

## Appendix A

A list and description of harvesting methods available for cost modeling in FIA BioSum.

### Low Slope Harvests:

#### Cable CTL

With a cut-to-length (CTL) cable-yarding system, mechanized single-grip harvesters fell, limb, and buck the trees and bunch the logs along predesignated yarding corridors and along harvester trails between corridors. A cable yarder transports the bunched logs to the landing (a standing skyline with motorized slackpulling carriage was the only machine for which data were available). Logs to be hauled in log form are loaded onto trucks, and logs to be chipped are processed through a disk chipper and blown into chip vans. The CTL system is applicable where the terrain is gentle enough and trees are small enough to allow the use of a harvester. It is not very common but shows promise for reducing the costs and residual stand damage associated with manual-felling log-length cable yarding. Cable-yarders do not have the log-length constraints of forwarders.

#### Ground-based CTL

With a ground-based cut-to-length system, mechanized single-grip harvesters fell, limb, and buck the trees at the stump and pile the logs at trailside. Logs are transported to the landing by forwarders. Logs to be hauled in log form are loaded onto log trucks, and logs to be chipped are processed through a disk chipper and blown into chip vans. Because of the forwarder's high center of gravity, the ground-based CTL system is limited to gentler slopes than are the other tractive systems, and at the upper limits of slope, to terrain that is fairly uniform rather than dissected. In addition, forwarder trails must run close to the fall line and must be laid out on a parallel, uniformly spaced network so the harvester can access the whole area. The physical constraints of the harvester and forwarder limit this system to trees under about 20 inches diameter at breast height (dbh). Mills that prefer logs longer than the forwarder can carry may pay less for short CTL logs. Forwarders carry rather than drag logs and can travel on mats of the tops and limbs left by harvesters. Managers may therefore prefer CTL systems when it is critical to leave residues onsite, minimize soil disturbance, begin operations earlier in the year and continue longer, and minimize aesthetic impact. Cut-to-length systems have safety advantages and can operate with small landings, but they are typically more expensive than mechanized-felling WT systems.

#### Ground-based Manual Log

With a ground-based manual-felling log-length system, trees are chainsaw-felled, limbed, and bucked into logs at the stump. Rubber-tired skidders (choker and grapple) collect the logs and transport them to the landing. Logs to be hauled in log form are loaded onto log trucks, and logs to be chipped for board products or fuel are processed through a disk chipper and blown into chip vans. A ground-based manual-felling log-length system is normally used where trees are large enough that they must be bucked into two or more pieces to remove them from the woods. It also may be used when managers wish to retain tops, limbs, and their associated nutrients on site.

#### Ground-based Manual WT

With a ground-based manual-felling Whole Tree system, trees are felled with chainsaws but not limbed or bucked. Rubber-tired skidders (choker and grapple) collect and transport whole trees. Trees are chipped or processed mechanically with stroke or single-grip processors and loaded onto trucks. A ground-based manual-felling WT system would typically be used for smaller trees than would the manual-felling log-length method and where feller bunchers are unavailable or when managers wish to confine machine traffic to a sparse network of skid trails. It often will be the most economical system where few trees per acre are to be removed. It is appropriate where managers wish to remove residues from the site to reduce fuel loading.

#### Ground-based Mechanized WT

With a ground-based mechanized-felling Whole Tree system, trees are felled and bunched; drive-to-tree machines are assumed for flat ground, whereas swing-boom and self-leveling versions are included for steeper terrain. Rubber-tired grapple skidders transport bunches to the landing. Trees are chipped or processed mechanically with stroke or single-grip processors and loaded onto trucks. A ground-based mechanized –felling WT system is normally used when most or all of the trees to be removed are small enough to be handled by a feller buncher. It is useful where fuel loading is high because it removes tops and limbs from the stand. Because all operators are in machines, this system is safer than either of the manual-felling systems, where fallers and choker setters are exposed to the dangers of falling trees and rolling logs.

#### Helicopter CTL

With a cut-to-length helicopter-yarding system, a mechanical harvester fells, limbs, and bucks trees at the stump. Subsequent activities are the same as for the manual-felling log-length system. The CTL system is only applicable where terrain conditions allow access and operation of a mechanical harvester. If use of a harvester is possible, planners should consider carefully before using a helicopter for yarding rather than a much less costly forwarder.

### **Steep Slope Harvests:**

#### Cable Manual WT\Log

Cable-yarding typically is used on steeper terrain, and landings may not have enough space to accommodate a processor as well as a loader and chipper. In these situations a manual WT\log-length system may be appropriate for fuel reduction operations. Trees to be shipped can be felled and then yarded as whole trees, and those to be processed into sawlogs can be felled, limbed, and bucked prior to yarding. This combination reduces the amount of tops and limbs added to surface fuels as compared to using a log-length system exclusively, but removes less fuel than would the pure WT system.

#### Cable Manual WT

With a manual-felling whole tree cable-yarding system, trees are felled with chainsaws, but are not limbed or bucked (trees too large to be yarded in one piece or too large to be mechanically processed at the landing are limbed and bucked in the woods). Cable-yarders transport the trees to the landing for chipping or mechanical processing and loading onto trucks. This system is appropriate where managers wish to remove residues from the site to reduce fuel loading.

#### Cable Manual Log

With a manual-felling log-length cable-yarding system, trees are chainsaw-felled, limbed and bucked at the stump. Cable-yarders transport the logs to the landing. Logs to be hauled in log form are loaded onto trucks, and logs to be chipped are processed through a disk chipper and blown into chip vans. Manual felling is the most common means of preparing trees for yarding because it can be used on essentially any type of terrain.

#### Helicopter Manual WT

Because helicopters are generally used on steeper terrain, the most common helicopter system (manual-felling log-length) uses chainsaws to fell, limb, and buck trees at the stump. The helicopters then transport the logs out of the stand. Large landings are required because of the high production rates of helicopters and to provide adequate space for safe operation of equipment outside the load drop zone. Because large landings are typically few and far between, yarding distances for helicopters are generally longer than they would be for ground-based or cable operations. Logs to be hauled in log form are loaded onto trucks, and those to be chipped are processed through a disk chipper and blown into chip vans.

## Appendix B

### Using FIA Diameter Increment Data to Calibrate Basal Area Growth in FVS

The large-tree diameter increment models embedded within FVS that are relied on by FVS projections to estimate basal area growth are based on the best available data that is generally representative of growing conditions for forests within a variant's geographic extent. However, local variation in environmental factors (e.g., soils, microclimate, understory vegetation, moisture availability) can result in local departures from what these increment models predict. When periodic increment data is available to FVS, it can be used to scale the basal area growth projections to reflect local deviations from the regional growth trends represented in the models (Dixon 2013, Section 6.5.2.1).

FIA data typically contains at least one tree record with **radial** increment data derived via tree coring, per species, per crown class, per FIA condition. In addition, on plots that have been remeasured (for example 30 percent of the plots in OR and CA as of this writing), it is possible to calculate **diameter** increment as the difference between the current and previously recorded diameters. Neither of these kinds of data are readily available in FIADB. However, working with an FIA analyst, these can be obtained.

By default, FVS requires a minimum of five observations per species. However this minimum is a parameter that can be changed using the CALBSTAT keyword. If relying on core data, it will almost certainly have to be changed because FIA plot data typically contains fewer observations than this default value. For the large tree diameter growth model trees are considered "large" for modeling purposes when they are above a threshold diameter. . This is usually 3.0 inches dbh but check section 4.7, Large Tree Growth Relationships in the variant overview documentation for the variant you are using to see what this threshold is. With some variants, such as Blue Mountains, it is 3.0 inches dbh for all species, whereas with the Inland Empire and Eastern Montana variants, it is 3.0 inches dbh for all conifer species (except juniper which is only considered in the small tree height growth model) and 1.0 inches dbh for cottonwoods and other hardwoods. With other variants, such as Central States and Lake States, this threshold between the large tree and the small tree growth models is 5 inches dbh.

To take advantage of calibration, FVS needs actual measurements of diameter growth from at least some of the trees to be projected. A common method is using an increment core to get 10 year radial growth, but there are other methods such as subsequent re-measurements, as noted above. The user needs to specify the method used with the GROWTH keyword. For a full description of this keyword and its parameters, which include the other methods that can be used see Van Dyck and Smith-Mateja 2000, which can be accessed at: <http://www.fs.fed.us/fmssc/ftp/fvs/docs/qtr/keyword.pdf>. Another option for telling FVS what method was used is the DG\_Trans (diameter growth translation code) field in the FVS\_StandInit table in DB\_FVS. For these codes and descriptions of other fields in this and other tables please see Crookston and others (2003).

The diameter increment scale factor, calculated by FVS from the increment data provided, is used as a multiplier that adjusts the FVS predicted change in squared diameter (which relates to basal area increment, Dixon 2013). After running the key file, look in the calibration statistics section in the output (.out) file. Essential FVS (Dixon 2013), page 74, shows the calibration statistics section from an example main output file. Scale factors outside the range 0.5 to 2.0 should arouse concern, as they are indicative of potential problems in the increment data. For each species, an initial scale factor is given. If diameter growth is not in the tree input file, this value will be 1.0.

### **Inputting growth data into FVS**

Periodic diameter growth is entered in the input tree records, which FVS expects to be in inches of diameter growth (to the nearest tenth of an inch). Therefore, if your data is from an increment core (radial growth), multiply it by 2 to convert radius to diameter. Make sure you know what units the growth data are in and make the conversion. For example, FIA diameter growth is radial growth in 1/20<sup>th</sup> inches. Dividing this by 10 gets you diameter growth.

If you are using text files (e.g. .fvs tree files) there is an implied decimal on the last digit. For example, if it is 4.0 inches, enter 40 in the appropriate column. For a full description of periodic diameter growth see page of 56 in Dixon 2013; for how to format tree input tree records see pages 61-62. If you are using the database extension, however, you may enter 4.0 or 4 and FVS will interpret it as 4 inches.

Increment data can still be useful even when there are insufficient numbers of observations per plot to calibrate. When this is the case, use the Calibration Statistics post processor, which grabs all the scale factors from all stands in a simulation and computes an average multiplier that you then can add with the READCorD keyword. For more detailed information on this keyword please see page 56 of Van Dyck and Smith-Mateja (2000) and the chapter 'FVS Self-Calibration' on page 294 of Vandendriesche (2010). For more information on using scale factors as multipliers see pages 151-152, the section 'How to Determine Multiplier Values, of Essential FVS (Dixon 2013). This is the method to use to get better results for those species that don't have enough growth measurements (Chad Keyser, personal communication).

### **Further reading**

Crookston, Nicholas L.; Gammel, Dennis L.; Rebain, Stephanie; Robinson, Donald; Keyser, Chad E. 2003 (revised April 2014). Users guide to the Database Extension of the Forest Vegetation Simulator Version 2.0. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 57p.

<http://www.fs.fed.us/fmfc/ftp/fvs/docs/gtr/DBSUserGuide.pdf>

Dixon, Gary E. 2002 (revised 2014). Essential FVS: A user's guide to the Forest Vegetation Simulator. USDA Forest Service, Forest Management Service Center. Fort Collins, CO. 244 p. <http://www.fs.fed.us/fmfc/ftp/fvs/docs/gtr/EssentialFVS.pdf>

Van Dyck, Michael G. and Smith-Mateja, Erin E. 2000 (revised 2014). Keyword Reference Guide for the Forest Vegetation Simulator. USDA Forest Service, Forest Management Service Center. Fort Collins, CO. 119 p. <http://www.fs.fed.us/fmfc/ftp/fvs/docs/gtr/keyword.pdf>

Vandendriesche, Don. 2010. FVS out of the box-assembly required. In Jain, Theresa B.; Graham, Russell T.; and Sandquist, Jonathan, tech. eds. 2010. Integrated management of carbon sequestration and biomass utilization opportunities in a changing climate: Proceedings of the 2009 National Silviculture Workshop; 2009 June 15-18; Boise, ID. Proceedings RMRS-P-61. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 351 p. [http://www.fs.fed.us/rm/pubs/rmrs\\_p061/rmrs\\_p061\\_289\\_306.pdf](http://www.fs.fed.us/rm/pubs/rmrs_p061/rmrs_p061_289_306.pdf)

## Appendix C

### Regeneration

Accounting for regeneration in FVS growth projections is imperative to output validity. Currently, the only areas for which FVS provides a “full” establishment model are western Montana, central and northern Idaho, and coastal Alaska. The remaining states are equipped with only a “partial” establishment model, meaning that only regeneration from planting or stump sprouting is included in the growth projections (Vanendriesche 2010). For these areas, an understory estimation procedure has been developed to import seedling/sapling recruitment (Vanendriesche 2009). The Repute application has been archived and is not currently supported by FVS staff, but can still be downloaded from the software archive page: <http://www.fs.fed.us/fmsc/fvs/software/archive.php>

Before starting the regeneration process in Repute, it is recommended that users convert the FVS text files created by BioSum into an Access database. This can be done using the Predispose application found on the same software archive webpage: <http://www.fs.fed.us/fmsc/fvs/software/archive.php>. To be compatible with BioSum, the SCRIPT\_VB\_PREDISPOSE\_FIXTREEID.txt script found in the project/fvs/scripts folder needs to be run on the Predispose database. Instructions for that process are found within the script. Once the text files are converted into a database and the FIXTREEID script run, stands can be subdivided into groups that have a similar species composition.

### Simulating Regeneration using Repute

#### Step – I: Initialization in Suppose

1. Select stands that belong to a forest type. This can be accomplished by selecting a group created within the Predispose database, if applicable. If all stands in the input database are the same forest type, add all stands.

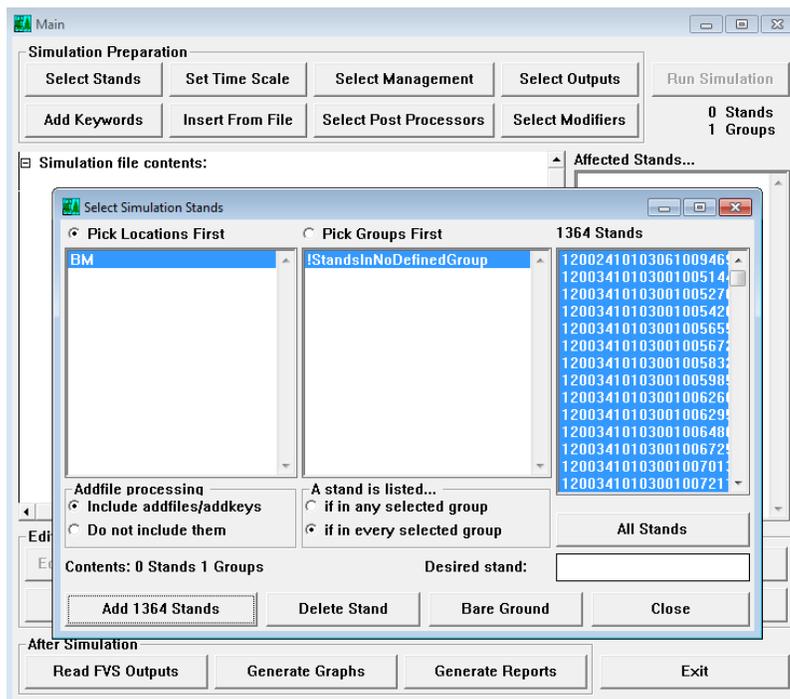


Figure 9.1 – Add stands to FVS simulation

2. Set:
  - Inventory Year to 2011 (**INVYEAR**)
  - Number of Cycles to 1 (**NUMCYCLE**)
  - Set time Interval to 0 for all time cycles and projection cycle length to 10 (**TIMEINT**)
3. Click the **<Select Output>** button. Under Base FVS Treelists, choose to '**Build FVS Stand Alone Tree list for Inventory year**'

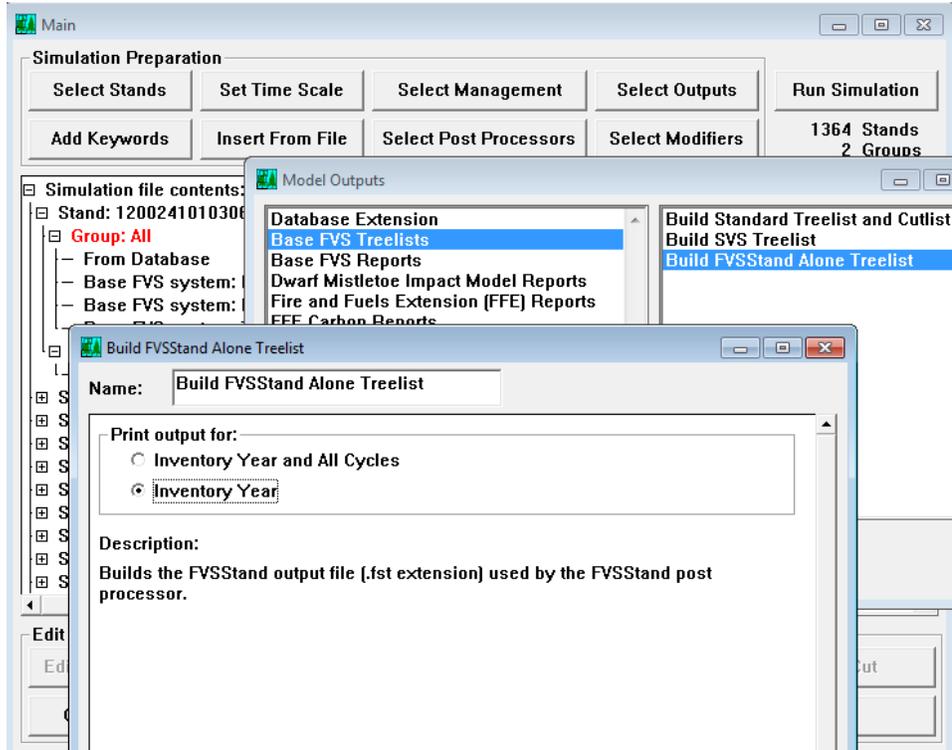


Figure 9.2 – In model outputs, select Build FVSSStand Alone Treelist

4. Under Base FVS Reports, delete all the tables except 'Delete the summary statistics table'.

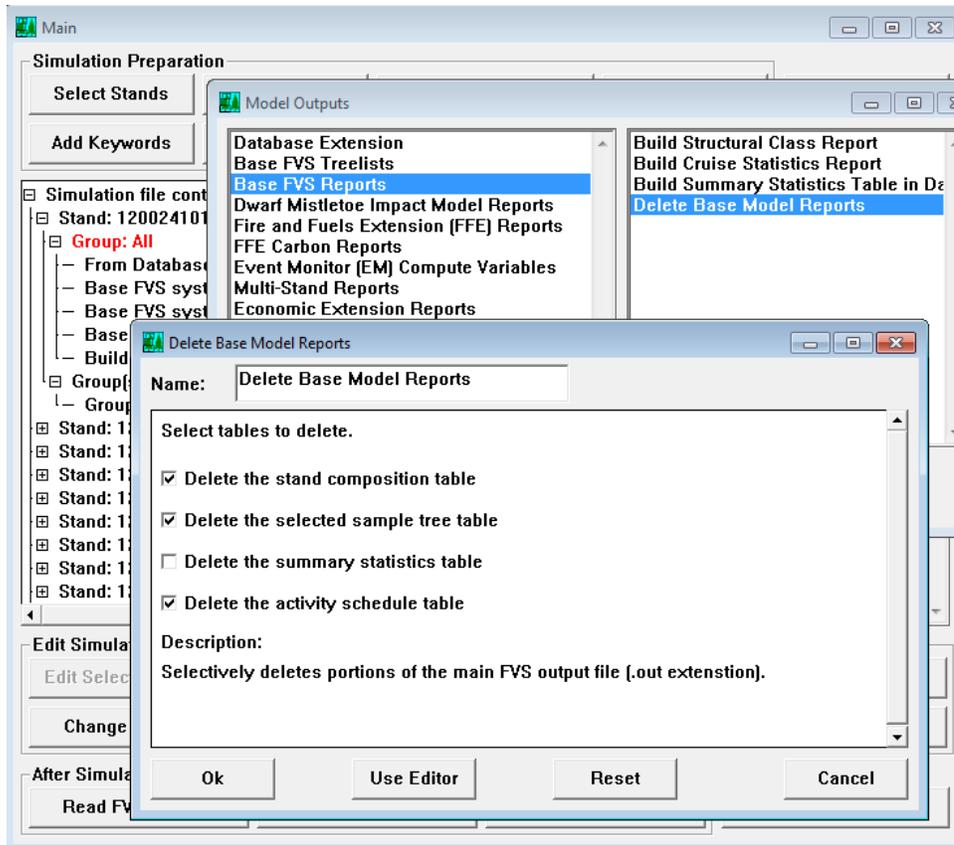


Figure 9.3 – Delete all reports except summary statistics table

5. Click the <Select Post Processors> button, and choose to include **Add FVStand Alone: Generate Dynamic Yield Reports.**

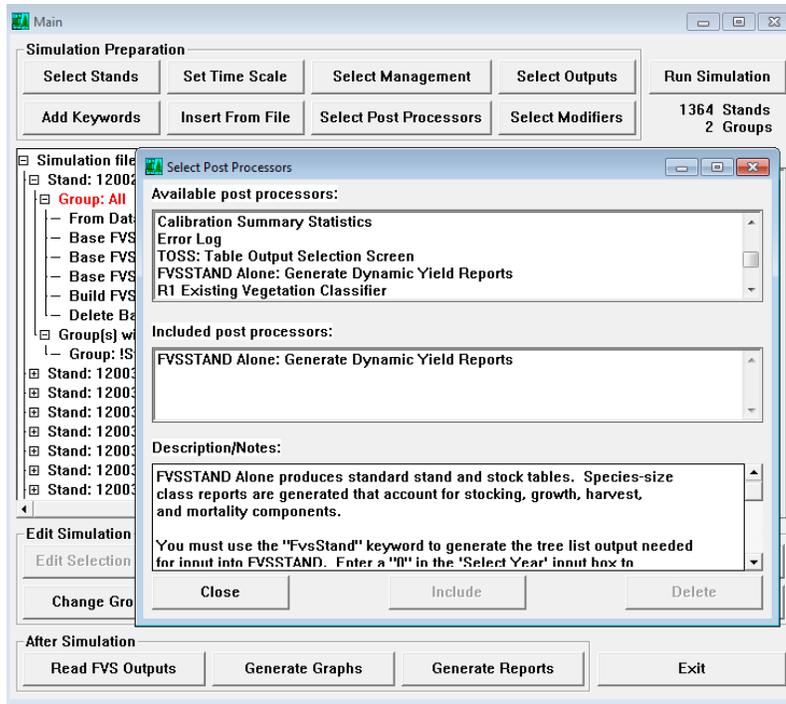


Figure 9.4 – Add the FVSStand Alone post processor

6. Save the FVS key file. (This is the first of a few Repute key files, so something similar to 'variant\_REPUTE1.key' would be appropriate.)
7. Run simulation.

```

C:\windows\system32\cmd.exe

START OF SIMULATION PERIOD      REMOVALS/ACRE      AFTER TREATMENT      GROWTH
YEAR  TREES /ACRE  BA  SDI  TOP  HT  QMD  TOTAL TREES  TOTAL MERCH  CU FT  BA  SDI  TOP  HT  QMD  PER YR  CU FT
1     0     0     0     0  0.0  0     0     0     0     0     0     0  0.0  0     0     0
11    0     0     0     0  0.0  0     0     0     0     0     0     0  0.0  0     0     0

BM FVS VARIANT  --  RU:06/26/15

STAND = 1200341050406300724690001  MANAGEMENT CODE = NONE
Stand 1200341050406300724690001 at BM

SUMMARY STATISTICS <BASED ON TOTAL STAND AREA>

START OF SIMULATION PERIOD      REMOVALS/ACRE      AFTER TREATMENT      GROWTH
YEAR  TREES /ACRE  BA  SDI  TOP  HT  QMD  TOTAL TREES  TOTAL MERCH  CU FT  BA  SDI  TOP  HT  QMD  PER YR  CU FT
1     40    50    78  73 15.1 1672  0     0     0  50  78  73 15.1 27 16
11    36    50    77  81 15.9 1782  0     0     0  50  77  81 15.9  0  0
  
```

Figure 9.5 – Stands running through FVS via cmd.exe

8. When the FVS simulation completes, the FVSSTAND Alone Wizard will pop up. In the window titled Step 2 of 3, simply click <Next>, no changes are needed.
9. In the next step, under Vegetation Classification, verify that the correct USFS Region is selected. Then click <Finish>.

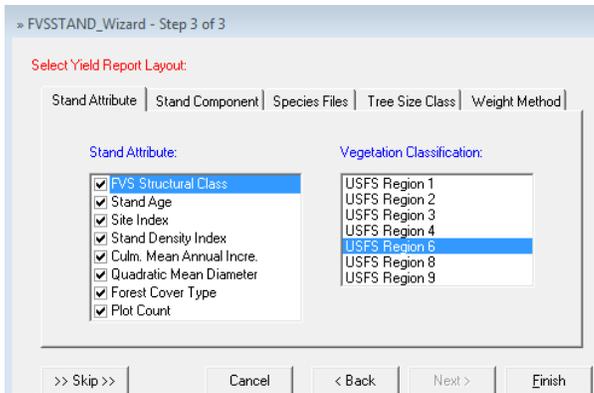


Figure 9.6 – Select the correct USFS Region for the variant.

10. After FVSStand is finished running, a window will appear saying that the process is complete. Click **<OK>**.
11. Close the next two windows.

### Step – II: Prepare and configure Repute

1. Open Repute, found in the Start Menu under the FVS heading.
2. In the Configuration tab, select the correct variant.
3. In the Species Group tab, make species groups by including major species. For example, groups can be made by including each species that contributes at least 1% of the total tree count. It is necessary to create at least two groups, a DEFAULT group that contains “Other Softwood” and “Other Hardwood”, and another group that contains the remaining species.

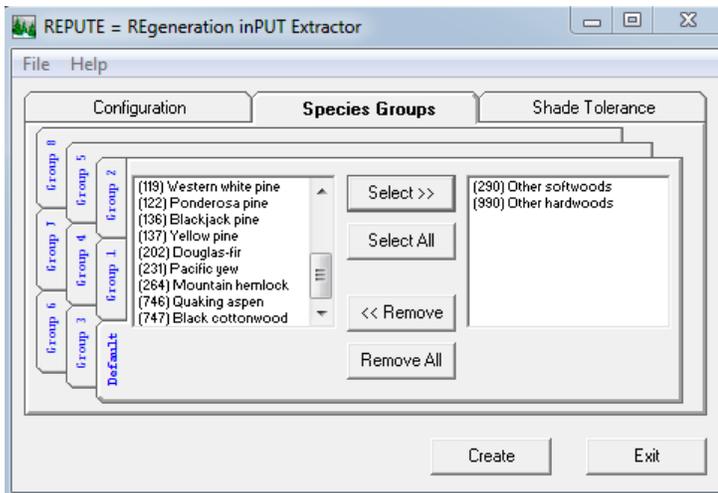


Figure 9.7 – Create species groups in Repute.

4. Upon saving the configuration by selecting **<Save Setup>**, invoke **<Compute Addfile>** from File menu.
5. In the subsequent prompt, select the .PT1 file created in step 1. This file can be found in the \fvs\data\WS\Fvsstand\Prt folder, and will have the same name as the Repute key file created in step 1. Click **<Open>**.

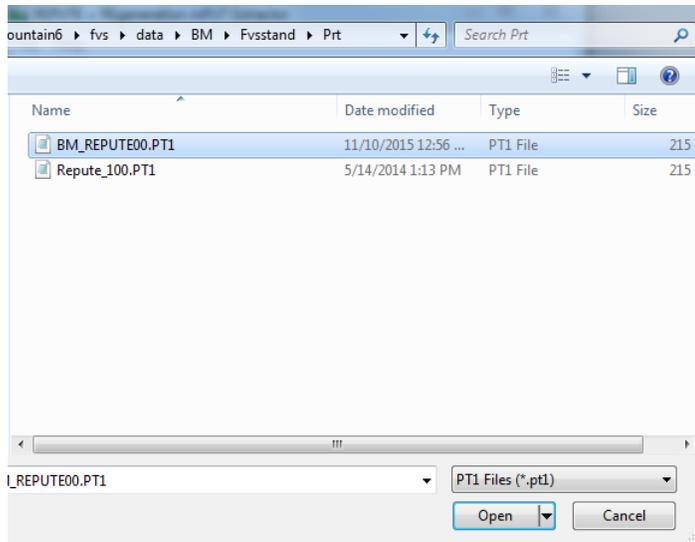


Figure 9.8 – Navigate to the .PT1 file created in Step 1.

6. <Exit> from Repute.
7. The file Cmp\_Repute.kcp is now created inside /fvs/data/variant/Fvsstand/Repute folder. Copy this file to the FVS root folder in the BioSum project. Rename if necessary. For example, *variant\_cmp\_repute.kcp*

### Step – III: Generate data in FVS Suppose using configuration from Repute

1. Use the same configuration in Suppose as in Step I
2. Insert the Cmp\_Repute.kcp file created in Step II – 5, using the <Insert From File> button.
3. Remove **FVSStand alone** from Post Processors, add **Compute – Table of Compute Variables**.

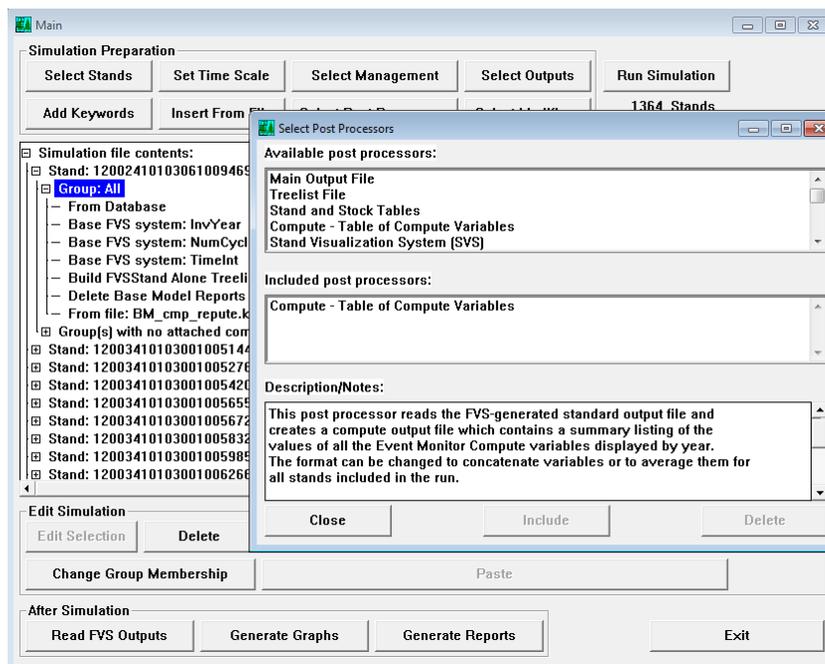


Figure 9.9 – Add the Compute post processor.

4. Save configuration to a new key file, for example *variant\_REPUTE2.key*.

- Run the simulation.
- After the simulation completes, the table of computed variables will pop up. To be compatible with Repute, the table must be saved in concatenated, comma delimited format. To do this selected the **Concatenated**, and **Comma Delimited Table** Format icons from the top toolbar.

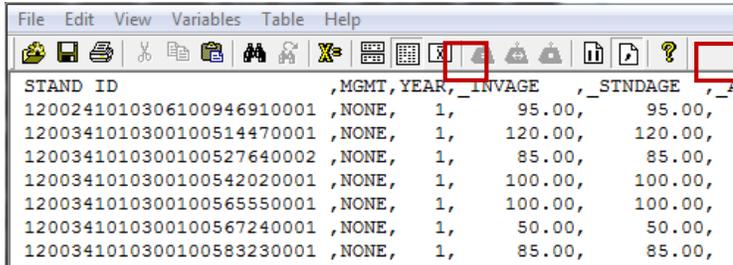


Figure 9.10 – Save the compute table in concatenated, comma delimited format.

- Save the file with a .csv file extension in the */fvs/data/variant/FVSSStand/Prt* folder.

#### Step – IV: Prepare regeneration file in Repute

- Open Repute. Use the text boxes to modify diameter ranges for seedlings or saplings. Specifying a Maximum Diameter of 1” is recommended, see next section for more details.

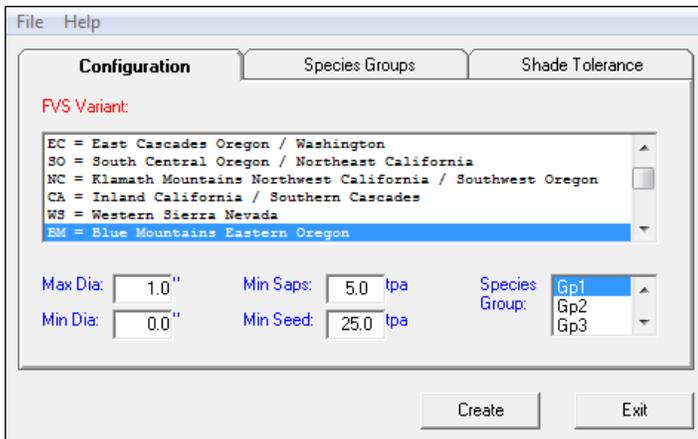


Figure 9.11 – Specify diameter ranges for seedlings and saplings.

- Select species group and click **<Create>** from configuration tab.
- Supply \*.prt file and \*.csv files, found in the */fvs/data/variant/FVSSStand/Prt* folder when prompted.
- After Repute is finished, a pop up window will appear. Select **<OK>**.
- Enter the a file name for the .kcp file when prompted. For example, *variant\_REPUTE\_FINAL.kcp*. Make a copy of the file and save it to the *fvs/data/variant* folder.

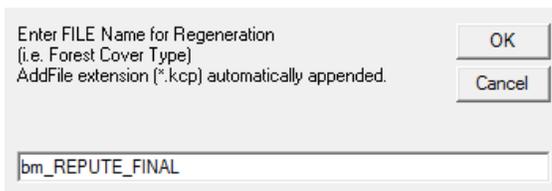


Figure 9.12 – Save the kcp file for use in rxpackage simulations

- When running the FVS simulations for the BioSum analysis, add the .kcp file created in the previous step to all projections.

Repeat Step I – IV above for other forest types and for each variant.

## Recommended Modifications for Greater Realism in Regeneration Estimates

### Issue Description

BioSum analyses in 2014 that relied on Repute to model regeneration following treatment implementation have caused FVS to generate large numbers of relatively large saplings and seedlings, early in the stand projections following treatment. It was surmised that this resulted in considerable ladder fuels that led to post-treatment estimates of torching probability that defied credibility and rendered most treatments entirely ineffective by the hazard metrics typically relied upon. Moreover, Repute was generating seedlings of many more tree species than are present in the overstory of any given plot, which could introduce errors in terms of the representation of ladder fuel development, not to mention stand composition (and its growth and value when harvested) when modeled a few decades out. Identified here are some strategies that help to resolve the issue.

- Problem:** Repute is adding saplings that are suspiciously large.

#### Solution:

- Don't allow Repute to generate KCP code that induces the production of saplings. In the Repute user interface, specify a Max Diameter of "1.0". If the default of 3" is used, two sets of NATURAL keywords are created, one set generating saplings and another generating seedlings.

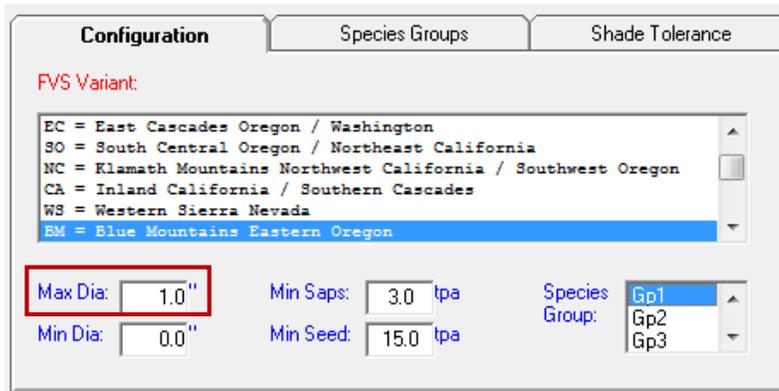


Figure 9.13 – Change max diameter to 1" to avoid the creation of saplings.

- Problem:** Repute is adding seedlings that are suspiciously large.

#### Solution:

- In the Repute generated .kcp file, delete the "average height of seedlings at five years" parameter in **each** statement that begins with a "NATURAL" keyword. Experimentation has demonstrated that leaving this value blank induces FVS to use species-specific formulas to create what appear to be more appropriately sized seedlings.

```
Natural          2  ParmS(GF, &
Max((855.351-SpMcDBH(1,GF,0,0,1,0,999,0)),0)* &
LinInt(SpMcDBH(11,ALL,0,0.2,200,1,500,0),BSDIMAX*0.55,BSDIMAX*1.00,1,0)*
&
```

```

LinInt(SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0
),1), &
0.00,0.02,0.02,0.05,0.05,1.99,0.40,0.40,0.80,0.80,1.00,1.00), &
100.00, 0.00, 17.0, 0)

```



```

Natural          2      Parns(GF, &
Max((855.351-SpMcDBH(1,GF,0,0,1,0,999,0)),0)* &
LinInt(SpMcDBH(11,ALL,0,0.2,200,1,500,0),BSDIMAX*0.55,BSDIMAX*1.00,1,0)*
&
LinInt(SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0
),1), &
0.00,0.02,0.02,0.05,0.05,1.99,0.40,0.40,0.80,0.80,1.00,1.00), &
100.00, 0.00)

```

3. **Problem:** Seedlings are not being added at the correct time in the growth simulation.

**Solution:**

- To add seedlings in each of the two decades following a thinning, modify the event monitor IF-THEN statement within the Repute generated .kcp file. Note: The default Repute .kcp file has only one IF-THEN statement and set of NATURAL keywords, the revised method requires two IF-THEN statements and two sets of NATURAL keywords (see Figure 9.11).
- To specify at what point after a thinning seedlings are to be added, modify the year/cycle parameter within each NATURAL keyword. The example below adds seedlings in year 10 and year 20 **when using the BioSum cycle break pattern of 1-8-1-1-8-1-1-8-1-1-9**. If using a standard 10-10-10-10 cycle break pattern, use parameter values of 1 and 10 (instead of 2 and 12).

```

If          0
SpMcDBH(1,ALL,0,0,1,0,999,0) LE _SEED AND &
SpMcDBH(11,ALL,0,1.0,200,1.0,500,0) LE BSDIMAX*0.85 AND &
(_RGN EQ 1 OR _RgnSt LE 1) AND _RgnSt NE 12 AND _CANOPY LT 3 AND EVPHASE
EQ 2
Then
Estab
Natural          0      Parns(DF, ....)
Natural          0      Parns(LP, ....)
End

```



```

IF          0
CUT EQ 1
Then
Natural          3      Parns(DF, ....)
Natural          3      Parns(LP, ....)
End

IF          0
CUT EQ 1

```

```

Then
Natural          13      Parns(DF, ...)
Natural          13      Parns(LP, ...)
End

```

4. **Problem:** Species not currently found in a stand are being added as seedlings.

**Solution:**

- a. Consider binning stands into smaller, more homogenous groups, and creating a REPUTE .kcp file for each group.
- b. If a (above) is not practical, or does not substantially remediate the issue, make a slight modification to the “TPA” parameter of **each** NATURAL keyword. By changing a single value within the last Linear Interpolation statement of the “TPA” parameter from “.40” to “.00”, no species will be added to the stand as seedlings unless that species is already present in the tree list at the time of evaluation.

```

Natural          2      Parns(GF, &
Max((855.351-SpMcDBH(1,GF,0,0,1,0,999,0)),0)* &
LinInt(SpMcDBH(11,ALL,0,0.2,200,1,500,0),BSDIMAX*0.55,BSDIMAX*1.00,1,0)*
&
LinInt(SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0
),1), &
0.00,0.02,0.02,0.05,0.05,1.99,0.40,0.40,0.80,0.80,1.00,1.00), &
100.00, 0.00)

```



```

Natural          2      Parns(GF, &
Max((855.351-SpMcDBH(1,GF,0,0,1,0,999,0)),0)* &
LinInt(SpMcDBH(11,ALL,0,0.2,200,1,500,0),BSDIMAX*0.55,BSDIMAX*1.00,1,0)*
&
LinInt(SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0
),1), &
0.00,0.02,0.02,0.05,0.05,1.99,0.00,0.40,0.80,0.80,1.00,1.00), &
100.00, 0.00)

```

For a more in-depth exploration of the NATURAL keywords created by REPUTE, including the complex “TPA” parameter, see below.

\*\*\*\*\*

**Example REPUTE generated NATURAL keyword:**

```

Natural          0      Parns(GF, &
Max((855.351-SpMcDBH(1,GF,0,0,1,0,999,0)),0)* &
LinInt(SpMcDBH(11,ALL,0,0.2,200,1,500,0),BSDIMAX*0.55,BSDIMAX*1.00,1,0)*
&

```

```

LinInt(SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0
),1), &
0.00,0.02,0.02,0.05,0.05,1.99,0.40,0.40,0.80,0.80,1.00,1.00), &
100.00, 0.00, 17.0, 0)

```

**Parameters Defined:**

**NATURAL** (NATURAL regeneration)

Regeneration Establishment Extension

Variants: All

Related keywords: PLANT

Specifies natural regeneration that will be added to the stand.

**field 1:** Year or cycle of regeneration. An entry is required, and must be equal to, or greater than, the disturbance date specified on the ESTAB keyword.

0

**field 2:** Species code for trees to be naturally regenerated. Entry required

GF – Grand fir

**field 3:** Number of trees per acre of the species designated in field 2 to be regenerated.

Default = 0

```

Max((855.351-SpMcDBH(1,GF,0,0,1,0,999,0)),0)*
LinInt(SpMcDBH(11,ALL,0,0.2,200,1,500,0),BSDIMAX*0.55,BSDIMAX*1.00,1,0)*
LinInt(SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0),1)
0.00,0.02,0.02,0.05,0.05,1.99,0.40,0.40,0.80,0.80,1.00,1.00)

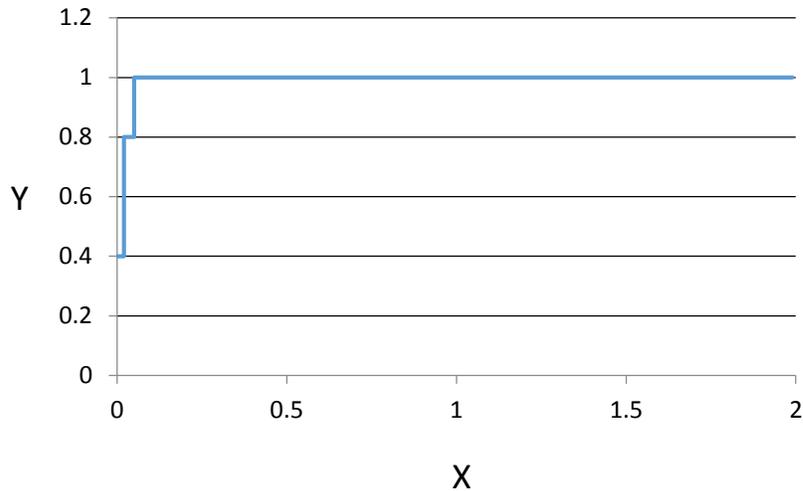
```

This one requires a bit more breakdown. Let's take it line by line.

- I.  $\text{Max}((855.351 - \text{SpMcDBH}(1, \text{GF}, 0, 0, 1, 0, 999, 0)), 0)$  – The TPA of all GF seedlings currently in the stand subtracted from the maximum number of seedlings that could be added to the stand.  
*855.351 (a species specific value generated by REPUTE based on the seedling counts in the supplied FVStandAlone table. This is the maximum TPA that will be added.) minus SpMcDBH(1,GF,0,0,1,0,999,0), the TPA of all Grand fir seedlings currently in the stand.*
- II.  $\text{LinInt}(\text{SpMcDBH}(11, \text{ALL}, 0, 0.2, 200, 1, 500, 0), \text{BSDIMAX} * 0.55, \text{BSDIMAX} * 1.00, 1, 0)$  – the Stand Density Index (SDI) of all non-seedling trees, as a proportion of maximum SDI.  
*LinInt (a linear interpolation) of SpMcDBH(11,ALL,0,0.2,200,1,500,0) the SDI of all trees with a DBH greater than or equal to .2, with BSDIMAX\*0.55 55% of maximum SDI being x1, BSDIMAX\*1.00 maximum SDI being x2, 1 being y1, and 0 being y2.*
- III.  $\text{LinInt}(\text{SpMcDBH}(2, \text{GF}, 0, 3.0, 99, 0, 999, 0) / \text{Max}(\text{SpMcDBH}(2, \text{All}, 0, 3.0, 99, 0, 999, 0), 1))$

0.00,0.02,0.02,0.05,0.05,1.99,0.40,0.40,0.80,0.80,1.00,1.00) - the percentage of all trees with a DBH > 3.0 that are Grand fir, as represented by a non-linear proportional value.

LinInt (a linear interpolation) of SpMcDBH(2,GF,0,3.0,99,0,999,0)/Max(SpMcDBH(2,All,0,3.0,99,0,999,0),1 the percentage of all trees with a DBH > 3.0 that are Grand fir, with x1=0, x2=.02, x3=.02, x4=.05, x5=.05, x6=1.99, y1=.40 (or .00 if you end up changing it to prevent new species from appearing as seedlings), y2=.40, y3=.80, y4=.80, y5=1, and y6=1.



- IV. Put it all together... the TPA parameter is equal to:  
 The TPA of all GF seedlings currently in the stand, subtracted from the maximum number of seedlings that could be added to the stand, multiplied by the Stand Density Index(SDI) of all non-seedling trees as a proportion of maximum SDI (scaled between 1 and 0 over the range 55% to 100% of Before Treatment Maximum Stand Density Index, and then multiplied by the percentage of all trees with a DBH > 3.0 that are Grand fir, as represented by a non-linear proportional value.

**field 4:** Percent survival expected for this species at the end of the current cycle—if inserted at year 2, for example, and it is a 9 year cycle, then this represents survival at the end of year 10.

Range: 0-100, Default = 100

100.00

**field 5:** Average seedling age in years for the year specified in field 1. Default = 2

0.00

**field 6:** Average seedling height in feet five years from the time of seedling appearance or at the end of the cycle, whichever is earlier.

17.0 - optional parameter, leave blank to let FVS determine seedling height.

**field 7:** Shade code. Default = 0

0 Seedlings occur uniformly on plots throughout the stand, irrespective of overstory.

- 1 Seedlings occur more frequently on plots with more overstory basal area.
- 2 Seedlings occur more frequently on plots with less overstory basal area.

0

### **Literature Cited**

GTR INT-279, User's Guide to the Regeneration Establishment Model..., p. 11

Essential FVS: A User's Guide to the Forest Vegetation Simulator, s. 5.4.3.1.211/20/2014

## Appendix D

### Sequence number definition in FVS module

Recommended sequence number assignments to force matching pre/post-year values between POTFIRE and SUMMARY tables.

- For use when FFE variables are of interest. Integrates POTFIRE Base Year values with records in rxpackage specific outputs.
- FVS Suppose Version 2.04 or later
- Cycle pattern:

Timeint	1	1
Timeint	2	8
Timeint	3	1
Timeint	4	1
Timeint	5	8
Timeint	6	1
Timeint	7	1
Timeint	8	8
Timeint	9	1
Timeint	10	1
Timeint	11	9

NUMCYCLE 11

- Treatments applied in either cycle 1, 4, 7, or 10.

ID: 1      Table: FVS\_SUMMARY      Type: DEFAULT

	PRE-TREATMENT SEQNUM	POST-TREATMENT SEQNUM
Cycle 1	<input type="text" value="1"/>	<input type="text" value="2"/>
Cycle 2	<input type="text" value="4"/>	<input type="text" value="5"/>
Cycle 3	<input type="text" value="7"/>	<input type="text" value="8"/>
Cycle 4	<input type="text" value="10"/>	<input type="text" value="11"/>

Figure 10.1 – SUMMARY table SEQNUM assignments

**ID: 2**      **Table: FVS\_CUTLIST**      **Type: DEFAULT**

	PRE-TREATMENT SEQNUM	POST-TREATMENT SEQNUM
<b>Cycle 1</b>	1	Not Used
<b>Cycle 2</b>	4	Not Used
<b>Cycle 3</b>	7	Not Used
<b>Cycle 4</b>	10	Not Used

Figure 10.2 – CUTLIST table SEQNUM assignments

**ID: 3**      **Table: FVS\_STRCLASS**      **Type: DEFAULT**

	PRE-TREATMENT SEQNUM		POST-TREATMENT SEQNUM	
<b>Cycle 1</b>	1	0 = Before Tree Removal	2	0 = Before Tree Removal
<b>Cycle 2</b>	4	0 = Before Tree Removal	5	0 = Before Tree Removal
<b>Cycle 3</b>	7	0 = Before Tree Removal	8	0 = Before Tree Removal
<b>Cycle 4</b>	10	0 = Before Tree Removal	11	0 = Before Tree Removal

Figure 10.3 – STRCLASS table SEQNUM assignments

**ID: 4**      **Table: FVS\_POTFIRE**      **Type: DEFAULT**

	PRE-TREATMENT SEQNUM		POST-TREATMENT SEQNUM
<b>Cycle 1</b>	1	<input checked="" type="checkbox"/> Base Year	3
<b>Cycle 2</b>	4		6
<b>Cycle 3</b>	7		9
<b>Cycle 4</b>	10		12

Figure 10.4 – POTFIRE table SEQNUM assignments

SEQNUM table breakdown, for reference (pre and post):

POTFIRE SeqNum	SUMMARY SeqNum	Year	Cycle Length
Base Yr.			
2	1	1	1
3	2	2	8
4	3	9	1
5	4	10	1
6	5	11	8
7	6	19	1
8	7	20	1
9	8	21	8
10	9	29	1
11	10	30	1
12	11	31	8
13	12	39	1
14	13	40	

## Appendix E

### Fuel Reduction Cost Simulator (FRCS)

FRCS estimates a harvest cost in dollars per acre for each stand and package/treatment/cycle combination based on parameters calculated by the BioSum processor. Currently, FRCS processing occurs via macros and scripts within an MS Excel workbook (frcs.xls), a copy of which is placed in project\_name/processor/db when the BioSum project is first defined. In the event that it becomes corrupted, it can easily be replaced with the copy stored at C:\Program Files (x86)\FIA PNW Portland Forestry Sciences Lab\FIA BioSum\db (just copy it to the processor directory).

By opening this Excel workbook, the user can optionally change machine costs for the various types of machines used, select the use of move-in costs and set FRCS to calculate costs of collecting and chipping residues (rather than handling these outside the FRCS model as average per acre costs). These are the only changes that can 1) be made on this interface page and 2) influence model calculations; all other FRCS options that a user might select in the workbook interface will be overwritten by the parameters supplied by BioSum's Processor module. See "Users Guide for FRCS: Fuel Reduction Cost Simulator Software" for further information on the effect of these selections: [www.fs.fed.us/pnw/pubs/pnw\\_gtr668.pdf](http://www.fs.fed.us/pnw/pubs/pnw_gtr668.pdf).

For these optional parameter customizations to take effect during a Processor simulation, the Excel workbook file must be saved after making the desired edits and before starting the BioSum Processor.

Follow the steps outlined below only if you 1) wish to select cut type, change machine costs, or to include/exclude move-in costs or the costs of collecting and handling residues, or 2) you wish to empirically explore the assumptions, parameters or equations embedded within FRCS.

1. Click the **<Start FRCS>** button to load the FRCS.xls worksheet in Excel.
2. The entry form shown will be displayed. A prompt will ask whether you wish to format toolbars. If you do not receive this prompt, the FRCS file is not in a trusted location (hence macros are disabled) and you should change the trust center settings to include its location as trusted (File, Options, Trust Center, Trust Center Settings, Add new location, enter or navigate to the directory holding your BioSum project, and check the box labeled "subfolders of this location are also trusted", then click OK, click OK, then exit Excel, without saving changes, and start FRCS again). To explore the many worksheets within FRCS, answer NO to the toolbar formatting prompt. If seeking only to make modifications on the interface page, as outlined below, answer YES or NO (it will not matter).

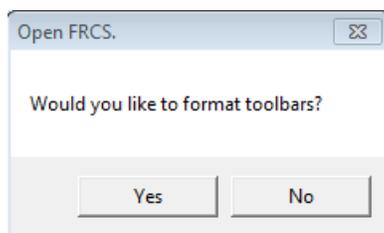
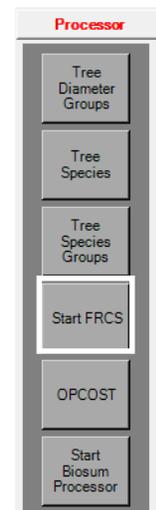


Figure 11.1 - Displayed when FRCS.xls is opened

3. **Cut Type** selection is found in the left pane of the data entry screen (see *Figure 11.2*). Select **<Partial Cut>** (default) or **<Clearcut>**. According to the User's guide for FRCS, some of the difference in cost between partial cutting and clearcutting for cable yarding systems may be anomalous. On average, the clearcutting studies are older than the partial cutting studies. Many of the clearcutting studies include equipment that is older, less efficient, and not commonly used today. The other values in the



configuration pane will be populated for each stand by BioSum's Processor module before the FRCS simulation begins.

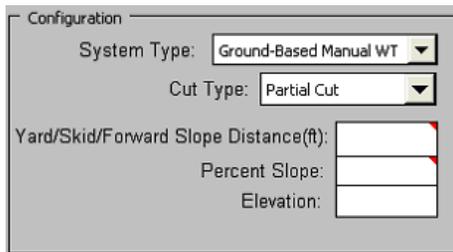


Figure 11.2 - Configuration pane. Select Cut Type here.

4. The center pane provides an opportunity to modify default machine costs and to choose whether or not to include move-in costs, for which parameters can be specified (see Figure 11.3). Note that these assignments are global (not specific to a given harvest system type, and unrelated to any values that happen to be currently displayed in the left pane).

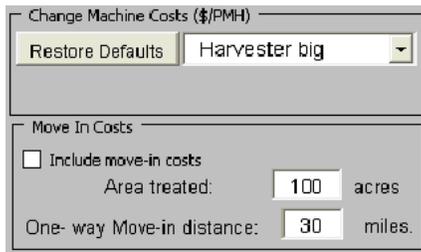


Figure 11.3 - Change Machine Costs and choose Move-In Cost handling in the middlepane.

The machine operating costs should include the full cost of ownership, labor, and fuel. The machine costs used by FRCS can be changed in order to more closely align the per-hour costs of equipment operation to locally prevailing costs. To change the default machine costs, select the machine that needs to be changed from the drop-down list under **Change Machine Costs** in the user interface. Once a piece of equipment has been selected, a text box will appear prompting the user to enter the new per-hour machine costs.

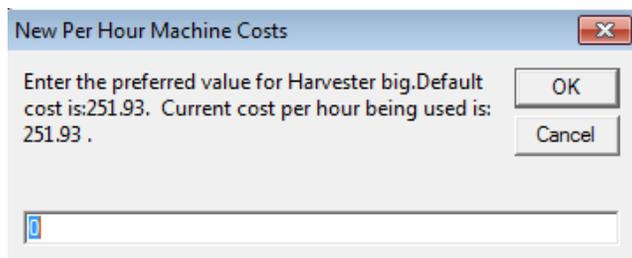


Figure 11.4 - Enter new Per-Hour Machine Costs.

The text box displays the current per-hour value and an entry field that can accept a revised value. If the value has already been changed from the default, and **<Cancel>** is selected (instead of entering a new, or the same value in the entry field), the value will revert to the default. The default machine costs for the various machines are shown in table 11.1.

Table 11.1 – FRCS default machine costs (dollars per machine hour)

Machine type	Cost (\$/PMH)
Bundler	207.42
Chainsaw	93.55
Chipper big	262.75
Chipper small	64.53
Fbuncher Drive To Tree	125.39
Fbuncher Self Leveling	284.42
Fbuncher Swing Boom	237.59
Forwarder big	216.84
Forwarder small	149.25
Harvester big	251.93
Harvester small	200.44
Loader big	191.78
Loader small	147.1
Processor big	282.7
Processor small	246.03
Skidder big	170.79
Skidder small	146.96
Yarder intermediate	328.18
Yarder small	233.25

5. Once a new value has been entered, it is retained by FRCS until the user either revises the cost or resets to the default costs by clicking **<Reset Defaults>**. Default Machine values were last revised by Han-sup Han in December 2010. The following example details the typical considerations that go into calculating cost per machine hour.
6. The section for entering move-in costs is shown at the bottom of *Figure 11.3*. To include the costs of moving equipment to the harvesting unit, check the box labeled **Include move-in costs**. Also enter the **Area treated** (in acres) and the **One-way Move-in distance** (in miles). A limitation of customizing move-in costs using this interface when performing a BioSum analysis is that given their dispersion over a large landscape, BioSum stands would likely have a broad range of move-in costs, and all the stands in a Processor generated batch will be represented as having the same move-in cost.
7. The top right panel labeled **Residue Handling** (*Figure 11.5*) is used to select whether to include the cost of collecting and chipping residues. Check the box to include these costs. This option is not available for some systems. For the three WT systems, the tops and limbs are transported to the landing as part of the tree. If this option is selected, a chipper will be included in the equipment configuration and the tops, limbs and small trees will be converted to dirty chips at the landing. This is accomplished at a small addition to overall cost because the tops and limbs are at the landing and only incur the added cost of chipping. The only other system for which this option is available is the ground-based CTL system. In this case, a bundler is used to gather up and bundle the tops and limbs that have been left in windrows by the CTL operation. These bundles will be transported to the landing on a forwarder for subsequent chipping. The cost of recovering and chipping CTL residues is considerably greater than for residues from a WT system.

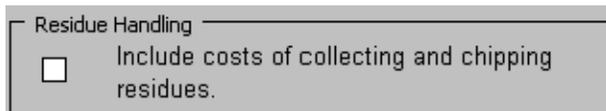


Figure 11.5 - Check to include costs of residue handling.

8. The section labeled **Tree Characteristics** as well as the **Yard/Skid/Forward Slope Distance(ft), Percent Slope, Elevation** in the **Configuration** section, and the **Cut Tree Table** information, will be supplied through the BioSum processor batch file. Once all changes have been entered, be sure to **<Close>** and **<Save>** FRCS.xls before continuing.

Note: For each harvest type, FRCS contains maximum value limits for several attributes including: slope, yarding distance, and tree volume. Current FRCS limits (as of 2013) for each harvest method are detailed in *Figure 10.6*. If any of the specified limits are exceeded a harvest cost per acre will not be calculated for that record.

Limit Category (Max.)	Ground-Based				Cable				Helicopter	
	Mech WT	CTL	Manual WT	Manual Log	Manual WT/Log	Manual WT	Manual Log	CTL	Manual Tree Length	CTL
LLT/ac	none	10	none	none	none	none	none	10	none	10
LLT as % of ALT	none	10	none	none	none	none	none	10	none	10
TreeVol, ft3: Chip	80	80	80	80	80	80	80	80	80	80
TreeVol, ft3: Small Log	80	80	80	0	0	80	0	80	0	80
TreeVol, ft3: Large Log	250	100	500	0	0	500	0	100	0	100
TreeVol, ft3: All Log	250	0	500	250	250	500	250	0	250	0
TreeVol, ft3: Avg Vol	250	0	500	250	250	500	250	0	250	0
Slope, %	40	40	40	40	100	100	100	40	100	40
Yarding distance, ft	none	none	none	none	1,300	1,300	1,300	1,300	10,000	10,000

Figure 11.6 – FRCS maximum value limits for each harvest method.