. The last simulated condition should look like this. (*Hint: to add the legend, from the Simulation Map window, select the “Simulations | Show Legend” menu option*).



- ☑ Right-click the Alternative, **AltCottonwood**, and select **Plot Size**.



- ☑ Use the animation and size plot to answer the following questions.

- ◇ How tall did the Cottonwoods get?
- ◇ Why did the Max Size series change slope on 15Jan?
- ◇ Why is the Average Size series different than the Max Size series?

Part 2: Mobile Ecological Community Simulation

- ☑ In this part of the workshop, you will define rules that govern how a community named "delta_smelt" moves, run multiple simulations and analyze results. The study area, layout, data import, community definition and recruitment rule steps have already been completed. Further, an alternative and simulation has been created and run which recruits smelt as a stationary community. You will add a mobility component to the community simulation by creating three simulations: movement, movement through a medium and movement through a medium with density rules.

Getting Started

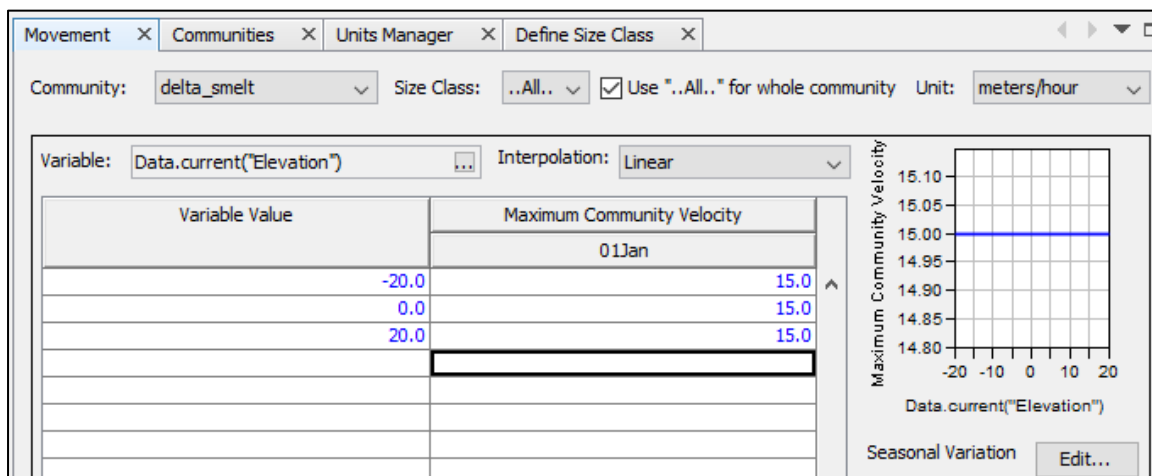


- ☑ Close **HEC-EFMSim** and then reopen the software *(this step is needed to clear the Cottonwood project)*.
- ☑ Use the "**File | Open Project**" menu option to open a project named **Delta_Smelt_2020.prj**. It is located at **C:\Workshops\EFMSim\Delta_Smelt_2020** (or in a location determined by the workshop facilitator).
- ☑ Feel free to review the Data, Communities, and Logic interfaces. To summarize, a single constant elevation data set was imported. The delta_smelt community recruits on March 4th of each year based on elevation (this has no ecological basis; it is done only to create a community to move).

Simulating Movement


- ☑ To open the layout interface...
 - Click the **Layouts** button on the left hand side of the interface (or select the "**Windows | Control Panel**" menu option if the button is not visible).
 - The Study Area and Stream Region should be visible. In the **Layout Map** window, navigate to the "**Layouts | Open**" menu option.
 - Select **Layout2** and click **OK**. (If *Layout2* is already open select the appropriate tab).
 - Use the **Zoom** tool to get a better look at the Study Area (left click and drag to zoom in and right click to zoom out).
- ☑ Click the green **Communities** button to access the Communities tabs.
 - In the **Movement** tab, input the following parameters to define the physical movement capabilities of delta_smelt.
 - **Community:** delta_smelt
 - **Size Class:** ..All..
 - **Unit:** meters/hour
 - Variable: Elevation (selected from the **Variable Picker** dialog)
 - **Interpolation:** Linear
 - In the table, fill in **-20, 0** and **20** (in the **Variable Value** column) and a constant **15.0** (in the **Maximum Community Velocity** column).

- Be sure to hit the **Apply** button when you are finished. Note, the **Apply** button is located at the bottom of the **Movement** tab, maximize the HEC-EFMSim main window to access the button if it is off the screen.



- In the **Units Manager** tab, make sure that, under **Density** project unit, the **Community To Project** cell has a value of **1**. If it does not, enter a value of **1** and click **Apply**.

Community Name (Size Variable, Units)	Density (count/area)	
	Community To Project	Project To Community
delta_smelt (count, individuals)	1	

- ☑ Now, click on the green **Logic** button on the left.
 - In the **Instinctual Rules** tab (if necessary, use the navigation arrows (◀ or ▶ to find the tab), make a new rule  named **Smelt_Instinct**.
 - Assign the **delta_smelt** community and the **Adult** size class.
 - To identify where the smelt will want to move, enter in the following text under Location (WKT): **POINT (630617 4222976)**
 - In the **Strength (Function of Season)** panel, enter the following dates and factors.

Date	Factor (0 to 1)
01Jan	0.0
05Mar	0.0
06Mar	1.0
31Dec	1.0

- Enter in **1.0** for the Weight, **Linear** for Dissipate, **50000** Map units for the Radius.
- Double-check all above information has been entered correctly and click **Apply**.

- ☑ Navigate to the Simulation module by clicking the **“View | Simulation”** menu option.

Note: A simulation named **Smelt_Recruit**, which recruits smelt as a stationary community, has already been run.

- Right click on the Simulations tree, select **New Simulation**, and create a new simulation named **Smelt_Move** with a start date of **01Mar2011**, an end date of **31Mar2011** and a **ONE_DAY** time step.

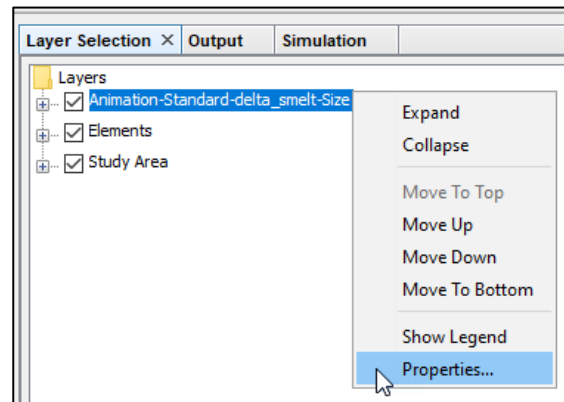
The image shows a 'New Simulation' dialog box with the following fields and values:

- Name: Smelt_Move
- Description: (empty)
- Start Date: 01Mar2011
- End Date: 31Mar2011
- Time Step: ONE_DAY

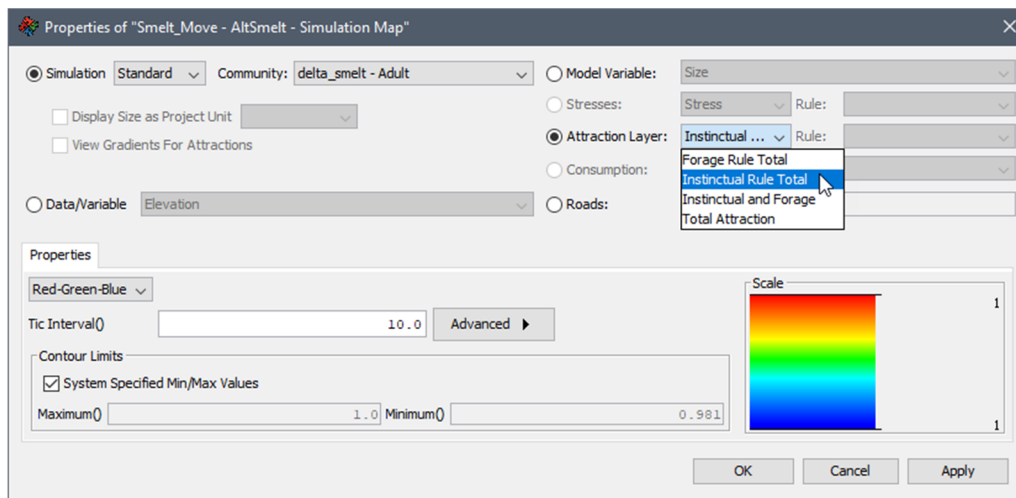
Buttons: OK, Cancel

- Expand the Simulations tree, right click on **Smelt_Move**, uncheck the **Create Shape Files** option, and select **Add Alternative**, highlight **AltSmelt**, and click **OK**.
 - To compute, right-click the simulation and select **Compute All**.
 - Once the simulation is done, make the **AltSmelt** alternative active by right-clicking on it and selecting **Set Map**.
 - Click the **View Animation** button to access Animation Controls and view the animation.
- ☑ To predict the way a community will move when ecological factors affect their choices, attraction layers can be generated to show the probable direction of movement.
 - ◇ Based on the location of the element assigned in the Instinctual Rule, what do you imagine the Instinctual Attraction Layer will look like?

- To view the Instinctual Attraction Layer, from the **Layer Selection** tab, right-click on the **Animation** layer under the Layer Selection tab and select **Properties**.



- In the **Properties** interface select the Simulation radio button and choose **Standard** and the **delta_smelt - Adult** community. Next, select the Attraction Layer radio button and choose **Instinctual Rule Total**. Click **Apply**. Click **OK**.



- From the Simulation tab, click the **View Animation** button and play the animation to see the attraction layer.
- Right-click on **AltSmelt** (under the Smelt_Move simulation) and select **Plot Density**.
- Use the animation and corresponding density plot to answer the following:
 - ◇ When do most of the smelt make it to the location of instinctual attraction?

Movement Through a Medium

- ☑ Select the “**Windows | Communities | All**” menu option to open the **Movement** tab.
 - In the **Movement** tab, from the **Medium that attraction works through and suitabilities** panel, select the following from the dropdown lists.
 - **Region Map:** Regions
 - **Region:** River
 - **Interaction of ...:** Weighted Average (density given priority)
 - Make sure to hit the **Apply** button when you are finished.

Medium that attraction works through and suitabilities

Region Map	Region	Medium	Suitabilities
Region	River		

Spread Attraction through medium based on suitabilities
 Adjust Attraction based on suitability


Move whenever a more advantageous location is available

Move when a location % or more advantageous is available

Interaction of density and instinctual/forage potential fields:

Weighted average (density given priority)

Apply

- ☑ Now we are ready to simulate movement through a region. Go to the Simulation module by clicking the “**View | Simulation**” menu option.
 - Right click on the Simulations tree, select **New Simulation**, and create a new simulation named **Smelt_Move_Region** with a start date of **01Mar2011**, an end date of **31Mar2011** and a **ONE_DAY** time step.
 - Expand the Simulations tree, right click on **Smelt_Move_Region**, select **Add Alternative**, highlight **AltSmelt**, and click **OK**.
 - To compute, right-click the simulation  uncheck the **Create Shape Files** option, and select **Compute All**.
 - Once the simulation is done, make the **AltSmelt** alternative active by right-clicking on it and selecting **Set Map**.
 - Click the **View Animation** button to access Animation Controls and view the animation.
 - Right click on **AltSmelt** and select **Plot Density**.
 - Use the animation and corresponding density plot to answer the following:

- ◇ What do you think the instinctual attraction layer will look like now? When do most of the smelt make it to the location of instinctual attraction? How does this differ from the Smelt_Move simulation? Why?

- ◇ According to the Density plot, what is the maximum density at the end of the Smelt_Move_Region simulation?

Part 3: Simulating Interactions between Ecological Communities

In this part of the workshop, you will define rules that govern how two communities named "Grass" and "Rabbits" interact and analyze results. The study area, layout, data import, prepare for simulation, community definitions, and recruitment and growth rules have already been completed. A simulation has already been created called "Rabbits_Grass" for which **you will create five alternatives**: foraging with a small radius, foraging with a larger radius, consumption by true predation, consumption by browsing, and consumption by browsing only seedlings. A recruitment alternative has already been created and run.

Getting Started



- Close **HEC-EFMSim** and then reopen the software *(this step is needed to clear the Delta Smelt project)*.
- Use the "**File | Open Project**" menu option to open a project named **Rabbits_Grass_2020.prj**. It is located at **C:\Workshops\EFMSim\Rabbits_Grass_2020** (or in a location determined by the workshop facilitator).
- Feel free to review the Data, Communities, and Logic interfaces. To summarize, a single constant elevation data set was imported. The Grass community recruits from January 5th to January 9th of each year based on elevation and the seedlings and adults grow at constant rates of 0.10 and 0.01 per time step, respectively. The Rabbit community recruits on January 10th of each year based on elevation and movement capabilities have also been defined.

- ☑ To open the layout interface...
 - Click the **Layouts** button on the left hand side of the interface (or select the **"Windows | Layouts | All"** menu option if the button is not visible).
 - The outline of the Study Area should be visible. In the **Layout Map** tab, navigate to the **"Layouts | Open"** menu option.
 - Select **Layout1** and click **OK**.
 - Use the **Zoom** tool to get a better look at the Study Area (left click and drag to zoom in and right click to zoom out).


Creating Project Units

- ☑ Click the green **Communities** button to access the Communities tabs.
 - In the **Units Manager** tab, click the **Add Project Unit** button and enter **Biomass** for the Name and **oz** for the Units. Click **OK**.

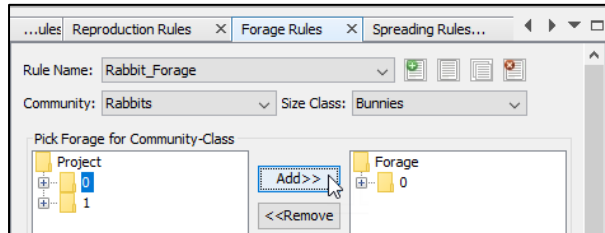
- Input the following parameters to define the **Density** and **Biomass** Project units of Rabbits and Grass. Use the Edit Equation **...** button (you must click inside of a cell to make this button appear) and the Variable Picker **VAR** (this gives you the \$CU and \$PU functions) to fill in these equations. Click **Apply**.

Community Name (Size Variable, Units)	Density (count/area)		Biomass (oz)	
	Community To Project	Project To Community	Community To Project	Project To Community
Grass (Height, feet)	$110.0 - \$CU * 10.0$	$11.0 - \$PU * 0.1$	$0.0001 * \$CU$	$10000.0 * \$PU$
Rabbits (Weight, ounces)	$\$CU / 355090$		$\$CU$	$\$PU$

Foraging with a Small Radius

- ☑ Click the green **Logic** button on the left to access the Logic tabs.
 - In the **Forage Rules** tab, create a new rule  called **Rabbit_Forage**.
 - Assign the **Rabbits** community and the **Bunnies** size class.

- In the **Pick Forage for Community-Class** panel, highlight the **0** folder, under the Project folder, and click **Add>>** to add the Grass community to Forage.



- From the Forage Units dropdown, select **Biomass**.
- From the **Strength (function of forage and season)** panel:
 - In the Forage – Strength (-1 to 1) table, right-click in the Forage cell and select **Insert Row(s)...** then enter **5** and click **OK**.

Fill in the following values:

Forage	Strength (-1 to 1)
0.0	0.0
0.00001	0.1
0.00005	0.4
0.0001	0.7
0.0003	0.9
0.001	1.0

- In the Date – Factor (0 to 1) table, right-click in the Date cell and select **Insert Row(s)...** then enter **3** and click **OK**.

Fill in the following values:

Date	Factor (0 to 1)
01Jan	0.0
10Jan	0.0
11Jan	1.0
31Dec	1.0

- Enter a weight of **1.0, Linear** for Dissipate, **200** Map units for Radius and click **Apply**.

- ☑ Now we are ready to create a new alternative for the Forage Rule we just made.
- ☑ Click on the pink **Scenario Builder** button on the left to access the **Alternatives** tab.
 - Make a new alternative by clicking the **+** button. Name the alternative **Forage**, choose both the **Rabbits** and **Grass** communities, select **Layout1**, and select **Centroid**.

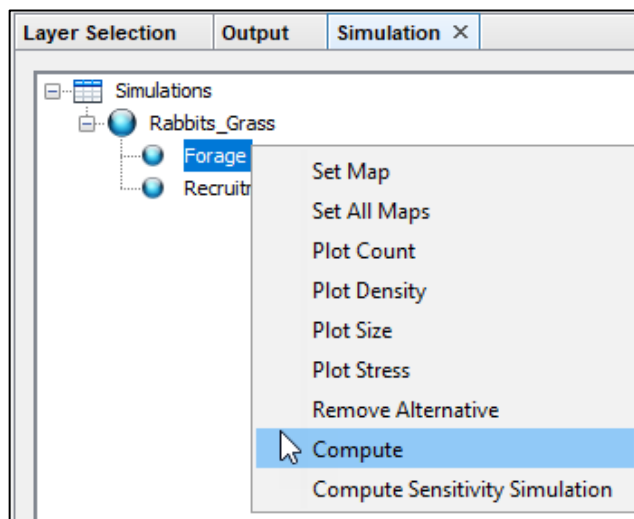
Name:	Community	Boundary Condition	Layout	Data Control	Data Type	Hatchery Plan
Recruitment	Grass Rabbits		Layout1	Centroid		No Plan
Forage	Grass Rabbits		Layout1	Centroid		No Plan

- ☑ Navigate to the Simulation module by clicking the **"View | Simulation"** menu option.

Note: A simulation named **Rabbits_Grass**, which has an alternative that recruits rabbits and grass as stationary communities, has already been run. This simulation has a start date of 01Jan and an end date of 28Feb and uses daily time steps.

- From the Simulation tab, expand the Simulations tree, right-click on **Rabbits_Grass**, make sure the **Create Shape Files** option is unchecked and click **Add Alternative** from the shortcut menu, highlight **Forage**, and click **OK**.

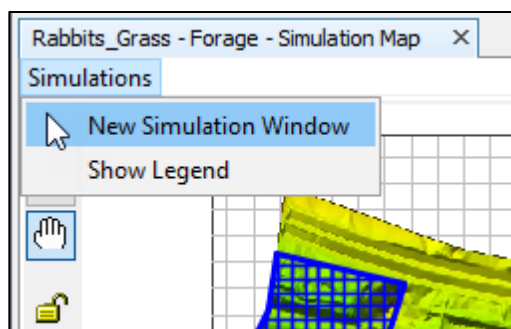
- To compute, expand **Rabbits_Grass** simulation and right-click the **Forage** alternative and select **Compute**.
(Do NOT compute all)



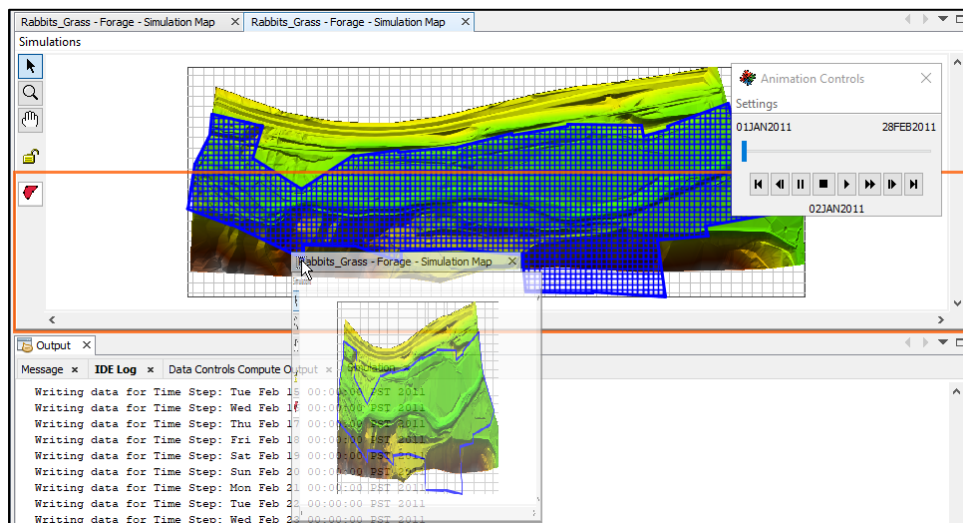
- Once the simulation is done computing, make the **Forage** alternative active (right-click and select **Set Map**).

- Click the **View Animation** button to view the animation and access Animation Controls.

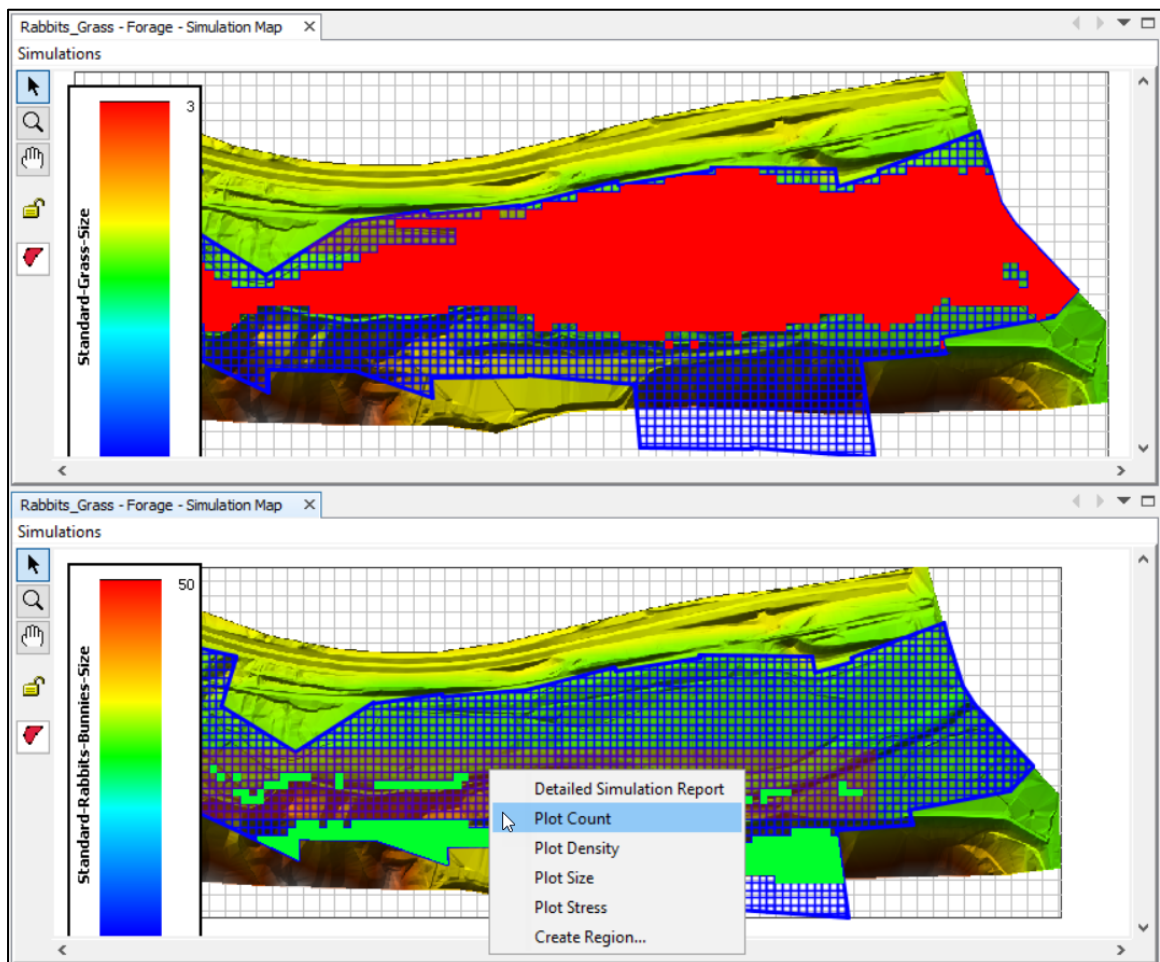
- To view the progress of both communities at the same time, click on **Simulations** in the viewing port and select **New Simulation Window**.



- A new tab should appear with a duplicate window of the simulation. Drag this tab down to the lower half of the simulation window until a red/orange split screen box appears telling you where to drop it.



- Now you can assign each community to a simulation window by clicking on each simulation tab in turn and going to the **Animation** layer found in the **Layer Selection** tab. Right click on **Animation** and select **Properties** to assign a community to that simulation tab.
- To view plots for any part of the communities, click and drag the cursor over the area of interest and right click in that space to select the plots.



- Use the animation and corresponding count plot to answer the following:
 - ◇ How many rabbits moved from their original recruitment position? Why didn't the entire community move?


Foraging with a Large Radius

Select the **"Windows | Logic | All"** menu option.

- In the **Forage Rules** tab, make sure that the **Rabbit_Forage** rule you created earlier is still selected and change the Radius to **500** Map units. Click **Apply**. Everything else should remain the same.

Now we are ready to create a new alternative for the Forage Rule we just changed.

Click on the pink **Scenario Builder** button on the left to access the **Alternatives** tab.

- Make a new alternative by clicking the  button. Name the alternative **Forage Big Radius**, choose both the **Rabbits** and **Grass** communities, select **Layout1**, and select **Centroid**.

Navigate to the Simulation module by clicking the **"View | Simulation"** menu option.

- Expand the Simulations tree, right click on **Rabbits_Grass**, select **Add Alternative**, highlight **Forage Big Radius**, and click **OK**.
- To compute, expand **Rabbits_Grass** and right-click the **Forage Big Radius** alternative and select **Compute**.

- Once the simulation is done computing, make the **Forage Big Radius** alternative active by right-clicking on it and selecting **Set Map**.

- This animation is better viewed side-by-side with the smaller radius alternative. This can be achieved by clicking on the top simulation's tab and making the **Forage Big Radius** alternative active in that window. Do the same to the bottom simulation but make the **Forage** alternative active. Make sure for each simulation window the **Rabbits-Bunnies-Size** animation layer is active in the **Layer Selection** tab. If it is not, right click on the **Animation** layer and select **Properties** to change communities.

- Click the **View Animation** button to access Animation Controls and view the animation.


- To view plots for any part of the communities, click and drag the cursor over the area of interest and right click in that space to select the plots.

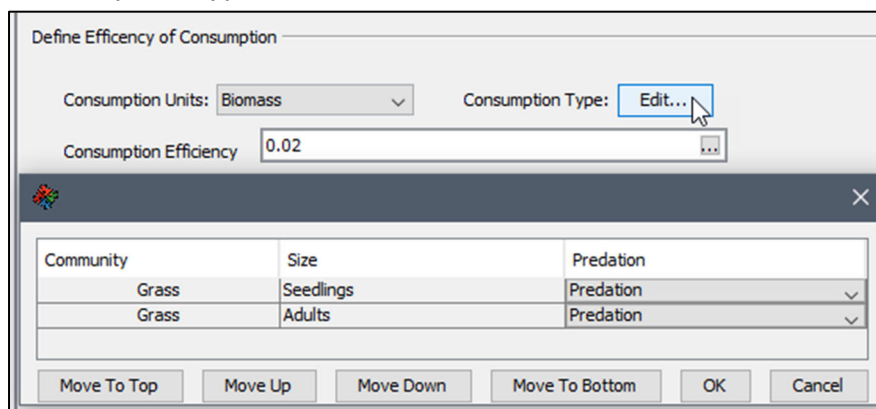
- Use the animation and corresponding count plot to answer the following:

◇ How many rabbits have now left their original recruitment position?

Consumption by True Predation

Select the **"Windows | Logic | All"** menu option.


- In the **Consumption Rules** tab, create a new rule  named **Rabbit_Consumption**.
- Assign the **Rabbits** community and the **Bunnies** size class.
- In the **Define How Much is Eaten** panel, select the **Constant Rate** radio button and enter a value of **0.015**.
- In the **Define Efficiency of Consumption** panel, enter the following:
 - Consumption Units: **Biomass**
 - Consumption Efficiency: **0.02**
 - Consumption Type: **Predation**



- In the **Define What is Eaten First** panel, click on the **Evenly distributed per % lumped and available forage** radio button.
- Click **Apply**.

Now we are ready to make a new alternative for the Consumption Rule we just created.

Click on the pink **Scenario Builder** button on the left to access the **Alternatives** tab.

- Make a new alternative by clicking the  button. Name the alternative **True Predation**, choose both the **Rabbits** and **Grass** communities, select **Layout1**, and select **Centroid**.

Navigate to the Simulation module by clicking the **"View | Simulation"** menu option.

- Expand the Simulations tree, right click on **Rabbits_Grass**, select **Add Alternative**, highlight **True Predation**, and click **OK**.
- To compute, expand **Rabbits_Grass** and right-click the **True Predation** alternative and select **Compute**.

- Once the simulation is done computing, make the **True Predation** alternative active by right-clicking on it and selecting **Set Map**.
- Click the **View Animation** button to access Animation Controls and view the animation.
- This animation should be viewed with both the Rabbits and Grass communities visible on a split screen so the effects of predation can be seen in both communities at the same time.
- Use the animation and corresponding plots to answer the following:

◇ What were the maximum and average grass sizes at the last time step?

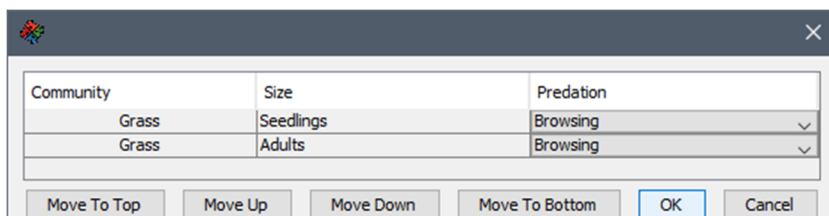
◇ What were the maximum and average rabbit sizes at the last time step?

◇ How many rabbits were left in the western part of the simulation plot? Why do you think they were cut off from the rest of the community?

◇ If the simulation were allowed to continue, what do you think would happen to the remaining grass? How would this effect the rabbit community?

Consumption by Browsing

- ☑ Select the **"Windows | Logic | All"** menu option.
- In the **Consumption Rules** tab, select the **Rabbit_Consumption** rule you created earlier and change the **Consumption Type** to **Browsing** for both the Rabbits and Grass communities. Click **OK**.



- Everything else remains the same for the Consumption rule. Click **Apply**.

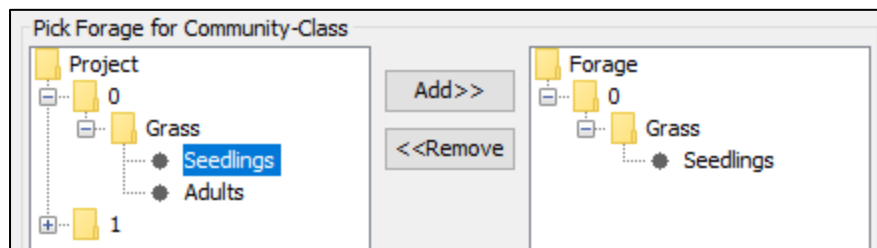
Now we are ready to make a new alternative for the Consumption Rule we just changed.

- ☑ Click on the pink **Scenario Builder** button on the left to access the **Alternatives** tab.

- Make a new alternative by clicking the **+** button. Name the alternative **Browsing**, choose both the Rabbits and Grass communities, select Layout1, and select Centroid.
- Navigate to the Simulation module by clicking the **“View | Simulation”** menu option.
- Expand the Simulations tree, right click on **Rabbits_Grass**, select **Add Alternative**, highlight **Browsing**, and click **OK**.
 - To compute, expand **Rabbits_Grass** and right-click the **Browsing** alternative and select **Compute**.
 - Once the simulation is done computing, make the **Browsing** alternative active by right-clicking on it and selecting **Set Map**.
 - Click the **View Animation** button to access Animation Controls and view the animation.
 - This animation is better viewed side-by-side with the **True Predation** alternative. This can be achieved by creating four simulation windows and switching two windows to one alternative and two windows to the other alternative. Each of the two windows could then be assigned a different community.
 - Use the animation and corresponding plots to answer the following:
 - ◇ What were the maximum and average sizes of the Grass community at the last time step? Are these values different from the True Predation values? Why or why not?
 - ◇ What were the maximum and average sizes of the Rabbit community at the last time step? Are these values different from the True Predation values? Why or why not?


Consumption by Browsing Only Seedlings

- Select the **“Windows | Logic | All”** menu option.
- In the **Forage Rules** tab, select the **Rabbit_Forage** rule you created earlier.
 - In the **Pick Forage for Community-Class** panel, highlight the **0** folder under the Forage folder and click **<<Remove**.
 - Now expand the **0** folder and just highlight the **Seedlings** size class. Click on **Add>>** to add the Seedlings class to the Forage folder.



- All other data remains the same in the Forage rule. Click **Apply**.

Now we are ready to make a new alternative for the Forage Rule we just changed.

- ☑ Click on the pink **Scenario Builder** button on the left to access the **Alternatives** tab.
 - Make a new alternative by clicking the  button. Name the alternative **Browsing Seedlings**, choose both the Rabbits and Grass communities, select Layout1, and select Centroid.
- ☑ Navigate to the Simulation module by clicking the **“View | Simulation”** menu option.
 - Expand the Simulations tree, right click on **Rabbits_Grass**, select **Add Alternative**, highlight **Browsing Seedlings**, and click **OK**.
 - To compute, expand **Rabbits_Grass** and right-click the **Browsing Seedlings** alternative and select **Compute**.
 - Once the simulation is done computing, make the **Browsing Seedlings** alternative active by right-clicking on it and selecting **Set Map**.
 - Click the **View Animation** button to access Animation Controls and view the animation.
 - This animation is better viewed side-by-side with the **Browsing** alternative. This can be achieved by creating four simulation windows and switching two windows to one alternative and two windows to the other alternative. Each of the two windows could then be assigned a different community.
 - Use the animation and corresponding plots to answer the following:
 - ◇ How does browsing only seedlings differ from browsing all size classes? Does the average grass size differ from the other simulations? Are the rabbits bigger or smaller?
 - ◇ Why does the Forage Attraction Layer for the rabbits change dramatically after February 7th? What happens on February 8th?