# Simulating Fire Hazard Reduction, Wood Flows, and Economics of Fuel Treatments with FVS, FEEMA, and FIA Data

**Glenn A. Christensen**
**Roger D. Fight**
**R. James Barbour**

**Abstract**—This paper demonstrates protocols to analyze and illustrate trends in the long-term effects of repeated fire hazard reduction entries at broad state-level scales. The objectives of this analysis are to determine the effectiveness of two stand treatment options designed to immediately reduce and maintain lower wildfire hazards. Long-term effects of fire hazard reduction are reported for and the stocking, size, and species mix of trees logs that might be removed for wood products. We developed methods that use readily available tools to provide this information and relate it to treatment effectiveness in reducing fire hazard over time. The scope of the project covers all forested areas of Montana and New Mexico. Analysis is based on data collected by the Forest Service's Forest Inventory and Analysis (FIA) program for both States, but other types of inventory data for smaller land areas also could be used. The primary tools for this analysis are FVS, the Fire and Fuels Extension (FFE) model, and the Financial Evaluation of Ecosystem Management Activities (FEEMA) model. Model output from more than 1,000 plots is summarized using macros written for Microsoft Excel, SAS statistical software, and Microsoft Access. These protocols can be used to simulate a variety of broad-scale management options using stand level data that are readily available. This information could be invaluable to evaluate future management options over a wide range of spatial and temporal scales.

Substantial funding has recently been allocated to understanding options for long-term fire suppression effects and hazard reduction options for the Intermountain West. One such study is, "Assessing the Need, Costs, and Potential Benefits of Prescribed Fire and Mechanical Treatments to Reduce Fire Hazard in Montana and New Mexico" (Barbour and others, unpublished paper). Some of the methods used for that study are described in this paper. The analysis is part of the Joint Fire Sciences Program to develop protocols for use in determining hazard reduction treatment needs, treatment cost, and associated benefits at a State level. The objectives of the study were to (1) quantify existing stand conditions for major forest types in terms of density, structure, and species composition, and prioritize by need for hazard reduction treatment, (2) develop and compare alternative cutting and prescribed burning prescriptions for reducing high-hazard conditions in major forest types, (3) determine treatment costs, (4) determine potential revenue from timber products generated from the hazard reduction harvest treatments, (5) compare the future mix of timber products under alternative treatment scenarios, and (6) describe the potential for analyzing noncommodity resources under treatment and no-treatment scenarios (Barbour and others, unpublished paper).

Our objective was to simulate broad-scale wildfire reduction options using readily available tools and stand-level data. This paper describes the tools and analytical approaches used. The scope of the analysis includes all forested lands in Montana and New Mexico. Our analysis determined and illustrated trends in the long-term effects of repeated hazard reduction entries: the long-term effects in terms of the stocking, size, and species mix of stands, and the long-term effects, in terms of size and species mix, of trees and logs that might be removed and utilized for wood products. We also wanted to accomplish this analysis using readily available models, software, and data typically collected as part of comprehensive forest inventories.

## Flow of Analysis

Analysis was based on data collected by the Forest Service's Forest Inventory and Analysis (FIA) program for both States, but other types of inventory data could also be used such as stand exam data. The primary tools for this analysis were the Forest Service's Forest Vegetation Simulator (FVS) growth and yield model (Stage 1973; Wykoff and others 1982), the FVS Fire and Fuels Extension (FFE) (Beukema and others 2000), and the Financial Evaluation of Ecosystem Management Activities (FEEMA) model (Fight and Chmelik 1998). To provide exact control of treatment execution and specific output variables, the Event Monitor (Crookston 1990) within FVS was used extensively. Microsoft Excel and Access were used to format, sort, and summarize data.

Our approach was to (1) extract the most recent forest inventory data, (2) apply a hazard reduction treatment using FVS, (3) use the FFE model to determine prefire and postfire hazard conditions for treated stands, (4) use a listing of removed trees from FVS as input to FEEMA (a customized version) to buck each tree into logs, calculate volume, and

In: Crookston, Nicholas L.; Havis, Robert N., comps. 2002. Second Forest Vegetation Simulator Conference; 2002 February 12–14; Fort Collins, CO. Proc. RMRS-P-25. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Glenn A. Christensen is a Forester (gchristensen@fs.fed.us), Forest Inventory and Analysis Program. Roger D. Fight is a Principle Economist (rfight@fs.fed.us), Human and Natural Resource Interactions Program. R. James Barbour is a Wood Scientist (jbarbour01@fs.fed.us), Focused Science Delivery Program. All are at the USDA Forest Service, Northwest Research Station, P.O. Box 3890, Portland, OR 97208.

assign a dollar value, (5) store results from FVS, FFE, and FEEMA in a database so that summary statistics for any variable may be easily generated for any variable and subtotaled by any desired classification, and (6) report these data via standardized, tabular formats (fig. 1).

The large size of the study area poses challenges in obtaining current inventory data for the entire area (for example, for all ownerships) and in getting these data into a useable format. Because several models are used, custom linkages between them are needed to build an integrated analytic system, and because hundreds, perhaps thousands, of plots may be processed, this linkage needs to be as automated and seamless as possible. After data from each plot completes simulation, results need to be calculated. In order for results to be based on any desired grouping or subset, output from each plot for each year, each treatment, and each tree needs to be tracked. Finally, all of this information has to be distilled into a meaningful package that provides enough detailed information to make informed decisions, but not so detailed that extracting important results is overly laborious. The following sections describe how we overcame these obstacles and developed a methodology that can be readily used for analysis of forest lands where multiple plots need to be evaluated. The analysis is divided into three basic parts: data preparation, model simulations, and output summarization.

## Data Preparation

The first and most important part of the analysis is to obtain inventory data that reflects as accurately as possible current vegetation for the area of interest. For our analysis we used the latest FIA inventory covering all forested ownerships of Montana and New Mexico. These data were gathered with assistance from the Forest Service's Forest Management Service Center (FMSC) and the Rocky Mountain Research Station. A total of 1,278 plots, roughly half from each State, are used in the analysis. These plots are not necessarily on an evenly distributed systematic grid. To

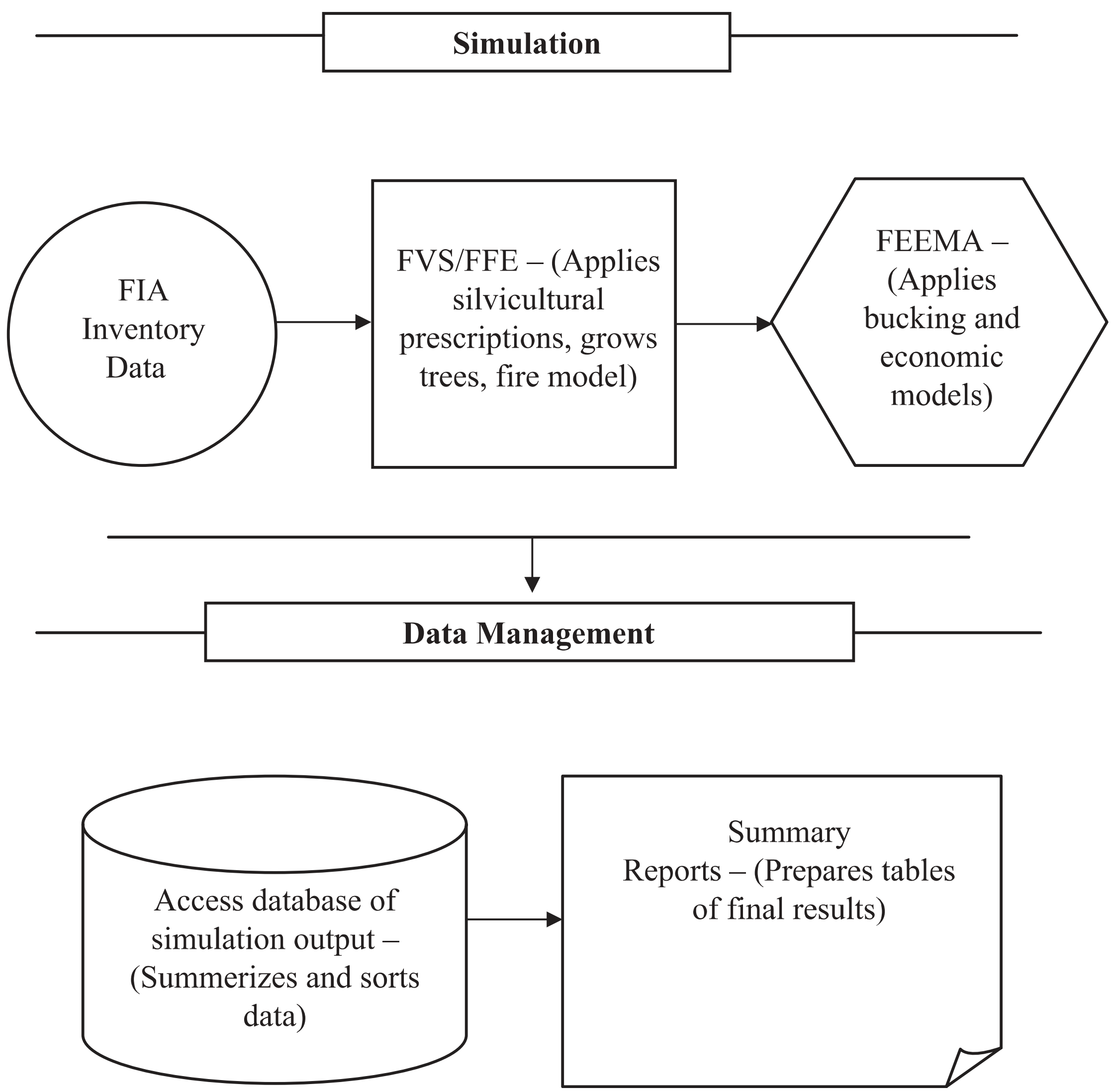


**Figure 1**—General flow of simulation and result reporting.

compensate for this, results are summarized to provide mean values weighted by each plot's expansion factor. The basic data needed to run FVS from the inventories include plot level information such as slope, the number of acres each plot represents (expansion factor or sampling factor), specific sampling design information, and site index. Tree level measurements included species, diameter at breast height (d.b.h.), height, and crown ratio.

Before FVS could be used, inventory data had to be in a specific FVS readable format, with one file per FIA plot. This format differs by region and even within a region from one inventory to the next. Using one of the conversion utilities that have been developed and with help from the FMSC, data were reformatted and the needed FVS files assembled. Two types of files were created for FVS. The tree list file contained measurements for every tree on a plot and the stand list file contained attributes (for example, measurement date, file path to the tree data file, age, habitat type, sampling information, and file path to any files with additional information) for every plot.

Next, stand list files were resorted to group plots into "cases" (combinations of forest type, region, ownership, slope, and current fire hazard). Silvicultural prescriptions were developed that could be applied to each case. These prescriptions are all formatted for FVS using a keyword file. To facilitate tracking of simulation results in the final database, all plots are renumbered using a system that allows identification of the plot, case, year, and treatment. A macro written in Excel was used to rename each plot and build new stand list files for each case. The macro worked from three worksheets: one listing a cross-reference of old to new plot numbers, one that is a stand list file for all plots, and one listing plot numbers desired in the new stand list file. The macro produces a new worksheet that is saved as a space delimited text file (FVS format) and used as the new stand list file. The macro also provides the file path to a specific keyword file used for that case. Treatment keyword files are created using the Suppose interface (Crookston 1997) for FVS. The keyword file includes the commands FVS uses to apply thinning treatments, run the FFE model, and additional calculations needed such as trees per acre harvested or posttreatment basal area.

Before plots could be assigned to a specific case, the current fire hazard rating needed to be determined. We accomplished this by running all plots through FFE. To obtain an initial rating for this analysis, we used crowning index as a proxy for potential fire hazard (Fielder and others, unpublished paper). Crowning index is the wind speed necessary to sustain a fire within the crown layer of a stand. To ensure that all stands were current, FVS was used to grow the stands to a common starting year of 2000. Stands were rated as "low" or "high" hazard based on their crowning index at year 2000.

## Model Simulations

All FVS and FFE simulations were initiated from the Suppose interface. For every case, treatment and growth were simulated for 100 years for each silvicultural prescription. For this analysis, we used two prescriptions, each a thinning from below (a thinning that removes the smallest trees first) to a diameter or basal area limit. A diameter limit of 9 inches d.b.h. and a basal area limit of 50 percent were used for both States. The diameter-limit treatment removed all trees less than the target d.b.h. but was further bounded by a minimum reserve basal area to ensure acceptable stocking in the residual stand. The 50 percent basal area treatment removed from below half the basal area. This treatment has no upper diameter limit but is also bounded by a minimum reserve basal area to ensure enough overstory trees remain. Minimum reserve basal area varied from 40 $ft^2$ to 80 $ft^2$ per acre, depending on forest type, State, and geographic region within the State. To reduce fire hazard (that is, to increase crowning index), thinning from below reduced the overall stand density, helped remove ladder fuels, and reduced crown bulk density. Crown bulk density is one of the primary variables that determine crowning index. In addition to thinning, each treated plot also received a prescribed burn in association with each treatment interval. In some cases, plots that may have not been eligible for thinning were still treated with a prescribed burn. For this analysis we used the default prescribed burn values in FFE. Thinning reentry and burning schedules are defined for each case in the keyword file. If a plot was initially rated as "low" fire hazard, treatment was delayed by one entry interval.

The Event Monitor ensured that FVS applied each silvicultural prescription as intended. This allowed us to use IF/THEN statements to evaluate each plot for treatment eligibility. If a plot met the initial criteria, the Event Monitor provided precise control over which trees were removed. Another advantage of using the Event Monitor is the COMPUTE keyword. By using this keyword, we were able to create custom variables that calculate specific information such as pre and posttreatment conditions (for example, basal area, trees per acre, quadratic mean diameter) and information on exactly what was removed (for example, volume, trees per acre, and basal area by diameter class). By using these variables in conjunction with IF/THEN statements, residual stand conditions could be calculated before FVS applied the actual treatment.

After each case was processed through FVS and FFE, output from both models was used as input for further analysis with FEEMA (fig. 1). FEEMA uses a listing of harvested trees, available via the CUTLIST and TREELIST keywords in FVS, as input for bucking, log allocation, and financial analysis. An import utility within FEEMA allows direct importing of FVS tree list files to create FEEMA stand files for each cut list. Note that a stand file in FEEMA is not the same as a stand list file in FVS; in this analysis, a stand in FEEMA is the same as a plot in FVS. Because stand file names are concatenations of the plot name used in the FVS run and the year of removal (indicated for each cut list header), it is essential to adopt a plot naming convention. In addition to using the tree list files from FVS, the output files are also used to obtain results. FVS output files contain pre and posttreatment plot variables calculated via the "COMPUTE" keyword and fire related data generated by FFE.

The FEEMA model was used to summarize volume and species composition of utilized trees, volume of logs by size class, and the net value of thinning treatments. To provide information on the logs that would be available to industry rather than specific products, the analysis was done with log pricing rather than final product pricing. The customized version of FEEMA allowed results to be processed through a series of macros written in Excel that placed the needed data items into one Excel worksheet for importing into an ACCESS database.

## Output Summarization

At this point of the analysis all FIA plot data had been processed with FVS, FFE, and FEEMA. FEEMA results have been summarized and are now ready to be imported into Access database tables (fig. 1). FVS output files have been produced and are now ready to be summarized. Because FVS writes its output report as a text file, macros were written using a text editor capable of recording and playing macros that manipulate these files. Macros were written to search each FVS output file for specific data from each plot. These raw data were then copied and pasted into a space-delimited file amenable to import into Access. For this analysis, these data included plot name, information in the FFE reports, and all the COMPUTE variables.

Final summary reports were assembled from the Access table of output. Each row in this database represents a tree that can be tracked to a specific treatment, case, year harvested, and plot. Reports on total number of plots and acres treated can be easily generated by simple summation. For this analysis, plots in Montana represent an average of approximately 6,000 acres and for New Mexico approximately 6,600 acres; however, this value can vary from less than 1,000 acres to more than 10,000 acres depending on the forest strata. Thus, observations are weighted by plot expansion factors before summation. More complex summaries are also possible—for example, mean and error statistics by forest type, region, ownership, and so forth—through the use of Access queries and reports. Examples of final tables (fig. 2, 3, and 4) show the range of attributes that can be summarized.

**C.1 Average Residual Stand Characteristics for Douglas-Fir Forest Type in Montana**

Western Montana, Forest Service Ownership

Page C.1.1

**Gentle Slope - Low Hazard**

| Year: 2030 | Rx | BA | TPA | QMD | %BA CUT |
|---|---|---|---|---|---|
| Mean | 9 in. | 119 | 92 | 16.9 | 12 |
| SE | | *10* | *18* | *0.8* | *2* |
| Mean | 50% | 85 | 57 | 20.8 | 37 |
| SE | | *3* | *14* | *1.3* | *3* |
| **Year: 2060** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 126 | 54 | 21.4 | 7 |
| SE | | *9* | *5* | *0.8* | *2* |
| Mean | 50% | 80 | 25 | 26.3 | 26 |
| SE | | | *4* | *1.1* | *2* |
| **Year: 2090** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 142 | 41 | 25.3 | 5 |
| SE | | *9* | *3* | *0.7* | *1* |
| Mean | 50% | 80 | 20 | 29.7 | 22 |
| SE | | | *3* | *1.1* | *1* |

**Gentle Slope - High Hazard**

| Year: 2000 | Rx | BA | TPA | QMD | %BA CUT |
|---|---|---|---|---|---|
| Mean | 9 in. | 92 | 100 | 13.0 | 32 |
| SE | | *6* | *6* | *0.3* | *2* |
| Mean | 50% | 85 | 106 | 13.8 | 38 |
| SE | | *2* | *11* | *0.6* | *2* |
| **Year: 2030** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 97 | 72 | 16.0 | 7 |
| SE | | *5* | *4* | *0.4* | *2* |
| Mean | 50% | 80 | 66 | 17.5 | 20 |
| SE | | | *10* | *0.7* | *1* |
| **Year: 2060** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 111 | 56 | 19.2 | 5 |
| SE | | *5* | *3* | *0.4* | *1* |
| Mean | 50% | 80 | 39 | 21.2 | 19 |
| SE | | | *3* | *0.6* | *1* |
| **Year: 2090** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 124 | 48 | 21.9 | 3 |
| SE | | *5* | *2* | *0.4* | *1* |
| Mean | 50% | 80 | 26 | 24.8 | 18 |
| SE | | | *2* | *0.6* | *1* |

**Steep Slope - Low Hazard**

| Year: 2030 | Rx | BA | TPA | QMD | %BA CUT |
|---|---|---|---|---|---|
| Mean | 9 in. | 100 | 69 | 18.2 | 9 |
| SE | | *6* | *9* | *0.7* | *1* |
| Mean | 50% | 82 | 40 | 21.7 | 32 |
| SE | | *1* | *5* | *1.0* | *3* |
| **Year: 2060** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 116 | 47 | 22.4 | 4 |
| SE | | *6* | *3* | *0.6* | |
| Mean | 50% | 80 | 32 | 25.0 | 23 |
| SE | | | *7* | *0.9* | *1* |
| **Year: 2090** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 132 | 39 | 25.9 | 3 |
| SE | | *7* | *3* | *0.6* | |
| Mean | 50% | 80 | 21 | 29.3 | 19 |
| SE | | | *4* | *0.8* | *1* |

**Steep Slope - High Hazard**

| Year: 2000 | Rx | BA | TPA | QMD | %BA CUT |
|---|---|---|---|---|---|
| Mean | 9 in. | 108 | 109 | 13.8 | 25 |
| SE | | *6* | *7* | *0.4* | *2* |
| Mean | 50% | 87 | 81 | 15.4 | 40 |
| SE | | *2* | *7* | *0.6* | *2* |
| **Year: 2030** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 135 | 76 | 18.5 | 2 |
| SE | | *7* | *5* | *0.4* | *1* |
| Mean | 50% | 80 | 35 | 21.5 | 26 |
| SE | | | *2* | *0.6* | *1* |
| **Year: 2060** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 151 | 60 | 21.9 | 4 |
| SE | | *8* | *4* | *0.4* | *1* |
| Mean | 50% | 80 | 22 | 26.3 | 23 |
| SE | | | *1* | *0.5* | *1* |
| **Year: 2090** | **Rx** | **BA** | **TPA** | **QMD** | **%BA CUT** |
| Mean | 9 in. | 167 | 53 | 24.8 | 3 |
| SE | | *8* | *3* | *0.5* | |
| Mean | 50% | 80 | 18 | 29.7 | 20 |
| SE | | | *1* | *0.5* | *1* |

Rx = Treatment BA = Basal Area (sq.ft./ac) TPA = Trees/ac QMD = Quadratic mean diameter(in.)
SE = Standard Error (+/- Cubic Ft./ac.) %BACUT = % of total basal area harvested
Note: Values are averages and cannot necessarily be cross-referenced.

**Figure 2**—Example of residual stand characteristics report.

**D.1 Average Volume of Utilized Trees by DBH Class for Douglas-fir Forest Type in Montana**

Western Montana, Forest Service Ownership

Page D.1.1

**Gentle Slope - Low Hazard**

| RX | 7-10 | (SE) | 10-13 | (SE) | 13-16 | (SE) | 16+ | (SE) | Total | (SE) |
|---|---|---|---|---|---|---|---|---|---|---|
| Year: 2030 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 86 | 31 | 186 | 54 | 266 | 57 | 582 | 168 | 1,121 | 69 |
| Year: 2060 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 11 | 6 | 6 | 5 | 53 | 35 | 583 | 100 | 652 | 87 |
| Year: 2090 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 7 | 4 | 14 | 8 | 27 | 19 | 459 | 53 | 506 | 39 |

**Gentle Slope - High Hazard**

| RX | 7-10 | (SE) | 10-13 | (SE) | 13-16 | (SE) | 16+ | (SE) | Total | (SE) |
|---|---|---|---|---|---|---|---|---|---|---|
| Year: 2000 | | | | | | | | | | |
| 9 in. | 234 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 234 | 36 |
| 50% | 303 | 52 | 275 | 55 | 40 | 20 | 1 | 1 | 619 | 28 |
| Year: 2030 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 50 | 15 | 58 | 17 | 173 | 37 | 122 | 34 | 403 | 20 |
| Year: 2060 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 18 | 11 | 52 | 15 | 89 | 24 | 243 | 32 | 402 | 3 |
| Year: 2090 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 4 | 4 | 10 | 7 | 28 | 14 | 383 | 33 | 425 | 26 |

**Steep Slope - Low Hazard**

| RX | 7-10 | (SE) | 10-13 | (SE) | 13-16 | (SE) | 16+ | (SE) | Total | (SE) |
|---|---|---|---|---|---|---|---|---|---|---|
| Year: 2030 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 58 | 26 | 178 | 37 | 225 | 48 | 334 | 99 | 795 | 9 |
| Year: 2060 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 18 | 12 | 10 | 5 | 38 | 11 | 475 | 66 | 541 | 55 |
| Year: 2090 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 3 | 1 | 4 | 2 | 6 | 3 | 436 | 34 | 449 | 30 |

**Steep Slope - High Hazard**

| RX | 7-10 | (SE) | 10-13 | (SE) | 13-16 | (SE) | 16+ | (SE) | Total | (SE) |
|---|---|---|---|---|---|---|---|---|---|---|
| Year: 2000 | | | | | | | | | | |
| 9 in. | 180 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | 27 |
| 50% | 311 | 41 | 390 | 80 | 158 | 55 | 66 | 33 | 925 | 40 |
| Year: 2030 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 7 | 4 | 27 | 11 | 217 | 40 | 518 | 84 | 769 | 43 |
| Year: 2060 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 2 | 2 | 17 | 9 | 13 | 8 | 593 | 38 | 624 | 26 |
| Year: 2090 | | | | | | | | | | |
| 9 in. | | | | | | | | | | |
| 50% | 2 | 1 | 6 | 3 | 13 | 8 | 499 | 26 | 520 | 18 |

Rx = Treatment Volume is merchantable cubic feet/acre by DBH Class(in.)

SE = Standard Error (+/- cubic ft./ac.)

**Figure 3**—Example report of volume of utilized trees by diameter class.

**I.1 Average Proportion of Stands by Net Value Category for Douglas-fir Forest Type in Montana**

Western Montana, Forest Service Ownership

Page I.1.1

**Gentle Slope - Low Hazard**

| RX | <-100$ | -100$ to 100$ | 100$ to 500$ | 500$ to 1000$ | >1000$ |
|---|---|---|---|---|---|
| Year: 2030 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.23 | 0.05 | 0.23 | 0.18 | 0.32 |
| Year: 2060 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.08 | 0.04 | 0.17 | 0.21 | 0.50 |
| Year: 2090 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.07 | 0.07 | 0.15 | 0.19 | 0.52 |

**Gentle Slope - High Hazard**

| RX | <-100$ | -100$ to 100$ | 100$ to 500$ | 500$ to 1000$ | >1000$ |
|---|---|---|---|---|---|
| Year: 2000 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.68 | 0.10 | 0.20 | 0.02 | 0.00 |
| Year: 2030 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.30 | 0.11 | 0.30 | 0.20 | 0.09 |
| Year: 2060 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.16 | 0.10 | 0.29 | 0.37 | 0.08 |
| Year: 2090 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.02 | 0.06 | 0.24 | 0.53 | 0.14 |

**Steep Slope - Low Hazard**

| RX | <-100$ | -100$ to 100$ | 100$ to 500$ | 500$ to 1000$ | >1000$ |
|---|---|---|---|---|---|
| Year: 2030 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.47 | 0.06 | 0.16 | 0.22 | 0.09 |
| Year: 2060 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.20 | 0.15 | 0.29 | 0.15 | 0.22 |
| Year: 2090 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.11 | 0.04 | 0.30 | 0.39 | 0.15 |

**Steep Slope - High Hazard**

| RX | <-100$ | -100$ to 100$ | 100$ to 500$ | 500$ to 1000$ | >1000$ |
|---|---|---|---|---|---|
| Year: 2000 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.81 | 0.00 | 0.07 | 0.05 | 0.07 |
| Year: 2030 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.10 | 0.12 | 0.29 | 0.29 | 0.20 |
| Year: 2060 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.05 | 0.07 | 0.14 | 0.53 | 0.21 |
| Year: 2090 | | | | | |
| 9 in. | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 50% | 0.07 | 0.02 | 0.09 | 0.70 | 0.13 |

Rx = Treatment Proportion = the proportion of stands in net value catagories within each type, year and treatment

**Figure 4**—Example report of financial results using FEEMA output.

## Conclusions

This analytic approach has been extended for other study areas, including the Blue Mountains Demonstration Project in Northeastern Oregon, where a detailed analysis of fuels reduction treatments on three National Forests (Umatilla, Malheur, and Wallowa-Whitman) is under way. The FIA BioSum model, which seeks to evaluate potential biomass available from fire hazard reduction treatments in the Western United States, has significantly expanded the capability and complexity of this analytic framework by adding spatially explicit representation of biomass accumulation potential over existing road networks.

The analytic approach and software summarized here, built on a foundation of publicly available data and models, enable managers to address questions concerning forest management over a large area with great detail. The scope of silvicultural prescriptions that can be evaluated is limited only by an analyst's imagination and the capabilities of the models. By using the Event Monitor within FVS, complex treatments can be simulated. The FFE model allows analysis of wildfire potential, response to treatments, and use of prescribed burning. If only these models were used, summary would be possible at a tree level, but by using FEEMA, each harvested tree can be evaluated even further by accounting for treatment costs and conducting log level analyses. Finally, using Access database tables to store all raw simulation output, results can be sorted and summed using custom defined criteria and classes. This allows results from hundreds or thousands of plots to be quickly compiled into manageable, meaningful results. The report-writing feature of Access can be used to automate result generation for commonly requested table formats.

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