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Thinning and Prescribed Fire and Projected Trends in Wood Product Potential, Financial Return, and Fire Hazard in Montana

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Abstract

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This work was undertaken under a joint fire science project "Assessing the need, costs, and potential benefits of prescribed fire and mechanical treatments to reduce fire hazard." This paper compares the future mix of timber products under two treatment scenarios for the state of Montana. We developed and demonstrated an analytical method that uses readily available tools to evaluate pre- and posttreatment stand conditions; size, species, and volume of merchantable wood removed during thinnings; size and volume of submerchantable wood cut during treatments; and financial returns of prescriptions that are applied repeatedly over a 90-year period.

Keywords: Wood products, thinning, fire hazard, financial return, Montana.

Executive Summary

This work was initiated under a Joint Fire Science Program-funded project ”Assessing the needs, costs, and potential benefits of prescribed fire and mechanical treatments to reduce fire hazard.” We developed and demonstrated an analytical method that uses readily available tools to evaluate pretreatment and posttreatment stand conditions; size, species, and volume of merchantable wood removed during thinnings; size and volume of submerchantable wood cut during treatments; and financial returns of prescriptions that are applied repeatedly over 90 years. In this paper we compare the potential mix of timber products recovered under two treatment scenarios applied in Montana.

The treatment scenarios simulated here were not intended as solutions to the fuel hazard problem per se. They are, however, representative of approaches that are currently being applied on the ground, and our intention was to illustrate (1) the use of existing tools to evaluate the effectiveness and cost of implementing these types of treatments and (2) the likely results of repeatedly applying these treatments over long timeframes. There are important policy issues associated with both parts of the analysis. Our analysis suggests that only a relatively small proportion of existing stands could be treated without a subsidy if either of the prescriptions modeled here is used. Even so, almost 1,000,000 acres could be treated without a subsidy. Fire hazard is initially reduced by these treatments. The effects of subsequent treatments range from barely maintaining the initial improvement to continuous improvement over a 10-decade period. Projections of repeated applications of these treatments suggest that they also could have unintended consequences by creating conditions conducive to bark beetle (*Dendroctonus* spp.) outbreaks or by reducing stand densities below acceptable levels. Neither option studied provided for regeneration of stands, so age-class distribution would eventually become a problem in stands managed under either prescription. Our main conclusions, therefore, are that (1) it is important to consider the long-term consequences of fuels treatments and (2) existing tools can provide useful information about the short- and long-term effects of many proposed treatments.

Findings

A variety of silvicultural treatments can be modeled by using these methods. One of the treatments we chose to illustrate the methods was to thin from below to 9 in diameter at breast height (d.b.h.) with a minimum residual basal area (BA) and follow with a prescribed burn, then every 30 years to reevaluate for thinning and to burn whether rethinned or not (TB9). The key findings of that scenario follow.

- The initial effect of this prescription on fire hazard was modest. Repeat entries did little more than maintain the initial gains.
- There was a substantial long-term downward trend in the projected basal area mortality expected during prescribed burn treatments.
- Basal area built up over time, perhaps to levels that would put the stands at risk of insect outbreaks.
- There was no merchantable volume harvested under this prescription after the first thinning.
- No cases were found where the harvested material would cover the cost of conducting the thinning either currently or in future entries given existing market conditions. (If volumes removed from skid trails or cable corridors were included in these calculations, the results might have been different.)

- If the TB9 prescription were widely implemented and if policy called for utilization of the removed volume, investments in new processing capacity would be necessary because this prescription yields only submerchantable trees after the first entry.

The other treatment we chose was to thin from below up to 50 percent of standing basal area with a minimum residual basal area and follow with a prescribed burn, then every 30 years reevaluate for thinning and burn whether rethinned or not (50BA). The key findings of that scenario follow.

- The initial effect of this prescription on fire hazard was modest, but there was continued improvement with successive entries.
- There was a substantial long-term downward trend in the projected basal area mortality expected during prescribed burn treatments.
- Basal area stabilized near the minimum residual basal area required under the prescription.
- The merchantable volume harvested was lower in future entries than in the initial entry, but the d.b.h. of harvested trees increased to greater than 16 in over the simulation period.
- The prescription made no provision for regenerating the stand, so repeated entries often lowered the number of trees per acre to well below full stocking levels. In practice, managers would almost certainly alter prescriptions to regenerate stands before this happened.
- Typically, less than 20 percent of the high-hazard plots had net financial returns of more than $100 per acre, but this amounted to more than 790,000 acres of Douglas-fir and almost 180,000 acres of ponderosa pine where this treatment could potentially be implemented without a subsidy.
- Most cases showed a positive net return from thinnings by the end of the simulation period.

The results suggest that both of the simulated prescriptions reduced fire hazard over the long term, but they were not equally effective. Over the course of several entries, the basal-area-limited prescription created stands that were open with a few scattered large trees, whereas the diameter-limited prescription created dense stands with many midsize trees. The diameter-limited prescription sometimes resulted in combinations of basal area, tree size, and stand age that raise concerns over insect outbreaks, specifically Douglas-fir beetles (*Dendroctonus pseudotsuga* Hopkins), western pine beetles (*D. brevicomis* Le Conte), and mountain pine beetles (*D. ponderosae* Hopkins). In general, however, it was possible to use these treatments to develop a wide range of density and tree size combinations over the simulation period. Even with the simple prescriptions modeled here, it would be possible to select stands with different initial conditions and ages and apply the prescriptions at different times to develop a diverse set of conditions on a landscape. We did not explore such spatial or temporal arrangements of treatments, but this undoubtedly would be important when developing management plans that consider the interactions of fuel reduction treatments with multiple resource values and episodic disturbances on large landscapes.

In terms of wood utilization, the analysis showed that the diameter-limited prescriptions produced only small volumes of small trees from the first entry and minimal volumes in subsequent entries. These prescriptions almost universally had negative net returns, even without considering the costs of a regular cycle of prescribed fire, so a substantial subsidy would be required to implement them. If these prescriptions were widely implemented and if industrial capacity were developed to use the wood removed under them, it would be important to size processing plants and develop treatment schedules to ensure a sustainable supply of raw material.

The basal-area-limited treatment produced more volume than the diameter-limited prescription and sometimes showed a positive net return. This prescription produced trees and logs in a variety of sizes. Although the average diameter of cut trees increased with successive entries, the total volume per thinning generally declined over time.

Contents

Introduction

This study was undertaken with funding from the Joint Fire Science Program (JFSP) to develop protocols for use in determining the magnitude of hazard reduction treatment needs, treatment cost, and associated benefits at a state level. The objectives of the study include (1) quantifying existing stand conditions for major forest types in terms of density, structure, and species composition, and prioritizing by need for hazard reduction treatment, (2) developing and comparing alternative cutting and prescribed burning prescriptions for reducing high-hazard conditions in major forest types, (3) determining potential revenue from timber products generated from the hazard reduction harvest treatments, (4) comparing the future mix of timber products under alternative treatment scenarios, and (5) describing the potential for analyzing noncommodity resources under treatment and no-treatment scenarios. This report demonstrates the protocols developed under JFSP funding to analyze and illustrate trends in the long-term effects of repeated hazard reduction entries in terms of the stocking, size, and species mix of residual stands and the size and species mix of trees and logs that might be removed and used for wood products.

Montana was selected as an example because recent inventories were available. Montana's forest products industry is well established with the technological capability to process the numerous small-diameter logs expected from fuel hazard reduction treatments. A similar analysis was conducted for New Mexico where the existing industry is small and not geared toward using this type of material (see Fight et al. 2004).

If widely adopted, the types of treatments proposed as a means of reducing forest fire hazards could have implications for future forest conditions as profound as past management practices, principally harvesting and fire exclusion that led to the existing conditions. Changes of that magnitude have the potential to affect many forest values such as fisheries, wildlife, timber, nontimber forest resources, environmental services, and amenities. Some of these changes will likely be considered positive and some will likely be considered negative. How they are viewed depends on the resource in question and the relative importance given to different resource values. It is neither our place nor our intent to say which changes are more important or whether they are desirable or undesirable. Our intent is to provide a set of protocols that use existing tools[1] and data[2] that are available to analysts employed by federal, state, and private land management organizations. The interpretations we provide in this report are intended as neutral examples illustrating these protocols. Our protocols can be used to conduct analyses and display information about fire hazard, stand conditions, and removed materials. We anticipate that this information will be useful to decisionmakers who formulate fire management policy and devise implementation strategies.

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[1] For example, Forest Vegetation Simulator (FVS), Fire and Fuels Extension (FFE), Financial Evaluation of Ecosystem Management Activities (FEEMA), Microsoft Access (the use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service), etc. (see "Methods and Assumptions" section).

[2] We used forest inventory and analysis (FIA) plot-level data, but many types of stand-level data are adequate for these protocols.

The types of treatments proposed to reduce fire hazard could also have important implications for the volume and characteristics of timber available for the production of forest products. Significant shifts in the species or size composition, for example, could influence the economic viability of the industry and affect the economic health of the people and communities in which timber processing occurs.

This report is intended to supply information to a broad range of decisionmakers concerned with forest fire hazard including federal, state, and private forest land managers, planners, and others with an interest in the management of forests in the Western United States.

Geographic and Forest Type Detail

Montana was divided into western and eastern regions for analysis and reporting. The division generally follows the Continental Divide. Within each geographic area, forests were further divided into 11 forest types: Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), lodgepole pine (*Pinus contorta* Dougl. ex Loud.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), moist low-elevation mixed conifers, dry low-elevation mixed conifers, upper-elevation mixed conifers, western larch (*Larix occidentalis* Nutt.), spruce/fir (*Picea* spp./*Abies* spp.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), quaking aspen (*Populus tremuloides* Michx.), and cottonwood (*Populus* spp.). We performed our analyses on the Douglas-fir and ponderosa pine forest types because they were identified by the Montana technical contact team[3] (TCT) as being of high concern and having a high potential for hazard reduction treatments. These forest types have relatively short fire-return intervals and are likely candidates for hazard reduction treatments. They were also extensive enough to supply sufficient forest inventory and analysis (FIA) data with which to provide a meaningful illustration of our protocols. We report results by two ownership categories: national forest land and other land. These categories were chosen to make the most efficient use of the available FIA data. With additional stand exam data it would be possible to further refine ownership classes. In this report each combination of region, owner group, forest type, slope category, and hazard category is referred to as a "case" and each application of a treatment (a thinning or prescribed fire) within each case is referred to as an "entry." Reporting within the two ownership classes was further broken down into current forest fire hazard condition and slope. The maximum number of reporting categories (cases) for the Montana study was 32 (2 regions by 2 owner groups by 2 forest types by 2 slope categories by 2 hazard categories).

Methods and Assumptions

The objective of this analysis was to show the results of two stand treatment options intended to reduce fire hazard both now and in the future. Evaluations include (1) residual stand structure, (2) volume, size, and characteristics of merchantable trees cut through time, (3) the volume and size of submerchantable (biomass) trees cut through time, and (4) the financial feasibility of treatments. A detailed description of our modeling techniques is given by Christensen et al. (2002)

We used existing modeling tools and inventory data linked in a way that allowed a comprehensive analysis over a range of treatment options. Primary tools included the Forest Vegetation Simulator (FVS) growth and yield model (Crookston 1990, Stage

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[3] A group of experts were assembled to comment on the design of and outcomes from this analysis. They are Donald Artley, Montana Department of Natural Resources and Conservation; Danny Castillo, USDA Forest Service Northern Region; Dennis Dupuis, Salish and Kootenai Tribal Forestry; Bruce Reid, USDI Bureau of Land Management; and Gordy Sanders, Montana Tree Farmers and Pyramid Lumber.

1973), the Fire and Fuels Extension (FFE) model as part of FVS (Beukema et al. 1997, Scott and Reinhardt 2001), and the Financial Evaluation of Ecosystem Management Activities (FEEMA) model (Fight and Chmelik 1998). Data were stored in a Microsoft Access database, and a standard set of reports was developed within the database. Use of these tools makes the analysis portable to anywhere in the Western United States where an FVS variant with an FFE extension and a FEEMA variant are available. The tools are familiar to, or can be readily learned by, forest planning and analysis staff within federal agencies and most state or private organizations. Where they exist, other growth models, fire models, and financial models could be substituted for the ones we used.

Measurements of current forest vegetation are from data collected by the Forest Service FIA program. Our methods are general, however, and adequate data can be obtained from a wide range of stand exam or other stand-level data that are suitable for use as input data to FVS. An important caveat here is that stand-level data should be collected in such a way that they comprise a statistically representative sample of the vegetation population on the target landscape.

We examined 678 candidate FIA plots with a sampling weight of approximately 6,000 acres each. When more than 50 plots were available for a given case,[4] a sample of 50 plots was randomly selected to represent all the area in that case. When fewer than 50 plots were available for a given case, all of the plots were used in the analysis. Cases with fewer than 10 plots were not included in the analysis because there were insufficient data to adequately represent potential variation. Alternatively, it is possible to analyze all plots regardless of sample size and examine results for individual plots rather than average results. We felt that this method would be tedious and not allow us to provide a compact illustration of our methods. Individual analysts might, however, be interested in identifying plot conditions where the probability of some desired outcome, such as financially viable activities, is high. In that case, analysis of individual plots might be desirable.

Fire hazard rating is based on estimates of the crowning index for each decade provided by the FFE of FVS. Crowning index is the windspeed necessary to sustain a crown fire. It is calculated from the crown bulk density for the stand. The lower the crowning index, the higher the probability that a crown fire will be sustained (Scott and Reinhardt 2001). Crowning index values reported are after thinning (if called for) and prescribed fire treatment.

Forest inventory and analysis data were converted into FVS input files, and a silvicultural treatment regime was simulated. The silvicultural regimes simulated in this analysis were intentionally kept simple to provide an uncomplicated illustration of the protocols and to provide benchmark results that could be used to refine treatment options. In other parts of this study another more complex prescription was used, but it was not used in our analysis because we were unable to model it in FVS.[5]

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[4] Each case is the combination of ownership, forest type, fire hazard, and slope.

[5] Fiedler, C.E.; Keegan, C.E., III; Woodall, C.W. [et al.] 2001. A strategic assessment of fire hazard in Montana; A strategic assessment of fire hazard in New Mexico. Reports submitted to the Joint Fire Science Program Board, 3833 S. Development Ave., Boise, ID 83705.

For each harvest made in FVS, a list of cut trees was recorded and then imported into the FEEMA model. The FEEMA model determined merchantability of each tree, based on a minimum small-end diameter (SED) of 5.0 in inside the bark and a minimum log length of 8 ft for upper logs and 16 ft for butt logs. The FEEMA model tallied individual logs and produced an output file summarizing volume by species, tree diameter at breast height (d.b.h.), and log SED. These results were compiled in a database. Results from the simulations were calculated as the average of the FIA plots selected for each case (50 or fewer as described above) weighted by the appropriate plot expansion factor (the number of acres represented by a plot). Whole-tree stem volumes of biomass (submerchantable) trees from 1 to 7 in d.b.h. were estimated by using FVS. We did not calculate total biomass (total stem, limbs, and foliage) volume or weight for the biomass trees.

Fire Hazard Reduction Treatments

Silvicultural prescriptions were developed in consultation with the TCT. The objective was to cover a range of treatment options. In general, a treatment can be a thinning, a thinning followed by burning (prescribed fire), or a maintenance burn (prescribed fire) without a thinning. We used thinning treatments that included thinnings from below to different diameter and basal area targets, followed by a prescribed burn. Thinning was simulated with FVS. Prescribed burning was simulated by using the FFE model. The crowning index from the FFE model was used as a surrogate for fire hazard. We segregated all plots into high, medium, and low fire hazard based on crowning indices, which are expressed as windspeed of <25 mph (high hazard), 25 to <50 mph (moderate hazard), and 50+ mph (low hazard). For the ponderosa pine forest type we grouped the plots with high and medium fire hazard, and in the Douglas-fir forest type we grouped the plots with medium and low fire hazard. For reporting purposes, output tables are labeled as “high” or “low” fire hazard with the grouping indicated at the beginning of the results section for each forest type. This designation indicates the relative importance of treating stands in the indicated crowning index classes for that forest type. Treatments in plots designated as low were deferred for one treatment simulation cycle (30 years).

Forest Vegetation Simulator Variants

Three FVS variants were used for this analysis. The eastern Montana variant was used for all of eastern Montana. In western Montana, the northern Idaho variant was used except for the Kootenai National Forest and the Tally Lake Ranger District of the Flathead National Forest where the Kootenai variant was used.

Prescriptions

Two generalized prescriptions were applied to both forest types. The first was a thin-from-below to 9 in d.b.h. It is referred to as TB9 in the text. The second is a thin-from-below to up to 50 percent of standing basal area. It is referred to as 50BA in the text. Details of the treatment for each forest type and geographic locations follow.

Douglas-fir—The thinning reentry interval is 30 years with prescribed burning immediately following each entry (thinning and burning included in the same FVS simulation cycle). The TB9 prescription required a minimum residual basal area of 45 ft^2/ac in western Montana and 40 ft^2/ac in eastern Montana. The 50BA prescription required a minimum residual basal area of 80 ft^2/ac in western Montana and 70 ft^2/ac in eastern Montana. Stands that did not have sufficient basal area to qualify for a thinning were burned and were reconsidered for thinning at the next thinning cycle (30 years).

Ponderosa pine—The thinning reentry interval is 30 years with prescribed burning immediately following each entry (thinning and burning included in the same FVS simulation cycle). The TB9 prescription required a minimum residual basal area of 40 ft^2/ac in western Montana and 35 ft^2/ac in eastern Montana. The 50BA prescription required a minimum residual basal area of 50 ft^2/ac in western Montana and 40 ft^2/ac in eastern Montana. Stands that did not have sufficient basal area to qualify for a thinning were burned and were reconsidered for thinning at the next thinning cycle (30 years).

Effectiveness of Hazard Reduction Treatments

Linear regression analysis was used to identify trends in the long-term effectiveness of treatments in lowering fire hazard. The regression tested for a time trend and a treatment effect in the predicted crowning index. The dependent variable in these regressions was the average predicted crowning index for the high-hazard plots for a given forest type and treatment. The independent variables were decades numbered from 1 to 10, dummy variable for decade of treatment, and dummy variable for the decade following treatment. Dummy variables have a value of 1 for data points that have the attribute and zero otherwise. The model form was $Y = a + b$(decade) + c(decade of treatment dummy) + d(decade following treatment dummy). Any of the three variables that were not statistically significant at the 5-percent level were deleted from the model, and the model was rerun. Results from this analysis helped to illustrate whether there was improvement in crowning index immediately after entries or during the decade following entries, how crowning index changed between entries, and whether there was a long-term trend of improvement in crowning index.

A similar analysis was used to identify trends in the average basal area mortality expected from the prescribed burns. The dependent variable in these regressions was the average predicted basal area mortality (percentage) for a prescribed burn for the high-hazard plots for a given forest type and treatment.

Financial Analysis

The FEEMA model was used to rate the potential net revenue from the thinnings. The analysis was done for a single set of economic assumptions that represent mixed market conditions. The market conditions used represent a market for lumber and a market for chip logs down to 5 in SED. Although the pricing was done on a log basis rather than the tree basis used in another part of the study, the prices were made as comparable as possible (see footnote 5). The financial returns should be regarded as optimistic because of the assumed market for chip logs, but useful in identifying the relative financial feasibility of different cases and changes in feasibility of future versus current treatments. Costs included cutting small trees that are cut and treated in place and cutting trees that are used for products. Costs of other harvest-related activities such as road building or repair and environmental remediation, which can vary widely, were not included, nor were revenues associated with timber removed from skid trails or cable corridors. Ground-based equipment was assigned a lower cost than cable yarding systems. Stump-to-truck costs were based on Hartsough et al. (2001). Ground-based equipment was assumed on slopes of less than 35 percent. Hauling costs were \$28 per 100 ft^3 for all species and areas. See appendix 1 (tables 1 through 3) for a full description of economic assumptions.

Results and Discussion

Douglas-Fir

The total area and number of FIA inventory plots included in this analysis for the Douglas-fir forest type are shown in appendix 2 (table 4). Douglas-fir plots were segregated by high crowning index (<25 mph windspeed) and low/moderate crowning index (25+ mph windspeed) for the analysis presented here. For brevity, these two groups are referred to as high fire hazard and low fire hazard in all of the tables for this species.

Treatment effect on fire hazard—Regression analysis indicated both a time trend (positive coefficient on decade) and a cyclical treatment effect (a positive coefficient on the decade following treatment) on average crowning index for the 50BA prescription in the Douglas-fir high-hazard stands. This means that each subsequent treatment brought the crowning index higher (a lower hazard) than the previous treatment. The results from the Douglas-fir high-hazard stands with TB9 treatment had a cyclical treatment effect (a positive coefficient on the decade following treatment) and a small time trend. There was improvement with each entry, but after the initial increase, the crowning index declined to a level only slightly above the previous entry by the time of the next entry. These comparisons are clearly seen in the plot of the predicted average values for fire hazard index shown in figure 1. Recall that the crowning index for all high-hazard plots was initially less than 25, so the first point in the figure includes the improvement associated with the initial treatment.

Figure 2 shows the analogous comparison for the predicted average basal area mortality resulting from prescribed burns. In spite of the fact that the effect on crowning index is quite different between the treatments, the effect on potential basal area mortality is strikingly similar. This means that even though the ability to carry a crown fire is different, the ability of the trees to withstand low-intensity fires, such as prescribed fire, is similar. By the 10^{th} decade of the simulation, expected basal area mortality drops to around 5 percent for both prescriptions.

Initial stand summary—The initial stand conditions for high- and low-fire-hazard cases differ systematically when paired by geographic region, owner, and slope. The low-hazard cases consistently have lower basal area, fewer trees per acre, and larger quadratic mean diameters (QMD) (app. 3, tables 6 through 9). A typical comparison is shown for western Montana in figure 3.

Residual stand summary—The results presented in figure 4 illustrate how stand conditions would change over time for Douglas-fir plots. Although the results shown in the figure are for Forest Service land in western Montana, they are similar to those for other ownerships and geographic regions in Montana (app. 4, tables 14 through 17). When the two prescriptions are applied repeatedly over the course of a century, our analysis suggests that the 50BA prescription will result in less-crowded stand conditions with fewer but larger trees than the TB9 prescription.

The main difference between the treatment projections is that the diameter-limited prescription (TB9) resulted in an accumulation of basal area over time, whereas the basal-area-controlled prescription (50BA) reduced basal area to the minimum value, 80 ft^2/ac in this case, and kept it there throughout the simulation. Under the diameter-limited prescription, basal area and QMD increased over time while trees per acre declined. This happened because the prescription generally removed all of the trees under 9 in before the minimum basal area was reached. Basal area increased because the trees over 9 in d.b.h. were never removed, and as they grew, basal area continued to accumulate. Trees per acre declined because few, if any, trees under 9 in

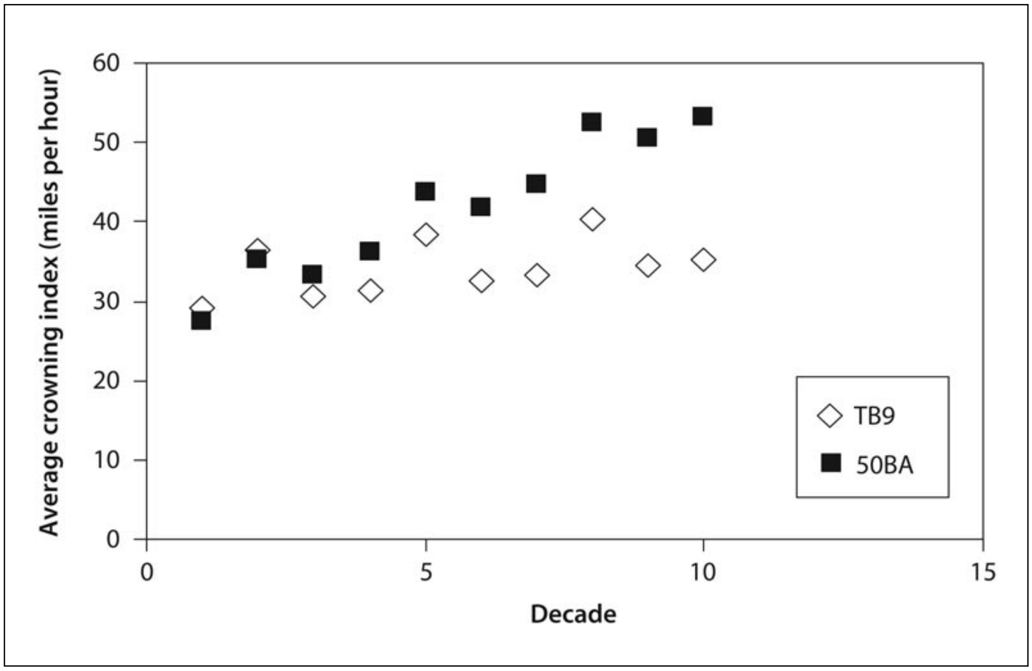

Figure 1—Predicted average crowning index over time for high-fire-hazard Douglas-fir plots in Montana by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

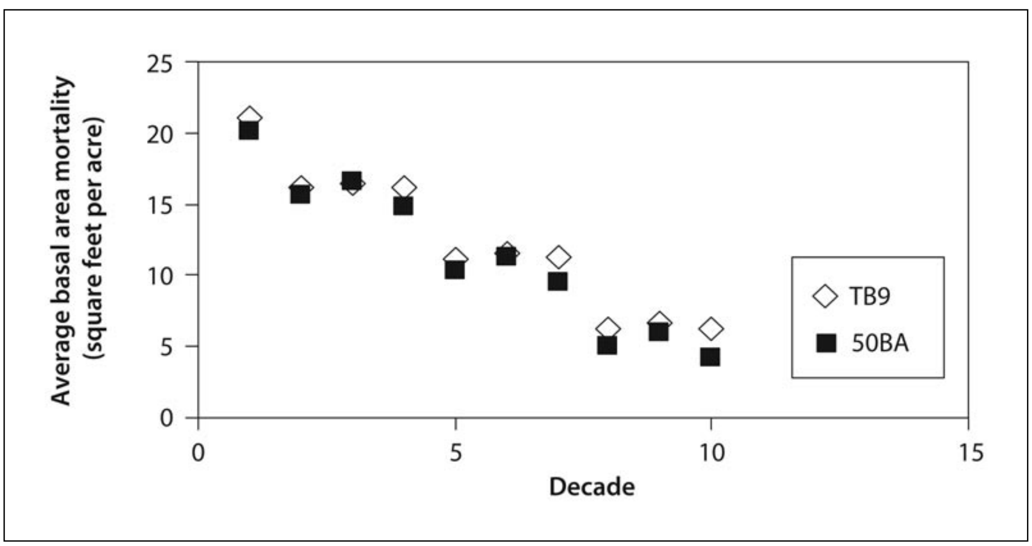

Figure 2—Predicted average basal area mortality over time for high-fire-hazard Douglas-fir plots in Montana by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

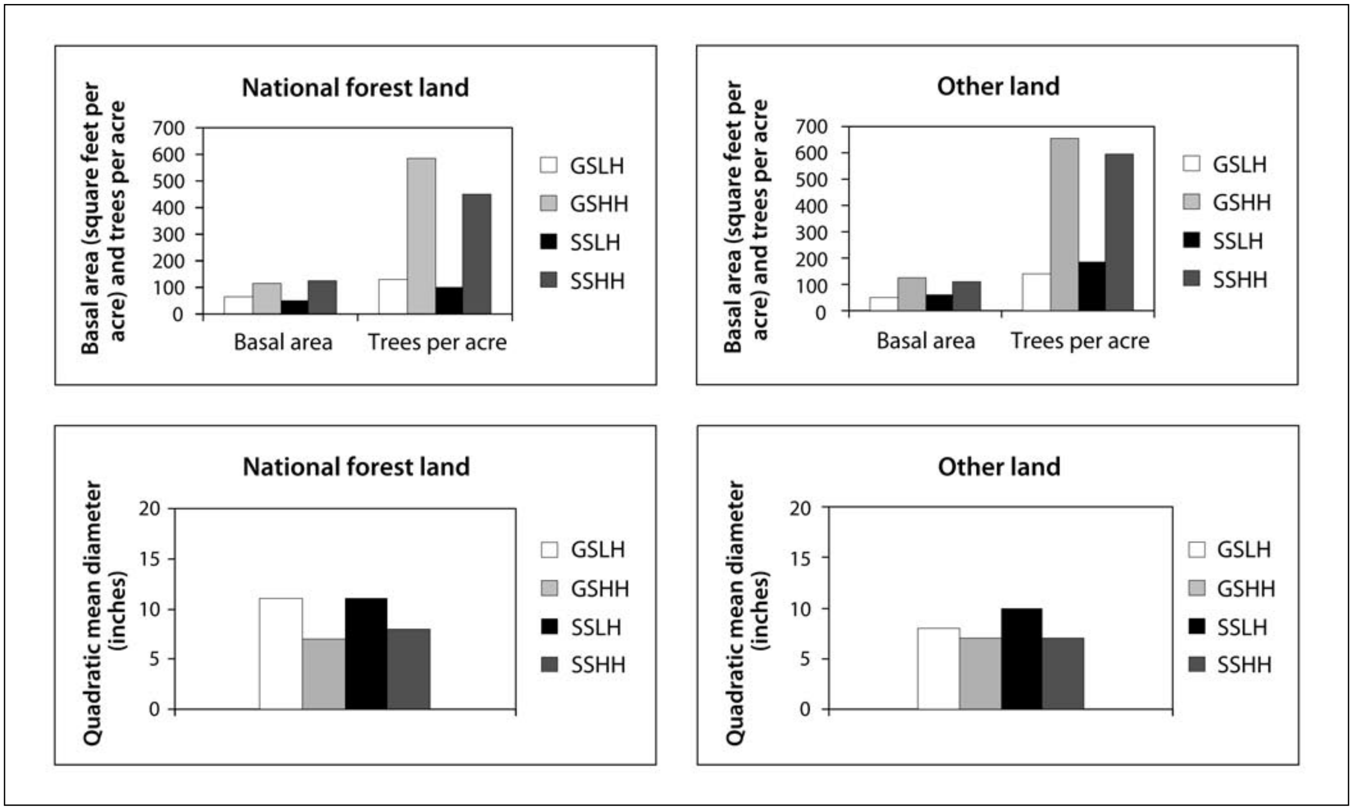

Figure 3—Initial stand conditions for Douglas-fir plots on steep slopes in western Montana: basal area, number of trees per acre, and quadratic mean diameter, reported by gentle slope low or high fire hazard (GSLH or GSHH) and steep slope low or high fire hazard (SSLH or SSHH).

survived to become large trees, but some of those larger than 9 in died in each growing cycle (10 years). With no understory trees to replace them, the number of trees per acre declined over time.

The accumulation of basal area projected under the TB9 prescription is an issue that forest managers or planners might want to consider more closely. Our analysis suggests that this prescription will generally be sufficient to keep treated stands in the moderate fire hazard class and that mortality associated with prescribed burns, and presumably other low-intensity fires, will decline over time under both prescriptions. Stands managed under these prescriptions for a long time, however, will have very different structures. Both of these stand structures might be regarded as desirable components of a landscape at some level. The 50BA prescription creates open stands with scattered large trees. The TB9 prescription creates densely stocked stands with trees more uniform in size. In some cases, the resulting conditions reach a point where the stands are high hazard for Douglas-fir bark beetle (*Dendroctonus pseudotsuga* Hopkins) outbreaks.[6] Neither prescription allows for regeneration of an understory and recruitment of smaller trees into the overstory, so both will eventually lead to single-story stands.

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[6] Gibson, K. 2001. Personal communication. Entomologist, U.S. Department of Agriculture, Forest Service Forest Health Protection, P.O. Box 7669, Missoula MT 59807.

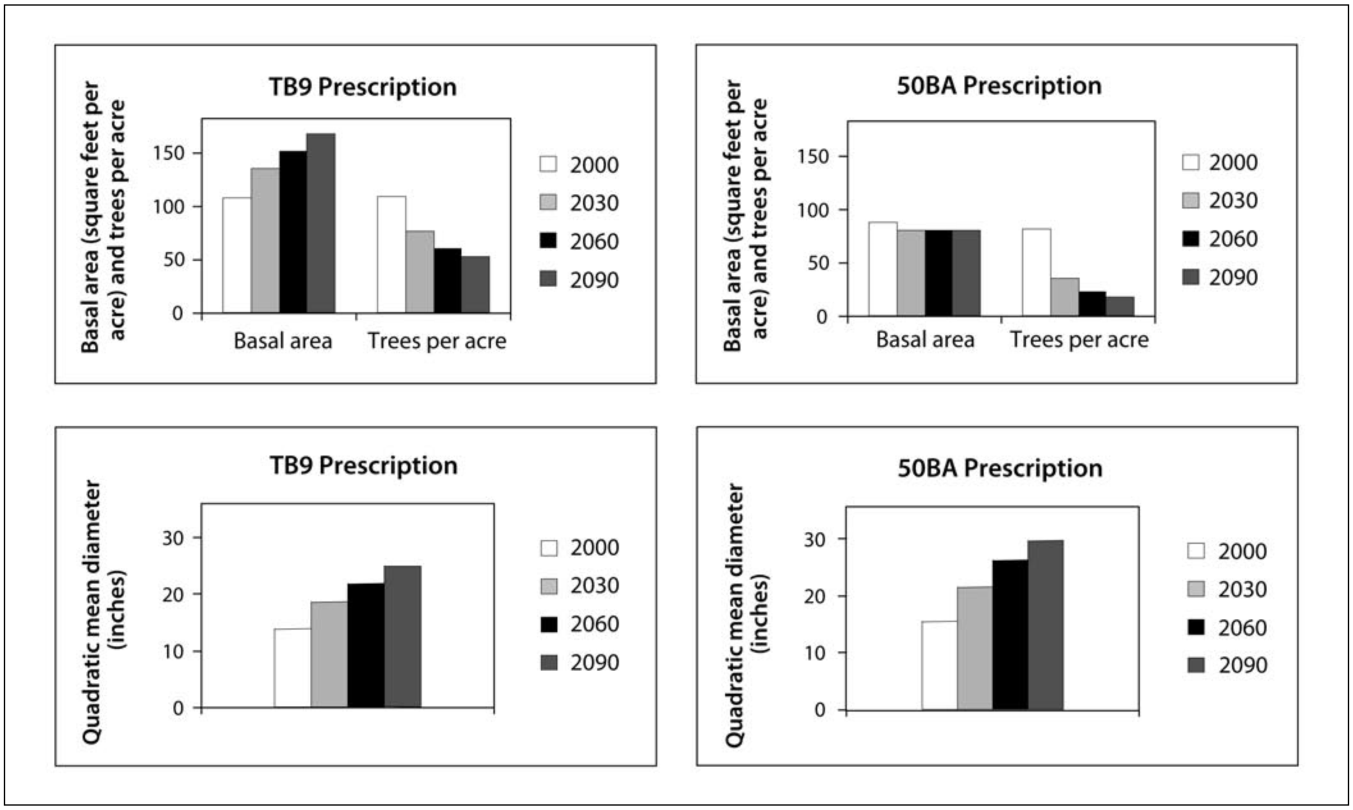

Figure 4—Residual conditions projected for Douglas-fir plots on steep slopes with high fire hazard on national forests in western Montana (average values for thinned plots only): basal area, number of trees per acre, and quadratic mean diameter, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

Merchantable volume by diameter at breast height class—Data for average removed volume of trees 7 in d.b.h. and larger are reported in appendix 5 (tables 22 through 25). As a rule of thumb, sale administrators experienced with small-diameter timber sales typically look for at least 600 ft^3 of removed volume per acre.[7] None of the cases reported for the TB9 prescription yield that much volume, but 12 of the 16 cases under the 50BA prescription did yield at least 600 ft^3/ac in the first entry. In some cases, the merchantable volume in the first entry was more than 1,000 ft^3/ac.

An example of the change in harvest volume for one case by entry is shown in figure 5. The TB9 prescription did not result in any merchantable volume after the first entry, and this was also true for all other cases using this prescription. The greatest volume was removed from the 50BA prescription during the first entry, and the volume removed in the second entry was less than the first in all but one case. In some cases, the volume remained fairly constant over time from the 50BA prescription, but in others it continued to decline as it does in figure 5.

[7] Wynsma, B. 2001. Personal communication. Timber sale administrator, U.S. Department of Agriculture, Forest Service, Idaho Panhandle National Forest, Bonners Ferry Ranger District, Bonners Ferry, ID 83805.

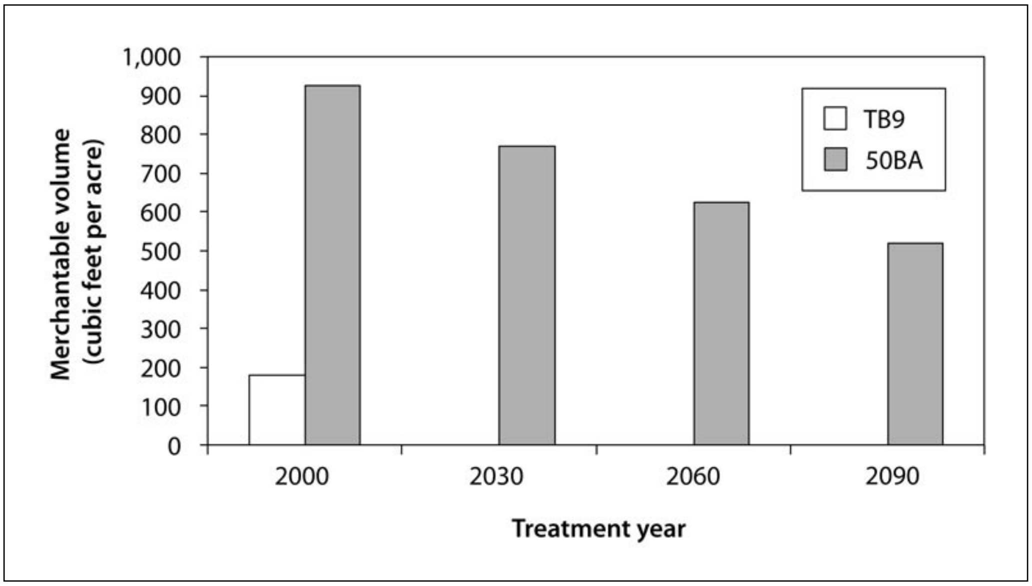

Figure 5—Average merchantable volume projected to be removed from Douglas-fir plots on national forests in western Montana on steep slopes with high fire hazard, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

The characteristics of the volume removed under the 50BA prescription also change considerably over time (fig. 6). At the beginning of the simulation period (2000), most of the volume removed was in the 7- to 10-in and 10- to 13-in d.b.h. classes. By the second entry (2030), almost no volume was in these classes, and most of the volume came from trees greater than 13 in d.b.h. Volume removed during the third and fourth entries came almost exclusively from trees greater than 16 in d.b.h.

Stem biomass volume of trees 1- to 7-in diameter at breast height—Total stem volumes of cut trees less than 7 in d.b.h. are illustrated in figure 7. Under both prescriptions the initial entry yields by far the largest volume of trees in the 1- to 7-in d.b.h. class. After the initial entry, the volume of small trees that were cut sometimes fluctuated with either prescription, but it always remained well below the initial volume. Detailed results for all cases are found in appendix 6 (tables 30 through 33). There currently is not a reliable pulp market in Montana and no biomass market. Assuming a moisture content of 50 percent and a specific gravity of 0.40, these volumes convert to 6 to 10 green tons per acre. This estimate does not include limbs and foliage, so the total biomass could be considerably higher. These trees are either an opportunity or a disposal problem depending on whether markets are developed for them. Analyses like this one might prove useful when considering siting biomass-processing facilities, but scheduling of treatments also is an important issue because most of the volume occurs in the initial entry. Over time the supply of small trees would be expected to decline following broad application of either prescription.

Average small-end diameter of removed logs—The TB9 prescription always produces logs that are only slightly larger than 5 in with small-end diameters ranging from 5.0 to 5.7 in (app. 7, table 38). This happens because the largest merchantable tree removed under this prescription is 9 in d.b.h., and such trees do not yield logs much larger than 5 in SED. With current technology, large volumes of logs in this size range

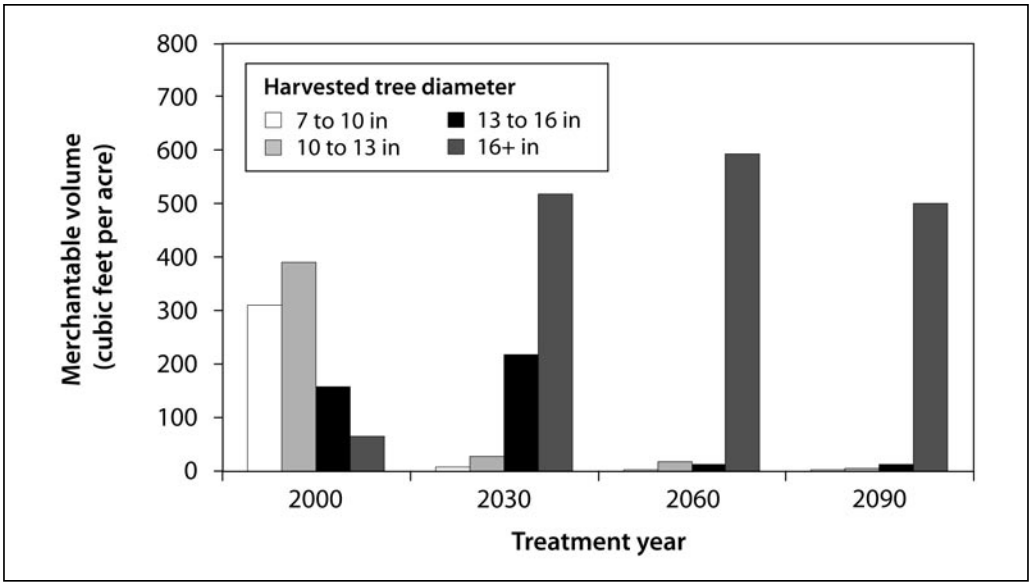

Figure 6—Average merchantable volume projected to be removed from Douglas-fir plots on national forests in western Montana on steep slopes with high fire hazard, by tree diameter at breast height.

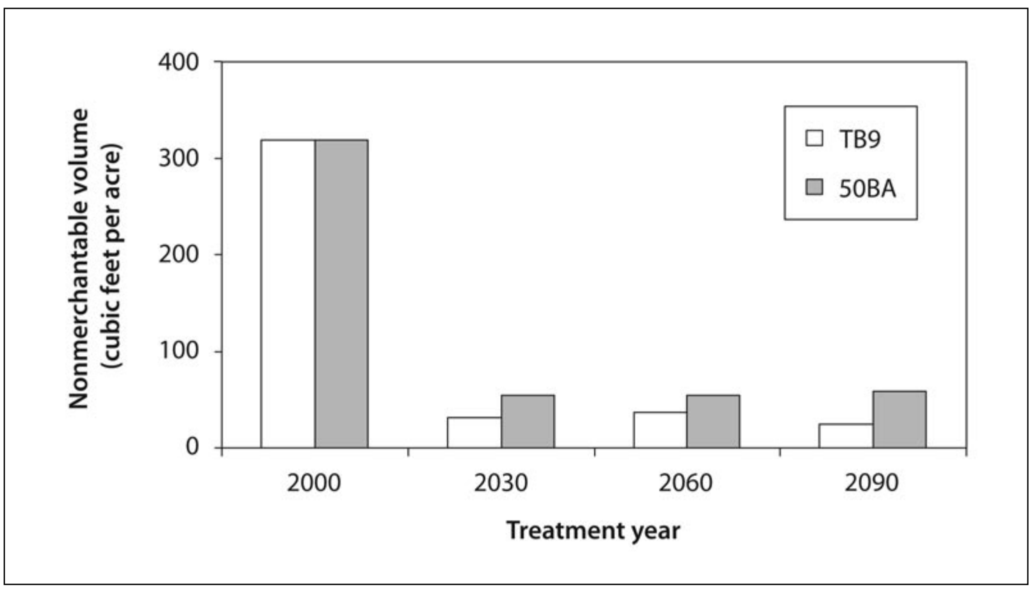

Figure 7—Projected nonmerchantable volume in trees 1- to 7-inch diameter at breast height cut from Douglas-fir plots on national forests in western Montana on steep slopes with high fire hazard, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

would create a problem for conventional solid wood processors because of the inefficiencies of manufacturing either lumber (Barbour 1999) or veneer (Christensen and Barbour 1999). Progress has been made recently in identifying alternative uses for such small-diameter logs, e.g., structural round wood (LeVan-Green and Livingston 2001, Wolfe and Hernandez 1999), but markets are poorly developed.

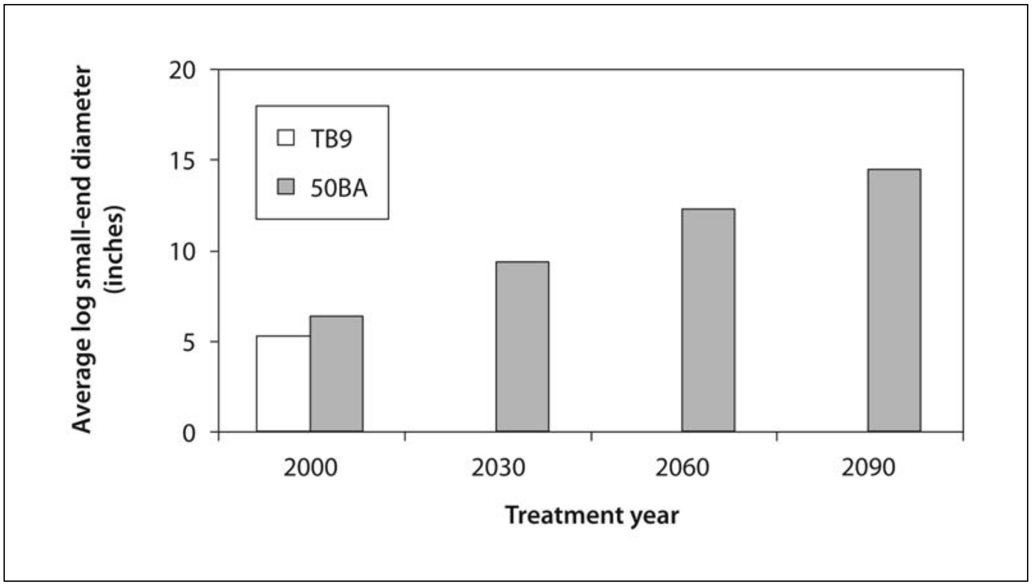

Figure 8—Volume-weighted average log small-end diameters for wood projected to be removed from Douglas-fir plots on national forests in western Montana on steep slopes with high fire hazard, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

Log SED increases over time for the 50BA prescription as expected in light of the comparison of tree sizes (fig. 8). Most cases reach average SEDs of 10 in or more in the third entry, and modern random-length dimension sawmills often process logs that average less than 10 in,[8] so this mix of logs is well suited for many existing mills.

Although the size of the logs increases over time for the 50BA prescription, the average merchantable volume removed decreases by more than one-third over the same period (fig. 5). The actual reduction may be more than shown here because sometimes stands that were thinned in the first cycle do not qualify to be thinned in a subsequent cycle and are excluded from the averages shown in this figure. This means that although the quality of the raw material might increase over time, the quantity could decline depending on the scheduling of treatments within a fixed area.

Percentage of volume removed, by species—In all cases most of the volume removed under both prescriptions is Douglas-fir. Representative results are presented in figure 9. There was little difference in the species composition of the harvested material under the two prescriptions. White wood (true firs, spruce, lodgepole pine, and other minor conifer species) proportion of the harvested volume removed is slightly higher during the first entry than later, but over time there is no real species shift. These results suggest that if species-dependent processing options were established in an area where large-scale fire hazard reduction treatments in Douglas-fir stands were taking place, differences in tree size from the two prescriptions would likely be a more important issue than species mix. Detailed results for all cases are found in appendix 8 (tables 40 through 43).

[8] Armstrong, R. 2000. Personal communication. Vice President, USNR Corporation, 558 Robinson Rd., Woodland, WA 98674-9547.

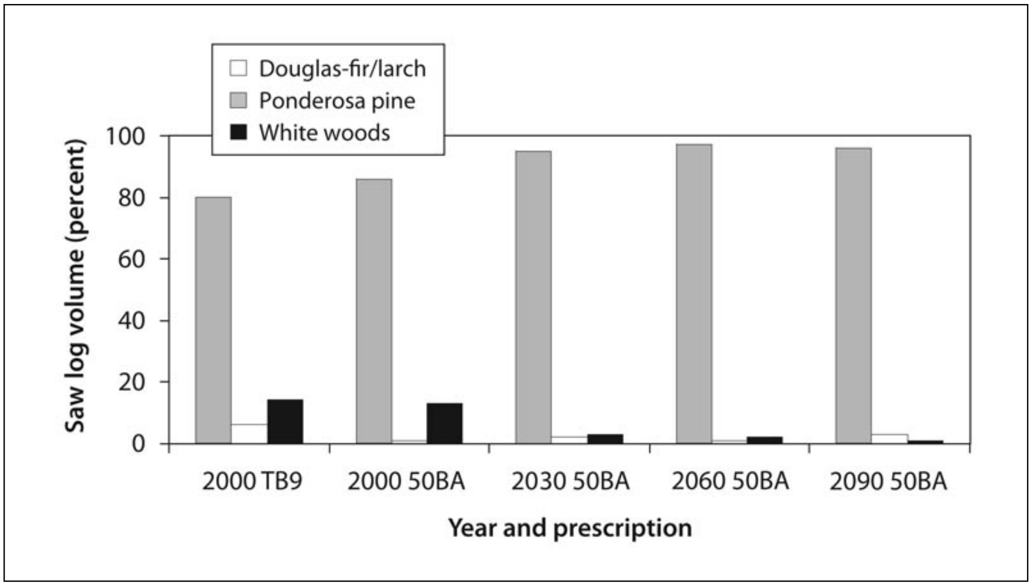

Figure 9—Percentage of saw log volume, by species projected for Douglas-fir plots on national forests in western Montana on steep slopes with high fire hazard. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

Financial analysis—Results from the financial analysis suggest that in many cases the first entry will require a subsidy of $100 or more per acre for either the TB9 or 50BA prescription. In fact, all of the plots treated with the TB9 prescription required at least a $100 per acre subsidy. The situation improved over time under the 50BA prescription (fig. 10). Except for the first entry, no merchantable volume was removed under the TB9 prescription, so activities under that prescription always had negative net returns. These estimates include the costs of treating material that is not economical to use for products. They do not include the costs of prescribed fires, which occur on a 30-year cycle on high-hazard stands whether or not plots are thinned. They also occur on a 30-year cycle on low-hazard stands, but do not start until the beginning of the second cycle. The financial results are summarized for all cases in appendix 9 (tables 48 through 51).

Ponderosa Pine

The total area and number of FIA inventory plots included in this analysis for the ponderosa pine forest type are shown in appendix 2 (table 5). Ponderosa plots were segregated by high/moderate hazard (<50 mph windspeed) and low hazard (50+ mph windspeed) for the analysis presented here. For brevity, these two groups are referred to as high fire hazard and low fire hazard in all of the tables for this species.

Treatment effect on fire hazard—Regression analysis indicated both a time trend (positive coefficient on decade) and a cyclical treatment effect (positive coefficients for the decade of treatment and the decade following treatment) on average crowning index for the 50BA prescription in the ponderosa pine high-hazard plots. This means that each subsequent entry brought the crowning index higher (a lower hazard) than the previous entry. The results from the ponderosa pine high-hazard plots using the TB9 prescription showed no trend for improvement over time, and there was only a small effect in the decade following treatment. The effect is small enough that the

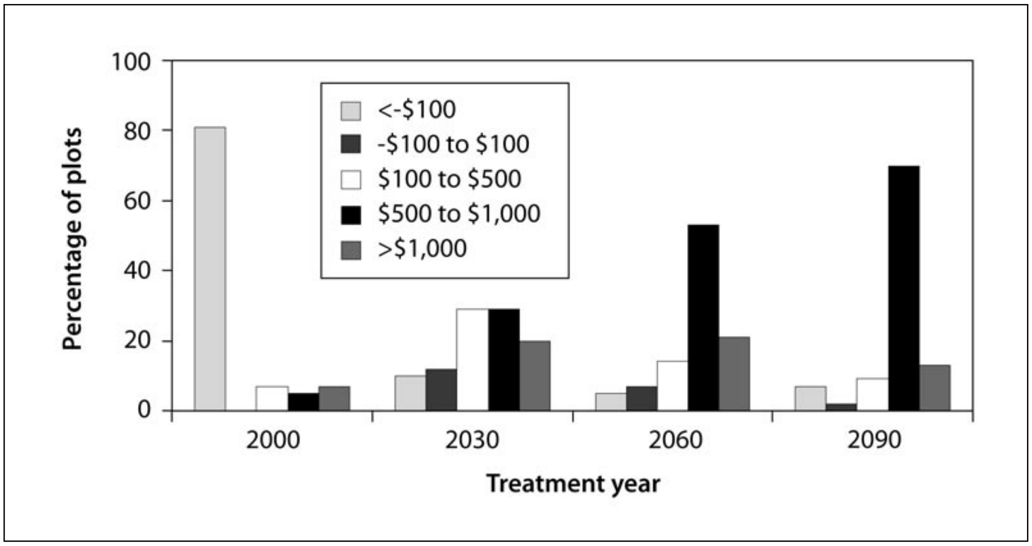

Figure 10—Net value per acre projected for the 50BA prescription from Douglas-fir plots on national forests in western Montana on steep slopes with high fire hazard.

hazard index hovers around 50 mph throughout the 10-decade period. These comparisons are clearly seen in a plot of the predicted average value for fire hazard index in figure 11.

Figure 12 shows an analogous comparison for the predicted average basal area mortality from prescribed burns. In spite of the fact that the effects of the two prescriptions on crowning index are quite different, their effects on potential basal area mortality are strikingly similar. This means that even though the likelihood that trees will carry a crown fire is different for each prescription, the ability of the trees to withstand prescribed fire is similar, with expected basal area mortality dropping to around 5 percent in both cases over the projection period. This result suggests that by the 10^{th} decade of the simulation, both prescriptions create stand conditions where trees are relatively resilient to low-intensity fires.

Initial stand summary—The initial stand conditions for high- and low-fire-hazard cases differ systematically when paired by geographic region, owner, and slope. The low-hazard cases consistently have lower basal area, fewer trees per acre, and larger quadratic mean diameters (app. 3, tables 10 through 13). Typical comparisons are shown for both national forest land and other forest land in western Montana (fig. 13).

Residual stand summary—The results presented in figure 14 illustrate how stand conditions changed over time for ponderosa pine plots. Although the results shown in the figure are for Forest Service land in western Montana, they are similar to those for other ownerships and geographic regions in Montana (app. 4, tables 18 through 21). Our analysis suggests that when repeatedly applied over the course of a century, the 50BA prescription will result in less-crowded stand conditions with fewer but larger trees than the TB9 prescription.

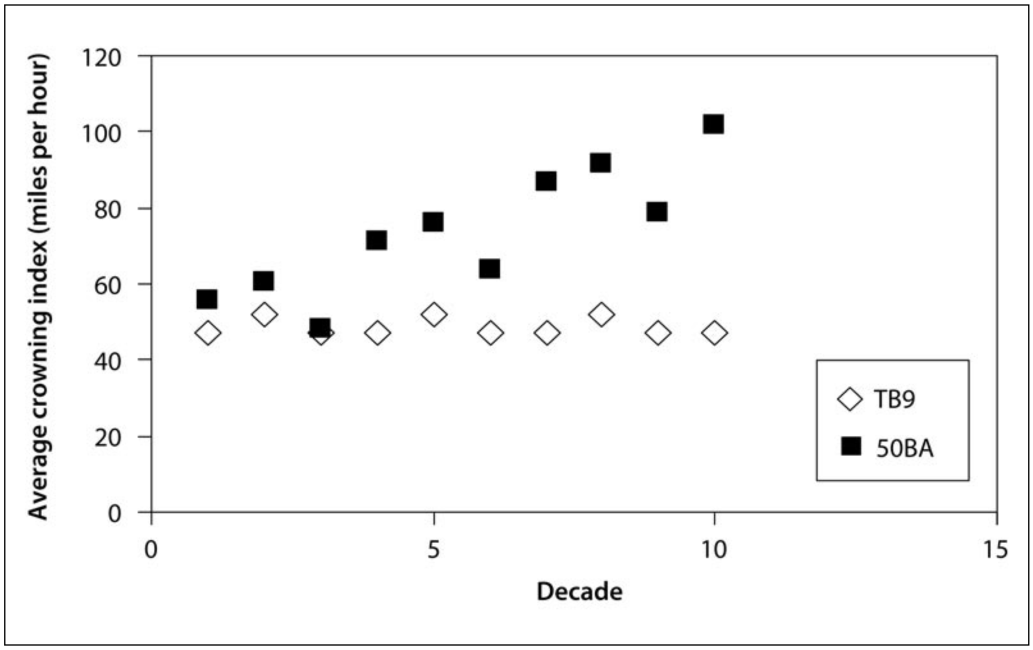

Figure 11—Predicted average crowning index for high-fire-hazard ponderosa pine plots in Montana, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

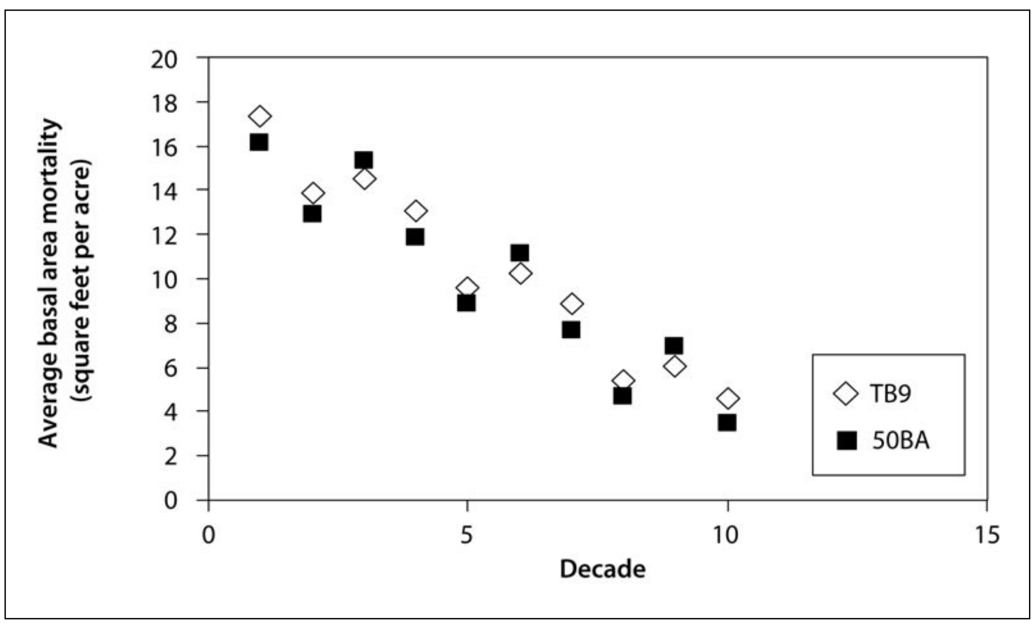

Figure 12—Predicted average basal area mortality for high-fire-hazard ponderosa pine plots in Montana, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

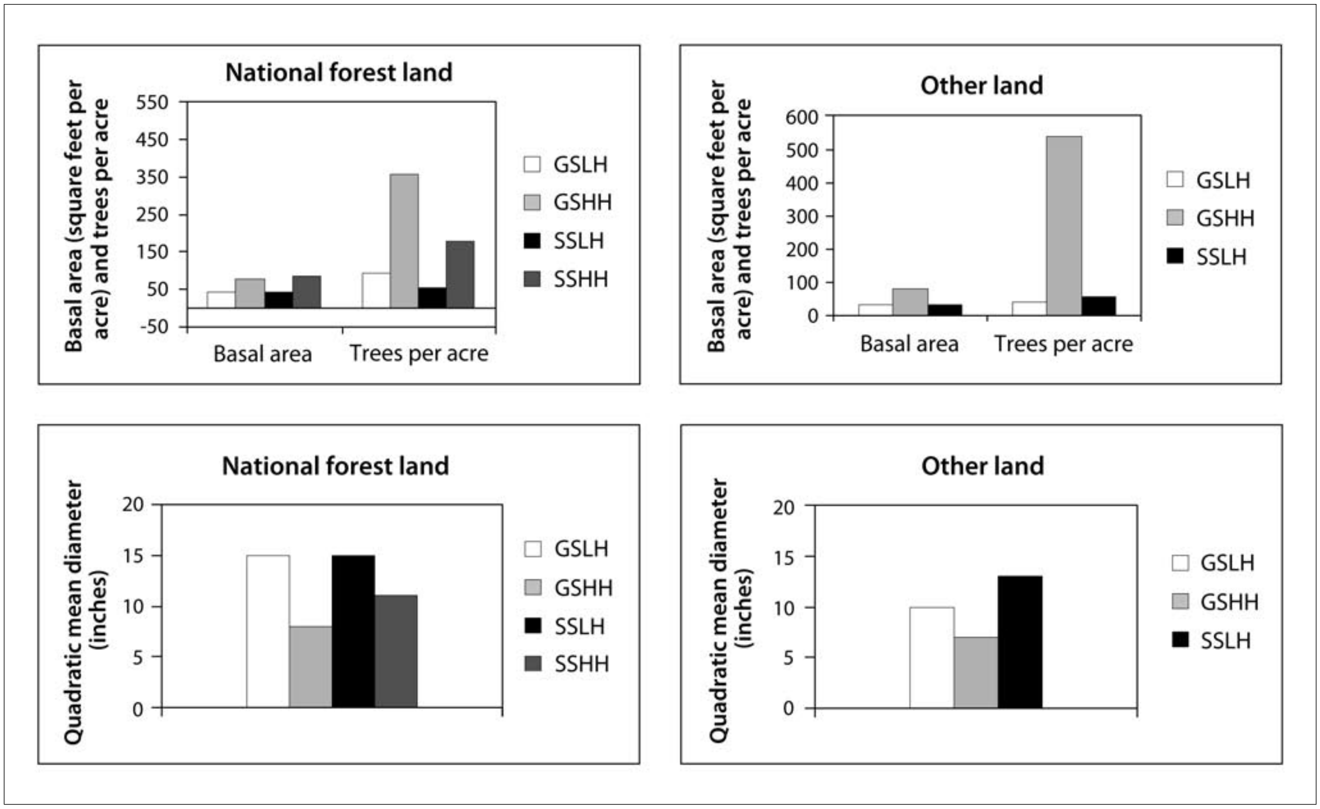

Figure 13—Initial stand conditions for ponderosa pine plots in western Montana: basal area, number of trees per acre, and quadratic mean diameter, reported by gentle slope low or high fire hazard (GSLH or GSHH) and steep slope low or high fire hazard (SSLH or SSHH).

As with Douglas-fir, the diameter-limited prescription (TB9) resulted in an accumulation of basal area over time, whereas the basal-area-controlled prescription (50BA) reduced basal area to the minimum value for this forest type,[9] and kept it there throughout the simulation. Basal areas in plots treated under the TB9 prescription reach an average of 90 ft^2/ac in the second or third treatment cycle, and after a century they were all over 100 ft^2/ac. These plots are reaching the combinations of age and basal area where they would be considered at risk for attack by mountain pine beetles (*Dendroctonus ponderosae* Hopkins) and western pine beetles (*D. brevicomis* Le Conte) (see footnote 6). If such regimes are followed on a large proportion of the landscape, extensive insect outbreaks could eventually become a problem.

Merchantable volume by tree diameter at breast height class—Data for average removed merchantable volume of trees 7 in d.b.h. and larger are reported in appendix 5 (tables 26 through 29). As with Douglas-fir, cut volumes were not high. In 7 of the 13 cases where there were sufficient data to conduct the analysis, more than 600 ft^3/ac was removed under the 50BA prescription for at least one entry. Five of those cases yielded more than 600 ft^3/ac in more than one entry. In contrast, harvested volume never averaged more than 150 ft^3/ac under the TB9 prescription.

[9] Basal areas of 50 ft^2/ac in western Montana and 40 ft^2/ac in eastern Montana.

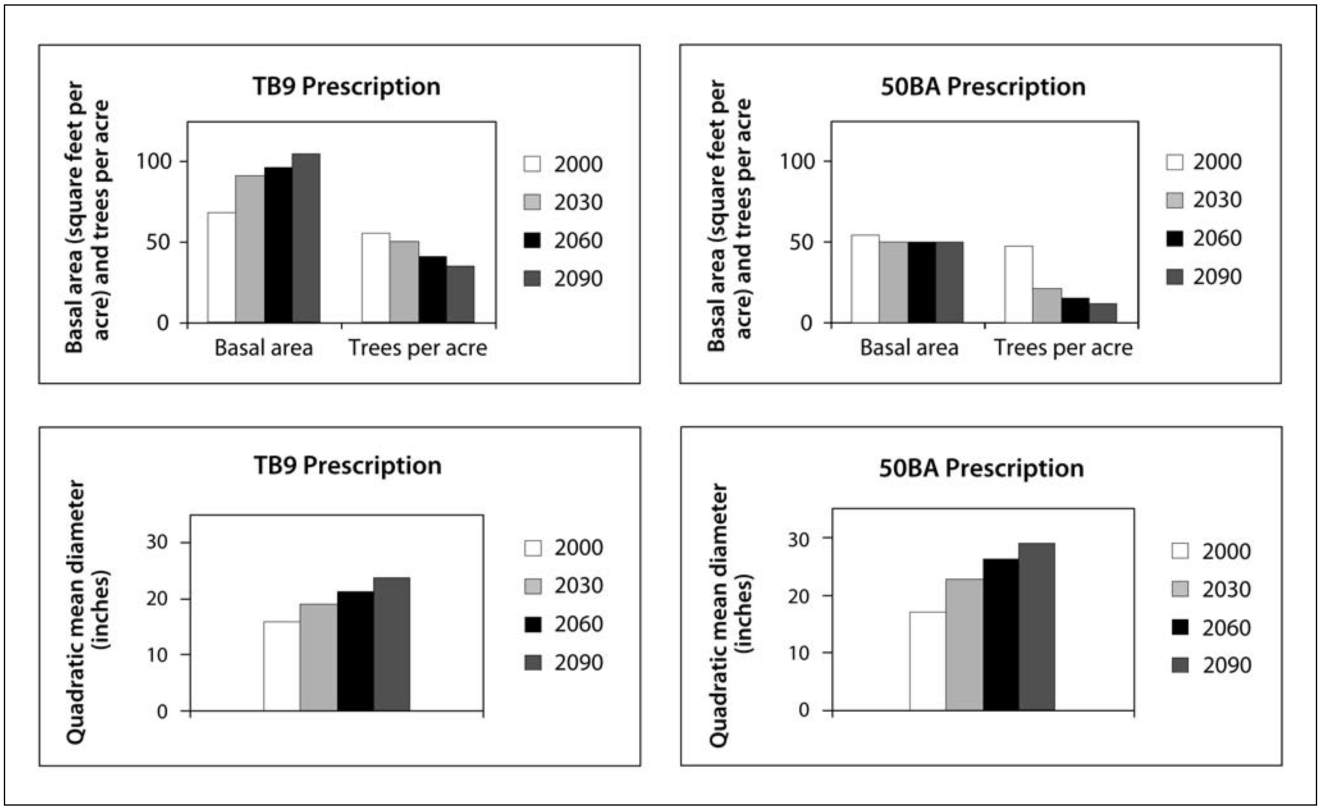

Figure 14—Residual conditions projected for ponderosa pine plots on steep slopes with high fire hazard on national forests in western Montana (average values for thinned plots only): basal area, number of trees per acre, and quadratic mean diameter, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

An example of the change in harvest volume for one case by entry is shown in figure 15. The TB9 prescription did not result in measurable merchantable volume after the first entry. This was true for all cases analyzed for ponderosa pine both in eastern and western Montana. The greatest volume was removed from the 50BA prescription during the first entry, and the volume removed in subsequent entries declined. Trees in all diameter classes were removed during the first entry (fig. 16). In subsequent entries, volume was almost exclusively removed in the largest diameter class (16+ in at d.b.h.). This is a fairly common result in the other cases for ponderosa pine regardless of ownership, geographic location, or slope class.

Stem biomass volume of trees 1 to 7 in diameter at breast height—As with Douglas-fir, the initial entry for both prescriptions yielded by far the largest volume of trees in the 1- to 7-in d.b.h. class. Characteristic results for the total stem volume of trees less than 7 in d.b.h. are illustrated in figure 17. The volume cut in this size class ranged from about 160 ft^3/ac to more than 350 ft^3/ac in the initial entry and between 50 and 150 ft^3/ac in subsequent entries (app. 6, tables 34 through 37). After the initial entry, the volume of small trees cut was generally lower for the TB9 prescription and volumes from both prescriptions sometimes fluctuated, but they always remained well below the initial volume. Because there are few markets in Montana for trees less than 7 in d.b.h., most of this material would be either cut and treated in place or cut and left at the landing.

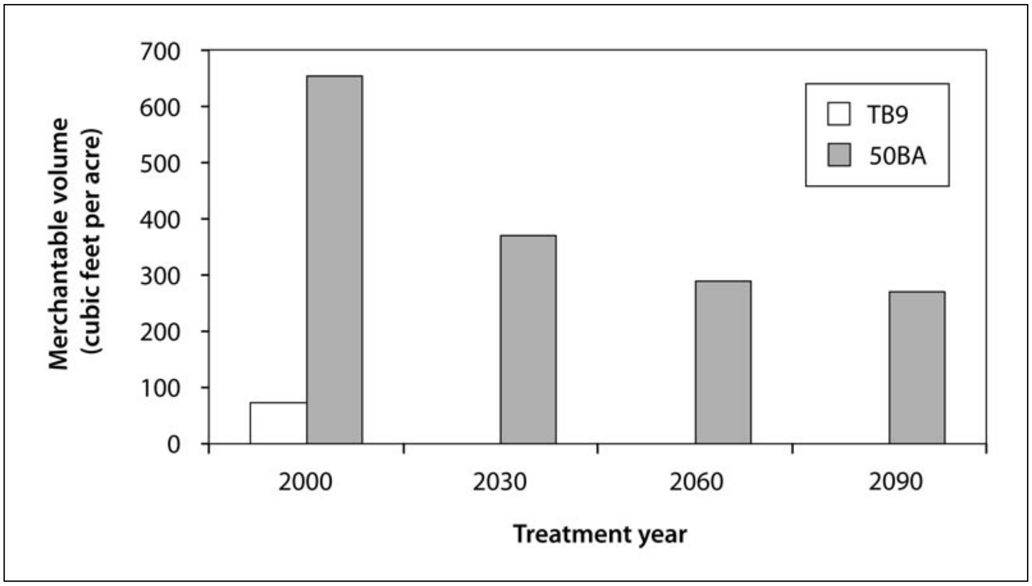

Figure 15—Average merchantable volume projected to be removed from ponderosa pine plots on national forests in western Montana on steep slopes with high fire hazard, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

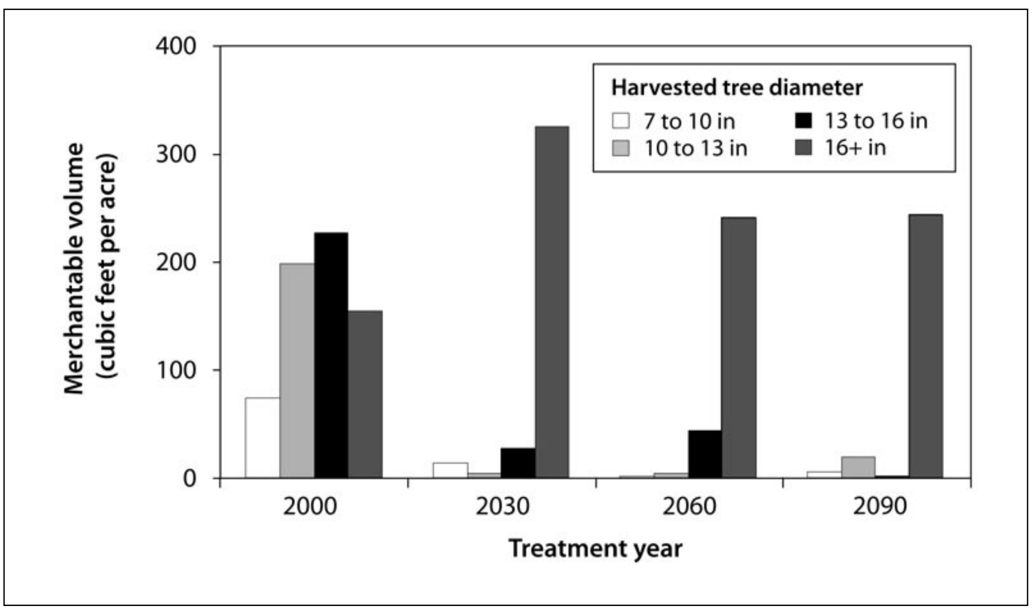

Figure 16—Average merchantable volume projected to be removed from ponderosa pine plots on national forests in western Montana on steep slopes with high fire hazard, by tree diameter at breast height.

Average small-end diameter of removed logs—Results for average SED for one ponderosa pine case are shown in figure 18. As with Douglas-fir plots, the TB9 prescription always produces logs that are only slightly larger than 5 in on the small end (5.0 to 5.7 in) (see appendix 7 table 39). Processing problems for logs this size were

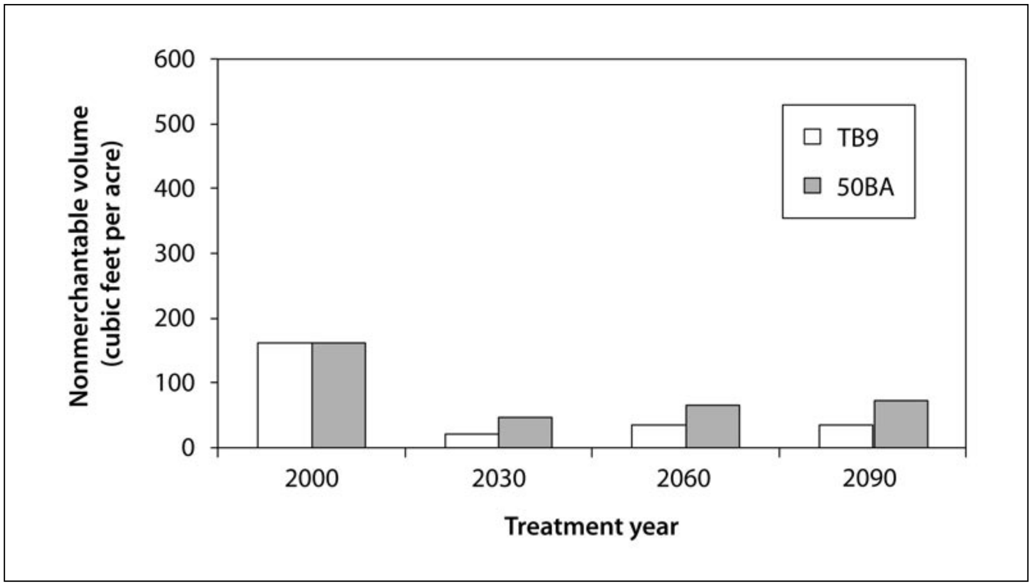

Figure 17—Projected nonmerchantable volume in trees 1- to 7-inch diameter at breast height cut from ponderosa pine plots on national forests in western Montana on steep slopes with high fire hazard, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

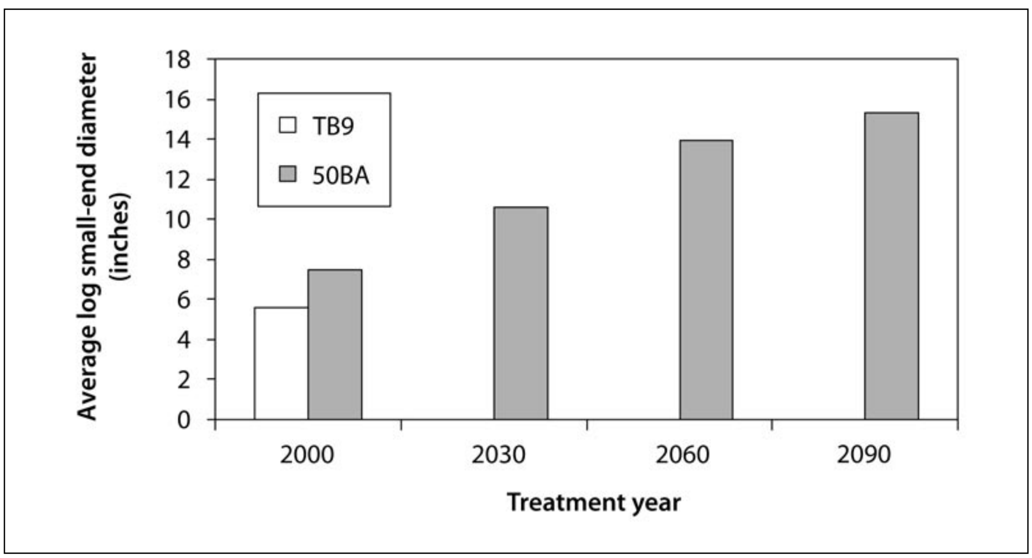

Figure 18—Volume-weighted average log small-end diameters for wood projected to be removed from ponderosa pine plots on national forests in western Montana on steep slopes with high fire hazard, by prescription. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

already discussed for Douglas-fir, but the problem is even more pronounced for ponderosa pine because dimension lumber is a poor option for this material (Lowell and Green 2001).

Log SED increases over time for the 50BA prescription, often averaging greater than 15 in. If logs in these diameter classes were to become available, they would almost certainly find markets. They are small enough to be accommodated by newer high-technology mills, yet large enough, and in this situation old enough, that reasonable yields of higher valued appearance grades (particularly Factory grades) of lumber might be expected from them (Lowell and Green 2001, Plank 1982, Willits 1994).

As with Douglas-fir, there was a tradeoff between log size and average merchantable volume removed. In the example shown in figures 15 and 17, volume removed declined by almost one-half between the first and the last entry. This means that over time the timber volume removed to maintain low fire hazard might decrease but the value of wood products might increase.

Percentage of volume removed by species—Ponderosa pine was the most abundant species removed from the ponderosa pine plots (app. 8, tables 44 through 47). The results in figure 19 for the TB9 prescription show one of the few entries in any case where pine was not the major contributor of removed volume. The results shown for the 50BA prescription are far more characteristic. There was a moderate shift in species because the amounts of Douglas-fir and white woods removed tended to decline rapidly with successive thinnings, so timber removed after the first entry was about 80 percent pine.

Financial analysis—Results from the financial analysis are also similar to those for Douglas-fir. They suggest that in many cases the first entry will require a subsidy of $100 or more per acre for either the TB9 or 50BA prescription. In fact, all of the plots treated with the TB9 prescription required at least a $100 subsidy. Except for the first entry, no merchantable volume was removed under the TB9 prescription, so activities under that prescription always had negative net returns. The situation improved over time under the 50BA prescription (fig. 20). During the first entry a mix of diameters were removed (fig. 16), but nearly 60 percent of the plots had negative net returns. In the subsequent entries almost all of the removed volume was from trees greater than 16 in d.b.h. Many of these entries had a positive net return. These estimates include the cost of treating material that is not economical to use for products. They do not include the cost of prescribed fire, which occurs on a 30-year cycle on high-hazard stands whether or not plots are thinned. Fires are also prescribed on a 30-year cycle on low-hazard stands, but not until the beginning of the second cycle. The financial results are summarized for all cases in appendix 9 (tables 52 through 55).

Conclusion

In this report we demonstrate the use of existing tools and database manipulations to evaluate fire hazard treatments for large landscapes. The data needed to conduct these analyses are available from the USDA Forest Service FIA Program for most forested areas in the United States. Finer scale analyses can also be performed by using these analytical methods if a systematic inventory is available. Both TB9 and 50BA prescriptions improved the fire hazard rating over the initial conditions, but the 50BA prescription was more effective. The 50BA prescription further reduced fire hazard with each sequential entry, whereas the TB9 prescription merely lowered fire hazard rating and kept it there with subsequent treatments. The residual stands from the two prescriptions were also quite different, and these differences increased over time. The most noticeable difference was the accumulation of basal area under the TB9 prescription. Over the course of many decades, the two prescriptions will create very different structural conditions in stands with identical initial conditions. The 50BA

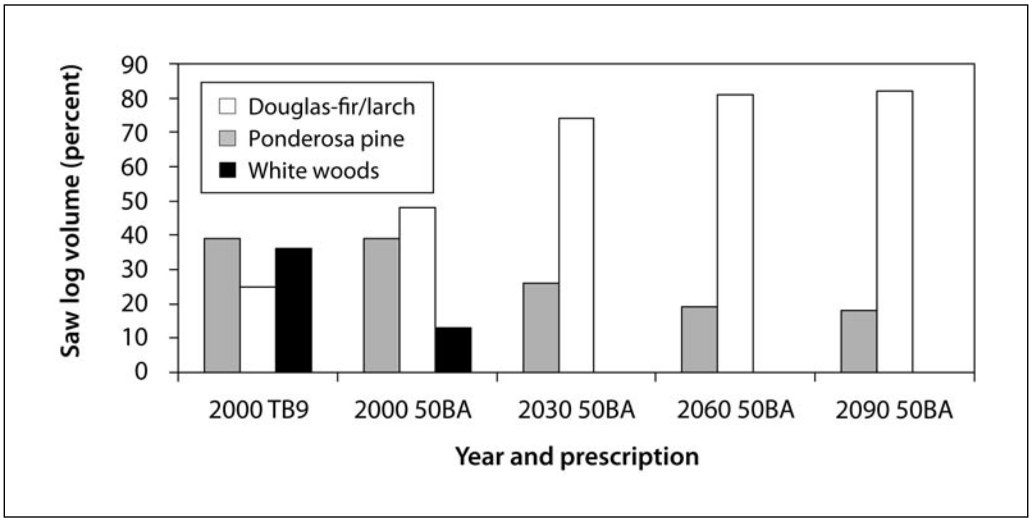

Figure 19—Percentage of saw log volume by species projected for ponderosa pine plots on national forests in western Montana on steep slopes with high fire hazard. TB9 = thin from below to 9 inches diameter at breast height. 50BA = thin from below to 50 percent of basal area.

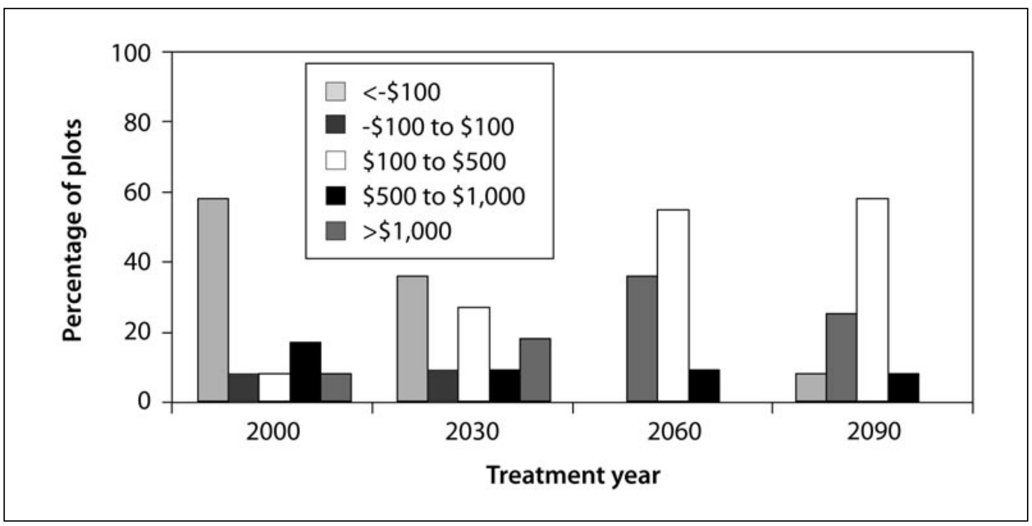

Figure 20—Net value per acre for the 50BA prescription projected for ponderosa pine plots on national forests in western Montana on steep slopes with high fire hazard. 50BA = thin from below to 50 percent of basal area.

prescription resulted in less dense stands with fewer, but larger, trees than did the TB9 prescription. Neither prescription, as written, makes a provision for recruitment of young trees into the overstory, so this aspect of the prescriptions would need to be changed if they were used operationally.

The TB9 prescription never produces substantial amounts of merchantable timber, and after the first entry it does not produce any merchantable timber. The 50BA prescription produces merchantable timber at every entry, and the size of the trees removed increases with each subsequent entry, although volume declines with time.

Both prescriptions yield moderate amounts (usually 100 to 400 ft^3/ac) of small trees (<7 in d.b.h.) in the first entry, but in later entries they produce much less of this small timber. This is primarily a result of prescribed burning following each entry. Without the prescribed burns, small trees would probably be more abundant. The results suggest that if an interim solution to the excess fuel problem were to establish some type of biomass utilization industry and a wide-scale prescribed burning schedule were implemented in stands after the initial fuel reduction treatment, it would be important to plan for a declining volume of small-diameter timber over time regardless of which prescription was used.

Only small sawlogs are produced from the TB9 prescription, and none are produced after the first entry. Finding a market for these logs is likely to be difficult. The 50BA prescription produces larger logs, and their size increases over time. The fact that there was no species shift over time suggests that size presents a more important planning issue for processors than species mix.

Financial analyses suggest that at least initially, the two prescriptions examined here will require subsidies to implement in a large proportion of Montana even without considering the cost of the prescribed fire treatments. The results also suggest that by using prescriptions like the 50BA prescription, the situation could improve with time. Even though there are situations where this prescription could be applied with a positive net return, there are many land use restrictions or other constraints that were not accounted for in our analysis. It seems likely that any large-scale program will treat a mix of stands with both positive and negative net returns and that it will not be possible or even desirable to simply search the landscape for those stands where a positive return is likely. If prescriptions are limited to ones similar to those evaluated here, the number of instances where negative returns were projected suggests that any large-scale fuels reduction program will likely require substantial subsidies.

Metric Equivalents

When you know	Multiply by:	To find:
Acres (ac)	0.41	Hectares
Inches (in)	2.54	Centimeters
Feet (ft)	.3048	Meters
Square feet (ft^2)	.093	Square meters
Cubic feet (ft^3)	.028	Cubic meters
Cubic feet per acre (ft^3/acre)	.06997	Cubic meters per hectare
Square feet per acre (ft^2/acre)	.229	Square meters per hectare
Miles per hour (mph)	1.61	Kilometers per hour
Pounds per cubic foot (lb/ft^3)	16.03	Kilograms per cubic meter
Tons per acre (t/acre)	2.24	Tonnes or megagrams per hectare

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Acronym Glossary

d.b.h.—Diameter at breast height

FEEMA—Financial evaluation of ecosystem management activities

FFE—Fire and fuels extension

FIA—Forest inventory and analysis

FVS—Forest vegetation simulator

QMD—Quadratic mean breast-height diameter

SED—Small-end diameter of logs

TCT—Technical contact team: advisory groups representing state, private, and federal forest managers. Representatives were staff or administrators with state or regionwide responsibility.

TB9—Thin from below to 9 inches d.b.h. with a minimum residual basal area

50BA—Thin from below up to 50 percent of standing basal area with a minimum residual basal area

Appendix 1: Cost and Log Price Assumptions

Cost assumptions are for harvesting, hauling, and treating unutilized trees. Ground-based harvesting systems are assumed for gentle slopes (<35 percent). Cable systems are assumed for steep slopes. Harvesting costs used differ by tree size and volume per acre that is harvested. An average hauling cost of $28 per hundred cubic feet was used for all cases. Log prices used are for a mixed log market. Because of the tendency for high-cost wood to be the last supply to enter the market in good times and the first supply to leave the market in bad times, there are bound to be periods of lower prices where net revenues will be significantly less favorable than we report (tables 1 through 3).

Table 1—Harvesting costs

Tree diameter at breast height	Volume harvested (cubic feet per acre)			
	400	**700**	**1,000**	**1,500**
Inches	*- - - - Dollars per 100 cubic feet - - - -*			
Gentle slope:				
6	83	81	79	76
8	74	72	71	68
10	66	64	62	59
12	57	55	53	50
14	48	46	44	41
16	48	46	44	41
Steep slope:				
6	172	134	123	114
8	162	125	113	104
10	153	115	104	95
12	143	109	94	85
14	136	106	89	82
16	134	103	86	78

Table 2a—Costs for treating unutilized trees by slashing[a]

Number of trees	Dollars per acre
<300	105
300 to 1,000	225
1,000 to 2,000	250
>2,000	280

[a] Cost of slashing, and treating trees less than 4 inches diameter at breast height.

Table 2b—Costs for treating unutilized trees by yarding[a]

Slope	Dollars per 100 cubic feet
Gentle	80
Steep	130

[a] Cost of skidding/yarding unutilized trees greater than 4 inches at breast height.

Source: Data were provided (8-8-2001) by Bureau of Business and Economic Research, University of Montana.

Table 3—Log prices for Montana

Small-end diameter	Douglas-fir and larch	Hemlock and fir	Ponderosa pine	Lodgepole pine
Inches	*- - - - - - - - - Dollars per 100 cubic feet - - - - - - - - -*			
7	169	132	132	143
8	189	147	189	161
10	227	178	227	197
12	265	208	265	233
14	304	238	304	268
16	342	269	342	280
17	360	284	361	280
18	360	290	370	280

Source: Developed from data provided (8-8-2001) by the Bureau of Business and Economic Research, University of Montana.

Appendix 2: Acreage and Number of Inventory Plots

The number of forest inventory plots and the number of acres that they represent for each case (a combination of forest type, region, ownership, fire hazard, and slope) for which we report results are shown in tables 4 and 5.

Table 4—Acreage and number of inventory plots for the Douglas-fir forest type in Montana

Land type	Acres	Number of plots
Western Montana:		
National forest land—		
Steep slope, high fire hazard	1,110,929	50
Gentle slope, high fire hazard	391,177	50
Steep slope, low fire hazard	377,362	50
Gentle slope, low fire hazard	180,592	29
Subtotal	2,060,060	
Other land—		
Steep slope, high fire hazard	320,337	50
Gentle slope, high fire hazard	681,644	50
Steep slope, low fire hazard	247,955	44
Gentle slope, low fire hazard	582,582	50
Subtotal	1,832,518	
Eastern Montana:		
National forest land—		
Steep slope, high fire hazard	788,983	50
Gentle slope, high fire hazard	397,766	50
Steep slope, low fire hazard	196,576	31
Gentle slope, low fire hazard	177,926	28
Subtotal	1,561,251	
Other land—		
Steep slope, high fire hazard	394,057	50
Gentle slope, high fire hazard	322,964	50
Steep slope, low fire hazard	56,647	10
Gentle slope, low fire hazard	241,519	38
Subtotal	1,015,187	
Total	6,469,016	

Table 5—Acreage and number of inventory plots for the ponderosa pine forest type in Montana

Land type	Acres	Number of plots
Western Montana:		
National forest land—		
Steep slope, high fire hazard	74,843	10
Gentle slope, high fire hazard	62,709	11
Steep slope, low fire hazard	57,627	12
Gentle slope, low fire hazard	43,472	10
Subtotal	238,651	
Other land—		
Steep slope, high fire hazard	—	<10
Gentle slope, high fire hazard	194,724	28
Steep slope, low fire hazard	73,065	12
Gentle slope, low fire hazard	119,736	20
Subtotal	387,525	
Eastern Montana:		
National forest land—		
Steep slope, high fire hazard	24,137	13
Gentle slope, high fire hazard	222,140	32
Steep slope, low fire hazard	—	<10
Gentle slope, low fire hazard	—	<10
Subtotal	246,277	
Other land—		
Steep slope, high fire hazard	261,392	32
Gentle slope, high fire hazard	840,053	46
Steep slope, low fire hazard	167,702	26
Gentle slope, low fire hazard	565,328	39
Subtotal	1,834,475	
Total	2,706,928	

— = not available.

Appendix 3: Average Initial Stand Characteristics

Average basal area, average trees per acre, and average quadratic mean diameter were all calculated for trees 1 in diameter at breast height and larger. The standard errors for each variable also are reported. It is important to recognize that these data represent average stand conditions, and it is not possible to calculate the third variable from the other two as can be done for a single stand (tables 6 through 13).

Table 6—Average initial stand characteristics for the Douglas-fir forest type in western Montana, national forest land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1993	Gentle slope, low hazard	Mean	63	129	10.5
		SE[d]	10	22	.8
1993	Gentle slope, high hazard	Mean	117	586	6.7
		SE	8	62	.3
1993	Steep slope, low hazard	Mean	51	102	11.0
		SE	4	11	.8
1993	Steep slope, high hazard	Mean	126	451	8.0
		SE	8	51	.4

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 7—Average initial stand characteristics for the Douglas-fir forest type in western Montana, other land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1989	Gentle slope, low hazard	Mean	48	142	8.0
		SE[d]	6	22	.7
1989	Gentle slope, high hazard	Mean	124	656	6.9
		SE	8	79	.4
1989	Steep slope, low hazard	Mean	60	183	9.5
		SE	4	23	.6
1989	Steep slope, high hazard	Mean	109	594	6.6
		SE	6	59	.3

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 8—Average initial stand characteristics for the Douglas-fir forest type in eastern Montana, national forest land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1997	Gentle slope, low hazard	Mean	58	99	11.3
		SE[d]	6	16	.9
1997	Gentle slope, high hazard	Mean	147	336	9.8
		SE	9	29	.4
1997	Steep slope, low hazard	Mean	55	97	12.3
		SE	6	17	.9
1997	Steep slope, high hazard	Mean	131	451	8.5
		SE	9	60	.5

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 9—Average initial stand characteristics for the Douglas-fir forest type in eastern Montana, other land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1988	Gentle slope, low hazard	Mean	50	88	10.2
		SE[d]	6	13	.8
1988	Gentle slope, high hazard	Mean	123	406	8.7
		SE	7	61	.4
1988	Steep slope, low hazard	Mean	57	148	10.8
		SE	13	52	2.3
1988	Steep slope, high hazard	Mean	115	458	8.0
		SE	6	59	.4

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 10—Average initial stand characteristics for the ponderosa pine forest in western Montana, national forest land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1995	Gentle slope, low hazard	Mean	44	94	14.7
		SE[d]	11	46	3.9
1995	Gentle slope, high hazard	Mean	78	357	8.0
		SE	15	74	1.4
1995	Steep slope, low hazard	Mean	41	53	15.4
		SE	6	15	3.1
1995	Steep slope, high hazard	Mean	84	179	11.0
		SE	8	42	1.0

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 11—Average initial stand characteristics for the ponderosa pine forest type in western Montana, other land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1989	Gentle slope, low hazard	Mean	30	38	10.4
		SE[d]	6	8	1.5
1989	Gentle slope, high hazard	Mean	78	537	6.6
		SE	10	97	.6
1989	Steep slope, low hazard	Mean	33	55	12.8
		SE	5	16	1.3

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 12—Average initial stand characteristics for the ponderosa pine forest type in eastern Montana, national forest land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1997	Gentle slope, high hazard	Mean	80	270	8.0
		SE[d]	12	49	0.6
1997	Steep slope, high hazard	Mean	54	377	8.5
		SE	11	158	1.3

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Table 13—Average initial stand characteristics for the ponderosa pine forest type in eastern Montana, other land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*Number*	*Inches*
1988	Gentle slope, low hazard	Mean	27	44	10.3
		SE[d]	2	5	.6
1988	Gentle slope, high hazard	Mean	75	299	7.7
		SE	5	34	.3
1988	Steep slope, low hazard	Mean	28	65	9.1
		SE	3	9	.7
1988	Steep slope, high hazard	Mean	66	390	6.9
		SE	6	69	.4

Note: Values are averages and cannot necessarily be cross referenced.
[a] BA = basal area.
[b] TPA = trees per acre.
[c] QMD = quadratic mean diameter.
[d] SE = standard error (+/-).

Appendix 4: Average Residual Stand Characteristics

Average residual stand characteristics are intended to provide resource managers with an idea of the composition and structure of residual stands after each thinning entry. These summary statistics were generated by using output from the Forest Vegetation Simulation growth model simulations from the individual forest inventory and analysis plots included in each case. Average basal area, average trees per acre, and average quadratic mean diameter are averages of plot-level results weighted by the expansion factor (the area represented by a plot) for the plot. Trees less than 1 in diameter at breast height were eliminated from this analysis to give a more meaningful representation of the overstory stand conditions.

The major focus of this analysis was the types of raw materials that might be produced from various cutting treatments. As a result, only plots where thinnings were applied in any given entry are included in the analysis presented for residual stand conditions. This makes the information reported in this appendix consistent with the other results included in this report. It is a relatively simple matter to alter the Microsoft Access reports to include any combination of plots so the tables and appendixes could include all plots, only the unthinned plots, or only the thinned plots as reported here (tables 14 through 21).

Table 14—Average residual stand characteristics projected for the Douglas-fir forest type in western Montana, national forest land

Year	R_x[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	119	92	16.9	12	100	69	18.2	9
		SE[g]	10	18	.8	2	6	9	.7	1
	50BA[h]	Mean	85	57	20.8	37	82	40	21.7	32
		SE	3	14	1.3	3	1	5	1.0	3
2060	TB9	Mean	126	54	21.4	7	116	47	22.4	4
		SE	9	5	.8	2	6	3	.6	1
	50BA	Mean	80	25	26.3	26	80	32	25.0	23
		SE	1	4	1.1	2	1	7	.9	1
2090	TB9	Mean	142	41	25.3	5	132	39	25.9	3
		SE	9	3	.7	1	7	3	.6	1
	50BA	Mean	80	20	29.7	22	80	21	29.3	19
		SE	1	3	1.1	1	1	4	.8	1
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	92	100	13.0	32	108	109	13.8	25
		SE	6	6	.3	2	6	7	0.4	2
	50BA	Mean	85	106	13.8	38	87	81	15.4	40
		SE	2	11	.6	2	2	7	.6	2
2030	TB9	Mean	97	72	16.0	7	135	76	18.5	2
		SE	5	4	.4	2	7	5	.4	1
	50BA	Mean	80	66	17.5	20	80	35	21.5	26
		SE	1	10	.7	1	1	2	.6	1
2060	TB9	Mean	111	56	19.2	5	151	60	21.9	4
		SE	5	3	4	1	8	4	.4	1
	50BA	Mean	80	39	21.2	19	80	22	26.3	23
		SE	1	3	.6	1	1	1	.5	1
2090	TB9	Mean	124	48	21.9	3	167	53	24.8	3
		SE	5	2	.4	1	8	3	.5	1
	50BA	Mean	80	26	24.8	18	80	18	29.7	20
		SE	1	2	.6	1	1	1	.5	1

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.

Table 15—Average residual stand characteristics projected for the Douglas-fir forest type in western Montana, other land

Year	Rx[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft^2/acre	*No.*	*Inches*	*Percent*	*Ft^2/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	110	71	17.3	10	103	73	16.9	7
		SE[g]	6	5	.4	1	5	5	.5	1
	50BA[h]	Mean	82	43	20.3	37	80	49	18.8	31
		SE	1	4	.9	3	1	4	.7	2
2060	TB9	Mean	118	57	20.8	6	126	57	20.8	1
		SE	7	6	.6	1	5	3	.5	1
	50BA	Mean	80	45	24.5	23	80	28	24.1	20
		SE	1	18	.9	1	1	2	.7	1
2090	TB9	Mean	130	42	24.2	5	145	48	24.2	1
		SE	1	2	.6	1	6	3	.5	1
	50BA	Mean	80	20	29.0	21	80	20	28.0	17
		SE	1	3	.7	1	1	1	.6	1
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	86	110	12.2	36	78	96	12.2	37
		SE	5	6	.5	3	6	5	.3	2
	50BA	Mean	84	128	13.3	39	83	139	12.0	33
		SE	1	15	.7	2	1	12	.6	2
2030	TB9	Mean	97	69	16.4	7	95	63	16.5	3
		SE	5	4	.4	2	7	4	.3	1
	50BA	Mean	80	59	17.3	22	80	57	17.7	20
		SE	1	6	.7	2	1	5	.8	2
2060	TB9	Mean	106	52	19.4	5	112	51	19.9	2
		SE	5	2	.4	1	8	3	.4	1
	50BA	Mean	80	41	21.4	19	80	35	21.9	20
		SE	1	6	.7	1	1	3	.7	1
2090	TB9	Mean	121	44	22.5	3	124	43	22.8	2
		SE	6	2	.3	1	8	2	.4	1
	50BA	Mean	80	31	24.8	17	80	26	25.7	17
		SE	1	6	.7	1	1	3	.7	1

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.

Table 16—Average residual stand characteristics projected for the Douglas-fir forest type in eastern Montana, national forest land

Year	R_x[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	89	119	12.0	22	93	204	11.3	15
		SE[g]	11	18	0.5	5	10	86	1.0	3
	50BA	Mean	71	64	17.9	32	71	47	20.6	34
		SE	1	15	1.1	3	1	15	1.5	4
2060	TB9	Mean	106	164	10.9	1	113	97	14.6	3
		SE	—	—	—	—	—	—	—	—
	50BA	Mean	70	27	23.2	20	70	26	24.0	15
		SE	1	3	.9	2	1	3	1.4	1
2090	TB9	Mean	110	44	21.5	5	103	38	22.7	4
		SE	6	2	.5	1	8	3	.8	1
	50BA	Mean	70	21	26.7	16	70	20	26.6	15
		SE	1	3	1.0	1	1	2	1.2	1
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	117	119	13.3	27	95	113	12.6	32
		SE	9	7	.5	3	8	8	.5	3
	50BA	Mean	87	84	15.8	43	85	105	14.6	42
		SE	3	10	.7	2	3	14	.9	2
2030	TB9	Mean	136	86	16.9	2	106	69	17.0	2
		SE	10	5	.4	1	10	6	.6	1
	50BA	Mean	70	40	20.1	25	70	36	21.1	20
		SE	1	4	.8	2	1	4	1.4	3
2060	TB9	Mean	145	68	19.6	4	114	55	19.7	3
		SE	10	5	.4	1	11	5	.7	1
	50BA	Mean	70	29	23.2	17	70	30	23.2	15
		SE	1	4	.8	1	1	4	1.3	1
2090	TB9	Mean	155	58	22.2	4	127	47	22.5	3
		SE	11	4	.4	1	11	4	.7	1
	50BA	Mean	70	20	26.4	16	70	22	25.6	15
		SE	1	1	.7	1	1	2	1.0	1

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 17—Average residual stand characteristics projected for the Douglas-fir forest type in eastern Montana, other land

Year	R_x[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	80	106	11.6	3	92	121	11.5	17
		SE[g]	20	23	.5	1	26	6	1.8	8
	50BA[h]	Mean	71	38	20.2	32	73	42	22.4	37
		SE	1	4	1.1	3	2	14	3.0	7
2060	TB9	Mean	68	147	9.1	1	—	—	—	—
		SE	14	18	.4	1	—	—	—	—
	50BA	Mean	70	25	23.7	21	70	18	28.8	22
		SE	1	1	.7	2	1	4	2.7	3
2090	TB9	Mean	123	45	22.6	3	133	35	26.4	6
		SE	4	2	.4	1	17	4	1.7	1
	50BA	Mean	70	18	27.6	19	70	13	34.0	1
		SE	1	1	.6	1	1	3	3.0	1
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	101	106	13.2	28	89	103	12.7	35
		SE	6	6	.3	3	6	7	.3	3
	50BA	Mean	81	86	14.6	42	80	102	13.4	40
		SE	2	8	.5	2	2	9	.5	2
2030	TB9	Mean	120	76	17.0	5	111	74	16.8	4
		SE	7	4	.3	1	7	5	.3	1
	50BA	Mean	71	39	19.9	31	70	42	18.8	23
		SE	1	4	.7	2	1	3	.7	2
2060	TB9	Mean	139	60	20.5	6	130	58	20.7	4
		SE	8	3	.4	1	9	4	.4	1
	50BA	Mean	70	25	24.8	26	70	26	23.4	23
		SE	1	2	.8	1	1	2	.7	1
2090	TB9	Mean	155	49	24.0	6	148	48	23.9	4
		SE	9	3	.5	1	10	3	.6	1
	50BA	Mean	70	17	29.4	25	70	19	28.2	23
		SE	1	1	.9	1	1	2	.8	1

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 18—Average residual stand characteristics projected for the ponderosa pine forest type in western Montana, national forest land

Year	R_x[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft^2/acre	*No.*	*Inches*	*Percent*	*Ft^2/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	80	71	15.0	15	67	36	21.1	9
		SE[g]	13	18	1.1	5	7	8	2.5	4
	50BA[h]	Mean	56	46	17.7	35	50	24	21.0	33
		SE	6	14	2.3	6	1	4	2.0	5
2060	TB9	Mean	97	54	18.7	7	82	30	24.6	6
		SE	13	12	0.9	3	9	6	2.3	2
	50BA	Mean	52	20	23.0	35	50	13	28.2	25
		SE	2	4	1.8	4	1	2	2.1	2
2090	TB9	Mean	112	46	21.7	4	94	27	27.7	4
		SE	12	8	0.9	2	11	6	2.3	1
	50BA	Mean	50	13	27.4	32	50	9	32.5	25
		SE	1	2	1.5	3	1	1	1.9	2
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	72	92	13.4	29	68	55	15.9	21
		SE	11	17	1.6	5	11	9	1.3	6
	50BA	Mean	58	114	14.9	38	54	48	17.1	40
		SE	4	48	2.2	5	2	13	1.5	4
2030	TB9	Mean	90	63	17.1	9	91	50	19.0	3
		SE	11	8	1.4	4	11	7	1.1	1
	50BA	Mean	52	33	20.7	38	50	21	22.7	24
		SE	1	10	1.9	3	1	4	1.5	3
2060	TB9	Mean	112	52	20.7	4	96	41	21.3	5
		SE	11	6	1.2	1	11	5	1.0	1
	50BA	Mean	50	16	26.0	36	50	15	26.3	23
		SE	1	3	1.5	3	1	2	1.4	1
2090	TB9	Mean	130	46	23.6	3	105	35	23.8	3
		SE	12	5	1.2	1	12	4	1.0	1
	50BA	Mean	50	11	30.1	31	50	12	28.8	22
		SE	1	1	1.4	2	1	2	1.5	1

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.

Table 19—Average residual stand characteristics projected for the ponderosa pine forest type in western Montana, other land

Year	Rx[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	70	42	17.9	9	78	43	20.3	8
		SE[g]	7	4	.9	1	6	9	1.4	2
	50BA[h]	Mean	52	26	21.0	37	52	20	23.2	36
		SE	1	5	1.4	4	2	3	1.5	4
2060	TB9	Mean	85	45	21.1	9	93	34	24.0	4
		SE	7	8	1.4	2	8	6	1.4	1
	50BA	Mean	50	25	26.0	37	50	13	28.5	30
		SE	1	11	1.6	2	1	2	1.5	3
2090	TB9	Mean	105	34	26.0	6	108	29	27.9	3
		SE	8	6	1.5	2	9	5	1.4	1
	50BA	Mean	50	31	29.5	29	50	8	33.8	26
		SE	1	13	2.2	2	1	1	1.4	2
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	71	74	13.2	34	—	—	—	—
		SE	8	6	.5	4	—	—	—	—
	50BA	Mean	60	68	14.2	42	—	—	—	—
		SE	3	7	.8	2	—	—	—	—
2030	TB9	Mean	100	53	18.7	10	—	—	—	—
		SE	8	4	.4	2	—	—	—	—
	50BA	Mean	55	22	22.4	44	—	—	—	—
		SE	2	1	.7	1	—	—	—	—
2060	TB9	Mean	126	44	23.1	3	—	—	—	—
		SE	8	3	.5	1	—	—	—	—
	50BA	Mean	51	12	28.6	38	—	—	—	—
		SE	1	1	.7	2	—	—	—	—
2090	TB9	Mean	146	38	26.7	2	—	—	—	—
		SE	9	2	.5	1	—	—	—	—
	50BA	Mean	50	9	33.5	33	—	—	—	—
		SE	1	1	.8	1	—	—	—	—

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 20—Average residual stand characteristics projected for the ponderosa pine forest type in eastern Montana, national forest land

Year	R_x[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft^2/acre	*No.*	*Inches*	*Percent*	*Ft^2/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	—	—	—	—	—	—	—	—
		SE[g]	—	—	—	—	—	—	—	—
	50BA[h]	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	85	98	12.9	28	43	54	12.6	42
		SE	11	12	.5	2	3	7	1.2	9
	50BA	Mean	62	59	14.6	46	50	76	12.8	40
		SE	6	7	.6	2	5	19	1.8	6
2030	TB9	Mean	87	61	16.2	11	71	41	18.5	10
		SE	11	8	.6	4	5	5	.9	2
	50BA	Mean	47	43	18.1	40	44	21	20.8	44
		SE	3	11	1.0	2	2	2	1.2	2
2060	TB9	Mean	90	55	18.1	14	89	32	22.8	6
		SE	11	8	.9	2	7	3	.8	2
	50BA	Mean	42	29	20.6	32	40	10	28.0	43
		SE	1	9	1.0	2	1	1	1.2	2
2090	TB9	Mean	103	40	21.4	13	102	27	26.8	4
		SE	12	4	.6	2	7	2	.8	1
	50BA	Mean	40	14	24.0	30	40	7	33.6	36
		SE	1	1	.8	2	1	1	1.2	2

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 21—Average residual stand characteristics projected for the ponderosa pine forest type in eastern Montana, other land

Year	R_x[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA	TPA	QMD	BA CUT
			Ft^2/acre	*No.*	*Inches*	*Percent*	*Ft^2/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	54	67	12.2	7	62	75	12.3	16
		SE[g]	10	12	.6	3	9	10	.4	3
	50BA[h]	Mean	43	27	17.8	34	45	28	17.9	38
		SE	1	2	.6	3	2	2	.6	3
2060	TB9	Mean	86	116	11.8	7	97	121	12.5	6
		SE	6	6	.4	1	12	15	.5	2
	50BA	Mean	40	17	21.7	37	41	19	21.7	34
		SE	1	1	.6	2	1	2	.9	2
2090	TB9	Mean	102	52	18.8	15	100	46	19.6	12
		SE	7	2	.4	1	10	3	.6	1
	50BA	Mean	40	13	24.5	37	40	14	24.4	30
		SE	1	1	.6	1	1	2	.9	2
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	63	79	12.0	35	57	67	12.7	34
		SE	5	5	.3	3	3	4	.3	3
	50BA	Mean	53	67	12.6	44	48	59	13.7	45
		SE	3	5	.4	2	2	8	.6	2
2030	TB9	Mean	81	65	15.4	10	75	46	17.2	8
		SE	6	4	.4	1	5	3	.6	1
	50BA	Mean	44	28	17.6	40	41	23	21.1	38
		SE	1	2	.4	2	1	4	1.0	3
2060	TB9	Mean	99	52	18.7	12	89	34	21.7	5
		SE	7	3	.4	1	6	1	.6	1
	50BA	Mean	41	20	20.8	35	40	12	27.1	35
		SE	1	2	.6	2	1	1	1.1	1
2090	TB9	Mean	115	45	21.5	12	100	28	25.3	4
		SE	8	3	.5	1	6	1	.6	1
	50BA	Mean	40	14	24.0	34	40	8	32.1	32
		SE	1	1	.6	1	1	1	1.2	1

Note: Values are averages and cannot necessarily be cross referenced.
[a] R_x = treatment.
[b] BA = basal area.
[c] TPA = trees per acre.
[d] QMD = quadratic mean diameter.
[e] BA CUT = percentage of total basal area harvested.
[f] TB9 = thin from below to 9 inches diameter at breast height.
[g] SE = standard error (+/-).
[h] 50BA = thin from below to 50 percent of basal area.

Appendix 5: Average Volume of Utilized Trees

Resource managers who plan and conduct fuel mitigation treatments and contractors who bid on the treatments need information on the merchantable volume and size of trees to be removed during treatments. Such information is presented in this appendix. The tables included in this appendix summarize average cubic-foot volume harvested per acre, with standard errors (see tables 22 through 29). Reporting results by 3-in diameter classes provides a sense of the relative importance of different tree sizes. Processing output for all trees 7 in diameter at breast height and larger through the Financial Evaluation of Ecosystem Management Activities (FEEMA) model generates the data needed for tables. Merchantable volume is calculated by summing all of the logs that FEEMA recovered from each tree up to a 5-in top. All values are stand averages weighted by plot expansion factors. All tree species are combined. Cases where less than 50 cubic feet of material was removed are left blank because this amount of volume is considered insignificant and including it makes the output in later appendixes (e.g., 7 and 8) confusing.

Table 22—Average volume of utilized trees by diameter class projected for the Douglas-fir forest type in western Montana, national forest land

			Diameter at breast height (inches)									
Year	R_X[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	—	—	—	—	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	86	18	266	582	952	58	178	225	334	795
		SE	31	54	57	163	69	26	37	48	99	9
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	11	6	53	583	652	18	10	38	475	541
		SE	6	5	35	100	87	12	5	11	66	55
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	7	14	27	459	506	3	4	6	436	449
		SE	4	8	19	53	39	1	2	3	34	30
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	234	0	0	0	234	180	0	0	0	180
		SE	36	0	0	0	36	27	0	0	0	27
	50BA	Mean	303	275	40	1	619	311	390	158	66	925
		SE	52	55	20	1	28	41	80	55	33	40
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	50	58	173	122	403	7	27	217	518	769
		SE	15	17	37	34	20	4	11	40	84	43
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	18	52	89	243	402	2	17	13	593	624
		SE	11	15	24	32	3	2	9	8	38	26
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	4	10	28	383	425	2	6	13	499	520
		SE	4	7	14	33	26	1	3	8	26	18

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 23—Average volume of utilized trees by diameter class projected for the Douglas-fir forest type in western Montana, other land

			Diameter at breast height (inches)									
Year	R_x[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	61	0	0	0	61	—	—	—	—	—
		SE[c]	24	0	0	0	24	—	—	—	—	—
	50BA[d]	Mean	115	222	285	395	1,017	92	177	226	244	738
		SE	41	50	49	103	91	17	36	47	74	42
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	10	16	61	482	569	2	23	93	382	500
		SE	4	7	20	72	56	1	9	24	52	28
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	5	9	10	485	509	1	1	1	447	451
		SE	2	4	8	36	28	1	1	1	33	32
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	210	0	0	0	210	201	0	0	0	201
		SE	29	0	0	0	29	24	0	0	0	24
	50BA	Mean	277	194	74	46	591	189	190	64	0	444
		SE	41	46	26	23	12	40	49	27	0	45
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	51	119	130	106	406	43	58	51	315	468
		SE	19	29	30	38	10	11	20	19	83	67
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	10	40	82	301	433	5	47	126	273	451
		SE	4	15	24	56	43	2	12	25	47	11
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	8	20	22	345	394	1	2	24	411	438
		SE	4	9	10	36	27	1	2	9	28	18

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 24—Average volume of utilized trees by diameter class projected for the Douglas-fir forest type in eastern Montana, national forest land

Year	Rx[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Diameter at breast height (inches)									
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	—	—	—	—	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	69	135	168	187	559	20	183	122	301	627
		SE	20	42	39	91	41	14	62	51	119	72
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	16	9	38	305	368	3	0	38	214	255
		SE	13	7	29	56	48	3	0	38	39	44
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	2	3	33	236	275	1	8	2	246	258
		SE	1	3	17	33	25	1	6	2	30	25
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	246	0	0	0	246	176	0	0	0	176
		SE	34	0	0	0	34	38	0	0	0	38
	50BA	Mean	306	314	198	141	957	201	255	100	91	646
		SE	46	51	53	71	47	40	57	31	53	32
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	1	64	120	387	572	17	71	56	327	470
		SE	1	16	33	92	77	9	56	21	90	83
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	0	1	37	219	257	1	15	44	140	200
		SE	0	1	13	29	24	1	7	16	31	24
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	0	0	3	246	250	1	7	25	207	239
		SE	0	0	3	23	22	1	5	10	28	22

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 25—Average volume of utilized trees by diameter class projected for the Douglas-fir forest type in eastern Montana, other land

			Diameter at breast height (inches)									
Year	R_x[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	—	—	—	—	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	36	178	223	210	647	2	165	81	382	629
		SE	10	35	50	66	59	2	131	58	233	197
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	10	35	54	286	386	0	0	135	265	400
		SE	3	12	14	51	34	0	0	102	102	94
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	6	3	4	380	393	0	0	0	364	364
		SE	3	3	4	55	53	0	0	0	52	52
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	215	0	0	0	215	221	0	0	0	221
		SE	29	0	0	0	29	34	0	0	0	34
	50BA	Mean	241	271	131	52	695	206	188	55	11	459
		SE	30	50	37	33	32	31	44	20	9	26
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	8	69	135	385	598	6	98	91	162	358
		SE	4	28	34	83	70	3	26	27	42	28
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	1	3	25	417	445	1	3	40	341	385
		SE	1	3	12	40	35	1	2	15	41	34
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	1	4	3	394	402	0	2	10	403	415
		SE	1	3	2	25	23	0	2	6	27	23

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 26—Average volume of utilized trees by diameter class projected for the ponderosa pine forest type in western Montana, national forest land

			Diameter at breast height (inches)									
Year	R_X[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	65	0	0	0	65	60	0	0	0	60
		SE[c]	35	0	0	0	35	36	0	0	0	36
	50BA[d]	Mean	76	233	203	95	606	85	47	150	261	543
		SE	53	121	156	57	46	58	20	119	158	102
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	13	86	121	466	686	4	15	52	255	326
		SE	10	82	100	147	6	2	10	28	88	56
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	6	0	0	605	610	7	0	7	301	315
		SE	4	0	0	167	164	3	0	7	58	47
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9[c]	Mean	89	0	0	0	89	74	0	0	0	74
		SE	37	0	0	0	37	34	0	0	0	34
	50BA[d]	Mean	162	141	92	86	482	74	198	227	155	655
		SE	67	81	63	83	55	32	81	91	77	79
2030	TB9[c]	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	22	153	145	357	677	13	4	28	325	370
		SE	14	66	83	148	68	9	3	18	108	95
2060	TB9[c]	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	7	59	35	558	659	2	4	44	241	290
		SE	4	59	22	145	115	1	4	32	45	25
2090	TB9[c]	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	8	0	0	459	467	6	19	2	243	269
		SE	3	0	0	75	70	4	18	2	32	13

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 27—Average volume of utilized trees by diameter class projected for the ponderosa pine forest type in western Montana, other land

			Diameter at breast height (inches)									
Year	R_x[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			- - - - - - - - - Cubic feet per acre - - - - - - - - -					*- - - - - - - - - - Cubic feet per acre - - - - - - - - -*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	—	—	—	—	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	26	124	228	393	771	67	168	96	320	651
		SE	7	36	69	158	7	39	87	34	97	91
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	19	30	65	563	677	12	4	16	510	543
		SE	3	10	30	97	48	5	2	11	122	110
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
			—	—	—	—	—	—	—	—	—	—
	50BA	SE	19	8	0	425	452	11	4	1	384	401
			5	2	0	64	53	3	2	1	81	74
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	139	0	0	0	139	—	—	—	—	—
		SE	22	0	0	0	22	—	—	—	—	—
	50BA	Mean	144	190	119	65	518	—	—	—	—	—
		SE	23	51	52	54	46	—	—	—	—	—
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	24	46	122	786	978	—	—	—	—	—
		SE	10	19	25	126	79	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	10	2	18	862	892	—	—	—	—	—
		SE	2	1	14	107	99	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	18	3	1	547	570	—	—	—	—	—
		SE	4	1	1	57	49	—	—	—	—	—

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 28—Average volume of utilized trees by diameter class projected for the ponderosa pine forest type in eastern Montana, national forest land

			Diameter at breast height (inches)									
Year	R_X[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	—	—	—	—	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	135	0	0	0	135	90	0	0	0	90
		SE	36	0	0	0	36	45	0	0	0	45
	50BA	Mean	214	225	56	13	508	35	21	25	3	83
		SE	53	64	26	10	9	16	21	19	3	17
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	0	60	162	317	540	59	136	176	271	643
		SE	0	30	52	96	78	15	69	61	70	102
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	2	19	5	224	250	28	12	30	626	697
		SE	1	11	5	67	65	7	5	28	89	34
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	1	4	2	121	129	40	15	1	384	440
		SE	1	3	1	19	18	6	5	1	52	31

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 29—Average volume of utilized trees by diameter class projected for the ponderosa pine forest type in eastern Montana, other land

			Diameter at breast height (inches)									
Year	R_X[a]	Measure	7 to 10	10 to 13	13 to 16	16+	Total	7 to 10	10 to 13	13 to 16	16+	Total
			Cubic feet per acre					*Cubic feet per acre*				
			Gentle slope, low hazard					**Steep slope, low hazard**				
2030	TB9[b]	Mean	—	—	—	—	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—	—	—
	50BA[d]	Mean	3	35	66	97	200	21	47	72	72	213
		SE	2	11	18	32	27	15	17	32	33	31
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	3	3	5	132	143	0	0	8	170	179
		SE	1	2	3	23	21	0	0	6	30	28
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	6	6	1	89	103	4	3	0	95	102
		SE	2	3	1	11	8	2	2	0	15	13
			Gentle slope, high hazard					**Steep slope, high hazard**				
2000	TB9	Mean	120	0	0	0	120	74	0	0	0	74
		SE	20	0	0	0	20	15	0	0	0	15
	50BA	Mean	141	119	64	0	324	98	109	46	5	258
		SE	25	28	30	0	28	15	26	20	5	7
2030	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	1	39	147	165	352	13	23	82	429	547
		SE	1	12	34	39	33	4	13	26	70	46
2060	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	2	5	6	196	208	29	15	15	393	452
		SE	1	2	3	32	30	8	6	7	47	28
2090	TB9	Mean	—	—	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—	—	—
	50BA	Mean	3	2	6	118	128	21	10	16	282	329
		SE	1	1	3	16	15	4	2	12	26	8

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Appendix 6: Average Volume of Unutilized Trees

Volumes for trees in the 1- to <4-in and 4- to <7-in diameter at breast height classes are reported in this appendix. These biomass volumes are total tree volume estimates taken directly from the Forest Vegetation Simulation model. Unutilized tree volumes are reported to provide information on the total amount of bole wood biomass that needs to be processed to accomplish the fuel reduction treatment. This material is generally too small to be handled commercially, but occasionally price spikes in either hog fuel or pulp chips make removal of some of these trees financially viable. Also, as new technologies arise, alternative uses might be found for these trees, so information on their volume is useful for planning (tables 30 through 37).

Table 30—Average volume of trees cut but not utilized, by diameter class, projected for the Douglas-fir forest type in western Montana, national forest land

			Diameter at breast height (inches)					
Year	R_X[a]	Measure	1 to 4	4 to 7	Total	1 to 4	4 to 7	Total
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	103	37	140	56	34	90
		SE[c]	22	9	17	10	12	13
	50BA[d]	Mean	103	37	140	56	34	90
		SE	22	9	17	10	12	13
2060	TB9	Mean	45	12	57	23	6	29
		SE	4	5	3	2	1	1
	50BA	Mean	49	36	85	26	16	42
		SE	5	12	7	2	3	2
2090	TB9	Mean	41	7	49	22	6	28
		SE	4	3	1	2	1	1
	50BA	Mean	49	24	72	26	13	39
		SE	5	4	7	2	2	2
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	123	311	434	80	238	318
		SE	17	52	37	14	38	30
	50BA	Mean	123	311	434	80	238	318
		SE	17	52	37	14	38	30
2030	TB9	Mean	32	43	75	11	20	31
		SE	9	17	17	3	9	9
	50BA	Mean	34	63	97	17	37	54
		SE	9	18	17	3	12	11
2060	TB9	Mean	22	22	44	19	19	37
		SE	4	9	8	4	5	6
	50BA	Mean	41	34	75	28	26	54
		SE	5	10	8	3	5	1
2090	TB9	Mean	19	9	28	14	11	25
		SE	4	4	5	3	4	4
	50BA	Mean	39	43	82	28	30	58
		SE	5	11	9	3	6	4

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.

Table 31—Average volume of trees cut but not utilized, by diameter class, projected for the Douglas-fir forest type in western Montana, other land

			Diameter at breast height (inches)					
Year	R_x[a]	Measure	1 to 4	4 to 7	Total	1 to 4	4 to 7	Total
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	43	62	105	18	46	64
		SE[c]	6	16	13	3	12	10
	50BA[d]	Mean	43	62	105	18	46	64
		SE	6	16	13	3	12	10
2060	TB9	Mean	38	10	49	10	1	11
		SE	6	3	5	1	1	1
	50BA	Mean	42	14	56	12	3	15
		SE	6	3	4	1	1	1
2090	TB9	Mean	36	11	47	10	1	11
		SE	5	3	5	1	1	1
	50BA	Mean	40	25	66	12	3	15
		SE	5	5	3	1	1	1
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	108	419	527	83	318	401
		SE	24	47	31	13	34	15
	50BA	Mean	108	419	527	83	318	401
		SE	24	47	31	13	34	15
2030	TB9	Mean	29	42	71	21	17	38
		SE	5	11	10	4	3	4
	50BA	Mean	29	43	72	16	27	42
		SE	4	11	9	2	4	3
2060	TB9	Mean	24	21	45	14	22	36
		SE	4	4	4	2	5	4
	50BA	Mean	39	38	76	17	18	35
		SE	5	6	1	2	3	1
2090	TB9	Mean	19	12	31	12	13	25
		SE	4	2	3	2	3	2
	50BA	Mean	36	39	74	16	17	33
		SE	4	7	2	2	2	2

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.

Table 32—Average volume of trees cut but not utilized, by diameter class, projected for the Douglas-fir forest type in eastern Montana, national forest land

			Diameter at breast height (inches)					
Year	R_X[a]	Measure	1 to 4	4 to 7	Total	1 to 4	4 to 7	Total
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	54	28	82	50	30	80
		SE[c]	12	13	14	12	12	14
	50BA[d]	Mean	54	28	82	50	30	80
		SE	12	13	14	12	12	14
2060	TB9	Mean	22	18	41	15	15	30
		SE	4	5	2	2	6	6
	50BA	Mean	22	13	35	15	17	32
		SE	4	2	2	3	6	6
2090	TB9	Mean	19	25	43	13	13	26
		SE	2	4	4	2	2	2
	50BA	Mean	21	25	45	14	10	24
		SE	2	4	4	3	1	1
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	36	199	235	65	352	417
		SE	7	34	30	15	82	77
	50BA	Mean	36	199	235	65	352	417
		SE	7	34	30	15	82	77
2030	TB9	Mean	11	6	17	8	5	13
		SE	1	1	1	1	1	1
	50BA	Mean	13	10	23	10	10	20
		SE	1	2	1	1	3	2
2060	TB9	Mean	24	13	38	16	8	24
		SE	4	3	3	3	2	2
	50BA	Mean	25	19	44	16	11	27
		SE	4	3	2	3	2	1
2090	TB9	Mean	27	13	40	17	10	27
		SE	4	3	3	3	2	2
	50BA	Mean	25	24	49	16	12	28
		SE	4	4	2	2	2	1

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.

Table 33—Average volume of trees cut but not utilized, by diameter class, projected for the Douglas-fir forest type in eastern Montana, other land

			Diameter at breast height (inches)					
Year	**Rx[a]**	**Measure**	**1 to 4**	**4 to 7**	**Total**	**1 to 4**	**4 to 7**	**Total**
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	18	24	42	52	64	116
		SE[c]	3	7	6	22	38	34
	50BA[d]	Mean	18	24	42	52	64	116
		SE	3	7	6	22	38	34
2060	TB9	Mean	32	31	62	21	17	38
		SE	2	2	7	5	3	7
	50BA	Mean	31	34	65	20	18	39
		SE	2	3	7	5	3	7
2090	TB9	Mean	31	40	71	23	25	48
		SE	3	3	7	6	4	9
	50BA	Mean	33	40	72	22	21	44
		SE	3	4	7	6	3	8
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	32	248	279	45	299	344
		SE	10	44	41	10	52	48
	50BA	Mean	32	248	279	45	299	344
		SE	10	44	41	10	52	48
2030	TB9	Mean	25	20	45	18	13	32
		SE	2	2	4	1	1	3
	50BA	Mean	26	24	50	19	18	37
		SE	2	2	4	1	3	1
2060	TB9	Mean	29	30	59	23	21	44
		SE	2	3	4	2	2	3
	50BA	Mean	28	41	69	22	26	48
		SE	2	3	6	2	2	4
2090	TB9	Mean	32	30	62	25	22	47
		SE	3	3	5	2	2	4
	50BA	Mean	29	47	76	23	29	52
		SE	2	3	6	2	2	5

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.

Table 34—Average volume of trees cut but not utilized, by diameter class, projected for the ponderosa pine forest type in western Montana, national forest land

			Diameter at breast height (inches)					
Year	**R_X[a]**	**Measure**	**1 to 4**	**4 to 7**	**Total**	**1 to 4**	**4 to 7**	**Total**
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	26	90	116	7	23	31
		SE[c]	9	27	12	2	19	18
	50BA[d]	Mean	26	90	116	7	23	31
		SE	9	27	12	2	19	18
2060	TB9	Mean	37	36	72	20	20	40
		SE	11	16	1	3	7	7
	50BA	Mean	44	52	96	25	34	59
		SE	9	17	17	3	7	14
2090	TB9	Mean	30	26	56	19	12	31
		SE	11	15	10	4	4	6
	50BA	Mean	47	62	108	26	46	73
		SE	7	15	23	3	8	17
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	69	263	332	42	119	161
		SE	17	63	25	15	66	51
	50BA	Mean	69	263	332	42	119	161
		SE	17	63	25	15	66	51
2030	TB9	Mean	17	54	71	14	7	21
		SE	3	29	26	3	2	1
	50BA	Mean	22	60	83	16	30	46
		SE	3	28	23	3	12	8
2060	TB9	Mean	23	14	37	21	15	36
		SE	5	7	4	4	6	2
	50BA	Mean	44	51	95	32	34	66
		SE	4	11	18	4	6	11
2090	TB9	Mean	16	7	24	17	19	36
		SE	4	5	3	4	9	6
	50BA	Mean	55	59	114	33	41	73
		SE	6	9	23	4	8	12

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.

Table 35—Average volume of trees cut but not utilized, by diameter class, projected for the ponderosa pine forest type in western Montana, other land

			Diameter at breast height (inches)					
Year	Rx[a]	Measure	1 to 4	4 to 7	Total	1 to 4	4 to 7	Total
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	15	57	72	13	20	33
		SE[c]	2	10	5	2	4	5
	50BA[d]	Mean	15	57	72	13	20	33
		SE	2	10	5	2	4	5
2060	TB9	Mean	43	55	98	16	17	33
		SE	7	15	7	3	3	6
	50BA	Mean	55	71	126	21	24	46
		SE	9	15	10	3	4	8
2090	TB9	Mean	36	34	70	13	12	25
		SE	8	12	8	2	3	4
	50BA	Mean	61	58	119	25	25	50
		SE	8	7	16	4	5	9
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	117	235	352	—	—	—
		SE	26	38	21	—	—	—
	50BA	Mean	117	235	352	—	—	—
		SE	26	38	21	—	—	—
2030	TB9	Mean	38	49	87	—	—	—
		SE	5	12	7	—	—	—
	50BA	Mean	53	39	93	—	—	—
		SE	7	6	7	—	—	—
2060	TB9	Mean	22	10	32	—	—	—
		SE	3	3	2	—	—	—
	50BA	Mean	52	42	94	—	—	—
		SE	6	5	10	—	—	—
2090	TB9	Mean	15	5	20	—	—	—
		SE	3	1	2	—	—	—
	50BA	Mean	61	59	120	—	—	—
		SE	6	6	13	—	—	—

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 36—Average volume of trees cut but not utilized, by diameter class, projected for the ponderosa pine forest type in eastern Montana, national forest land

			Diameter at breast height (inches)					
Year	R_X[a]	Measure	1 to 4	4 to 7	Total	1 to 4	4 to 7	Total
			- - - *Cubic feet per acre* - - -			- - - *Cubic feet per acre* - - -		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	—	—	—	—	—	—
		SE[c]	—	—	—	—	—	—
	50BA[d]	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	46	159	206	92	172	263
		SE	15	28	17	44	57	35
	50BA	Mean	46	159	206	92	172	263
		SE	15	28	17	44	57	35
2030	TB9	Mean	43	51	94	22	41	63
		SE	16	24	26	2	6	10
	50BA	Mean	38	73	111	24	44	68
		SE	14	33	33	3	6	11
2060	TB9	Mean	44	60	103	21	29	50
		SE	3	7	12	5	6	6
	50BA	Mean	42	67	109	33	38	70
		SE	2	6	13	5	6	12
2090	TB9	Mean	46	61	106	17	23	40
		SE	3	7	13	4	6	4
	50BA	Mean	45	70	115	35	42	77
		SE	3	7	14	5	5	14

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 37—Average volume of trees cut but not utilized, by diameter class, projected for the ponderosa pine forest type in eastern Montana, other land

			Diameter at breast height (inches)					
Year	**R_x[a]**	**Measure**	**1 to 4**	**4 to 7**	**Total**	**1 to 4**	**4 to 7**	**Total**
			- - - Cubic feet per acre - - -			*- - - Cubic feet per acre - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[b]	Mean	24	20	44	19	18	37
		SE[c]	1	2	5	1	6	4
	50BA[d]	Mean	24	20	44	19	18	37
		SE	1	2	5	1	6	4
2060	TB9	Mean	52	64	115	36	42	78
		SE	2	4	12	1	4	10
	50BA	Mean	51	71	121	37	45	82
		SE	2	6	12	1	5	10
2090	TB9	Mean	51	62	113	40	41	81
		SE	2	4	12	1	3	11
	50BA	Mean	54	90	145	40	56	96
		SE	2	7	14	2	6	12
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	42	175	217	61	224	286
		SE	10	28	22	21	30	14
	50BA	Mean	42	175	217	61	224	286
		SE	10	28	22	21	30	14
2030	TB9	Mean	40	36	76	26	35	62
		SE	1	3	7	3	6	4
	50BA	Mean	39	37	76	35	50	85
		SE	1	3	7	2	8	7
2060	TB9	Mean	49	54	104	23	17	40
		SE	2	4	10	3	3	3
	50BA	Mean	47	61	107	38	42	79
		SE	2	5	10	2	4	9
2090	TB9	Mean	57	69	126	19	12	31
		SE	2	6	11	2	2	2
	50BA	Mean	55	79	134	43	46	89
		SE	2	7	12	3	5	10

[a] R_x = treatment.
[b] TB9= thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] 50BA = thin from below to 50 percent of basal area.

Appendix 7: Average Small-End Diameter of Utilized Logs

Information on average sawlog size is reported in this appendix. These data provide millowners with information on how the size of logs generated from fuel reduction treatments might be expected to change over time. Tables 38 and 39 show the average small-end diameter (SED) of logs removed during treatments, by entry. The SEDs of individual logs are output from Financial Evaluation of Ecosystem Management Activities (FEEMA) weighted by volume and plot expansion factor. The minimum diameter log included in FEEMA output is 5 in. All tree species are combined.

Table 38—Average small-end diameter of utilized logs projected for the Douglas-fir forest type in Montana

Type	Measure	Entry 1[a] TB9[e]	Entry 1[a] 50BA[f]	Entry 2[b] TB9	Entry 2[b] 50BA	Entry 3[c] TB9	Entry 3[c] 50BA	Entry 4[d] TB9	Entry 4[d] 50BA
		Inches							
Western Montana:									
National forest land—									
Steep slope, high fire hazard	Mean	5.6	6.8	—	10.0	—	13.1	—	15.4
	SE[g]	.05	.17	—	.31	—	.35	—	.40
Gentle slope, high fire hazard	Mean	5.5	6.4	—	8.3	—	10.1	—	12.5
	SE	.05	.14	—	.29	—	.38	—	.36
Steep slope, low fire hazard	Mean	—	—	—	9.1	—	11.6	—	14.6
	SE	—	—	—	.44	—	.54	—	.53
Gentle slope, low fire hazard	Mean	—	—	—	9.4	—	13.1	—	15.3
	SE	—	—	—	.41	—	.64	—	.74
Other land—									
Steep slope, high fire hazard	Mean	5.4	6.0	—	8.1	—	10.5	—	13.1
	SE	.04	.17	—	.44	—	.48	—	.47
Gentle slope, high fire hazard	Mean	5.5	6.4	—	8.3	—	10.4	—	12.1
	SE	.04	.20	—	.35	—	.39	—	.48
Steep slope, low fire hazard	Mean	—	—	—	7.8	—	11.2	—	13.9
	SE	—	—	—	.31	—	.43	—	.47
Gentle slope, low fire hazard	Mean	—	—	5.5	8.4	—	11.8	—	14.7
	SE	—	—	.09	.37	—	.50	—	.52
Eastern Montana:									
National forest land—									
Steep slope, high fire hazard	Mean	5.4	6.8	—	9.6	—	11.1	—	12.6
	SE	.04	.24	—	.62	—	.64	—	.56
Gentle slope, high fire hazard	Mean	5.5	6.9	—	9.7	—	11.9	—	13.3
	SE	.05	.21	—	.36	—	.45	—	.48
Steep slope, low fire hazard	Mean	—	—	—	8.9	—	12.0	—	13.0
	SE	—	—	—	.48	—	.76	—	.83
Gentle slope, low fire hazard	Mean	—	—	—	7.8	—	10.6	—	13.2
	SE	—	—	—	.39	—	.56	—	.50
Other land—									
Steep slope, high fire hazard	Mean	5.5	6.2	—	8.8	—	11.0	—	14.2
	SE	.04	.14	—	.33	—	.43	—	.43
Gentle slope, high fire hazard	Mean	5.5	6.4	—	9.3	—	12.2	—	14.8
	SE	.04	.17	—	.31	—	.44	—	.53
Steep slope, low fire hazard	Mean	—	—	—	9.8	—	13.2	—	16.2
	SE	—	—	—	.98	—	1.40	—	1.53
Gentle slope, low fire hazard	Mean	—	—	—	8.5	—	10.9	—	13.7
	SE	—	—	—	.33	—	.42	—	.41

— = no logs with small-end diameter >5 inches harvested.
[a] Entry date 1: 2000 for high-fire-hazard stands, 2030 for low-fire-hazard stands.
[b] Entry date 2: 2030 for high-fire-hazard stands, 2060 for low-fire-hazard stands.
[c] Entry date 3: 2060 for high-fire-hazard stands, 2090 for low-fire-hazard stands.
[d] Entry date 4: 2090 for high-fire-hazard stands.
[e] TB9 = thin from below to 9 inches diameter at breast height.
[f] 50BA = thin from below to 50 percent of basal area.
[g] SE = standard error (+/-).

Table 39—Average small-end diameter of utilized logs projected for the ponderosa pine forest type in Montana

Type	Measure	Entry 1[a] TB9[e]	Entry 1[a] 50BA[f]	Entry 2[b] TB9	Entry 2[b] 50BA	Entry 3[c] TB9	Entry 3[c] 50BA	Entry 4[d] TB9	Entry 4[d] 50BA
		Inches							
Western Montana:									
National forest land—									
Steep slope, high fire hazard	Mean	5.6	7.5	—	10.6	—	13.9	—	15.3
	SE[g]	.18	.43	—	.97	—	.92	—	1.18
Gentle slope, high fire hazard	Mean	5.5	7.8	—	9.7	—	13.5	—	16.6
	SE	.15	.95	—	1.04	—	.89	—	.82
Steep slope, low fire hazard	Mean	—	—	5.5	8.7	—	12.1	—	16.5
	SE	—	—	.02	1.20	—	1.28	—	1.30
Gentle slope, low fire hazard	Mean	—	—	5.4	7.8	—	11.5	—	15.1
	SE	—	—	.13	.74	—	.99	—	1.01
Other land—									
Steep slope, high fire hazard	Mean	—	—	—	—	—	—	—	—
	SE	—	—	—	—	—	—	—	—
Gentle slope, high fire hazard	Mean	5.5	6.2	—	10.5	—	15.2	—	18.1
	SE	.06	.22	—	.43	—	.47	—	.42
Steep slope, low fire hazard	Mean	—	—	—	9.9	—	13.6	—	16.0
	SE	—	—	—	.81	—	1.05	—	.81
Gentle slope, low fire hazard	Mean	—	—	—	9.1	—	13.0	—	16.5
	SE	—	—	—	.80	—	.73	—	.66
Eastern Montana:									
National forest land—									
Steep slope, high fire hazard	Mean	5.3	6.2	—	9.2	—	14.0	—	16.1
	SE	.15	.71	—	.62	—	.55	—	.96
Gentle slope, high fire hazard	Mean	5.4	6.3	—	9.2	—	10.7	—	12.3
	SE	.07	.15	—	.32	—	.59	—	.65
Steep slope, low fire hazard	Mean	—	—	—	—	—	—	—	—
	SE	—	—	—	—	—	—	—	—
Gentle slope, low fire hazard	Mean	—	—	—	—	—	—	—	—
	SE	—	—	—	—	—	—	—	—
Other land—									
Steep slope, high fire hazard	Mean	5.3	6.1	—	10.4	—	13.8	—	15.3
	SE	.04	.17	—	.51	—	.67	—	.75
Gentle slope, high fire hazard	Mean	5.3	5.9	—	8.2	—	10.2	—	12.1
	SE	.04	1.4	—	.21	—	.34	—	.40
Steep slope, low fire hazard	Mean	—	—	—	7.7	—	10.3	—	11.4
	SE	—	—	—	.26	—	.37	—	.60
Gentle slope, low fire hazard	Mean	—	—	—	7.9	—	10.6	—	11.4
	SE	—	—	—	.26	—	.39	—	.47

— = no logs with small-end diameter >5 inches harvested.
[a] Entry date 1: 2000 for high-fire-hazard stands, 2030 for low-fire-hazard stands.
[b] Entry date 2: 2030 for high-fire-hazard stands, 2060 for low-fire-hazard stands.
[c] Entry date 3: 2060 for high-fire-hazard stands, 2090 for low-fire-hazard stands.
[d] Entry date 4: 2090 for high fire hazard stands.
[e] TB9 = thin from below to 9 inches diameter at breast height.
[f] 50BA = thin from below to 50 percent of basal area.
[g] SE = standard error (+/-).

Appendix 8: Average Percentage of Volume, by Species, of Utilized Trees

Information presented in this appendix provides estimates of the species mix of logs removed during various treatment entries. The average percentage of volume in each of the three main groups, Douglas-fir/larch, ponderosa pine, and white woods, is displayed. Calculation is based on the average merchantable harvest volume (cubic feet/acre) from Financial Evaluation of Ecosystem Management Activities (FEEMA), weighted by the expansion factor (tables 40 through 47).

Table 40—Average percentage of log volume by species projected for the Douglas-fir forest type in western Montana, national forest land

Year	R_X[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			Percent			*Percent*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	50BA[e]	Mean	67	8	25	71	13	16
		SE	16	2	6	13	2	3
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	71	17	12	89	9	2
		SE	15	4	3	15	1	1
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	79	15	6	91	8	1
		SE	16	3	1	14	1	1
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	77	3	20	80	6	14
		SE	13	1	3	14	1	2
	50BA	Mean	75	3	22	86	1	13
		SE	14	1	4	14	1	2
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	85	5	10	95	2	3
		SE	14	1	2	15	1	1
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	85	11	4	97	1	2
		SE	13	2	1	15	1	1
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	89	8	3	96	3	1
		SE	13	1	1	14	1	1

— = no harvested volume.

[a] R_x = treatment.

[b] White woods = all other species.

[c] TB9 = thin from below to 9 inches diameter at breast height.

[d] SE = standard error (+/-).

[e] 50BA = thin from below to 50 percent of basal area.

Table 41—Average percentage of log volume by species projected for the Douglas-fir forest type in western Montana, other land

Year	R_x[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			Percent			*Percent*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	62	12	26	—	—	—
		SE[d]	16	3	7	—	—	—
	50BA[e]	Mean	77	9	14	80	12	8
		SE	15	2	3	13	2	1
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	78	16	5	79	19	1
		SE	14	3	1	13	3	1
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	76	21	2	75	23	3
		SE	12	3	1	11	3	1
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	77	3	20	88	3	8
		SE	13	1	3	13	1	1
	50BA	Mean	77	7	16	81	4	15
		SE	14	1	3	17	1	3
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	91	6	3	89	6	4
		SE	16	1	1	16	1	1
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	90	9	1	90	9	1
		SE	14	1	1	15	1	1
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	85	12	3	86	13	0
		SE	13	2	1	14	2	0

— = no harvested volume.
[a] R_x = treatment.
[b] White woods = all other species.
[c] TB9 = thin from below to 9 inches diameter at breast height.
[d] SE = standard error (+/-).
[e] 50BA = thin from below to 50 percent of basal area.

Table 42—Average percentage of log volume by species projected for the Douglas-fir forest type in eastern Montana, national forest land

Year	Rx[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			- - - - - - - - - *Percent* - - - - - - - - -			- - - - - - - - - *Percent* - - - - - - - -		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	50BA[e]	Mean	79	0	21	89	0	11
		SE	19	0	5	24	0	3
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	99	0	0	86	0	14
		SE	22	0	0	22	0	4
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	96	4	0	95	4	1
		SE	20	1	0	21	1	1
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	86	2	12	97	0	3
		SE	15	1	2	17	0	1
	50BA	Mean	83	2	16	90	0	10
		SE	13	1	2	17	0	2
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	93	1	6	95	0	5
		SE	15	1	1	21	0	1
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	98	0	2	92	4	3
		SE	16	0	1	18	1	1
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	96	2	1	95	2	4
		SE	15	1	1	17	1	1

— = no harvested volume.

[a] R_x = treatment.

[b] White woods = all other species.

[c] TB9 = thin from below to 9 inches diameter at breast height.

[d] SE = standard error (+/-).

[e] 50BA = thin from below to 50 percent of basal area.

Table 43—Average percentage of log volume by species projected for the Douglas-fir forest type in eastern Montana, other land

Year	Rx[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			- - - - - - - - - Percent - - - - - - - - -			*- - - - - - - - - Percent - - - - - - - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	50BA[e]	Mean	87	6	7	79	0	21
		SE	18	1	1	35	0	9
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	80	16	4	91	0	9
		SE	14	3	1	37	0	4
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	88	10	2	95	5	0
		SE	15	2	1	39	2	0
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	87	4	9	88	5	8
		SE	13	1	1	13	1	1
	50BA	Mean	90	3	7	91	1	8
		SE	13	1	1	15	1	1
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	90	5	5	89	3	7
		SE	13	1	1	16	1	1
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	91	8	1	84	12	4
		SE	13	1	1	13	2	1
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	90	8	2	92	7	1
		SE	13	1	1	14	1	1

— = no harvested volume.
[a] R_x = treatment.
[b] White woods = all other species.
[c] TB9 = thin from below to 9 inches diameter at breast height.
[d] SE = standard error (+/-).
[e] 50BA = thin from below to 50 percent of basal area.

Table 44—Average percentage of log volume by species projected for the ponderosa pine forest type in western Montana, national forest land

Year	R_X[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			Percent			*Percent*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	0	86	14	68	32	0
		SE[d]	0	50	8	48	23	0
	50BA[e]	Mean	16	79	5	35	65	0
		SE	7	35	2	14	27	0
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	11	88	0	36	64	0
		SE	5	36	0	14	24	0
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	0	100	0	35	65	0
		SE	0	41	0	13	25	0
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	40	60	0	39	25	36
		SE	23	35	0	22	14	21
	50BA	Mean	34	66	0	39	48	13
		SE	14	27	0	13	16	4
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	27	73	0	26	74	0
		SE	9	24	0	8	24	0
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	13	87	1	19	81	0
		SE	4	27	1	6	26	0
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	11	87	2	18	82	0
		SE	3	28	1	5	25	0

— = no harvested volume.
[a] R_x = treatment.
[b] White woods = all other species.
[c] TB9 = thin from below to 9 inches diameter at breast height.
[d] SE = standard error (+/-).
[e] 50BA = thin from below to 50 percent of basal area.

Table 45—Average percentage of log volume by species projected for the ponderosa pine forest type in western Montana, other land

Year	R_X[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			- - - - - - - - - *Percent* - - - - - - - - -			- - - - - - - - - *Percent* - - - - - - - - -		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	50BA[e]	Mean	5	95	0	18	82	0
		SE	2	29	0	6	26	0
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	21	79	0	29	71	0
		SE	5	20	0	9	21	0
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	18	82	0	23	77	0
		SE	4	21	0	7	23	0
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	28	69	3	—	—	—
		SE	6	14	1	—	—	—
	50BA	Mean	27	71	1	—	—	—
		SE	6	15	1	—	—	—
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	20	78	2	—	—	—
		SE	4	14	1	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	14	85	1	—	—	—
		SE	3	15	1	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	17	83	0	—	—	—
		SE	3	15	0	—	—	—

— = no harvested volume.
[a] R_x = treatment.
[b] White woods = all other species.
[c] TB9 = thin from below to 9 inches diameter at breast height.
[d] SE = standard error (+/-).
[e] 50BA = thin from below to 50 percent of basal area.

Table 46—Average percentage of log volume by species projected for the ponderosa pine forest type in eastern Montana, naional forest land

Year	Rx[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			Percent			*Percent*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	50BA[e]	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	17	83	0	0	100	0
		SE	4	21	0	0	71	0
	50BA	Mean	8	92	0	21	79	0
		SE	2	21	0	11	39	0
2030	TB9	Mean	—	—	—	12	88	0
		SE	—	—	—	4	27	0
	50BA	Mean	9	91	0	8	92	0
		SE	2	20	0	2	27	0
2060	TB9	Mean	18	76	7	8	80	12
		SE	10	44	4	3	28	4
	50BA	Mean	2	97	1	0	100	0
		SE	1	19	1	0	29	0
2090	TB9	Mean	0	53	47	19	66	15
		SE	0	53	47	8	27	6
	50BA	Mean	4	95	1	2	98	0
		SE	1	18	1	1	28	0

— = no harvested volume.

[a] R_x = treatment.

[b] White woods = all other species.

[c] TB9 = thin from below to 9 inches diameter at breast height.

[d] SE = standard error (+/-).

[e] 50BA = thin from below to 50 percent of basal area.

Table 47—Average percentage of log volume by species projected for the ponderosa pine forest type in eastern Montana, other land

Year	Rx[a]	Measure	Douglas-fir and larch	Ponderosa pine	White woods[b]	Douglas-fir and larch	Ponderosa pine	White woods
			- - - - - - - - - *Percent* - - - - - - - - -			- - - - - - - - - *Percent* - - - - - - - - -		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	50BA[e]	Mean	1	99	0	4	96	0
		SE	1	19	0	1	24	0
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	1	99	0	0	100	0
		SE	1	18	0	0	23	0
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	2	98	1	4	95	1
		SE	1	16	1	1	20	1
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	4	96	0	4	96	0
		SE	1	17	0	1	19	0
	50BA	Mean	4	96	0	5	95	0
		SE	1	16	0	1	18	0
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	3	97	0	5	95	0
		SE	1	15	0	1	19	0
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	2	98	0	9	90	0
		SE	1	15	0	2	16	0
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	50BA	Mean	4	96	0	3	96	0
		SE	1	14	0	1	17	0

— = no harvested volume.
[a] R_x = treatment.
[b] White woods = all other species.
[c] TB9 = thin from below to 9 inches diameter at breast height.
[d] SE = standard error (+/-).
[e] 50BA = thin from below to 50 percent of basal area.

Appendix 9: Average Proportion of Stands by Net Value Category

Data presented in this appendix provide information about the extent to which the thinning treatments have sufficient value to be self-financing as timber sales. The net value estimates are based on a mixed market for logs and a market for chip logs. These results should be regarded as an optimistic estimate of the ability to pay for these treatments via timber sales because of the assumed market for chip logs. The range of net value and the recognition that there are many stands that will not have a positive net value from thinning under any foreseeable circumstances are the important results. Because these results include calculations involving economic assumptions for which standard errors are unknown, standard errors are also unknown for these results and therefore none are reported (tables 48 through 55).

Table 48—Average proportion of stands by net value per acre category projected for the Douglas-fir forest type in western Montana, national forest land

Year	R_x[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
			Gentle slope, low hazard					**Steep slope, low hazard**			
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.23	.05	.23	.18	.32	.47	.06	.16	.22	.09
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.08	.04	.17	.21	.50	.20	.15	.29	.15	.22
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.07	.07	.15	.19	.52	.11	.04	.30	.39	.15
			Gentle slope, high hazard					**Steep slope, high hazard**			
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.68	.10	.20	.02	0	.81	0	.07	.05	.07
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.30	.11	.30	.20	.09	.10	.12	.29	.29	.20
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.16	.10	.29	.37	.08	.05	.07	.14	.53	.21
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.02	.06	.24	.53	.14	.07	.02	.09	.70	.13

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

Table 49—Average proportion of stands by net value per acre category projected for the Douglas-fir forest type in western Montana, other land

Year	Rx[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
				Gentle slope, low hazard					Steep slope, low hazard		
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.27	.07	.17	.00	.50	.54	.08	.11	.11	.16
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.08	.14	.14	.17	.47	.05	.29	.32	.13	.21
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.05	.05	.07	.34	.49	.07	.09	.34	.39	.11
				Gentle slope, high hazard					Steep slope, high hazard		
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.76	.07	.07	.04	.07	.93	.04	0	.02	0
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.25	.11	.42	.14	.08	.60	.06	.06	.14	.14
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.12	.14	.30	.23	.21	.23	.25	.15	.28	.10
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.13	.06	.25	.23	.33	.07	.07	.45	.33	.07

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

Table 50—Average proportion of stands by net value per acre category projected for the Douglas-fir forest type in eastern Montana, national forest land

Year	R_X[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
				Gentle slope, low hazard					Steep slope, low hazard		
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.43	.09	.26	.13	.09	.47	.24	.06	.00	.24
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.17	.09	.39	.17	.17	.28	.17	.50	.06	0
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.04	.08	.63	.21	.04	.19	.24	.52	.05	0
				Gentle slope, high hazard					Steep slope, high hazard		
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.59	.04	.07	.13	.17	.80	.08	.05	.03	.05
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.07	.26	.33	.02	.31	.35	.30	13	.04	.17
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.07	.26	.38	.24	.05	.32	.39	.25	.00	.04
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.09	.12	.47	.26	.07	.09	.58	.30	0	.03

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

Table 51—Average proportion of stands by net value per acre category projected for the Douglas-fir forest type in eastern Montana, other land

Year	R_x[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
		Gentle slope, low hazard					Steep slope, low hazard				
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.15	.19	.23	.12	.31	.43	.29	0	0	.29
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	0	.20	.46	.26	.09	.14	.14	.43	.14	.14
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.03	.05	.41	.35	.16	0	0	.71	.29	0
		Gentle slope, high hazard					Steep slope, high hazard				
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.61	.12	.10	.06	.10	.90	.02	.08	0	0
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.11	.17	.30	.17	.26	.43	.30	.22	.03	.03
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.06	.04	.33	.23	.33	.17	.24	.38	.17	.05
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.06	.06	.24	.30	.34	.07	.07	.44	.35	.07

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

Table 52—Average proportion of stands by net value per acre category projected for the ponderosa pine forest type in western Montana, national forest land

Year	R_X[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
			Gentle slope, low hazard					Steep slope, low hazard			
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.43	.14	0	.29	.14	.43	.14	0	.29	.14
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	0	0	.29	.43	.29	.38	.13	.38	.13	0
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	0	0	.14	.57	.29	0	.25	.50	.25	0
			Gentle slope, high hazard					Steep slope, high hazard			
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.70	.10	0	.10	.10	.58	.08	.08	.17	.08
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.18	.18	0	.36	.27	.36	.09	.27	.09	.18
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	0	0	.27	.45	.27	0	.36	.55	.09	0
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	0	0	.18	.55	.27	.08	.25	.58	.08	0

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

Table 53—Average proportion of stands by net value per acre category projected for the ponderosa pine forest type in western Montana, other land

Year	Rx[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
				Gentle slope, low hazard					Steep slope, low hazard		
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.23	.08	.08	.08	.54	.27	.09	.18	.36	.09
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.06	.11	.11	.28	.44	.08	0	.50	.25	.17
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.16	.05	0	.42	.37	.08	.08	.42	.25	.17
				Gentle slope, high hazard					Steep slope, high hazard		
2000	TB9	1.00	0	0	0	0	—	—	—	—	—
	50BA	.67	.10	.10	.07	.07	—	—	—	—	—
2030	TB9	1.00	0	0	0	0	—	—	—	—	—
	50BA	.06	.13	.03	.29	.48	—	—	—	—	—
2060	TB9	1.00	0	0	0	0	—	—	—	—	—
	50BA	.00	0	.10	.26	.65	—	—	—	—	—
2090	TB9	1.00	0	0	0	0	—	—	—	—	—
	50BA	.00	.03	.10	.42	.45	—	—	—	—	—

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

— = no data.

Table 54—Average proportion of stands by net value per acre category projected for the ponderosa pine forest type in eastern Montana, national forest land

Year	Rx[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
		Gentle slope, low hazard					Steep slope, low hazard				
2030	TB9[b]	—	—	—	—	—	—	—	—	—	—
	50BA[c]	—	—	—	—	—	—	—	—	—	—
2060	TB9	—	—	—	—	—	—	—	—	—	—
	50BA	—	—	—	—	—	—	—	—	—	—
2090	TB9	—	—	—	—	—	—	—	—	—	—
	50BA	—	—	—	—	—	—	—	—	—	—
		Gentle slope, high hazard					Steep slope, high hazard				
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.82	.09	.05	.05	0	1.00	0	0	0	0
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.16	.20	.28	.20	.16	.31	.23	.23	.23	0
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.24	.38	.24	.03	.10	0	0	.38	.23	.38
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.33	.27	.33	.03	.03	.08	.08	.31	.46	.08

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.
[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] 50BA = thin from below to 50 percent of basal area.
— = no data.

Table 55—Average proportion of stands by net value per acre category projected for the ponderosa pine forest type in eastern Montana, other land

Year	R_X[a]	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000	<-$100	$-100 to $100	$100 to $500	$500 to $1,000	>$1,000
		Gentle slope, low hazard					Steep slope, low hazard				
2030	TB9[b]	1.00	0	0	0	0	1.00	0	0	0	0
	50BA[c]	.39	.36	.18	.06	0	.71	.19	.10	0	0
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.39	.39	.17	.06	0	.50	.41	.09	0	0
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.44	.49	.05	.03	.00	.44	.52	.04	0	0
		Gentle slope, high hazard					Steep slope, high hazard				
2000	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.87	.04	.04	.02	.02	.97	0	.03	0	0
2030	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.28	.30	.21	.09	.12	.29	.16	.16	.19	.19
2060	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.20	.46	.22	.09	.04	.16	.13	.25	.31	.16
2090	TB9	1.00	0	0	0	0	1.00	0	0	0	0
	50BA	.30	.52	.13	.02	.02	.13	.16	.59	.09	.03

Note: Proportion = the proportion of stands in net value categories for each forest type, year, and treatment.

[a] R_x = treatment.

[b] TB9 = thin from below to 9 inches diameter at breast height.

[c] 50BA = thin from below to 50 percent of basal area.

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