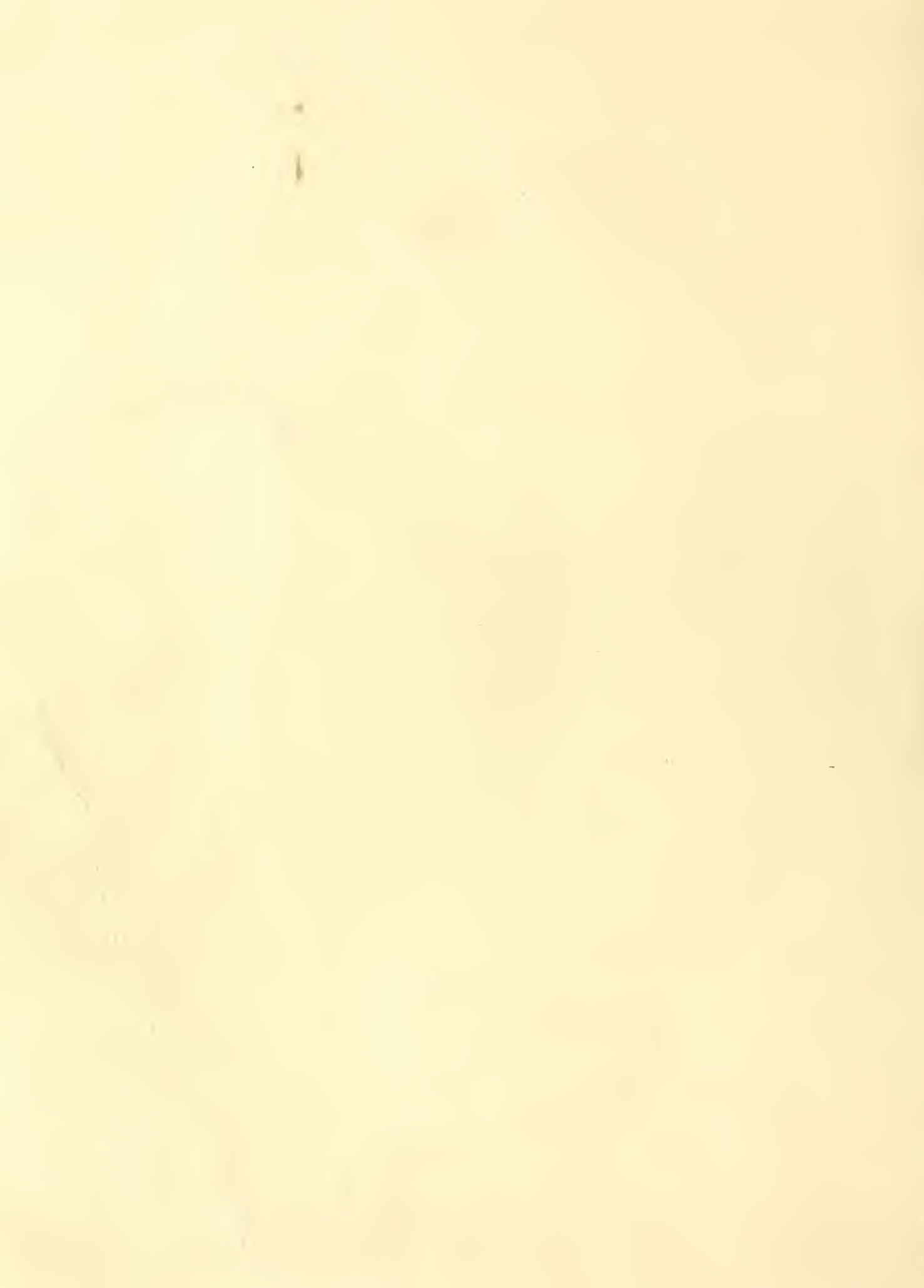


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United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

Research Note
PNW-RN-502
March 1991



Sensitivity of TRIM Projections to Management, Harvest, Yield, and Stocking Adjustment Assumptions

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Abstract

The Timber Resource Inventory Model (TRIM) was used to make several projections of forest industry timber supply for the Douglas-fir region. The sensitivity of these projections to assumptions about management and yields is discussed. A base run is compared to runs in which yields were altered, stocking adjustment was eliminated, harvest assumptions were changed, and management intensity assumptions were changed. The objective was to determine if there is a difference in supply projections and age-class distributions in the short term (20 years) and the long term (50 years) when assumptions are changed.

Changing harvest assumptions had an effect on yield projections and age-class distributions only when artificially high and low harvests were applied. Harvesting oldest age classes first had little effect on age-class distribution projections or supply projections. Changing assumptions about intensity of management and yields can have an effect on supply projections in both the short and the long term. Intensifying current management, deemphasizing harvest of older age classes, and using modified yield functions increased supply projections. The model showed that long-term volume projections decrease when future inventories are managed in the same way as current inventories. Age-class distributions were not significantly affected by changing assumptions for management and yield.

Keywords: Supply projections, age-class distribution, sensitivity analysis.

Introduction

The Timber Resource Inventory Model (TRIM) (Tedder and others 1987) is a precursor to ATLAS (Aggregate Timberland Assessment System)¹ the computer model used by the USDA Forest Service in the 1989 RPA Timber Assessment.² The Forest

¹ Mills, John R.; Kincaid, Jonna C. 1989. Aggregate timberland assessment system. Unpublished manuscript. On file with: Pacific Northwest Research Station, Forest Investment, Marketing, and Trade Research, P.O. Box 3890, Portland, OR 97208-3890.

² Haynes, Richard W. 1988. An analysis of the timber situation of the United States: 1989-2040. Parts I and II. Review Draft. On file with: Pacific Northwest Research Station, Forest Investment, Marketing, and Trade Research, P.O. Box 3890, Portland, OR 97208-3890.

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Service is using ATLAS to assess the state of the forest resources of the United States and the probable future conditions of those forests. Both TRIM and ATLAS are yield table projection systems, developed to model forest inventory changes over time in response to different levels of management and to removals from specific area strata in specified age-class proportions. The objective of this study was to determine the short-term (20 years) and long-term (50 years) sensitivity of the regional timber-availability projections of TRIM to yield table assumptions and various silvicultural impacts. Yields were projected under various management assumptions and harvest regimes.

Several projections of forest industry timber supply in the Douglas-fir region were created. A comparative analysis was made to evaluate the sensitivity of TRIM to assumptions about management and yields. A base simulation was compared to simulations in which yields were altered, stocking adjustment was eliminated, and management intensity³ assumptions were changed. In addition, the base run was compared to runs in which harvest assumptions were changed.

In the short term, the projections were constrained by current inventory, growth functions, and harvest levels. In the long term, projections were constrained by growth functions and harvest levels. Eight projections were created to test the short- and long-term sensitivity of TRIM to changes in assumptions.

Data used in this study were taken from USDA Forest Service Pacific Northwest Region inventory data as reported by Mills.⁴ The projections were created by using inventory data from inventory plots located in forest industry Douglas-fir, sites 1 and 2. It was determined that the data set used for this study had about 40 percent of the total forest industry inventory in the inventory group, "Pacific Northwest-west forest industry softwoods." The harvest requests were derived from the 1990 RPA timber assessment (see footnote 2). The harvest requests for the assessment were made by using the timber assessment market model (TAMM) (Adams and Haynes 1980, Haynes and Adams 1985) in conjunction with ATLAS. As such, the requests represent harvest levels established by supply and demand interactions. I set harvest requests at 40 percent of the projected demands for the Pacific Northwest, because I used about 40 percent of the timber volume in the assessment.

³ Management intensity refers to an assumption on the management practices used and their resulting yields. In TRIM and ATLAS, the management intensities and their corresponding yields are supplied by the user; for example, management intensity 1 in the data set used for this study is analogous to empirical yields. Higher management intensities, such as 4 or 5 for Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), assume certain planting densities, thinning regimes, and possible fertilization or use of genetic stock.

⁴ Mills, John R. 1989. Inventory, growth, and management assumptions for the 1989 RPA timber assessment. Part II: The North and West. Manuscript in preparation. On file with: Pacific Northwest Research Station, Forest Investment, Marketing, and Trade Research, P.O. Box 3890, Portland, OR 97208-3890.

A summary of the runs analyzed follows:

Analysis of stocking adjustment:

Run 1—Base run.

Run 2—Base run without stocking adjustment.

Analysis of harvest sensitivity:

Run 3—Oldest age-classes harvested first.

Run 4—Constant volume demand set at long-term sustained yield.

Run 5—Constant volume demand set at half long-term sustained yield.

Analysis of management intensity and yield function sensitivity:

Run 6—Acres allowed to shift into higher management intensities during current rotation.

Run 7—Modified yield functions.

Run 8—No management intensity shifting.

The TRIM Model

The TRIM model uses volume tables with volume set as a function of age, site, species, and average stand density. Stands following the same yield function are grouped together in TRIM and are referred to as a basic resource unit (BRU). Inventory in a particular BRU is in the same site, species, owner group, and region. In the data set used for this study, a species group in the same site has from two to five management intensities, each with its own yield table. Basic resource units containing the same site and species can be combined into a grouped resource unit (GRU) to provide summary statistics, such as a grouping called Douglas-fir low site forest industry.

The TRIM model allows for adjustments in stocking percentages for stands as they age and recognizes that stand density changes with time. This adjustment is called approach to normality and has been used in conjunction with growth predictions from normal yield tables since the 1940s (Briegleb 1942, Chambers 1980, McArdle and others 1961). The stocking adjustment equation in TRIM adjusts the relative stocking ratio based on user-supplied parameters. The starting TRIM timber inventory is an aggregation of timber stands arrayed by age classes. The inventory in each age class is calibrated to the yield table with a stocking ratio (stand volume over yield table volume). The stocking ratio is adjusted by an approach-to-normal function in each period and is used with the yield table to calculate the stand volume in the subsequent age class. The stocking-adjustment equation in TRIM is established as a simple linear function where stocking in one decade is set equal to a coefficient multiplied by the stocking level in the prior decade with an intercept term included in the equation. Stocking is defined as the ratio of actual inventory per acre to the yield table inventory per acre.

The stocking adjustment equation in the TRIM data set for the Pacific Northwest region is as follows:

$$ST_{t+1} = a + b \cdot ST_t, \quad (1)$$

where ST = stocking,
t = time t,
a = intercept, and
b = slope.

The intercept and slope are constant across ages, stocking levels, and management intensities. The equation varies only with species and site.

If the stocking adjustment equation is not used, TRIM responds by forcing all stands within a stocking level to the user-supplied stocking level midpoint in the first period. If most stands were stocked below the stocking level midpoint, this would result in a substantial increase in growth rate in the first period and no rate change thereafter. If the user wants the stand to stay at the original level of stocking, the adjustment function can be retained but modified, so that the stands remain at their initial stocking level.⁵

Two sets of harvest restrictions were imposed on all runs in this study: (1) minimum harvest ages and (2) proportions of harvest to be extracted by age group within each BRU. The former was treated as an absolute constraint and the latter as a target that could be violated.

Each management intensity in TRIM is associated with a yield table. As acres are shifted into and out of management intensities, the yield tables associated with the acres also change. In the data for the Douglas-fir region, acres were shifted into higher management intensities⁶ at regeneration, thereby reflecting the assumption that a higher percentage of regenerated timberland in the Pacific Northwest will be managed intensively in the future.

Analysis of stocking adjustment sensitivity—Runs 1 and 2 tested the sensitivity of TRIM to the stocking adjustment equation. Run 1, the base run, used the inventory data for forest industry Douglas-fir BRUs. Run 2, the base run without stocking adjustment, used an intercept of 0.001 and a slope of 0.999 in the stocking adjustment equation, as previously explained.

⁵ TRIM will not accept a slope of 1 or an intercept of 0 in the stocking adjustment equation, but the slope can be set at 0.999 and the intercept at 0.001 to realistically simulate no approach to normality.

⁶ Higher management intensity refers to more intensive management assumptions. Lands in management intensity 1 might be shifted to management intensities 3, 4, or 5 when regenerated, thereby reflecting the assumption that lands currently under little or no intensive management will be more intensively managed (that is, thinned or fertilized) in the next rotation.

Analysis of harvest sensitivity—The base run was compared to a run in which oldest age classes were harvested first (run 3) and to two constant-demand projections (runs 4 and 5). Run 3 removed the oldest age classes first, until specified harvest requests were met. For the Pacific Northwest data, proportions of harvest to be extracted by age group within each inventory group (BRU) were preset. If there was not enough volume in the inventory to meet the harvest request, TRIM defaulted to an oldest-first harvest regime, harvesting the oldest age classes until the volume request for that period was met. For this run, harvest proportions were set so that the oldest age classes were harvested until the volume request was fulfilled.

Runs 4 and 5 were made under the assumption of constant volume demand. Run 4 removed a constant amount of volume in each period, the amount determined by the long-term sustained yield. Run 5 was constant-volume demand removals in each period, set at 50 percent of long-term sustained yield.

The long-term sustained yield (LTSY) was calculated as follows:

$$LTSY = \sum_{s,m} \text{period} \times CMAI_{s,m} \times \text{total acres}_{s,m} , \quad (2)$$

where period = 10 years,

CMAI = culmination of mean annual increment of future stands,

s = site, and

m = management intensity.

Analysis of management intensity and yield table sensitivity—In this study, it was assumed that acres could shift to higher management intensities only when harvested and regenerated. In run 6, age-class limits were included in the data input. As a result, acres up to the user-supplied age limits could be shifted among user-determined management intensities, which resulted in management shifting occurring in current inventories. Table 1 illustrates the age limits imposed for shifting among management intensities. For run 7, new yield tables for all management intensities were used. Yields for management intensity 1 (growth yields) were altered considerably.

Table 1—Age limit imposed on growth-yields management intensity (management intensity 1) for shifting to other management intensities

| Management intensity shift | Age limit | |
|--|-------------------|--------|
| | Site 1 | Site 2 |
| | ----- Years ----- | |
| From growth yields to stocking control | 40 | 40 |
| From growth yields to stocking control with fertilization | 40 | 40 |
| From growth yields to stocking control, fertilization, and commercial thinning | 30 | 40 |

Harvests were projected without any acreage shifting to higher management intensities in run 8. In the base run, when initial inventory was harvested, a proportion of the acres were shifted to higher management intensities. This reflected the assumption that timberland currently under little or no management will be managed more intensively after being harvested and replanted. This run, without shifts in management intensity, tested the sensitivity of TRIM projections to intensified future management.

Analysis

Analysis of Stocking Adjustment Sensitivity (Runs 1 and 2)

Harvest—The harvest requests were the same for runs 1 and 2 and were met by both projections. The harvest levels reflected the projected demands in the Douglas-fir region.

Inventory—It is interesting to contrast inventory projections between run 1, with stocking adjustment, and run 2, without the approach to normal function. In figure 1, the gap between inventories from run 1 (with) and run 2 (without) widened continuously throughout the projection. Table 2 summarizes, by period, the gap in terms of percentage of inventory with stocking control. For the first decade, the difference between the projections was 2.44 percent. By the second decade, the difference in inventories between runs 1 and 2 doubled to 4.98 percent. By the end of the projection, the difference in inventories between runs 1 and 2 was 14.17 percent. In both the short term (decades 1 and 2) and the long term (decades 3 through 5), a considerable difference in inventory projections occurred between runs with the same management assumptions and yield tables, with and without stocking adjustment.

Growth—Run 2 had difficulty in meeting the harvest request and maintaining adequate growing stock. The gap between absolute growth in runs 1 and 2 widened throughout the projection period (table 3).

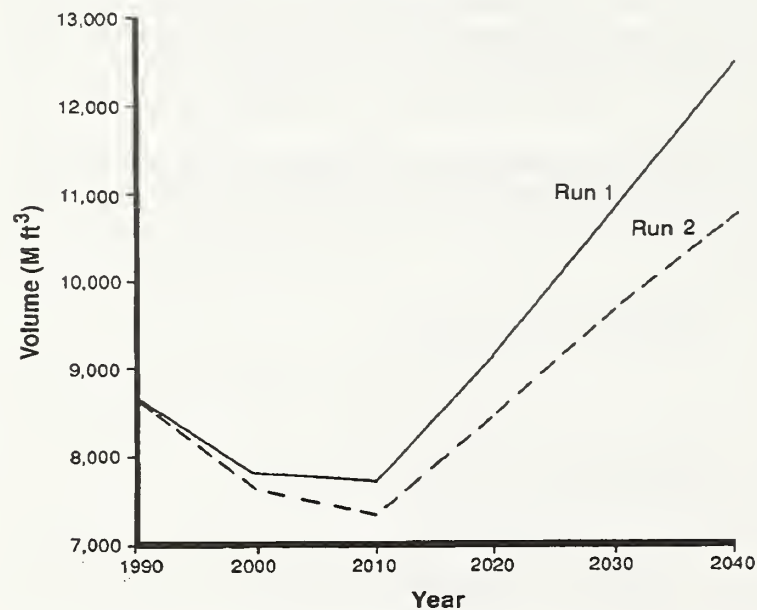


Figure 1—Inventory projections with and without an approach to normal: base run (run 1) and no approach to normality (run 2).

Table 2—Inventory increase with stocking control

| Year | Increase |
|------|----------------|
| | <i>Percent</i> |
| 2000 | 2.44 |
| 2010 | 4.98 |
| 2020 | 7.52 |
| 2030 | 10.81 |
| 2040 | 14.17 |

Table 3—Growth projections for approach-to-normal analysis comparing the base run to the projection without an approach to normality

| Year | Base run (run 1) | No normality (run 2) |
|------|-------------------------------|----------------------|
| | <i>----- Cubic feet -----</i> | |
| 2000 | 3686.81 | 3496.5 |
| 2010 | 3966.06 | 3767.01 |
| 2020 | 4392.48 | 4079.87 |
| 2030 | 4836.98 | 4336.63 |
| 2040 | 5107.43 | 4505.00 |

Age-class distribution—Age-class distributions for runs 1 and 2 did not differ in the first three periods of the projection. In the last three periods, run 2 had less inventory in the oldest age classes. Table 4 illustrates the age-class distribution in 2040, the end of the simulation.

Harvest—Run 4, with removal requests set at LTSY, was unable to meet the harvest request after the second decade (fig. 2). Run 5, with harvest set at 50 percent of LTSY, met the harvest request in all periods. All runs using the harvest determined by the TAMM/ATLAS interaction met the harvest request in all periods.

Inventory—Inventories are a reflection of the ability of a run to meet the harvest request and maintain growing stock. Run 4 (LTSY) had the lowest inventories of runs 1, 3, 4, and 5 (fig. 3). Inventories for run 4 dropped until 2010 and then remained about level. Runs 1, 3, and 5 accumulated inventories throughout the projection. Run 5 (half LTSY), maintained the highest inventories in all periods. The use of variable harvest requests set at levels determined with a TAMM/ATLAS interaction (run 1, base run) resulted in virtually identical inventories as using the same harvest request but allowing oldest age classes to be harvested first (run 3).

Analysis of Harvest Sensitivity (Runs 1, 3, 4, and 5)

Table 4—Age distribution in 2040, in an approach-to-normal analysis, comparing the base run (run 1) to the projection without an approach to normality (run 2)

| Age class | Base run (run 1) | No normality (run 2) |
|-------------------|------------------|----------------------|
| ----- Acres ----- | | |
| 0-10 | 707,156 | 735,781 |
| 20 | 372,600 | 399,794 |
| 30 | 550,330 | 572,728 |
| 40 | 548,282 | 546,440 |
| 50 | 498,155 | 491,700 |
| 60 | 149,459 | 79,539 |

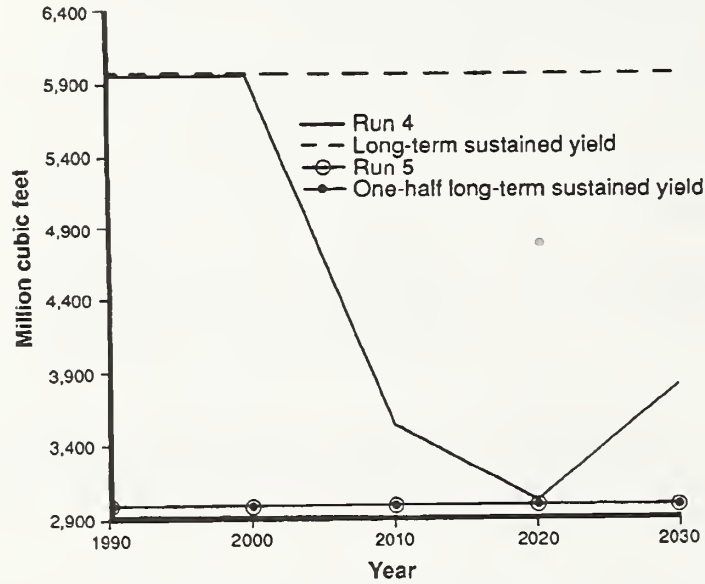


Figure 2—Harvest projections for the constant volume demand set at long-term sustained yield (run 4) and half long-term sustained yield (run 5), including harvest requests for long-term sustained yield and half long-term sustained yield.

Growth—Growth is dependent on the age-class distribution and amount of inventories. Up to 2020, run 5 (half LTSY) had the most absolute growth of runs 1, 3, 4, and 5 (fig. 4); however, growth for run 5 dropped off after 2020. Inventories for run 5 accumulated in all periods (fig. 3). Growth leveled off while inventories accumulated, because inventories were shifting to older age classes. The harvest request was low, so acres accumulated in older age classes, where growth is slow but volumes are high.

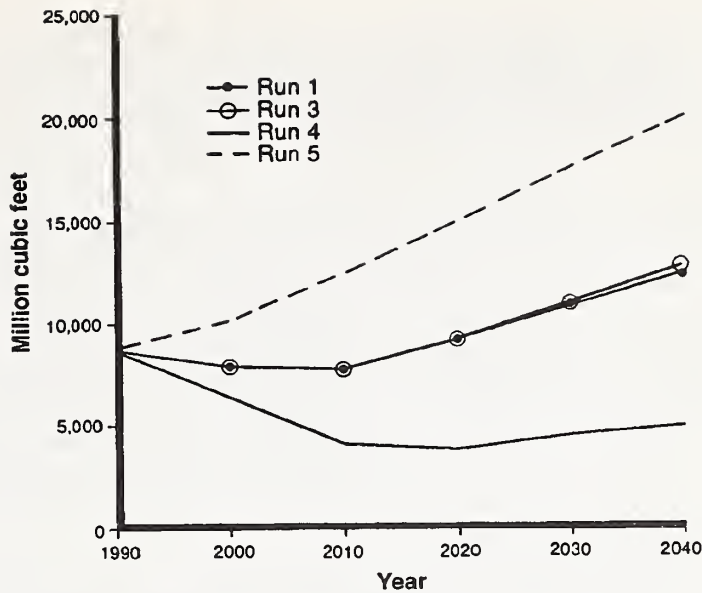


Figure 3—Inventory projections for the harvest-sensitivity analysis: base run (run 1), oldest-first harvest regime (run 3), long-term sustained yield harvest (run 4), and half long-term sustained yield harvest (run 5).

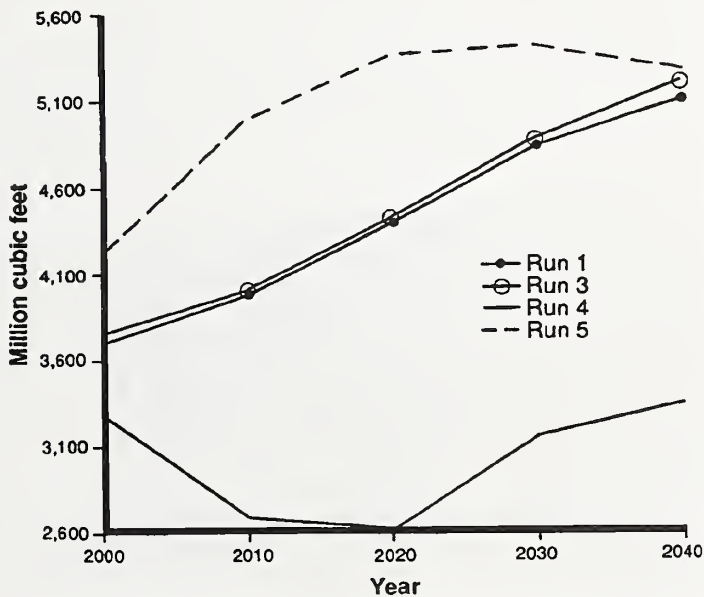


Figure 4—Growth projections for the harvest sensitivity analysis: base run (run 1), oldest-first harvest regime (run 3), long-term sustained yield harvest (run 4), and half long-term sustained yield harvest (run 5).

Growth for run 4 (LTSY) (fig. 4), the lowest of runs 1, 3, 4, and 5 in all periods, dropped until 2020 and then began to climb. As acres were harvested and regenerated, they shifted into higher management intensities. The increased growth for run 4 in 2030 and 2040 reflected the increased management intensity assumption.

Run 1 (the base run) and run 3 (oldest first) showed increasing growth throughout the projection (fig. 4). Run 3 had slightly more absolute growth than run 1 in all periods by about the same amount. Slow-growing acres were shifted more rapidly into higher management intensities and faster growing, younger age classes in run 3. Run 1 stayed below run 3 in growth, but the runs did not diverge over time.

Age-class distribution—An important concern in the use of any predictive model is the type of harvest regulation⁷ it imposes. The TRIM model is a de facto regulation model.⁸ Harvest proportions by age class can be set to meet the user's goals for future age-class distribution, but with insufficient initial inventory, TRIM defaults to an oldest-first harvest regime. In the projections of future inventories for the Douglas-fir region, older age classes invariably were eliminated. Of the four runs compared in this section, only run 5, with harvests set at half LTSY, had older age classes in the inventory throughout the projection. The oldest age class remaining in future periods in runs 1, 3, and 4 was age 60. Age-class distributions for runs 1, 3, 4, and 5 for the last decade of the simulation are given in table 5. Some older inventories may accumulate after 2040.

Harvest—Runs 1, 6, 7, and 8 all met the harvest request in all periods.

Inventory—Figure 5 demonstrates that allowing acres to shift to higher management intensities during the current rotation (run 6) resulted in higher inventories after 2000 than in the base run (run 1). Run 6 got a jump on growth by having acres shift to higher yields in the first periods of the projection. This demonstrates the care that must be taken in shifting acres in the first few periods of a projection to higher management intensities, thereby dramatically increasing their projected yields. A stand can increase its growth rate immediately when stand treatments are applied; the degree of increase must be carefully ascertained.

⁷ "Harvest regulation" is used as a synonym for forest regulation. Foresters historically have defined a managed forest as a target that, once achieved, would give a stable output. The organization of a forest to provide an even flow of timber products forms the heart of traditional forest management for timber production (Davis and Johnson 1987). Computer models for forest management impose particular kinds of forest regulation, given the structure of the model itself, and it is important to know what type of harvest regime and age-class structure will result from the user assumptions. Questions that should be addressed include: Will the model allow a diversity of age-class distribution under given harvest levels? and Will the model allow for increasing or decreasing harvest levels over time? The implicit assumptions imposed by the design of the program directly affect the outcome, thereby affecting the ability of the model to project realistic outcomes.

⁸ De facto in that TRIM is not intended to impose particular age-class structures on forests; but it does, because of the structure and therefore the implicit assumptions in the model.

Table 5—Age distribution in 2040, harvest-sensitivity analysis, comparing the number of acres in each age class in the base run (run 1), the oldest-first harvest projection (run 3), the long-term sustained yield harvest projection (run 4), and the half long-term sustained yield harvest projection (run 5)

| Age class | Run 1 | Run 3 | Run 4 | Run 5 |
|-------------------|---------|---------|-----------|---------|
| ----- Acres ----- | | | | |
| 0-10 | 707,156 | 671,854 | 1,276,697 | 507,486 |
| 20 | 372,600 | 369,947 | 590,577 | 280,072 |
| 30 | 550,330 | 553,940 | 885,157 | 310,715 |
| 40 | 548,282 | 555,627 | 73,551 | 304,040 |
| 50 | 498,155 | 560,045 | 0 | 509,508 |
| 60 | 149,459 | 114,569 | 0 | 517,702 |
| 70 | 0 | 0 | 0 | 256,828 |
| 80 | 0 | 0 | 0 | 139,631 |

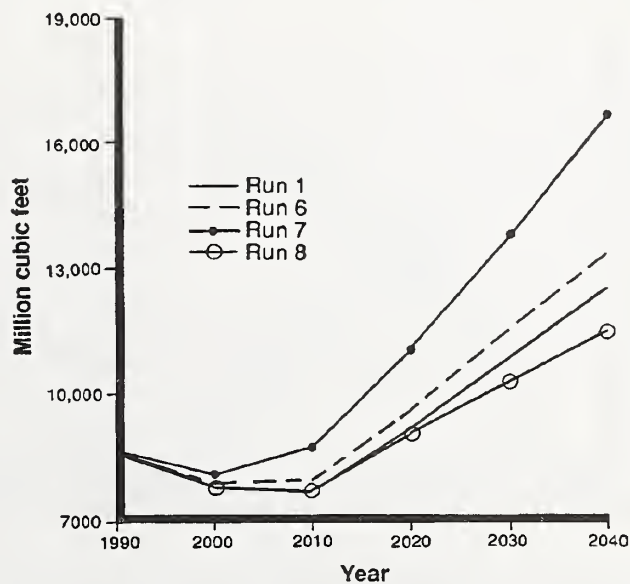


Figure 5—Inventory projections for the analysis of management and yield table sensitivity: base run (run 1), current management intensity shifting (run 6), modified yields projection (run 7), and no management intensity shifting (run 8).

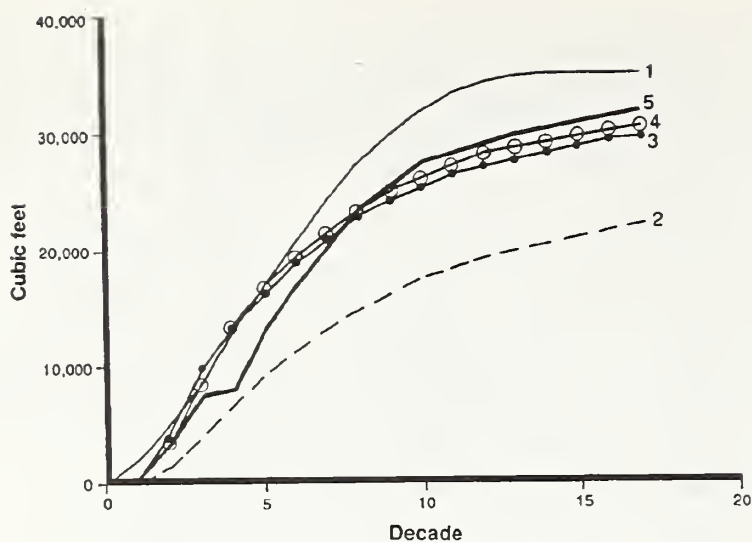


Figure 6—Modified Douglas-fir high site yields for management intensities 1 through 5.

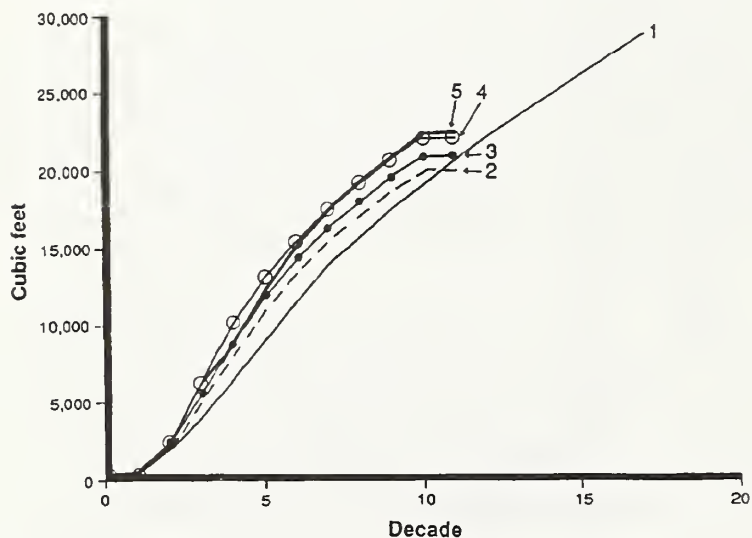


Figure 7—Original Douglas-fir high site yields for management intensities 1 through 5.

Using modified yield functions resulted in the highest inventories throughout the projection; the difference increased dramatically in the long term. The primary difference between the original and the modified yield functions for Douglas-fir was management intensity 1, growth yields. The modified yield function for the yield table classification "high site Douglas-fir management intensity 1" (growth yields) was higher than that for all other management intensities (fig. 6). The high-site yields used for all other projections in this study (fig. 7) showed growth yields (management intensity 1) lower than those for all other management intensities until age 110. Growth yields are projected to age 170; all other management intensities are projected to age 110.

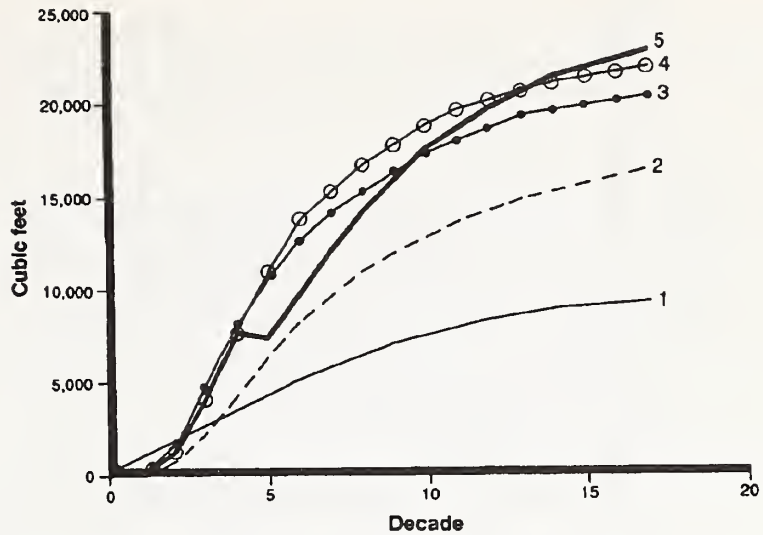


Figure 8—Modified Douglas-fir medium site yields for management intensities 1 through 5.

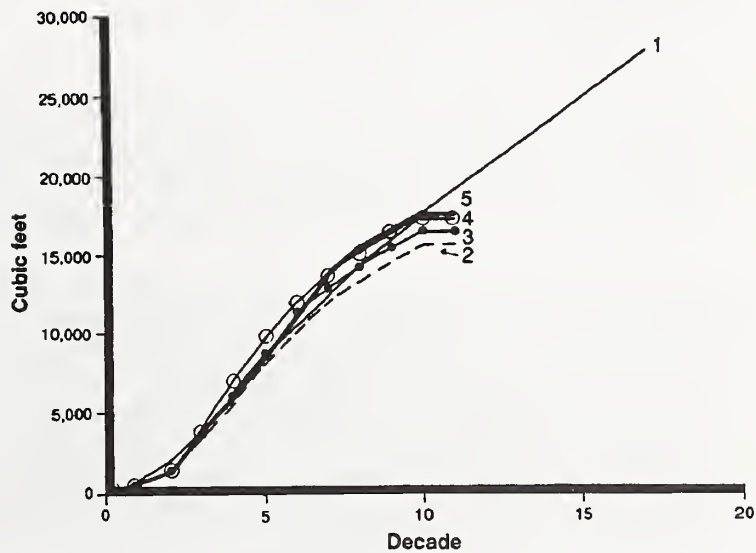


Figure 9—Original Douglas-fir medium site yields for management intensities 1 through 5.

The modified yield function for medium-site Douglas-fir in management intensity 1 was far below the other management intensities (fig. 8). The medium-site yields used in this study showed growth yields above normal yields (management intensity 2) but below all other management intensity yields from age 40 to age 70 (fig. 9). The high inventories of the modified yields projection (run 7) primarily were the reflection of the higher volume assumed for all management intensities in high-site lands, particularly in older age classes. The yield functions for management intensities 2 through 5 also were higher for medium-site modified yields, particularly in older age classes. Supply projections resulting from run 7 demonstrated the importance of accurate yield functions, particularly for long-range planning.

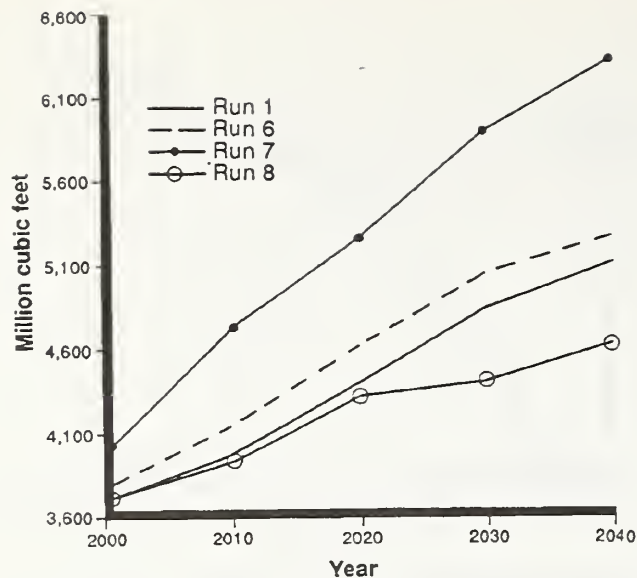


Figure 10—Growth projections for the analysis of management and yield table sensitivity: base run (run 1), current management intensity shifting (run 6), modified yields projection (run 7), and no management intensity shifts (run 8).

Keeping all acres in the original management intensities throughout the projection resulted in the lowest inventory projections in the long term (fig. 5). An assumption that all acres will be managed in the future as they are currently (run 8) had little effect before 2020 but had considerable effect on long-term projections. Run 8 demonstrated the importance of assumptions for future management of timberlands.

Growth—Growth trends for runs 1, 6, 7, and 8 show the same concepts outlined in the discussion of inventory trends for this analysis of management intensity and yield table sensitivity. Allowing acres to shift into higher management intensities in current inventories (run 6) made a substantial difference in both the short and the long term compared to the base run (run 1) (fig. 10). Not allowing any shifts in management intensity to occur made little difference until 2020 but had a substantial effect in 2030 and 2040. The modified yield tables projection (run 7) showed considerably more growth, in both the short and the long term, than did the base run.

Age-class distribution—The age-class distribution for run 1 (base run) contained no inventory older than 60 after 1990. Allowing current inventory to shift to higher management intensities (run 6) resulted in slightly more inventory in the 60-year age class in 2030 and 2040. The difference in age-class distribution between runs 1 and 6 was not appreciable, however. The age-class distributions for modified yield functions (run 7) and for no shifts in management intensity (run 8) also were virtually the

same as for the base run. Given the initial age-class distribution of the inventory and the harvest requests from the interaction of TAMM and ATLAS, the age-class distribution in future periods was not sensitive to changes in yield tables and management intensities.

Conclusions

I have shown that the difference among runs with and without stocking adjustment is appreciable both in the short and the long term. The rate of change in stocking in the field depends primarily on the initial stocking of the stand and the initial age of the stand. Stocking increases more rapidly in younger than in older age classes and more rapidly when density is low. In TRIM, the slope of the stocking-adjustment equation can be changed twice, at ages assigned by the user: The slope can be halved and then zeroed. The slope is not sensitive to the initial age of the stand. When more than one stocking level exists in a GRU, as in the data set used for this study, all stocking levels are assigned the same stocking adjustment. In this study, the same stocking-adjustment equation was used for all management intensities in a GRU (Alexander 1988).

Harvest levels used for all variable-harvest simulations in this study are an approximation of actual projected harvest levels over the next 50 years. If it is assumed that the correct yield tables were used and that the stocking adjustment equation is correct, then inventories increase in the long run (fig. 1, run 1), thereby indicating that more could be harvested after 2010 than presently assumed.

If it is assumed that stocking adjustment is included in the yield tables used for the west-side Douglas-fir data set and that a separate function for stocking adjustment should not be included to adjust yields in current inventories, then inventories over time increase at a lower rate after 2010.

Harvests based on constant-volume demand are often projected for Government timberlands in the form of nondeclining even-flow policies. Allowable cuts, as these harvests are termed, are calculated from current inventories and yields from future forests. The two harvest projections based on constant-volume demand used in this study were relatively simple calculations based only on future yields, assuming no additional constraints will be placed on future forests that will change their yields. In addition, the harvests were applied to private timberland. The harvest levels from private timberland are market responsive and quite variable. The two runs with constant demand show the results of applying harvests too high to be sustained (run 4) and so low that considerable inventories accumulate in older age classes (run 5). Run 4 cuts volume to the extent that very little inventory stays in age classes older than 30. Run 5 cuts so little that inventories accumulate in ages 70 to 110. The two runs illustrate two extremes in harvesting to which TRIM is fairly responsive.

Harvesting the oldest age classes first, until volume requests are met, makes little difference in inventories (fig. 3). In 2040, there is a little more volume in a forest where oldest age classes are always preferentially cut. Assumptions that the oldest trees will be harvested first can often be used in projection models of timber supply. The distribution of acres by age class is not much different between the base run and the run assuming the oldest trees are harvested first. The difference in inventories and age-class distributions is negligible between the oldest-first harvest regime and the projection assuming proportionate removals across age classes. This can be attributed to initial inventory characteristics and the level of harvest requests in each period. There has been concern among foresters that if an oldest-first harvest regime is used, a de facto forest regulation model is imposed. If all information supplied in this study on yields, management, harvest levels, current inventories, and so on was correct, the harvest regime used does not seem to make a significant difference in inventories or age class distribution.

In projections of timber supplies in the Douglas-fir region, current inventories, harvest requests, minimum allowable harvest ages (the minimum age at which a stand can be harvested [not to be confused with the target rotation age]), and harvest proportions by age class contribute to the elimination of older age classes in future periods. Two possible ways to leave older age classes in future inventories in TRIM are (1) to determine how much future inventory is to be left and remove it from the database used to make the projections, or (2) to rewrite the code to force TRIM to leave certain numbers of acres or percentages of inventories in given age classes. At present, TRIM does not leave isolated older age classes in future inventories, given current inventories and projected demand.

The age-class distribution is not overly sensitive to the harvest proportions by age class. Long-term volume projections are somewhat sensitive to assumptions about harvest proportions. Volume projections have a direct effect on supply projections. It is important to evaluate the degree of accuracy desired in supply projections when predicting future harvest proportions by age-class.

Run 6 immediately accelerates growth by having acres shift to higher yields in the first few periods of the projection. Shifting acres to higher management intensities in current inventories makes some difference in yields in the short term (less than 20 years) and more difference in the long term (fig. 5). A stand can increase its growth rate immediately when stand treatments are applied, but the degree of increase must be projected cautiously. A long-term increase in volume projections results from an assumption of increased yields in current inventories from immediate management intensification. If current inventories are not being subjected to management intensification, this increase in volume is not realistic. A long-term decrease in volume projections also results from the assumption that future stands will be managed the same as present stands (fig. 5, run 8). The assumptions for management intensities, both at present and in the future, have important effects on volume projections in the long term.

Using the modified yield functions results in higher inventories throughout the projection, and the difference increases dramatically in the long term. Yield functions have a considerable effect on supply projections. The age-class distribution between the base run and the run with modified yield functions is essentially the same in both the short and the long term. Yield table development is very important for plausible simulations of supply but has little effect on projections of age-class distributions.

Before accepting projections of timber inventories and growth under a given harvest regime in TRIM or any projection model, policy makers should assure themselves that the yield tables reflect the yields they are supposed to represent, that stocking adjustment is included and is realistic, and that the projected harvest levels are justifiable. Policy makers otherwise could find themselves planning for a future that is far different than assumed.

Variations among projections in TRIM that use the same data set but differ in the set of assumptions are a result not only of the user supplied assumptions on yields, management, harvests, and stocking but also of the structure of TRIM itself.

Literature Cited

- Adams, Darlus M.; Haynes, Richard W. 1980.** The 1980 softwood timber assessment market model: structure, projections, and policy simulations. Forest Science. Monograph 22. 64 p.
- Alexander, Susan J. 1988.** Sensitivity of TRIM projections to management and stocking adjustment assumptions. Corvallis, OR: Oregon State University. 96 p. M.S. thesis.
- Briegleb, P.A. 1942.** Progress in estimating trend of normality percentage in second-growth Douglas-fir. Journal of Forestry. 40: 785-793.
- Chambers, Charles J. 1980.** Empirical growth and yield tables for the Douglas-fir zone. Olympia, WA: Washington Department of Natural Resources. DNR Rep. 41.
- Davis, Laurence S.; Johnson, K. Norman. 1987.** Forest management. New York: McGraw-Hill Book Co. 790 p.
- Haynes, R.W.; Adams, D.M. 1985.** Simulations of the effects of alternative assumptions on demand-supply determinants on the timber situation in the United States. Forest Resource Economics Research publication [not numbered]. Washington, DC: U.S. Department of Agriculture, Forest Service. 113 p.
- McArdle, Richard E.; Meyer, Walter H.; Bruce, Donald. 1961.** The yield of Douglas-fir in the Pacific Northwest. Tech. Bull. 201. Washington, DC: U.S. Department of Agriculture. 74 p.
- Tedder, P.L.; LaMont, Richard N.; Kincaid, Jonna C. 1987.** The timber resource inventory model (TRIM): a projection model for timber supply and policy analysis. Gen. Tech. Rep. PNW-GTR-202. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 82 p.

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