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

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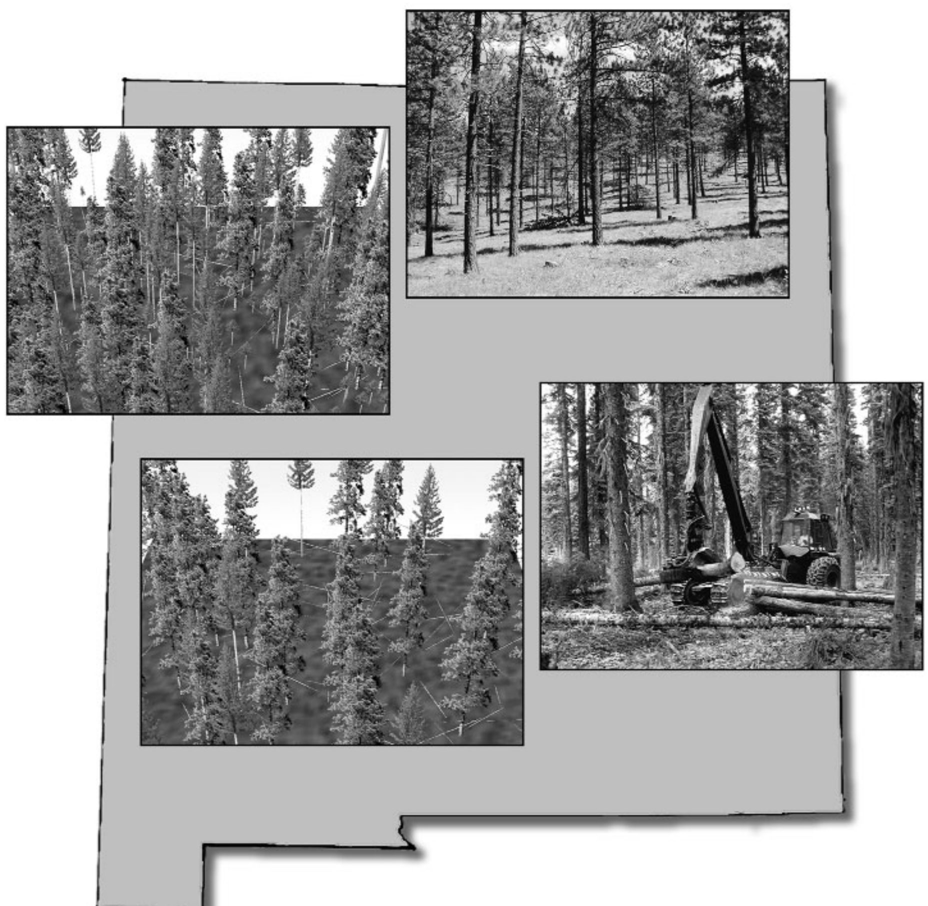

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Abstract

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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 projects under two treatment scenarios for New Mexico. 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, New Mexico.

Executive Summary

This work was initiated under a Joint Fire Science Program (JFSP)-funded project, "Assessing the need, 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 thinning; size and volume of submerchantable wood cut during treatments; and financial returns of prescriptions that are applied periodically over 90 years. In this paper we compare the potential mix of timber products recovered under two treatment scenarios applied in the state of New Mexico.

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 repeated application of these treatments over long timeframes. There are important policy issues associated with both parts of the analysis. Our analysis suggests that none of the existing stands could be treated without a subsidy by using either of the prescriptions modeled here, and although the immediate effects on fire hazard are modest, they generally result in a substantial reduction in fire hazard over time. Projections of repeated application of these treatments suggest that they could have unintended consequences. 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 fuel 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. We chose two for illustrative purposes: (1) thin from below to 9 in diameter at breast height (d.b.h.) (TB9) with a minimum residual basal area, then burn 10 years after thinning and every 20 years thereafter, then reevaluate for thinning every 30 years; and (2) thin from below to 16 in d.b.h. (TB16) with a minimum residual basal area, then burn 10 years after thinning and every 20 years thereafter, then reevaluate for thinning every 30 years. The key findings follow.

- The initial effect of these prescriptions on fire hazard was modest, but over time, fire hazard decreased substantially.
- There was a substantial long-term downward trend in the projected basal area mortality expected from the prescribed burn treatments.
- The minimum basal area after the first thinning was 80 ft^2, and basal area under both treatments tended to stabilize near that level over time.
- There were few cases where any harvested volume from any thinning was considered merchantable.
- There were no cases where the harvested material could be expected to compensate for the cost of conducting the thinning either now or in the future, given existing markets for small (<9.5 in) logs. (If volumes removed from skid trails or cable corridors were included in these calculations, the results might have been different).

The results suggest that both of the simulated prescriptions reduced fire hazard over the long term with the TB16 prescription producing slightly more reduction in fire

hazard. After several entries, treated stands in most cases approached the minimum basal area of 80 ft^2 required for second and future thinnings. In a few cases, the diameter limit resulted in basal area building up in larger trees to more than 80 ft^2. In general, the TB16 treatment had about the same basal area but with fewer trees per acre and a larger average stand diameter.

In terms of wood utilization, the analysis showed that both prescriptions produced only small volumes of small trees from the first and subsequent entries. In many cases, stands had too little basal area growth to qualify for stand treatments after the initial thinning. These prescriptions 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.

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Introduction

This study was initiated 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 are to (1) quantify existing stand conditions for major forest types in terms of density, structure, and species composition, and prioritize stands by need for hazard-reduction treatment; (2) develop and compare alternative cutting and prescribed burning prescriptions for reducing high-hazard conditions in major forest types; (3) determine potential revenue from timber products generated from the hazard-reduction harvest treatments; (4) compare the future mix of timber products under alternative treatment scenarios; and (5) describe 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.

New Mexico was selected as an example because recent forest inventories were available, because the forest products industry in that state is in decline, and because there currently are no mills capable of processing small logs. The New Mexico situation is in sharp contrast to that in Montana (see Barbour et al. 2004) where the forest products industry is well established and has technological capability to process the small-diameter logs expected from fuel-hazard-reduction treatments. That analysis is being published separately.

If widely adopted, the types of treatments proposed to reduce forest fire hazards could have implications for future forest conditions as profound as those from past management practices—principally harvesting, grazing, 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 and nontimber forest resources, environmental services, and amenities. Some of these changes likely will be considered positive, whereas others likely will be considered negative depending on how the resource in question is viewed relative to other 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] available to analysts in federal, state, and private land management organizations. The interpretations we provide 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 these results also 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 use Forest Inventory and Analysis (FIA) plot-level data, but many types of stand-level data are adequate for these protocols.

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

Geographic and Forest Type Detail

There are 10 forest types in New Mexico: aspen, juniper, pinyon/juniper, spruce/fir, dry mixed conifer, moist mixed conifer, riparian, oak, ponderosa pine/grass, and ponderosa pine/shrub. Because the same prescription would be used for both ponderosa pine types, they were combined into one type for this analysis. A technical contact team[3] assisted us with this study. They suggested two forest types (ponderosa pine and dry mixed conifer) as having high fire hazard, a priority for receiving hazard-reduction treatments, and covering enough area to have a sufficient number of forest inventory and analysis (FIA) plots to do the analyses. The maximum number of cases for the New Mexico study is 16 (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 designed 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 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 in federal agencies and most state or private organizations. Where they exist, other growth models, fire models, and financial models could be substituted for those used in this analysis.

Measurements of current forest vegetation are from data collected by the USDA Forest Service's FIA Program as categorized and processed by cooperators and reported in a companion study supported under the same JFSP project. Our methods are general, however, and adequate data can be obtained from a variety 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 comprise a statistically representative sample of the vegetation population on the target landscape.

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[3] The technical contact team consisted of Regis Cassidy, Southwest Region, USDA Forest Service; Sam Loftin, Los Alamos National Laboratory; Hal Luedtke and Bev Schwab, Bureau of Indian Affairs, Southwest Region; and Charlie Wicklund, State of New Mexico, Forestry Division.

We examined 600 candidate plots with a sampling weight of approximately 6,600 acres each. When more than 50 plots were available for a given case,[4] a sample of 50 plots was randomly selected to represent the area in that case. When fewer than 50 plots were available for a given case, all 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]

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 6 in inside the bark and a minimum log length of 8 ft for top logs and 16 ft for butt logs. This determined the logs that had to be taken to the landing, but only logs 9 in and larger were assumed to have sufficient market value to be hauled to a mill and utilized. Only logs 9 in and larger are assigned a price, and therefore, only trees large enough to produce at least a 16-ft log with an SED of 9 in are assigned a value. 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 of simulation output for all sample plots included in the analysis. 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 4 in d.b.h. were estimated by FVS. Stem volumes of 4 to 14 in d.b.h. trees were estimated with FEEMA to a 2-in top, inside bark. We did not calculate biomass (total stem, limbs, and foliage) volume or weight for the unutilized trees.

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

[5] By Fiedler, C.E.; Keegan, C.E. III; Woodall et al. 2001. A strategic assessment of fire hazard in Montana, and a strategic assessment of fire hazard in New Mexico. (Submitted under separate cover to the JFSP Board, 3833 S. Development Ave., Boise, ID 83705).

Fire-Hazard-Reduction Treatments

Silvicultural prescriptions were developed in consultation with the technical contact team. The objective was to cover a variety 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. 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 reporting purposes, output tables are labeled as "high" or "low" (moderate plus low) fire hazard. 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

The 2001 version of the central Rockies variant of FVS was used for all of New Mexico. This version replaces the GENGYM stand-level growth model (Edminster et al. 1991) with a distance-independent individual tree growth model similar to those used in most other FVS variants.

Prescriptions

Prescriptions are identical for ponderosa pine and dry mixed-conifer forest types. The thinning reentry interval is 30 years with prescribed burning 10 years after the initial thinning and repeated every 20 years thereafter. One prescription is a thin-from-below to 9 in d.b.h., with a minimum residual basal area of 50 ft^2/acre for the initial thinning and 80 ft^2/acre for subsequent thinnings (TB9). The second prescription is a thin-from-below to 16 in d.b.h. with a minimum residual basal area of 50 ft^2/acre for the initial thinning and 80 ft^2/acre for subsequent thinnings (TB16). Stands that did not have sufficient basal area to qualify for a thinning were reconsidered at the next thinning cycle (30 years). No prescribed burning was done until a thinning had occurred.

Effectiveness of Fire-Hazard-Reduction Treatments

Linear regression analysis was used to identify trends in the long-term effectiveness of treatments in reducing 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 fire hazard plots for a given forest type and treatment. The independent variables were decades numbered from 1 to 10 and dummy variables for decade of treatment, and the decade following treatment. Dummy variables have a value of one 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 determine whether there was improvement in crowning index immediately after and, 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 potential 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 in the high fire hazard plots for a given forest type and treatment.

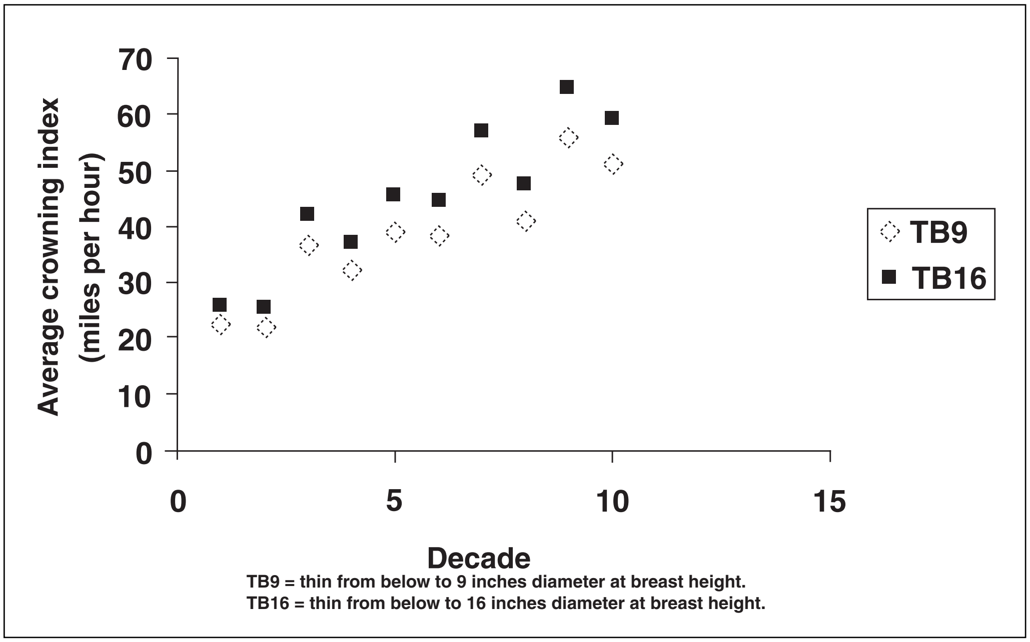

Figure 1—Predicted average crowning index for high fire hazard dry mixed-conifer plots in New Mexico by prescription.

Financial Analysis

The FEEMA model was used to rate the potential net revenue from thinnings. The market conditions used represent a moderate lumber market with no market for chip logs. With the limited forest products industry in New Mexico, even moderate prices should be regarded as optimistic, at least in the near term, but useful in identifying the relative financial feasibility of different cases. Although the pricing is done on a log basis rather than the tree basis used in another part of the study, the prices are made to be as comparable as possible (see footnote 5). Costs include cutting small trees that are cut and treated in place as well as cutting trees that are used for products. Costs of other harvest-related activities such as roads and environmental remediation, which can differ widely, are not included, nor were revenues associated with timber removed from skid trails or cable corridors accounted for. Ground-based equipment was assigned a lower cost than cable yarding systems. Stump-to-truck costs are based on Hartsough et al. (2001). Ground-based equipment is assumed on slopes of less than 40 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

Dry Mixed Conifers

The total acreage and number of FIA inventory plots included in this analysis for the dry mixed-conifer forest type are shown in appendix 2 (table 4). Dry mixed-conifer plots were segregated by high fire hazard (<25 mph windspeed) and low/moderate fire hazard (25+ mph windspeed). These two groups are referred to as high fire hazard and low fire hazard in all tables for this forest type.

Treatment effect on fire hazard—Regression analysis indicated both a time trend (positive slope coefficient on decade) and a cyclical treatment effect (a positive coefficient on the decade following burning and a smaller negative coefficient on the decade following thinning) on average crowning index for both the TB9 and the TB16 prescriptions in the dry mixed-conifer high fire hazard stands (fig. 1). It is not

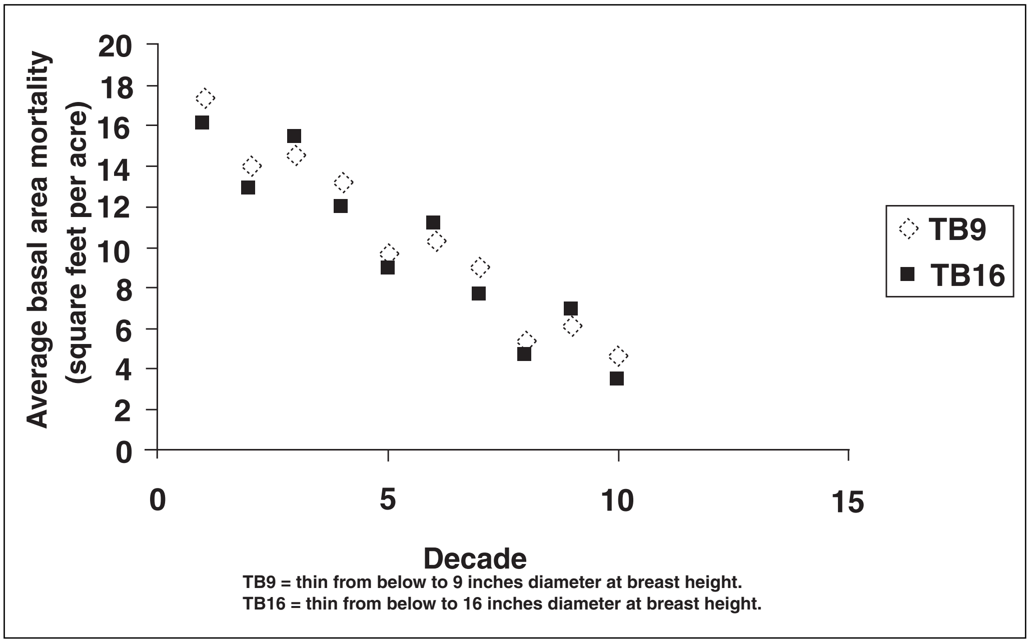

Figure 2—Predicted average basal area mortality for high fire hazard dry mixed-conifer plots in New Mexico by prescripion.

surprising that thinning did not have a strong effect statistically because after the first thinning, many stands did not qualify for any further thinning during the 10-decade simulation period. Although the trends identified here are large, the regressions are weak in explaining the total variation. It is probably unreasonable to draw conclusions about the effectiveness of thinning versus prescribed fire treatments from this analysis. It is reasonable to conclude that the treatments in aggregate have a significant effect on crowning index over time.

Figure 2 shows the analogous comparison for the predicted average basal area mortality resulting from prescribed burns. The effect on potential basal area mortality is almost the same for the two prescriptions. In both cases there is a time trend (a negative coefficient on decade) and an effect in the decade following the decade in which prescribed burning is done (a negative coefficient on the decade following prescribed fire). The potential basal area mortality begins relatively high, over 40 percent, for both ponderosa pine and dry mixed-conifer stands in New Mexico. By the end of the simulation period, however, it is only about 10 percent. This result suggests that by the 10th decade of the simulation, both prescriptions create stand conditions where trees are relatively resilient to low-intensity fires.

Initial stand summary—When paired by owner and slope, the initial stand conditions for high and low fire hazard cases differ in that low fire hazard stands clearly have larger trees. Basal areas and numbers of trees per acre do not exhibit a consistent pattern of differences (fig. 3).

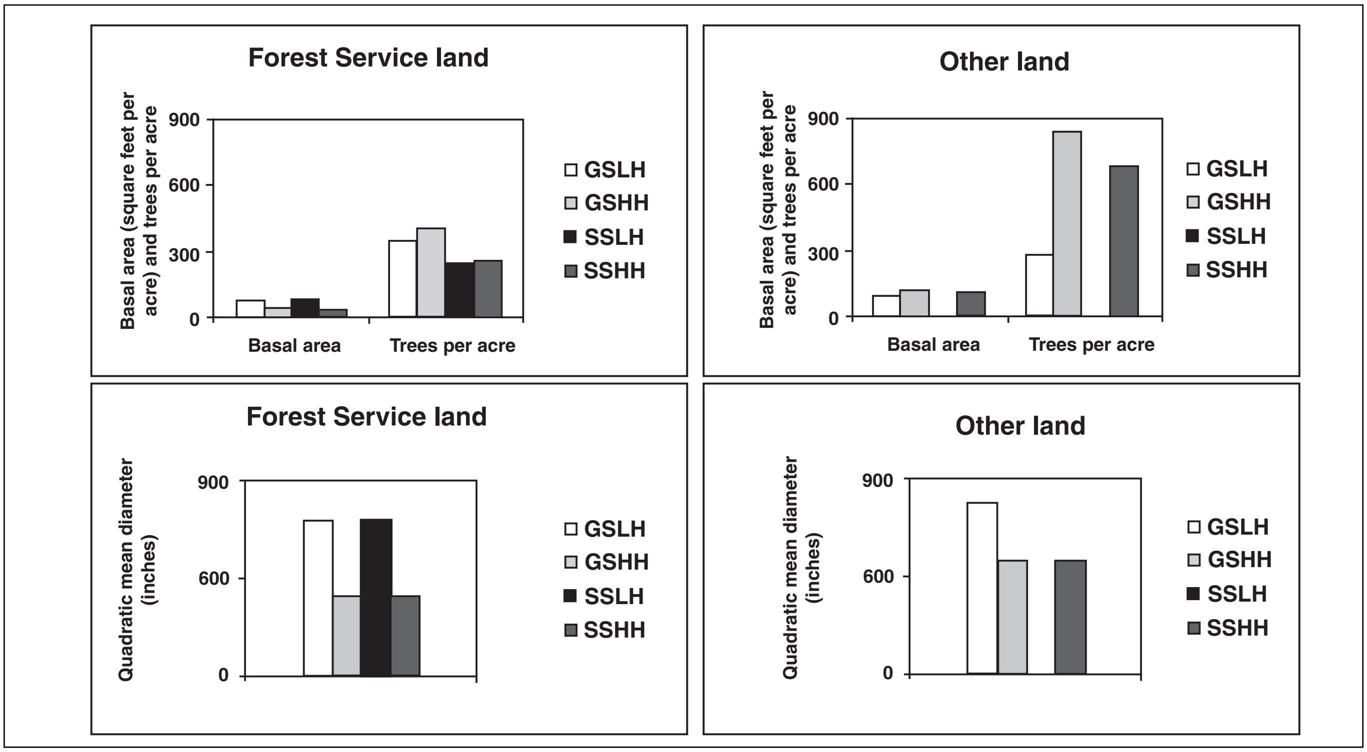

Figure 3—Initial stand conditions for dry mixed-conifer plots in New Mexico: basal area, number of trees per acre, and quadratic mean diameter, reported by gentle slope low or high fire hazard (GSLH or GSHH) and steep slope low or high fire hazard (SSLH or SSHH).

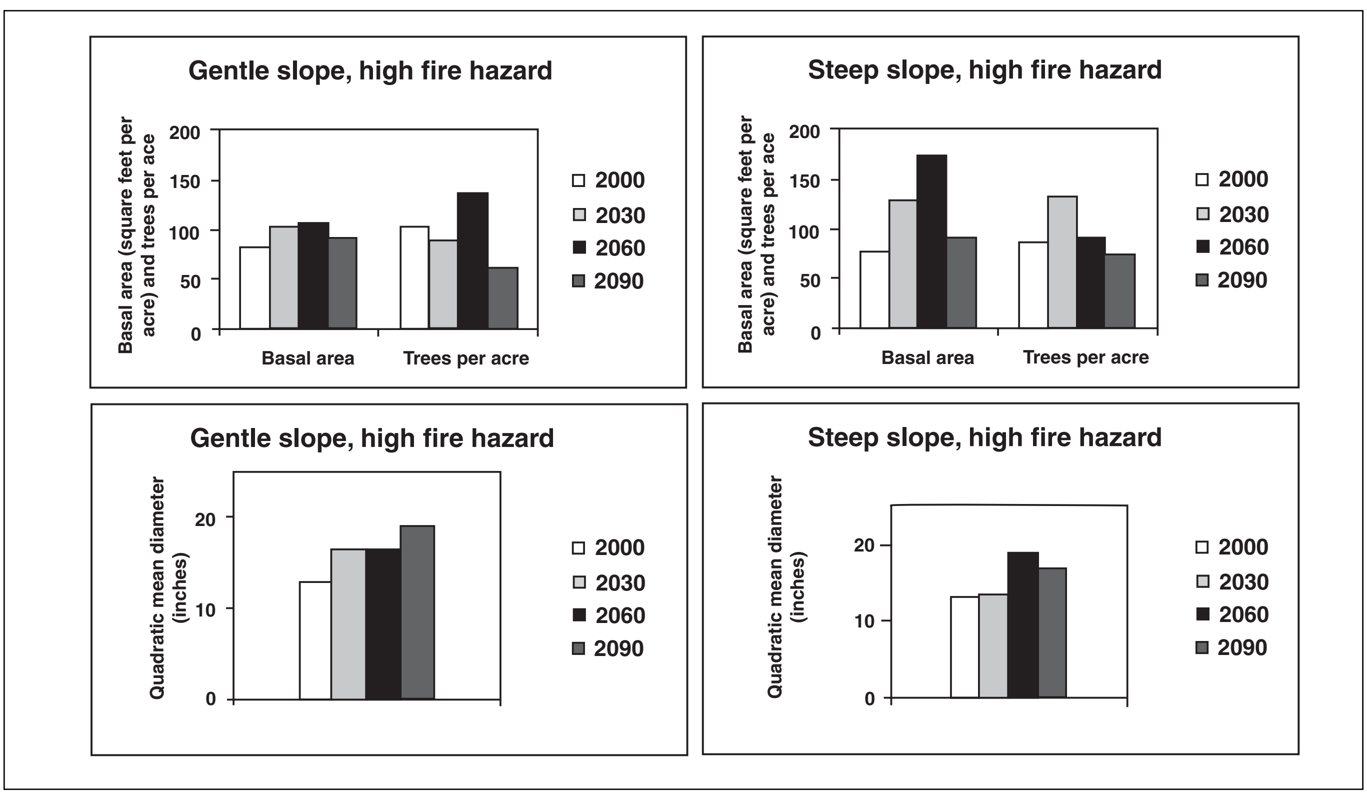

Figure 4—Residual conditions projected for dry mixed-conifer plots on gentle and steep slopes with high fire hazard on lands other than national forests in New Mexico (average values for thinned plots only): basal area, number of trees per acre, and quadratic mean diameter, by prescription.

Residual stand summary—The residual stand summary shows conditions after thinning for thinned stands only. It is important to understand that after the first thinning occurs (year 2000 for high fire hazard stands and 2030 for low fire hazard stands), many stands are never thinned again because they do not reach 80 ft^2 of basal area. The residual stand summaries beyond that period generally represent less than a third of the total stands for that case. Thinned stands show basal area stabilizing at around 80 ft^2 (the required minimum for second and all future thinnings) whether it started above or below that level. The number of trees per acre tended to fluctuate depending on the amount of regeneration and the effects of thinning and prescribed fire. Quadratic mean diameter tended to increase except in those cases where large pulses of regeneration cause the average basal area per tree to drop (app. 4). Two examples that cover most of the range in residual stand characteristics are shown in figure 4.

Basal areas do not generally reach extreme levels under repeated entries of either the TB9 or TB16 prescription in this forest type, and as a result, insects and disease outbreaks would probably not be of as widespread a concern for cases in New Mexico as they are for some of the cases in Montana (Barbour et al. 2004).

Merchantable volume by diameter-at-breast-height class—Data for average volume removed of trees 10 in d.b.h. and larger are reported in appendix 5 (tables 14 and 15). Three of the low fire hazard cases had one or more plots that produced small volumes of merchantable timber under the TB16 prescription during the first thinning (<450 ft^3). Three of the high fire hazard cases also had one or more plots that produced small volumes of merchantable timber under the TB16 prescription during the first thinning (<250 ft^3/acre): Two of high fire hazard cases on lands other than national forests, and one or more plots that yielded small volumes of merchantable timber in the second thinning cycle (<450 ft^3/acre). No merchantable timber removal was projected from any of the other cases. Although these volumes have been labeled “merchantable,” that does not mean that they could be sold as a timber sale. The financial results indicate that such small volumes would not likely result in a positive net value to a purchaser.

The low yields of saw logs result from a combination of stand conditions, the type of prescriptions, and the utilization standard. Prescriptions that create generally more open conditions or involve group selections would yield greater quantities, and in some cases, larger diameter saw logs than the thin-from-below prescriptions simulated here. The market for small saw logs is, however, limited in New Mexico and indeed in the entire Southwest (Larson and Mirth 2001), so it is not clear whether such logs would find purchasers even if they were available[6] (Temple et al. 1999). Much of the existing capacity in the Southwest was established to process larger and older pine logs than would be expected from most restoration treatments, and in their survey of the existing industry, Mater Engineering (footnote 6) listed only one sawmill that purchased logs in the 9-in-diameter range and none that used smaller logs. They did identify several users of house logs who purchase logs down to 8 in SED and 8 ft long, but it is unlikely that these manufacturers could use substantially larger volumes of these short, small-diameter logs than they already do.

[6] Mater Engineering. 1998. Final report: phase I business plan development for the Grand Canyon Forest Partnership. Corvallis, OR: Mater Engineering. [Pages unnumbered]. On file with: Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208.

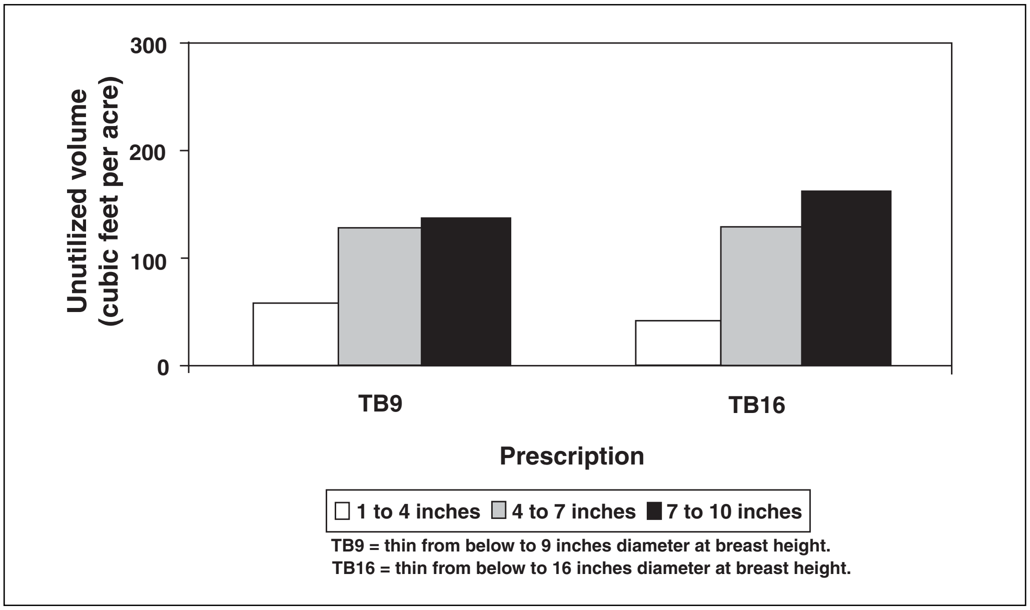

Figure 5—Projected unutilized cut volume in trees 1 to 10 inches diameter at breast height from dry mixed-conifer plots on lands other than national forests in New Mexico on gentle slopes with high fire hazard, by diameter class and prescription.

Stem biomass volume of trees 1 to 10 in diameter at breast height—The volumes of small trees that need to be removed to implement the prescriptions in the first thinning cycle are not large. They are typically 30 to 300 ft^3/acre for the TB9 prescription and 50 to 300 ft^3/acre for the TB16 prescription. These volumes tend to be distributed over all diameter classes with greater volumes being in the classes above 7 in d.b.h. This is an encouraging result for those interested in trying to find uses for currently submerchantable material (see LeVan-Green and Livingston 2001) because it means that more of the volume that might potentially be removed is in size classes that approach current merchantability standards than in the very small classes. Less encouraging is that at 50 lbs/ft^3, these volumes would have less than 8 green ton per acre (green ton is 2,000 lbs of undried biomass material). That is far below the concentrations of commercial biomass that energy producers such as those in northern California look for in financially viable biomass energy harvest treatments.[7] Figure 5 shows a case that is on the high end of the range. Volumes are typically much less after the initial thinning. In addition, many stands are not thinned at all after the initial thinning because they do not build up the 80 ft^2 of basal area required to qualify for a subsequent thinning. Details for all cases are found in appendix 6.

Average small-end diameter of removed logs—The TB9 prescription does not produce any logs that are considered merchantable. Log SED increases over time for the TB16 prescription increasing from about 6.5 to 9.6 in. There are, however, few cases that yield merchantable log volumes in successive entries (app. 7). Progress has been made recently in identifying alternative uses for small logs, e.g., structural round wood (LeVan-Green and Livingston 2001, Wolfe and Hernandez 1999), but markets are poorly developed.

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[7] Jolley, S. 1995. Stand structure changes resulting from biomass harvesting in natural forests of northern California. 21 p. Unpublished report. On file with: Wheelabrator Shasta Energy Company, 20811 Industry Road, Anderson, CA 96007.

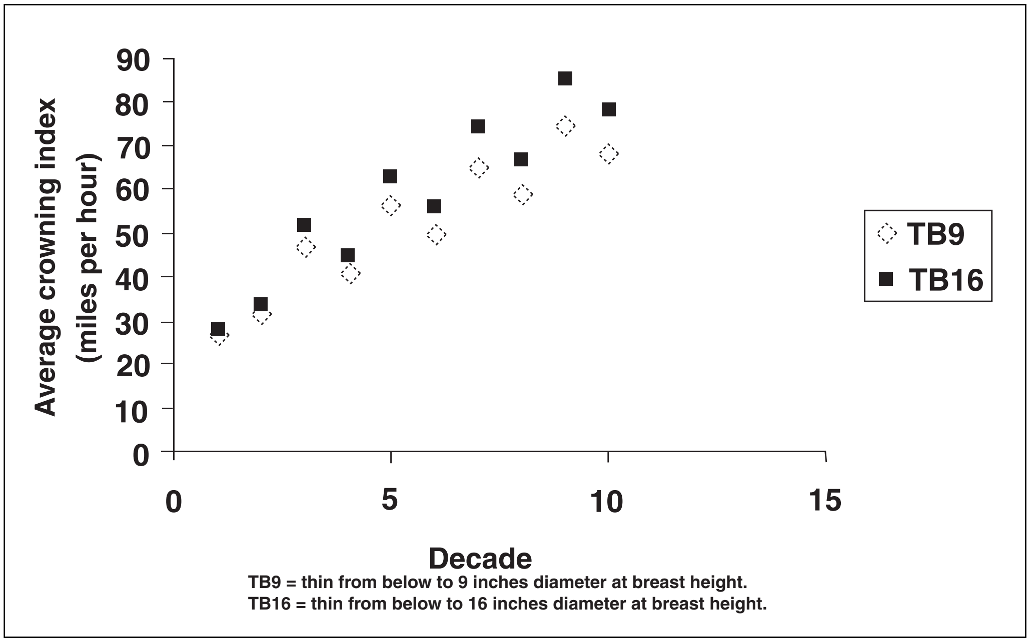

Figure 6—Predicted average crowning index for high fire hazard ponderosa pine plots in New Mexico by prescription.

Percentage of volume removed by species—Harvests ranged from mostly ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) to mixtures that included over half Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). White woods were typically an insignificant component. There were so few cases where merchantable timber was to be harvested that it was not possible to identify patterns in the species mix over time (app. 8).

Financial analysis—There were no instances in this analysis where thinnings would yield a positive net return when valued for conventional solid wood products. None of the TB16 or TB9 cases showed a net return in the plus or minus $100-per-acre category. In most cases, the net return for both regimes fell in the -$500- to -$100-per-acre category. This included the cost of slashing and treating trees less than 4 in d.b.h. and the cost of skidding or yarding other unutilized trees to a landing. It does not include the cost of prescribed fire that occurs 10 years after the first thinning and on a 20-year cycle thereafter (app. 9).

Ponderosa Pine

The total area and number of FIA plots included in this analysis for the ponderosa pine forest type are shown in appendix 2. Ponderosa pine plots were segregated by high fire hazard (<25 mph windspeed) and low/moderate hazard (25+ mph windspeed). These two groups are referred to as high fire hazard and low fire hazard in all tables for this forest type.

Treatment effect on fire hazard—Regression analysis indicated both a time trend (positive slope coefficient on decade) and a cyclical treatment effect (a positive coefficient on the decade following burning) on average crowning index for both the TB9 and the TB16 prescriptions in the ponderosa pine high fire hazard stands (fig. 6). It is not surprising that thinning did not enter the equation because after the first

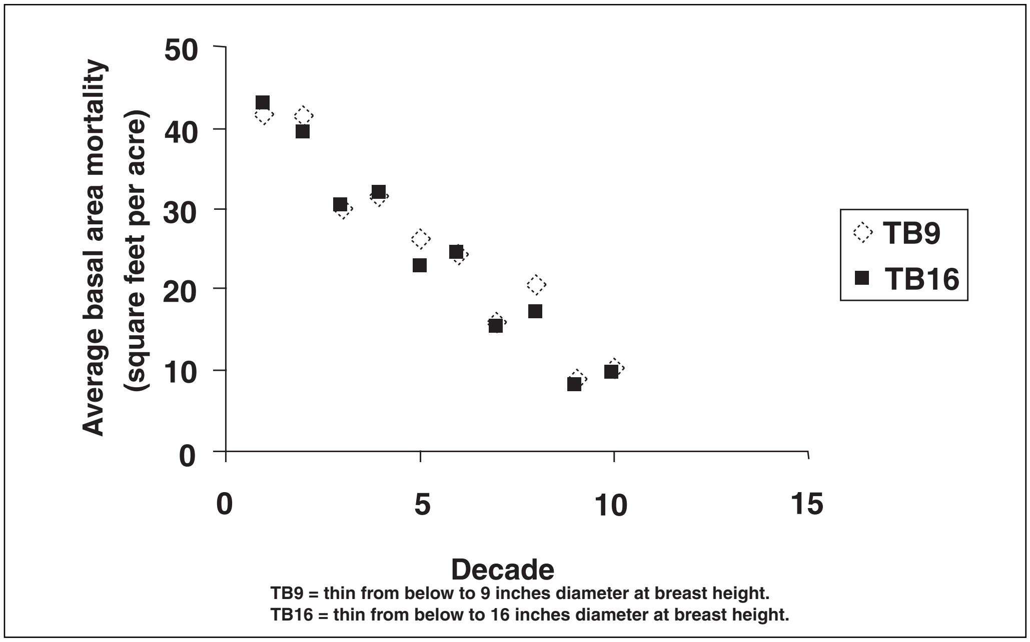

Figure 7—Predicted average basal area mortality for high fire hazard ponderosa pine plots in New Mexico by prescription.

thinning, many stands did not qualify for any further thinning during the simulation period. Although the trends identified here are large, the regressions are weak in explaining the total variation. It is probably unreasonable to draw conclusions about the effectiveness of thinning versus prescribed fire treatments from this analysis. It is reasonable to conclude that the treatments in aggregate have a significant effect on crowning index over time.

Figure 7 shows the analogous comparison for the predicted average basal area mortality resulting from prescribed burns. The effect on potential basal area mortality is almost the same for the two prescriptions. In both cases there is a time trend (a negative coefficient on decade) and an effect in the decade following the decade in which prescribed burning is done (a negative coefficient on the decade following prescribed fire). There is also a small positive effect (increasing potential mortality) in the decade following thinning for the TB9 prescription, but it is small enough that the predicted points fall almost on top of each other. The potential basal area mortality begins relatively high, over 40 percent, for both ponderosa pine and dry mixed-conifer stands in New Mexico. By the end of the simulation period, however, it is only about 10 percent. 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—On steep slopes, the low fire hazard plots have lower basal area composed of a smaller number of trees with a higher average diameter (fig. 8). This is similar to what we found in a companion study for Montana (Barbour et al. 2004). This pattern is not apparent on the gentle-slope plots where there are no obvious differences between low and high fire hazard plots.

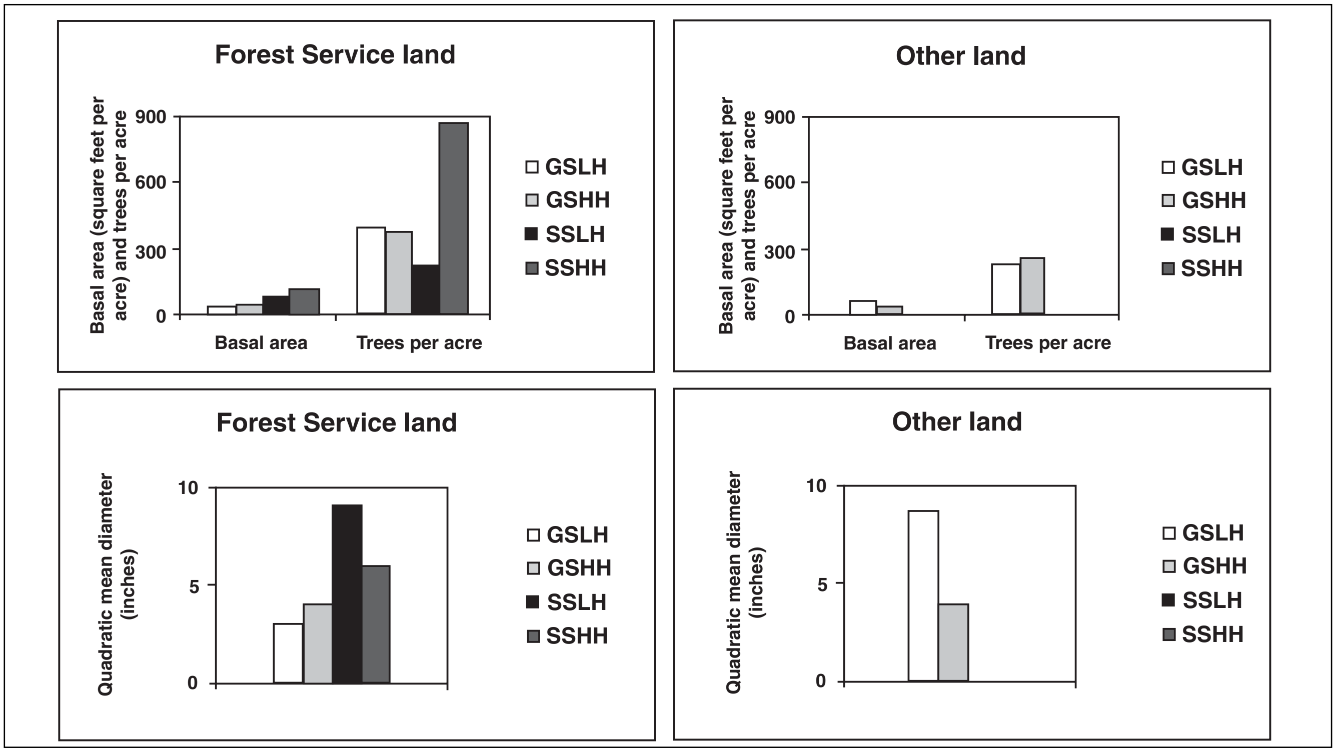

Figure 8—Initial stand conditions for ponderosa pine plots in New Mexico: basal area, number of trees per acre, and quadratic mean diameter, reported by gentle slope low or high fire hazard (GSLH or GSHH) and steep slope low or high fire hazard (SSLH or SSHH).

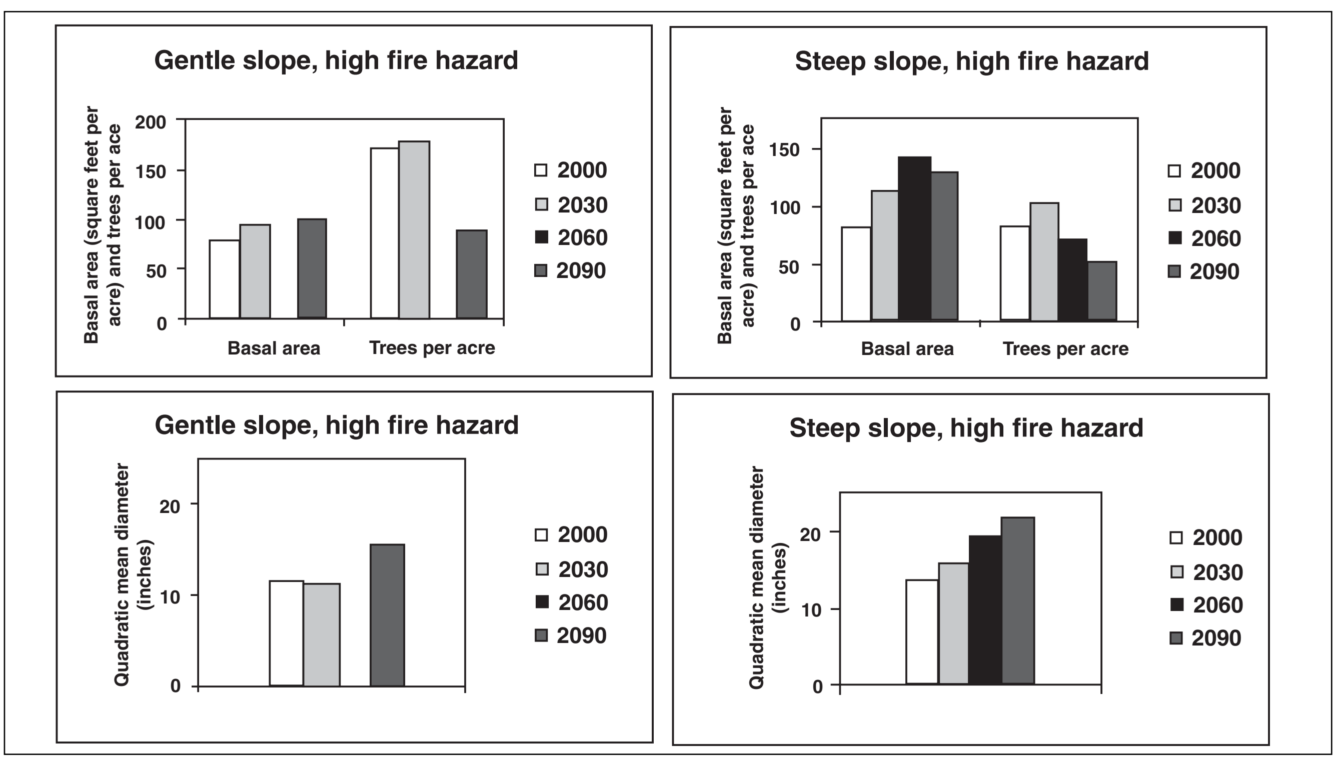

Figure 9—Residual conditions projected for ponderosa pine plots on gentle and steep slopes with high fire hazard on national forests in New Mexico (average values for thinned plots only): basal area, number of trees per acre, and quadratic mean diameter, by prescription.

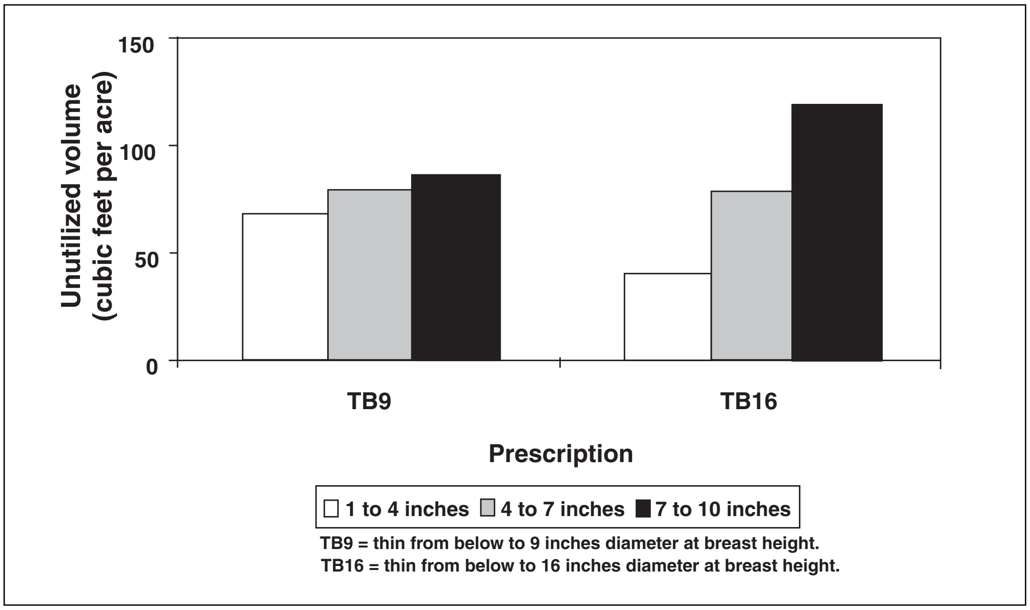

Figure 10—Projected unutilized cut volume in trees 1 to 10 inches diameter at breast height from ponderosa pine plots on national forests in New Mexico on steep slopes with high fire hazard, by diameter class and prescription.

Residual stand summary—In the simulation, basal area did not always accumulate over time in response to repeated low thinnings. In two of the three high fire hazard cases, the prescriptions reduced basal area to the minimum of 80 ft^2/acre by the second thinning then kept it at that level through all subsequent entries. In the other case, basal area increased between each of the first three entries then declined. The results for high fire hazard stands on national forests are shown in figure 9. Other stand characteristics varied fairly consistently over the simulation. Trees per acre generally declined with each subsequent entry, and quadratic mean diameter generally increased, but occasionally there was a large pulse of regeneration that greatly increased trees per acre (app. 4).

Merchantable volume by tree diameter-at-breast-height class—Data for average volume removed of trees 10 in d.b.h. and larger are reported in appendix 5 (tables 16 and 17). No volume from the TB9 prescription is considered merchantable in our analysis, and only logs that come from trees greater than 10 in d.b.h. in the TB16 prescription are counted as merchantable. As a result, few cases produced merchantable volume. Three of the low fire hazard cases produced small volumes (<475 ft^3/acre) of merchantable timber under the TB16 prescription during the first thinning. Two of the high hazard cases also produced small volumes (<110 ft^3/acre) of merchantable timber under the TB16 prescription during the first thinning. One high fire hazard case on national forest land also yielded a small volume (<60 ft^3/acre) of merchantable timber in the second thinning cycle. No merchantable timber is removed from any of the other cases. Although these volumes have been labeled “merchantable,” that does not mean that they could be sold as a timber sale. The financial results indicate that such small volumes would not likely result in a positive net value to a purchaser.

Stem biomass volume of trees 1 to 10 in diameter at breast height—In most cases, there was no volume cut in either the TB9 or TB16 prescription after the first thinning. Cut volumes in the first thinning were generally less than 200 ft^3/acre and often much lower than that (app. 6). An example of unutilized volumes for the steep slope, high fire hazard, national forest case is shown in figure 10. More volume is cut in the 7- to 10-in d.b.h. class under the TB16 prescription than the TB9 prescription because 10-in d.b.h. trees are sometimes removed in the TB16 prescription. These findings parallel what was found for the dry mixed-conifer stand type.

Although trees in the 4- to 10-in diameter range are not considered merchantable in this analysis, considerable research effort is being expended in trying to find ways to process this type of material to partially or wholly offset the costs of fuel-reduction treatments (Barbour 1999, Larson and Mirth 2001, LeVan-Green and Livingston 2001, Lowell and Green 2001, Wolfe and Hernandez 1999). Even so, there are currently only limited markets for logs less than 10 in SED (see footnote 6, Temple 1999).

Average small-end diameter of removed logs—As with the dry mixed-conifer stand type, the TB9 prescription does not produce any logs that are considered merchantable. Log SED increases over time for the TB16 prescription, increasing from about 6.6 to about 7.5 in (app. 7). There are, however, few cases that yield merchantable log volumes in successive entries (app. 7). Progress has been made recently in identifying alternative uses for small logs, e.g., structural roundwood (LeVan-Green and Livingston 2001, Wolfe and Hernandez 1999), but markets are poorly developed.

Percentage of volume removed by species—Ponderosa pine was the dominant species removed from the six cases where saw logs were produced, accounting for 74 to 100 percent of the volume. In these cases, most of the remaining volume was distributed equally among white woods and Douglas-fir (app. 8). The value of this material for forest products depends on the age and growing conditions of these stands. Larger and older pine with few scattered branches could yield high-value appearance-grade lumber; however, smaller and younger pine does not produce good-quality structural lumber (Erikson et al. 2000, Willits et al. 1996) or veneer (Willits et al. 1997).

Financial analysis—There were no instances in this analysis where thinnings would yield a positive net return when valued for conventional solid wood products. With one minor exception, none of the TB16 or TB9 cases showed a net return in the minus to plus $100-per-acre category. In most cases, the net return for both regimes fell into the -$100 to -$500 category. This includes the cost of slashing and treating trees less than 4 in d.b.h. and the cost of skidding or yarding other unutilized trees to a landing. It does not include the cost of prescribed fire that occurs 10 years after the first thinning and on a 20-year cycle thereafter (app. 9).

Conclusion

This report demonstrates 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 also can be performed by using these analytical methods if a systematic inventory is available.

The thin-from-below regimes used in this analysis do not produce any noteworthy volume after the first thinning. In addition, volume that is produced from the first thinning is mostly unmerchantable because of the structure of the existing wood products industry in New Mexico. Even if markets were available for the smaller material removed during thinning treatments, average per-acre volume yields are low. This may make it difficult to site and supply wood-processing facilities that require large volumes to operate economically.

Our results do, however, suggest that in most cases, the thin-from-below regime in combination with regular prescribed burning does reduce fire hazard over the long term and does not result in an accumulation of basal area that might lead to insect or other forest health problems. Broad application of these treatments likely would be limited by both fire hazard and wildlife considerations. For example, although some of our treatments create stands that would be a component of suitable habitat for the northern goshawk (*Accipiter gentiles*), goshawks and many other important wildlife species require a landscape composed of a variety of stand conditions (Reynolds et al. 1992). Additionally, treatments that leave fewer trees would provide greater fuel-reduction benefits. This suggests that a broader range of prescriptions than we dealt with should be considered for a broad-scale fuels management program.

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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Abbreviation and 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
JFSP—Joint Fire Science Program
QMD—quadratic mean breast-height diameter
SED—small-end diameter of logs
TB9—thin-from-below to 9 inches d.b.h. with a minimum residual basal area
TB16—thin-from-below to 16 inches d.b.h. 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 (<40 percent). Cable systems are assumed for steeper 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. The market conditions used represent a moderate lumber market with no market for chip logs. 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 more unfavorable than we report (see 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 – 1,000	225
1,000 – 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 diameter breast height.

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

Table 3—Log prices for New Mexico

Small-end diameter	Douglas-fir and larch	White fir	Ponderosa pine
Inches	-----------*Dollars per 100 cubic feet*--------		
9.6	112	109	112
12.6	165	159	167
16.6	226	226	240

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, 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 dry mixed-conifer forest type in New Mexico

Land type	Acres	Number of plots
National forest land:		
Steep slope, high fire hazard	368,876	50
Gentle slope, high fire hazard	505,578	50
Steep slope, low fire hazard	58,726	10
Gentle slope, low fire hazard	72,912	12
Subtotal	1,006,092	
Other land:		
Steep slope, high fire hazard	163,233	23
Gentle slope, high fire hazard	249,426	38
Steep slope, low fire hazard	—	<10
Gentle slope, low fire hazard	60,462	10
Subtotal	473,121	
Total	1,479,213	

— = not available.

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

Land type	Acres	Number of plots
National forest land:		
Steep slope, high fire hazard	124,169	20
Gentle slope, high fire hazard	622,272	50
Steep slope, low fire hazard	66,952	10
Gentle slope, low fire hazard	765,147	50
Subtotal	1,578,540	
Other land:		
Steep slope, high fire hazard	—	<10
Gentle slope, high fire hazard	522,877	50
Steep slope, low fire hazard	—	<10
Gentle slope, low fire hazard	309,587	42
Subtotal	832,464	
Total	2,411,004	

— = 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 (see tables 6 through 9).

Table 6—Average initial stand characteristics for the dry mixed-conifer forest type in New Mexico, national forest land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*No.*	*Inches*
1998	Gentle slope, low hazard	Mean	85	351	7.8
		SE[d]	8	71	.7
1998	Gentle slope, high hazard	Mean	46	403	4.0
		SE	7	113	.7
1998	Steep slope, low hazard	Mean	73	247	8.4
		SE	14	69	.9
1998	Steep slope, high hazard	Mean	37	252	4.1
		SE	6	71	.7

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 dry mixed-conifer forest type in New Mexico, other land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft^2/acre	*No.*	*Inches*
1999	Gentle slope, low hazard	Mean	98	285	9.0
		SE[d]	14	66	.7
1999	Gentle slope, high hazard	Mean	119	836	5.8
		SE	8	109	.3
1999	Steep slope, high hazard	Mean	113	686	5.9
		SE	9	84	.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 ponderosa pine forest type in New Mexico, national forest land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft²/acre	*No.*	*Inches*
1998	Gentle slope, low hazard	Mean	39	397	2.8
		SE[d]	7	110	.5
1998	Gentle slope, high hazard	Mean	42	379	3.8
		SE	7	101	.6
1998	Steep slope, low hazard	Mean	75	223	9.3
		SE	9	46	.9
1998	Steep slope, high hazard	Mean	118	872	5.6
		SE	10	126	.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 9—Average initial stand characteristics for the ponderosa pine forest type in New Mexico, other land

Year		Measure	BA[a]	TPA[b]	QMD[c]
			Ft²/acre	*No.*	*Inches*
1999	Gentle slope, low hazard	Mean	68	241	8.8
		SE[d]	6	47	.5
1999	Gentle slope, high hazard	Mean	37	274	3.8
		SE	6	80	.6

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 with 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 to project 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 relatively simple 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 is reported here (see tables 10 through 13).

Table 10—Average residual stand characteristics projected for the dry mixed-conifer forest type in New Mexico, national forest land

Year	Rx[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA[b]	TPA[c]	QMD[d]	BA CUT[e]
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	92	75	15.1	29	101	87	14.6	24
		SE[g]	5	4	.4	5	12	7	.8	6
	TB16[h]	Mean	56	26	20.4	56	60	39	18.2	53
		SE	3	3	.9	4	4	9	1.5	5
2060	TB9	Mean	93	174	13.7	10	113	292	14.1	5
		SE	8	110	3.9	9	16	241	4.6	5
	TB16	Mean	80	942	4.0	17	80	383	15.6	7
		SE	—	—	—		1	393	10.4	7
2090	TB9	Mean	80	660	4.7	11	98	404	12.8	4
		SE	—	—	—	—	17	378	8.0	4
	TB16	Mean	88	24	25.9	0	80	809	4.3	7
		SE	—	—	—	—	—	—	—	-—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	76	165	12.5	24	68	148	11.6	25
		SE	6	41	1.0	3	6	42	.9	4
	TB16	Mean	60	133	12.7	34	60	137	12.1	31
		SE	4	42	1.0	4	5	43	1.0	5
2030	TB9	Mean	82	179	11.0	14	82	122	12.2	25
		SE	2	72	3.1	3	2	38	2.5	10
	TB16	Mean	80	109	14.9	16	80	96	15.4	21
		SE	1	54	4.2	6	1	34	2.7	6
2060	TB9	Mean	—	—	—	—	80	300	7.0	35
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	80	20	27.3	4	80	301	7.0	35
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	83	69	17.0	8	80	79	15.3	12
		SE	2	26	2.6	3	1	24	2.4	3
	TB16	Mean	82	56	18.3	6	80	63	16.4	7
		SE	2	20	1.9	2	1	13	1.3	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] TB16 = thin from below to 16 inches diameter at breast height.

Table 11—Average residual stand characteristics projected for the dry mixed-conifer forest type in New Mexico, other land

Year	Rx[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA[b]	TPA[c]	QMD[d]	BA CUT[e]
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	98	77	16.1	18	—	—	—	—
		SE[g]	10	14	.9	3	—	—	—	—
	TB16[h]	Mean	64	31	19.6	42	—	—	—	—
		SE	6	1	1.0	7	—	—	—	—
2060	TB9	Mean	118	67	18.5	2	—	—	—	—
		SE	9	10	1.2	1	—	—	—	—
	TB16	Mean	89	66	19.5	1	—	—	—	—
		SE	7	34	5.0	1	—	—	—	—
2090	TB9	Mean	102	55	18.5	5	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	81	22	26.1	1	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	82	104	12.9	36	78	87	13.1	39
		SE	6	13	.5	2	7	7	.6	3
	TB16	Mean	72	86	14.1	44	59	60	14.6	51
		SE	6	14	.9	3	5	7	.8	4
2030	TB9	Mean	103	91	16.4	6	129	132	13.3	8
		SE	6	20	1.3	3	46	12	3.1	8
	TB16	Mean	97	86	16.9	13	80	84	15.8	25
		SE	7	25	1.3	4	1	54	5.2	8
2060	TB9	Mean	107	137	16.4	5	174	92	18.6	2
		SE	8	56	2.2	3	—	—	—	—
	TB16	Mean	103	111	17.9	6	—	—	—	—
		SE	11	64	2.5	4	—	—	—	—
2090	TB9	Mean	92	63	18.9	7	91	75	16.8	2
		SE	4	16	1.8	3	7	30	2.2	1
	TB16	Mean	84	43	21.1	9	80	52	19.2	8
		SE	3	9	1.5	3	1	18	3.3	7

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] TB16 = thin from below to 16 inches diameter at breast height.

Table 12—Average residual stand characteristics projected for the ponderosa pine forest type in New Mexico, national forest land

Year	Rx[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA[b]	TPA[c]	QMD[d]	BA CUT[e]
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	84	101	13.1	41	95	76	15.7	18
		SE[g]	7	11	.7	5	7	8	.7	3
	TB16[h]	Mean	56	60	15.4	59	55	27	20.4	51
		SE	3	11	1.2	3	4	4	1.3	4
2060	TB9	Mean	93	416	12.2	13	105	58	18.2	0
		SE	8	341	3.1	8	14	10	.3	—
	TB16	Mean	80	1,078	3.9	29	—	—	—	—
		SE	1	422	.9	4	—	—	—	—
2090	TB9	Mean	80	239	12.7	8	89	39	20.6	0
		SE	1	233	6.1	7	—	—	—	—
	TB16	Mean	80	1,000	3.8	1	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	67	147	12.1	28	82	82	13.8	33
		SE	5	45	1.1	4	9	8	.7	4
	TB16	Mean	61	136	12.5	33	74	69	14.6	40
		SE	5	46	1.1	5	10	9	.7	4
2030	TB9	Mean	81	154	11.7	17	113	102	16.0	2
		SE	1	57	2.3	3	13	33	2.1	1
	TB16	Mean	80	111	14.1	16	106	97	17.1	5
		SE	1	40	3.2	5	18	45	2.9	3
2060	TB9	Mean	—	—	—	—	142	70	19.3	3
		SE	—	—	—	—	12	7	.2	1
	TB16	Mean	80	20	27.3	4	152	76	19.2	2
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	86	76	16.2	9	129	51	21.7	4
		SE	2	20	1.9	3	21	10	.4	2
	TB16	Mean	81	64	16.8	9	105	41	22.5	3
		SE	1	15	1.5	2	18	10	1.9	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] TB16 = thin from below to 16 inches diameter at breast height.

Table 13—Average residual stand characteristics projected for the ponderosa pine forest type in New Mexico, other land

Year	Rx[a]	Measure	BA[b]	TPA[c]	QMD[d]	BA CUT[e]	BA[b]	TPA[c]	QMD[d]	BA CUT[e]
			Ft²/acre	*No.*	*Inches*	*Percent*	*Ft²/acre*	*No.*	*Inches*	*Percent*
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[f]	Mean	87	73	15.3	17	—	—	—	—
		SE[g]	4	5	.5	2	—	—	—	—
	TB16[h]	Mean	58	34	18.4	40	—	—	—	—
		SE	2	2	.6	3	—	—	—	—
2060	TB9	Mean	102	97	15.0	15	—	—	—	—
		SE	12	32	2.8	14	—	—	—	—
	TB16	Mean	80	725	4.5	38	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	80	735	4.5	11	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	83	534	16.4	0	—	—	—	—
		SE	3	491	13.3	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	65	116	11.9	31	—	—	—	—
		SE	5	20	1.1	4	—	—	—	—
	TB16	Mean	56	101	12.4	38	—	—	—	—
		SE	4	21	1.1	5	—	—	—	—
2030	TB9	Mean	82	162	11.6	25	—	—	—	—
		SE	2	74	3.0	10	—	—	—	—
	TB16	Mean	80	162	9.6	24	—	—	—	—
		SE	1	29	.9	21	—	—	—	—
2060	TB9	Mean	80	300	7.0	35	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	80	114	20.5	14	—	—	—	—
		SE	1	133	9.6	15	—	—	—	—
2090	TB9	Mean	84	62	16.3	12	—	—	—	—
		SE	4	13	2.2	5	—	—	—	—
	TB16	Mean	82	53	17.3	7	—	—	—	—
		SE	2	7	1.2	3	—	—	—	—

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] TB16 = thin from below to 16 inches diameter at breast height.

Appendix 5: Average Volume of Utilized Trees

Resource managers who plan and conduct fuels mitigation treatments and contractors who bid on the treatments need information on the merchantable volume and size of trees removed during treatments. The tables included in this appendix summarize average cubic-foot volume harvested per acre, with standard errors in parentheses (see tables 14 through 17). Processing output for all trees 10 in diameter at breast height and larger through the Financial Evaluation of Ecosystem Management Activities (FEEMA) model generates the data for these tables. Merchantable volume is calculated by summing all logs that FEEMA recovered from each tree up to a 6-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., app. 7 and 8) confusing.

Table 14—Average volume of utilized trees projected for the dry mixed-conifer forest type in New Mexico, national forest land

			Diameter at breast height (inches)	
Year	R_x[a]	Measure	10 to 16	10 to 16
			Cubic feet per acre	*Cubic feet per acre*
			Gentle slope, low hazard	**Steep slope, low hazard**
2030	TB9[b]	Mean	—	—
		SE[c]	—	—
	TB16[d]	Mean	326	443
		SE	40	58
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
			Gentle slope, high hazard	**Steep slope, high hazard**
2000	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	59	—
		SE	28	—
2030	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Table 15—Average volume of utilized trees projected for the dry mixed-conifer forest type in New Mexico, other land

			Diameter at breast height (inches)	
Year	R_x[a]	Measure	10 to 16	10 to 16
			Cubic feet per acre	*Cubic feet per acre*
			Gentle slope, low hazard	**Steep slope, low hazard**
2030	TB9[b]	Mean	—	—
		SE[c]	—	—
	TB16[d]	Mean	293	—
		SE	43	—
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
			Gentle slope, high hazard	**Steep slope, high hazard**
2000	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	81	232
		SE	25	65
2030	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	136	404
		SE	53	132
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Table 16—Average volume of utilized trees projected for the ponderosa pine forest type in New Mexico, national forest land

			Diameter at breast height (inches)	
Year	R_X[a]	Measure	10 to 16	10 to 16
			Cubic feet per acre	*Cubic feet per acre*
	Gentle slope, low hazard			**Steep slope, low hazard**
2030	TB9[b]	Mean	—	—
		SE[c]	—	—
	TB16[d]	Mean	127	474
		SE	38	56
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
	Gentle slope, high hazard			**Steep slope, high hazard**
2000	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	103
		SE	—	39
2030	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	57
		SE	—	57
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—

[a] R_X = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Table 17—Average volume of utilized trees projected for the ponderosa pine forest type in New Mexico, other land

			Diameter at breast height (inches)	
Year	Rx[a]	Measure	10 to 16	10 to 16
			Cubic feet per acre	*Cubic feet per acre*
			Gentle slope, low hazard	**Steep slope, low hazard**
2030	TB9[b]	Mean	—	—
		SE[c]	—	—
	TB16[d]	Mean	256	—
		SE	5	—
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
			Gentle slope, high hazard	**Steep slope, high hazard**
2000	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	69	—
		SE	33	—
2030	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2060	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—
2090	TB9	Mean	—	—
		SE	—	—
	TB16	Mean	—	—
		SE	—	—

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Appendix 6: Average Volume of Unutilized Trees

Volumes for trees in the 3- to <4-, 4- to <7-, and 7- to <10-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 biomass that needs to be processed to accomplish the fuel-reduction treatments. New technologies might provide alternative uses for these trees so information on their volume may be useful for planning (see tables 18 through 21).

Table 18—Average volume of trees cut but not unutilized, by diameter class projected for the dry mixed-conifer forest type in New Mexico, national forest land

Year	Rx[a]	Measure	3 to 4	4 to 7	7 to 10	Total	3 to 4	4 to 7	7 to 10	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	2	32	73	107	4	60	57	122
		SE[c]	2	11	27	20	3	34	26	26
	TB16[d]	Mean	2	32	117	151	4	60	76	141
		SE	2	11	30	17	3	34	27	20
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	0	13	24	37	0	40	71	111
		SE	—	8	16	17	—	16	28	28
	TB16	Mean	0	13	39	52	0	40	89	129
		SE	—	8	24	24	—	16	35	34
2030	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Table 19—Average volume of trees cut but not unutilized, by diameter class projected for the dry mixed-conifer forest type in New Mexico, other land

			Diameter at breast height (inches)							
Year	Rx[a]	Measure	3 to 4	4 to 7	7 to 10	Total	3 to 4	4 to 7	7 to 10	Total
			- - - - - Cubic feet per acre - - - - -				*- - - - - Cubic feet per acre - - - - -*			
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[b]	Mean	4	25	49	79	—	—	—	—
		SE[c]	3	12	25	20	—	—	—	—
	TB16[d]	Mean	4	25	84	113	—	—	—	—
		SE	3	12	40	34	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	12	130	135	277	20	134	108	262
		SE	4	20	21	17	8	24	27	25
	TB16	Mean	12	130	168	310	20	134	151	305
		SE	4	20	29	4	8	24	38	26
2030	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	1	1	—	—	—	—
		SE	—	—	1	1	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	1	1	1
		SE	—	—	—	—	—	1	1	1
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Table 20—Average volume of trees cut but not unutilized, by diameter class projected for the ponderosa pine forest type in New Mexico, national forest land

			Diameter at breast height (inches)							
Year	Rx[a]	Measure	3 to 4	4 to 7	7 to 10	Total	3 to 4	4 to 7	7 to 10	Total
			- - - - - Cubic feet per acre - - - - -				*- - - - - Cubic feet per acre - - - - -*			
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[b]	Mean	3	19	48	70	2	25	85	113
		SE[c]	3	10	22	22	1	13	16	14
	TB16[d]	Mean	3	19	75	97	2	25	120	147
		SE	3	10	34	34	1	13	21	14
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	2	40	33	75	9	79	85	172
		SE	2	28	21	33	4	21	22	9
	TB16	Mean	2	40	47	89	9	79	116	203
		SE	2	28	27	37	4	21	32	19
2030	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	1	1
		SE	—	—	—	—	—	—	1	1
	TB16	Mean	—	—	—	—	—	—	2	2
		SE	—	—	—	—	—	—	1	1

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Table 21—Average volume of trees cut but not unutilized, by diameter class projected for the ponderosa pine forest type in New Mexico, other land

			Diameter at breast height (inches)							
Year	Rx[a]	Measure	3 to 4	4 to 7	7 to 10	Total	3 to 4	4 to 7	7 to 10	Total
			- - - - - Cubic feet per acre - - - - -				*- - - - - Cubic feet per acre - - - - -*			
			Gentle slope, low hazard				**Steep slope, low hazard**			
2030	TB9[b]	Mean	3	27	54	84	—	—	—	—
		SE[c]	—	—	—	—	—	—	—	—
	TB16[d]	Mean	3	25	83	110	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
			Gentle slope, high hazard				**Steep slope, high hazard**			
2000	TB9	Mean	0	38	73	111	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	0	38	93	131	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2030	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—	—	—
		SE	—	—	—	—	—	—	—	—

[a] R_x = treatment.
[b] TB9 = thin from below to 9 inches diameter at breast height.
[c] SE = standard error (+/-).
[d] TB16 = thin from below to 16 inches diameter at breast height.

Appendix 7: Average Small-End Diameter of Utilized Logs

Information on average saw log size is reported in this appendix. These data provide mill owners with information on how the size of logs generated from fuel-reduction treatments might be expected to change over time. Tables 22 and 23 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 factors. The minimum diameter log included in FEEMA output is 6 in. Because a 9-in tree will not yield a 16-ft log with a minimum 6-in SED, there is no volume or average log size reported for TB9 treatments. All tree species are combined.

Table 22—Average small-end diameter of utilized logs projected for the dry mixed-conifer forest type in New Mexico

	Entry: 1[a]		Entry: 2[b]		Entry: 3[c]		Entry: 4[d]	
	TB9[e]	TB16[f]	TB9[e]	TB16[f]	TB9[e]	TB16[f]	TB9[e]	TB16[f]
	Inches							
National forest land:								
Steep slope, high fire hazard	—	6.5	—	—	—	—	—	—
Gentle slope, high fire hazard	—	6.8	—	—	—	—	—	—
Steep slope, low fire hazard	—	—	—	8.0	—	—	—	—
Gentle slope, low fire hazard	—	—	—	7.6	—	—	—	—
Other land:								
Steep slope, high fire hazard	—	6.7	—	8.6	—	—	—	9.6
Gentle slope, high fire hazard	—	6.3	—	7.5	—	7.9	—	8.6
Steep slope, low fire hazard	—	—	—	—	—	—	—	—
Gentle slope, low fire hazard	—	—	—	7.6	—	—	—	—

Note: blank entries for average diameter indicate 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] TB16 = thin from below to 9 inches diameter at breast height.

Table 23—Average small end-diameter of utilized logs projected for the ponderosa pine forest type in New Mexico

	Entry: 1[a]		Entry: 2[b]		Entry: 3[c]		Entry: 4[d]	
	TB9[e]	TB16[f]	TB9[e]	TB16[f]	TB9[e]	TB16[f]	TB9[e]	TB16[f]
	Inches							
National forest land:								
Steep slope, high fire hazard	—	6.5	—	7.6	—	—	—	6.6
Gentle slope, high fire hazard	—	6.9	—	—	—	—	—	8.2
Steep slope, low fire hazard	—	—	—	7.7	—	—	—	—
Gentle slope, low fire hazard	—	—	—	6.8	—	—	—	—
Other land:								
Steep slope, high fire hazard	—	—	—	—	—	—	—	—
Gentle slope, high fire hazard	—	6.6	—	—	—	—	—	—
Steep slope, low fire hazard	—	—	—	—	—	—	—	—
Gentle slope, low fire hazard	—	—	—	7.4	—	—	—	—

Note: blank entries for average diameter indicate 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] TB16 = thin from below to 9 inches diameter at breast height.

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

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, 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 (see tables 24 through 27).

Table 24—Average percentage of log volume by species projected for the dry mixed-conifer forest type in New Mexico, national forest land

Year	Rx[a]	Measure	Douglas fir	Ponderosa pine	White woods[b]	Douglas fir	Ponderosa pine	White woods[b]
			- - - - - - - - Percent - - - - - - - -			*- - - - - - - - Percent - - - - - - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	TB16[e]	Mean	43	53	4	40	52	8
		SE	13	16	1	16	21	3
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	8	92	0	—	—	—
		SE	4	46	—	—	—	—
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—

Note: blanks indicate 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] TB16 = thin from below to 16 inches diameter at breast height.

Table 25—Average percentage of log volume by species projected for the dry mixed-conifer forest type in New Mexico, other land

Year	Rx[a]	Measure	Douglas fir	Ponderosa pine	White woods[b]	Douglas fir	Ponderosa pine	White woods[b]
			- - - - - - - - Percent - - - - - - - -			*- - - - - - - - Percent - - - - - - - -*		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	TB16[e]	Mean	46	35	19	—	—	—
		SE	16	12	7	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	68	29	4	68	11	21
		SE	21	9	1	23	4	7
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	55	45	0	97	0	3
		SE	39	32	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—

Note: blanks indicate 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] TB16 = thin from below to 16 inches diameter at breast height.

Table 26—Average percentage of log volume by species projected for the ponderosa pine forest type in New Mexico, national forest land

Year	Rx[a]	Measure	Douglas fir	Ponderosa pine	White woods[d]	Douglas fir	Ponderosa pine	White woods[d]
			- - - - - - - - *Percent* - - - - - - - -			- - - - - - - - *Percent* - - - - - - - -		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	TB16[e]	Mean	6	83	11	9	88	4
		SE	2	34	5	3	33	1
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	15	74	11
		SE	—	—	—	7	33	5
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	0	100	0
		SE	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—

Note: blanks indicate 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] TB16 = thin from below to 16 inches diameter at breast height.

Table 27—Average percentage of log volume by species projected for the ponderosa pine forest type in New Mexico, other land

Year	Rx[a]	Measure	Douglas fir	Ponderosa pine	White woods[d]	Douglas fir	Ponderosa pine	White woods[d]
			- - - - - - - - *Percent* - - - - - - - -			- - - - - - - - *Percent* - - - - - - - -		
			Gentle slope, low hazard			**Steep slope, low hazard**		
2030	TB9[c]	Mean	—	—	—	—	—	—
		SE[d]	—	—	—	—	—	—
	TB16[e]	Mean	1	96	2	—	—	—
		SE	1	17	1	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
			Gentle slope, high hazard			**Steep slope, high hazard**		
2000	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	8	92	0	—	—	—
		SE	4	46	—	—	—	—
2030	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2060	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
2090	TB9	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—
	TB16	Mean	—	—	—	—	—	—
		SE	—	—	—	—	—	—

Note: blanks indicate 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] TB16 = thin from below to 16 inches diameter at breast height.

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 moderate market for lumber and no market for chip logs. The range of net value, and the recognition that few if any stands will have a positive net value from thinning under any foreseeable circumstances, is the important result. Because these results involve calculations involving economic assumptions for which standard errors are unknown, standard errors are also unknown for these results, and therefore none are reported (see tables 28 through 31).

Table 28—Average proportion of stands by net value per acre category projected for the dry mixed-conifer forest type in New Mexico, national forest land

Year	Rx[a]	-$1,000	-$1,000 to -$500	-$500 to -$100	-$100 to $100	$100 to $500	-$1,000	-$1,000 to -$500	-$500 to -$100	$100 to $100	$100 to $500
			Gentle slope, low hazard					Steep slope, low hazard			
2030	TB9[b]	0	0.25	0.75	0	0	0.25	0.38	0.38	0	0
	TB16[c]	.08	.50	.42	0	0	.38	.50	.13	0	0
2060	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0
2090	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0
			Gentle slope, high hazard					Steep slope, high hazard			
2000	TB9	0	.17	.83	0	0	.14	.29	.57	0	0
	TB16	.04	.26	.70	0	0	.33	.14	.52	0	0
2030	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0
2060	TB9	—	—	—	—	—	—	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0
2090	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0

Note: proportion is the proportion of stands in net value categories within each type, year, and treatment.

[a] R_x = treatment.

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

[c] TB16 = thin from below to 16 inches diameter at breast height.

Table 29—Average proportion of stands by net value per acre category projected for the dry mixed-conifer forest type in New Mexico, other land

Year	Rx[a]	-$1,000	-$1,000 to -$500	-$500 to -$100	-$100 to $100	$100 to $500	-$1,000	-$1,000 to -$500	-$500 to -$100	$100 to $100	$100 to $500
			Gentle slope, low hazard					Steep slope, low hazard			
2030	TB9[b]	0	0.10	0.90	0	0	—	—	—	—	0
	TB16[c]	0	.40	.60	0	0	—	—	—	—	—
2060	TB9	0	0	1.00	0	0	—	—	—	—	0
	TB16			1.00	0	0	—	—	—	—	—
2090	TB9	0	0	1.00	0	0	—	—	—	—	0
	TB16	0	0	1.00	0	0	—	—	—	—	0
			Gentle slope, high hazard					Steep slope, high hazard			
2000	TB9	.22	.44	.33	0	0	.40	.30	.30	0	0
	TB16	.33	.39	.28	0	0	.60	.15	.25	0	0
2030	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	.50	.50	0	0
2060	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	—	—	—	—	—
2090	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0

Note: proportion is the proportion of stands in net value categories within each type, year, and treatment.

[a] R_x = treatment.

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

[c] TB16 = thin from below to 16 inches diameter at breast height.

Table 30—Average proportion of stands by net value per acre category projected for the ponderosa pine forest type in New Mexico, national forest land

Year	Rx[a]	-$1,000	-$1,000 to -$500	-$500 to -$100	-$100 to $100	$100 to $500	-$1,000	-$1,000 to -$500	-$500 to -$100	$100 to $100	$100 to $500
			Gentle slope, low hazard					Steep slope, low hazard			
2030	TB9[b]	0.10	0.24	0.67	0	0	0	0.22	0.78	0	0
	TB16[c]	.14	.33	.52	0	0	.11	.78	.11	0	0
2060	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	—	—	—	—	—
2090	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	—	—	—	—	—
			Gentle slope, high hazard					Steep slope, high hazard			
2000	TB9	.05	.15	.80	0	0	.25	.45	.30	0	0
	TB16	.10	.15	.75	0	0	.40	.35	.25	0	0
2030	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0
2060	TB9	—	—	—	—	—	—	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0
2090	TB9	0	0	1.00	0	0	0	0	1.00	0	0
	TB16	0	0	1.00	0	0	0	0	1.00	0	0

Note: proportion is the proportion of stands in net value categories within each type, year, and treatment.

[a] R_x = treatment.

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

[c] TB16 = thin from below to 16 inches diameter at breast height.

Table 31—Average proportion of stands by net value per acre category projected for the ponderosa pine forest type in New Mexico, other land

Year	Rx[a]	-$1,000	-$1,000 to -$500	-$500 to -$100	-$100 to $100	$100 to $500	-$1,000	-$1,000 to -$500	-$500 to -$100	$100 to $100	$100 to $500
			Gentle slope, low hazard					Steep slope, low hazard			
2030	TB9[b]	0	0.09	0.91	0	0	—	—	—	—	—
	TB16[c]	0	.26	.71	.03	0	—	—	—	—	—
2060	TB9	0	0	1.00	0	0	—	—	—	—	—
	TB16	0	0	1.00	0	0	—	—	—	—	—
2090	TB9	0	0	1.00	0	0	—	—	—	—	—
	TB16	0	0	1.00	0	0	—	—	—	—	—
			Gentle slope, high hazard					Steep slope, high hazard			
2000	TB9	.05	.32	.63	0	0	—	—	—	—	—
	TB16	.11	.37	.53	0	0	—	—	—	—	—
2030	TB9	0	0	1.00	0	0	—	—	—	—	—
	TB16	0	0	1.00	0	0	—	—	—	—	—
2060	TB9	0	0	1.00	0	0	—	—	—	—	—
	TB16	0	0	1.00	0	0	—	—	—	—	—
2090	TB9	0	0	1.00	0	0	—	—	—	—	—
	TB16	0	0	1.00	0	0	—	—	—	—	—

Note: proportion is the proportion of stands in net value categories within each type, year, and treatment.

[a] R_x = treatment.

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

[c] TB16 = thin from below to 16 inches diameter at breast height.

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