IDENTIFYING TREATMENT OPPORTUNITIES ON NONINDUSTRIAL PRIVATE TIMBERLANDS IN WESTERN MONTANA

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INTRODUCTION

The Intermountain Station collects extensive, "stand" level data in order to assess the extent and condition of the forest resources of a particular State. This data, when combined with an estimate of stocking, can be used to identify broad silvicultural treatment opportunities. The treatment opportunities will provide additional insight as to the general condition of the forest resources, and could serve as starting points for regional planning efforts.

Often, the primary purpose of silvicultural treatments is to bring stocking to some desired management level by manipulating stand density. Managing density is critical in controlling stand development (Daniel and others 1979; USDA 1985). An accurate estimate of stand density is crucial to any procedure designed to identify treatment opportunities.

One method of estimating density is Reineke's stand density index, or SDI (Reineke 1933). SDI expresses stand density, in trees per acre, relative to the biological maximum density a species can attain at a particular average stand diameter, usually 10 inches. The ratio of the current SDI of a stand to its maximum forms a relative density index. These values can be compared to desired relative density levels to determine the adequacy of the stand's stocking to meet a management objective.

This estimate of stocking based on relative density, combined with Forest Survey variables such as volume per acre, average diameter, and age, formed the basis for a procedure designed to identify the broad silvicultural treatment opportunities described in this paper. Similar efforts have been done for many other States, (Smith and Spencer 1985; Smith and Moyer 1984; MacLean 1980; Knight and McClure 1974) but none attempted to use SDI as the means of estimating stocking. As a secondary objective, the feasibility of using SDI as a stand level estimator of density with forest level data was assessed.

OBJECTIVE

The primary objective of the study was to develop the methodology to identify broad silvicultural treatment opportunities for nonindustrial private (NIP) timberland in western Montana using Forest Survey data. The study assumes a management goal of maximum volume production at the stand level. The purpose of the stand treatments is to maintain stand stocking at levels necessary to meet this goal.

A screening process was designed to identify treatment opportunities in three steps:

1. First, each timberland location was screened by specific Forest Survey site variables to estimate the area of nonindustrial private timberland considered physically and biologically suitable to support forest management operations on a sustained basis.

2. Next, Reineke's Stand Density Index (SDI) was used as the basis for generating a relative density index (RDI) to assess the stocking level of each

suitable timberland location. Stocking was assessed relative to a management goal of maximum cubic-foot volume production at the stand level.

3. Then, the RDI value for each location was combined with Forest Survey "stand" level variables to identify silvicultural treatment opportunities.

Due to the extensive nature of the inventory data, the treatment opportunities are meant to serve as starting points in the assessment of the silvicultural needs of western Montana's nonindustrial private timberlands. No attempt was made to develop detailed, stand-by-stand prescriptions or management regimes. The study provides information about physical management opportunities only. The economic viability of any treatment was not considered.

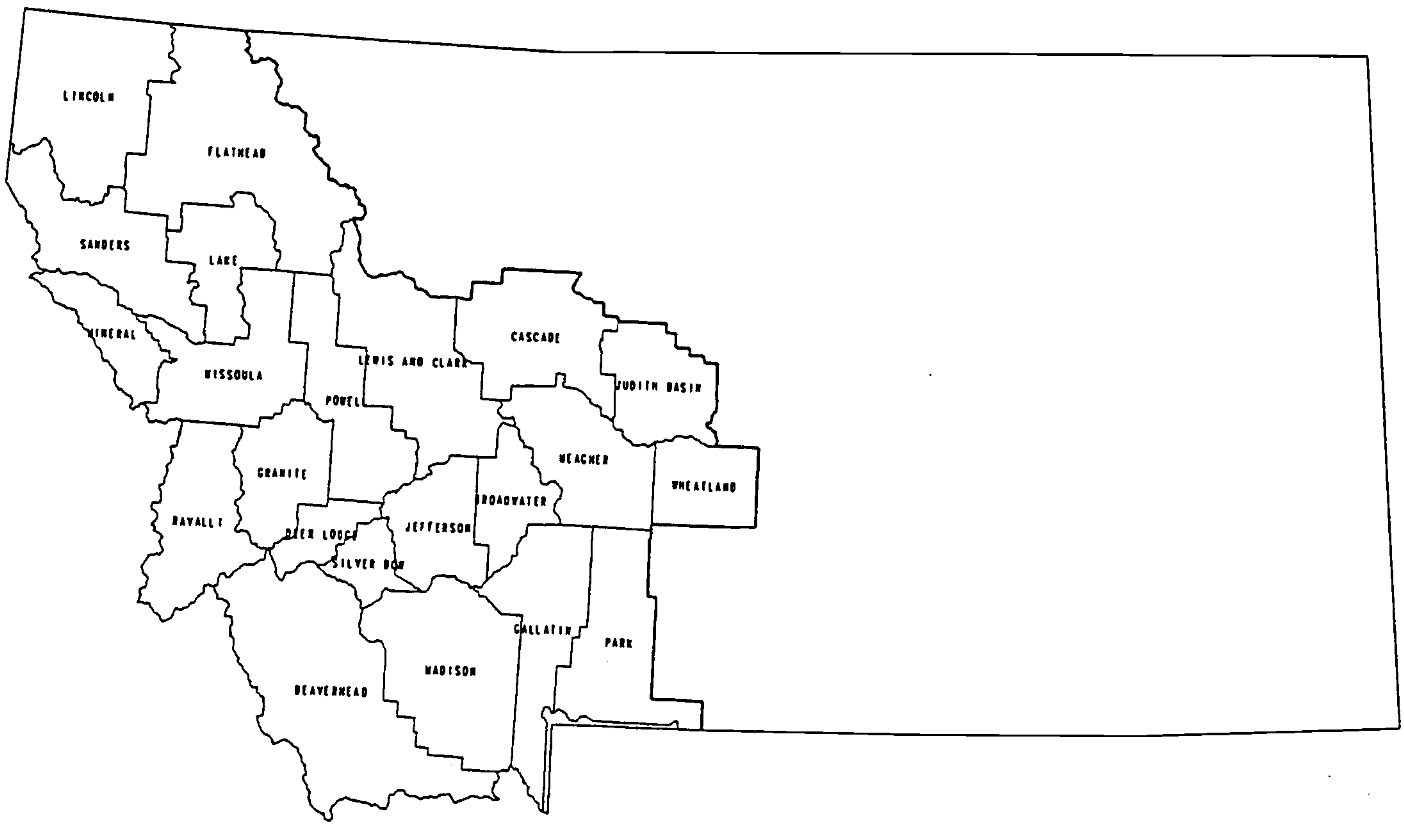


Figure 1. Map of the study area, composed of 22 counties in western Montana.

PRIMARY DATA SOURCE

The screening procedure was developed using the latest Forest Survey inventory data collected in 1989. The inventory partitioned the State into five sample areas, formed by grouping individual counties. The study combined four of these sample areas into a single unit composed of 22 counties (Figure 1).

The sample-based inventory used a two-phase statistical design and provided reliable statistics at the State and sample area levels.

Phase 1 of the inventory estimated the areas of sampling strata. Sampling stratum for the Montana inventory was the area of forest land by owner group within an individual county. The nonindustrial private forest land was the stratum screened in this study. The area in each stratum was estimated by classifying 80,997 points placed at 1,000-meter intervals on National Forest System photography and National High Altitude photography. Photo scales ranged from 1:15,000 to 1:60,000. The points were assumed to be classified without error.

The inventory was designed to provide strata area estimates accurate at the State level to 1 standard deviation of the total. Expansion factors for the sampling strata means were computed from the photo points, adjusted to meet Bureau of the Census gross areas by county.

Land classification and estimates for timberland characteristics and volume were based on observations and measurements recorded at 976 forested locations visited during Phase 2 of the inventory. Sample trees were selected using a 10-point cluster (USDA Forest Service 1989). Trees less than 5.0 inches in diameter at breast height (d.b.h.) were measured on a 1/300-acre fixed plot at points 1-3. Trees 5.0 inches d.b.h. or larger were selected using a variable radius plot, based on a 40 basal area factor angle gauge. Volume and defect were computed using the most appropriate equations including those developed by Kemp (1958) and Moisen (1990).

The field and photo data were entered into a computer file and edited to assure accuracy and coding consistency. The compiled field data file was merged with the stratum weights files and expanded into statistical summaries, a portion of which were used in this study. Standard error percentages for major land classes and volume estimates were calculated at the 67 percent confidence level and are reported in Tables 10 and 11.

METHODS

The procedure used to screen Forest Survey timberland locations in order to identify treatment opportunities was developed in three steps. The steps are described in detail and form the decision criteria represented by Figure 2.

Step 1. Estimate of NIP timberland area considered suitable for treatment.

Because each timberland acre differs in its ability to respond to treatment, an estimate of the area best suited to management is necessary. Suitability, for the purpose of this study, was defined by the operability and productivity standards used by the Montana Department of State Lands (DSL), Forestry Division, to prioritize the treatment opportunities on private lands (Long 1990).

Degree of slope and forest tract size were key variables used to determine the operability of a particular site. The land-based harvest systems normally used in Montana are primarily limited to sites with slopes of less than 80 percent. Isolated forest tracts of less than 10 acres are considered too small

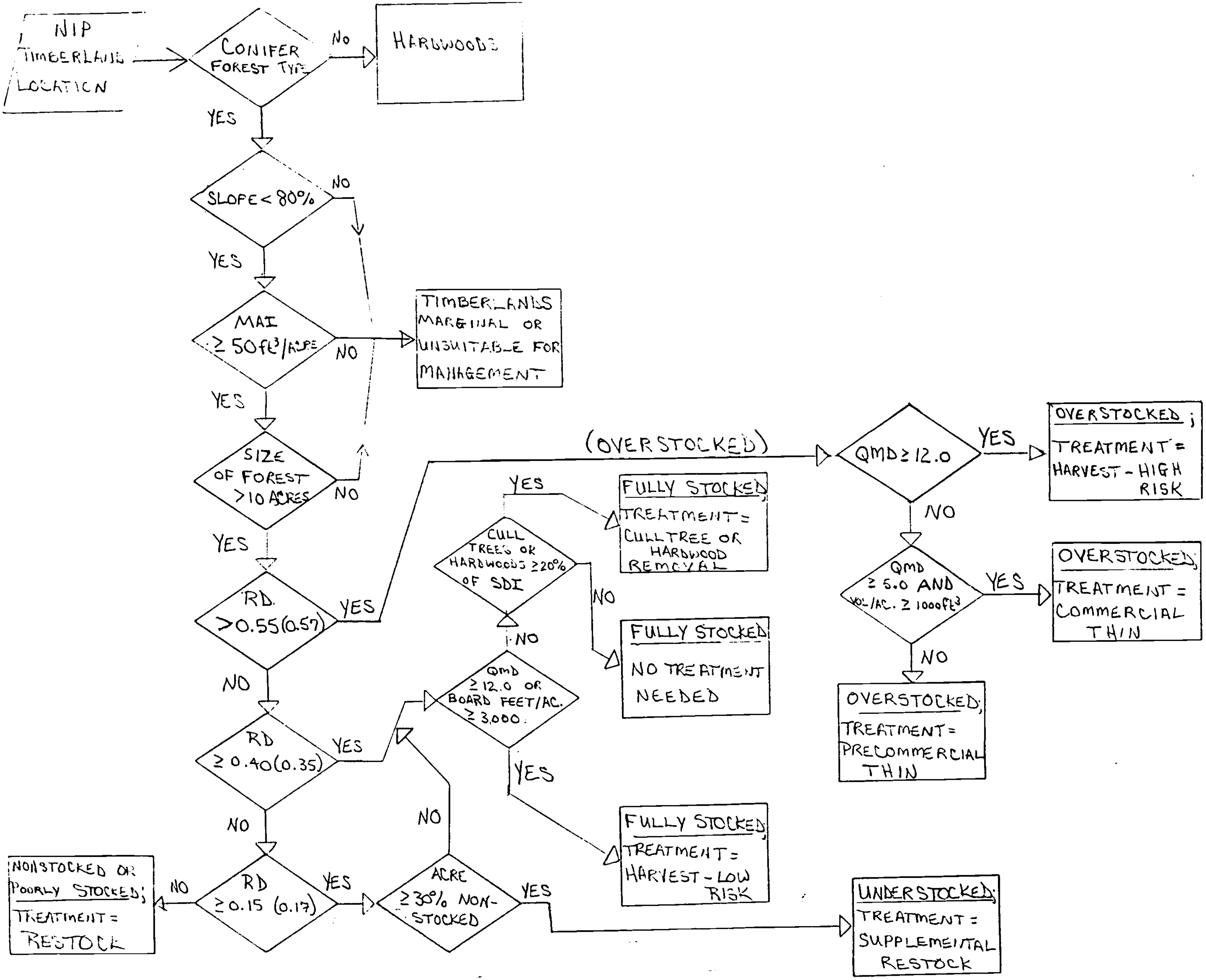


Figure 2. Decision logic used to screen nonindustrial private timberland locations in western Montana to identify treatment opportunities.

to offer a profitable management opportunity to most forest owners. Private timberlands failing to meet either the slope or tract-size standard generally are given low treatment priority by DSL. Forest Survey locations failing to meet either standard were considered inoperable and were excluded from silvicultural treatment considerations at this point in the screening process.

The same is true for timberlands which do not meet a minimum potential productivity standard of at least 50 cubic feet per acre per year. Potential productivity is based on net growth of fully-stocked stands at culmination of mean annual increment (MAI), referenced to site index trees (Brickell 1970). In cases where suitable site trees are unavailable, the sites are assigned a default value of 40 cubic feet per acre per year.

Timberlands with productive potential less than the minimum standard are considered only marginally suitable for management by DSL. Forest Survey locations failing to meet the productivity standard were excluded from further screening.

This study included only conifer forest types. Hardwood forest types such as cottonwood, aspen, and birch, generally are not important sources of commercial wood products. An estimate of the area of hardwoods in private ownership is given to account for these lands, and to adjust Montana's total timber base to reflect only the area of conifer forest types.

As a result of the first step of the screening procedure, the NIP timberland locations with slopes greater than 80 percent, productive potential of less than 50 cubic feet per acre per year, or in isolated patches of less than 10 acres in size, were labeled either marginal or unsuitable for management. The acres represented by these locations were removed from the suitable timber base and excluded from further consideration for silvicultural treatment.

Excluding the timberland acres for the reasons given does not necessarily mean that they could not provide wood products on a sustained basis. These acres represent sites where, generally, the biological potential to produce timber products is lower, or the harvest costs higher, when compared to that of "suitable" acres. Means of improving site productivity by fertilization or use of genetically improved planting stock are possible, but require greater investment in time and money. In addition, some acres likely offer the potential to harvest valuable, large sawlog material making costly, nonconventional logging methods a viable option. However, these scenarios were not considered in this analysis.

Step 2. Determine the relative stocking level of each suitable timberland location in the Douglas-fir and lodgepole pine forest types.

Reineke's (1933) Stand Density Index, or SDI, was the basis for formulating a relative density index (RDI) to assess the level of stocking on each suitable timberland location. Stocking was assessed relative to a management goal of maximum cubic-foot volume production at the stand level.

Stand Density Index -- A Brief Description

SDI was developed to assess stocking in even-aged, natural stands. The index is based on the relationship between the number of trees per acre in a particular stand and the stand quadratic mean diameter (QMD). This relationship, when plotted on a log-log scale, forms a straight line with a slope of approximately -3/2 (Figure 3). Reineke's equation for this relationship is:

$$\log N = -1.605 \log D + K$$

where

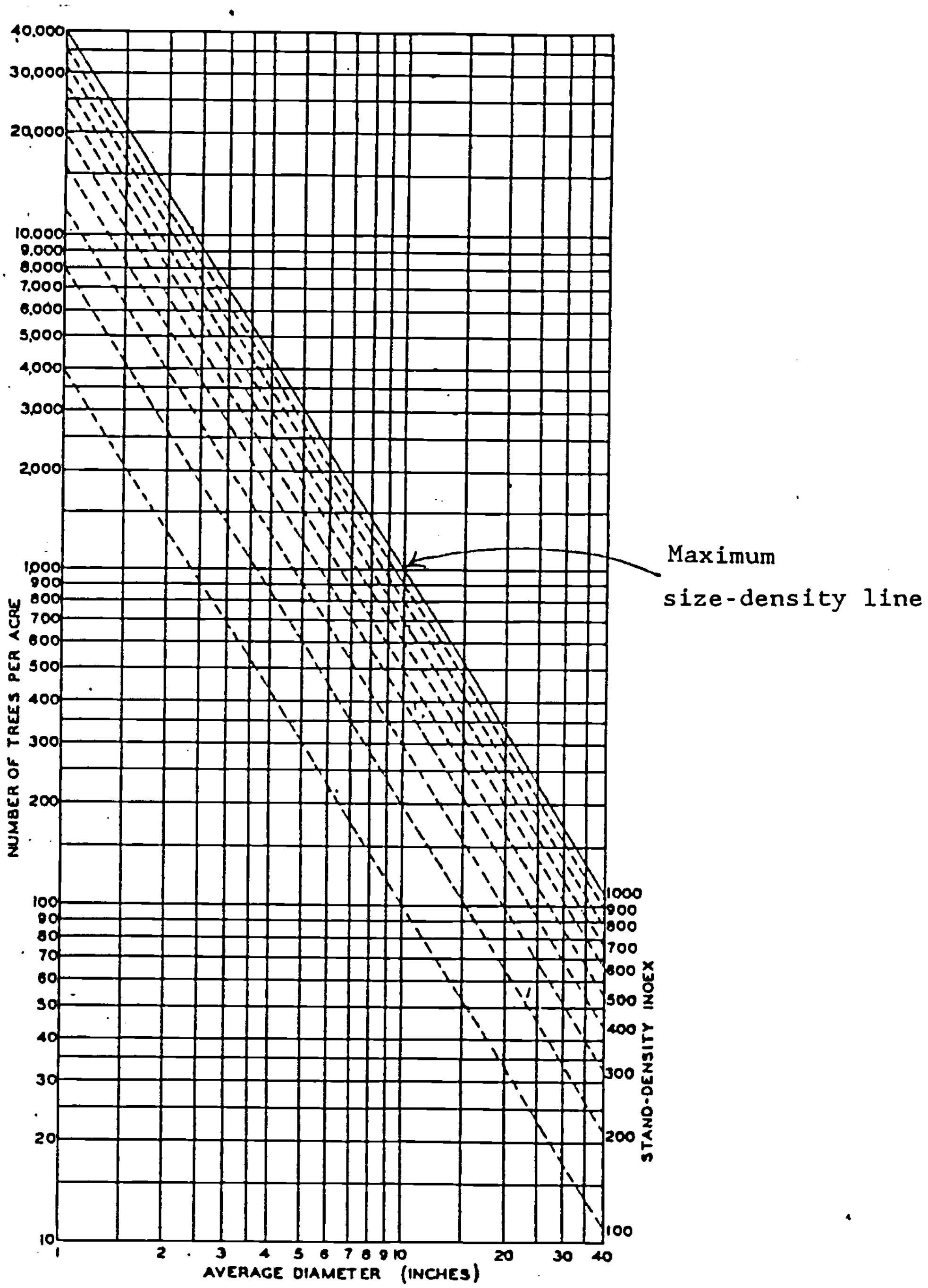
N = the number of trees on a per acre basis

D = the diameter of the tree of average basal area (QMD)

K = a constant which varies by tree species.

Thus, as the average diameter of the trees within a stand increases, the number of trees per acre decreases at a constant rate of -1.605, or approximately -3/2.

The solid line in Figure 3 represents the maximum size-density line for a particular species, and is equivalent to 100 percent density. For comparative purposes, SDI is given for a stand with a QMD of 10 inches. Because the slope of the maximum size-density line is considered constant for most species, only the number of trees per acre at maximum SDI will differ. This permits the



Reference curve (solid line). The stand-density index of each of the broken-line parallel curves is the number of trees indicated by each at 10 inches average diameter

Figure 3. Graphic representation of Reineke's average tree size-density relationship (Reineke 1933).

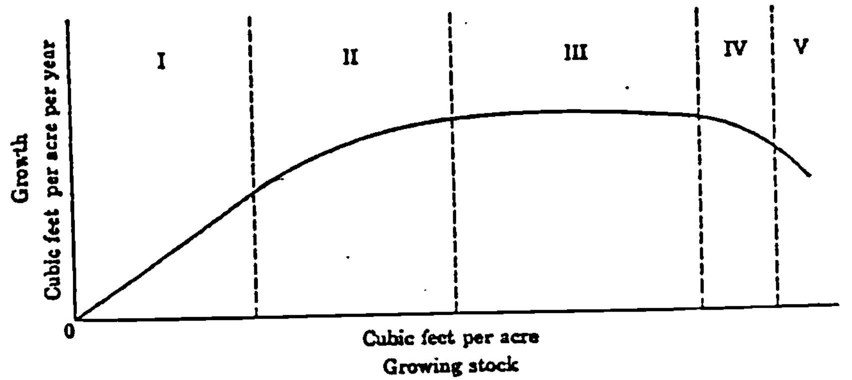
development of a relative density index which can be used to compare the adequacy of stocking--percent of maximum--of stands of different species, at different stages of development, to meet a particular management goal (MacLean 1979).

Generating a Relative Density Index

Generating the relative density index used in the screening procedure was based on elements of Reineke's size-density relationship, Langsaeter's (Smith 1962) yield-density theory, and elements taken from Drew and Flewelling (1979) in their construction of a stand density management diagram for Douglas-fir plantations, and McCarter and Long's (1986) construction of a similar diagram for lodgepole pine.

Langsaeter's yield density theory is illustrated in Figure 4. The five zones reflect the effect of increasing density, expressed in cubic feet per acre, on stand growth.

Zone I represents a stocking level below the point of inter-tree competition. At this level, growth per acre is directly proportional to density. Drew and Flewelling estimated that this occurred at densities less than 15 percent of the maximum for Douglas-fir, or at a relative density of less than 0.15 (Figure 5). The number in parentheses in Figure 5, 0.17 in this case, is the relative density below which this is thought to occur in lodgepole pine. In both cases, the site is considered underutilized.



The relationship between density of stocking, measured in cubic volume, and growth in cubic volume, as postulated by Langsaeter [1941]. In Density Type I the trees stand so far apart that they do not influence each other and growth is directly proportional to the volume of growing stock. The effect of slight competition in Density Type II is indicated by a declining rate of increase in increment with respect to stand volume. In the broad range of stocking indicated by Density Type III, increment of cubic volume is virtually independent of variations in stocking; the usual objective of thinning is to keep the growing stock somewhere within this optimum range. In Density Types IV and V the effects of extreme competition are reflected in a decline in growth with increasing density. Density Type V corresponds to the condition of stagnation. It is probable that a similar relationship exists between stand density and growth if both are measured in terms of basal area.

Figure 4. Graphic representation of Langsaeter's yield-density theory (Smith 1962).

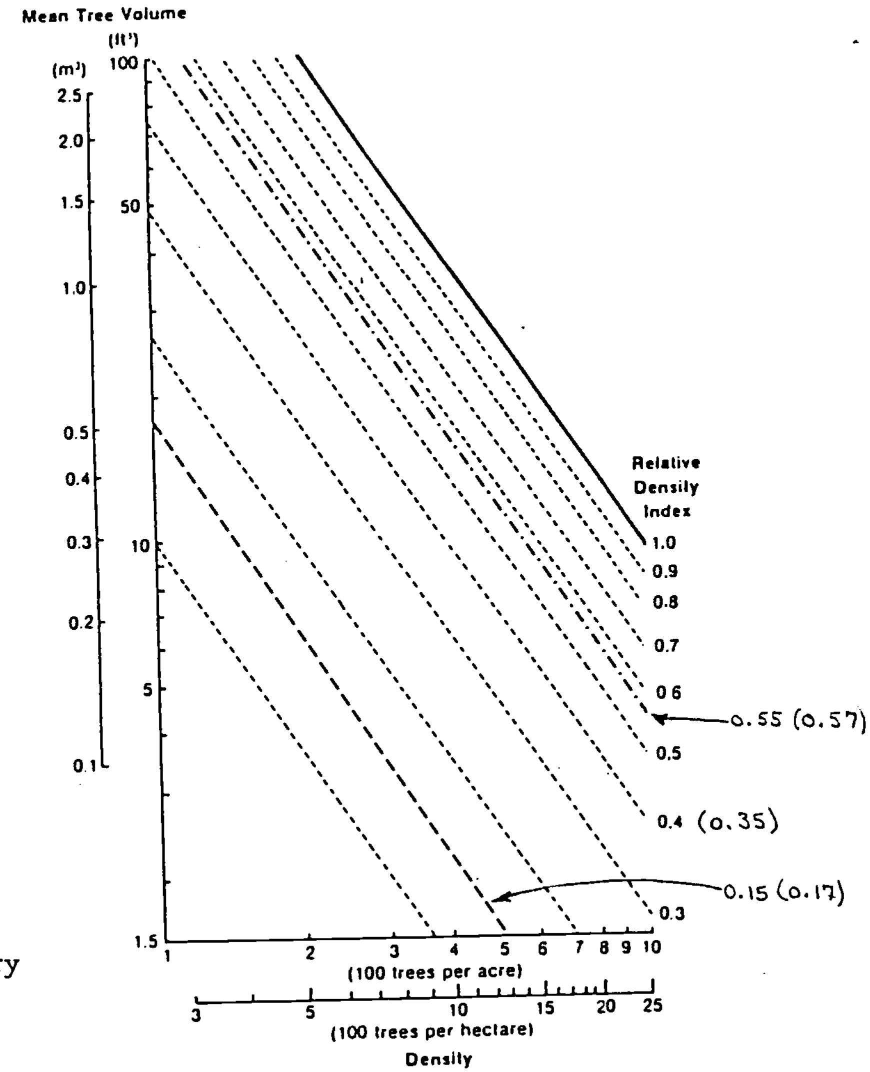


Figure 5. Stand management diagram with a Relative Density Index for Douglas-fir (Drew and Flewelling 1979) and lodgepole pine (McCarter and Long 1986).

Zone II reflects the effect on growth of the onset of tree competition due to increased density. Growth per acre is still increasing, but at a decreasing rate due to the decreasing growth rate of individual trees. This is estimated to occur between 0.15-0.40 relative density for Douglas-fir and 0.17-0.35 for lodgepole pine. Increases in stand density at this point in the stand's development are still possible, particularly if maximum stand growth is desired. However, mean tree size will be smaller as a consequence.

In Zone III, growth is relatively unaffected by a wide range of stand density. Theoretically, net stand volume growth is at a maximum at this range of densities. This is thought to occur between 0.4-0.55 relative density for Douglas-fir and between 0.35-0.57 for lodgepole pine. Given maximum stand volume production as the assumed goal, this is the range of relative density at which stands could potentially be managed (Long 1985). However, other management considerations, such as susceptibility to insects and disease at high stand densities, may necessitate lower relative densities.

Langsaeter's Zones IV and V represent stands with high densities where net stand growth is declining due to increasing losses to mortality. Drew and Flewelling identified these zones with the range of relative density from 0.55-1.0 (1.0 is equivalent to maximum SDI), and called this range the zone of imminent competition-mortality. The zone is estimated to occur between 0.57-1.0 relative density for lodgepole pine.

The theory for maintaining stands at densities below the zone of imminent competition-mortality is that, although tree mortality is found at all levels of density, the probability of a tree dying is reduced if density is reduced (Drew and Flewelling 1979). Hence, the rationale for thinning is based to some degree on this theory.

A summary of the estimated relative density values established for Douglas-fir and lodgepole pine stands is given below:

Relative Density		Management Goal Stocking Level	Comments
Douglas-fir	Lodgepole pine		
>0.55	>0.57	Overstocked	Zones IV and V of Langsaeter's theory. Stands within Drew and Flewelling's zone of imminent competition-mortality. Volume losses likely to occur if stands left at density levels this high.
0.4-0.55	0.35-0.57	Fully stocked	Langsaeter's Zone III, growth independent of density. This is the range of maximum stand volume production. Stands could be managed within this range of relative density.
0.15-0.4	0.17-0.35	Understocked	Langsaeter's Zone II, full site utilization, increasing stand growth but at a decreasing rate due to decreasing growth rate of individual trees. Potential exists to increase stocking by stand treatment.
0.15	0.17	--	Point of crown closure and onset of inter-tree competition.
<0.15	<0.17	Poorly stocked or nonstocked	Langsaeter's Zone I, no inter-tree competition. Site is not fully utilized. Regeneration may be necessary.

Calculating Relative Density by Location

With the establishment of the relative density (RD) values to be used in the screening procedure, the next step was to calculate the relative density of each Forest Survey location.

The basic equation for calculating the location RD is:

$$RD = SDI_o / SDI_{max}$$

where:

RD = the relative density of the location

SDI_{max} = the maximum size-density line for a particular species and habitat type, expressed at an average stand diameter of 10 inches.

SDI_o = the current stand density for each location expressed at an average stand diameter (QMD) of 10 inches.

The SDI_{max} values for Douglas-fir and lodgepole pine were those used in the Stand Prognosis Model (Johnson 1990). The maximum size-density values were based on habitat type (Pfister 1977) to account for differences in site quality (see list in Appendix 1).

Reineke's assumption that the slope of the maximum size-density line remains constant for most species was assumed valid for this study, although this has been questioned recently (Lonsdale 1990; Weller 1990; Long and Smith 1984). However, Reineke's belief that a single maximum size-density line is constant for a species regardless of site quality, has not always been accepted (Bickford and others 1957) and, in fact, some now regard this as invalid (Barreto 1989). The differences in site quality are reflected in the elevation--number of trees per acre--of the maximum size-density line, represented by K, the intercept in Reineke's SDI equation. Because better sites can support more trees per acre at a particular average diameter than can poor-quality sites, the SDI_{max} values are now often based on habitat type.

Although Drew and Flewelling used only a single maximum SDI value in their work with Douglas-fir, their relative density indices are applicable to all SDI_{max} values for that species. The actual number of trees at a given relative density will vary with site quality. This is probably also true for lodgepole pine.

Calculating Stand Density Index by Location

Calculating SDI_o, the stand density index for each location, was done using a method developed by Stage (1968). Stage's calculation is additive, tree-by-tree, so that the contribution to SDI of each tree, or class of trees, can be ascertained. This additive feature is of value in uneven-aged stands where the average diameter (QMD) is relatively meaningless due to the skewed diameter distribution (Long and Daniel 1990).

Stage's basic formula used to calculate SDI_o for each location is given below:

$$SDI_o = \sum_{i=1}^{N} (a + bd_i^2)$$

where

SDI_o = the current stand-density index at a QMD = 10 inches for each location

N = the number of trees per acre

a and b = coefficients depending on the average diameter of all trees

d_i = the diameter of the i^{th} tree in the tally.

Additional detail for the calculation of the a and b coefficients is given in Appendix 2.

All trees greater than 1.0 inch d.b.h. tallied at each location went into the SDI_o calculation after they were expanded to an acre basis using factors developed by Forest Survey. Since both growing-stock and cull trees were included, the contribution to SDI_o of the cull component was tracked separately for fully-stocked stands in the screening procedure to identify a possible cull removal treatment opportunity.

Step 3. Identify Treatment Opportunities

The choice of a particular treatment opportunity relied heavily on the assessed stocking level of each timberland location, represented by that location's estimated relative density. Once a location was sorted into a stocking class, specific Forest Survey stand level variables were used to determine the most appropriate treatment option. The stand level variables partly reflect the general "break-points" used by the Montana DSL when planning silvicultural treatments for their own lands.

While the suitability screening dealt with all forest types, only Douglas-fir and lodgepole pine were screened for stocking and treatment opportunity at this point, to test the procedure.

OVERSTOCKED STANDS

Overstocked stands have a relative density greater than the desired management level for maximum volume production (RD greater than 0.55 for Douglas-fir and greater than 0.57 for lodgepole pine). These stands fall within Drew and Flewelling's zone of imminent competition-mortality, and are considered high priority for treatment. For overstocked stands, the primary break-points in the decision criteria for treatment are mean stand diameter and volume per acre.

TREATMENT OPPORTUNITY OPTIONS FOR OVERSTOCKED STANDS

Commercial Thin--The stands in this treatment opportunity average at least 1,000 cubic feet of volume per acre and have a QMD greater than or equal to 5.0 inches. The volume and size requirement are needed as a minimum, to assure the availability of merchantable volume.

Precommercial Thin--Stands not meeting the minimum size or volume requirement. Thinning these stands essentially removes little or no commercial volume but is necessary to increase stand vigor.

Harvest-High Risk--The stands in this option have a QMD greater than or equal to 12.0 inches. They are considered high risk due to the overstocked condition which tends to lower vigor, making them susceptible to attack from insects and disease.

FULLY-STOCKED STANDS

Fully-stocked stands have a relative density within the range where stand cubic-foot volume growth is at a maximum (0.4-0.55 for Douglas-fir and 0.35-0.57 for lodgepole pine). They are currently considered low priority with respect to silvicultural treatment needs, and some may need no treatment at this time.

TREATMENT OPPORTUNITY OPTIONS FOR FULLY-STOCKED STANDS

Harvest-Low Risk--These stands average at least 3,000 board feet (Scribner log rule) per acre or have a QMD greater than or equal to 12.0 inches. The minimum board-foot volume requirement is necessary for a sawtimber harvest operation to be profitable. The size requirement is the average tree size managed for by Montana's DSL at rotation age. The stands are considered low risk to attack from pests since stand vigor is generally high. Unless the harvest volume is needed, these stands essentially can be left alone as long as relative density remains within the fully-stocked range, and stand vigor is maintained.

Cull Tree/Hardwood Removal--These stands do not meet either minimum harvest requirement, but have a cull tree or hardwood component making up at least 20 percent of the total SDI. This category identifies stands where a sanitation cut may be beneficial to remove an unwanted stand component competing with desirable trees for limited site resources.

No Treatment--Stands in this option qualify for neither option above, and are currently growing at maximum cubic-foot growth. No treatment is necessary while stands are producing at the maximum rate.

UNDERSTOCKED STANDS

Understocked stands have a relative density somewhere between the point of crown closure (onset of competition) and the lower bound for maximum volume production (0.15-0.4 for Douglas-fir and 0.17-0.35 for lodgepole pine). However, since the relative density levels are based on trees greater than or equal to 1.0 inches d.b.h., understocked stands may be at full stocking if stocking in seedlings is considered. If this is the case, the stands are treated as fully stocked and are sorted into the appropriate treatment opportunity listed under the Fully Stocked stocking level.

TREATMENT OPPORTUNITY OPTIONS FOR UNDERSTOCKED STANDS

Supplemental Restock--To qualify for this treatment a stand must be 70 percent stocked or less, on a per acre basis. This is ascertained by checking the cover class code recorded for each of the 10 points of the location cluster. (A point is considered nonstocked if less than 4 trees are tallied, and no seedlings are present on a 1/20-acre subplot). This treatment identifies potential problems concerning the distribution of trees over the entire area. If the trees are clumped, this option could identify the need for thinning as well as the need for planting.

POORLY-STOCKED OR NONSTOCKED STANDS

Nonstocked or poorly-stocked stands have relative densities below the point of crown closure (less than 0.15 for Douglas-fir and less than 0.17 for lodgepole pine) and are not fully utilizing the site. In some cases, densities are so low that a seed source may be unavailable, and natural regeneration would be slow or might never occur.

TREATMENT OPPORTUNITY OPTIONS FOR POORLY-STOCKED OR NONSTOCKED STANDS

Restock--the most likely course of action at relative densities this low is to plant. Earlier harvests or other stand treatment is often the cause for the low stocking. The site may not have been regenerated, or the regeneration may have failed.

RESULTS

Marginal and Unsuitable Lands -- Adjustments to the NIP Timber Base

The classification of inventory locations into the marginal or unsuitable categories was straightforward. Each NIP timberland location (all conifer forest types) was screened by a single Forest Survey variable, so a simple "yes" or "no" answer was all that was required. Table 1 summarizes the results of the screening to determine management suitability for each NIP location.

There are nearly 2.0 million acres of NIP owned conifer timberland in western Montana and just over 1.0 million acres can be considered suitable for silvicultural treatment. Given the criteria used in this study, and some underlying assumptions about present costs of timber operations and current market conditions, the suitable acres should be given higher priority when planning stand treatments.

Table 2 gives the area of marginal and unsuitable land by forest type. Apparently, operability is not a problem on NIP timberland in western Montana, either due to slope or size of forest tract. The 22,600 acres considered unsuitable is only 1 percent of the total area of NIP timberland (conifer forest types).

Productivity could be a factor, however. Almost 935,500 acres have the potential to produce less than 50 cubic feet of volume per acre annually, and 583,000 acres of this are Douglas-fir. Site fertilization would likely improve the productive potential of these acres, but this option was not included in the study.

Privately owned hardwood timberlands amounted to 167,500 acres, primarily aspen, cottonwood, and birch. These forest types were excluded from consideration for treatment.

Suitable Timberlands - Stocking Levels and Treatment Opportunities

Suitable NIP timberlands, by definition, support stands capable of producing at least 50 cubic feet of volume per acre annually, have slopes of less than 80 percent, and are at least 10 acres in size. Table 3 is a summary of these acres by stocking class and treatment opportunity.

Overstocked Stands

Nearly 58,000 acres of Douglas-fir and lodgepole pine were found to be overstocked with respect to maximum volume production as the stocking goal. Over 32,000 of the overstocked acres qualified for commercial thinning, and about 26,000 acres are in need of precommercial thinning. None of the overstocked acres fell in the Harvest-High Risk option due to small average stand diameter.

All of the Precommercial Thin acres were lodgepole pine stands with QMD's of 3 - 4 inches, and trees per acre ranging from over 1,600 to more than 4,500 stems (Table 4). The stands in the Commercial Thin option tended to be older (60 - 160 years) with volumes from 2,500 to over 5,000 cubic feet per acre. Trees per acre tended to be relatively high, with most of the stands supporting between 800 - 1,000 stems (Table 5).

The risk of losing volume to mortality is assumed higher in these stands due to the high tree density. If tree vigor has been reduced substantially, these stands are likely more susceptible to attack from insects and disease.

Therefore, a high priority should be given to treating overstocked stands to reduce stocking to the desired level.

Fully-Stocked Stands

The majority of the Douglas-fir and lodgepole pine stands were fully stocked, and were estimated to be at the maximum stand volume production level. The 412,700 acres were split roughly 3:1 between the Harvest-Low Risk and No Treatment categories, respectively (Table 3). None of the stands had a cull or hardwood component large enough to fall in the Cull/Hardwood Removal treatment.

The 253,200 fully-stocked acres of Douglas-fir available for harvest represents more than 43 percent of the suitable area of this valuable tree species. The 70,200 acres of lodgepole pine that are currently fully stocked are about half the total area of this forest type. Board-foot volume on the Harvest-Low Risk acres was as little as 3,000 to just over 16,500 per acre (Table 6).

The basic difference between the Harvest-Low Risk and No Treatment opportunities (Table 7) is the availability of enough volume--greater than 3,000 board feet per acre--on the Harvest-Low Risk acres to assure a profitable sawtimber harvest operation. Stands in either treatment option, however, are in no immediate need of attention, and could be considered low management priority.

Understocked Stands

The single treatment opportunity for understocked stands, called Supplemental Restock, was intended to identify the potential need for planting, or other method of regeneration, to bring them to full stocking. Planting would only be necessary in cases where individual stands were not likely to grow into a full stocking condition within an acceptable time frame set by the manager. In fact, many of the stands have nearly adequate stocking--trees per acre--and may only need to be "spot" planted (Table 8). The nearly 124,000 acres classified understocked could be considered of moderate treatment priority.

Poorly-Stocked or Nonstocked Stands

Poorly-stocked and nonstocked stands have relative densities which put them below the point of crown closure, and are not fully utilizing the site. The single option for treatment was to regenerate the acres, which would likely entail some degree of site preparation and planting.

Few of the stands qualifying for the Restock Treatment had over 100 trees per acre (Table 9). However, some of the 134,400 acres in this category may have been recently clearcut, shelterwood cut, or have previously undergone other treatment. If so, the necessity of restocking would depend upon the lapsed time since the previous treatment, and the success of the initial attempt to regenerate the site, either naturally or by planting.

In any case, stands with stocking levels this low are likely candidates for treatment, and should be considered high priority.

CONCLUSIONS

Sensitivity Level of the Screening Procedure

The screening procedure outlined in Figure 2 was the result of a "trial-and-error" process. Many combinations of Forest Survey variables were used, with the different stocking level estimates, to try to make each treatment opportunity option "make sense" given the management objective. Because the results of the study were intended to be useful at the regional planning level, the procedure needed to produce broad estimates to serve as an overall assessment of the condition of the NIP timberland.

At that level of sensitivity, the screening process functioned reasonably well. Tables 4-9 are the individual treatment opportunities with the Forest Survey locations screened into each one. Some of the more important inventory stand level variables are included. (The key to the stand variable abbreviations is given in Appendix 3.)

Overall, the stand-level data holds up well against the treatment assigned to that stand by its relative density. There are cases, however, where stands are apparently assigned the wrong treatment, or could qualify for more than one option, when stand attributes other than relative density are considered.

This situation most often arose in stands having undergone previous stocking manipulation, or harvest. Interpreting current stocking levels can be difficult if a stand is being managed with a different production goal in mind. Large sawtimber production, maintaining minimum crown area and tree vigor, or providing wildlife cover, all require various stocking levels in order to achieve the desired stand structure. Current stand stocking may be adequate to produce sawlogs, but could be considered inadequate if maximum stand growth is the goal.

All-age stands also create a problem. SDI was developed for use with even-aged, natural stands where stand age and average stand diameter are statistically meaningful. Stage's additive formula can address the problem of skewed diameter distributions by assessing stocking contribution by diameter class or size-class. This would provide better information about stand structure on which to base treatment opportunities, but would require additional assessment of how stocking should be distributed by diameter class, a key factor of an uneven-aged approach to stand management. The complexities of uneven-aged stand management are likely beyond the capacity of general resource inventory data to provide the detailed stand level data needed.

There is opportunity for improving the screening procedure to address these and other problems encountered. Additional refinements will help, but will unlikely resolve every situation.

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Appendix 1. Maximum stand density index (MAXSDI) values for habitat types in Montana.

Key to Species

DF	Douglas-fir (*Pseudotsuga menziesii*)
LP	lodgepole pine (*Pinus contorta*)
ES	Engelmann spruce (*Picea engelmanii*)
AF	subalpine fir (*Abies lasiocarpa*)
PP	ponderosa pine (*Pinus ponderosa*)
WB	whitebark pine (*Pinus albicaulis*)

Appendix 2. Formulae

Quadratic Mean Diameter (QMD) - diameter of the tree of average basal area

$$QMD = \left(\sum_{i=1}^{n} d_i^2 / n\right)^{1/2}$$

where

n = number of trees in the diameter class

Reineke's Stand Density Index (SDI)

$$\log N = -1.605 \log D + K$$

where

N = number trees per acre

D = diameter of tree of average basal area (QMD)

K = constant varying by species

Stage's tree-by-tree calculation of SDI

$$SDI = \sum_{i=1}^{N} (a + bd_i^2)$$

where

N = number of trees per acre inches in average d.b.h.

a and b = coeficients depending on the average diameter of all trees

d_i = the diameter of the ith tree in the tally

$$a = 10^{-K} \left(1-\frac{K}{2}\right) \left(\Sigma d_i^2/N\right)^{K/2}$$

and

$$b = 10^{-K} \left(\frac{K}{2}\right) \left(\Sigma d_i^2/N\right)^{(K/2-1)}$$

where

K = a constant equal to -1.605

Appendix 3. Key to Table Abbreviations

CFCL	the total cubic-foot cull volume per acre for the Forest Survey location.
CFVOL	the total cubic-foot growing-stock volume per acre for Forest Survey location
CO	county
LOC	Forest Survey location number.
CUT	the type(s) of cutting evidenced on the Forest Survey location, most recent and a previous harvest, if any.

CODE	TYPE OF CUTTING
0	None
1	Fuelwood
2	Post-pole Harvest
3	Overstory Removal
4	Thinning
5	Selective Harvest
6	Clearcut
7	Seed tree
8	Other
9	Land Clearing

EF	the expansion factor; the number of acres the location represents for that stratum.
FT	forest type (1 = Douglas-fir, 61 = lodgepole pine)
HIS	cutting history, estimated time since last timber or wood harvesting occurred.
MAI	the potential mean annual increment for the Forest Survey location, measured in cubic feet per acre per year.
QMD	the stand quadratic mean diameter; the diameter of the tree of average basal area.
REPT	the number of points in the location 10-point cluster, that are fully stocked with at least 4 live trees.
RDI	the relative density index for the Forest Survey location (the ratio of SDITOT/SDIMAX).
SDIMAX	the maximum stand density index for a particular habitat type.
SDITOT	the calculated stand density index for the Forest Survey location.
SDICL	the stand density index of the cull tree component in the stand.
SDIHRD	the stand density index of the hardwood component in the stand.

SCRCL the total cull board foot volume per acre (Scribner) for Forest Survey location.

SCRVOL the total board foot volume per acre (Scribner) for the Forest Survey location.

STAGE the stand age class for the Forest Survey location:

CODE	AGE (years)	CODE	AGE (years)
1	1 - 10	8	71 - 80
2	11 - 20	9	81 - 90
3	21 - 30	10	91 - 100
4	31 - 40	12	101 - 120
5	41 - 50	14	121 - 140
6	51 - 60	16	141 - 160
7	61 - 70	18	161 - 180

SZFOR the estimated size (in acres) of the forested area in which the Forest Survey location is established.

TPA the expanded number of trees per acre for the Forest Survey location.

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Maximum size-density line

Table 1. Area of Nonindustrial Private timberland by forest type and management suitability class.

	Treatment			
	(1) Suitable for Management	(2) Marginal	(3) Unsuitable for Management	Total
	Acres	Acres	Acres	Acres
Forest Type				
(01) Douglas Fir	587,813	583,148	22,628	1,193,589
(11) Ponderosa Pine	169,852	153,246	.	323,098
(33) Grand Fir	23,093	.	.	23,093
(35) Engelmann Spruce	31,721	4,160	.	35,881
(36) Spruce/Subalpine fir	42,771	26,276	.	69,047
(41) Western Redcedar	12,547	.	.	12,547
(48) Western Hemlock	6,274	.	.	6,274
(54) Western Larch	24,566	19,275	.	43,841
(61) Lodgepole Pine	141,074	106,022	.	247,096
(96) Whitebark Pine	.	18,485	.	18,486
(98) Limber Pine	.	23,911	.	23,911
Total	1,039,712	934,525	22,628	1,996,865

Table 2. Area of Marginal and Unsuitable timberland by forest type and classification criteria.

	Treatment			
	Marginal	Unsuitable		
	.	.		
	Productivity < 50 CUFT/Acre/Year	Slope >= 80%	Stand Size < 10 Acres	Total
	Acres	Acres	Acres	Acres
orest Type				
01) Douglas Fir	583,148	16,774	5,854	605,777
11) Ponderosa Pine	153,246	.	.	153,246
35) Engelmann Spruce	4,160	.	.	4,160
36) Spruce/Subalpine fir	26,276	.	.	26,276
54) Western Larch	19,275	.	.	19,275
61) Lodgepole Pine	106,022	.	.	106,022
96) Whitebark Pine	18,486	.	.	18,486
98) Limber Pine	23,911	.	.	23,911
otal	934,525	16,774	5,854	957,153

Table 3. Area of Suitable Douglas-fir and lodgepole pine timberland by stocking class and treatment opportunity.

	(1) Overstocked		(2) Fully Stocked		(3) Understocked	(4) Poorly Stocked or Nonstocked	
	Treatment		Treatment		Treatment	Treatment	
	Commercial Thinning	PCT	Harvest-Low Risk	No Treatment	Supplemental Restock	Restock	Total
	Acres	Acres	Acres	Acres	Acres	Acres	Acres
rest Type							
1) Douglas Fir	28,082	.	253,232	89,242	105,441	111,816	587,813
2) Lodgepole Pine	4,160	25,746	55,030	15,177	18,426	22,535	141,074
otal	32,242	25,746	308,262	104,419	123,867	134,351	728,887

Table 4. Douglas-fir and lodgepole pine timberland locations with stand level variables, sorted into the Precommercial Thinning treatment opportunity.

Treatment=PCT

CO	LOC	FT	SDIMAX	SDITOT	RDI	MAI	QMD	TPA	STAGE	REPT	CFVOL	CFCL	SCRVOL	SCRCL	SZFOR	CUT	HIS	SDICL	SDIHRD	EF
23	26	61	707	515.664	0.72937	94	3	3319.49	6	10	819.03	0	0.000	0	8	80	4	16.476	0	7163.15
47	171	61	775	438.117	0.62983	55	4	1914.50	7	10	1585.48	0	471.452	0	8	0	0	50.511	0	4378.99
53	67	61	768	444.212	0.57840	129	4	1641.72	5	10	1757.07	0	670.552	0	8	0	0	0.000	0	3677.63
57	32	61	768	701.362	0.91323	55	3	4548.91	9	10	957.08	0	0.000	0	7	0	0	104.625	0	5526.50

Table 5. Douglas-fir and lodgepole pine timberland locations with stand level variables, sorted into the Commercial Thinning treatment opportunity.

Treatment=Commercial Thinning

CO	LOC	FT	SDIMAX	SDITOT	ROI	MAI	QMD	TPA	STAGE	REPT	CFVOL	CFCL	SCRVOL	SCRCL	SZFOR	CUT	HIS	SDICL	SDIHRD	EF
39	1	61	635	427.649	0.67346	65	6	1057.19	7	5	3339.39	16.026	5803.36	71.393	8	80	4	19.6369	0.000	4160.16
39	147	1	634	379.602	0.59374	62	8	553.22	10	3	3581.68	0.000	9986.10	0.000	4	0	0	41.1645	0.000	4160.16
53	56	1	696	398.460	0.57250	84	6	825.29	8	2	2537.79	61.360	5664.04	0.000	8	43	4	58.6886	106.814	4378.99
53	97	1	696	441.066	0.63372	83	8	636.76	10	8	4772.73	26.083	13431.26	120.360	7	50	4	31.4250	0.000	8677.63
63	82	1	775	506.958	0.65414	57	7	910.81	16	10	4305.97	159.202	10457.02	899.298	8	0	0	34.5025	0.000	5503.36
77	137	1	768	472.453	0.61517	82	7	916.13	12	10	5112.77	0.000	19136.88	0.000	8	0	0	36.7330	7.544	5361.82

Table 6. Douglas-fir and lodgepole pine timberland locations with stand level variables, sorted into the Harvest-Low Risk treatment opportunity.

--- Treatment=Harvest-Low Risk ---

CO	LOC	FT	SDIMAX	SDITOT	RDI	MAI	QMD	TPA	STAGE	REPT	CFVOL	CFCL	SCRVOL	SCRCL	SZFOR	CUT	HIS	SDICL	SDIHRD	EF
7	93	1	696	174.959	0.28011	69	10	203.86	8	10	1548.37	0.000	6408.65	0.00	8	0	0	0.0000	0.000	5072.23
13	147	1	467	236.554	0.50654	53	12	169.75	10	3	2457.17	0.000	9147.56	0.00	5	45	4	0.0000	0.000	8445.39
13	166	1	467	215.430	0.46131	61	12	152.12	10	5	2487.31	79.542	9423.50	197.19	8	50	4	12.0896	0.000	8445.39
29	234	1	696	203.265	0.29205	73	8	278.88	7	10	1626.47	142.505	4803.31	69.74	8	50	4	17.1246	0.000	8409.76
29	271	1	707	318.986	0.45118	104	7	517.18	8	10	3552.92	0.000	12747.02	0.00	8	50	4	0.0000	0.000	8409.76
29	322	1	467	133.693	0.28628	74	11	113.00	6	10	1105.09	15.263	3843.65	0.00	6	50	4	7.8594	0.000	8409.76
31	3	1	467	168.575	0.36097	55	9	210.60	9	10	1242.31	0.000	3874.33	0.00	5	0	0	0.0000	0.000	4477.30
31	18	1	696	258.887	0.37196	70	8	380.09	8	10	2113.95	0.000	3872.39	0.00	7	0	0	0.0000	0.000	4477.30
39	24	1	634	170.554	0.26901	50	9	218.98	10	9	1354.36	86.794	4460.25	122.88	8	55	3	41.1549	0.000	4160.16
39	108	1	768	337.495	0.43945	51	7	625.83	12	10	2641.48	0.000	7164.37	0.00	8	28	4	13.0423	0.000	4160.16
39	116	1	696	191.502	0.27515	50	8	261.60	16	10	1564.99	0.000	4835.90	0.00	6	45	4	0.0000	0.000	4160.16
39	127	1	696	320.323	0.46024	55	8	419.77	16	10	2958.39	54.290	9089.90	206.13	7	50	4	21.4913	0.000	4160.16
39	145	1	768	240.221	0.31279	78	10	233.05	9	10	3145.91	0.000	10330.08	0.00	8	50	4	0.0000	0.000	4160.16
39	146	1	634	236.407	0.37288	60	7	399.11	12	10	1540.22	65.724	6330.01	128.47	6	0	0	6.7648	0.000	4160.16
43	5	1	467	142.396	0.30492	51	11	126.26	9	9	1193.95	0.000	4658.83	0.00	4	95	3	0.0000	0.000	5548.87
43	11	1	634	178.457	0.28148	55	11	159.87	10	8	1646.23	0.000	5838.10	0.00	7	15	4	0.0000	0.000	5548.87
47	12	1	707	287.842	0.40713	103	6	697.89	9	10	2273.23	185.673	9287.46	1075.01	8	0	0	37.3346	71.544	8048.41
49	249	61	768	331.957	0.43224	59	5	988.07	8	10	1840.90	0.000	3113.68	0.00	8	58	4	0.0000	17.734	5623.86
49	263	1	696	332.592	0.47786	88	8	526.72	9	3	2374.26	0.000	10195.08	0.00	8	0	0	0.0000	0.000	5623.86
49	350	1	634	258.941	0.40842	64	9	301.79	9	8	2316.49	184.988	5745.47	376.15	8	88	4	18.6071	0.000	5623.86
49	363	1	768	276.383	0.35987	76	6	687.07	8	10	2147.04	141.699	7141.37	0.00	7	0	0	18.0539	155.363	5623.86
53	77	1	634	229.350	0.36254	30	11	211.21	9	8	3027.70	55.466	10588.96	0.00	7	44	2	8.5665	7.799	8677.63
53	217	1	707	261.630	0.37006	67	6	551.60	9	10	1745.90	94.590	3620.69	419.20	8	55	4	30.0192	0.000	8677.63
53	251	1	707	241.653	0.34180	130	7	398.33	7	10	2740.32	0.000	5943.70	0.00	8	55	4	0.0000	0.000	8677.63
53	255	1	696	259.810	0.37329	100	9	304.49	12	10	3257.91	0.000	12344.74	0.00	8	50	4	0.0000	0.000	8677.63
59	16	61	707	359.572	0.50873	36	4	427.53	9	10	5329.16	233.220	16510.16	67.70	6	0	0	24.8345	0.000	5484.13
59	37	61	768	258.528	0.33663	50	8	383.07	12	10	3052.13	0.000	3860.94	0.00	8	0	0	0.0000	0.000	5484.13
59	146	1	696	202.892	0.29151	53	6	449.35	6	10	979.92	17.445	3027.34	0.00	4	25	4	32.0312	61.608	5484.13
59	173	1	696	154.791	0.22240	55	12	109.16	10	9	1667.52	0.000	6617.74	0.00	7	0	0	0.0000	0.000	5484.13
59	190	61	696	394.348	0.56731	50	6	392.45	14	10	3412.79	92.784	5365.59	112.81	8	0	0	7.4628	0.000	5484.13
63	21	61	635	311.907	0.49119	112	9	400.17	7	8	4043.01	87.365	7596.43	132.77	8	0	0	27.2994	119.576	5503.36
63	28	61	768	311.479	0.40557	77	6	796.94	8	10	2312.95	33.662	7130.56	154.88	8	50	4	7.9298	7.644	5503.36
63	69	61	707	251.225	0.35534	93	6	547.32	7	10	2560.51	0.000	6639.13	0.00	8	50	4	0.0000	0.000	5503.36
63	30	61	634	213.157	0.33621	81	7	414.65	8	10	2505.34	0.000	10912.47	0.00	8	80	4	0.0000	0.000	5503.36
63	103	1	634	263.362	0.41540	86	3	371.27	7	8	2371.19	56.146	6031.93	0.00	8	55	4	9.4587	0.000	5503.36
63	179	1	696	241.552	0.34705	61	9	293.44	7	10	2134.41	162.334	6829.05	116.81	8	50	4	23.2482	0.000	5503.36
63	232	1	696	160.412	0.23049	104	11	130.78	10	9	2294.73	0.000	9130.80	0.00	8	80	4	0.0000	0.000	5503.36
67	32	1	696	310.124	0.44558	64	9	342.21	9	3	2956.35	93.672	9934.12	0.00	6	0	0	19.5525	0.000	9093.32
67	146	1	696	292.110	0.41970	59	10	287.10	10	4	3039.50	156.798	3882.70	56.12	8	0	0	15.8842	0.000	9093.32
77	121	1	634	229.351	0.36175	62	4	378.50	12	10	1176.30	42.225	3145.01	19.20	7	58	4	38.9933	0.000	5361.82
77	123	1	634	239.440	0.37767	65	3	337.67	10	10	2165.30	0.000	4750.69	0.00	3	50	4	0.0000	0.000	5361.82
77	135	1	467	233.677	0.50038	59	11	202.65	12	10	1981.36	53.842	7520.81	256.17	5	0	0	18.7069	0.000	5361.82
77	139	1	768	161.338	0.21008	64	7	310.71	10	9	1330.40	0.000	4260.33	0.00	8	50	4	0.0000	0.000	5361.82
77	207	1	634	207.153	0.32674	58	12	162.15	10	10	2418.84	0.000	9254.06	0.00	7	55	4	0.0000	0.000	5361.82
81	29	1	696	171.409	0.24628	70	7	327.34	9	3	1355.31	38.873	4316.98	0.00	8	25	1	8.4491	0.000	5854.28
81	43	1	707	376.530	0.53257	111	5	1350.15	9	10	1913.87	0.000	6033.38	0.00	8	50	4	8.6835	0.000	5854.23
89	31	61	707	334.513	0.47314	99	7	603.77	8	10	4271.65	0.000	5736.77	0.00	8	11	3	31.7031	0.000	6273.65
89	104	1	768	162.788	0.21196	110	2	1623.55	7	10	733.31	0.000	3591.91	0.00	6	50	3	0.0000	0.000	6273.65
89	235	1	634	320.567	0.50563	60	6	763.92	10	10	2163.51	0.000	6477.91	0.00	8	50	4	32.2066	0.000	6273.65
93	3	61	635	330.453	0.52040	66	5	858.65	12	9	2553.65	0.000	4695.61	0.00	7	40	4	10.5344	0.000	4666.38
93	46	1	467	187.861	0.40231	50	9	237.52	9	3	1139.01	31.174	4232.63	0.00	8	0	0	39.1137	0.000	4666.38

Table 7. Douglas-fir and lodgepole pine timberland locations with stand level variables, sorted into the No Treatment option.

-- Treatment=No Treatment --

CO	LOC	FT	SDIMAX	SDITOT	RDI	MAI	QMD	TPA	STAGE	REPT	CFVOL	CFCL	SCRVOL	SCRCL	SZFOR	CUT	HIS	SDICL	SDIHRD	EF
29	319	1	634	307.020	0.48426	51	4	1315.95	8	10	1305.33	0.0000	2604.78	0.0000	8	30	4	13.4064	0.00000	8409.76
29	379	1	696	105.719	0.15190	74	4	439.14	8	10	426.01	0.0000	253.66	0.0000	8	30	4	8.8676	0.00000	8409.76
29	405	1	634	158.748	0.25039	52	7	269.63	9	10	1057.52	73.8637	1354.20	0.0000	9	50	4	18.7123	0.00000	8409.76
53	54	1	634	313.322	0.49499	51	3	1727.77	7	10	825.57	0.0000	323.92	0.0000	8	38	4	11.9247	0.00000	8677.63
53	55	1	634	122.473	0.19317	63	5	436.49	9	9	603.20	0.0000	338.65	0.0000	5	34	3	0.0000	0.00000	8677.63
53	73	1	768	139.564	0.24683	55	4	702.36	10	10	1130.36	27.7157	1375.23	0.0000	7	50	4	9.4166	8.56744	8677.63
53	205	1	467	73.448	0.15728	73	6	160.11	5	8	452.36	0.0000	1475.09	0.0000	7	50	4	0.0000	0.00000	4378.99
61	13	61	707	263.098	0.37920	59	6	558.05	8	10	2317.54	0.0000	1962.91	0.0000	8	40	4	0.0000	0.00000	9815.52
63	207	1	696	110.557	0.15885	56	7	187.90	10	8	362.57	63.8027	2171.72	77.6263	8	80	4	7.0703	0.00000	5503.36
77	102	1	467	123.004	0.26339	59	7	243.47	4	10	620.43	0.0000	2642.43	0.0000	8	80	4	0.0000	0.00000	5361.82
77	129	1	634	128.644	0.20291	51	6	287.02	8	10	705.85	0.0000	2446.34	0.0000	8	55	4	12.7629	0.00000	5361.82
77	179	1	467	154.115	0.33001	58	6	398.44	4	9	611.97	0.0000	368.37	0.0000	6	20	3	0.0000	0.00000	5665.01
77	199	61	768	184.003	0.23959	61	8	261.99	10	8	2564.38	0.0000	1948.41	0.0000	8	11	1	0.0000	0.00000	5361.82
81	11	1	696	210.031	0.30177	58	7	399.90	8	10	1573.60	0.0000	2492.33	0.0000	8	30	4	13.4196	0.00000	5854.28
81	173	1	696	217.289	0.31220	61	4	1134.25	5	10	797.55	53.5181	1717.17	0.0000	8	50	4	34.9877	0.00000	5854.28

Table 8. Douglas-fir and lodgepole pine timberland locations with stand level variables, sorted into the Supplemental Restock treatment opportunity.

-- Treatment=Supplemental Restock --

LOC	FT	SDIMAX	SDITOT	RDI	MAI	QMD	TPA	STAGE	REPT	CFVOL	CFCL	SCRVOL	SCRCL	SZFOR	CUT	HIS	SDICL	SDIHRD	EF
30	1	467	119.128	0.25509	63	15	63.003	10	8	1403.11	0.000	6304.98	0.000	7	67	4	0.0000	0.0000	5072.23
103	1	467	94.795	0.20299	65	8	137.937	7	3	700.30	0.000	3673.45	0.000	8	0	0	0.0000	0.0000	5072.23
106	1	696	226.038	0.32477	74	10	212.515	12	1	2409.63	0.000	10691.70	0.000	6	80	4	0.0000	0.0000	8445.39
107	61	768	206.467	0.26384	73	12	159.435	10	6	3645.32	0.000	15271.38	0.000	6	0	0	0.0000	0.0000	8445.39
211	1	696	224.423	0.32245	57	8	344.099	9	5	1694.09	0.000	4821.39	0.000	8	0	0	16.4471	0.0000	8445.39
349	1	696	105.495	0.15157	57	11	88.972	10	9	1131.10	0.000	3908.67	0.000	5	80	3	0.0000	0.0000	8409.76
34	1	696	223.919	0.32172	56	11	185.031	12	7	2563.45	0.000	3735.74	0.000	6	55	4	0.0000	0.0000	4477.30
135	1	696	111.492	0.16019	79	13	45.052	12	0	1611.10	0.000	7979.33	0.000	6	40	4	0.0000	0.0000	4477.30
136	1	696	115.393	0.16579	69	13	43.534	3	4	1205.62	0.000	6227.96	0.000	7	0	0	0.0000	0.0000	4477.30
148	1	696	225.052	0.32335	58	12	167.505	9	4	2260.44	0.000	3611.25	0.000	6	0	0	0.0000	0.0000	4477.30
149	1	696	175.632	0.25234	64	12	125.743	9	6	2200.20	0.000	8880.63	0.000	6	50	4	0.0000	0.0000	4535.40
155	61	696	131.391	0.13950	57	10	131.410	9	3	1899.07	0.000	6213.09	0.000	8	0	0	0.0000	0.0000	4477.30
174	1	696	215.856	0.31014	74	10	199.725	9	4	2075.33	0.000	7064.78	0.000	8	55	3	0.0000	34.1004	4477.30
39	1	696	203.971	0.29306	53	7	342.309	8	7	1451.95	134.946	3332.04	19.742	4	0	0	47.6680	0.0000	5484.13
15	61	707	236.713	0.33481	82	8	318.638	9	6	3664.99	72.686	5216.83	342.191	8	0	0	14.1921	0.0000	5503.36
231	1	696	189.307	0.27199	67	8	254.472	10	0	2107.35	0.000	4529.58	0.000	7	82	4	0.0000	0.0000	5503.36
234	1	695	132.479	0.19034	79	11	107.868	3	7	1547.72	0.000	5933.61	0.000	7	55	3	0.0000	0.0000	5503.36
165	1	635	141.314	0.22254	57	14	82.460	14	10	1717.31	57.324	7241.29	78.088	7	54	4	5.9938	0.0000	9093.32
110	1	634	130.799	0.20616	64	10	125.550	10	7	1165.32	0.000	3739.58	0.000	8	50	4	0.0000	0.0000	5361.82
130	1	696	250.075	0.35930	65	5	751.203	6	5	983.54	60.722	2157.34	61.635	7	88	4	19.1822	0.0000	5854.29
256	1	634	204.699	0.32287	77	10	214.240	10	4	2275.18	144.194	10014.54	178.959	7	40	4	14.7614	0.0000	6273.65

Table 9. Douglas-fir and lodgepole pine timberland locations with stand level variables, sorted into the Restock treatment opportunity.

------------------------------ Treatment=Restock ------------------------------

	LOC	FT	SDIMAX	SDITOT	RDI	MAI	QMD	TPA	STAGE	REPT	CFVOL	CFCL	SCRVOL	SCRCL	SZFOR	CUT	HIS	SDICL	SDIHRD	EF
7	32	61	696	86.730	0.12461	62	7	151.409	14	10	1100.39	0.000	4264.62	0.000	8	67	3	0.0000	0.0000	5072.23
9	231	1	696	103.741	0.14905	63	12	81.736	10	2	1052.47	0.000	3949.46	0.000	3	99	3	0.0000	0.0000	8409.76
9	272	1	634	58.369	0.09207	68	10	57.162	7	9	489.48	0.000	1508.24	0.000	7	50	3	0.0000	0.0000	4378.99
9	343	1	768	6.378	0.00831	71	2	100.000	1	9	0.00	0.000	0.00	0.000	7	60	3	0.0000	0.0000	4378.99
9	411	1	467	68.446	0.14656	97	9	79.332	8	8	747.41	0.000	2767.29	0.000	7	70	3	0.0000	7.1000	8409.76
9	36	1	768	106.820	0.13909	73	9	125.453	9	10	1404.58	0.000	3386.22	0.000	8	40	3	0.0000	0.0000	4160.16
7	16	1	467	20.323	0.04352	75	12	14.717	1	10	226.24	0.000	857.56	0.000	8	30	3	0.0000	0.0000	8048.41
7	56	1	696	83.679	0.12023	88	11	68.159	9	8	969.91	141.228	3541.05	171.288	7	0	0	12.8034	0.0000	8048.41
7	169	1	696	93.097	0.13376	53	4	379.982	7	7	448.51	0.000	872.23	0.000	6	50	3	13.0355	0.0000	8048.41
9	244	1	696	72.393	0.10401	62	13	46.619	3	1	331.02	0.000	3170.62	0.000	6	0	0	0.0000	23.5859	5623.86
3	313	1	696	92.773	0.13329	92	8	135.619	8	10	752.65	0.000	3383.97	0.000	8	55	3	0.0000	0.0000	8677.63
7	328	1	696	96.693	0.13893	71	14	57.253	12	10	1362.27	0.000	6146.00	0.000	6	0	0	0.0000	0.0000	5526.50
9	52	1	696	77.514	0.11137	51	11	65.907	7	10	608.25	0.000	1887.97	0.000	5	0	0	0.0000	0.0000	5484.13
9	54	1	696	20.473	0.02941	57	12	15.276	1	9	193.33	0.000	722.35	0.000	6	50	4	0.0000	0.0000	5484.13
1	28	1	696	34.542	0.04963	102	12	27.095	7	10	477.06	0.000	1777.04	0.000	3	64	2	0.0000	0.0000	9815.52
5	73	61	707	101.823	0.14402	64	3	825.473	3	10	107.96	0.000	360.46	0.000	8	60	4	0.0000	0.0000	5503.36
0	119	1	696	42.556	0.06114	59	15	19.359	10	4	424.03	0.000	1938.29	0.000	8	50	4	0.0000	0.0000	5685.58
7	140	1	696	101.207	0.14541	54	10	95.452	7	10	753.99	0.000	2060.99	0.000	8	50	4	0.0000	0.0000	5361.82
1	233	61	707	106.744	0.15098	79	13	72.555	9	0	1444.90	36.704	5413.79	58.603	8	0	0	7.5252	30.4139	5685.58
9	51	61	707	18.902	0.02674	99	15	10.196	0	3	277.06	0.000	1331.35	0.000	7	25	3	0.0000	0.0000	6273.65
9	55	1	696	91.783	0.13187	117	5	255.320	7	10	640.09	0.000	2567.38	0.000	8	0	0	0.0000	0.0000	6273.65

Table 10. Area of Nonindustrial Private timberland in western Montana by forest type with Percent Standard Error.

	AREA	STANDARD ERRORS
DOUGLAS-FIR	1,334,146.6	5.5
W. HEMLOCK	6,273.6	100.0
M. HEMLOCK	0	0
PONDEROSA PINE	1,518,780.9	4.4
WESTERN WHITE PINE	0	0
LODGEPOLE PINE	263,395.0	14.7
WESTERN LARCH	43,840.7	38.3
WESTERN REDCEDAR	12,547.3	69.0
LIMBER PINE	46,953.7	41.0
GRAND FIR	23,093.2	57.4
SPRUCE-FIR	87,533.8	25.4
WHITE FIR	0	0
SPRUCE	42,435.3	39.5
OTHER WEST SOFTWOODS	0	0
TOTAL SOFTWOOD TYPES	3,379,000.1	2.6
ASPEN	167,972.5	19.8
COTTONWOOD	214,290.1	16.6
TOTAL HARDWOOD TYPES	382,262.6	12.3
ALL TIMBER TYPES	3,761,262.8	2.2

Table 11. Volumes on Nonindustrial Private timberland in western Montana by forest type with Percent Standard Error

Type of Volume	Douglas-fir	Percent Standard Error	Lodgepole Pine	Percent Standard Error
Cubic Feet	1,624,519,674.0	7.4	525,401,494.5	18.1
International 1/4-inch	6,124,577,920.3	8.1	1,251,889,407.1	21.8
Scribner	4,961,876,613.1	8.2	1,054,125,786.6	21.9