FVS Training Guide

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Getting Started

In the following section, you will install Forest Vegetation Simulator (FVS) and its associated files, explore the components of the interface, and learn how to create new FVS projects.

Installing FVS

The Forest Vegetation Simulator (FVS) is a browser-based forest modeling system utilizing the Shiny web application framework to interact with FVS geographic growth and yield models. There are two configurations of FVS: an online configuration which stores software and projects (data and runs) on a server at Virginia Tech and a local configuration which stores software and projects on your computer. The online configuration requires you to create a project online using the FVS-Online website hosted by Virginia Tech, (https://charcoal2.cnre.vt.edu/FVSOnline/). Once you receive a response e-mail from the server, you can begin using FVS by clicking on the link provided in the response e-mail. The rest of this guide pertains to installing and using the local configuration of FVS.

The installation package for FVS may be found in the download section on the FVS Software Complete Package webpage (https://www.fs.usda.gov/fvs/software/complete.php). The installation package is a single executable that will install the standard suite of programs included with FVS. Installing all the components will require more than 250 MB of hard drive space and take about 10-15 minutes to install. Any program files from previous installations of the FVS Complete Package will be overwritten. All other project folders in the destination specified will not be overwritten. Depending on your security settings, you may need administrative privileges to install/unistall FVS.

To install the current FVS Software Complete Package, perform the following steps.

1. Click the link for the FVS Software Complete Package installation file to begin downloading it.
2. When prompted, Save the file to a location on your local computer.
3. When the executable has finished downloading, choose to open the installation executable by clicking the **Open** button. If you do not have this option, navigate to the directory where you specified the file be saved and double-click on the executable.
4. Following the FVS splash screen, select a location to save your FVS files or accept the default location and click the **Install** button.
5. When the installation is finished, click the **Finish** button.

The installation package will install an FVS Icon on your desktop that is linked to the FVS program located in your selected folder. Within the folder, you will find the default project folder named, *Project_1*. When FVS is started, *Project_1* will be the active project.

6. Double click the **FVS** icon on your desktop. FVS will open in your default browser.

Understanding the interface

At the top of the interface, you will see a title bar with information regarding the active project, the date and time you last accessed FVS, the release date, and the interface configuration.

Below the title bar you will see the main tab panel, consisting of six tabs: **Simulate**, **View Outputs**, **Visualize**, **View on Maps**, **Manage Projects**, and **Help**.

These tabs open pages that contain command items (buttons, selection and text boxes, and check boxes) as well as secondary tab panels that contain groups of command items.
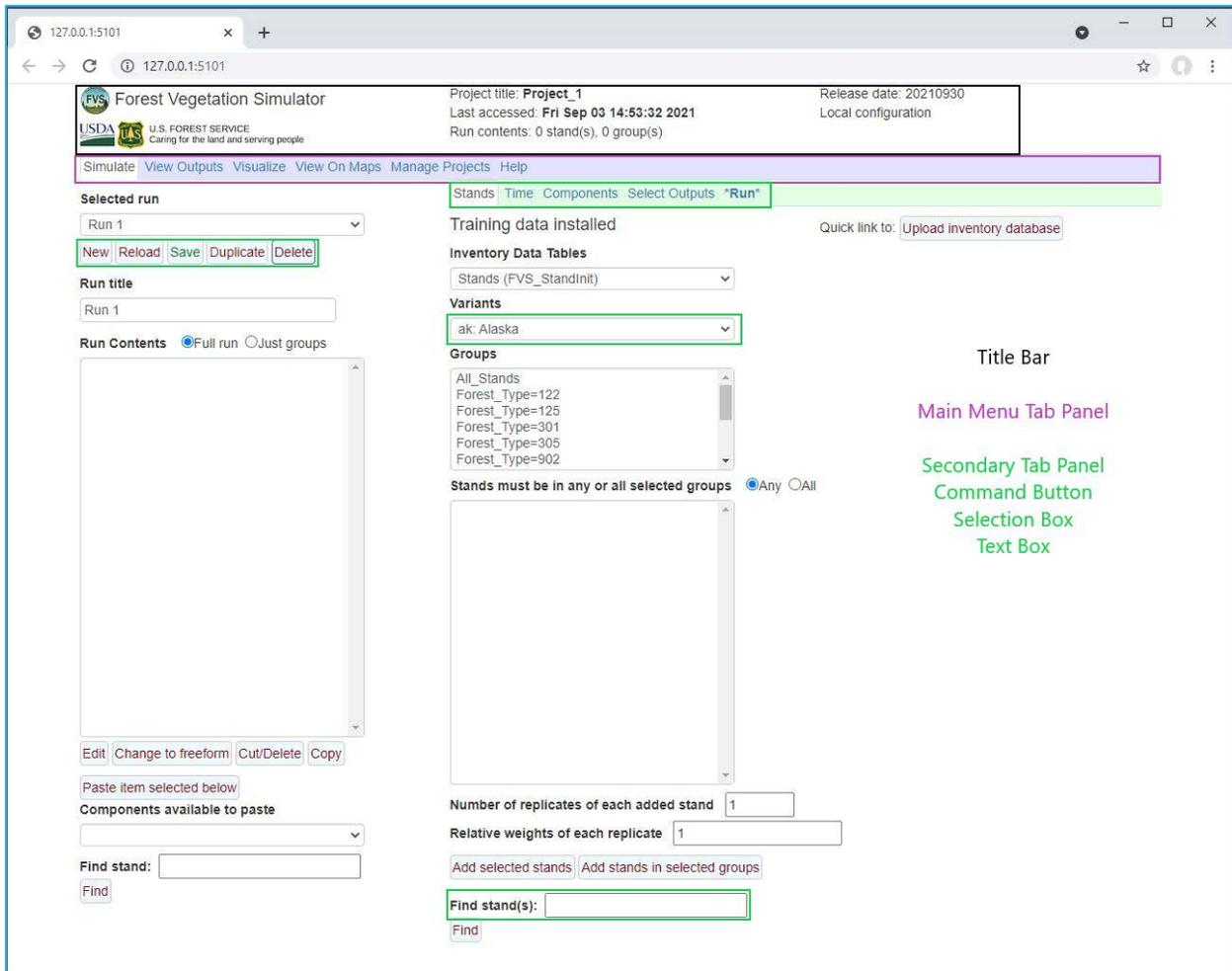
Below is a brief description of each main tab item.

Simulate

The **Simulate** tab is divided into two regions where on the left you have options to select or create runs and view/modify the active run contents. On the right, you have a secondary tab panel designed to help you parameterize runs. This tab panel is used to add stands to a run (**Stands**), set the time frame (**Time**), add instructions (**Components**), select output tables (**Select Outputs**), and run the simulation (**Run**). When the **Run** tab name is surrounded with asterisks, something has changed in your run and you should consider re-running the simulation.

View Outputs

The **View Outputs** tab contains a secondary tab panel on the left which allows you to load and explore FVS outputs (**Load** and **Explore** tabs) that were selected on the **Simulate > Select Outputs** tab or create user-defined outputs using custom queries (**Custom Query** tab) of available output tables. A **Describe tables** selection box is found on the right which provides descriptions of all variables contained in any FVS output table.

Visualize

The **Visualize** tab contains check boxes and selection boxes that allow you to display two sets of images of stands in any FVS run, if the **Stand visualization** check box was selected in the **Simulate > Select Outputs** tab prior to running the simulation. Each image set will contain three static images (perspective, profile, and overhead views) and one dynamic image (user may adjust view). Your browser may allow you to right click on any image and copy/save the image.

View on Maps

The **View on Maps** tab contains selection boxes that allow you to display FVS outputs from a selected run for stand polygons or points overlain on one of four Google base maps. The output may be viewed in tabular or graphical form by selecting the appropriate **Display** radio button.

Manage Projects

The **Manage Projects** tab contains a secondary tab panel which allows you to select, create, delete, and backup projects (**Manage Project**); import forest inventory input data and maps (**Import input data**); import runs, custom component files, graph settings, and queries from other projects (**Import runs and other items**); and, download input/output databases and run components (**Downloads**).

Help

The **Help** tab explains each of the aforementioned tab items in enough detail to guide you through making runs with FVS.

Creating an FVS project

FVS initially starts with a default project, named *Project_1,* which contains the training inventory dataset used in FVS training guides. The training data consists of inventory and map data in each Forest Service region of the United States. If you wish to create a new project with your own data, follow the steps below.

When you wish to run your data through FVS, we recommend creating a new FVS project using the **Manage Projects > Manage Project** tab. Once created, the new project will contain a copy of the training dataset mentioned above. You will be able to replace the training dataset with your own FVS-ready data using the **Manage Projects >Import input data > Upload inventory database** and **Upload Map data** options. The following steps describe how to create a new project and replace the existing training dataset with your own dataset. Once your new project is created, you can toggle back and forth between projects using the **Select project** selection window on the **Manage Projects > Manage project** tab. When you open a selected project, you will be sent to the **Simulate** tab for that project.

1. Select the **Manage Projects > Manage project** tab.
2. In the **Create a new project-New project title** text box, type in a name for your project such as, *"National Training."*
3. Click the **Make new project** button.
4. Once the project is created, use the **Start another project > Select project** selection window to select the *National Training* project and click the **Open selected project** button.

FVS will open a new browser window or tab with the **Simulate** tab activated for your project. At the top of the page, you'll see the project title has been set to the name you entered.

Replacing the training database

There are two ways to navigate to the **Upload inventory database** tab: (1) you can click the **Upload inventory database** button in the quick link section of the **Simulate > Stands** tab or you can navigate to the upload tab by clicking **Manage Projects > Import input data > Upload inventory database** tab. The **Upload inventory database** tab gives you the option to replace or add to the existing database with an FVS-ready database, as described in the User's Guide to the Database Extension. Acceptable database formats include SQLite databases (.db or .sqlite), Microsoft Access databases (.mdb or .accdb), or Microsoft Excel spreadsheets (.xlsx) where the table/sheet names are the same as the target table names. Column names and data types need to match the FVS input database structure. Replacing the existing database is a two-step process where you first upload an FVS-ready database, then you install the uploaded database. The steps to do so are clearly spelled out in FVS.

5. Select the **Upload inventory database** tab.
6. Follow the directions in **Step 1** section of the interface to upload your FVS-ready database.
7. Follow the directions in **Step 2** section of the interface to install the uploaded database.

Once your database is installed, you may upload your map data using the **Upload map data** tab. Many map file formats are supported, refer to this list for a list of file formats. To upload a map, first create a .zip file that contains a single directory (folder) where the coverages are stored. Then

upload the .zip file and let FVS try to load the appropriate files. If the .zip file contains more than one layer, you can select the layer that contains stand polygons (the system will attempt to make a valid selection). Note that the polygons must be identifiable by *StandID* but frequently the coverage data contains this information under a different variable name. FVS attempts to discover the correct variable to match to StandID. You can set the variable here if necessary.

If the geographic projection of your data is not stored with the data (usually it is part of the coverage data), then you can set the projection using the provided tools. You can select a projection from the list button or just type in the proj4 string into the text box. Note the projection is set or reset here but the spatial data are not re-projected. Any needed re-projection is done automatically.

Adding the map coverage is also a two-step process.

8. Select the **Manage Projects > Import input data > Upload Map data** tab.
9. In Step 1, click the **Browse** button and select the zip file containing your spatial dataset. As the data is uploaded, FVS will attempt to attach your spatial data to the tabular data loaded in the previous steps. If successful, FVS will display the joining variable along with the percent match.
10. Click the **Install imported spatial data** button to finish installing your map data.

If you do not have map data for your project, you can still view FVS outputs on a map if you enter latitude and longitude in your input stand data (FVS_StandInit table). When viewing FVS outputs on maps using this method, the stands will appear as points on your map.

You are now ready to simulate forest development within your project.

Module 1: Basic Runs

This module leads you through making single and multi-stand runs. All options to view output will be covered. These options include viewing FVS output overlain on a base map using the **View on Maps** tab, viewing stand images using the **Visualize** tab, and creating tabular and graphical output using the **View Outputs** tab. Two step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Base 1: Making a single stand run

In this exercise, you will use FVS to describe stand development for the next thirty years using the **View on Maps**, **Visualize**, and **View Outputs** tab options.

Starting a new run

Starting an FVS run begins with naming and saving your run. Upon startup, FVS reads the inventory data and activates the **Simulate** tab. The default run title is set to *Run 1*. A new run can be initiated by clicking the **New** button and typing in a new title in the **Run title** text box. The **Save** button saves the run.

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Base 1*.
3. Click the **Save** button.

Adding a stand into a run

Specific stands may be added to the run by using the selection tools in the **Stands** tab. Your selection choices impact options in a top-down manner where your choice of **Inventory Data Tables** will dictate which **Variants** are available and subsequently which **Groups** are available. Selecting a grouping code will display stands that meet all the above criteria specified. If multiple group codes are selected, the default is to display any stands that have at least one of the grouping codes. This may be changed to display only those stands that meet all the grouping codes selected by changing the option associated with the **Stands must be in any or all selected groups** radio buttons to *All* from *Any*. The *All_Stands* grouping code along with other grouping codes selected will be available in the output *FVS_Cases* table.

You can add a single stand by highlighting the stand and clicking the **Add selected stands** button. Once added to a run, the stand will be added to the **Run Contents** window.

Perform the following steps to add a stand into the run.

4. In the **Variants** selection box, select *ca : Inland CA, Southern Cascades*.
5. In the **Groups** selection box, select *Forest_Type=371* (California mixed conifer).
6. In the **Stands** selection box, select stand *050653Corner0402*.
7. Click the **Add selected stands** button.
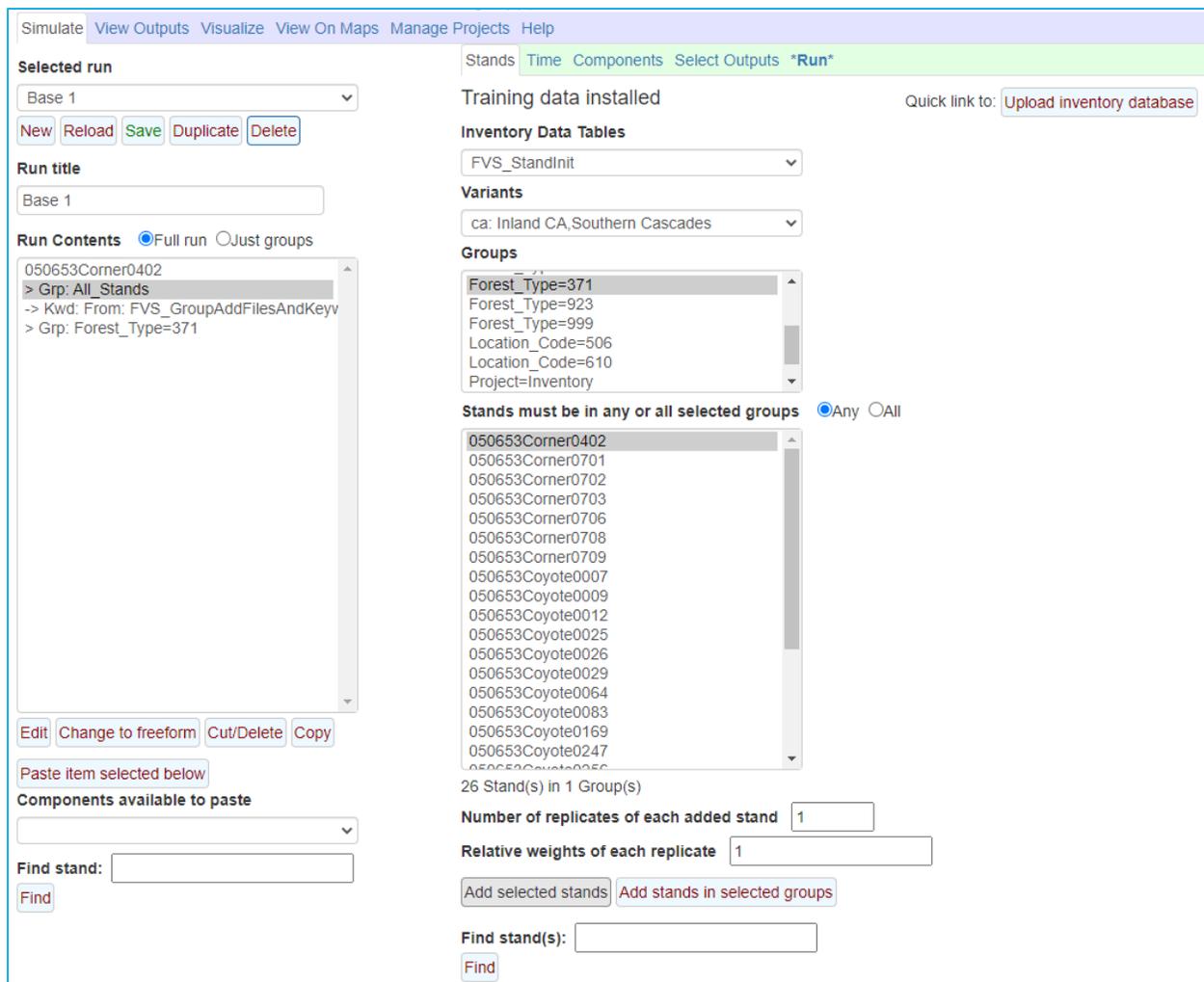
When you add a stand, FVS keywords assigned to stands or grouping codes assigned to the stand will be added into the simulation. In this dataset, keywords linking the FVS variant to the stand and tree data will be added from the *FVS_GroupAddfilesAndKeywords* table using the *All_Stands* grouping code. This can be seen in the **Run Contents** window with the indented line starting with *->Kwd:*.

Setting the time frame

8. Select the **Time** tab.

Setting the time frame of the run is done using the **Time** tab. By default, the common starting year is set to the current year and the common ending year is set to ten growth cycles in the future. For most variants, the default growth interval is ten years which results in a default simulation length of 100 years. The growth and reporting interval may be changed, and additional reporting years may be specified; however, care is needed as FVS can only simulate up to 40 total growth intervals.

Perform the following steps to set up a thirty-year simulation starting in 2022.

9. Change the **Common starting year** and **Common ending year** to *2022* and *2052*, respectively.
10. Read the **Projection Timing Summary** for a description of how your timing choices will affect the run.

Stands | Time | Components | Select Outputs | *Run*

Common starting year

2022

Common ending year

2052

Growth and reporting interval (years)

10

Additional output reporting years

Projection Timing Summary

FVS will project your data, beginning from the year of inventory, to the common starting year of **2022** for all stands. Thereafter, FVS will grow the stand, and provide output, in intervals of **10** years, with the simulation ending at the common ending year, for all stands, of **2052**. You will receive output for the additional year(s):

Selecting Outputs

11. Select the **Select Outputs** tab.

The **Select Outputs** tab allows you to request output tables for various output categories. Some tables are automatically produced, such as the *FVS_Summary* table and the *FVS_Compute* table, which includes common stand-level summary statistics and user-defined variables, respectively. Other outputs need to be selected using the check boxes provided.

In this exercise, you will select outputs that will describe stand composition and structure, surface biomass, and snags.

12. Check the **Stand visualization** box to request image files needed by **Visualize** option.
13. Check the **Tree lists** box to request output needed to create a stand and stock table.
14. Check the **Carbon and fuels** and **Snags and down wood** boxes to request output describing biomass in stand components.
15. Check the **Stand structure** box to request summary information on stand stratification and structure.

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Stands Time Components | Select Outputs | *Run*

Select outputs

Note that all outputs are put in output database except for the Stand visualization data.
FVS_Cases, FVS_Summary, FVS_Compute, and mistletoe (FVS_DM_Stnd_Sum,FVS_DM_Spp_Sum) are always produced.

☑ Stand visualization: Plot shape ⦿Round ○Square   Images per fire: 4

☑ Tree lists (FVS_Treelist, FVS_CutList, FVS_ATRTList, (StdStk-stand and stock))

☑ Carbon and fuels (FVS_Carbon, FVS_Consumption, FVS_Hrv_Carbon, FVS_Fuels)

☐ Fire and mortality (FVS_Potfire, FVS_BurnReport, FVS_Mortality)

☑ Snags and down wood (FVS_SnagSum, FVS_Down_Wood_Cov, FVS_Down_Wood_Vol)

☐ FFE canopy profile (FVS_CanProfile)

☐ FFE detailed snag (FVS_SnagDet)

☑ Stand structure (FVS_StrClass)

The **Describe tables** selection box at the bottom of the **Select Outputs** tab allows you to review table variables and their definitions. These definitions will provide most of the information you need to select the appropriate variables to describe your stand. Further information describing the variable calculation methods may be found in Essential FVS: A User's Guide to the Forest Vegetation Simulator (Dixon 2002), The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation (Rebain 2010), and other FVS documents found on the FVS documents webpage. The **Describe tables** selection box also appears in the **View Outputs > Load** tab.

16. Use the **Describe tables** selection box to familiarize yourself with the outputs associated with the tables selected above.

Describe tables

FVS_StrClass ▾

FVS_StrClass contains information on how many strata there are in a stand and descriptive information on the size, species, and percent cover of the trees in each stratum. The stand structure classification is also reported. There is one row for each cycle year when there is no harvest and two rows (before and after harvest) in cycles with a harvest.

Variable	Description
CaseID	Unique FVS case identifier that corresponds to the FVS_Cases table
StandID	Stand Identification Code
Year	Year of the Projection
Removal_Code	0 = Before tree removal, 1 = After tree removal
Stratum_1_DBH	Stratum 1 nominal dbh
Stratum_1_Nom_Ht	Stratum 1 nominal height
Stratum_1_Lg_Ht	Height of the tallest tree in stratum 1
Stratum_1_Sm_Ht	Height of the shortest tree in stratum 1
Stratum_1_Crown_Base	Weighted average height to crown base for trees in stratum 1
Stratum_1_Crown_Cover	Percent canopy cover, accounting for overlap, of trees in stratum 1

Running the simulation

17. Select the ***Run*** tab.

The final step of performing an FVS run is to save and run your simulation. This is accomplished through the **Run** tab. The **Run** tab title includes asterisks (***Run***) when there is a change from a previously saved version. Before clicking the **Save and Run** button on the **Run** tab, you can specify a

specific management identification code for the run. This allows you to display outputs from various runs based on unique management identifications. Management identifications are also used to create subsets of averages across stands when creating/viewing average composite tables.

18. Change the management identification code (**MgmtID**) to *Base.*
19. Click the **Save and Run** button.

FVS will save the run as *Base 1* with a management identification code of *Base.*

If the run is successful, you will see a figure reporting the volume per acre in the stand for the run time frame. Any errors in the run will be reported below the figure.
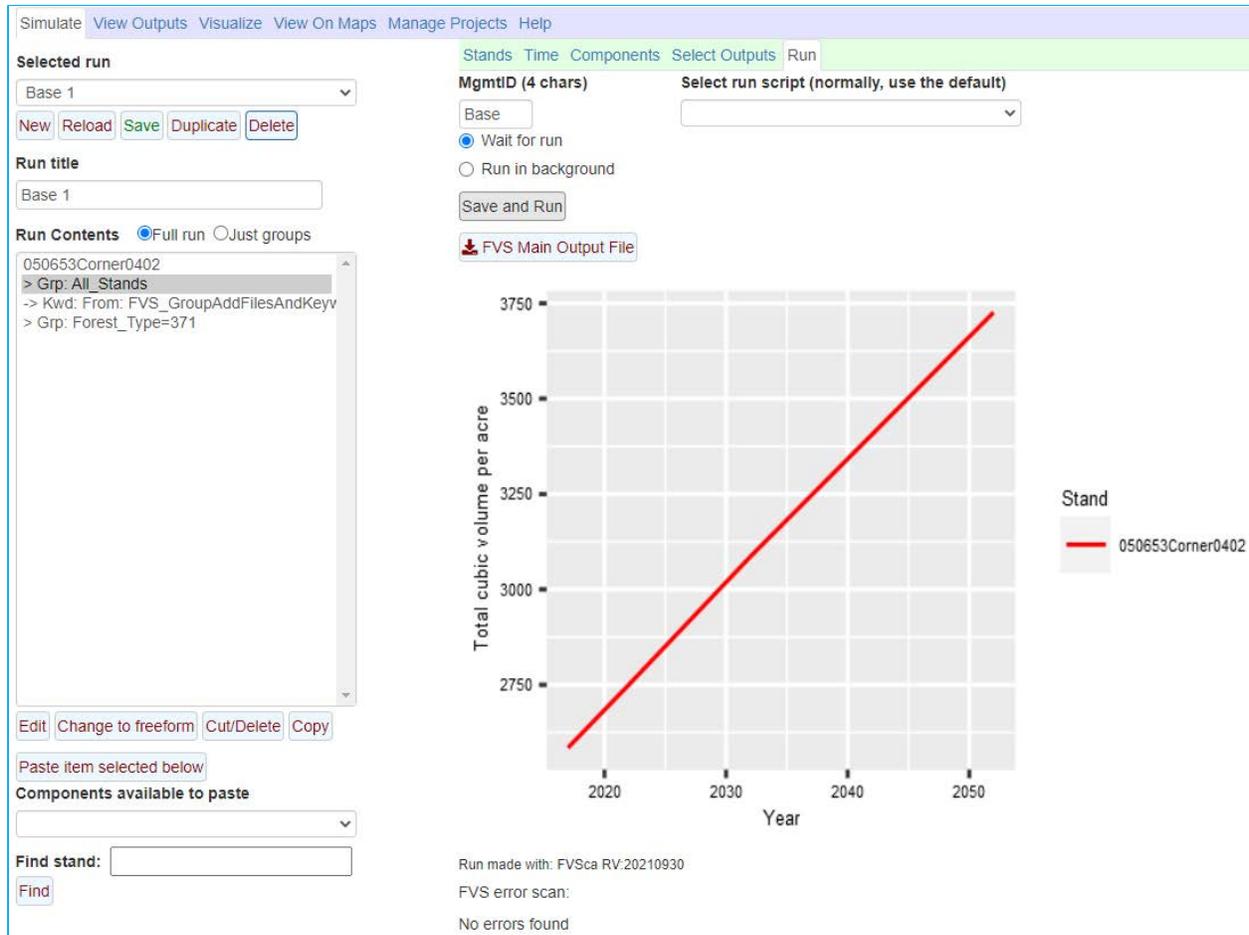
Describing stand development using View on Maps

20. Select the **View on Maps** tab.

One of the easiest ways to explore stand development is to view your output using the **View on Maps** tab. **View on Maps** will display FVS outputs for your location (either a stand polygon or point) projected on a base map.

21. Use the **Select Run** selection box to select *Base 1.*
22. Use the **Output Table** selection box to select *FVS_Summary2* table.
23. Use the **Variables** selection box to select *Age, Tpa,* and *BA.*

Once the variables are selected, an image of your stand (yellow point or boundary) will display over a base map. You have four base map options in the **Base Map** selection box, with the default being

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Google Hybrid map. If you move your cursor over the image, FVS will display the age, trees per acre, and basal area in the stand in a table over the projection period. By clicking the **graph** radio button in the **Display** area, you will see a figure of the first variable selected (*Age*) over the projection period. You can make a table/graph stick to the map by simply clicking anywhere over the stand point or polygon. The table/graph will stick where you click and may be closed by clicking the X in the upper right corner of the table/figure.

Cycling through a few stand variables allows you to view how the stand is developing over the simulation time frame. Viewing trees per acre (*Tpa*) and basal area (*BA*) show you how density changes, while viewing the quadratic mean diameter (*QMD*) and top height (*TopHt*) show you how tree size changes. Similarly, you can get estimates of total production by viewing the merchantable cubic foot volume (TPrd*MCuFt*) in the stand or by switching tables to view total stand biomass (*FVS_Fuels > Total_Biomass*) or total stand carbon (*FVS_Carbon > Total_Stand_Carbon*).
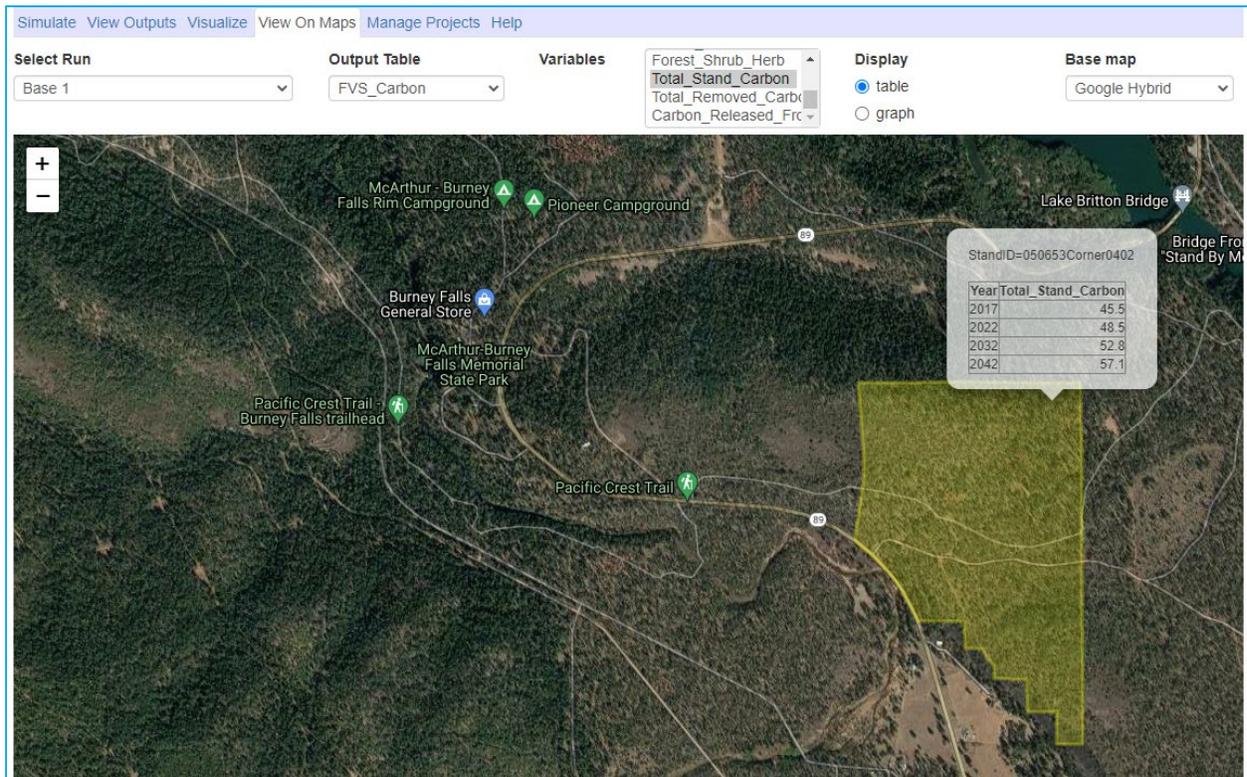
Describing stand development using Visualize

24. Select the **Visualize** tab.

The **Visualize** tab allows you to view and compare images of any stand in your run during your projection time frame. You may select up to two images at a time. Each selection pane allows you to select a run and an image file (case), as well as specify whether subplot boundaries, range poles, fire, and down trees will be included in the images. You also can specify the ground color. Once a run and image are selected, rendering of the image takes place. The speed of this process depends on the underlying tree list and may take some time for large lists. During rendering, it is important to wait before moving on to selecting a second image.

25. In the left **Select run** selection box, select *Base 1*.

26. In the left **Select image** selection box, select Stand=*050653Corner0402* Year=*2022 Beginning of cycle*.
27. Wait for image to be drawn.
28. In the right **Select run** selection box, select *Base 1*.
29. In the right **Select image** selection box, select Stand=*050653Corner0402* Year=*2052 Beginning of cycle*.

At the top of each image set, you will see static perspective, overhead, and profile images of the stand. These may be copy/pasted or saved to another document using a right click on the image. Below the static images you will see the dynamic image. Using your mouse, you can zoom in and out of the image, and flip or rotate the image. Once you have an image set, you may copy/paste or save the image using a right click on the image. If your browser does not give you the options to copy/paste or save, you can use a snipping tool or other screen capture programs to copy/paste or save your images.

30. Adjust the dynamic view to your liking and save the image.
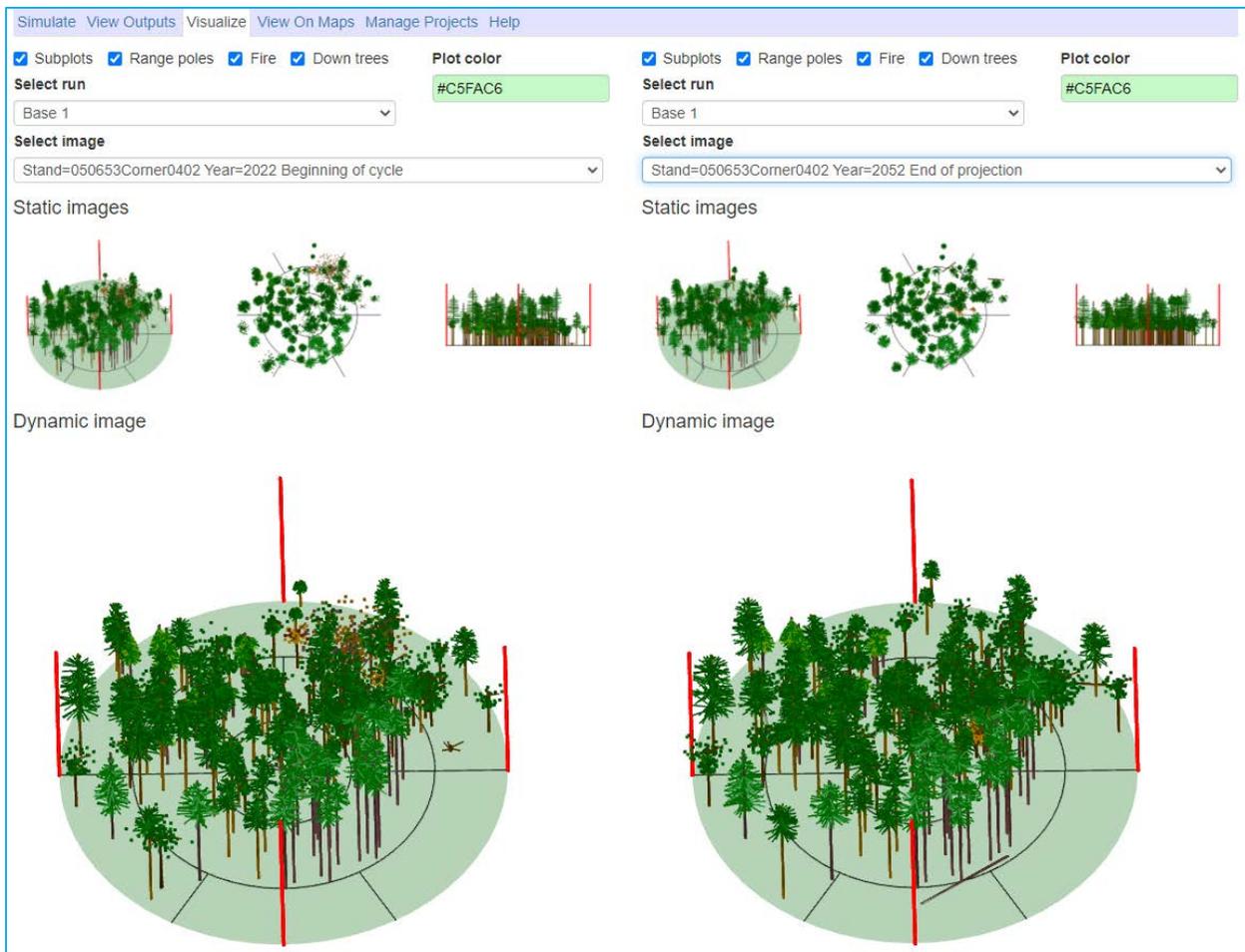
Describing stand development using View Outputs

31. Select the **View Outputs** tab.

The **View Outputs** tab allows you to explore FVS output data through a two-step process using the **Load** and **Explore** tabs or through custom SQL queries using the **Custom Query** tab. For most users,

exploring data using the two-step **Load/Explore** process will accomplish their needs and is the focus of this training.

32. If it is not already selected, select the **Load** tab.

To view outputs, you begin by choosing the species codes to use in the stand and stock tables, followed by loading the runs and FVS-generated output table(s) that interest you. When you select a table, all data columns are chosen by default; however, you can limit the database columns by selecting specific variables in the **Database variables to consider** selection box.

In addition to the traditional FVS-output tables, FVS generates a stand and stock table (StdStk) which reports trees per acre, basal area, and volumes by species and diameter class. By default, the stand and stock table is built with four-inch diameter classes (midpoint values reported in table); however, you have the ability to reset the diameter class width by changing the value in the **DBH class size** field and clicking the **Rebuild StdStk** button.

When selecting variables, you may review variable output definitions using the **Describe tables** selection box on the right side.

When selecting tables, you should only select tables of the same hierarchy (stand vs. diameter class vs. tree tables); otherwise, some non-sensical data may be provided. Always selecting the FVS_Cases table will give you most of the options for querying your output data.

33. In the **Runs to consider** selection box, select *Base 1*.
34. In the **Database tables to consider** selection box, make sure *FVS_Cases* and *FVS_Summary2* are selected.

Step two involves exploring the data you selected by selecting the **Explore** tab.

35. Select the **Explore** tab.

The selection tools on the left side of the **Explore** tab allow you to further refine your results by allowing you to select output for specific runs, groups, stands, management identification codes, years, species, diameter classes, and variables. If some selection criteria are not available, that means the tables you selected do not have that information.

36. In the **Years** selection window, select years *2022* through *2052*.
37. Using the check boxes in the lower left, select the following forest type, size class, and stocking class variables to include in the table to the right.
    a. *StandID*
    b. *Year*
    c. *ForTyp*
    d. *SizeCls*
    e. *StkCls*

Output selected will be displayed in the **Table** tab on the right side, which is then downloadable in either MS Excel format (.xlsx) or comma delimited format (.csv) by setting the file **Type** and clicking the **Download table** button. Download the table into an excel file and format the table for sharing with others.

38. Click the **Download table** button and save the output to your computer.
39. Open the MS Excel file.

40. Change the variable names to be easier to understand. Use the [Essential FVS: A User's Guide to the Forest Vegetation Simulator](#) (Dixon 2002), Appendix B, to translate the values into common terminology.

The resulting table should give viewers enough information so that they do not need to translate any of the output.

41. Close the MS Excel file and go back to FVS.

The data are also available to view in graphical form.

42. Click the **Select all** check box on the lower left side of the **Explore** window.
43. Select all years.
44. To view the selected outputs in graphical form, select the **Graphs** tab.

The **Graphs** tab provides access to graphing tools that operate on the data displayed in the table. The graphing options allow you to choose the type of the graph, the x and y axes, and labels. In addition, you can organize and label the output using horizontal and vertical facets and the plot-by code. While the facets allow you to organize multiple graphs side by side or top-down, the plot-by code allows you to display the outputs on one graph. Additional options are available when you choose to show more controls.

The best way to learn how the graphing tool works is to experiment. First display density over the time projection time frame.

45. Make the following changes to the graphing options:
    a. **Y-axis** .... *Tpa*
    b. **Vertical facet** .... *None*
    c. **X-axis** .... *Year*
    d. **Horizontal facet** .... *StandID*
    e. **Title** .... *Stand Density*
    f. **Y-label** .... *Trees Per Acre*

Once you finish the graph, depending on your browser, you may be able to do a right click and copy/paste or save the image. Another option to copy a graph is to use your operating system's snipping tool.
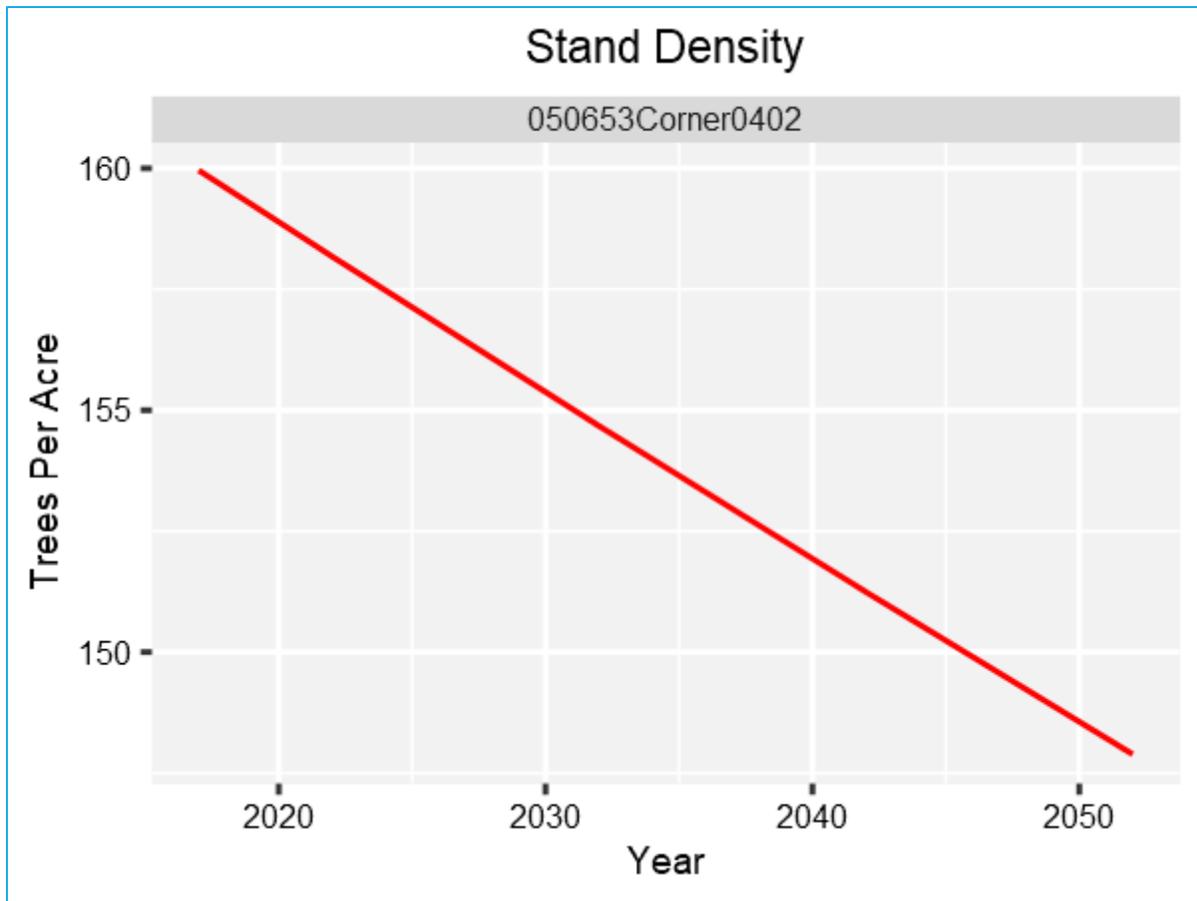
In the graph, you can see trees per acre fluctuating. In this case, you can see the regeneration modeling automatically adding trees into the simulation.

The graphing function is also useful in determining species composition within the stand. You will need to load the stand and stock table to explore species composition.

46. Select the **Load** tab**.**
47. In the **Runs to consider** selection box, select *Base 1*.
48. In the **Database tables to consider** selection box, select *StdStk*.
49. Select the **Explore** tab.
    a. **Years...........................** *2022* and *2052*
    b. **DBHClasses..................** All except the *All* category
50. Make sure the **Graphs** tab is selected.
51. Make the following changes to the graphing options:
    a. **Type.............................** *Bar*
    b. **Y-axis...........................** *LiveBA*
    c. **Vertical facet...............** *Year*
    d. **Width...........................** *6*
    e. **X-axis...........................** *DBHClass*
    f. **Horizontal facet..........** *StandID*
    g. **Plot-by code ....** *Species*
    h. **Height...........................** *4*
    i. **Title ....** *Stand Density*

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j. **Y-label**..........................*Basal Area Per Acre*
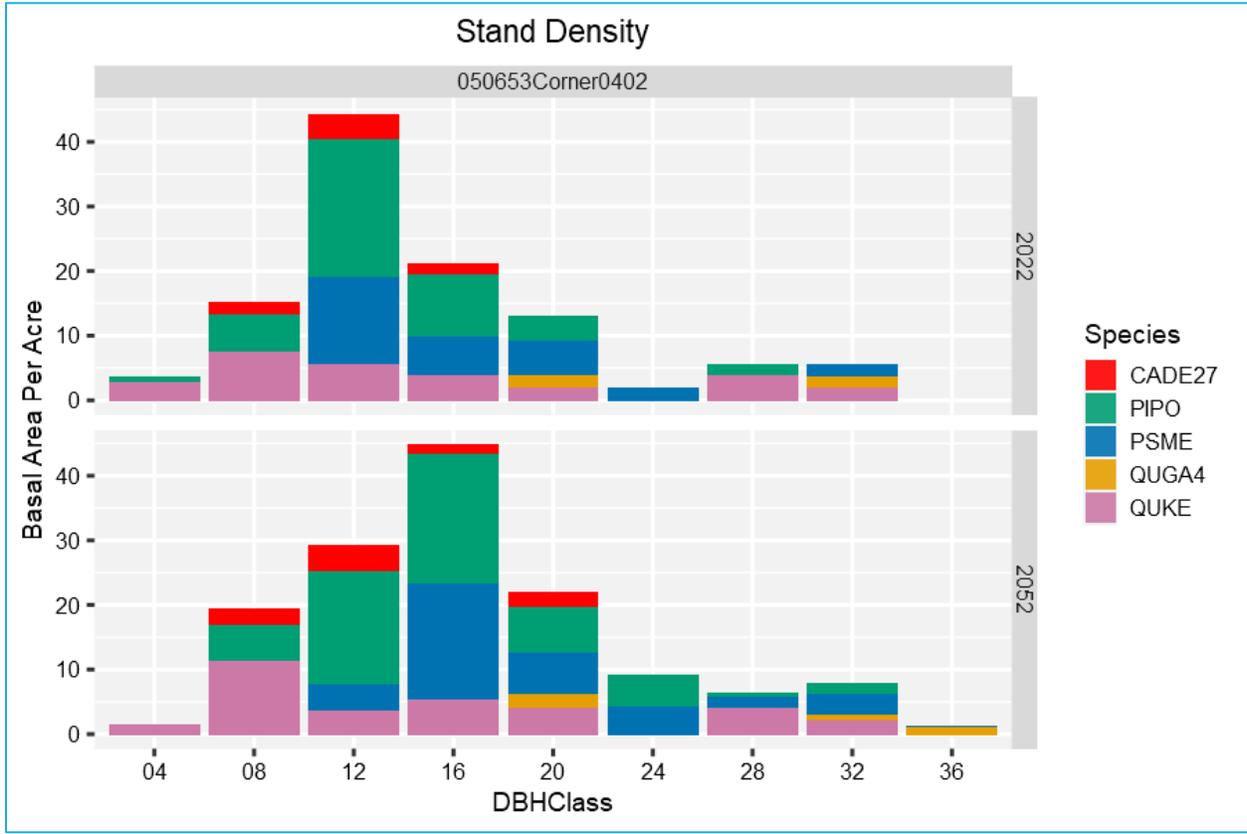
Using the outputs from this run, answer the following questions.

From the stand and stock table (*StdStk*), create and save figures that describe species composition for seedling/saplings, poletimber, and sawtimber size classes in 2022 and 2052.

From the structural class data (*FVS_StrClass*), how many strata are there in this stand and what is the canopy cover of each stratum in 2022 and 2052?

From the snag and fuels data (*FVS_SnagSum*, *FVS_Fuels,* and *FVS_Carbon*), describe snag, coarse woody debris dynamics, and carbon stocks over the time frame.

Base 2: Making a multi-stand run

In this exercise, you will use FVS to describe stand development for the next thirty years for groups of stands on the Lassen National Forest.

Starting a new run

You can start a new simulation by going to the **Simulate** tab and clicking the **New** button.

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Base 2*.
3. Click the **Save** button.

Adding stands into a run

Specific stands or groups of stands may be added to the run by using the selection tools on the **Stands** tab. You can add all stands in a grouping code by selecting a grouping code and clicking the **Add stands in the selected groups** button. Once added to a run, the stands will be added to the **Run Contents** window.

Perform the following steps to add all the paper birch stands (*Forest_Type=221*) into the simulation.

4. In the **Variants** selection box of the **Stands** menu, select *ca : Inland CA, Southern Cascades.*
5. In the **Groups** selection box, select *Location_Code=506* and *Forest_Type=221.*
6. With the **Stands must be in any or all selected groups** radio buttons, select *All.*
7. Click the **Add stands in selected groups** button.

Setting the time frame

8. Select the **Time** tab.

If you want output on a specific year that doesn't land on a cycle boundary, you can add additional reporting years by specifying the years in the **Additional output reporting years** text box.

Perform the following steps to set up a forty-year simulation starting in 2022, while also including an additional reporting year fifteen years into the simulation (2037).

9. Change the **Common starting year** and **Common ending year** to *2022* and *2062*, respectively.
10. Add *2037* to the **Additional output reporting years** text box.
11. Read the **Projection Timing Summary** for a description of how your timing choices will affect the run.

Adding additional user-defined outputs

12. Select the **Components** tab.
13. Select the **Event Monitor** tab.

Most FVS output variables are also available through the calculation of user-defined variables using Event Monitor-Compute options. With the Event Monitor, users may use these variables along with additional FVS functions and operators to create new variables. The compute expressions you create need to conform to Event Monitor coding standards, as described in section 5.5.2 Event Monitor Rules of Essential FVS: A User's Guide to the Forest Vegetation Simulator (Dixon 2002).

Perform the following steps to compute the canopy cover of trees greater than or equal to seven inches DBH.

14. Select *Compute Stand Variables with SpMcDBH Function* from selection box.

15. Change the **Component title** to *Compute PCC GE 7 inch DBH*
16. Enter the following parameters:
    a. **Year or cycle number:.** *0*
    b. **Enter the name** *PCCge7*
    c. **Attribute** .... *Canopy cover percent*
    d. **Lower DBH limit..........** *7*
    e. Leave all other parameters set to the default values.

Management Modifiers **Event Monitor** Economic Keywords Editor

Compute Stand Variables with SpMcDBH F ⌄

Component title Compute PCC GE 7 inch DBH

◉ Schedule by year ○ Schedule by condition

Year or cycle number 0

To request for all cycles, enter 0 (zero) in the 'Schedule by Year/Cycle' input box.

Enter the name for your user-defined variable (< 8 characters): PCCge7
Attribute to be returned Canopy cover percent ⌄
Species covered in the calculations All species ⌄
Tree value class covered All tree value classes ⌄

Lower DBH limit in the calculations (GE) 7

Upper DBH limit in the calculations (LT) 200

Lower height limit in the calculations (GE) 0

Upper height limit in the calculations (LT) 500

Calculations are for Live trees ⌄

Point Number or Group (0 = All Points) 0

Cancel Save in run Change to freeform

17. Click the **Save in Run** button.

Selecting Outputs

18. Select the **Select Outputs** tab.

In this exercise, you will ultimately be using images and composite tables to describe the group simulation. Check the following boxes.

19. Check the **Stand visualization, Tree lists, Carbon and fuels,** and **Snags and down wood** boxes.

Running the simulation

20. Select the ***Run*** tab.

The final step of performing an FVS run is to perform the run.

21. Change the management identification code (**MgmtID**) to *PIPO*.
22. Click the **Save and Run** button.

FVS will save the run as *Base 2* with a management identification code of *PIPO*. If the run is successful, you will see a figure reporting the volume per acre for all stands during the projection time frame.

NOTE: If you have simulations with many stands, you may want to choose the **Run in background** option instead of the **Wait for run** option. With the **Wait for run** option (default), you must wait for the run to finish before you can move on; however, by choosing **Run in background** you can continue working on other simulations while the simulation is running. The **Run in background** option more times than not, will decrease the simulation time. The **Background run status** window will keep you updated on all active background runs.

Describing stand development using View on Maps

23. Select the **View on Maps** tab.

The **View on Maps** tab will allow you to display FVS outputs for any of the stands in the run on a map. Hovering over stand points or polygons will allow you to explore the diversity of values in a specific run.

Check the forest type and canopy cover estimates of each stand in the simulation.

24. Use the **Select Run** selection box to select *Base 2*.
25. Use the **Output Table** selection box to select *FVS_Summary2* table.
26. Use the **Variable** selection box to select *ForTyp*.

Write down the forest types of a few stands.

27. Use the **Output Table** selection box to select *FVS_Compute* table.
28. Use the **Variable** selection box to select *PCCGE7*.

Write down the canopy cover range of the stands you identified above.

Describing stand development using Visualize

29. Select the **Visualize** tab.

The **Visualize** tab allows you to view and compare images of any stand in your simulation during your simulation timeframe; however, you do not get a combined image of all stands.

Use **Visualize** to check the structure and composition of the few stands you looked at previously.

30. In the left **Select Run** selection box select *Base 2*.
31. In the left **Select case** selection box, select *Stand=X* Year=*2022 Beginning of cycle*.
32. Continue viewing the rest of the stands you looked at before.

Do the images match with the forest type and canopy cover you recorded above for each stand? Why or why not?

Describing stand development using View Outputs

33. Select the **View Outputs** tab.
34. If it is not already selected, select the **Load** tab.

To view average outputs across a range of stands, you may select any of the runs and composite database tables. Composite tables are created when more than one stand is selected in the **Runs to consider** selection box, either through the selection of a single run with multiple stands or the selection of multiple runs. Composite tables are weighted averages (where values in the *Sam_Wt* column of the stand table are treated as weights) grouped by the management identification code associated with each stand. The composite tables are created for the summary table, the stand and stock table and the compute table. Composite tables are identified with the prepended letters *Cmp*.

As with the other FVS tables, you should only select tables of the same hierarchy (stand vs. diameter class vs. tree tables); otherwise, some non-sensical data may be provided.

In this run, explore the average compute and summary tables to describe stand density, size, volumes in 2022, 2037, and 2052.

35. In the **Runs to consider** selection box, select *Base 2.*
36. In the **Database tables to consider** selection box, select the *CmpCompute* and *CmpSummary2* tables.
37. Select the **Explore** tab.
    f. **Years**............................ *2022, 2037,* and *2052.*
38. Using the check boxes in the lower left, select *MgmtID, Year, CmpPCCGE1, CmpTPA, CmpBA, CmpTopHt, CmpQMD, CmpTCuFt,* and *CmpMCuFt.*
39. Select the **Tables** tab.
40. Save this information to a table by clicking the **Download table** button.

Describe the change in density, size, and volume for this group of stands.

Explore the average stand and stock table to describe species composition and size structure in 2022, 2037, and 2052.

41. Select the **Load** tab.
42. In the **Runs to consider** selection box, select *Base 2.*
43. In the **Database tables to consider** selection box, select the *CmpStdStk* table.
44. Select the **Explore** tab.
    g. **Years**............................ *2022, 2037,* and *2052.*
45. Select all the **DBHClasses** except the *All* category.
46. To view the selected outputs in graphical form, select the **Graphs** tab.
47. Make the following changes to the graphing options:
    a. **Type**............................. *Bar*
    b. **Y-axis**............................ *CmpLiveBA*
    c. **Vertical facet**............... *Year*
    d. **Width**............................ *6*
    e. **X-axis**............................ *DBHClass*
    f. **Horizontal facet** .... *MgmtID*
    g. **Plot-by code** .... *Species*
    h. **Height**........................... *4*
    i. **Title** .... *PIPO Stratum Density*
    j. **Y-label**........................... *Average Basal Area Per Acre*
    k. **More controls** .... *Show*
    l. **Bars** .... *Stacked*
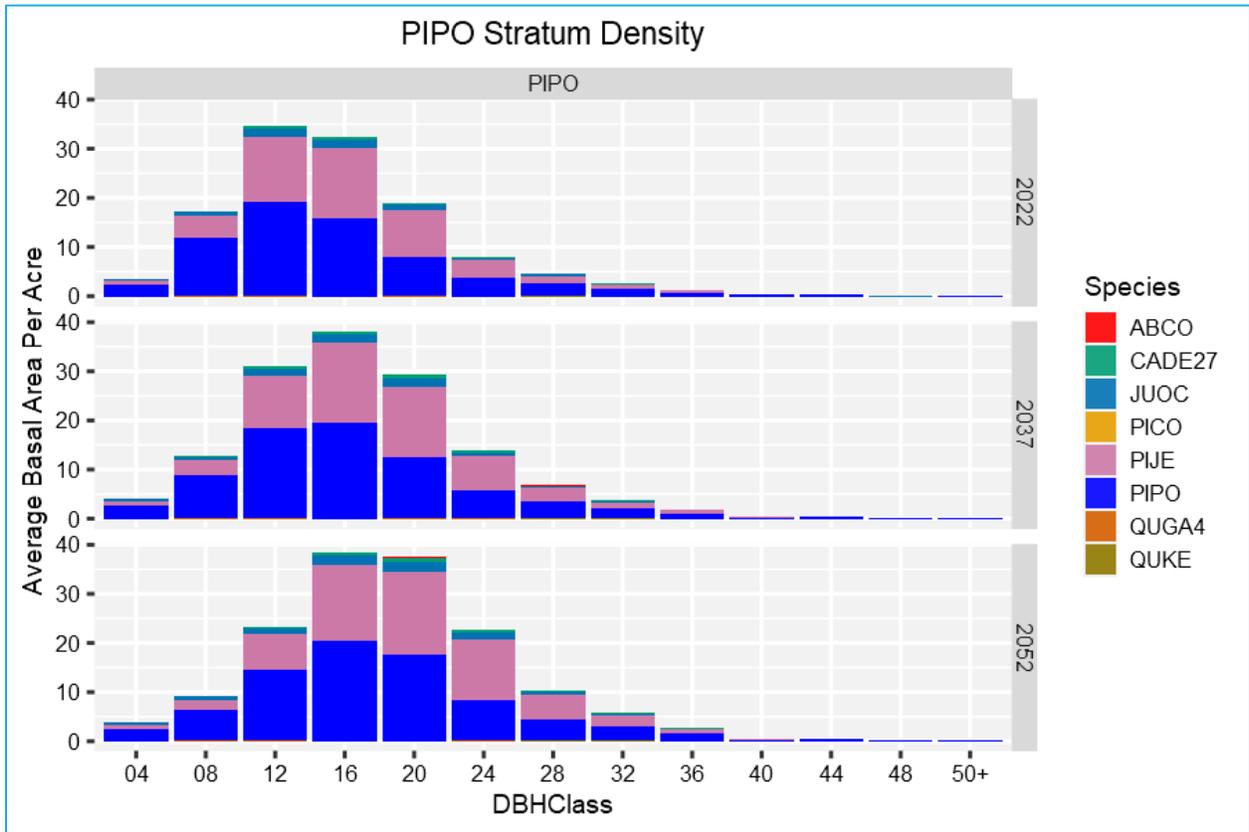
Describe the change in species composition and structure for this group of stands.

Base 3: Skills challenge

Perform a run for the mixed conifer stands (*Forest_Type=371*) in the Lassen National Forest project area. Create a document that describes average stand development for this group of stands as well as the ponderosa pine group from *Base 2*. Include:

- A table that summarizes density, size and volumes by forest type over the simulation period (*CmpSummary2* for all runs).
- A figure(s) that describes species composition for seedling/saplings, poletimber, and sawtimber (*CmpStdStk* for all runs).
- Figures that summarize the surface fuels and snags (*CmpCompute* for all runs).

NOTE: Composite tables for surface fuels and snags, as well as all Fire and Fuels Extension tables, are not created by FVS. Those variables will need to be computed using the **Event Monitor** compute options in order to create a composite table of the outputs.

Module 2: Input Data Exploration

In this module, you will explore the default training database that is loaded into FVS during the installation process. Two step-by-step exercises lead you through auditing the dataset. At the end of the module, you will find a skills challenge designed to test your comprehension of the module's topics.

Audit 1: Auditing input data

In this exercise, you will use FVS to inspect the inventory data for data entry errors.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Audit 1.*
3. Click the **Save** button.

Adding stands into a run

4. In the **Variants** selection box, select *ls : Lake States.*
5. In the **Groups** selection box, select *All_Stands.*
6. Click the **Add stands in selected groups** button.

All stands will be added to the **Run Contents** window.

Setting the time frame

7. Select the **Time** tab.
8. Change the common starting year and ending year to *2022* and *2022*, respectively.

This will grow your stands for one cycle, which is all you need to do to audit the data.

Selecting Outputs

9. Select the **Select Outputs** tab.
10. Check the **Tree lists** box to request treelist output.

Running the simulation

11. Select the ***Run*** tab.
12. Change the management identification code (**MgmtID**) to *Chck.*
13. Click the **Save and Run** button.

FVS will save the run as *Audit 1* with a management identification code of *Chck.*

If the run is successful, you will see a figure reporting the volume per acre in all stands for the specified time frame. Any errors in the run will be reported below the figure. **This is the first audit of the data.** If you receive any FVS errors, refer to Chapter 9 of the Essential FVS: A User's Guide to the Forest Vegetation Simulator (Dixon 2002) to understand the warning/error and determine your course of action.
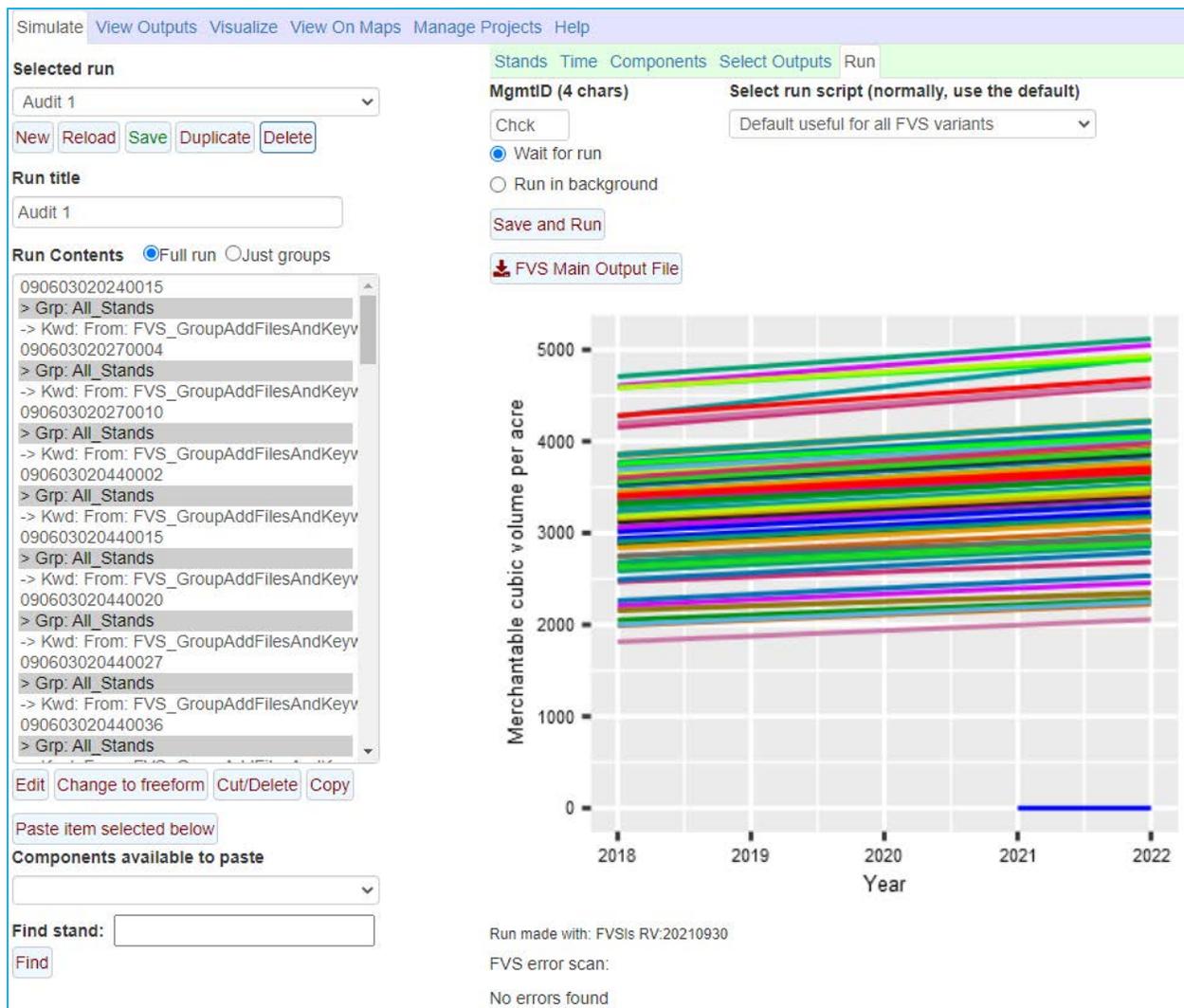
Examining the tree data

One of the best ways to check your data is to compare the heights and crowns of trees against their diameter in the inventory year. Since FVS will dub in heights and crowns of trees missing these values based in some part on species and tree diameter, plotting these relationships will show you how the dubbing functions are working. If any relationships or values look odd during this process, you can examine the tree records more closely in the input data (**Manage Projects > Import input data >View and edit existing tables** tab).

14. Select the **View Outputs > Load** tab.
15. In the **Runs to consider** selection box, select *Audit 1.*
16. In the **Database tables to consider** selection box, select *FVS_TreeList_East.*
17. On the right, use the **Describe tables** selection box to select the *FVS_Treelist_East* table and review the output variable definitions, especially *DBH, Ht,* and *PctCr.*
18. Select the **Explore** tab.

You will use the scatter plot graphing option to compare height and crown ratio by species for stands in the simulation.

19. In the left pane, select the first stand in the **Stands** selection box.

20. Select *2018* in the **Years** selection box.
21. Make sure the following variables are selected in the **Select variables** check boxes:
    a. *MgmtID, StandID, Year,* and *Species*
    b. *DBH, Ht,* and *PctCr.*
22. In the right pane, select the **Graphs** tab.
23. Make the following selections to compare tree height vs. DBH.
    c. **Type**...*scat*
    d. **Y-axis**..*Ht*
    e. **Vertical facet**...........................*None*
    f. **X-axis**.......................................*DBH*
    g. **Horizontal facet**.......................*StandID*
    h. **Plot-by code**............................*Species*

The graph will display the height-diameter relationships by species in the stand you selected. Species where the relationship appears to be a line will likely contain dubbed heights. Values off the line of the same species are likely measured heights.

Cycle through the list of stands and determine if any trees have suspect heights or diameters. If you find any, note the stand, species, and approximate diameter and height below. Hint: it might be easier to select all stands and a single species in the left pane, then set the **Horizontal facet** to *None* and **Plot-by code** to *StandID*. Then cycle through the species.

24. Change the **Y-axis** ....*PctCr*

Cycle through the list again and note any odd crown ratio-diameter relationships below.

If any values seem suspect and you have a correction to make, you can go to the **Manage Projects > Import input data >View and edit existing tables** tab to edit the input tree data.

Examining the stand data

Another way to check your data for underlying data errors is to display stand summary data for the inventory year. If any values look odd during this process, you can examine the stands more closely.

25. Select the **View Outputs > Load** tab.
26. In the **Runs to consider** selection box, select *Audit 1*.
27. In the **Database tables to consider** selection box, select *FVS_Summary2_East*.
28. On the right, use the **Describe tables** selection box to select and review the *FVS_Summary2_East* table outputs, especially *Age, Tpa, BA, SDI, CCF, TopHt, QMD, TCuFt,* and *MCuft*.
29. Select the **Explore** tab.

You will use the scatter plot graphing option to compare numerous stand attributes for the inventory year for stands in the simulation.

30. In the left pane, select the all the stands in the **Stands** selection box.
31. Select the **Years** ....*2018.*
32. Make sure the following variables are selected in the **Select variables** check box:
    i. *MgmtID, StandID,* and *Year*
    j. *Age, Tpa, BA, SDI, CCF, TopHt, QMD, MCuFt,* and *SCuft*

33. In the right pane, select the **Graphs** tab.
34. Make the following selections to compare age vs. year.
    a. **Type**............................. *scat*
    b. **Y-axis**............................ *Age*
    c. **Vertical facet**............... *None*
    d. **X-axis**............................ *Year*
    e. **Horizontal facet**.......... *None*
    f. **Plot-by code** .... *StandID*

The graph will display a line of values for the inventory year. Cycle through the Y-Axis variables and note any odd values below. If you find any, note the stand and approximate value below.

If any values seem suspect and you have a correction to make, you can navigate to the **Manage Projects > Import input data >View and edit existing tables** tab to edit the stand or tree data.

Audit 2: Obtaining inventory statistics

In this exercise, you will use FVS to inspect the sampling errors of the inventory data.

Duplicating an existing run

1. Within the **Simulate** tab, make sure *Audit 1* is in memory.
2. Begin a new simulation by clicking the **Duplicate** button.
3. Change the **Run title** to *Audit 2.*
4. Click the **Save** button.

All stands and actions from the previous run will be added to the new simulation.

Selecting Outputs

5. Select the **Select Outputs** tab.
6. Uncheck the **Tree lists** box.
7. Check the **Inventory Statistics** box.

Running the simulation

8. Select the ***Run*** tab.
9. Change the management identification code (**MgmtID**) to *SE.*
10. Click the **Save and Run** button.

FVS will save the run as *Audit 2* with a management identification code of *SE*.

If the run is successful, you will see a figure reporting the volume per acre in the stands for the simulation time frame. Any errors in the run will be reported below the figure.

Examining the Output Statistics

11. Select the **View Outputs** > **Load** tab.
12. In the **Runs to consider** selection box, select *Audit 2.*

FVS created two tables that describe stand inventory statistics: one for species (*FVS_Stats_Species*) and another one for the stand (*FVS_Stats_Stand*). Both tables report statistics for trees per acre, basal area per acre, total cubic feet volume, and board feet. The *Species* table reports means of these attributes by species. The *Stands* table reports the distribution of these attributes among sample points in the stand.

13. On the right, use the **Describe tables** selection box to review the *FVS_Stats_Species* table variables.

Follow the steps to produce figures showing species averages for each category.

14. Select the *FVS_Stats_Species* table in the **Database tables to consider** selection box.
15. Leave all the variables selected in the **Database variables to consider** selection box.
16. Select the **Explore** tab.
17. In the **Stands** selection box on the left side of the screen, select stand *090603020240015.*
18. In the **Select variables** area, make sure that all check boxes are checked.
19. Select the **Graphs** tab on the right.
20. Make the following selections to compare trees per acre represented by species.
    a. Set the **Type** of graph to *bar.*
    b. Set the **Y-axis** to *TreesPerAcre.*
        -

d. Set the **Horizontal facet** to *StandID*.

f. Set the **Plot-by code** to *None.*

The graph will show the mean trees per acre by species. Cycle through the Y-axis attributes and note the top two species in each category below.

To view the distribution of these attributes among sample points in the stand, load the *FVS_Stats_Stand* table and explore the outputs.

21. Select the **Load** tab.
22. In the **Runs to consider** selection box, select *Audit 2*.
23. On the right, use the **Describe tables** selection tab to review the *FVS_Stats_Stand* table variables.

Notice that you will retrieve the average as well as measures of variability of the stand and your sample for each attribute (*TREES/ACRE, CUBIC FEET/ACRE, BOARD FEET/ACRE, and BASAL AREA/ACRE*). Follow the steps to produce a table reporting stand statistics for each category.

24. Select the *FVS_Stats_Stand* table in the **Database tables to consider** selection box.
25. Leave all the variables selected in the **Database variables to consider** selection box.
26. Select the **Explore** tab.
27. In the **Stands** selection box on the left side of the screen, select stand *090603020240015*.
28. In the **Select variables** area, make sure that all check boxes are checked.
29. Select the **Tables** tab.

Scroll through the table and note the average, coefficient of variation, and sampling error (%) below.

What do the sampling error values tell you about the reliability of your inventory?

Use the **View On Maps** tab options to explore the sampling error for a few of your stands.

30. Select the **View On Maps** tab.
31. In the **Select Run** selection box, select *Audit 2.*
32. In the **Output Table** selection box, select *FVS_Stats_Stand.*
33. In the **Variable** selection box, select *Samp_Error_Percent*.

Move your cursor over a few stands and write down the sampling errors you see. If you would like to see sampling errors less than 20%, do you think the sampling protocols for this project adequately resulted in a robust dataset?

Audit 3: Skills challenge

Select all the stands from a different variant. Audit the stands using the procedures presented in this module to answer the questions below.

What dataset did you choose?

Are there any warnings associated with your data?

Do the individual tree sizes look reasonable? Specifically identify any stands/species/tree records where diameters, heights or crown ratios look suspect.

Report the range of stand densities (tpa, ba, and sdi) and volumes for the project.

Explore the sampling error for a few of your stands. Does sampling error change by the attribute reported? How So?

Do you think the sampling protocols for the project resulted in a robust dataset?

Module 3: Basic Management

This module leads you through simulating basic thinning actions. In practice, these are the basic building blocks you will use and combine to simulate more complex prescriptions during real-world applications of FVS. Three step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Thin 1: Thinning throughout a diameter range

In FVS, management actions are located in the **Simulate > Components > Management** tab. Common thinning options are shown by selecting *Thinning and Pruning Operations* in the **Categories** selection box. To thin a stand evenly within a specified diameter range, for specific species, to specific residual targets, whether the target be trees per acre, basal area per acre or even a simple proportion of trees to be left, choose the *Thin throughout a diameter range* option in the **Components** selection box.

In this exercise, you will thin evenly throughout three different diameter ranges in the year 2022. You will thin to 300 trees per acre all trees less than 6" DBH, you will remove 50 percent of the trees from 6-18" DBH, and you will thin to 20 square feet of basal area for trees with DBH greater than 18".

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Thin 1*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ie : Inland Empire.*
5. In the **Groups** selection box, select *Forest_Type=201* (Douglas-fir).
6. In the **Stands** selection box, select stand *01100201010077.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.

Perform the following step to set up a thirty-year run starting in 2022.

9. Change the **Common starting year** and **Common ending year** to *2022* and *2052*, respectively.

Adding the thins

10. Select the **Components > Management** tab.
11. From the **Categories** selection box, select *Thinning and Pruning Operations.*
12. From the **Components** selection box, select *Thin throughout a diameter range.*
13. Change the **Component title** to *Thin trees 0-6 inches DBH evenly to 300 TPA.*
14. Enter the following parameters:
    a. **Year or cycle number**...............*2022*
    b. **Density in terms of**..................*Trees per acre*
    c. **Residual Density**.......................*300*
    d. **Smallest DBH**...........................*0*
    e. **Largest DBH** *6*
    f. Leave all other parameters set to the default values.

15. Click the **Save in run** button.

Now add the other two thinning actions.

16. From the **Components** selection box, select *Thin throughout a diameter range.*
17. Change the **Component title** to *Thin 50% of trees 6-18 inches DBH evenly.*
18. Enter the following parameters:
    a. **Year or cycle number**...............*2022*
    b. **Proportion of trees to cut**........*0.50*
    c. **Smallest DBH**...........................*6*
    d. **Largest DBH** *18*
    e. Leave all other parameters set to the default values.
19. Click the **Save in run** button.
20. From the **Components** selection box, select *Thin throughout a diameter range.*
21. Change the **Component title** to *Thin trees 18+ inches DBH evenly to 20 BA.*
22. Enter the following parameters:
    a. **Year or cycle number**..*2022*
    b. **Density in terms of**......*Basal area*
    c. **Residual Density**..........*20*
    d. **Smallest DBH**...............*18*

41

e. Leave all other parameters set to the default values.
23. Click the **Save in run** button.

Selecting Outputs

24. Select the **Select Outputs** tab.
25. Check the **Stand visualization** box to request image files.
26. Check the **Tree lists** box to request output needed to create a stand and stock table.
27. Check the **Regeneration** box to request regeneration tables.

Running the simulation

28. Select the ***Run*** tab.
29. Change the management identification code (**MgmtID**) to *Even*.
30. Click the **Save and Run** button.

FVS will save the run as *Thin 1* with a management identification code of *Even*.

If the run is successful, you will see a figure reporting the volume per acre in the stand for the run time frame. The large drop in volume in 2022 indicates that at least one thinning occurred. Any errors in the run will be reported below the figure.
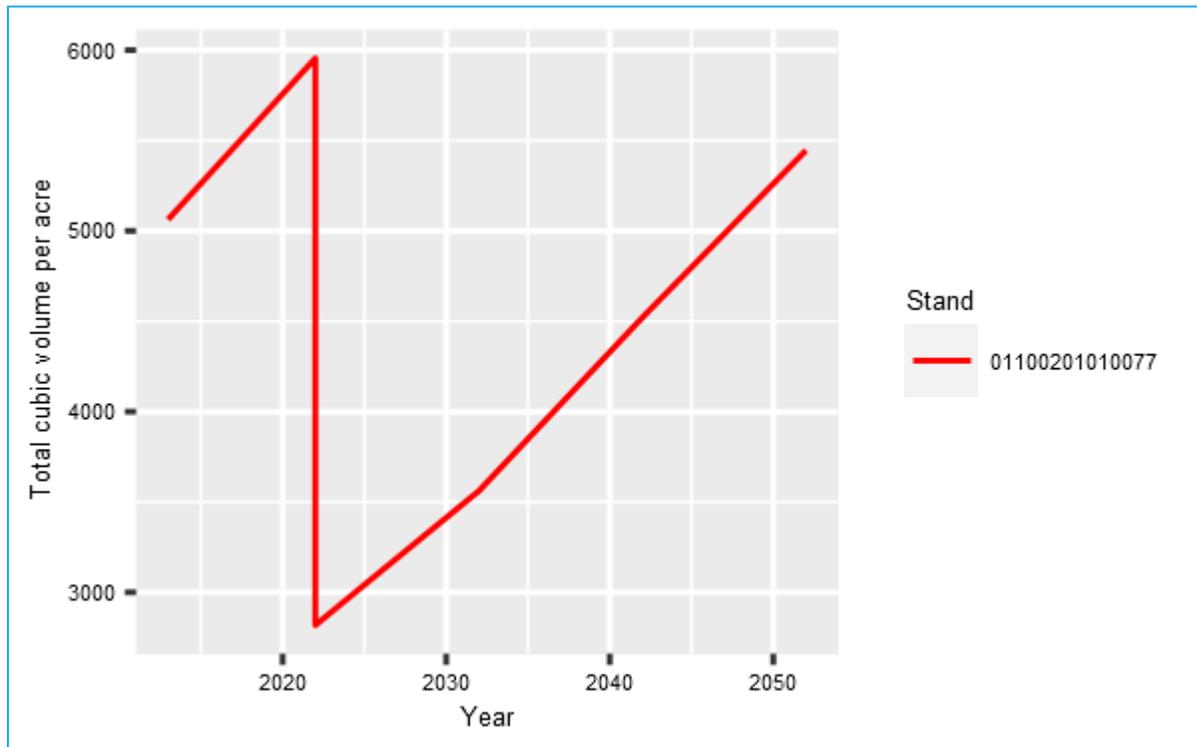
Examining the thinning effects

Begin exploring the effects of this run by using the **Visualize** tab to view pre- and post-harvest images.

31. Select the **Visualize** tab.
32. In the left **Select Run** selection box select *Thin 1*.
33. In the left **Select image** selection box, select *Stand=0110020101077 Year=2022 Beginning of cycle*

34. Wait for image to be drawn.
35. In the right **Select Run** selection box, select *Thin 1.*
36. In the right **Select image** selection box, select *Stand=0110020101077 Year=2022 Post cutting.*

Do the pre- and post-thinning images match your expectations? Why or why not?

Using the FVS output, complete the following tasks/questions using the **View Outputs > Load/Explore** tabs.

Load/Explore the stand summary table (*FVS_Summary2*) and report the trees per acre and board feet removed. Make sure you select the removal code variable (RmvCode) to be included in your table. This will let you know which rows are pre- and post-thinning.

37. Select the **View Outputs > Load** tab.
38. In the **Runs to consider** selection box, select *Thin 1.*
39. In the **Database tables to consider** selection box, select *FVS_Summary2.*
40. Select the **Explore** tab.
41. On the left side, ensure the checkboxes for *RmvCode, QMD, RTpa, RBdFt* are checked.
42. Make sure the **Tables** tab is selected.

In the table to the right, find the removed tpa and board feet. Write the values below.

Find the QMD variable. How did QMD change post-thinning? Can you explain the results?

In FVS, regeneration is produced in simulations through either a partial or full establishment model. The Inland Empire variant uses the full establishment model. In this model, both regeneration following significant disturbance and ingrowth during periods without disturbance are simulated. Sprouting of known sprouting species will also occur after cutting and burning activities that result in topkill.

Use the **Load/Explore** tabs to list the number of trees regenerating following the harvest for each species.

43. Select the **Load** tab.
44. In the **Runs to consider** selection box, select *Thin 1.*
45. In the **Database tables to consider** selection box, select *FVS_Regen_Tally.*
46. Select the **Explore** tab.
47. On the left side, check all check boxes.

Regeneration is added to FVS at cycle boundaries for a period of twenty years after a significant harvest. All trees labeled as "TpaBest" are added to the simulation, along with some additional trees not considered best trees. Record the trees per acre of best trees regenerating for each year.

Species							
2032							
2042							

Use the **Load/Explore** menus to list the total number of spouts following the harvest and the number of sprouts associated with each species.

48. Select the **Load** menu.
49. In the **Runs to consider** selection box, select *Thin 1.*
50. In the **Database tables to consider** selection box, select *FVS_Regen_Sprouts.*
51. Select the **Explore** menu.
52. On the left side, check all check boxes.

Record the number of sprouts by species below.

Sprouting species		
2032		

 Load/Explore the stand and stock table (*StdStk*) to check the thinning results of each cut. Using 4" diameter classes will allow you to view pre-thin, removed, and residual values for each diameter range: 0-6" = 4" class, 6-18" = 8, 12, and 16" classes, 18+" = 20" class and above. Create and save a graph of your results.

53. Select the **Load** tab.
54. In the **Runs to consider** selection box, select *Thin 1.*
55. In the **Database tables to consider** selection box, select *StdStk.*
48. Select the **Explore** tab.
    h. **Years**............................ *2022*
    i. **DBHClasses**.................. *04*
    j. **Species** .... *All*
49. To view the selected outputs in graphical form, select the **Graphs** tab.
50. Make the following changes to the graphing options:
    a. **Type**.............................. *Bar*
    b. **Y-axis**............................ *LiveTPA, HrvTPA, RsdTPA*
    c. **Vertical facet**............... *None*
    d. **Width**............................ *4*
    e. **X-axis**............................ *Year*
    f. **Horizontal facet** .... *StandID*
    g. **Plot-by code** .... *None*
    h. **Height**........................... *3*
    i. **Title** .... *Thinning Results*
    j. **Y-label**........................... *Trees Per Acre*
    k. **More controls** .... *Show*
    l. **Bars** .... *Side-by-side*

Were you successful in cutting the 0-6" DBH range to 300 trees per acre?

Alter the **DBHClass** and **Y-axis** selections to determine if you were successful in cutting 50% of the trees between 6 and 18" DBH as well as cutting the 18" and above trees to 50 square feet of basal area.

Thin 2: Thinning from below to a basal area residual with species preferences

Thinning with species preferences is an option with all management actions. However, the method used to assign a species preference depends on the management action chosen.

If you choose a management action that contains a targeted species option, the residual densities apply only to the species selected within the DBH or height range specified. In this way, you can remove specific species from diameter and height ranges within a stand. The *Thin throughout a diameter range* action shown in the previous exercise works in this manner.

If you choose a management action that does not contain a targeted species option, such as T*hin from Below* and *Thin from Above*, the residual densities apply to all species within the DBH or height range specified; however, there are a couple of ways to modify the removals based on species. First, you can specify a species to be excluded or re-included from scheduled harvest activities using the tree removal preference management action: *Exclude or include a species from harvest*. When excluded, FVS does not consider the excluded species density in the residual targets specified in the thinning. Second, for users looking to set a less rigid removal preference, there is the tree removal preference management action: *Removal pref by species*, which assigns a user-specified removal priority to each species.

When setting a species removal priority for these management actions, FVS uses a removal priority algorithm to decide which trees to cut first; see the equation below. The larger the tree record's calculated Removal Priority, the higher the probability that the tree record will get selected for removal. The removal priority is a function of tree DBH, species preference, tree value class, special tree status, dwarf mistletoe rating (western FVS variants) and plot density measures. By default, only the Fd variable and DBH of the tree records are considered; therefore, allowing FVS to thin from below or above.

Removal Priority = $(Fd \cdot DBH) + SP + (Ft \cdot IMC) + Fm + (Fs \cdot STS) + (Fpba \cdot PBAi) + (Fpccf \cdot PCCFi) + (Fptpa \cdot PTPAi)$

where:

Fd ....(−1) if thinning from below, (+1) if thinning from above

DBH .....Tree diameter at breast height

SP ....User-specified species preference

Ft.........User-specified multiplier for the tree value class code

IMC .....Tree value class code (see section 4.2.1)

Fm ....User-specified dwarf mistletoe preference

Fs.........User-specified multiplier for the tree special status code

STS ......Tree special status code (see Damage and Severity codes in section 4.2.1)

Fpba ....User-specified multiplier for the point estimate of stand basal area

PBAi ....Stand basal area estimate for the inventory point (i) on which the tree is located

Fpccf ...User-specified multiplier for the point estimate of stand crown competition factor

PCCFi....Estimate of the stand crown competition factor for the inventory point (i) on which the tree is located

Fptpa...User-specified multiplier for the point estimate of stand trees per acre

PTPAi...Stand trees per acre estimate for the inventory point (i) on which the tree is located

Species removal preferences that are positive numbers increase the removal priority, and negative numbers decrease the removal priority. In this manner, you can either increase or decrease a tree record's removal priority by changing the value of the species variable.

In this exercise, you will be performing two runs. In the first run, you will use the *Thin from Below* management action to achieve a residual density of 40 square feet of basal area above 7-inches DBH without targeting a specific species. In the second run, you will be thinning from below to the same residual density but will be favoring the removal of Douglas-fir and lodgepole pine over ponderosa pine. Both runs will project the stand for thirty years.

Starting the first run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Thin 2a*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ie : Inland Empire.*
5. In the **Groups** selection box, select *Forest_Type=221* (ponderosa pine).
6. In the **Stands** selection box, select stand *01100202010006.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2052*, respectively.

Adding the thinning

The *Thin from below* management action thins the stand from below to a residual trees per acre or basal area per acre density or to a residual percentage of those density statistics. The residual density may be set for a given diameter or height range. The tree record with the smallest diameter within the diameter and height range specified is cut first, then the next smallest tree record is cut and so on until the residual density is met. If the diameter and height ranges are left at the default values (minimum = 0 and maximum = 999) then the residual density is for the entire stand.

Another option in this management action is to reset the cutting efficiency through the **Proportion of trees left** field. This allows some smaller trees to be left in the stand. When FVS attempts to cut a tree record, the proportion of trees specified as left is used to determine how many trees per acre represented by the tree record are left standing. If left at the default proportion (0.0), FVS cuts all trees represented by the tree record; that is, the cutting efficiency is set to 1.0 - 0.0 = 1.

Reset the parameters of the thinning to thin from below to 40 square feet per acre of basal area in 2022 for all trees greater than or equal to 7" DBH. In this first run, species will not be preferentially removed from the stand during the thin from below.

10. Select the **Components > Management** tab.

11. From the **Categories** selection box, select *Thinning and Pruning Operations.*
12. From the **Components** selection box, select *Thin from below.*
13. Change the **Component title** to *Thin from below 7+.*
14. Enter the following parameters:
    a. **Year or cycle number**...............*2022*
    b. **Specify residual density**...........Basal area per acre
    c. **Residual Density**........................*40*
    d. **Proportion of trees left** *0*
    e. **Diameter lower limits**..............*7*
    f. **Diameter upper limits**..............*999*
    g. Leave all other parameters set to the default values.

Management	Modifiers	Event Monitor	Economic	Keywords	Editor

Categories

Thinning & Pruning Operations ⌄

Components

Thin from below ⌄

Component title   Thin from below 7+

◉ Schedule by year   ○ Schedule by condition

Year or cycle number   2022

Specify residual density

○ Trees per acre   0

○ Trees spacing (feet)   0

◉ Basal area per acre   40

○ Percent of trees per acre at year of thin   0

○ Percent of basal area at year of thin   0

Proportion of trees left (spacing adjustment, 1-CutEff)   0

Specify tree size limits of thinning

Diameter lower limits (inches)   7

Diameter upper limits (inches)   999

Height lower limits (feet)   0

Height upper limits (feet)   999

Cancel   Save in run   Change to freeform

15. Click the **Save in run** button.

Selecting Outputs

16. Select the **Select Outputs** tab.
17. Check the **Stand visualization** box to request image files.
18. Check the **Tree lists** box to request output needed to create a stand and stock table.

Running the simulation

19. Select the ***Run*** tab.
20. Change the management identification code (**MgmtID**) to T2*a*.
21. Click the **Save and Run** button.

FVS will save the run as *Thin 2a* with a management identification code of *T2a*.

Examining the thinning effects

In this exercise you will be examining the outcomes of the runs using **Visualize** and the **View Outputs** tabs.

Begin exploring the effects of this run by using **Visualize** tab to view pre- and post-harvest images. Rotate the images to a profile view and overhead view. Do the pre- and post-thinning images match your expectations. Why or why not?

Use the **View Outputs > Load/Explore** tabs to check the thinning results with the stand and stock table (*StdStk*). Using 2" diameter classes will allow you to view the stand at the 7" DBH break. First create a diameter distribution graph of harvested basal area across species.

List the harvested basal area values for the 4 species that were targeted in the thin from below.

Species	Harvested Basal Area

Change the graph parameters to determine if the residual density is 60 BA. Did you hit 40 BA? If not, try looking at the trees in the 8" diameter class and larger.

A second run will now be performed with the same thin from below action, but western hemlock and red alder will be preferentially removed during the thinning. You will use the previous run for the basis of this next run.

Starting the second run

22. Within the **Simulate** tab, duplicate run *Thin 2a* by clicking the **Duplicate** button.
23. Change the **Run title** to *Thin 2b*.

24. Click the **Save** button.
25. In the **Run Contents** window, ensure the *Grp: All_Stands* grouping code is selected.

You will now specify which species you want to preferentially remove in the thin form below that will occur in this simulation. Removal preferences can be specified for individual species or to groups of species. Since you are interested in targeting several species, a group of species will be defined.

Adding species preferences

26. Select the **Components > Management** tab.
27. From the **Categories** selection box, select *Identify Groups.*
28. From the **Components** selection box, select *General species group.*
29. Change the **Component title** to *Species to target: SPP_THIN.*
30. Enter the following parameters:
    a. **Specify a 2-10 character Species Group** ....SPP_THIN
    b. **Species** ....Douglas-fir
    c. **Species** ....lodgepole pine

Management	Modifiers	Event Monitor	Economic	Keywords	Editor

Categories

Identify Groups	⌄

Components

General species group	⌄

Component title | Species to target: SPP_THIN |

Identifies a group of species that can be referenced by a single name and included in any species field in management actions, species preferences or user-defined variables.

Warning: This species group identifier needs to come before the management action or output selection utilizing the group name.

Specify an 2-10 character Species Group | SPP_THIN
Species included in the group: | Douglas-fir | ⌄
Species included in the group: | lodgepole pine | ⌄
Species included in the group: | | ⌄

31. Click the **Save in run** button.

You will now specify that you want these species to be preferentially removed when a thinning occurs in your simulation. When using the species removal preference option, you must specify when this will take effect in a simulation. This option remains in effect until a second species removal preference option changes the removal priority of the species. In this simulation, you will have the removal preference take effect in 2022.

32. From the **Categories** selection box, select *Tree Removal Preference.*
33. From the **Components** selection box, select *Removal pref by species.*
34. Change the **Component title** to *Removal pref by species: SPP_THIN.*
35. Enter the following parameters:
    a. **Year of cycle number** *2022*
    b. **Species whose removal priority will be changed**......... SpGroup:SPP_THIN
    c. **Preference for removal** *10*

Stands Time Components Select Outputs ***Run***

Management Modifiers Event Monitor Economic Keywords Editor

Categories

Tree Removal Preference   ⌄

Components

Removal pref by species   ⌄

Component title   Removal pref by species: SPP_THIN

◉ Schedule by year   ○ Schedule by condition

Year or cycle number   2022
Species whose removal priority will be changed   SpGroup:SPP_THIN   ⌄
A positive value increases the chance for tree removal and a
negative value increases the chance of tree retention.

Preference for removal of the selected species   10
Cancel Save in run Change to freeform

36. Click the **Save in run** button.

Within FVS, there is an order preference for the *General species group* and *Removal pref by species* components within the **Run Contents** window. The *General species group* component must precede any other component which references the species group defined within the *General species group* component. In this case, *General species group* must precede the *Removal pref by species* component. If a *Removal pref by species* component is specified the same year that a thinning action is specified, the *Removal pref by species* component must precede the thinning component. In this case, the *Removal pref by species* component must precede the *Thin from below*. Given these rules, it will be necessary to relocate these components within the **Run Contents** window for this run.

37. Select the *Kwd: Thin from below 7+* component in the **Run Contents** window.
38. Click the **Cut/Delete** button.
39. Select the *Kwd:Removal pref by species: SPP_THIN.*
40. Click the **Paste item selected below** button.

You will now see the *Thin from below 7+* below the other keywords.

Running the simulation

41. Select the ***Run*** tab.
42. Change the management identification code (**MgmtID**) to T2*b*.

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43. Click the **Save and Run** button.

Examining the species preference effects

Use the **View Outputs - Load/Explore** tabs to check the thinning results with the stand and stock table (*StdStk*). Using 2" diameter classes will give allow you to view the stand at the 7" DBH break. Use the stand and stock table output to complete the following tasks/questions.

Using the diameter distribution graphs and the tabular stand and stock table, list the harvested basal area values for the 4 species thinned.

Species	Harvested Basal Area

How did the distribution of removed basal area change across species? Were you successful in removing less ponderosa pine and targeting more Douglas-fir and lodgepole pine?

What could you modify in the run to not cut any western larch?

Thin 3: Thinning to a percent canopy cover

In FVS, thinning targets don't always have to be in terms of basal area per acre or trees per acre; more complex density metrics can be used as targets as well. The **Thin to a residual percent canopy cover** management action can be used to achieve a desired residual percent canopy cover. This management action has the user specify the target residual percent canopy cover, the species that will be removed in the thinning, and the desired diameter range from which trees will be harvested. In addition, users can select a type of cutting control which determines how the thinning will be conducted to achieve the residual percent canopy cover target. A thinning can be conducted in one of three ways for the diameter range specified in the management action; 1) thinned evenly throughout the diameter range, 2) thinned from below, or 3) thinned from above.

In this exercise, you will be managing a stand to stay between 40-60% canopy cover within the merchantable timber size class (DBH ≥ 7") by thinning evenly throughout this diameter range. You will first perform a natural growth run and explore output from the structural class table. Then you will perform a second run where you thin a stand down to a residual canopy cover of 40% in the merchantable size class range and explore management outcomes with user defined compute variables.

Starting the natural growth run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Thin 3a*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *wc: West Cascades.*
5. In the **Groups** selection box, select *Forest_Type=201.*
6. In the **Stands** selection box, select stand *06180195590000005.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Set the timeframe for a 30-year projection starting in 2022.

Adding additional user-defined outputs

Add the additional output you need to explore the canopy cover of the stand based on specific size limits mentioned above.

10. Select the **Components > Event Monitor** tab.
11. Select the *Compute Stand Variables with SpMcDBH Function* from the selection box.
12. Change the **Component title** to *CC for DBH < 7 inches.*
13. Enter the following parameters:
    a. **Year or cycle number**...........................*0 (request is for all cycles)*
    b. **Enter the name** *CClt7*
    c. **Attribute to be returned**.....................*Canopy cover percent*
    d. **Upper DBH limit**...................................*7*
    e. **Calculations are for**..............................*Residual (after harvest) live trees*
    f. Leave all other parameters set to the default values.

14. Click the **Save in run** button.
15. Select the *Compute Stand Variables with SpMcDBH function from the selection box.*
16. Change the **Component title** to *CC for DBH >= 7 inches.*
17. Enter the following parameters:
    a. **Year or cycle number**............................ *0*
    b. **Enter the name** CCge9
    c. **Attribute to be returned**...................... Canopy cover percent
    d. **Lower DBH limit**.................................. 7
    e. **Calculations are for**............................. *Residual (after harvest) live trees*
    f. Leave all other parameters set to the default values.
18. Click the **Save in run** button.
19. Select the *Compute Stand Variables with SpMcDBH function from the selection box.*
20. Change the **Component title** to *Stand Canopy Cover*
21. Enter the following parameters:
    a. **Year or cycle number**............................ *0*
    b. **Enter the name** .... CCStand
    c. **Attribute to be returned**...................... Canopy cover percent
    d. **Calculations are for**............................. *Residual (after harvest) live trees*
    e. Leave all other parameters set to the default values.
22. Click the **Save in run** button.

Running the simulation

23. Select the ***Run*** tab.
24. Change the management identification code (**MgmtID**) to *CCNA.*
25. Click the **Save and Run** button.

FVS will save the run as *Thin 3a* with a management identification code of *CCNA.*

Starting the thinning run

You will now create a new run and perform a thinning to a residual percent canopy cover by evenly thinning all trees with DBH greater than 7".

26. Within the **Simulate** tab, begin a new simulation by clicking the **Duplicate** button.
27. Change the **Run title** to *Thin 3b.*
28. Click the **Save** button.

Adding the thinning

29. Select the **Components – Management** tab.
30. From the **Categories** selection box, select *Thinning and Pruning Operations.*
31. From the **Components** selection box, select *Thin to a residual percent canopy cover.*
32. Change the **Component title** to *Thin evenly to a PCC of 40% in 7+ trees.*
33. Enter the following parameters:
    a. **Year or cycle number**............................ *2022*
    b. **Residual canopy cover percent**............ *40*
    c. **Diameter lower limits**.......................... 7
    d. Leave all other parameters set to the default values.

34. Click the **Save in run** button.

Running the simulation

35. Select the ***Run*** tab.
36. Change the management identification code (**MgmtID**) to *CCTH*.
37. Click the **Save and Run** button.

FVS will save the simulation as *Thin 3b* with a management identification code of *CCTH*.

Examining the thinning effects on canopy cover

Use the **View Outputs > Load/Explore** tabs to check the canopy cover of the stand with the computed variables table (*FVS_Compute*).

Fill in the following information for 2022:

Variable	*CCNA* Canopy Cover	*CCTH* Canopy Cover
CCLT7		
CCGE7		
CCStand		

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Were you able to hit a target residual of 40% canopy cover in the merchantable timber size class with the thinning?

Why doesn't the canopy cover add up to the stand canopy cover?

Thin 4: Skills challenge

Using all the stands from the Douglas-fir forest type (201) on the Flathead National Forest (110), perform the following two runs; 1) one thirty-year natural growth run and 2) one thirty-year run where you will actively manage the stands. In the second run, your goal will be to thin the merchantable size class (DBH ≥ 7") from below to 40% canopy cover in 2022. In addition, you will specify that 50% of unmerchantable sized trees will be lost to logging damage during the harvest (hint: consider how you would implement this using one of the thinnings presented earlier, along with the *Biomass Removal and Retention* options).

Prepare a document that contains the following:

- A table that describes the composite density, size and volumes over the run time frame for both runs.
- A figure describing the composite volume harvested by species and size class.

Module 4: Fire and Fuels Management

This module leads you through simulating fire and fuels related management actions. You will learn about adding fire effects into your simulations and managing fuel loads through commonly practiced prescriptions. Four step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Fire 1: Simulating wildfire and a salvage harvest

In FVS, fire and fuels related management actions are in the **Simulate > Components > Management** tab. Common fuel treatments and salvage operations are shown by selecting *Fuel Treatments* and *Salvage Operations* in the **Components** selection box. Additional fire and fuels related options may be found by selecting the *Fire and Fuels Extension* in the **Simulate > Components > Keyword** tab.

In this exercise, you will explore simulating a wildfire and a subsequent salvage harvest.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Fire 1*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *cr: Central Rockies GENGYM.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *0302044019000039.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2052*, respectively.
10. Add the year *2024* to the **Additional output reporting years** text box.

Adding the additional year allows you to simulate the wildfire in 2022 and salvage the killed trees two years later.

Adding a wildfire event

The *SimFire* keyword allows you to schedule a fire with specific weather and time parameters.

11. Select the **Components > Keywords** tab.
12. From the **Extensions** selection box, select *Fire and Fuels Extension.*
13. From the **Keywords** selection box, select *SimFire.*
14. Change the **Component title** to *Simulate a wildfire in 2022.*
15. Enter the following parameters:
    a. **Year or cycle number**...............*2022*
    b. **Wind speed** *40*
    c. **Moisture level**..........................*1 = Very Dry*
    d. **Temperature**............................*80*
    e. **Mortality code** ....*1 = FFE estimates mortality*
    f. **Season of this fire**....................*4 = Fall*
    g. Leave all other parameters set to the default values.

16. Click the **Save in run** button.

Adding the salvage operation

The *Cut dead trees* management action allows you to harvest standing dead trees based on species, snag age, decay status, and diameter.

17. Select the **Components > Management** tab.
18. From the **Categories** selection box, select *Salvage Operations.*
19. From the **Components** selection box, select *Cut dead trees.*
20. Change the **Component title** to *Cut dead merchantable PIPO5.*
21. Enter the following parameters:
    a. **Year or cycle number** *2024*
    b. **Species** .... *ponderosa pine*
    c. **Minimum dbh of snags** *5*
    d. **Decay state to remove** .... *0 = Hard or soft snags*
    e. **Proportion of eligible snags to fell** *1.0*
    f. **Proportion of felled snags that are left in the stand** *0.1*
    g. Leave all other parameters set to the default values.

This is an image of the cut dead trees management action.

22. Click the **Save in run** button.

Salvaged volume is not found in the standard FVS outputs table; however, you can create a user-defined variable that returns the salvage volume by species and size class. Perform the following steps to add salvage volume to the outputs.

23. Select the **Event Monitor** tab.
24. Select the *Compute Stand Variables in editor* from the selection box.
25. Enter the following parameters to name your variable:
    a. Year or cycle number............................ *2024*
    b. Component title .... *Compute salvage volume*
    c. Enter this in the large text box............. *HarvPIPO =*
26. Enter the following parameters to set the variable equal to the salvaged ponderosa pine volume:
    a. FVS Functions .... SalvVol:
    b. Species included.................................. ponderosa pine
    c. Lower limit DBH 5
27. Click the **Insert function** button.

Management Modifiers Event Monitor Economic Keywords Editor

Compute Stand Variables in Editor ⌄

Component title Compute salvage volume

⦿ Schedule by year ○ Schedule by condition

Year or cycle number 2024

```
....+....1....+....2....+....3....+....4....+....5....+....6....+....7....+....8
HarvPIPO = SalvVol(PP,5,999)
```

Math: ⌄
Variables: ⌄
Species codes: ⌄
FVS Functions: ⌄

Enter one or more expressions that define *compute* variables. Example:
NormStk = 25000*((BADBH+1.)(-1.588))**
will define *normal stocking* (trees/acre) according to Haig's (1932) definition.

Cancel Save in run

28. Click the **Save in run** button.

Selecting Outputs

29. Select the **Select Outputs** tab.
30. Check the **Stand visualization, Carbon and fuels, Fire and mortality, Snag and down wood,** and **Regeneration** boxes.

Running the simulation

31. Select the ***Run*** tab.
32. Change the management identification code (**MgmtID**) to *WILD*.
33. Click the **Save and Run** button.

FVS will save the run as *Fire 1* with a management identification code of *WILD*.

If the run is successful, you will see a figure reporting the volume per acre in the stand for the run time frame. The large drop in volume in 2022 showcases the wildfire effects on the stand. Any errors in the run will be reported below the figure.
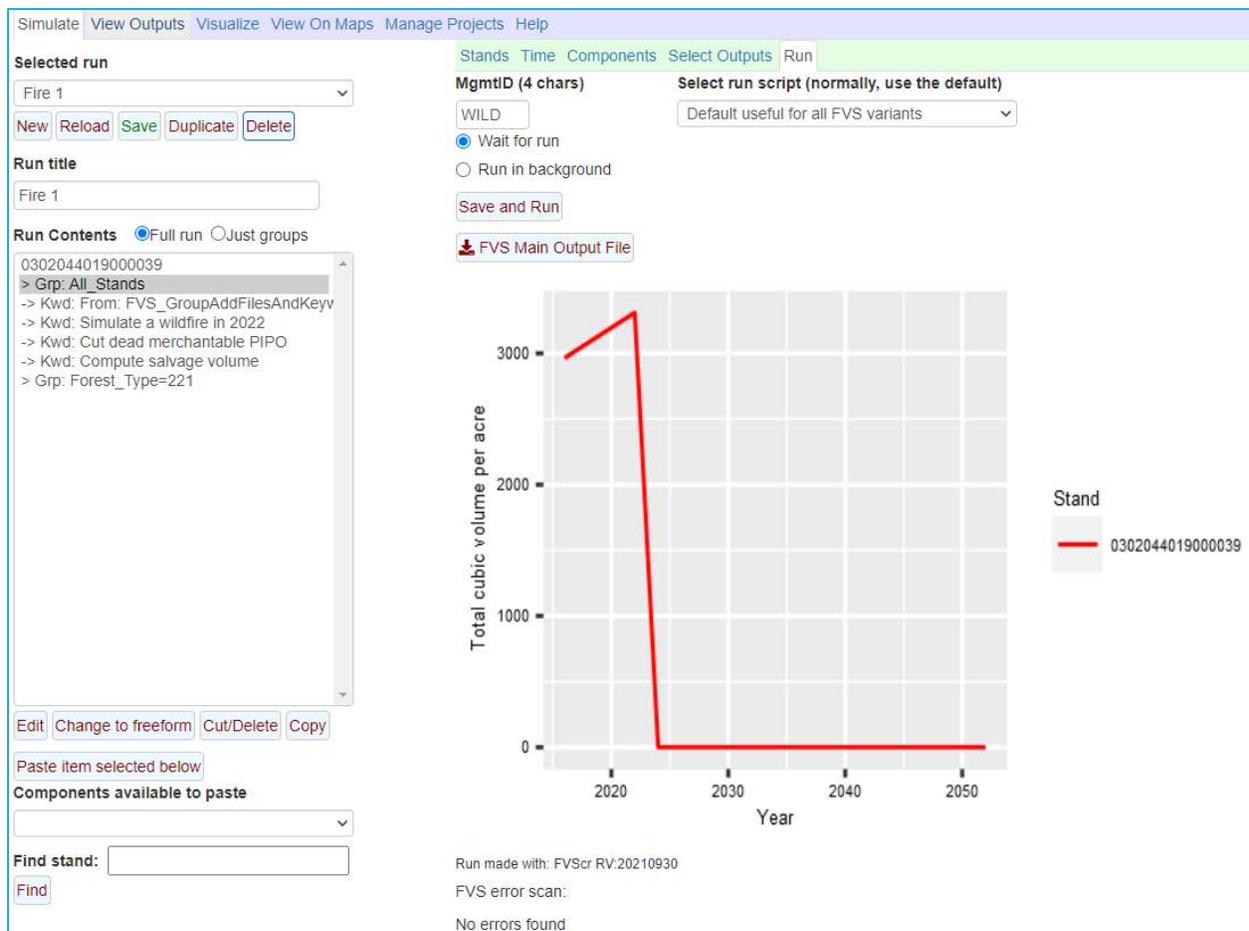
Examining the wildfire effects

Begin exploring the effects of this run by using **Visualize** tab to view pre- and post-salvage images.

34. Select the **Visualize** tab.
35. In the left **Select Run** selection box select *Fire 1*.
36. In the left **Select image** selection box, select *Stand=0302044019000039* Year=2024 *Beginning of cycle*.
37. Wait for image to be drawn.
38. In the right **Select Run** selection box, select *Fire 1*.
39. In the right **Select image** selection box, select *Stand=0302044019000039* Year=2024 *Post salvage.*

Do the pre- and post-salvage images match your expectations? Why or why not?

Use the **View Outputs > Load/Explore** tabs to answer the following questions.

From the summary output that was created, how were the trees per acre, basal area and QMD affected by the wildfire?

Perform these steps to obtain the answer.

40. Select the **View Outputs > Load** tab.

41. In the **Runs to consider** selection box, select *Fire 1.*
42. In the **Database tables to consider** selection box, select *FVS_Summary2.*
43. Select the **Explore** tab.
44. Select the **Tables** tab.

From the fire-caused mortality output, what are the top two species killed in the wildfire? Determine this by basal area and volume.

Perform these steps to obtain the answer.

45. Select the **Load** tab.
46. In the **Runs to consider** selection box, select *Fire 1.*
47. In the **Database tables to consider** selection box, select *FVS_Mortality.*
48. Use the **Describe tables** selection box to review the contents of the *FVS_Mortality* table. Note the size classes of each class.
49. Select the **Explore** tab.
50. On the left side, check all check boxes.
51. Select the **Tables** tab.

From the fuels and carbon output, how much biomass was consumed, and how much carbon was released by the wildfire?

Perform these steps to obtain the answer.

52. Select the **Load** tab.
53. In the **Runs to consider** selection box, select *Fire 1.*
54. In the **Database tables to consider** selection box, select *FVS_Carbon* and *FVS_Fuels* table.
55. Select the **Explore** tab.
56. On the left side, check the variables that answer the question in the check boxes.
57. Select the **Tables** tab.

From the computed output, how much merchantable ponderosa pine volume was harvested in the stand?

Perform these steps to obtain the answer.

58. Select the **Load** tab.
59. In the **Runs to consider** selection box, select *Fire 1.*
60. In the **Database tables to consider** selection box, select *FVS_Compute.*
61. Select the **Explore** tab.
62. On the left side, make sure the *HARVPIPO* variable is checked.
63. Select the **Tables** tab.

From the snag output, create a graph that describes the change in snags for the time frame.

Perform these steps to obtain the answer.

64. Select the **Load** tab.
65. In the **Runs to consider** selection box, select *Fire 1.*
66. In the **Database tables to consider** selection box, select *FVS_SnagSum.*
67. Use the **Describe tables** selection box to review the contents of the *FVS_SnagSum* table.
68. Select the **Explore** tab.
69. On the left side, check all check boxes.
70. To view the selected outputs in graphical form, select the **Graphs** tab.
71. Create and save the image.

From the regeneration output, make two graphs showing the number and size of sprouts by species.

Perform these steps to obtain the answer.

72. Select the **Load** tab.
73. In the **Runs to consider** selection box, select *Fire 1.*
74. In the **Database tables to consider** selection box, select *FVS_Regen_Sprouts.*
75. Select the **Explore** tab.
76. On the left side, check all check boxes.
77. To view the selected outputs in graphical form, select the **Graphs** tab.
78. Create and save the images.

Fire 2: Prescribed burning

In this exercise, you will simulate a prescribed burn.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Fire 2*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *cr: Central Rockies GENGYM.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *0302044019000039.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the Common starting year and Common ending year to *2022* and *2052*, respectively.

Adding the prescribed burn

You will use the *Prescribed burn* management action to simulate the burn. This management action uses the *Simfire* keyword to simulate the burn; however, unlike its use in simulating the wildfire, you set the weather parameters to simulate a prescribed burn.

10. Select the **Components > Management** tab.
11. From the **Categories** selection box, select *Fuel Treatments.*
12. From the **Components** selection box, select *Prescribed burn.*
13. Change the **Component title** to *Prescribed burn in 2022.*
14. Enter the following parameters:
    a. **Year or cycle number** *2022*
    b. **Wind speed** *8*
    c. **Moisture level** .... *2 = Dry*
    d. **Temperature** *70*
    e. **Mortality code** .... *1 = FFE estimates mortality*
    f. **Percentage of stand area burned** *70*
    g. **Season of this fire** .... *4 = Fall*
15. Click the **Save in run** button.

Selecting Outputs

16. Select the **Select Outputs** tab.
17. Check the **Stand visualization, Carbon and fuels, Fire and mortality,** and **Snag and down wood** boxes.

Running the simulation

18. Select the ***Run*** tab.
19. Change the management identification code (**MgmtID**) to *RXBR.*
20. Click the **Save and Run** button.

FVS will save the run as *Fire 2* with a management identification code of *RXBR.*

Examining the prescribed burn effects

Begin exploring the effects of this run by using **Visualize** tab to view pre- and post-burn images. Do the pre- and post-burn images match your expectations. Why or why not?

Use the **View Outputs > Load/Explore** tabs to describe the prescribed burn effects.

From the fire-caused mortality output, determine the fire-caused mortality by species. Did the percentages change by species?

From the snag output, were any large snags created by the prescribed burn? How long did they stay standing?

From the fire consumption output, how much litter, duff, material less than 3", and material greater than 3" were consumed by the prescribed burn?

From the fuels output, describe the surface and standing fuel loads over time.

Fire 3: Thinning followed by a pile burn

In this exercise, you will simulate a thinning followed by a pile and burn of the slash.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Fire 3*.
3. Click the **Save** button.

Adding two stands into a run

4. In the **Variants** selection box, select *cr: Central Rockies GENGYM.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stands *0302044019000010* and *0302044019000039.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the Common starting year and Common ending year to *2022* and *2052*, respectively.
10. Add the year *2024* to the **Additional output reporting years** text box.

Adding the fuels treatment

The *Thin with fuel piled and burned* management action allows you to thin a stand, manage logging slash and perform a subsequent pile and burn fuel treatment. Input parameters for the thinning include residual stand density (either trees per acre or basal area), diameter class interval, and the proportion of small trees left. Additional features control how much slash is left and how much surface fuel will be piled and burned. The proportion of surface fuel piled and burned applies to both the new activity fuels (slash) and any pre-existing surface fuel. Mortality from the pile burn can also be simulated.

11. Select the **Components > Management** tab.
12. From the **Categories** selection box, select *Fuel Treatments.*
13. From the **Components** selection box, select *Thin with fuel piled and burned.*
14. Enter the following parameters:
    a. **Year of thinning** *2022*
    b. **Residual density** *200*
    c. **Density in terms of** .... *Trees per acre*
    d. **Largest DBH** *11*
    e. **Proportion of small trees left** *0.05*
    f. **Slash left:** .... *Whole trees left*
    g. **Year of pile burn** *2024*
    h. **Proportion of surface fuel piled** *0.70*
    i. **Proportion of mortality for small trees** *0.05*
    j. **Largest tree killed (dbh in inches)** *3*
    k. Leave all other parameters set to the default values.

Management Modifiers Event Monitor Economic Keywords Editor

Categories

Fuel Treatments

Components

Thin with fuel piled and burned

Component title Thin with fuel piled and burned

Year of thinning *Mandatory field* 2022

Residual density (within specified tree size range) 200
Density is in terms of: Trees per acre

Smallest DBH to be considered for removal (greater than/equal) 0

Largest DBH to be considered for removal (less than) 11

Proportion of small trees left 0.05
Slash left: Whole trees left

Year of pile burn *Mandatory field* 2024

Proportion of surface fuel piled .70

Proportion of mortality for small trees during pile burn .05

Largest tree killed (dbh in inches) 3

Cancel Save in run Change to freeform

15. Click the **Save in run** button.

Selecting Outputs

16. Select the **Select Outputs** tab.
17. Check the **Stand visualization, Carbon and fuels, Fire and mortality, Snag and down wood,** and **Regeneration** boxes.

Running the simulation

18. Select the ***Run*** tab.
19. Change the management identification code (**MgmtID**) to *TwPB*.
20. Click the **Save and Run** button.

FVS will save the run as *Fire 3* with a management identification code of *TwPB*.

Examining the effects of the fuels treatment

Begin exploring the effects of this run by using **Visualize** tab to view pre- and post-treatment images for both stands. Adjust the images to determine the general effect on surface fuels and save the comparison. Did the treatment produce similar results? Why or why not?

69

Use the **View Outputs > Load/Explore** tabs to compare the fuels treatment between the two stands. Note: you can use the facets and plot-by options in the **Graphs** tab to compare the two stands.

From the summary output that was created, compare the standing and removed trees per acre from the thinning.

Which stand removed more trees per acre?

Was post-thinning trees per acre greater than 200? Why or Why not?

Make a graph of QMD for the two stands. Explain the shape of the curves for the time frame?

From the down woody volume output, which tree diameter classes had the biggest increase from the thinning and the biggest decrease from the pile burn in the two stands?

From the fuels output, how did surface fuels respond to the treatment?

From the sprouting and regeneration tally tables, what species regenerated following the fire?

Overall, what output(s) would you use to quickly describe the treatment effects in these two stands to your management team?

Fire 4: Masticating to reduce fuels

In this exercise you will be simulating the effects of a mastication treatment designed to reduce fuel loads and decrease ladder fuels.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Fire 4*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *cr: Central Rockies GENGYM.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *0302044019000039.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the Common starting year and Common ending year to *2022* and *2052*, respectively.

Adding the mastication

You will use the *Mastication* management action to simulate this treatment. This management action consists of a thinning treatment where all cut trees are chopped and left on the ground. The order in which FVS performs the steps are as follows. FVS cuts the trees and leaves the trees on the ground in the stand. Then FVS uses an option to move surface fuels to different size classes. At the time of the fuel move, FVS cannot distinguish between the new and the existing surface fuels, so it is up to you tell FVS what proportion of the surface fuel to move.

If all fuel is to be masticated, then the proportion of fuel to be masticated should be set to 1.0. If you want to masticate only new fuels, you need to set the proportion based on how much fuel was added to the surface. For instance, if you add 10 tons to 20 existing tons of fuel, you should set the proportion of fuel to be masticated to .33.

10. Select the **Components > Management** tab.
11. From the **Categories** selection box, select *Fuel Treatments.*
12. From the **Components** selection box, select *Mastication.*
13. Change the **Component title** to *Mastication in 2022.*
14. Enter the following parameters:
    a. **Year or cycle number** *2022*
    b. **Largest DBH to be masticated** 9
    c. **Proportion of trees masticated** 0.95
    d. **Size of masticated fuel** .... 2 = 0.25 to 1"
    e. **Proportion of surface fuel composed of masticated pieces** 0.70
    f. Leave all other parameters set to the default values.

15. Click the **Save in run** button.

Selecting Outputs

16. Select the **Select Outputs** tab.
17. Check the **Carbon and fuels** and **Fire and mortality** boxes.

Running the simulation

18. Select the ***Run*** tab.
19. Change the management identification code (**MgmtID**) to *MAST*.
20. Click the **Save and Run** button.

FVS will save the run as *Fire 4* with a management identification code of *MAST*.

Examining the effects of the fuels treatment

Use the **View Outputs > Load/Explore** tabs to describe the impact of this fuels treatment.

From the summary output that was created, describe the effects on stand size, density, and volume pre- and post-treatment.

From the fuels output, how did the mastication impact the fuel loads? What fuel size class saw the largest reduction?

From the potential fire output, was the mastication treatment effective at reducing the potential fire severity?

Fire 5: Skills challenge

Stand *0302044019000039* borders a new subdivision, Ponderosa Flats, where there is concern that the stand may pose a risk to the subdivision during fire season. Use FVS to evaluate treatment alternatives that are designed to decrease stand fire hazard while maintaining some canopy cover. Create a one-page document that will be used to describe options during a field trip with resource specialists and the public.

Here are some alternatives to be considered:

    a.   Doing nothing
    b.   Prescribed burning
    c.   Thinning with fuel piled and burned or mastication

Module 5: Complex Management

This module leads you through simulating management designed to create or enhance within stand structural diversity. Three step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Complex 1: Thinning to a variable density

In this exercise, you will use FVS to explore increasing stand structural heterogeneity via variable density thinning using the *Thin points* management action. Whereas most FVS thinning options specify a residual density target for the stand as a whole, the *Thin Points* management action allows you to specify residual density targets for individual points in stand. To use this option, you need to set the residual density targets for each inventory point you plan to cut in the stand.

You will use the following information to thin stand *061880195670001844* to variable densities.

Group Point	Inventory Points	Residual Density (basal area)
Low	1, 3, 5	80
Mod	2, 4, 6	120
High	7	160

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Complex 1.*
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *wc: West Cascades.*
5. In the **Groups** selection box, select *Forest_Type=201.*
6. In the **Stands** selection box, select stand *061880195670001844.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2062*, respectively.

Adding the point thinnings

To set the residual density by inventory point group, you will first group the points into three categories: low, moderate, and high residual densities.

10. Select the **Components > Management** tab.
11. From the **Categories** selection box, select *Identify Groups.*
12. From the **Components** selection box, select *Create a group of points.*
13. Change the **Component title** to *Low-density points group.*
14. Enter the following parameters:
    a. **Specify a 3-10 character Point Group**................*Low*
    b. **Point Number**...*1*
    c. **Point Number**...*3*
    d. **Point Number**...*5*

15. Click the **Save in run** button.
16. From the **Components** selection box, select *Create a group of points.*
17. Change the **Component title** to *Moderate-density points group.*
18. Enter the following parameters:
    a. **Specify a 3-10 character Point Group** ....*Moderate*
    b. **Point Number** *2*
    c. **Point Number** *4*
    d. **Point Number** *6*
19. Click the **Save in run** button.
20. From the **Components** selection box, select *Create a group of points.*
21. Change the **Component title** to *High-density points group.*
22. Enter the following parameters:
    a. **Specify a 3-10 character Point Group** ....*High*
    b. **Point Number** *7*
23. Click the **Save in run** button.

Now that the point groups are created, thin the points to the residual density targets.

24. From the **Categories** selection box, select *Thinning & Pruning Operations.*
25. From the **Components** selection box, select *Thin points.*
26. Change the **Component title** to *Thin low-density points.*
27. Enter the following parameters:
    a. **Year or cycle number** *2022*
    b. **Point Number or Group (0 = all points)** ....*Low*
    c. **Point thinning residual attribute** ....*2 = basal area*
    d. **Residual target for the attribute specified** *80*
    e. **Smallest DBH** *5*
    f. **Cutting control** ....*Thin from below*
    g. Leave all other parameters set to the default values.

| Management | Modifiers | Event Monitor | Economic | Keywords | Editor |

Categories

Thinning & Pruning Operations ⌄

Components

Thin points ⌄

Component title   Thin low-density points

◉ Schedule by year   ○ Schedule by condition

Year or cycle number   2022

Point Number or Group (0 = all points) Low
Point thinning residual attribute 2 = basal area ⌄

Residual target for the attribute specified 80

Cutting efficiency 1
Species to be removed All species ⌄

Smallest DBH to be considered for removal (greater than/equal) 5

Largest DBH to be considered for removal (less than) 999
Cutting control Thin from below in the specified diameter ⌄
Point reference Code 1 = point numbers will be as entered in the input data ⌄

Cancel Save in run Change to freeform

28. Click the **Save in Run** button.
29. From the **Components** selection box, select *Thin points*.
30. Change the **Component title** to *Thin moderate-density points.*
31. Enter the following parameters:
    a. **Year or cycle number**...*2022*
    b. **Point Number or Group (0 = all points)**............*Moderate*
    c. **Point thinning residual attribute**......................*2 = basal area*
    d. **Residual target for the attribute specified**.......*120*
    e. **Smallest DBH**..*5*
    f. **Cutting control**...*Thin from below*
    g. Leave all other parameters set to the default values.
32. Click the **Save in Run** button.
33. From the **Components** selection box, select *Thin points*.
34. Change the **Component title** to *Thin high-density points.*
35. Enter the following parameters:
    h. **Year or cycle number**...*2022*
    i. **Point Number or Group (0 = all points)**............*High*
    j. **Point thinning residual attribute**......................*2 = basal area*

k. **Residual target for the attribute specified**.......*160*
l. **Smallest DBH**..*5*
m. **Cutting control**...*Thin from below*
n. Leave all other parameters set to the default values.
36. Click the **Save in Run** button.

Adding additional user-defined outputs

To check that individual points are being thinned correctly, use the **Event Monitor** to compute the density of each inventory point group.

37. Select the **Event Monitor** tab.
38. Select the *Compute Stand Variables with SpMcDBH Function.*
39. Change the **Component title** to *Compute LowBA.*
40. Enter the following parameters:
   a. **Year or cycle number**...............*0*
   b. **Enter the name** ....*LowBA*
   c. **Attribute to be returned**..........*Basal area per acre*
   d. **Lower DBH limit**.......................*5*
   e. **Calculations are for**..................*Residual (after harvest) live trees*
   f. **Point Number or Group**...........*Low*
   g. Leave all other parameters set to the default values.
41. Click the **Save in Run** button.

Use the Copy/Paste/Edit options below the **Run Contents** window to compute variables representing residual basal area on moderate (ModBA) and high (HighBA) residual density plots.

42. Highlight the *Kwd: Compute LowBA* option.
43. Click the **Copy** button.
44. Click the **Paste item selected below** button <u>twice</u>.
45. Highlight the second *Compute LowBA* option in the **Run Contents** window.
46. Click the **Edit** button.
47. Change the **Component title** to *Compute ModBA.*
48. Change the following parameters:
   o. **Enter the name** ....*ModBa*
   p. **Point Number or Group**...........*Moderate*
49. Click the **Save in run** button.
50. Highlight the last *Compute LowBA* option in the **Run Contents** window.
51. Click the **Edit** button.
52. Change the **Component title** to *Compute HighBA.*
53. Change the following parameters:
   q. **Enter the name** ....*HighBa*
   r. **Point Number or Group**...........*High*
54. Click the **Save in run** button.

Selecting Outputs

55. Select the **Select Outputs** tab.
56. Check the **Stand visualization** box to request image files.

57. Check the **Tree lists** box to request output needed to create a stand and stock table.
58. Check the **Regeneration** box to request regeneration tables.

Running the simulation

59. Select the ***Run*** tab.
60. Change the management identification code (**MgmtID**) to *VDT*.
61. Click the **Save and Run** button.

Examining the thinning effects

Begin exploring the effects of this run by using the **Visualize** tab to view pre- and post-harvest images.

62. Select the **Visualize** tab.
63. Deselect the *Down trees* check box for both images.
64. In the left **Select Run** selection box select *Complex 1*.
65. In the left **Select image** selection box, select *Stand=061880195670001844 Year=2022 Beginning of cycle*.
66. Wait for image to be drawn.
67. In the right **Select Run** selection box, select *Complex 1*.
68. In the right **Select image** selection box, select *Stand=061880195670001844 Year=2022 Post cutting*.

In the prescription, there were three residual densities prescribed. Do the images match what you were expecting to see? Why or why not?

Complete the following tasks/questions using the **View Outputs > Load/Explore** tabs.

Load/Explore the computed variables output and report the residual densities of the plot groups.

69. Select the **View Outputs > Load** tab.
70. In the **Runs to consider** selection box, select *Complex 1.*
71. In the **Database tables to consider** selection box, select *FVS_Compute* table.
72. Select the **Explore** tab.

Scroll through the table and describe the density of the plot groups over time.

Load/Explore the summary output to report total and merchantable volume harvested.

73. Select the **Load** tab.
74. In the **Runs to consider** selection box, select *Complex 1.*
75. In the **Database tables to consider** selection box, select the *Summary2* table.
76. Select the **Explore** tab.

Scroll through the table. What was the total and merchantable volume removed?

Load/Explore the stand and stock table output to create a diameter distribution graph showing species density over the projection time frame.

77. Select the **Load** tab.
78. In the **Runs to consider** selection box, select *Complex 1.*
79. In the **Database tables to consider** selection box, select *StdStk.*
80. Select the **Explore** tab.
81. Select **Years:** *2022, 2032, 2042, 2052, 2062.*
82. Select all numbered **DBHClasses.**
83. Click the **Graphs** tab.
84. Make the following changes to the graphing options:
    a. **Y-axis**..*LiveBA*
    b. **Vertical facet**..*Year*
    c. **X-axis**...*DBH class*
    d. **Horizontal facet**...*None*
    e. **Plot-by code**...*Species*
    f. **Width (in)**...*4*
    g. **Height (in)**..*3*
    h. **More controls**..*Show*

i. **Bars** ....*Stacked*
j. **Automatic facet wrap** ....*Off*

From the graphs, describe the species composition over the years in the graphs.

Complex 2: Regenerating a stand via group selection

In this exercise, you will use FVS to explore regenerating a stand via group selection using the stand replication option. Replication can occur by adding the same stand more than once or by specifying the number of replicates and their relative weights prior to adding the stand to a run. Replicating a stand prior to running the simulation allows you to perform unique management to each stand replicate. The run results in replicate output as well as composite output for the stand as a whole. For instance, if you want to thin 30% of a stand, put openings in another 30% of the stand, and skip or leave the rest of the stand unmanaged (40%), you can add three replicates with relative weights of 30, 30 and 40 so that you can prescribe the unique management in each replicate and obtain outputs describing each of the three areas as well as a properly weighted stand composite outputs for the run.

You will use the following information to regenerate stand *0002201703030113027177* with group selection using the replication method.

> Establish group openings in 25% of the stand every 30 years where you select the size of openings to be conducive to a mixture of shade intolerant and tolerant species. Retain all Sitka spruce in openings while cutting all other species greater than one inch in diameter.

Starting a new run
1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Complex 2.*
3. Click the **Save** button.

Adding the stand replicates

4. In the **Variants** selection box, select *ak: Alaska.*
5. In the **Groups** selection box, select *Forest_Type=301.*
6. In the **Stands** selection box, select stand *0002201703030113027177.*
7. In the **Number of replicates of each added stand** text box, enter *4.*
8. In the **Relative weights of each replicate** text box, enter *25.* This will give each replicate equal weighting of 25% (25/(4*25)).
9. Click the **Add selected stands** button.

The weights are used to modify the stand sampling weights specified in the input database. Often these sampling weights are stand sizes or the size of the land area represented by the stand. The set of replicate weights you enter is recycled, if necessary, so that each replicate gets a weight. For example, if you say you want 5 replications of each stand, and you enter 1, 2 for the weights, the resulting set will be 1, 2, 1, 2, and 1. The weighting logic includes a normalization step such that each weight is divided by the sum of the weights for the stand, resulting in a proportional adjustment to the replicate sample weights; for example, the resulting normalized weights of the above example would be 0.14, 0.29, 0.14, 0.29, and 0.14. The normalized weights are then multiplied by the stand sampling weight entered in the database and the results are entered into the FVS run so that the sampling weights for each replicate are correctly reported in the FVS output.
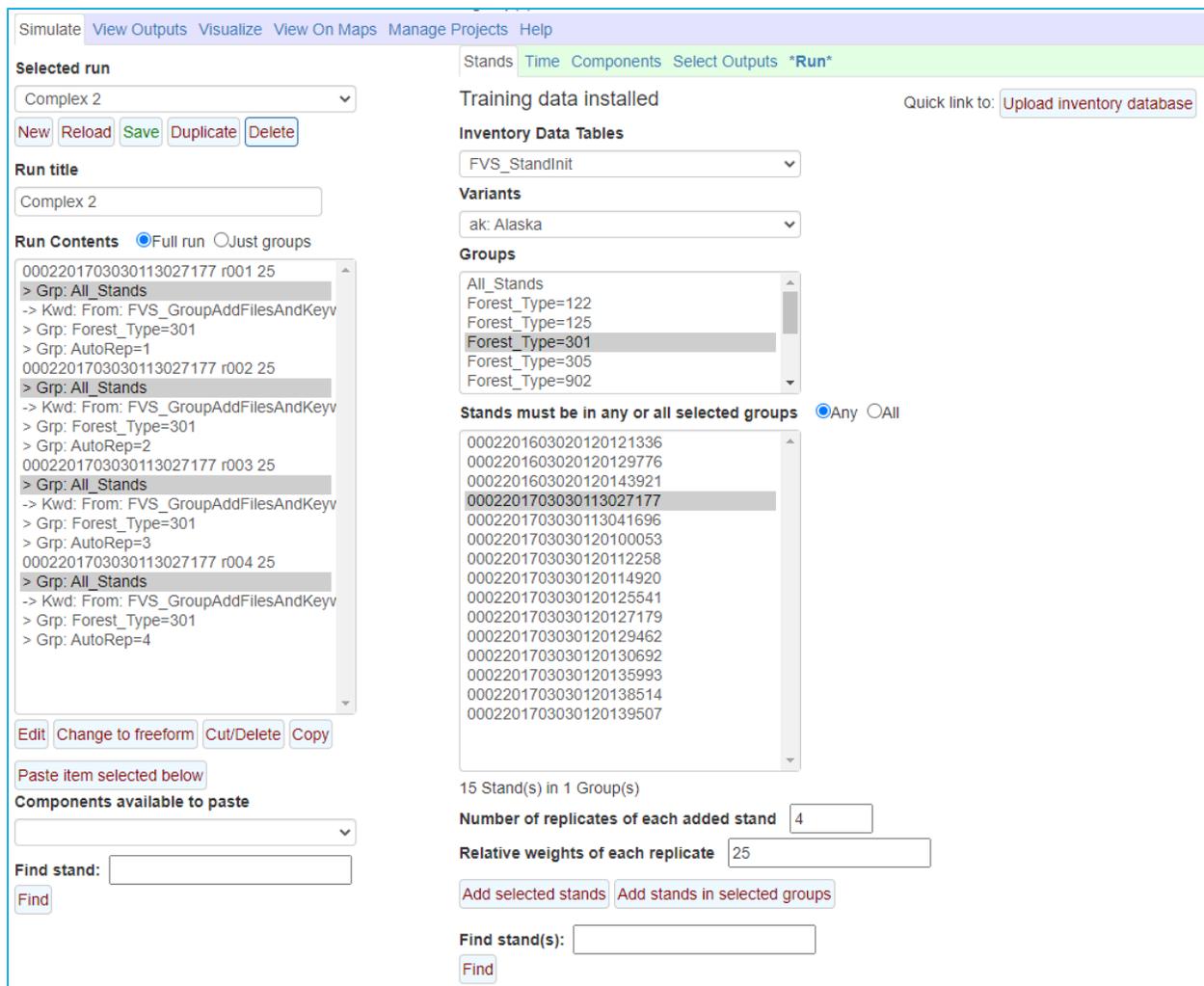
Setting the time frame

10. Select the **Time** tab.
11. Change the **Common starting year** and **Common ending year** to *2022* and *2152*, respectively.

Adding the group cuts

Each replicate will be modeled as separate group opening entries. You will start by omitting all Sitka spruce from cutting. The cutting steps are to cut all trees greater than 1.0-inch DBH in replicate *r001* in 2022 and 2142, replicate *r002* in 2052, replicate *r003* in 2082, and replicate *r04* in 2112.

12. Select the **Components > Management** tab.
13. From the **Categories** selection box, select *Tree Removal Preference*.
14. From the **Components** selection box, select *Exclude or include a species from harvest*.
15. Change the **Component title** to *Exclude PISI from harvest.*
16. Enter the following parameters:
    a. **Year or cycle number**.......................................*2022*
    b. **Species** ....*Sitka spruce*
    c. *Exclude the species from harvest*

17. Click the **Save in Run** button.

To apply management to a single replicate, simply click the replicate identification in the **Run Contents** window, then select the management option.

18. In the **Run Contents** window, select *0002201703030113027177 r001 25*.
19. From the **Categories** selection box, select *Thinning & Pruning Operations*.
20. From the **Components** selection box, select *Thin throughout a diameter range.*
21. Change the **Component title** to *Entry 1: Group Opening 2022.*
22. Enter the following parameters:
    a. **Year or cycle number** *2022*
    b. **Smallest DBH to be considered** *1*
    c. Leave all other parameters set to the default values.
23. Click the **Save in Run** button.

In the **Run Contents** window, you will notice that the management action has only been applied to the first replicate.
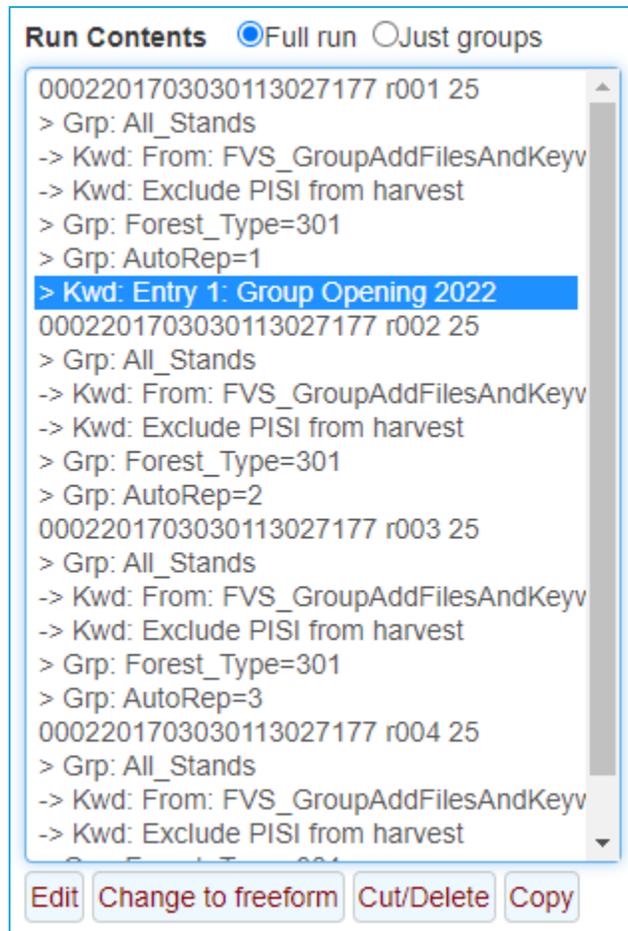
Use the **Copy/Paste/Edit** buttons below the **Run Contents** window with this management action to cut this replicate again in 2152.

24. In the **Run Contents** window, select *kwd: Entry 1: Group Opening 2022.*
25. Click the **Copy** button.
26. Click the **Paste item selected below** button.
27. Select the second *kwd: Entry 1: Group Opening 2022* action and click the **Edit** button.
    a. **Component title**..*Entry 5: Group Opening 2142*
    b. **Year or cycle number**...*2142*
    c. Leave all other parameters set to their values.
28. Click the **Save in Run** button.

Use the **Paste/Edit** buttons below the **Run Contents** window to add the group cuts to the other replicates.

29. In the **Run Contents** window, select *0002201703030113027177 r002 25.*
30. Click the **Paste item selected below** button.
31. Select the *kwd: Entry 1: Group Opening 2022* action attached to replicate *r002* and click the **Edit** button.
    a. **Component title**..*Entry 2: Group Opening 2052*
    b. **Year or cycle number**...*2052*
    c. Leave all other parameters set to their values.

32. Click the **Save in Run** button.
33. In the **Run Contents** window, select *0002201703030113027177 r003 25.*
34. Click the **Paste item selected below** button.
35. Select the *kwd: Entry 1: Group Opening 2022* action attached to replicate *r003* and click the **Edit** button.
   a. **Component title**...*Entry 3: Group Opening 2082*
   b. **Year or cycle number**.......................................*2082*
   c. Leave all other parameters set to their values.
36. Click the **Save in Run** button.
37. In the **Run Contents** window, select *0002201703030113027177 r004 25.*
38. Click the **Paste item selected below** button.
39. Select the *kwd: Entry 1: Group Opening 2022* action attached to replicate *r004* and click the **Edit** button.
   a. **Component title**...*Entry 4: Group Opening 2112*
   b. **Year or cycle number**.......................................*2112*
   c. Leave all other parameters set to their values.
40. Click the **Save in Run** button.

Adding regeneration

Given the cuts, it may be important to augment the estimated natural regeneration following harvests with additional regeneration you expect to regenerate from seed. To accomplish this, you will conditionally add natural regeneration following the harvest.

41. In the **Run Contents** window, select *Grp: All_stands.*
42. Select the **Components > Management** tab.
43. From the **Categories** selection box, select *Planting & Natural Regeneration.*
44. From the **Components** selection box, select *Plant/Natural with Full Estab Model.*
45. Change the **Component title** to *Add additional regeneration following harvests.*
46. Enter the following parameters:
47. Set the **Schedule the date of disturbance** radio button to *Schedule by condition.*
   a. **Create a condition**.......*After "significant" harvesting/thinning*
   b. Leave all other parameters set to the default values.
48. In **Regen 1)**, specify the following:
   a. **Type of regeneration scheduled:**......................*Natural*
   b. **Species** ....*Sitka spruce*
   c. **Trees/acre:**...*50*
49. In **Regen 2)**, specify the following:
   a. **Type of regeneration scheduled:**......................*Natural*
   b. **Species** ....*red alder*
   c. **Trees/acre:**...*40*
50. Leave all other parameters set to their values.
51. Click the **Save in Run** button.

Regeneration now includes natural regeneration from the full establishment model along with the added additional regeneration following all group entries along with ingrowth every twenty years absent of harvest in the replicates. While you will not model it here, if you turn off the full

establishment model in the previous step, you may need to consider adding additional species that will naturally occur following harvest as well as periodic ingrowth into the replicates.

Selecting Outputs

52. Select the **Select Outputs** tab.
53. Check the **Stand visualization, Tree lists**, and **Regeneration** boxes.

Running the simulation

54. Select the ***Run*** tab.
55. Change the management identification code (**MgmtID**) to *GS*.
56. Click the **Save and Run** button.

FVS will save the simulation as *Complex 2* with a management identification code of *GS*.

Examining the treatment effects

Begin exploring the effects of this run by using **Visualize** tab to view pre- and post-harvest images. The **Visualize** tab allows you to view and compare images of each replicate during the projection time frame; however, you do not get a combined image of all replicates.

In the prescription, only Sitka spruce should be left in the group openings. Use the images to describe the presence of Sitka spruce in the openings.

Use the **View Outputs > Load/Explore** tabs to further explore the run output.

In this run, you have summary tables, treelist tables, stand and stock tables, and regeneration tally tables for each stand replicate. You have a composite summary statistics table and a composite stand and stock table averaged across the replicates.

Load/Explore the summary output to begin exploring the density in each replicate. Create a table that shows basal area by year (columns) for each replicate.

Scroll through the table and describe the density of each replicate?

Load/Explore the stand and stock table output to explore species composition of each replicate over the projection time frame. Create a graph of the live and harvested basal area by species for each replicate during the cutting years. Describe how species composition differs between the replicates.

Load/Explore the regeneration output. What is the composition of the trees less than 1" in the stand following harvests by replicate?

How did the number of small trees in the stand change following harvests?

Load/Explore the composite summary output. Describe volume production in the stand over the projection time frame using the **Graphs** tab. Total production is the standing + harvested volume in the stand. Describe how total volume production is trending over the projection time frame.

Change the y-axis to total merchantable volumes. Does the trend change?

Load/Explore the composite stand and stock table to describe species composition at the start and end of the projection time frame. Describe the change in species composition for the stand.

Complex 3: Regenerating a stand via single tree selection

In this exercise, you will use FVS to explore regenerating a stand via single tree selection using the BDq approach (specifying a residual **B**asal area, maximum **D**iameter, and **q**-factor) with the *Thin to a Q-factor* management action. This management action is designed to thin across diameter classes to maintain a balanced, reverse-J diameter distribution.

The management action requires the user to supply the target residual density, q-factor, minimum and maximum tree diameters for the managed range, width for the diameter classes used, and the year, cycle, or condition to schedule the management.

The target residual density is for the diameter range specified and this can be set for basal area, SDI, or trees per acre. The q-factor indicates the steepness of the reverse-J curve approximation; with each diameter class having a target trees per acre equal to q-times that desired for the next larger diameter class. The minimum and maximum tree dbh identifies the diameter range for this management.

The diameter classes used are based on the values specified for maximum dbh, diameter class width, and minimum dbh. The diameter class identification starts with the maximum dbh, working through smaller diameters until reaching the specified minimum. For example, if the maximum diameter is 22 inches and 4-inch diameter classes are specified, the first class will be from 18 to 22, the second from 14 to 18, and continuing until the minimum dbh is reached. Note – If the last diameter class isn't the full width of the specified diameter class width, that class is excluded from management.

Based on the specified target residual density in the management range, FVS will identify how many trees (basal area) should optimally exist within each diameter class to achieve a diameter distribution resembling an approximate reverse-J. Diameter classes with an excess above the optimal residual for that class are considered for harvesting after accounting for diameter classes with a deficit.

When diameter classes with a deficit exist in the management range (actual is less than desired), the deficit basal area is proportionally distributed to the other classes where excess exists in order to maintain the target residual density within the range. A mathematical calculation is conducted to adjust the optimal residual in each diameter class with excess to maintain the target basal area residual for the diameter range and still show an approximate reverse-J diameter distribution. If the current residual within the diameter range is less than the target specified, then the management action will not be conducted for that year or cycle.

This management action also provides the user with an option to leave legacy overstory trees beyond the managed size class by specifying a residual number of trees or basal area acre. If a user would like to have the management action recur, it should be conditionally scheduled to occur periodically after a specific beginning year.

You will use the following information to regenerate stand *090603020480017* with single tree selection.

> **Cutting Cycle**..*Every 25 years, beginning in 2022*
> **Units for Residual Density** ....*Basal area per acre*
> **Residual Density**.....................................*90*
> **Value for Q-factor**.................................*1.3*
> **Species to be removed in this cut**........*All*
> **Smallest dbh for removal**.....................*1*

Largest dbh for removal........................*25*
Diameter class width...........................*2*
Number of Legacy Trees *0*
Basal Area of Legacy Trees...................*10*

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Complex 3.*
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ls: Lake States.*
5. In the **Groups** selection box, select *Forest_Type=801 (sugar maple-beech-yellow birch).*
6. In the **Stands** selection box, select stand *090603020480017.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2132*, respectively.
10. In the **Additional output reporting years** text box, add *2047* and *2097, separated by a space.*

Adding the single tree selection cuts

The stand will be periodically harvested every 25 years using the BDq approach.

11. Select the **Components > Management** tab.
12. From the **Categories** selection box, select *Regeneration Methods: Uneven-aged.*
13. From the **Components** selection box, select *Thin to a Q-factor.*
14. Select *Schedule by Condition radio button.*
15. Enter the following parameters:
    a. **Create a condition**..*Periodically staring in year*
    b. **Condition title**..*Every 25 years, starting in 2022*
    c. **Years before condition can become true again:**............25
    d. **Beginning year:**..2022
16. Specify the BDq parameters:
    a. **Residual density**..90
    b. **Value for Q-factor** 1.3
    c. **Species to be removed in this cut**..................................All species
    d. **Smallest DBH**...1
    e. **Largest DBH** 25
    f. **Diameter class width in inches**.....................................2
    g. **Basal Area of Legacy Trees**...10
    h. Leave all other parameters set to the default values.

Management Modifiers Event Monitor Economic Keywords Editor

Categories

Regeneration Methods: Uneven-aged ⌄

Components

Thin to a Q-factor ⌄

Component title   Thin to a Q-factor

○ Schedule by year   ● Schedule by condition

Create a condition

Periodically starting in year ⌄

Settings for the condition:

Condition title   Periodically starting in year

Years before condition can become true again: 25

Beginning year: 2022

Number of years after condition is found true: 0

For recurring entries select Schedule by Condition

Units for Residual Density Basal area per acre ⌄

Residual density for the diameter distribution and species specified 90

Value for Q-factor 1.3

Species to be removed in this cut All species ⌄

Smallest DBH to be considered for removal (greater than/equal) 1

Largest DBH to be considered for removal (less than) 25

Diameter Class width in inches 2

-----If managing for Legacy Trees specify criteria-----

Number of Legacy Trees 0

OR

Basal Area of Legacy Trees 10

Cancel Save in run Change to freeform

17. Click the **Save in Run** button.

Adding regeneration

Given the cuts, it is important to augment automatic regeneration with additional regeneration you expect to regenerate. To accomplish this, you will conditionally add natural regeneration following the harvest.

18. From the **Categories** selection box, select *Planting & Natural Regeneration*.
19. From the **Components** selection box, select *Plant/Natural with Partial Estab Model.*
20. Change the **Component title** to *Natural regeneration following harvests.*
21. Set the **Schedule the date of disturbance** radio button to *Attach to existing condition.*
22. Enter the following parameters:
23. In **Regen 1)**, specify the following:
    a. **Type of regeneration scheduled:**......................*Natural*
    b. **Species** ....*red maple*
    c. **Trees/acre:**...*200*
24. In **Regen 2)**, specify the following:
    a. **Type of regeneration scheduled:**......................*Natural*
    b. **Species** ....*sugar maple*
    c. **Trees/acre:**...*400*
25. Leave all other parameters set to their values.
26. Click the **Save in Run** button.
27. From the **Categories** selection box, select *Planting & Natural Regeneration*.
28. From the **Components** selection box, select *Plant/Natural with Partial Estab Model.*
29. Change the **Component title** to *Natural regeneration following harvests.*
30. Set the **Schedule the date of disturbance** radio button to *Attach to existing condition.*
31. Enter the following parameters:
32. In **Regen 1)**, specify the following:
    a. **Type of regeneration scheduled:**......................*Natural*
    b. **Species** ....*black cherry*
    c. **Trees/acre:**...*50*
33. In **Regen 2)**, specify the following:
    a. **Type of regeneration scheduled:**......................*Natural*
    b. **Species** ....*yellow birch*
    c. **Trees/acre:**...*10*
34. Leave all other parameters set to their values.
35. Click the **Save in Run** button.

Regeneration now includes the natural regeneration you specified from the partial establishment model along with automatic sprouting of known sprouting species.

Selecting Outputs

36. Select the **Select Outputs** tab.
37. Check the **Stand visualization, Tree lists**, and **Regeneration** boxes.

Running the simulation

38. Select the ***Run*** tab.
39. Change the management identification code (**MgmtID**) to *STS*.

40. Click the **Save and Run** button.

FVS will save the simulation as *Complex 3* with a management identification code of *STS*.

Examining the treatment effects

Begin exploring the effects of this run by using the **Visualize** tab to view pre- and post-harvest images.

Use the images to describe the canopy cover and structure of the stand.

Use the **View Outputs > Load/Explore** tabs to further explore the run output. In this run, you have summary tables, treelist tables, stand and stock tables, and regeneration sprout and tally tables for each stand replicate. Begin by exploring stand density for the projection time frame.

From the summary output, approximately how much basal area was removed in each cutting cycle?

Did you always hit your residual target of 90? Why or why not?

From the stand and stock table output, describe whether you were able to maintain or enhance a reverse-J diameter distribution.

Did species composition change as expected?

From the regeneration table output, what is the composition of the natural regeneration?

How did the number of small trees in the stand change following harvests?

Complex 4: Skills challenge

Choose a stand and develop a silvicultural prescription for that stand. Include all treatments you plan to perform during the projection time frame (equivalent to one rotation). Begin by writing a treatment timeframe below. Then simulate the prescription in FVS and create a document to share with a management team that describes stand composition and structure, harvest volumes, and any other pertinent information.

Module 6: Regeneration Modeling

This module explores how regeneration is simulated using the partial and full establishment models. Most Forest Service regions (all but Region 1 (Northern) and Region 10 (Alaska)) have the partial establishment model instead of the full establishment model. The difference between the models is that the partial establishment model requires the user to input regeneration other than sprouting into simulations, while the full establishment model automatically includes all regeneration. In addition to understanding the establishment models, you will learn how to save a keyword component set for use with other runs. Three step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Regen 1a: Adding ingrowth with the partial establishment model

In this exercise, you will periodically add naturally recurring regeneration, or ingrowth, into a simulation using the partial establishment model *Plant/Natural* management action.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Regen 1.*
3. Click the **Save** button.

Adding stand replicates

4. In the **Variants** selection box, select *ca: Inland CA, Southern Cascades.*
5. In the **Groups** selection box, select *Forest_Type=201.*
6. In the **Stands** selection box, select stand *06102460140600262.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2082*, respectively.

Adding ingrowth

The CA variant uses the partial-establishment model. This means FVS does not automatically produce regeneration, other than sprouting from known sprouting species. The user must supply information regarding the seedlings using one of two Keywords: *Plant* or *Natural*. The names of the keywords are self-explanatory; however, the keywords act in much the same way. The big difference is that *Plant* is used with economics extension to account for any dollar values associated with initial or post-harvest planting. Most users will utilize the *Planting & Natural Regeneration >Plant/Natural with Partial Estab Model* management action to select the regeneration to bring into a simulation. This option allows you to choose to use the *Plant* or *Natural* keywords.

The goal of this simulation is to use the *Natural* options to simulate naturally occurring ingrowth in a stand where no harvest or management action is planned. Regeneration will be scheduled in two separate years and will be composed of the two existing species in the stand.

Perform the following steps to add regeneration to the simulation.

10. Select the **Components > Management** tab.
11. From the **Categories** selection box, select *Planting & Natural Regeneration.*
12. From the **Components** selection box, select *Plant/Natural with Partial Estab Model.*
13. Change the **Component title** to *Ingrowth 2042.*
14. Set the **Year or cycle number** to *2042.*
15. Set the **Years following disturbance for site preparation to** *0.*
16. In **Regen 1)**, specify the following:
    a. **Years following disturbance for regeneration**............. *0*
    b. **Type of regeneration scheduled:**................................ *Natural*
    c. **Species** .... *White fir*
    d. **Trees/acre:**... *50*

     e. **Average height:**...2
     f. **Shade code:**..*Near dense plots*

17. In **Regen 2),** specify the following:
     a. **Years following disturbance for regeneration**..............0
     b. **Type of regeneration scheduled:**...............................*Natural*
     c. **Species** ....*Douglas-fir*
     d. **Trees/acre:**...20
     e. **Average height:**...5
     f. **Shade Code** ....*Near sparse plots*

18. Leave all other parameters set to their values.

The age is the age at planting. The average height of the seedlings can be adjusted by adjusting the "Ave height:" field. The height put in the field is the expected height at the end of the cycle or five years in the future, whichever is sooner.

19. Click the **Save in Run** button.

The full establishment models add ingrowth every 20 years absent of harvests. Model this by adding one more pulse of ingrowth in 2062. Use the **Copy/Paste/Edit** buttons below the **Run Contents** window to add the second ingrowth estimate.

20. In the **Run Contents** window, select *kwd: Ingrowth 2042.*
21. Click the **Copy** button.
22. Click the **Paste item selected below** button.
23. Select the second *kwd: Ingrowth 2042* action and click the **Edit** button.
    a. **Component title**....................................*Ingrowth 2062*
    b. **Year or cycle number**...........................*2062*
    c. Leave all other parameters set to their values.
24. Click the **Save in Run** button.

Selecting Outputs

25. Select the **Select Outputs** tab.
26. Check the **Stand visualization, Tree lists**, and **Regeneration** boxes.

Running the simulation

27. Select the ***Run*** tab.
28. Change the management identification code (**MgmtID**) to *InGr.*
29. Click the **Save and Run** button.

FVS will save the simulation as *Regen 1a* with a management identification code of *InGr.*

Examining the treatment effects

Begin exploring the effects of this run by using the **Visualize** tab to view the ingrowth. Since regeneration occurs at the end of the cycle where it was performed, you will select the cycle following regeneration for comparison.

30. Select the **Visualize** tab.
31. In the left **Select Run** dropdown, select *Regen 1a.*
32. In the left **Select image** dropdown, select stand=*06102460140600262 Year=2052 Beginning of cycle.*
33. In the right **Select Run** dropdown, select *Regen 1a.*
34. In the right **Select image** dropdown, select stand=*06102460140600262 Year=2072 Beginning of cycle.*

Do you see the ingrowth in the images? What happens to the ingrowth?

Use the **View Outputs > Load/Explore** tabs to explore the regeneration tables.

35. Select the **View Outputs > Load** tab.
36. In the **Runs to consider** selection box, select *Regen 1a.*
37. In the **Database tables to consider** selection box, select *FVS_Regen_Tally.*
38. Select the **Explore** tab.
39. Select all years in the **Years** selection box.
40. Select all variables with the **Select Variables** check boxes.
41. Select the **Tables** tab.

This table consists of a series of regeneration tallies. Regeneration tallies occur on cycle boundaries for 20 years following a disturbance/regeneration event. During the regeneration tally, seedlings are passed from the regeneration model into the main FVS growth model.

There are three portions of the regeneration tally table: 1) a summary of all trees regenerating during the cycle, 2) a summary of the average height of the seedlings at the end of the regeneration tally, and 3) a summary of all trees less than a given diameter in the model following the passing of the tally trees to the main model. For the CA variant, the latter variables include small trees less than 3" dbh.

From the results, determine if your inclusion of ingrowth occurred. Do the numbers match what you specified?

Describe the small trees in the stand following the tallies.

Load/Explore the stand and stock table output to create a diameter distribution graph showing species density over the projection time frame.

42. Select the **Load** tab.
43. In the **Runs to consider** selection box, select *Regen 1a.*
44. Change the **DBH class size** to 2.
45. Click the **Rebuild StdStk** button.
46. In the **Database tables to consider** selection box, select *StdStk.*
47. Select the **Explore** tab.
48. Select **Years:** *2022, 2042, 2062, 2082.*
49. Select all **DBHClasses** <= 8" dbh class.
50. Select the **Graphs** tab.
51. Make the following changes to the graphing options:
    a. **Y-axis** ....*LiveTPA*
    b. **X-axis** ....*DBHClass*
    c. **Vertical facet** ....*Year*
    d. **Horizontal facet** ....*StandID*
    e. **Plot-by code**..*Species*
    f. **Width (in)** *6*
    g. **Height (in)** *4*
    h. **More controls**...*Show*
    i. **Bars**...*Stacked*

From the graph, which seedlings species seem to have better survivability, which species do not?

Regen 1b: Examining ingrowth with the full establishment model

The Alaska (ak) variant includes the full establishment model. This means FVS automatically predicts regeneration based on site characteristics and disturbances. Information on how regeneration is predicted can be found in the Alaska variant overview. One key aspect of the Alaska full establishment model is that forest type is required to predict regeneration. If there are no live trees in a stand and forest type is not set to a valid Alaskan forest type, FVS will not automatically add regeneration.

In this exercise, you will examine the ezcruise and ingrowth options that automatically occur in a stand where no live tree records exist. You will add three replicates where one is simulated without any adjustments, one with forest type included, and the last one where white spruce and Sitka spruce are removed from the automatic tallies.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Regen 1b*.
3. Click the **Save** button.

Adding stand replicates

4. In the **Variants** selection box, select *ak: Alaska.*
5. In the **Groups** selection box, select *Forest_Type=125* (black spruce).
6. In the **Stands** selection box, select stand *0002201503010112247434.*
7. In the **Number of replicates of each added stand** text box, enter 3.
8. Click the **Add selected stands** button.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2082*, respectively.

Set the forest type and species multiplier

11. Select replicate two (… r002 1) in the **Run Contents** window.
12. Select the **Components > Keywords** tab.
13. From the **Extensions** selection box, select *Base FVS system.*
14. From the **Keywords** selection box, select *Modtype.*
15. Change the **Component title** to *Set forest type to black spruce.*
16. Enter the following parameters:
    a. **Forest type**..............................125
17. Click the **Save in run** button.
18. In the **Run Contents window,** select *Kwd: Set forest type to black spruce*
19. Click the **Copy** button.
20. Select replicate three (… r003 1) and click the **Paste item selected below** button.

Forest type is now set for replicates two and three. Now, add the species multiplier to the third replicate.

21. Select replicate three (… r003 1) in the **Run Contents** window.
22. Select the **Components > Keywords** tab.
23. From the **Extensions** selection box, select *Full Establishment Model.*

24. From the **Keywords** selection box, select *SpecMult.*
25. Change the **Component title** to *Remove PISI from ingrowth.*
26. Enter the following parameters:
    a. **Year or cycle number**...............1
    b. **Species** ....*Sitka spruce*
    c. **Multiplier value**........................0
27. Click the **Save in run** button.
28. From the **Keywords** selection box, select *SpecMult.*
29. Change the **Component title** to *Remove PIGL from ingrowth.*
30. Enter the following parameters:
    d. **Year or cycle number**...............1
    e. **Species** ....*white spruce*
    f. **Multiplier value**........................0
31. Click the **Save in run** button.

Selecting Outputs

32. Select the **Select Outputs** tab.
33. Check the **Stand visualization, Tree lists**, and **Regeneration** boxes.

Running the simulation

34. Select the ***Run*** tab.
35. Change the management identification code (**MgmtID**) to *InGr.*
36. Click the **Save and Run** button.

FVS will save the simulation as *Regen 1b* with a management identification code of *InGr.*

Examining the treatment effects

Begin exploring the effects of this run by using the **Visualize** tab to view the ingrowth in 2022. Since regeneration occurs at the end of the cycle where it was performed, you will select the cycle following regeneration for comparison.

37. Select the **Visualize** tab.
38. In the left **Select Run** dropdown, select *Regen 1b.*
39. In the left **Select image** dropdown, select stand=*0002201503010112247434 r001 Year=2022 Beginning of cycle.*

Notice that no trees are added. This is because forest type is not set for replicate 1. Now, look at replicates 2 and 3.

40. In the left **Select Run** dropdown, select *Regen 1b.*
41. In the left **Select image** dropdown, select stand=*0002201503010112247434 r002 Year=2022 Beginning of cycle.*
42. In the right **Select Run** dropdown, select *Regen 1b*.
43. In the right **Select image** dropdown, select stand=*0002201503010112247434 r003 Year=2022 Beginning of cycle.*
44. Repeat for year *2042 and 2062.*

Do you see the snags, initial regeneration, and ingrowth in the images? What happens to them over time?

Load/Explore the regeneration tables.

45. Select the **View Outputs > Load** tab.
46. In the **Runs to consider** selection box, select *Regen 1b.*
47. In the **Database tables to consider** selection box, select *FVS_Regen_Ingrowth.*
48. Select the **Explore** tab.
49. Select all years in the **Years** selection box.
50. Select all variables with the **Select Variables** check boxes.
51. Select the **Tables** tab.

This table consists of ingrowth estimates by species every 20 years. Since no live trees were found in the inventory year, the *EZCRUISE* option was invoked to automatically invoke regeneration at the end of the first cycle. The objective of including ingrowth thereafter, is to account for regeneration that continues to become established in sparsely stocked stands or under the overstory canopy. Tree records that are created for ingrowth tallies can include trees up to 20 years old, so an assortment of tree sizes is added to the tree list when ingrowth is represented.

From the results, what is species are included over time for the second and third replicates?

Were you successful in decreasing the Sitka spruce and white spruce from ingrowth in the third replicate?

Load/Explore the stand and stock table output to create a diameter distribution graph for the three replicates showing species density over the projection time frame.

52. Select the **Load** tab.
53. In the **Runs to consider** selection box, select *Regen 1b.*
54. Change the **DBH class size** to 2.
55. Click the **Rebuild StdStk** button.
56. In the **Database tables to consider** selection box, select *StdStk.*
57. Select the **Explore** tab.
58. Select **Years:** *2022, 2042, 2062, 2082.*
59. Select all **DBHClasses** with numbers.
60. Select the **Graphs** tab.
61. Make the following changes to the graphing options:
    a. **Y-axis** ....*LiveTPA*
    b. **Vertical facet** ....*Year*
    c. **X-axis** ....*DBHClass*
    d. **Horizontal facet** ....*StandID*
    e. **Plot-by code** ....*Species*
    f. **Width (in)** 6

g. **Height (in)** 4
h. **More controls** ....*Show*
i. **Bars** ....*Stacked*

From the graph, which seedlings species seem to have better survivability, which species do not?

Regen 2: Conditionally adding regeneration

In this exercise, you will be conditionally scheduling regeneration following a harvest using the Lake States variant which includes the partial establishment model. Conditional scheduling may be used when you want an activity to occur based on certain stand attributes or other considerations, as opposed to scheduling an activity based solely on time or cycle number.

In this exercise, you will conditionally schedule a clearcut to occur based on a stand age threshold being crossed. Then, if a harvest occurs, you will plant red pine on a 10 x 10 foot spacing.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Regen 2.*
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ls: Lake States.*
5. In the **Groups** selection box, select *Forest_Type=102 (red pine).*
6. In the **Stands** selection box, select stand *090603020270004.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2202*, respectively.

Adding a conditional clearcut

The *Clearcut/Coppice* management action cuts trees above a minimum diameter. This management action allows you to leave large legacy trees as residuals, simulating a clearcut with reserves. The underlying management action is **Thin throughout a diameter range**.

10. Select the **Components > Management** tab.
11. From the **Categories** selection box, select *Regeneration Methods: Even-aged.*
12. From the **Components** selection box, select *Clearcut/Coppice.*
13. Change the **Component title** to *Clearcut all trees (includes site prep).*
14. Select the **Schedule by condition** button.
15. Enter the following condition parameters:
    a. **Condition:** ....*Age is in a specified range.*
    b. **Years before condition can become true again**............*90*
    c. **Minimum Age**...*90*
    d. **Maximum Age**..999
16. Enter the following cutting parameters:
    a. **Diameter of smallest tree cut**.......................................*1*
    b. **Number of legacy trees per acre**..................................0
    c. Leave all other parameters set to the default values.
17. Click the **Save in run** button.

Since you are performing an even-aged regeneration harvest, reset the age of the stand following the clearcut.

18. Select the **Components > Keywords** tab.
19. From the **Extensions** selection box, select *Base FVS system.*
20. From the **Kewords** selection box, select *ResetAge.*
21. Select the **Attach to existing condition** button.
22. Enter the following parameters:
    a. **Number of years after condition is found true:** 5
    b. **New stand age** 5

When a management action or keyword is used in a condition, the **Year or cycle number** field is interpreted as "X years after the condition is met, implement the action."

23. Click the **Save in run** button.

Adding conditional regeneration

24. Select the **Components > Management** tab.
25. From the **Categories** selection box, select *Planting & Natural Regeneration.*
26. From the **Components** selection box, select *Plant/Natural with Full Estab Model.*
27. Change the **Component title** to *Plant PIRE.*
28. Set the **Schedule the date of disturbance** radio button to *Schedule by Condition.*
29. Accept the default condition.
30. Enter the following parameters:
    a. **Years following disturbance for site preparation** *1*
    b. **Sprouting** ....*On*
31. In **Regen 1)**, specify the following:
    a. **Years following disturbance for regeneration:** *0*
    b. **Type of regeneration scheduled:** ....*Plant*
    c. **Species** ....*red pine (plantation)*
    d. **Trees/acre:** *435*
32. Click the **Save in run** button.

Selecting Outputs

33. Select the **Select Outputs** tab.
34. Check the **Stand visualization, Tree lists**, and **Regeneration** boxes.

Running the simulation

35. Select the ***Run*** tab.
36. Change the management identification code (**MgmtID**) to *CCnP.*
37. Click the **Save and Run** button.

FVS will save the simulation as *Regen 2* with a management identification code of *CCnP.*

Examining the treatment effects

Begin exploring the effects of this run by using the **Visualize** tab to view the stand over time.

Compare the stand in the years of the harvest to current conditions.

Do the composition and size of the trees change? What is the difference?

Given the current stand image, do you think your long-term modeling is realistic? Why or why not?

Use the **View Outputs** tab to **Load/Explore** the summary output. In what years was the stand clearcut?

How long does it take the plantation to go from seedling/sapling to pulpwood to sawtimber sized following the second harvest?

Compare the stand size and density over the projection. How do the plantation statistics differ from the initial conditions?

Load/Explore the stand and stock table output to create a diameter distribution graph showing volume harvested by species for each clearcut. Do the species change for each harvest?

Load/Explore the regeneration output. What regeneration was included in the simulation after the harvests? Is this realistic?

How could you modify the regeneration estimates following harvest?

Regen 3: Creating a keyword component collection

Let's say you determine that the conditional management action you created in the *Regen 2* exercise would be an action you would include in other runs. Instead of re-creating the actions in new runs, FVS gives you the option to create and save run contents into what is called an FVS keyword component collection so that you can add the actions into other runs.

In this exercise, you will go back to the *Regen 2* run and save the clearcut and regeneration actions into an FVS component collection. You will then add all red pine stands into a run and import the keyword component collection into the run.

Creating a keyword component collection

Creating a keyword component collection from selected options allows you to save complex management actions and easily incorporate them into new runs. You are now going to save the clearcut with plant and ingrowth options from this run into a collection.

1. Within the **Simulate** tab, make sure *Regen 2* is the active run.
2. Click on the **Components > Editor** tab.
3. If a component exists, click the **New** button.
4. Set the **Component Title** to: *Ft102: Clearcut and Plant.*
5. In the **Run Contents** window:
   a. Highlight *Cnd: Age is in a specified range.*
   b. Click the **Append selected component from run** button.
   c. Highlight *Kwd: Clearcut all trees (includes site prep and release)*
   d. Click the **Append selected component from run** button.
   e. Highlight *Kwd:ResetAge*
   f. Click the **Append selected component from run** button.

Any line starting with an asterisk is a comment line. From the **Run Contents**, you can see the FVS keywords represented by the conditional clearcut; however, it is missing one keyword. That keyword is the *Endif* keyword which ends the conditional. FVS will add this keyword when you add the next condition.

Now add the conditional planting and ingrowth.

   g. Highlight *Cnd: After significant harvesting/thinning*
   h. Click the **Append selected component from run** button.
   i. Highlight *Kwd: Plant PIRE*
   j. Click the **Append selected component from run** button.

You will see that there is not an *Endif* at the end of this condition either. FVS will add an *EndIf* when you save the keywords into the component collection.

Now save the keywords to a component collection.

6. Click the **Save in component collection** button.

The collection is now available to add to any simulation in your project. Start a new simulation and add the collection into a run modeling all the red pine stands for the next 100 years.

Starting a new run

7. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
8. Change the **Run title** to *Regen 3.*
9. Click the **Save** button.

Adding stands into a run

10. In the **Variants** selection box, select *ls: Lake States.*
11. In the **Groups** selection box, select *Forest_Type=102.*
12. Click the **Add stands in selected groups** button.

Setting the time frame

13. Select the **Time** tab.
14. Change the **Common starting year** and **Common ending year** to *2022* and *2122*, respectively.

Importing the keyword component collection

15. Select the **Components > Editor** tab.
16. After making sure the **Existing component collection** selection is set to *Ft102: Clearcut and Plant*, click the **Save in run** button.

The **Run Contents** window will show the collection being attached to each stand in the run.
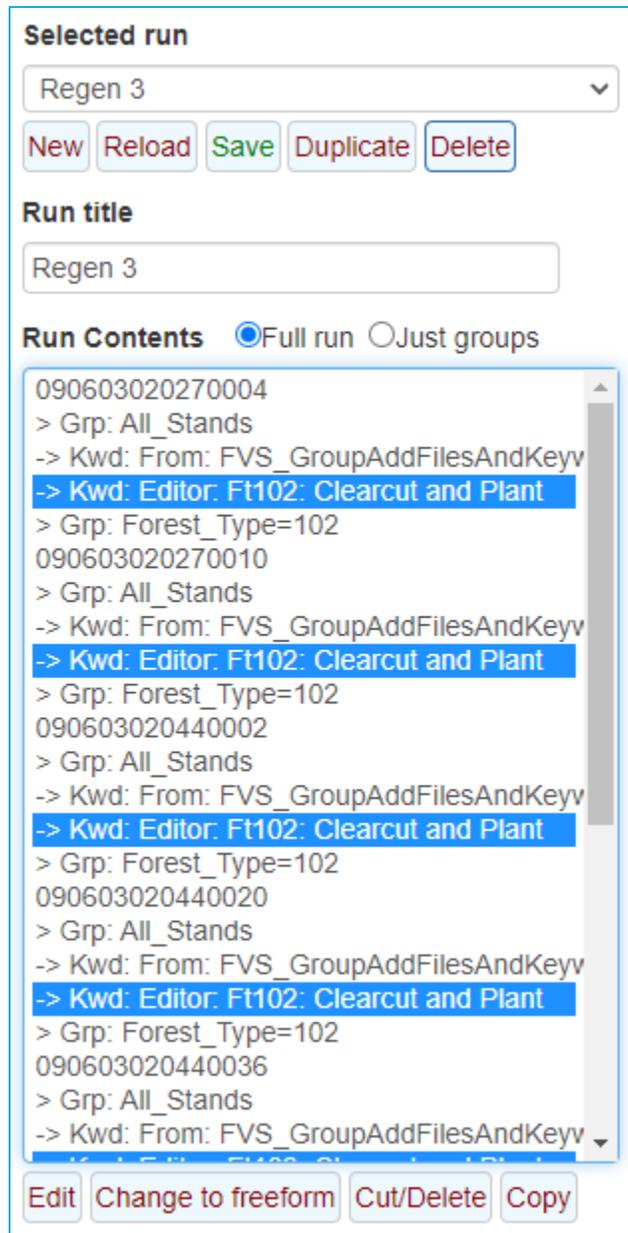
NOTE: before proceeding to the next step, edit the component collection that was attached in the **Run Contents** window. Check to see if there are *Estab – End* keywords encasing the establishment keywords. If not, add *Estab* on the line above * *Plant PIRE* and *End* above the last *EndIf* in the collection.

Selecting Outputs

17. Select the **Select Outputs** tab.
18. Check the **Stand visualization, Tree lists**, and **Regeneration** boxes.

Running the simulation

19. Select the ***Run*** tab.
20. Change the management identification code (**MgmtID**) to *RPCC*.
21. Click the **Save and Run** button.

FVS will save the simulation as *Regen 3* with a management identification code of *RPCC*.

Examining the treatment effects

Use the **View on Maps** tab to determine if all stands were regenerated. Are there any stands that were not regenerated right away? Why do you think this is?

Use the **View Outputs > Load/Explore** tabs to explore the summary output. What is the forest type, size class, and stocking class of each stand at time of harvest?

How long does it take the plantations to go from seedling/sapling to pulpwood to sawtimber sized?

Load/Explore the composite summary output. What is the average cubic feet volume removed from the run?

Load/Explore the composite stand and stock table output. What species are in the smallest diameter classes?

Regen 4: Skills challenge

For eastern white pine forest type (103) stands in the Lake States variant, create an ingrowth addfile to mimic the current average composition of the seedling/sapling layer. Then for all white pine stands, model a clearcut and plant management action with the ingrowth included. Create a document to share with a management team that describes stand composition and structure, harvest volumes, and any other pertinent information.

Module 7: Growth and Mortality Modifications

This module leads you through adding common growth and mortality modifiers in your runs. While the possibilities and options are numerous, these select exercises showcase the capabilities that are available to you. Three step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Mod 1: Adding large-tree diameter growth modifiers

Modifying diameter growth can take the form of modifiers used to adjust the underlying change in squared diameter (*DDS*) estimate or modifiers directly affecting the diameter growth estimate produced by the diameter growth model. The *DDS* multiplier, which is essentially a basal area increment estimate for large trees, can be set with the *Pre-calibration: multiplier to large tree diameter growth* and the *Adjust large tree basal area increment* modifiers, with the first one set for the entire run and the latter being able to be cycle specific. The *Fix diameter growth rates* modifier adjusts the final diameter growth estimate directly for trees within the specified species and size range during any cycle.

In this exercise, you will add a large-tree diameter growth modifier and compare the results to a run without the modifier.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Mod 1.*
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ci: Central ID.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *0402040043070306.*
7. Change the **Number of replicates of each added stand** to *2.*
8. Click the **Add selected stands** button.

The stand replicate numbers *r001* and *r002* can be seen in the **Run Contents** window directly following the stand ID.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Adding the growth modifier

In this example, it is assumed that FVS underpredicts ponderosa pine basal area increment by 25% in the project area. You will use the *Adjust large tree basal area increment* modifier. What constitutes a large tree is dependent on the variant and species. In case of ponderosa pine in the CA variant, a large tree is assumed to be above a 3-inch DBH. A multiplier value less than 1.0 will decrease the predicted growth rate and a value greater than 1.0 will increase the predicted growth rate. In your case, you will set the ponderosa pine basal area increment modifier to 1.25, a 25% increase in basal area increment. To compare runs with and without the growth modifier, you will add the modifier to the second replicate.

11. In the **Run Contents** window, select replicate *r002.*

By selecting the second replicate, the modifier will only be added to the second replicate.

12. Select the **Components > Modifiers** tab.
13. From the **Categories** selection box, select *Diameter Growth Modifiers.*
14. From the **Components** selection box, select *Adjust large tree basal area increment.*

15. Change the **Component title** to *Increase PIPO BAI 25%.*
16. Enter the following parameters:
    a. **Year or cycle number**..*1*
    b. **Species** ....*ponderosa pine*
    c. **Multiplier value**...........*1.25*

Management	Modifiers	Event Monitor	Economic	Keywords	Editor

Categories

Diameter Growth Modifiers ⌄

Components

Adjust large tree basal area increment ⌄

Component title Increase PIPO BAI 25%

⦿ Schedule by year ○ Schedule by condition

Year or cycle number: 1

Once this multiplier is in effect, it remains in effect until replaced by a subsequent multiplier.

Species to which multiplier is applied ponderosa pine ⌄

Multiplier value 1.25

Cancel Save in run Change to freeform

To affect all growth cycles, this modifier should be set in cycle 1. Since the option remains in effect until replaced, there is no need to add it again. However, if you were using this modifier to simulate the effects of a treatment, you may need to start and stop the modification. For instance, if you were simulating a crown touch release in 2022 that is predicted to increase growth by 20% for 20 years, you would specify this basal area increment modifier for 2022 with a value of 1.20 and again in 2042 with a value of 1.0, effectively turning on and off the modifier.

17. Click the **Save in run** button.

Selecting Outputs

18. Select the **Select Outputs** tab.
19. Check the **Tree lists** box.

Running the simulation

20. Select the ***Run*** tab.
21. Change the management identification code (**MgmtID**) to *LTdg*.
22. Click the **Save and Run** button.

FVS will save the simulation as *Mod 1* with a management identification code of *LTdg*.

Examining the modification effects

From the **Run tab** window, you will see the effects of the modifier on volume increment.

Run made with: FVSci RV:20210930

FVS error scan:

No errors found
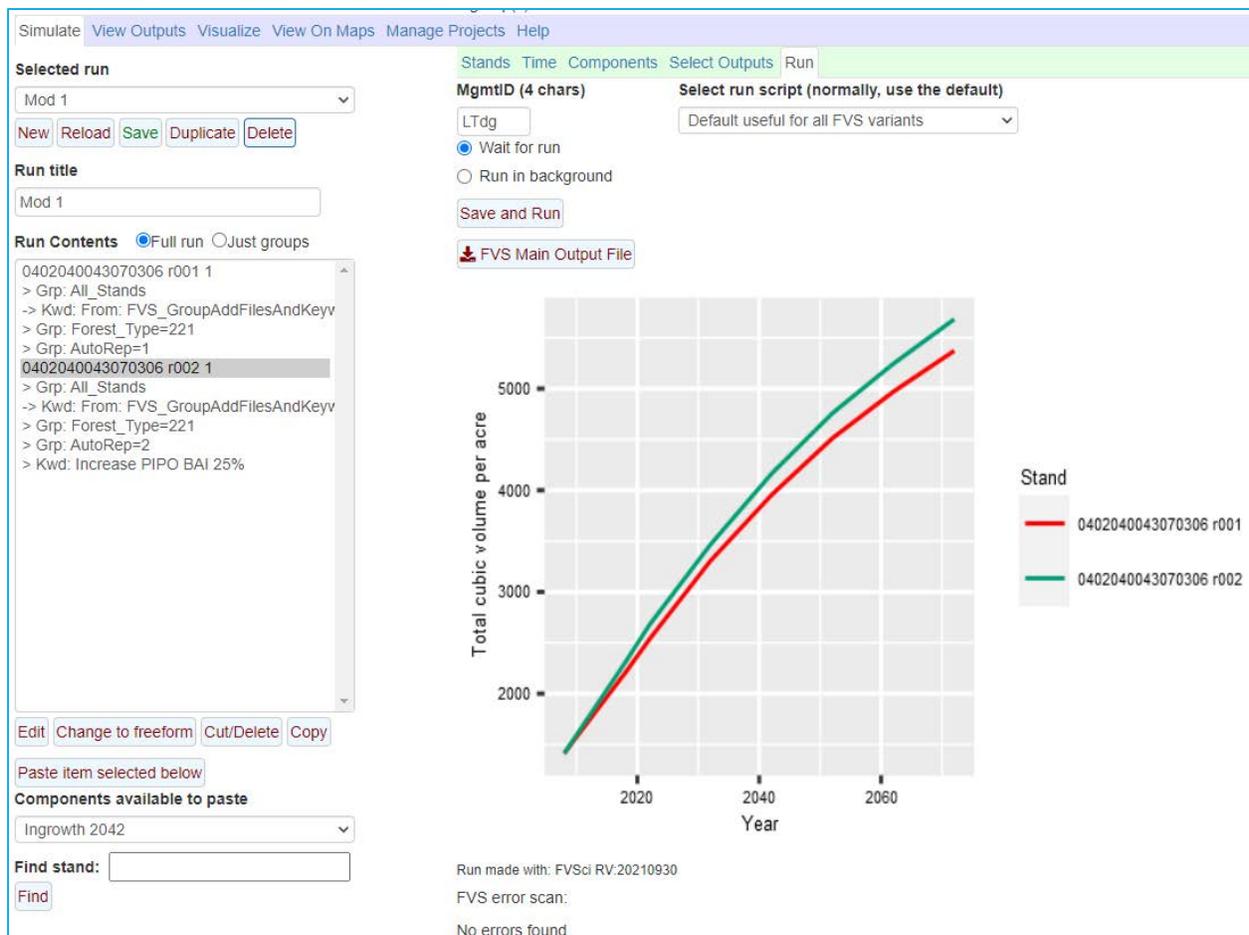
Use the **View Outputs > Load/Explore** menu with the treelist output to determine the effect on individual tree records. Download the table to a MS Excel file and track the growth difference of the tree with TreeIndex = 2. Record DBH and DG for 2022, 2042, and 2062. What was the long-term difference in tree growth?

Was height growth affected?

Back in FVS, use the **Graphs** tab to create and save boxplots of diameter growth over time for ponderosa pine. Do diameter growth increases continue for the projection time frame over the default run?

Load/Explore the summary output. Did the growth increase have much effect on overall stand density patterns?

Mod 2: Adding small-tree height growth modifiers

Modifying small-tree height growth can be accomplished by adjusting the small-tree height growth estimate or fixing the height growth. The difference is timing of the effect where the former occurs prior to diameter growth and remains in effect for the rest of the run whereas the latter occurs after diameter growth is estimated and may be specified for specific time intervals. This is important because if you choose to fix height growth, FVS does not subsequently modify the diameter growth estimate and you may get inappropriate height – diameter relationships for your modeled trees. That means, you may need to fix the small tree diameter growth too.

In this exercise, you will add a small-tree height growth modifier (*Adjust small tree height model*) and compare the results to a run without the modifier.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Mod 2*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ci: Central ID.*
5. In the **Groups** selection box, select *Forest_Type=201.*
6. In the **Stands** selection box, select stand *0402040043070310.*
7. Change the **Number of replicates of each added stand** to *2.*
8. Click the **Add selected stands** button.

The stand replicate numbers *r001* and *r002* can be seen in the **Run Contents** window directly following the stand ID.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Adding the growth modifier

In this example, you will increase the small-tree height growth of all trees by 25%. This estimate will be slightly muted by the fact that for the height growth estimates for large and small trees are splined together across a diameter range. Refer to section 4.6 of your variant overview to determine this range. A multiplier value less than 1.0 will decrease the predicted growth rate and a value greater than 1.0 will increase the predicted growth rate. In your case, you will set the small-tree height growth modifiers to 1.25, a 25% increase in height increment. To compare runs with and without the growth modifier, you will add the modifier to the second replicate.

11. In the **Run Contents** window, select replicate *r002.*

By selecting the second replicate, the modifier will only be added to the second replicate.

12. Select the **Components > Modifiers** tab.
13. From the **Categories** selection box, select *Height Growth Modifiers.*
14. From the **Components** selection box, select *Adjust small tree height model.*

15. Change the **Component title** to *Increase small tree HG 25%.*
16. Enter the following parameters:
    a. **Year or cycle number**............................*1*
    b. **Species** ....*All*
    c. **Multiplier value**....................................1.25

To affect all growth cycles, this modifier should be set in cycle 1. Since the option remains in effect until replaced, there is no need to add it again. However, if you were using this modifier to simulate the effects of a treatment, you may need to start and stop the modification. For instance, if you were simulating a release treatment for regeneration in 2022 that is predicted to increase growth by 20% for 10 years, you would specify this height growth modifier for 2022 with a value of 1.20 and again in 2032 with a value of 1.0, effectively turning on and off the modifier.

17. Click the Save in run button.

Selecting Outputs

18. Select the **Select Outputs** tab.
19. Check the **Tree lists** box.

Running the simulation

20. Select the ***Run*** tab.
21. Change the management identification code (**MgmtID**) to *SThg.*
22. Click the **Save and Run** button.

FVS will save the simulation as *Mod 1* with a management identification code of *SThg.*

Examining the modification effects
From the **Simulate** tab, you will see the effects of the modifier on volume increment.

Use the **View Outputs > Load/Explore** menu with the treelist output to determine the effect on individual tree records. Download the table to a MS Excel file and track the growth difference of the tree with TreeIndex = 1. Record Height and HG for 2022, 2042, and 2062. What was the long-term difference in tree growth?

Back in FVS, use the **Graphs** tab to create and save scatterplots of height growth over time by species. Do height growth increases continue for the projection time frame?

Load/Explore the summary output. Did the growth increase have much effect on overall stand height or volume patterns?

Mod 3: Applying additional mortality

At some point, you'll have a need to adjust FVS mortality rates, whether it is to correct for insect or disease epidemics, climatic events, senescence of older trees, or other causes. The modifier used to simulate acute mortality events is most often the *Adjust mortality rates* modifier. This modifier allows you to increase the mortality of species of a given size and location within a stand at a specific time period. Other modifiers, such as those that reset the carrying capacity of the stand (*Adjust maximum basal area* and *Adjust maximum SDI*) or set maximum sizes (*Set maximum tree size*) are more chronic in status, as they are set prior to simulation and alter the mortality estimates for the entire run. Here are some examples of where you might use these modifiers:

Adjust mortality rates:
- Update an inventory after a disturbance (wildfire, tornado, hurricane).
- Mimic an insect epidemic by increasing mortality of susceptible host species.
- Increase mortality to mimic self-thinning in young stands.
- Decrease mortality of species favored in crown touch release treatments.

Adjust maximum basal area and *Adjust maximum SDI*

- Increase/decrease species maximums based on local site characteristics.

Set maximum tree size

- Increase mortality and decrease growth of short-lived species once they are a given size.
- Increase mortality of species affected by endemic diseases such as Dwarf Misteltoe.

There are additional modifiers and keywords that impact recruitment and survival. These include:

Turn off sprouting/Adjust Sprouting

- Turn off/decrease sprout numbers/heights due to cutting or fire practices.
- Increase/decrease sprout numbers/heights due to parent tree size.

Fire and Fuels Extension: FMortMlt keyword

- Increase/decrease predicted fire-caused mortality by species and size due to prescribed fire practices

Base FVS system: SetSite keyword

- Change the plant community, carrying capacity, or site quality due to site degredation/enhancement from climate change or other factors during a run.

As you can see above, there are numerous ways to impact tree survival in FVS. If one of these options do not fit your need, you can simply cut the trees in your stand and use the biomass retention options to leave a proportion of them standing or down.

In this exercise, you will gain experience modifying mortality by increasing mortality in the stand due to insect activity. You will use the replicate method presented in the preceding exercises to compare the stand run with and without modification.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Mod 3*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ci: Central ID.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *0402040043070306.*
7. Change the **Number of replicates of each added stand** to *2.*
8. Click the **Add selected stands** button.

The stand replicate numbers *r001* and *r002* can be seen in the **Run Contents** window directly following the stand ID.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Adding the mortality modifier

The mortality modifier will be applied to species affected by mountain pine beetle. The first step will be to set up a species group of the affected species (lodgepole pine and ponderosa pine). Then the mortality modifier will be added to these species to simulate the increased mortality of the spruce trees (80% in trees >=5 inches DBH). To compare runs with and without the growth modifier, you will add the modifier to the second replicate.

11. In the **Run Contents** window, select replicate *r002.*

By selecting the second replicate, the modifier will only be added to the second replicate.

12. Select the **Components > Management** tab.
13. From the **Categories** selection box, select *Identify Groups.*
14. From the **Components** selection box, select *General species group.*
15. Change the **Component title** to *Species Group: host species*
16. Enter the following parameters:
    a. **Specify a 2-10 character Species Group** ....*Host*
    b. **Species** ....*lodgepole pine*
    c. **Species** ....*ponderosa pine*
17. Click the **Save in run** button.
18. Select the **Components > Modifiers** tab.
19. From the **Categories** selection box, select *Mortality Modifiers.*
20. From the **Components** selection box, select *Adjust mortality rates.*
21. Change the **Component title** to *Increase mortality to 80%.*
22. Enter the following parameters:
    a. **Year or cycle number**..1
    b. **Species** ....*SpGroup: Host*
    c. **Proportion of tree record that will be killed**............................*0.80*
    d. **Smallest DBH to which mortality rate will be applied** *5.0*
    e. Leave all other parameters set to their values.

We have set this modifier to cycle 1, which means it will only affect trees in the initial cycle. To affect all growth cycles, the timing should be set to 0. In addition, you chose the default functions of

replacing the predicted mortality for these tree records and to apply this mortality uniformly across the stand.

23. Click the **Save in run** button.

Selecting Outputs

24. Select the **Select Outputs** tab.
25. Check the **Tree lists** box.

Running the simulation

26. Select the ***Run*** tab.
27. Change the management identification code (**MgmtID**) to *PBdM*.
28. Click the **Save and Run** button.

FVS will save the simulation as *Mod 3* with a management identification code of *PBdM*.

Examining the modification effects

From the **Run tab** window, you will see the effects of the modifier on volume increment.

Use the **View Outputs > Load/Explore** tabs to determine the effect on total trees per acre and growth of the two runs. Specifically, create some graphs that demonstrate the effects on trees per acre, QMD, top height, and merchantable volume over the run. Describe what you are seeing.

Since mortality is reported for the previous cycle, specifically look at year *2022*.

Did the additional mortality affect 5 inch and greater of the target species? Prove this by creating/saving a graph.

Mod 4: Skills challenge

For the stands in the grand fir forest type (301), you expect climate to be less supportive of true firs over the next 100 years. From your research, you determine growth rates for these species are expected to decrease 40% by mid-century followed by a decreased carrying capacity for all species soon thereafter. Create a document to share with your management team that describes expected changes in species composition, structure, and volumes for standa *0402040043070320* and *0402040043070505*.

Module 8: Adjusting Default Relationships

This module leads you through some common adjustments made to default conditions. While the adjustments are numerous, these exercises illustrate some of the most common adjustments users make in FVS. Five step-by-step exercises are included in this module followed by a skills challenge designed to test your comprehension of the module's topics.

Adjust 1: Adjusting canopy cover estimates for different spatial distributions

Estimates for stand percent canopy cover (*PCC*) generated by FVS are, by default, based upon the assumption that trees are randomly distributed. The calculation of *PCC* involves first using estimated crown width values for individual trees as input into the equation for the area of a circle, resulting in an estimated projected crown area for each tree, assuming symmetric, continuous and circular cover. These individual crown area values are then expanded to a per acre basis, with these expanded values being subsequently summed and related to a single average acre to arrive at a stand-level uncorrected for crown overlap canopy cover estimate (*UNPCC*). Correcting this value for crown overlap is done using the below equation from Crookston and Stage (1999), which assumes a random spatial distribution of trees.

$$PCC = 100 * [1 - e^{(-0.01*UNPCC)}]$$

Given that a stand with a clumpier distribution will have a lower estimate of *PCC* than one with a random distribution, and that a stand with a uniform distribution will have a higher estimate of PCC, the ability to modify the spatial distribution assumption has been integrated into FVS. Users can modify *PCC* estimates through the *Adjust Overlap Assumption* modifier.

In this exercise, you will perform a thin from below to 60 square feet of basal area. You will compare using uniform vs. random vs. clumpy spatial distribution in FVS simulations.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Adjust 1*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *sn: Southern.*
5. In the **Groups** selection box, select *Forest_Type=503.*
6. In the **Stands** selection box, select stand *08210804560010.*
7. Change the **Number of replicates of each added stand** to *3.*
8. Click the **Add selected stands** button.

The stand replicate numbers *r001, r002, and r003* can be seen in the **Run Contents** window directly following the stand ID.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Adding the thinning

11. Select the **Components > Management** tab.
12. From the **Categories** selection box, select *Thinnning and Pruning Operations.*
13. From the **Components** selection box, select *Thin from below.*
14. Change the **Component title** to *Thin from below to 60 BA.*
15. Enter the following parameters:
    a. **Year or cycle number**...............*2022*

        b. **Basal area per acre**...................60
        c. **Diamter lower limits (inches)**..1
        d. Leave all other parameters set to the default values.
   16. Click the **Save in run** button.

Adding additional user-defined outputs

Now add the additional output you need to explore the canopy cover of the stand based on specific size limits.

   17. Select the **Event Monitor** tab.
   18. Select the *Compute Stand Variables with SpMcDBH function* from the selection box.
   19. Change the **Component title** to *Before thin percent canopy cover.*
   20. Enter the following parameters:
        a. **Year or cycle number**........................... *0*
        b. **Enter the name** .... *BTPCC*
        c. **Attribute to be returned**...................... *Canopy cover percent*
        d. **Lower DBH limit**.................................. *1*
        e. **Calculations are for**.............................. *Live trees*
        f. Leave all other parameters set to the default values.
   21. Click the **Save in run** button.
   22. Select the *Compute Stand Variables with SpMcDBH function from the selection box.*
   23. Change the **Component title** to *After thin percent canopy cover.*
   24. Enter the following parameters:
        a. **Year or cycle number**........................... *0*
        b. **Enter the name** .... *ATPCC*
        c. **Attribute to be returned**...................... *Canopy cover percent*
        d. **Lower DBH limit**.................................. *1*
        e. **Calculations are for**.............................. *Residual (after harvest) live trees*
        f. Leave all other parameters set to the default values.
   25. Click the **Save in run** button.

Adjusting the spatial distribution

To compare runs with and without the spatial adjustment, you will add the modifiers to the first (uniform) and third (clumpy) replicates.

   26. In the **Run Contents** window, select replicate *r001.*

By selecting the first replicate, the modifier will only be added to the first replicate.

   27. Select the **Components > Modifiers** tab.
   28. From the **Categories** selection box, select *Modify Percent Canopy Cover.*
   29. From the **Components** selection box, select *Adjust Overlap correction for thinning.*
   30. Change the **Component title** to *Adjust Overlap Correction: Mod Uniform.*
   31. Enter the following parameters:
        a. **Year or cycle number**.......................................*2022*
        b. **Overlap Coefficient (Distribution Type)**...........*1.52 (Moderately Uniform)*
   32. Click the **Save in run** button.
   33. In the **Run Contents** window, select replicate *r003.*
   34. Select the **Components > Modifiers** tab.

35. From the **Categories** selection box, select *Modify Percent Canopy Cover.*
36. From the **Components** selection box, select *Adjust Overlap correction for thinning.*
37. Change the **Component title** to *Adjust Overlap Correction: Mod Clumpy.*
38. Enter the following parameters:
    a. **Year or cycle number** *2022*
    b. **Overlap Coefficient (Distribution Type)** ....*0.60 (Moderately Clumpy)*
39. Click the **Save in run** button.

Selecting Outputs

No selections are needed since the summary and computed outputs are automatically created.

Running the simulation

40. Select the ***Run*** tab.
41. Change the management identification code (**MgmtID**) to *dPCC.*
42. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 1* with a management identification code of *dPCC.*
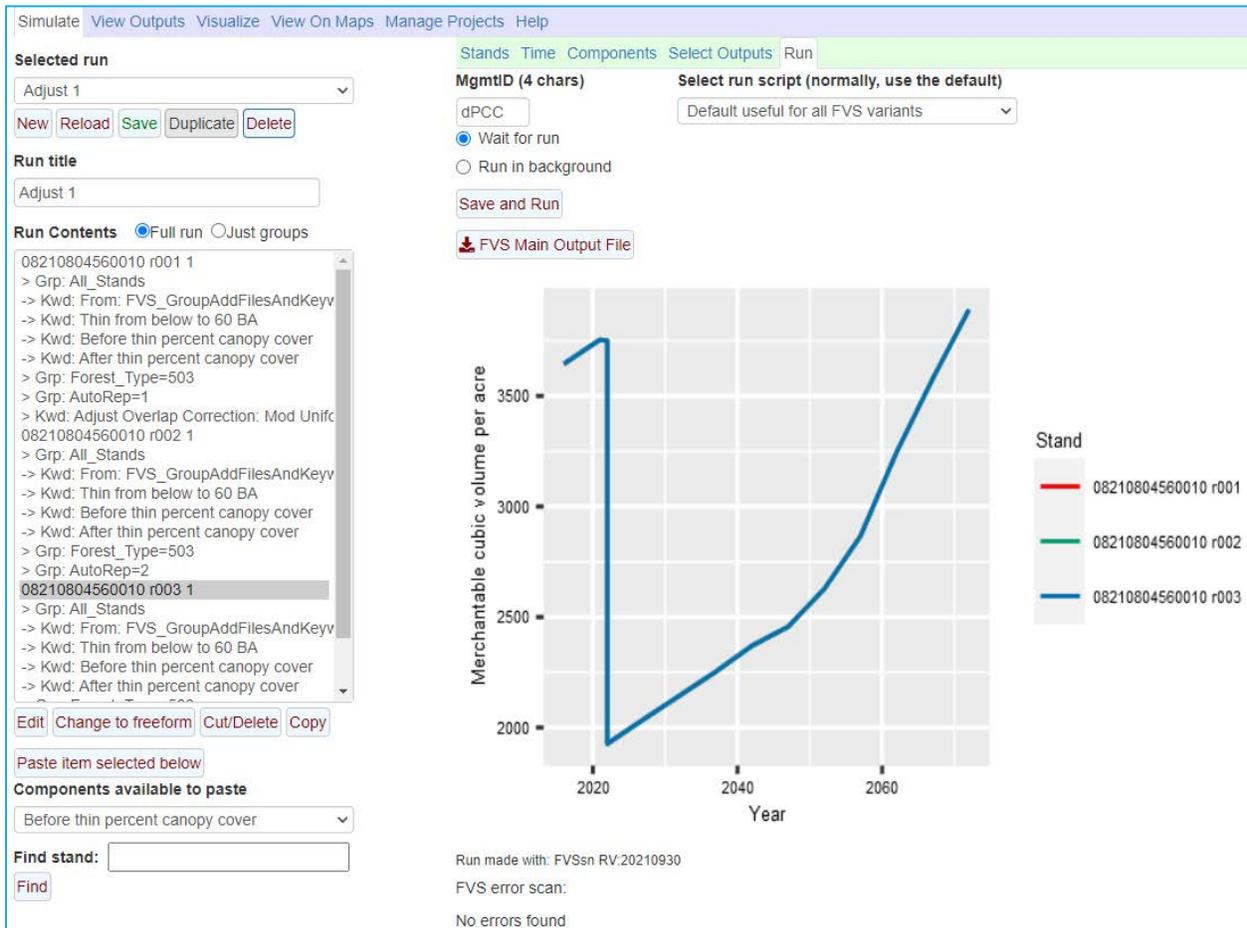
Examining the adjustment effects

From the **Run** tab window, you will see the effects of the modifier on volume increment. Notice that the three runs overlap each other. Investigate this further by comparing the summary output.

Use the **View Outputs > Load/Explore** tabs to explore the summary output. Create graphs using the **Plot-by code** to compare a few density, size, and volume estimates. Did the canopy cover spatial arrangement change in any patterns?

Load/Explore the compute output. From the tabular output, fill in the table below for 2022.

Replicate	Before Thinning Percent Canopy Cover	After Thinning Percent Canopy Cover
r001: uniform		
r002: random		
r003: clumpy		

By accounting for the desired post-treatment uniform spatial distribution, how was the canopy cover affected?

Why were the before thinning *PCC* values the same for both runs, but the after thinning *PCC* values different?

Why do you think modifying the *PCC* values from a random distribution to an assumed uniform distribution increased its value, and vice versa for an assumed clumpy distribution, all other density metrics being equal?

What thinning option could you use to exactly obtain a 50% after thin canopy cover target?

Adjust 2: Adjusting default fire weather conditions

The default environmental conditions (wind speed, temperature, and moisture levels) used in the potential fire report are often changed to represent certain percentile environmental conditions (for example, 95% weather conditions). One way to obtain weather data is by using the Weather Information Management System (WIMS) database and Fire Family Plus software. There are two sets of weather conditions that you may modify: a set for severe conditions and a set for moderate conditions. Setting these conditions may be done using the *Modify Potential Fire Conditions* modifiers or keywords.

In this exercise, you will compare the potential fire conditions for two runs, one with the default conditions and one with modified conditions.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Adjust 2.*
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ca: Inland CA, Southern Cascades.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *050653Suicide0074.*
7. Change the **Number of replicates of each added stand** to *2.*
8. Click the **Add selected stands** button.

The stand replicate numbers *r001* and *r002* can be seen in the **Run Contents** window directly following the stand ID.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Adjusting the potential fire weather conditions

To compare runs with and without tailored weather conditions, you will add the potential fire conditions modifiers to the second replicate.

11. In the **Run Contents** window, select replicate *r002.*

By selecting the second replicate, the modifiers will only be added to the second replicate.

12. Select the **Components > Modifiers** tab.
13. From the **Categories** selection box, select *Modify Potential Fire Conditions.*
14. From the **Components** selection box, select *Set wind speed for potential fires.*
15. Enter the following parameters:
    a. **20-foot wind speed for severe fires (mph):**................. *40*
    b. **20-foot wind speed for moderate fires (mph):** *20*
16. Click the **Save in run** button.
17. From the **Components** selection box, select *Set temperature for potential fires.*
18. Enter the following parameters:
    a. **Temperature for severe fires (F):**............................... *90*

b. **Temperature for moderate fires (F):**............................*70*

19. Click the **Save in run** button.
20. From the **Components** selection box, select *Set fuel moistures for potential fires.*
21. Change the **Component title** to *Set fuel moistures for potential fires: severe conditions.*
22. Enter the following parameters:
    a. **Values apply to:**..*1 = severe fires*
    b. **Percent moisture for 1-hour fuel (0-0.25")** *3*
    c. **Percent moisture for 10-hour fuel (025-1")**...................*4*
    d. **Percent moisture for 100-hour fuel (1-3")**....................*8*
    e. **Percent moisture for 3"+ fuel**......................................*11*
    f. **Percent moisture for duff**...*20*
    g. **Percent moisture for live woody fuels**.........................*78*
    h. **Percent moisture for live herb fuels**............................*78*
23. Click the **Save in run** button.
24. From the **Components** selection box, select *Set fuel moistures for potential fires.*
25. Change the **Component title** to *Set fuel moistures for potential fires: moderate conditions.*
26. Enter the following parameters:
    a. **Values apply to:**..*2 = moderate fires*
    b. **Percent moisture for 1-hour fuel (0-0.25")** *4*
    c. **Percent moisture for 10-hour fuel (025-1")**...................*5*
    d. **Percent moisture for 100-hour fuel (1-3")**....................*9*
    e. **Percent moisture for 3"+ fuel**......................................*15*
    f. **Percent moisture for duff**...*40*
    g. **Percent moisture for live woody fuels**.........................*86*
    h. **Percent moisture for live herb fuels**............................*86*

Selecting Outputs

27. Select the **Select Outputs** tab.
28. Check the **Fire and mortality** box.

Running the simulation

29. Select the ***Run*** tab.
30. Change the management identification code (**MgmtID**) to *dPOT.*
31. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 2* with a management identification code of *dPOT.*

Examining the adjustment effects

From the **Run** tab window, you will not see the effects of the modifier on volume increment. Notice that since you did not change any growth calculations, the volume output is the same for each replicate.

Use the **View Outputs > Load/Explore** tabs to explore the potential fire output. From the tabular output, describe how the modifications affected flame lengths, torching and crowning indices, canopy fuels, and potential mortality?

What was the overall impact the results?

Setting potential fire wind speed, temperature, and surface fuel moisture levels can certainly affect potential fire behavior and effects. FFE predicts fire intensity based on variables such as slope, the fuel model used (based on fuel loading and other stand attributes), mid-flame wind speed, fuel moisture levels, and canopy fuel attributes. These variables affect flame length, scorch height, and fire type, which in turn affect tree mortality. Fuel consumption and smoke production depend mainly on the amount, size, moisture content, and type of fuels present.

Adjust 3: Adjusting default fire behavior through fuel model selection

Fire behavior in FVS is computed using methods developed by Rothermel (1972), Albini (1976), Scott and Reinhardt (2001), and Scott (2001). These methods require a number of parameters that are not carried or readily calculated by FVS. As a result, the thirteen stylized fuel models proposed by Anderson (1982) are used to predict fire behavior. Additional fuel models (Scott and Burgan 2005) as well as custom fuel models are also available to predict fire behavior in FVS. FVS picks one or more of the thirteen fuel models based on existing fuel loads and stand conditions with variant specific logic (see the FVS-FFE documentation for the logic used for your variant).

The process of predicting fire behavior is often difficult to understand but can be generalized down to using the existing surface fuel loads to choose likely fuel models for the stand which in turn are used to predict fire behavior (fuels -> fuel models -> fire behavior). At any point during this simplified process, you can change default settings and ultimately alter fire effects. For instance, you can replace the fuel dubbing logic by entering the fuels loads or specifying a photo series directly into you input data. This would affect the fuel model selection and subsequent fire behavior. Or you could simply bypass all this logic by specifying the predicted flame lengths directly.

Most of the default variant-specific fuel model selection logic results in the selection of one of the thirteen Rothermel fuel models. To obtain one of the 40 Scott and Burgan fuel models, you will need to switch to the new fuel model selection process or specify the fuel model directly. One last option would be to use the fuel loads directly in predicting fire behavior.

In this exercise, you will look at the effects of one change: the selection of fuel models. In this exercise, you will do three simulations with the following selections:

> 3A: Default, no change (use one of the thirteen fuels models).
> 3B: Use the new fuel model selection logic (use one of the 40 new fuel models)
> 3C: Set the fuel model directly in predicting fire behavior

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Adjust 3a*.
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ca : Inland CA, Southern Cascades.*
5. In the **Groups** selection box, select *Forest_Type=221.*
6. In the **Stands** selection box, select stand *050653Suicide0074.*
7. Click the **Add selected stands** button.

Setting the time frame

8. Select the **Time** tab.
9. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Selecting Outputs

10. Select the **Select Outputs** tab.
11. Check the **Fire and mortality** box.

Running the simulation

12. Select the ***Run*** tab.
13. Change the management identification code (**MgmtID**) to *NONE.*
14. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 3a* with a management identification code of *NONE*.

Now, perform the second run where you change the fuel model selection logic to the "new" logic.

Duplicate initial run

15. Within the **Simulate** tab, begin a new simulation by clicking the **Duplicate** button.
16. Change the **Run title** to *Adjust 3b.*
17. Click the **Save** button.

Change the fuel model selection logic

18. Select the **Components > Modifiers** tab.
19. From the **Categories** selection box, select *Modify Fire Behavior.*
20. From the **Components** selection box, select *Select the "new" fuel model logic or modelled loads option.*
21. Change **Component Title** to *Use the "new" fuel model logic.*
22. Enter the following parameters:
    a. **Year or cycle number:** *1*
    b. **The fire behavior calculations should use:** .... *1 = the new fuel model selection logic*
    c. **Fuel model set for use** .... *1 = use the 40 new Scott and Burgan fuel models*
    d. Leave all other parameters set to the default values.
23. Click the **Save in run** button.

Running the simulation

24. Select the ***Run*** tab.
25. Change the management identification code (**MgmtID**) to *NEWF.*
26. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 3b* with a management identification code of *NEWF*.

Now, perform the third run where you set the fuel model directly.

Duplicate initial run

27. Within the **Simulate** tab, select *Adjust 3a* from the **Selected Run** tab.
28. Begin a new simulation by clicking the **Duplicate** button.
29. Change the **Run title** to *Adjust 3c.*
30. Click the **Save** button.

Set the fuel model

31. Select the **Components > Modifiers** tab.
32. From the **Categories** selection box, select *Modify Fire Behavior.*
33. From the **Components** selection box, select *Set fuel model(s).*

This modifier allows you to select up to four fuel models at a time. If more than one is specified, FVS will model fire behavior for all fuel models and then average the results based on the percentages specified.

34. Change **Component Title** to *Set fuel model: 183 100%.*
35. Enter the following parameters:
    a. **Year or cycle number:**...........................*1*
    b. **First fuel model:**...................................*183 = TL3 Moderate load conifer litter*
    c. **Weight given the first fuel model:**.......*100*
    d. Leave all other parameters set to the default values.
36. Click the **Save in run** button.

Running the simulation

37. Select the ***Run*** tab.
38. Change the management identification code (**MgmtID**) to *SETF.*
39. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 3c* with a management identification code of *SETF.*

Examining the adjustment effects
Use the **View Outputs > Load/Explore** to explore the potential fire output for all three runs. Fill in the tables below with the fuel model selections in 2022.

Run	MgmtID	Fuel Model 1	Percent	Fuel Model 2	Percent

Describe the effect that these models had on potential fire behavior by graphing using the **Plot-by code**.

Note you need to be aware of any **Set fuel model(s)** windows in your simulation or if the fuel model is being set in your input database, because user-set fuel models will always take precedence over default or new logic.

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Adjust 4: Adjusting default carbon calculations

Two primary adjustments are considered when using the carbon model. You can change the algorithms used to produce per unit area estimates of carbon for some pools; and, you can change the units the carbon estimates are reported in.

There are 5 main carbon pools that FFE tracks and reports: aboveground live trees (total and merchantable), aboveground dead trees, dead woody surface fuels, live surface fuels (shrubs and herbs), and belowground (live and dead) large root carbon. These pool calculation methods are explained in chapter 2.6 of The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation (Rebain 2010). You have the choice of selecting one of two methods of calculating aboveground live tree carbon: the variant-specific local biomass algorithms or the national-level allometric Jenkins equations, which are based on 10 species groups (Jenkins and others (2003). The default method is to use the local carbon estimates, in which case regional-specific volume and crown biomass equations are used to estimate total and merchantable aboveground live tree biomass, sans bark biomass. Alternatively, the Jenkins equations may be requested which will calculate aboveground total and merchantable biomass, including bark biomass. Regardless of the requested reporting method, the FFE-biomass is always the basis for aboveground dead, dead woody surface fuels, and the live surface fuels pools, while Jenkins-biomass is always the basis for live and dead root biomass. With the exception of the litter and duff pools, biomass found in the living and dead biomass is converted to units of carbon by multiplying by 0.5; litter and duff biomass are converted using a multiplier of 0.37.

In this exercise, you will thin a stand and compare the carbon output for the two calculation methods, one with the default local equations and one with Jenkins equations.

Starting a new run

1. Within the **Simulate** tab, begin a new simulation by clicking the **New** button.
2. Change the **Run title** to *Adjust 4.*
3. Click the **Save** button.

Adding a stand into a run

4. In the **Variants** selection box, select *ca : Inland CA, Southern Cascades.*
5. In the **Groups** selection box, select *Forest_Type=371.*
6. In the **Stands** selection box, select stand *050653Corner0402.*
7. Change the **Number of replicates of each added stand** to *2.*
8. Click the **Add selected stands** button.

The stand replicate numbers *r001* and *r002* can be seen in the **Run Contents** window directly following the stand ID.

Setting the time frame

9. Select the **Time** tab.
10. Change the **Common starting year** and **Common ending year** to *2022* and *2072*, respectively.

Adding the thinning

11. Select the **Components > Management** tab.
12. From the **Categories** selection box, select *Thinning and Pruning Operations.*

13. From the **Components** selection box, select *Thin throughout a diameter range.*
14. Change the **Component title** to *Thin throughout 2022.*
15. Enter the following parameters:
    a. **Year or cycle number** *2022*
    b. **Density in terms of** .... *Basal area*
    c. **Residual density** *60*
    d. **Smallest DBH** *5*
    e. Leave all other parameters set to the default values.
16. Click the **Save in run** button.

Adjusting the carbon calculation methods

To compare runs with the different carbon calculation methods, you will add the carbon calculation conditions modifier to the second replicate.

17. In the **Run Contents** window, select replicate *r002.*

By selecting the second replicate, the modifiers will only be added to the second replicate.

18. Select the **Components > Keywords** tab.
19. From the **Extensions** selection box, select *Fire and Fuels Extension.*
20. From the **Keywords** selection box, select *CarbCalc: Set the carbon accounting parameters.*
21. Change the **Component title** to *CarbCalc: Jenkins.*
22. Enter the following parameters:
    a. **Biomass predictions:** .... *1 = Use Jenkins and others (2003)*
    b. Leave all other parameters set to the default values.
23. Click the **Save in run** button.

Selecting Outputs

24. Select the **Select Outputs** tab.
25. Check the **Carbon and fuels** box.

Running the simulation

26. Select the ***Run*** tab.
27. Change the management identification code (**MgmtID**) to *dCBN.*
28. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 4* with a management identification code of *dCBN*

Examining the adjustment effects

From the **Run** tab window, you will not see the effects of the modifier on volume increment. Notice that since you did not change any growth calculations or volume calculation methods, the output is the same for each replicate.

Use the **View Outputs > Load/Explore** to explore the carbon output. From the tabular output just created, describe the change in carbon pools for standing and surface pools in 2022. Comparing these results, which of the carbon pools were affected by changing the biomass algorithms?

Did changing the algorithm change how much carbon was estimated to be removed in the thinning?

Load/Explore the harvested carbon output. Create a stacked bar chart of the carbon fates for the two runs and compare the harvested carbon status over the run timeframe? Did the pattern change with the calculation method?

Adjust 5: Adjusting default volume calculations

The default volume equations used in FVS are from the National Volume Estimator Library. Merchantability specifications are variant specific, and you should consult the variant overview for default values. The *Volume Modifiers* selections allow you to adjust volume merchantability specifications and include defect for a given species. You may adjust the default merchantability specifications for any species in your simulations; however, the default values have been approved by the regional FVS coordinator and it is best to not change the merchantability specifications unless your local market dictates a change. Volume defect can be included on individual tree records via damage/severity codes in the input tree data file or applied to all records of a given species through volume modifiers.

In this exercise, you will modify the previous exercise by using the *Add Volume Defect* modifier to include the defect proportions for two species. This modifier allows you to add average defect based on the size of trees. This is useful to include when defect wasn't taken with the inventory or when you establish new trees that will someday grow into merchantable size. You will use the table below to adjust the defect assumed for the previous exercise.

Species	Volume	5" Defect	10" Defect	15" Defect	20" Defect	>25" Defect
PP	Merchantable cubic and Board foot	0.14	0.14	0.17	0.20	0.25
BO	Merchantable cubic	0.12	0.13	0.16	0.19	0.21
BO	and Board foot	0.99	0.99	0.99	0.99	0.99

Starting a new run

1. Within the **Simulate** tab, make sure *Adjust 4* is in memory.
2. Begin a new simulation by clicking the **Duplicate** button.
3. Change the **Run title** to *Adjust 5.*
4. Click the **Save** button.

Adjusting tree defect

You will need to add defect to both replicates by clicking the *Group: All_Stands* group.

5. In the **Run Contents** window, select *Group: All_Stands.*
6. Select the **Components > Modifiers** tab.
7. From the **Categories** selection box, select *Volume Modifiers.*
8. From the **Components** selection box, select *Add Volume Defect.*
9. Change the **Component title** to *Add Volume Defect: PP*
10. Enter the following parameters:
    a. **Volume type affected** ....Merchantable cubic and Board foot
    b. **Species** ....*Ponderosa pine*
    c. **Volume defect proportion for a 5-inch tree** *0.14*
    d. **Volume defect proportion for a 10-inch tree**....*0.14*

- e. **Volume defect proportion for a 15-inch tree**....*0.17*
- f. **Volume defect proportion for a 20-inch tree**...*0.20*
- g. **Volume defect proportion for a 25-inch tree**...*0.25*
- h. **Volume defect proportion for a 30-inch tree**...*0.25*
- i. **Volume defect proportion for a 35-inch tree**....*0.25*
- j. **Volume defect proportion for a 40-inch tree**...*0.25*
- k. Leave all other parameters set to the default values.

11. Click the **Save in run** button.
12. From the **Components** selection box, select *Add Volume Defect.*
13. Change the **Component title** to *Add Merch CF Volume Defect: BO*
14. Enter the following parameters:
    - a. **Volume type affected**......................................Merchantable cubic
    - b. **Species**..*California black oak*
    - c. **Volume defect proportion for a 5-inch tree** *0.12*
    - d. **Volume defect proportion for a 10-inch tree**....*0.13*
    - e. **Volume defect proportion for a 15-inch tree**....*0.16*
    - f. **Volume defect proportion for a 20-inch tree**...*0.19*
    - g. **Volume defect proportion for a 25-inch tree** ...*0.21*
    - h. **Volume defect proportion for a 30-inch tree** ...*0.21*
    - i. **Volume defect proportion for a 35-inch tree**....*0.21*
    - j. **Volume defect proportion for a 40-inch tree**...*0.21*
    - k. Leave all other parameters set to the default values.
15. Click the **Save in run** button.
16. From the **Components** selection box, select *Add Volume Defect.*
17. Change the **Component title** to *Add Board Foot Defect: BO*
18. Enter the following parameters:
    - a. **Volume type affected**......................................*Board foot*
    - b. **Species**..California black oak
    - c. **Volume defect proportion for a 5-inch tree** *0.99*
    - d. **Volume defect proportion for a 10-inch tree**....*0.99*
    - e. **Volume defect proportion for a 15-inch tree**....*0.99*
    - f. **Volume defect proportion for a 20-inch tree**...*0.99*
    - g. **Volume defect proportion for a 25-inch tree** ...*0.99*
    - h. **Volume defect proportion for a 30-inch tree** ...*0.99*
    - i. **Volume defect proportion for a 35-inch tree**....*0.99*
    - j. **Volume defect proportion for a 40-inch tree**...*0.99*
    - k. Leave all other parameters set to the default values.
19. Click the **Save in run** button.

Selecting Outputs

20. Select the **Select Outputs** tab.
21. Add a check in the **Tree lists** box.

Running the simulation

22. Select the ***Run*** tab.
23. Change the management identification code (**MgmtID**) to *dDEF.*

24. Click the **Save and Run** button.

FVS will save the simulation as *Adjust 5* with a management identification code of *dDEF*

Examining the adjustment effects

From the **Run** tab window, you will not see the effects of the modifier on volume increment. Notice that since you changed the defect in both replicates, the output is the same for each replicate.

Use the **View Outputs > Load/Explore** to explore the summary output for the *Adjust 4* and *Adjust 5* runs. Using the **Graphs** tab, create a side-by-side comparison of volume for the two runs. Set the **horizontal facet** to *StandID* and the **Plot-by code** to *MgmtID*. Look at both merchantable and board foot only volumes. Did the defect have the same effect on the runs?

Repeat the steps above with the carbon output. Did the results change as volume did?

Adjust 6: Skills challenge

Create a keyword component collection that contains the potential fire conditions (*Adjust 2*), fuel model selection process (*Adjust 3b*), and Jenkins' carbon calculation methods (*Adjust 4*). Add all the ponderosa pine stands from the Lassen National Forest into a simulation and determine the impacts of a severe fire in 2031 on carbon stocks over the next 80 years. Create and implement a prescription designed to reduce carbon losses in the severe fire. Create a document that showcases the effects of managing for this possible event.