ECONOMICS OF STAND MANAGEMENT

David K. Lewis[1]

ABSTRACT

This paper sets out to demonstrate the importance of considering the wealth represented by the growing stock in economic analyses of stand management alternatives, and to demonstrate the role of thinning in the manipulation of the efficiency of growing stock in the management of shortleaf pine (Pinus echinata Mill.). These goals are achieved through a demonstration of the impact of four (4) simulated thinning regimens on the growth, yield, and economic performance of four (4) stands of shortleaf pine of varing ages and site classes in western Arkansas. The analysis demonstrates that thinning may reduce total yield and periodic annual increment following treatment. However, economic performance as measured by the value of total yield and periodic annual increment will be improved by thinning if the stand has sufficient time to recover from treatment. Economic efficiency of the growing stock is also improved by thinning if the stand has sufficient time to recover from treatment.

INTRODUCTION

Economics of shortleaf pine management in the Western Gulf Region. The current shortleaf pine (Pinus echinata Mill.) inventory in the Western Gulf Region, of Arkansas, Louisiana, Oklahoma, and Texas of 8.8 billion cubic feet has a growth rate of 495 million cubic feet per year (Murphy, 1975, 1976, 1977; van Hess, 1980).

Table 1. Growing Stock and Growth of Shortleaf Pine in the Western Gulf Region

State	Growing Stock	Growth
	(cu ft x 10^6)	(cu ft x 10^6)
Arkansas	938.7	51.9
Louisiana	4089.7	208.7
Oklahoma	2539.1	149.2
Texas	1217.4	85.1
TOTAL	8784.9	494.9

From: Table 13 in Murphy 1975, 1976, 1977; van Hess 1980.

[1]Associate Professor, Oklahoma State University, Stillwater, Oklahoma. Professional paper No. PP-2257 of the Agricultural Experiment Station, Oklahoma State University.

The current value of this inventory, based on average 1984 stumpage prices (Hussey, 1985), is $6.1 billion. The growth produced by this inventory, if valued at the same price, is $343 million.

Table 1. Growing Stock, Growth, Value of Shortleaf Pine in the Western Gulf Region

State	Western Gulf Region Growing Stock	Growth	Price	Growing Stock Value	Value of Growth
	(cu ft x 10^6)	(cu ft x 10^6)	($/cu ft)	($ x 10^6)	($ x 10^6)
Arkansas	938.7	51.9	0.76	713.412	39.444
Louisiana	4089.7	208.7	0.79	3230.863	164.873
Oklahoma	2539.1	149.2	0.61	1548.851	91.012
Texas	1217.4	85.1	0.56	681.744	47.656
TOTAL	8784.7	494.9		6174.87	342.985

From: Table 13 in Murphy 1975, 1976, 1977; Van Hess 1980 and Hussey, 1985.

In other words an asset worth approximately $6.2 billion is increasing in value at a rate of $343 million per year. This is a rate of 5.5 percent (5.5%) per year. At the same time the current alternative rate in this nations financial markets is from 7 to 9 percent. If this asset were to increase in value at a rate between 7 and 9 percent (7% - 9%) the value of the annual growth would range from $434 to $558 million. Can we as a profession ask our society to invest in the management of shortleaf pine when we have a record like this with the resources in our current inventory?

Economics of stand Management. Conventional economic evaluation is based on inputs and outputs in the form of cash flow. This concentrates the economic analysis of stand management on inputs and outputs of the forest stand, and tends to ignore questions of efficiency related to the use of growing stock in the management of these stands.

This paper proposes to examine the economics of stand management in terms of the stock of wealth created through forest growth and the stock of resources required to create this wealth. An economic analysis of investments associated with stand management in terms of wealth, a stock, instead of cash flows is consistent with the generally accepted economic theory of investment choice (Lewis, 1976). By following this pattern of analysis the concentration will be on the economic efficiency of the growing stock, which is the major resource utilized in the management of forests.

Objectives. The objectives of this paper are first to demonstrate the concept of "wealth" ("Present Certainty Equivalent Value") (Lewis, 1976) as an appropriate criteria for economic evaluation in stand management. Second to demonstrate the economic role of thinning in the management of shortleaf pine.

To achieve these objectives examples based on stand statistics from four different stands of shortleaf pine in northwestern Arkansas will be examined. These examples were selected from sample plot data collected by Dr. Thomas B. Lynch, Oklahoma State University, Department of Forestry, as part of study of

"Growth and Yield of Thinned Natural Shortleaf Pine on the Ouachita and Ozark National Forests", and include the following:

Stand Age (yr.)	Site Class (ht @ age 25)	Initial Volume (CCF/ac)
30	45	32
40	50	39
50	35	32
90	45	64

(Note: Site Classes are based site index curves developed by Graney and Burkhart (1973)).

Each of these examples will be examined in terms of yield and the economic efficiency of the growing stock given current stand conditions, and yield, and economic efficiency following a simulated thinning regimen. The yields for both the thinned and unthinned conditions are based on analyses by Murphy (1982), Murphy and Beltz (1981), and the U.S. Forest Service (1976). Based on these examinations some conclusions will be drawn regarding the "Economics of Stand Management for Shortleaf Pine".

GROWING STOCK EFFICIENCY IN UNTREATED SHORTLEAF PINE

Age 30, Site Class 45. The example of a 30 year old stand of shortleaf pine, site class 45, having an initial volume of 32 cunits per acre is expected to grow at an average rate of 74 cubic feet per acre per year during the 70 year period till it reaches age 100. At that time it is expected that the stand will have a standing volume of 84 cunits per acre.

In terms of economic performance, the growing stock in this stand has current value of $500 per acre, and is expected to increase in value at an average rate of $13 per acre per year during the 70 year period till age 100. At that time the growing stock is expected to have a value of $1,400 per acre. This is an average return on investment of 1.5 percent (1.5%) per year on the initial growing stock valued at $500 per acre.

Age 40, Site Class 50. The example of a 40 year old stand, site class 50, having an initial volume of 39 cunits per acre is expected to maintain an average growth rate of 69 cubic feet per acre per year during the 60 year period until the stand reaches age 100. At that time the stand is expected to have a standing volume of 80 cunits per acre.

The economic performance of this stand is forecast to be similar to the 30 year old stand. The growing stock in this example has an estimated stumpage value of $1,500 per acre, and is expected to increase in value at an average rate of $38 per acre per year. By age 100 the stand is estimated to be worth $3,800 per acre. This represents an average return on the invested growing stock of 1.6 percent (1.6%) per year.

Age 50, Site Class 35. The 50 year old stand, site class 35, having an initial volume of 32 cunits per acre is expected to grow at an average rate of 41 cubic feet per acre per year up to age 100 when the stand is expected to contain 52 cunits per acre of total volume.

This stand has an estimated value at the present time of $1,100 per acre and is expected to increase at a rate of $19 per acre per year for fifty years

when the growing stock is expected to be worth $2,100 per acre. This represents an average return of 1.2 percent (1.2%) per year on the $1,100 worth of growing stock invested for the 50 years.

90, Site Class 45. The 90 year old stand, site class 45, has a current growing stock inventory of 64 cunits per acre. In 30 years when this stand is 120 years old its estimated volume will be 75 cunits per acre and the stand will have maintained an average growth rate of 38 cubic feet per acre per year during the 30 year period.

The 64 cunits of the current inventory have an estimated stumpage value of $4,900 per acre and in 30 years when the stand is 120 years old the growing stock will have an estimated value of $6,300 per acre having increased in value at the rate of $45 per acre per year over the 30 year period. This will be an average rate of return on the invested growing stock of one percent (1%) per year.

Summary. The four examples range in age from 30 to 90 years in age and represent site classes ranging from 35 to 50 feet of height at age 25. These four stands have initial growing stock volumes ranging from 32 to 64 cunits per acre and are expected to achieve volumes ranging from 52 to 84 cunits per acre by age 100 while maintaining periodic annual increments ranging from 41 to 74 cubic feet per acre per year. In economic terms these examples represent growing stock investments ranging form $500 to $4,900 per acre and final yields ranging from $1,400 to $5,400 per acre at age 100. The value increases resulting from this growth range from $13 to $50 per acre per year. However, as investments these examples represent rates of return ranging from one to two percent (1% - 1.6%).

Summaries of this information on these four stands is given in Figures 1-5.

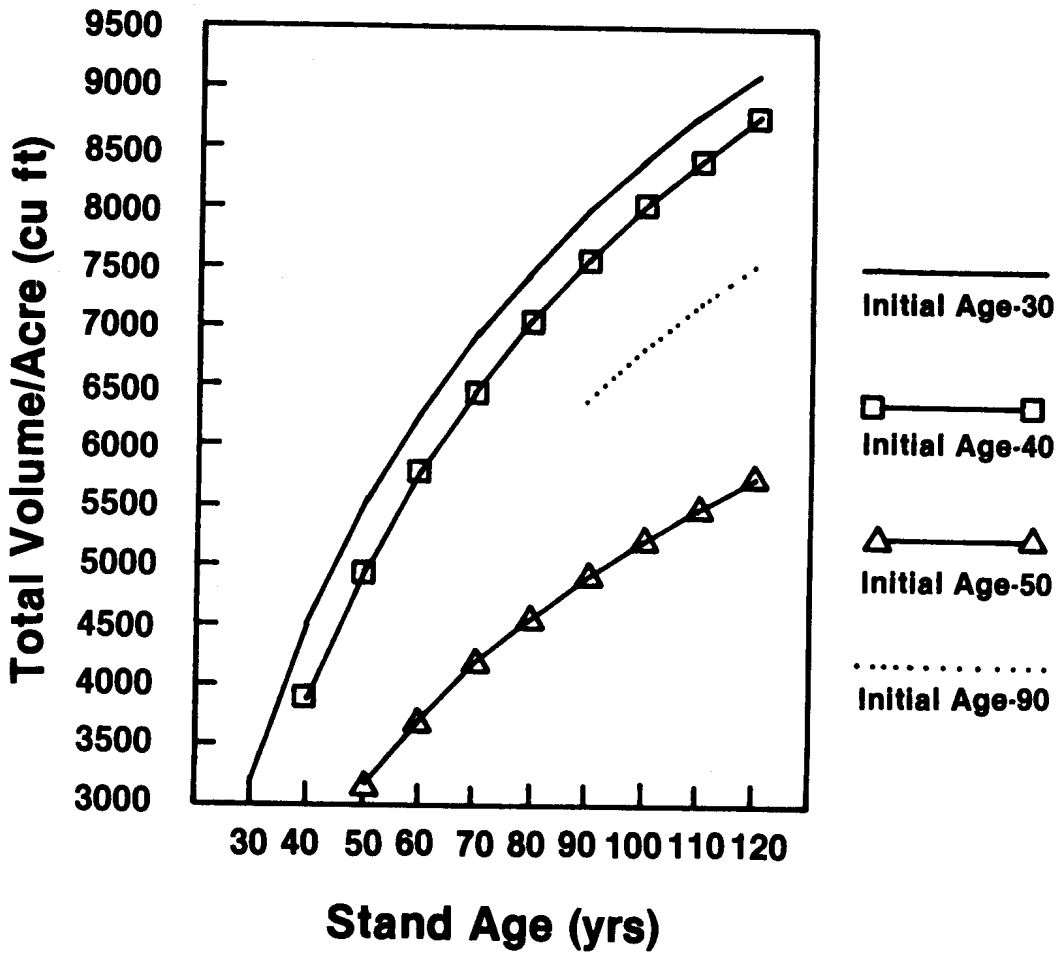

Figure 1. Total Stand Yield Per Acre by Stand and Age

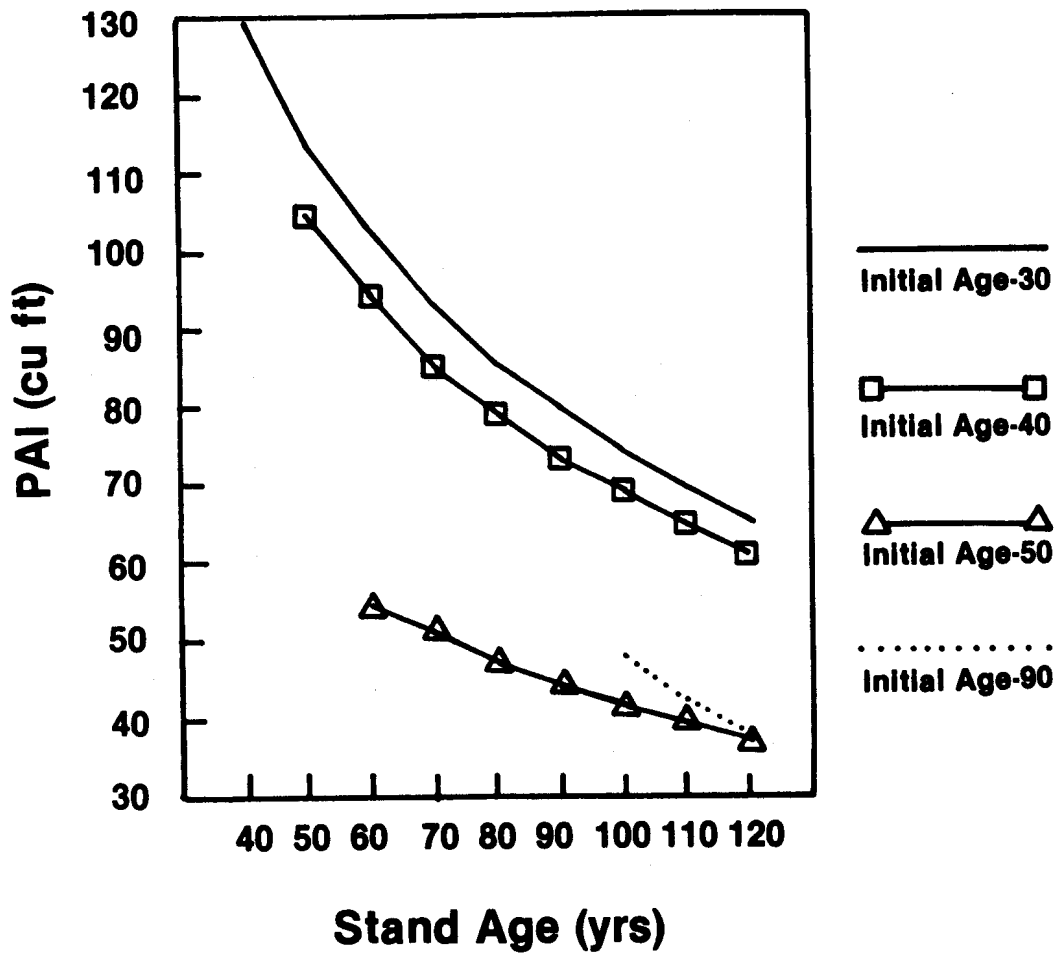

Figure 2. Periodic Annual Increment Per Acre by Stand and Age

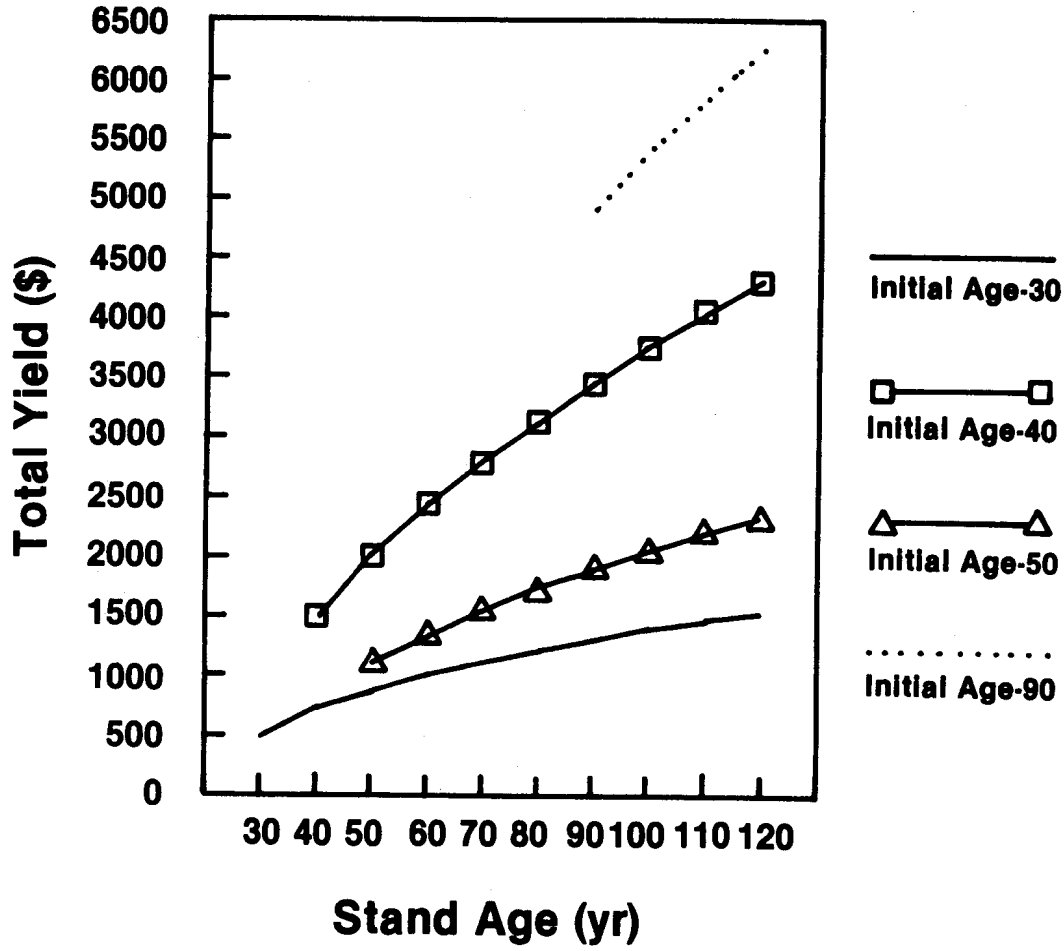

Figure 3. Yield Value Per Acre by Stand and Age

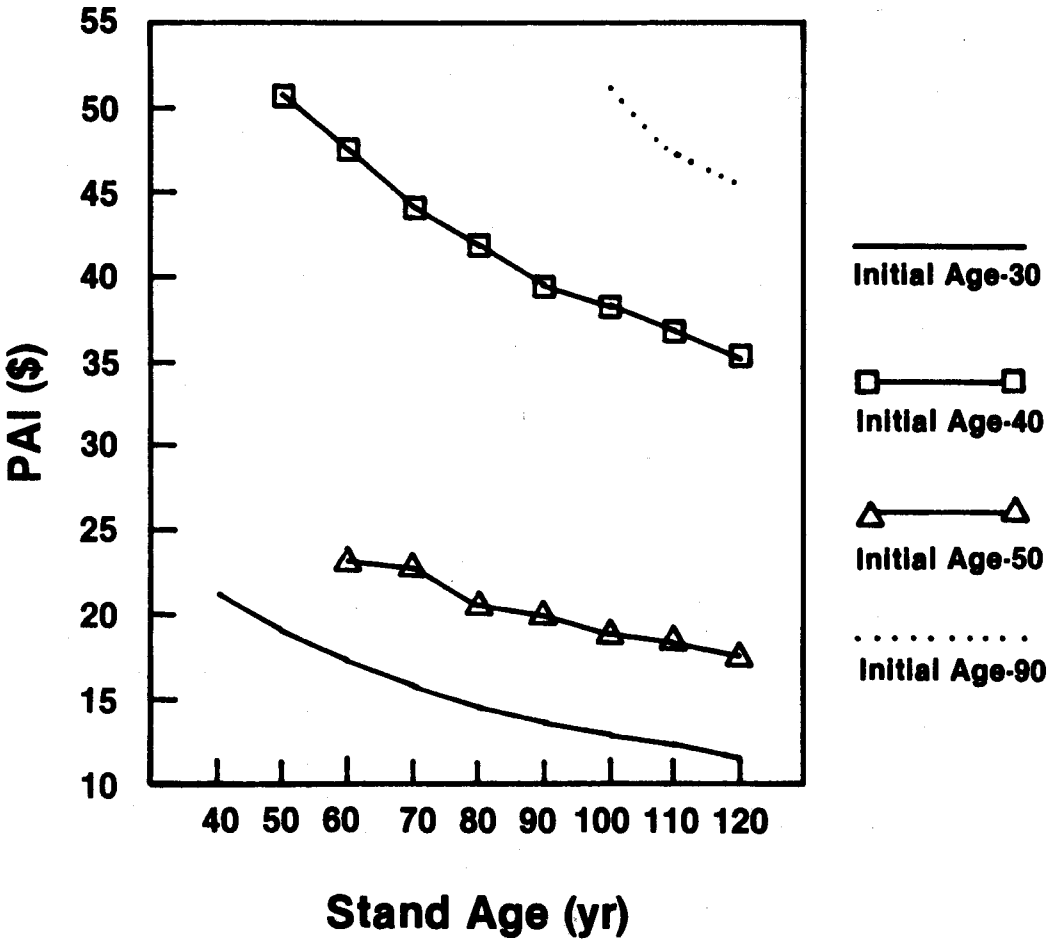

Figure 4. Periodic Annual Value Increment Per Acre by Stand and Age

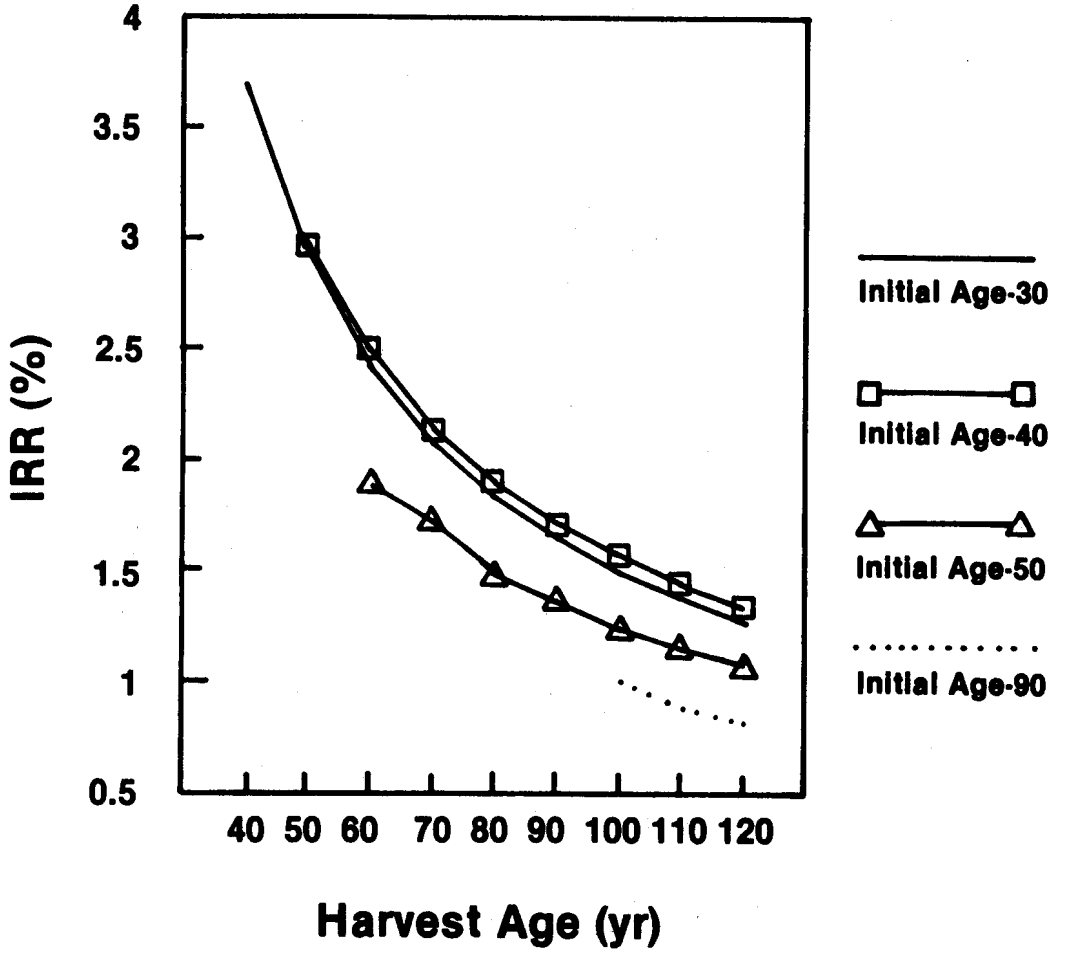

Figure 5. "Internal Rate of Return" From Initial Age to Final Harvest by Stand and Age of Final Harvest

IMPACT OF THINNING ON GROWING STOCK EFFICIENCY

To demonstrate the impact of thinning on the economic efficiency of the growing stock in these stands, each of the four stands will be subjected to three simulated low thinnings at ten year intervals, each of which will remove thirty percent (30%) of the growing stock basal area at the time of thinning. The effect of this thinning regimen on total yield, periodic annual increment, total value yield, periodic value increment, and internal rate of return will be examined.

Age 30, Site Class 45. After thinning at age 30; 30 and 40; and 30, 40, and 50 the total yield of the stand, including thinning removals, at age 100, is forecast to be 83, 82, and 82 cunits respectively. This compares to 84 cunits total yield at the same age in the unthinned case.

During the 70 years between the current age and age 100 the stand is expected to maintain periodic annual increments of 73, 72, and 71 cubic feet per acre periodic annual increment total yield respectively in comparison to the unthinned condition of 74 cubic feet per acre per year.

The value of total yield, including thinnings, for the three thinning regimens, with a final harvest at age 100, are $1,500, $1,500, and $1,600 per acre respectively These compare with a total yield value without thinnings at age 100 of $1,400 per acre.

The impact of these thinning regimens on periodic annual value increment is to increase it for the 70 year period from age 30 to age 100 to $14, $15, and $15 per acre per year for the thinnings at age 30; 30 and 40; and 30, 40, and 50 respectively.

The "Internal Rate of Return" is increased to 1.7, 1.8, and 2.0 percent (1.7%, 1.8%, and 2.0%) respectively as a result of the thinnings at age 30; 30 and 40; and 30, 40, and 50.

Age 40, Site Class 50. After thinning at age 40; 40 and 50; and 40, 50, and 60 the per acre total yield of the stand, including thinning removals, at age 100, is 80 cunits regardless of thinning regimen.

During the 60 years between the current age and age 100 the stand is expected to maintain periodic annual increments of 68, 68, and 69 cubic feet per acre in total yield. This is in comparison to the unthinnned condition of 69 cubic feet per acre per year.

The values of total yield per acre, including thinnings, for the three thinning regimens, with final harvest at age 100, are $4,100, $4,600, and $5,200 per acre respectively. These compare with $3,800 per acre expected without thinning.

The impact of these thinning regimes on periodic annual value increment per acre per year is to increase it for the 60 year period from age 40 to age 100 to $43, $51, and $62 for the thinnings at age 40; ages 40 and 50; and ages 40, 50, and 60 respectively. This is in comparison to the unthinned case which increased in value at a rate of $38 per acre per year during the 60 year period from age 40 to 100.

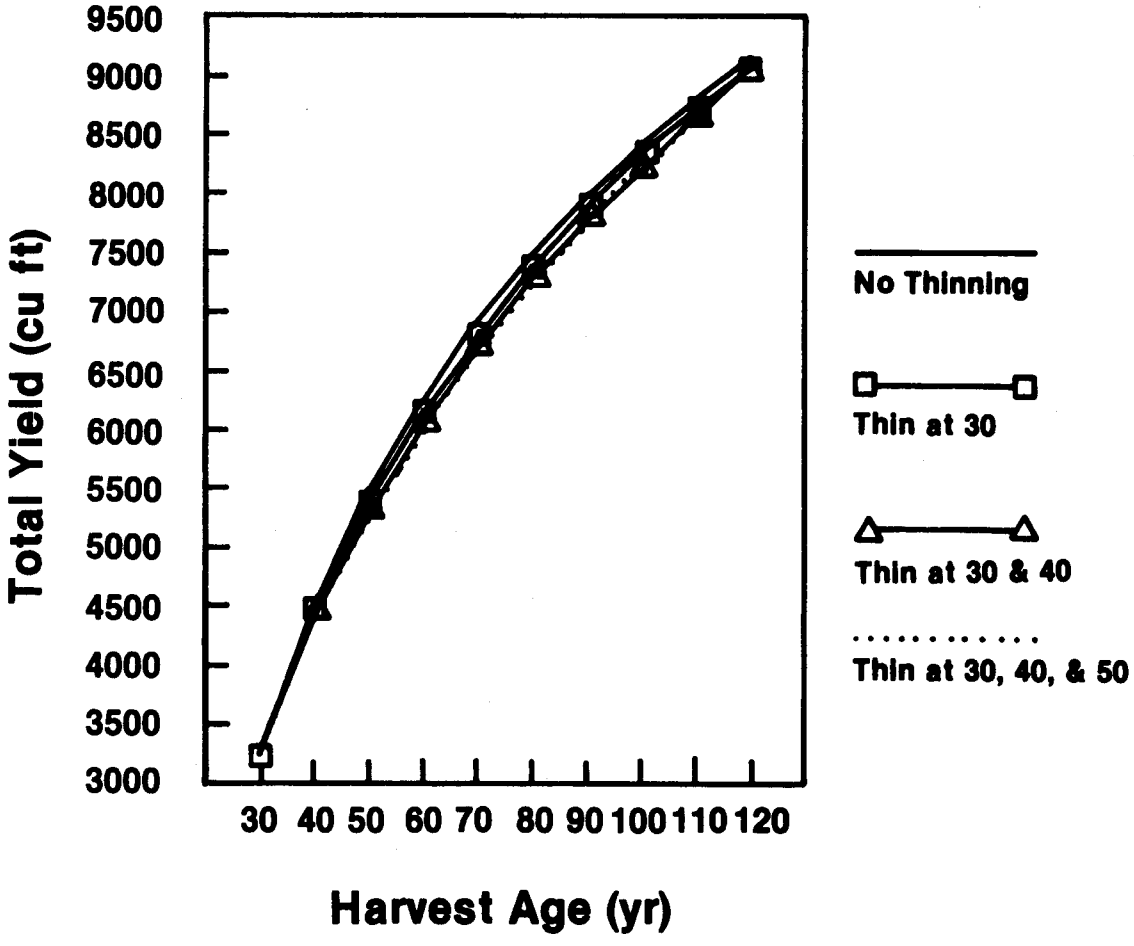

Figure 6. Total Stand Yield (Including Thinnings) Per Acre for Age 30, Site Class 45 by Thinning Regimen and Age at Final Harvest

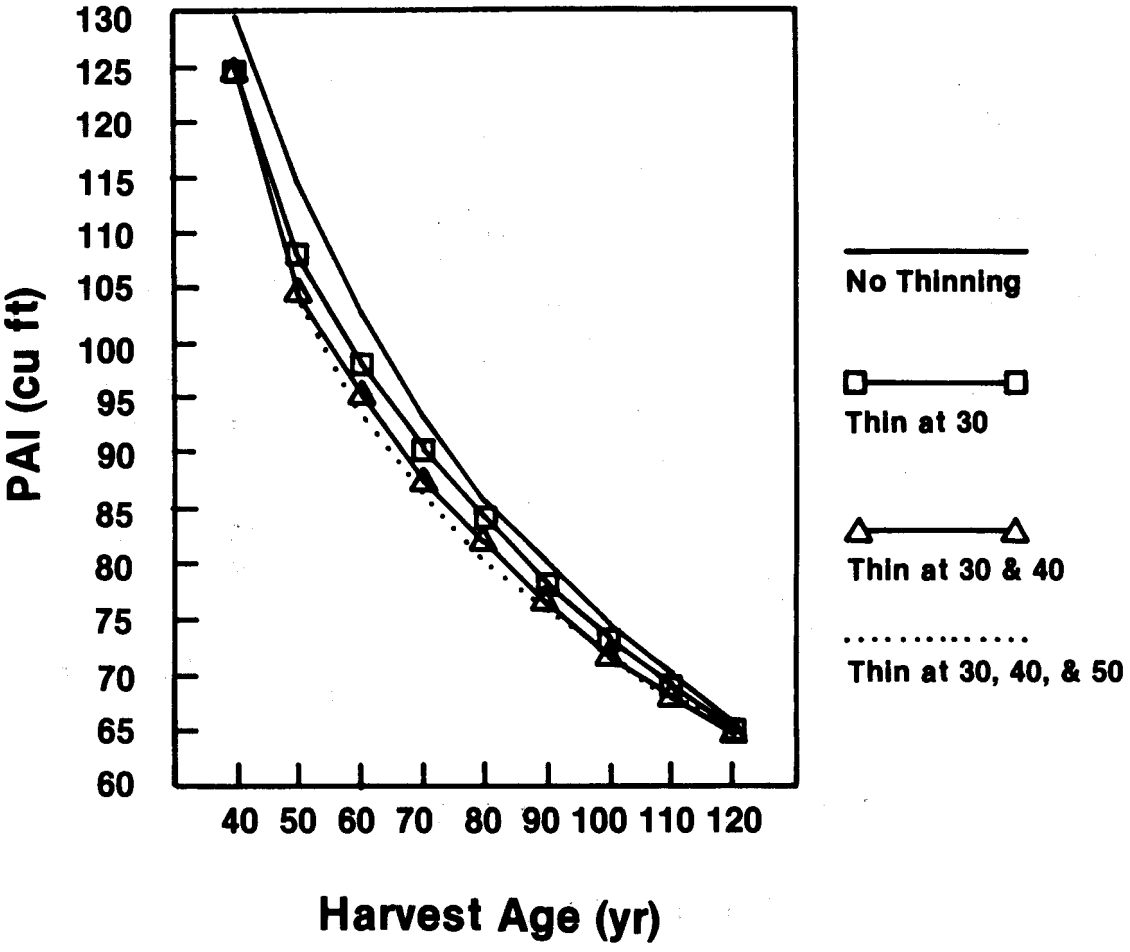

Figure 7. Periodic Annual Increment Total Yield Per Acre for Age 30, Site Class 45 by Harvest Age and Thinning Regimen

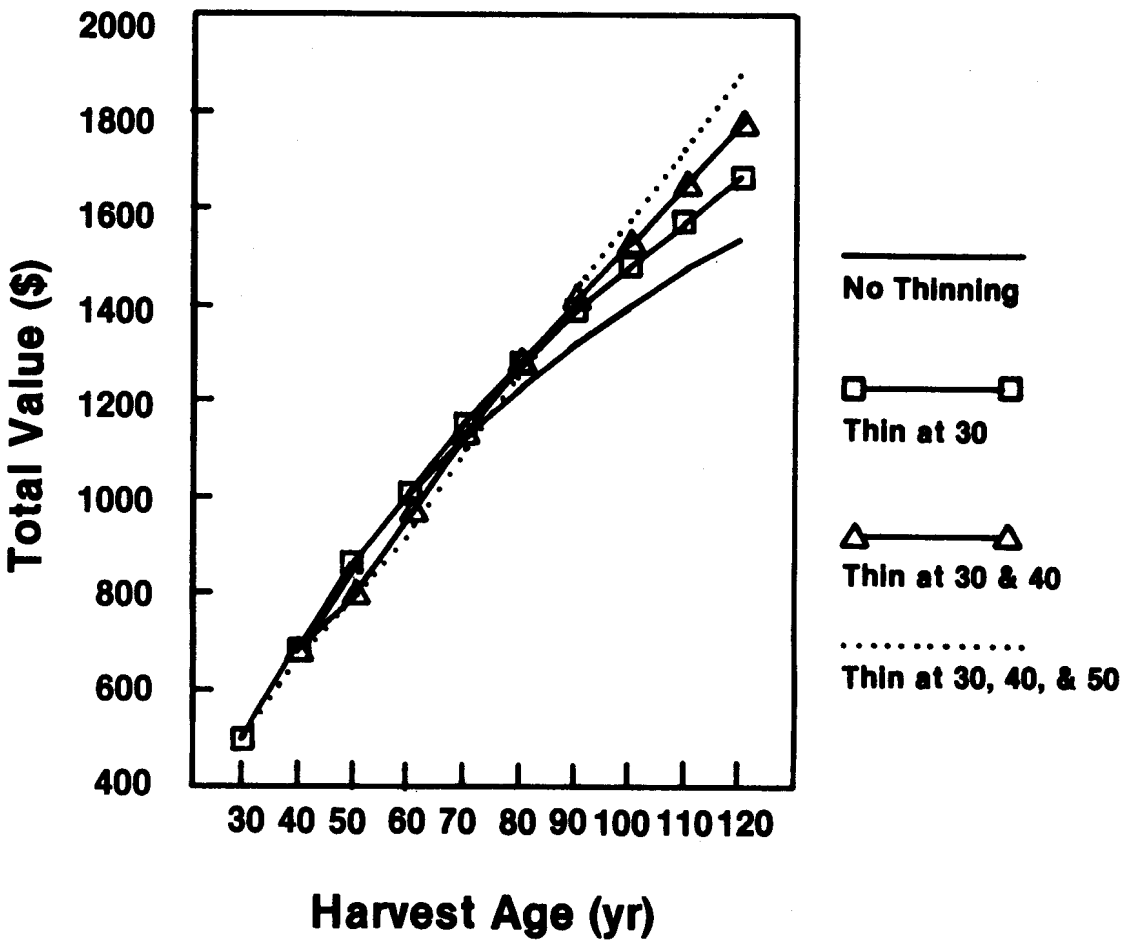

Figure 8. Value of Total Yield (Including Thinnings) Per Acre for Age 30, Site Class 45 by Thinning Regimen and Harvest Age

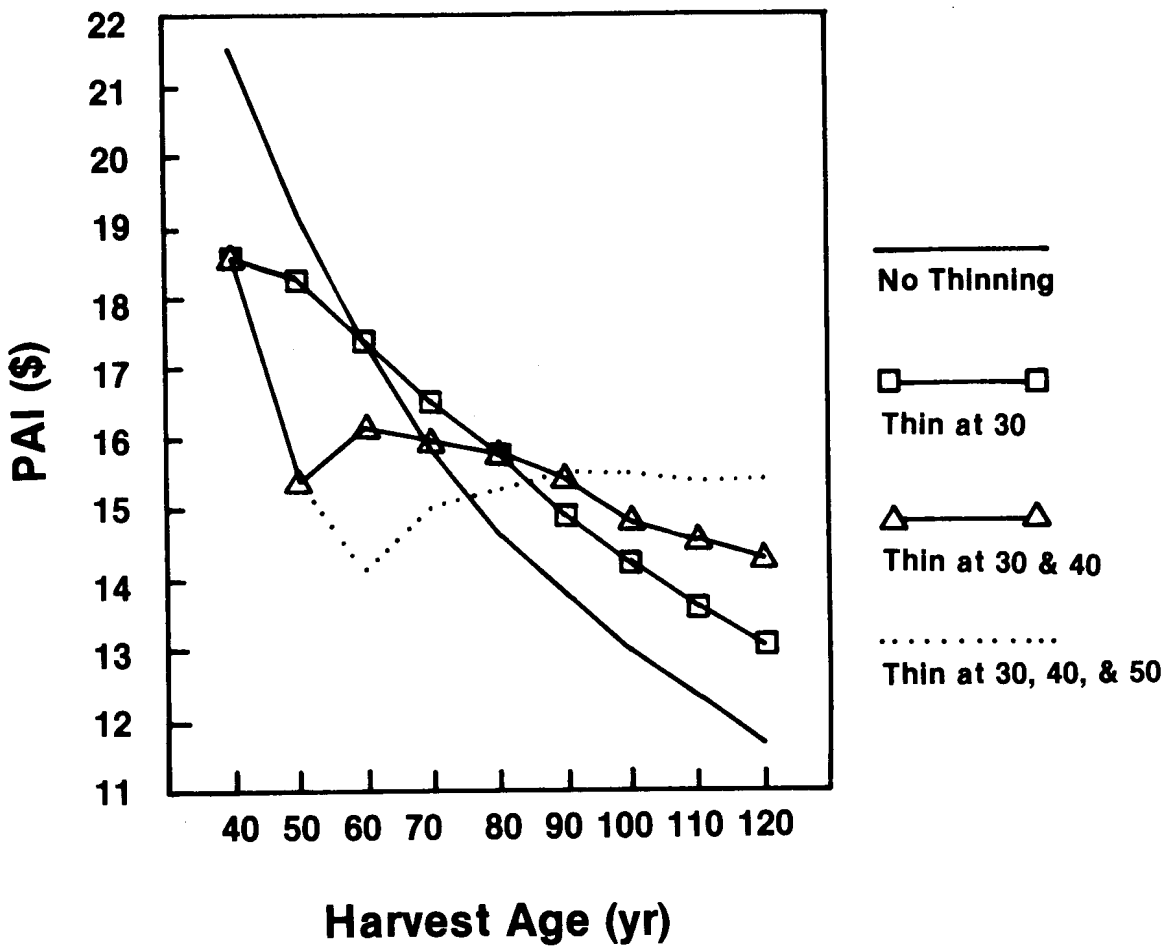

Figure 9. Periodic Annual Increment in Total Value Per Acre Per Year for Age 30, Site Class 45 by Thinning Regimen and Harvest Age

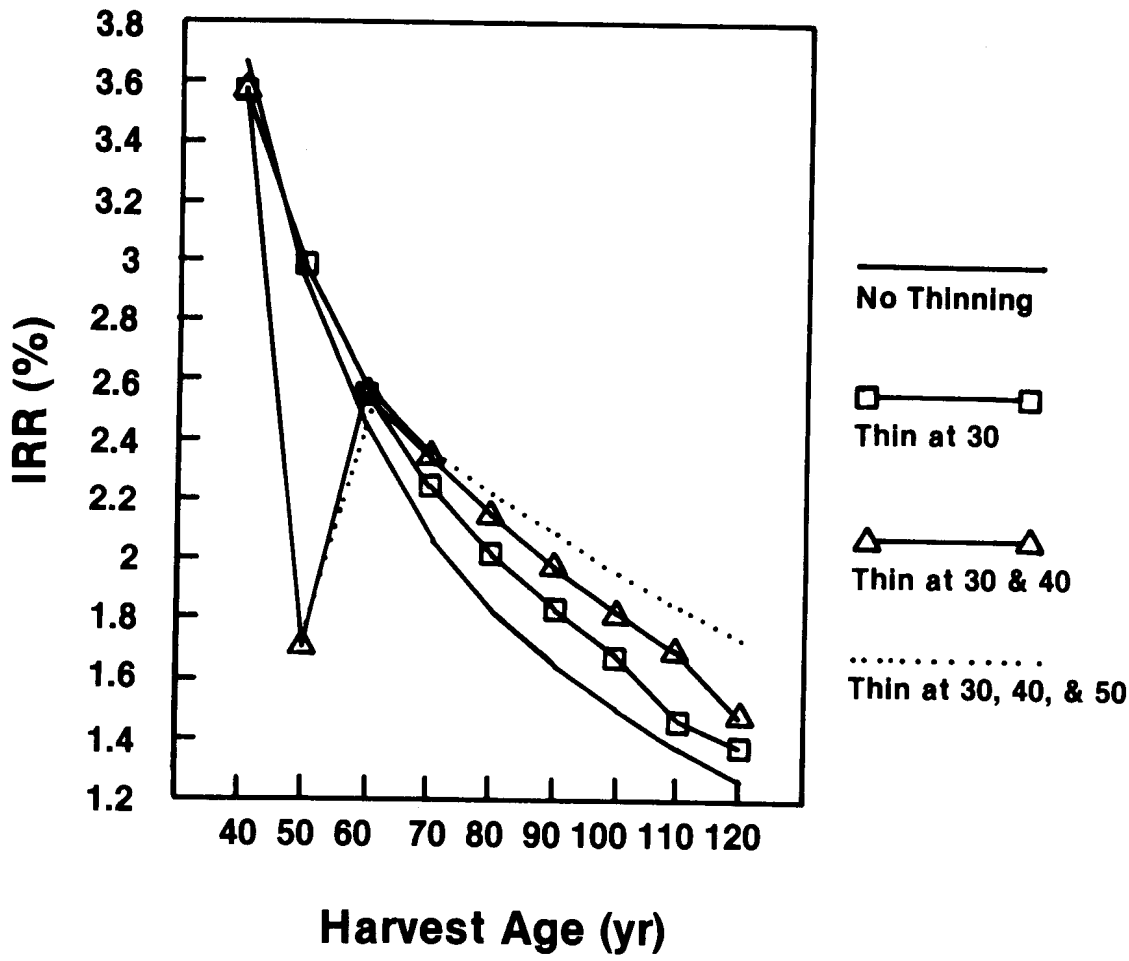

Figure 10. Internal Rate of Return for Age 30, Site Class 45 by Harvest Age and Thinning Regimen

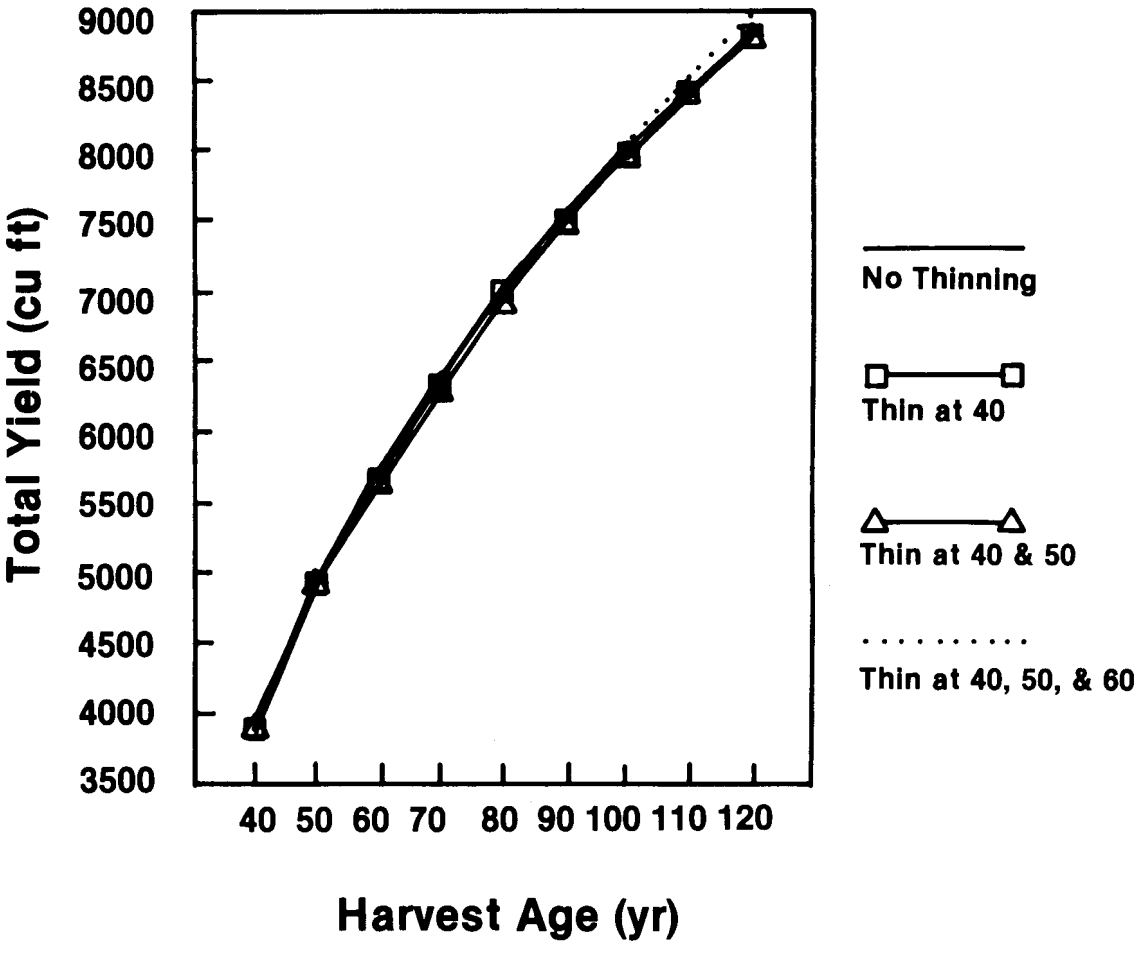

Figure 11. Total Stand Yield (Including Thinnings) Per Acre for Age 40, Site Class 50 by Thinning Regimen and Age at Final Harvest

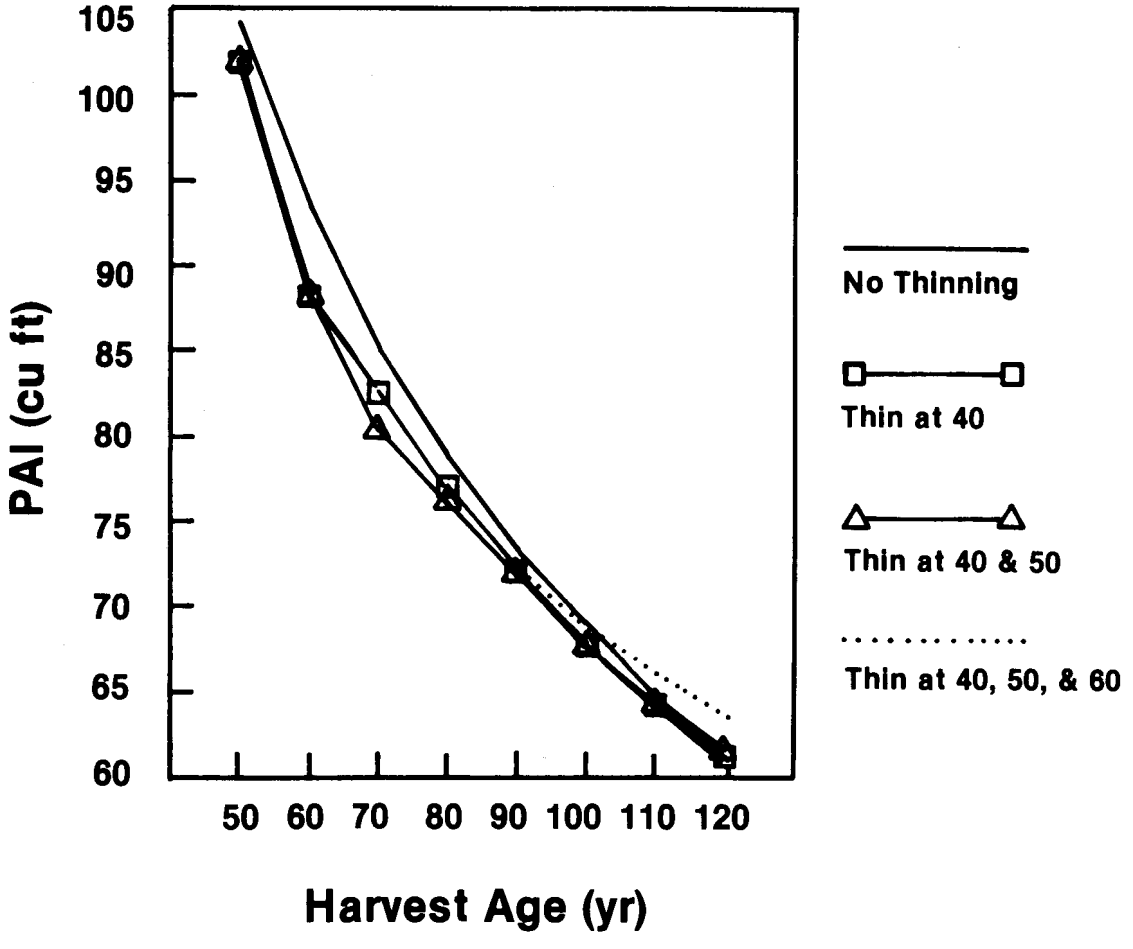

Figure 12. Periodic Annual Increment Per Acre Per Year Total Yield for Age 40, Site Class 50 by Harvest Age and Thinning Regimen

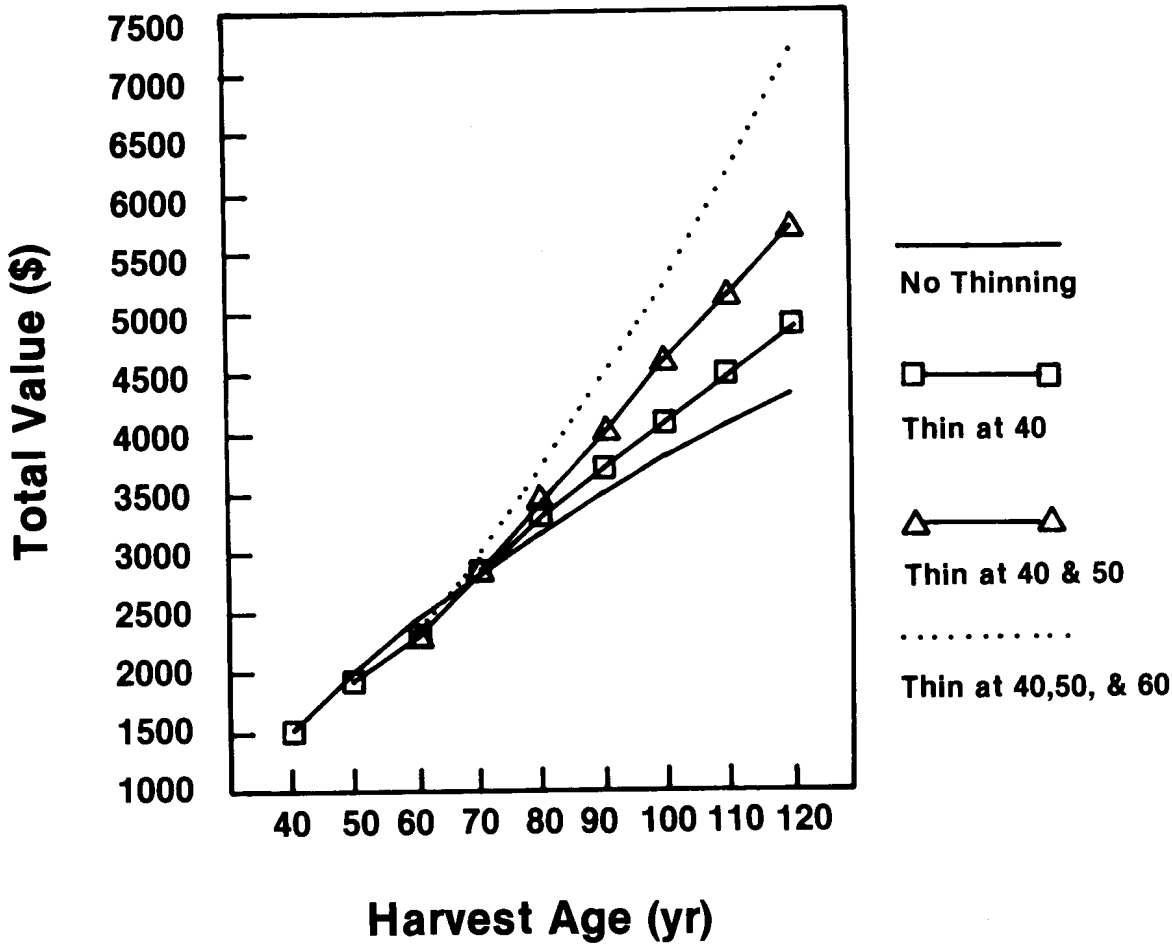

Figure 13. Value of Total Yield (Including Thinnings) Per Acre for Age 40, Site Class 50 by Thinning Regimen and Harvest Age

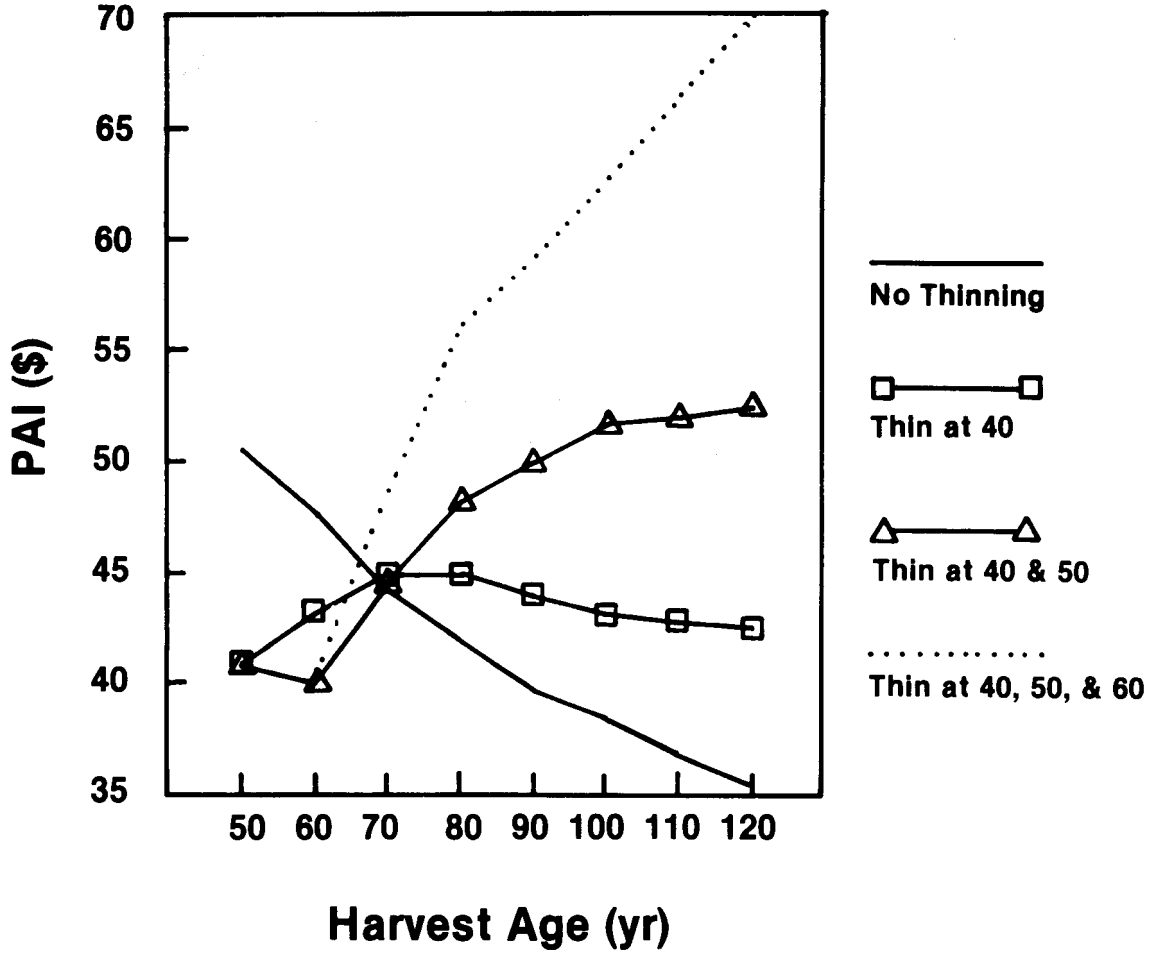

Figure 14. Periodic Annual Increment in Total Value Per Acre for Age 40, Site Class 50 by Thinning Regimen and Harvest Age

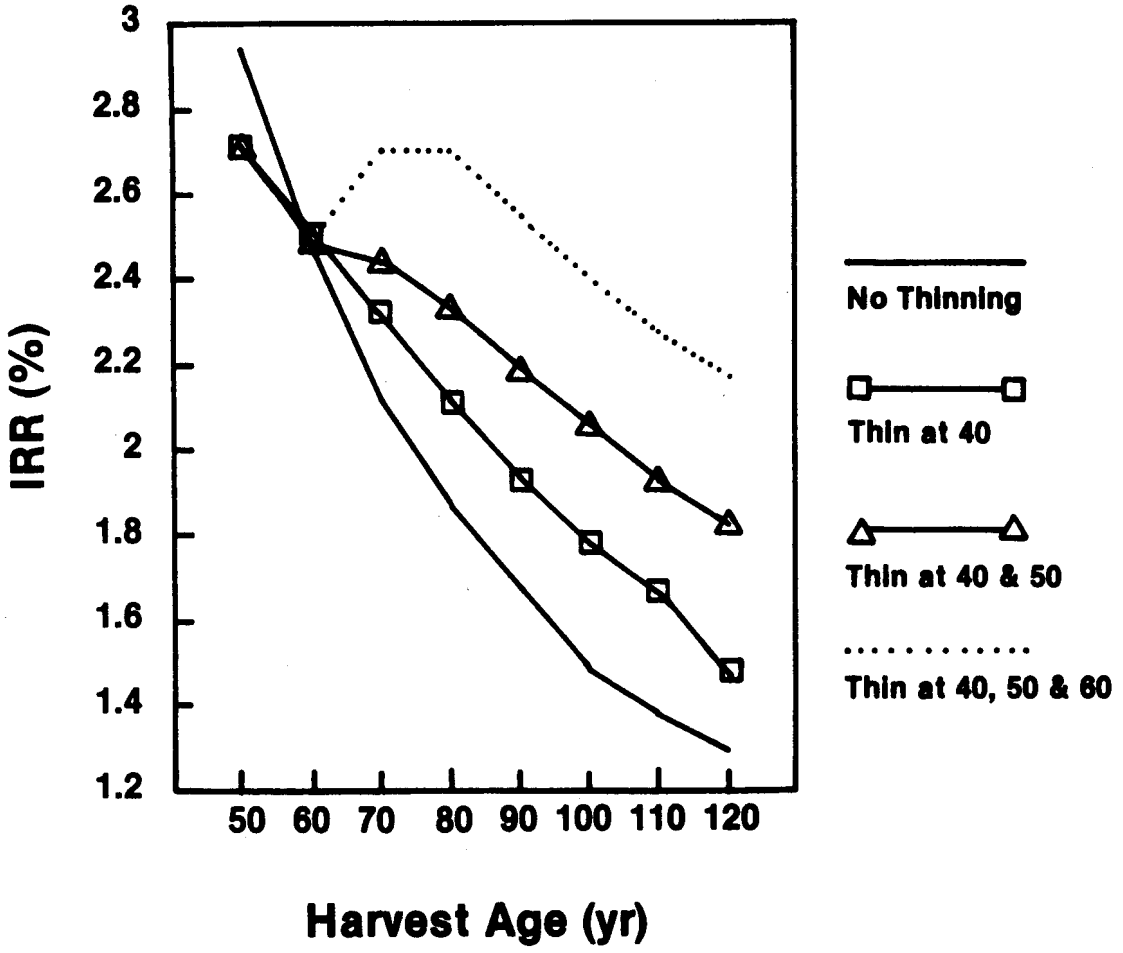

Figure 15. Internal Rate of Return for Age 40, Site Class 50 by Harvest Age and Thinning Regimen

The "Internal Rate of Return" is increased to 1.8, 2.1, and 2.4 percent (1.8%, 2.1%, and 2.4%) respectively as a result of the thinnings at age 40; 40, and 50; and 40, 50, and 60. Again this is in comparison to the unthinned case of 1.6 percent (1.6%).

Age 50, Site Class 35. After thinning at age 50; 50 and 60; and 50, 60, and 70 the total yield of the stand, including thinning removals, at age 100, is forecast to be 52, 51, and 52 cunits per acre respectively. This compares to 52 cunits per acre total yield at the same age in the unthinned case.

During the 50, years between the current age and age 100 the stand is expected to maintain periodic annual increments of 40, 40, and 42 cubic feet per acre periodic annual increment total yield respectively in comparison to the unthinned rate of 41 cubic feet per acre per year.

The value of total yield, including thinnings, for the three thinning regimens, with final harvest at age 100, are $2,200 $2,500, and $2,800 per acre respectively. These compare with $2,100 per acre expected without thinnings, at age 100.

The impact of these thinning regimens on periodic annual value increment per acre is to increase it for the 50 year period from age 50 to 100 to $21, $28, and $33 per acre per year for the thinnings at age 50; age 50 and 60; age 50, 60, and 70 respectively. For the same period the unthinned example increased at a rate of $19 per acre per year.

The "Internal Rate of Return" is increased to 1.4, 1.8, and 2.1 percent (1.4%, 1.8%, and 2.1%) respectively as a result of the thinnings at age 50; 50 and 60; and 50, 60, and 70.

Age 90, Site Class 45. After thinning at age 90; 90 and 100; and 90, 100, and 110 the total yield of the stand, including thinnings, at age 120, is forecast to be 75, 76, and 76, cunits per acre respectively This compares to 75 cunits per acre total yield at the same age in the unthinned case.

During the 30 years between the current age and age 120 the stand is expected to maintain periodic annual increments of 40, 41, and 42 cubic feet per acre respectively in comparison to the unthinned rate of 41 cubic feet per acre.

The value of total yield, including thinnings, for the three thinning regimens, with final harvest at age 120, are $6,300, $6,300, and $6,100 per acre respectively. These compare with $6,100 per acre expected without thinnings, at age 120.

The impact of these thinning regimens on periodic annual value increment per acre is to increase it for the light thinnings and reduce it for the heavy repeated thinnings over the thirty year period from age 90 to age 120. The periodic annual value increments per acre for the three thinnings simulated for these examples are $48, $46, and $42 per acre respectively. This compares to $45 per acre for the unthinned example.

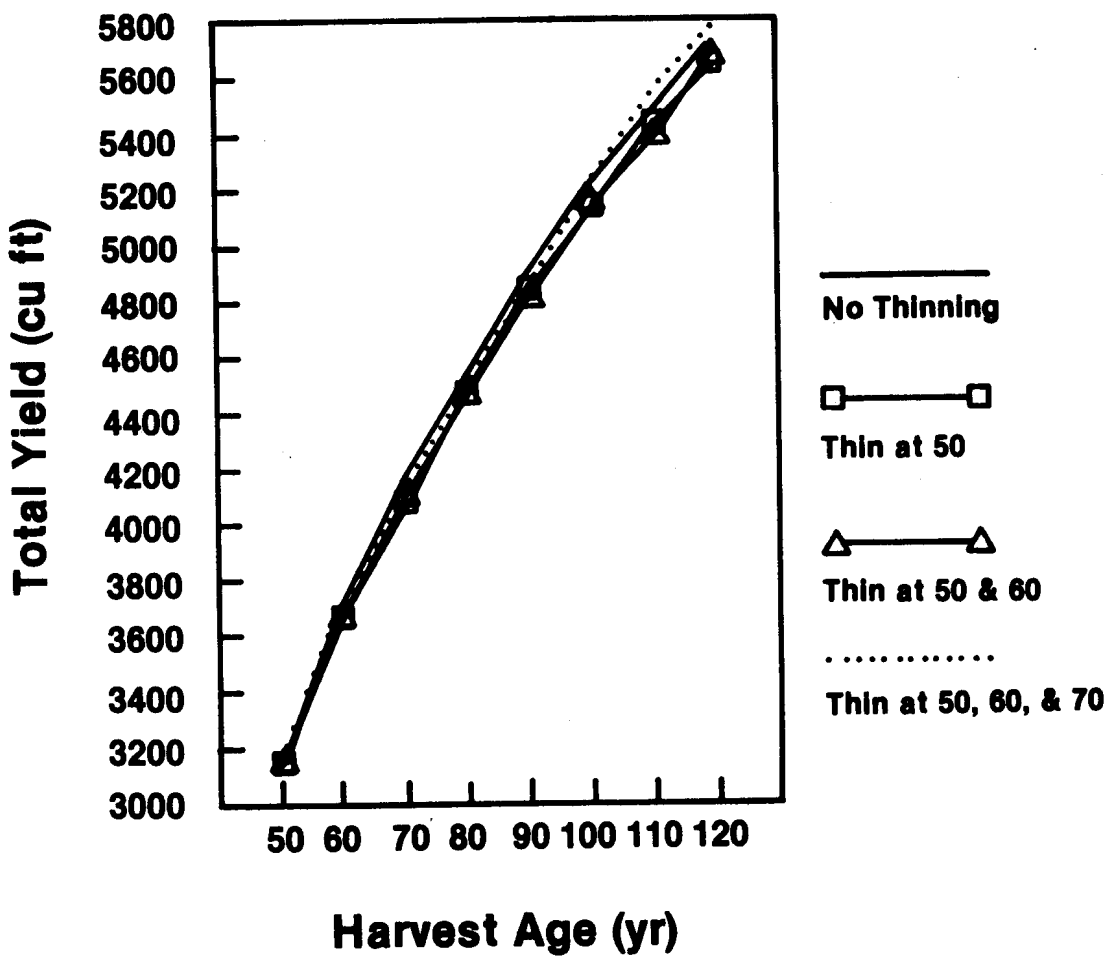

Figure 16. Total Stand Yield Per Acre (Including Thinnings) for Age 50, Site Class 35 by Thinning Regimen and Age at Final Harvest

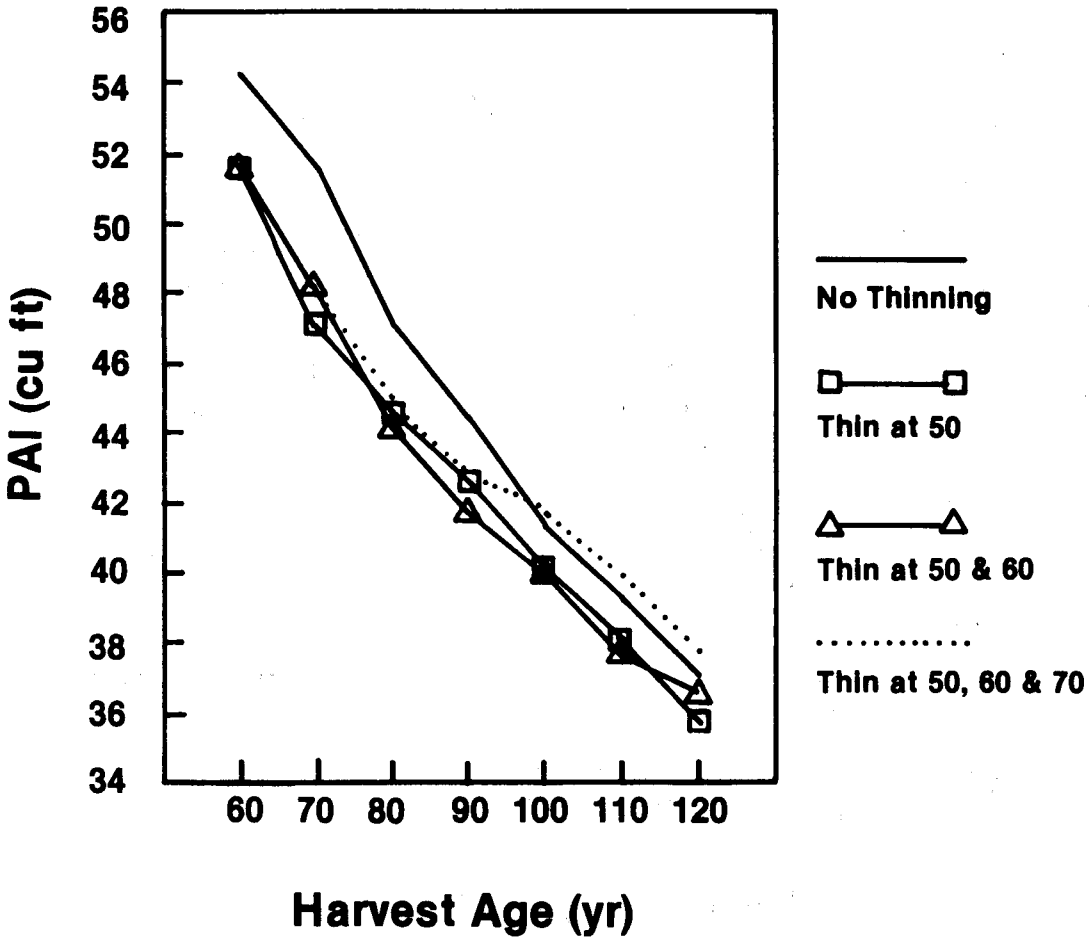

Figure 17. Periodic Annual Increment Per Acre Total Yield for Age 50, Site Class 35 by Harvest Age and Thinning Regimen

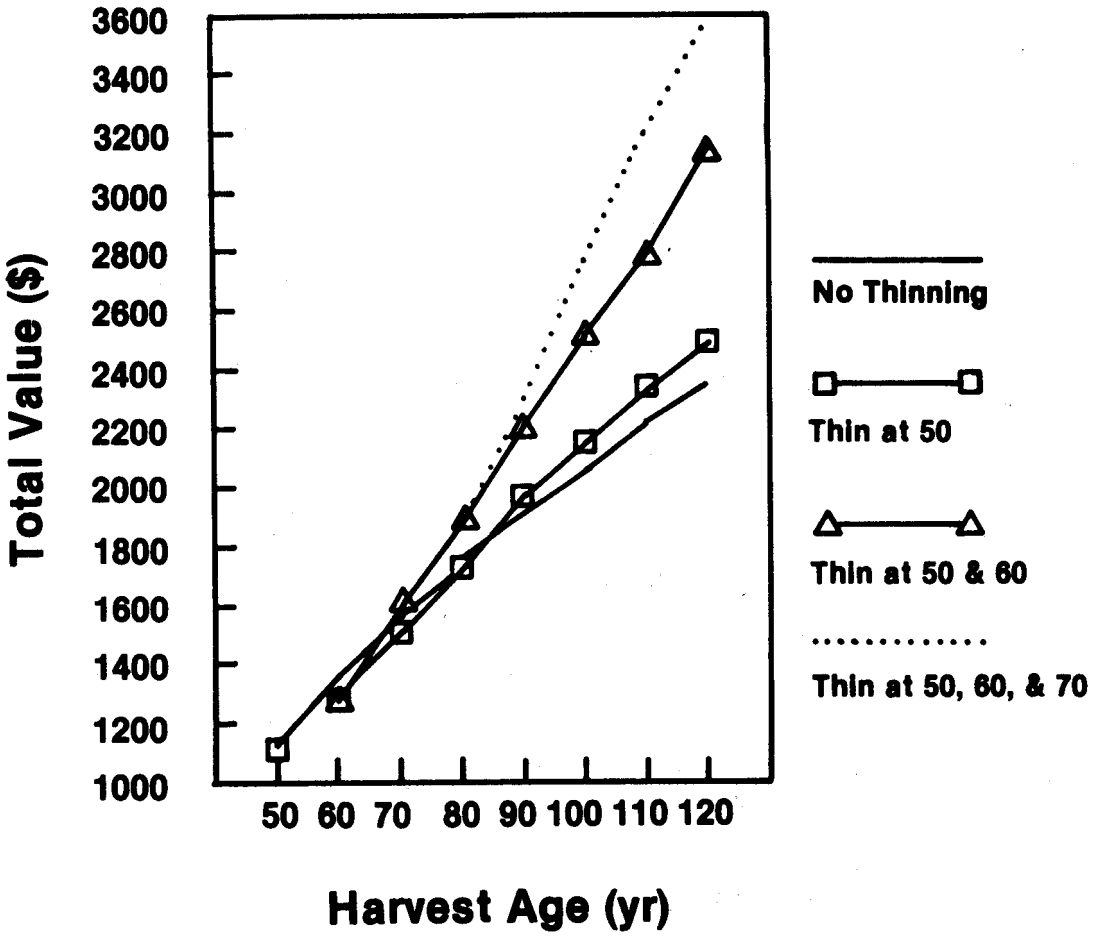

Figure 18. Value of Total Yield Per Acre (Including Thinnings) for Age 50, Site Class 35 by Thinning Regimen and Harvest Age

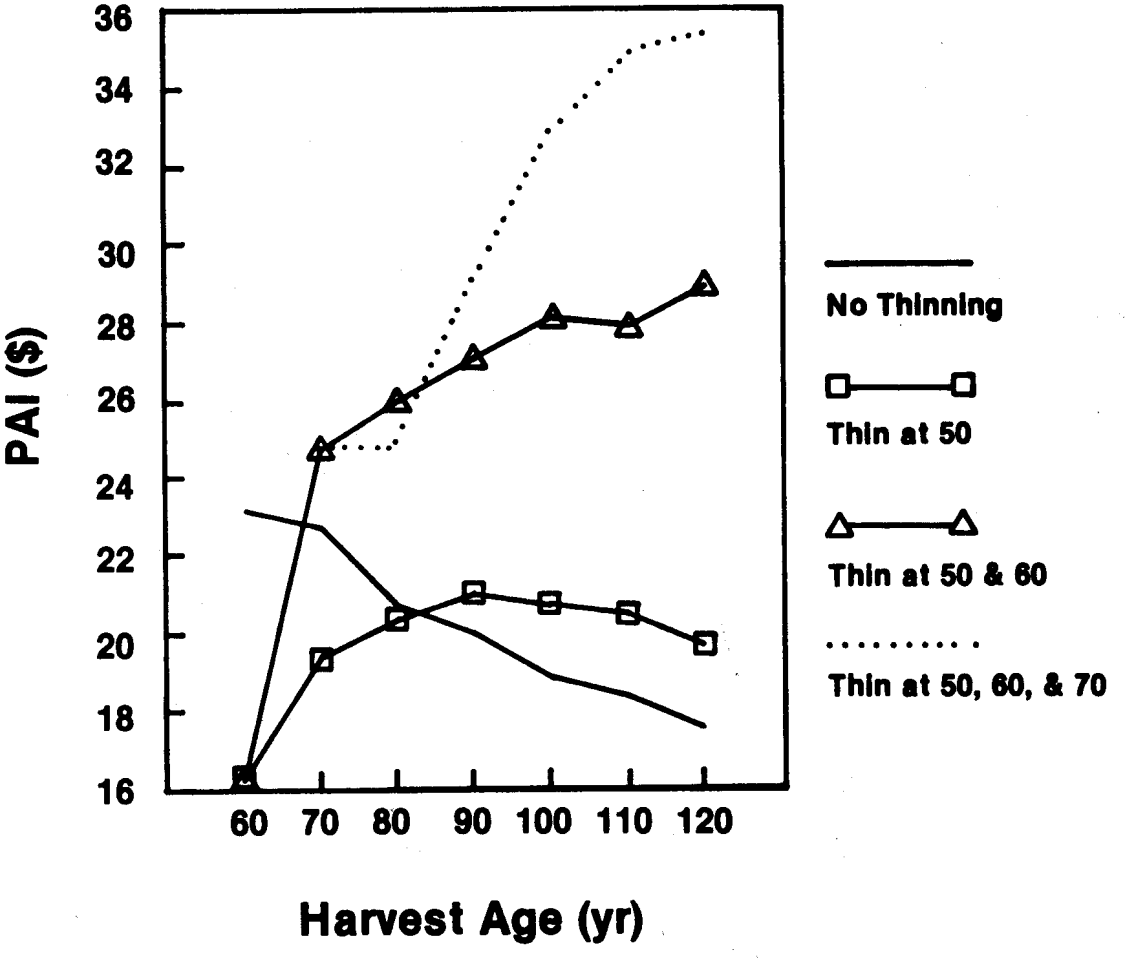

Figure 19. Periodic Annual Increment in Total Value Per Acre for Age 50, Site Class 35 by Thinning Regimen and Harvest Age

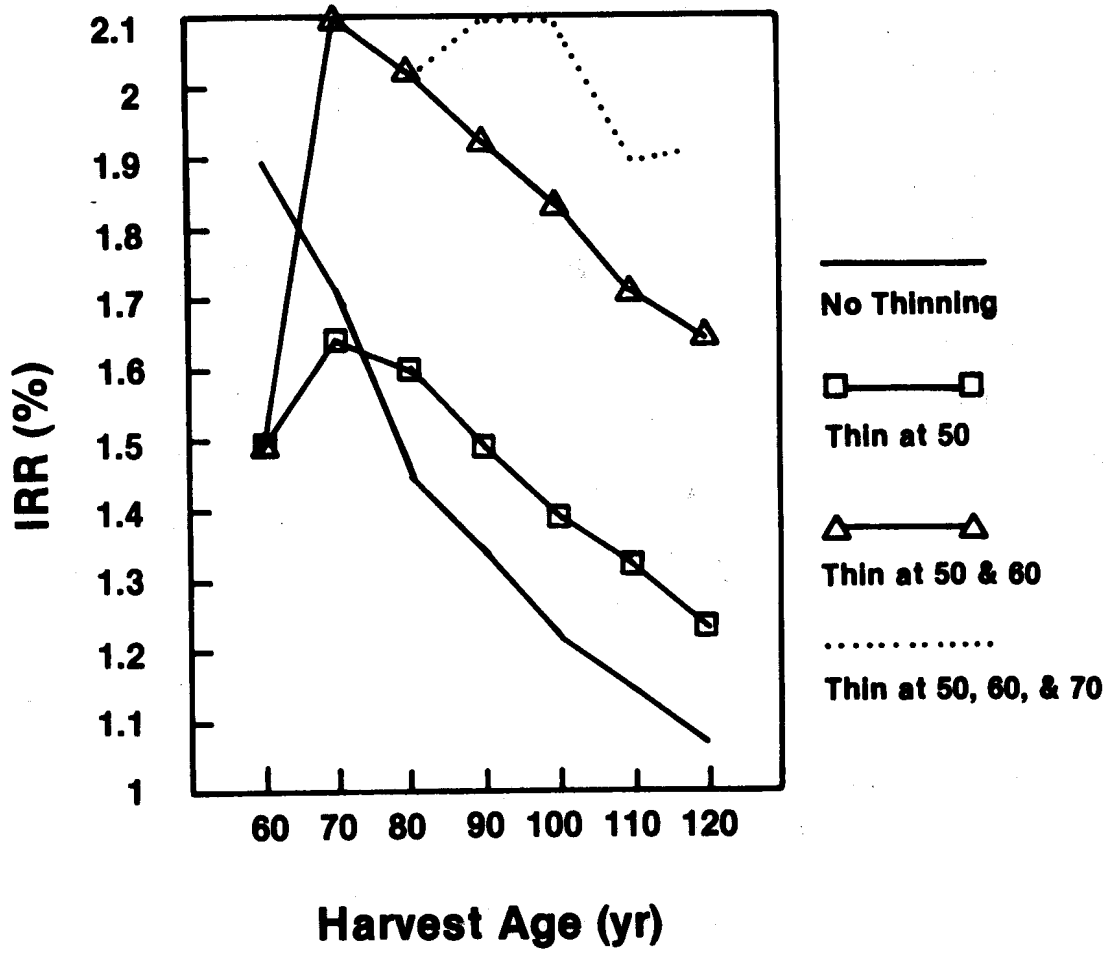

Figure 20. "Internal Rate of Return" for Age 50, Site Class 35 by Harvest Age and Thinning Regimen

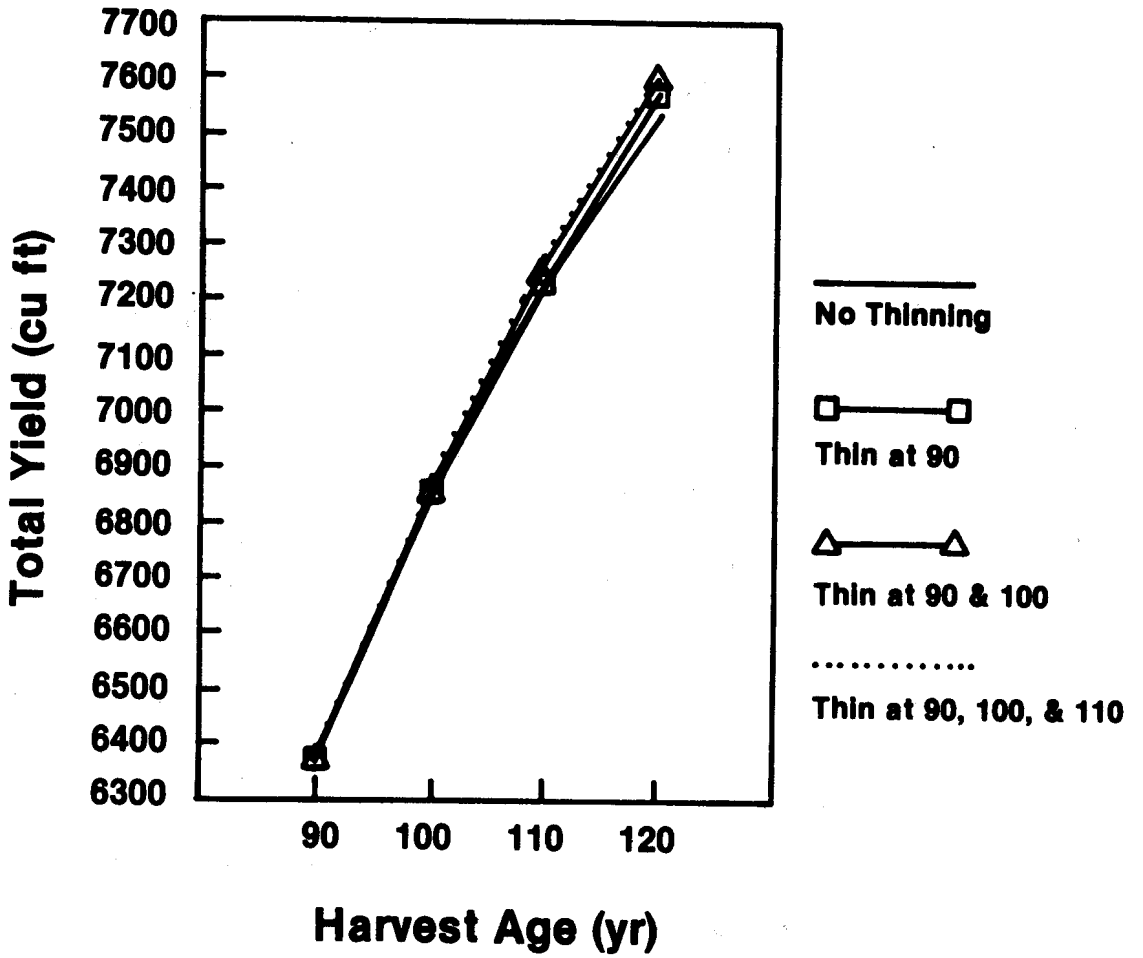

Figure 21. Total Stand Yield Per Acre (Including Thinnings) for Age 90, Site Class 45 by Thinning Regimen and Age at Final Harvest

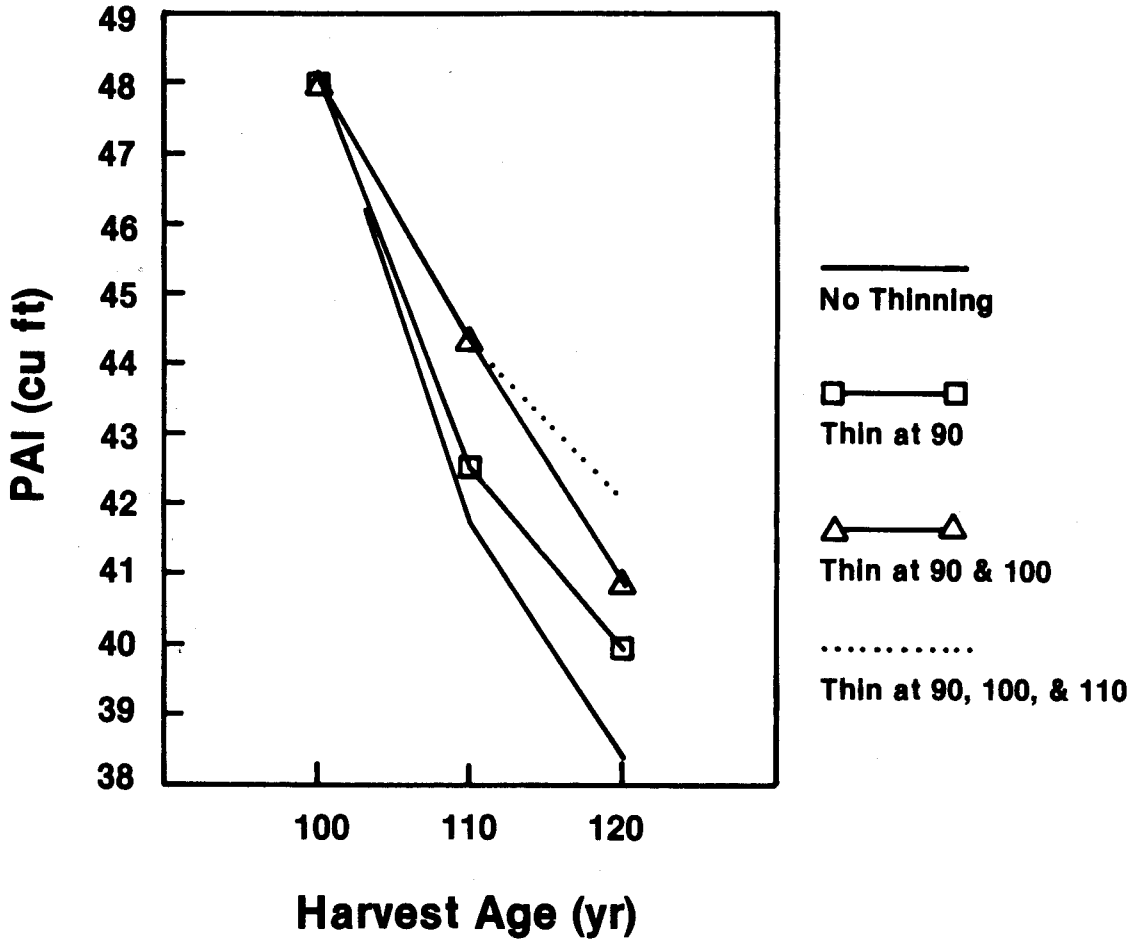

Figure 22. Periodic Annual Increment Per Acre Total Yield (Including Thinnings) for Age 90, Site Class 45 by Harvest Age and Thinning Regimen

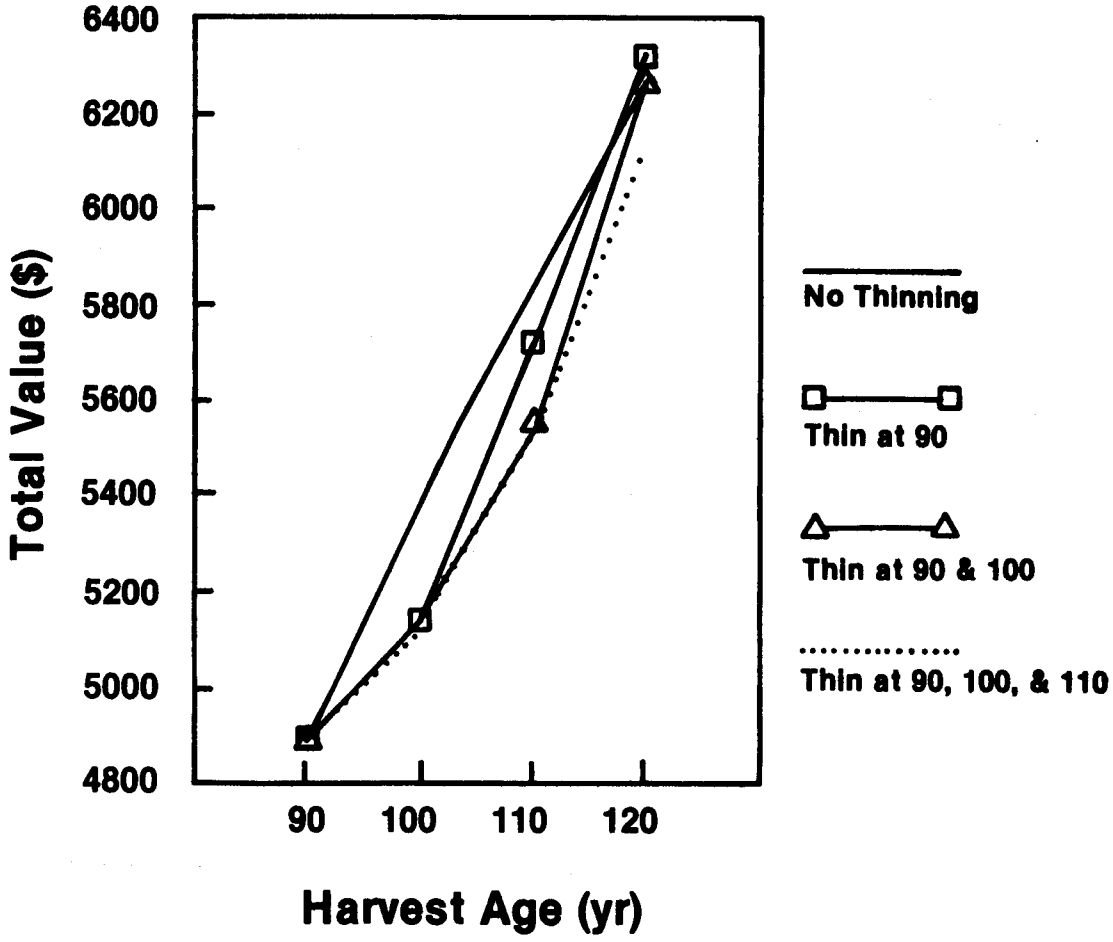

Figure 23. Value of Total Yield Per Acre (Including Thinnings) for Age 90, Site Class 45 by Thinning Regimen and Harvest Age

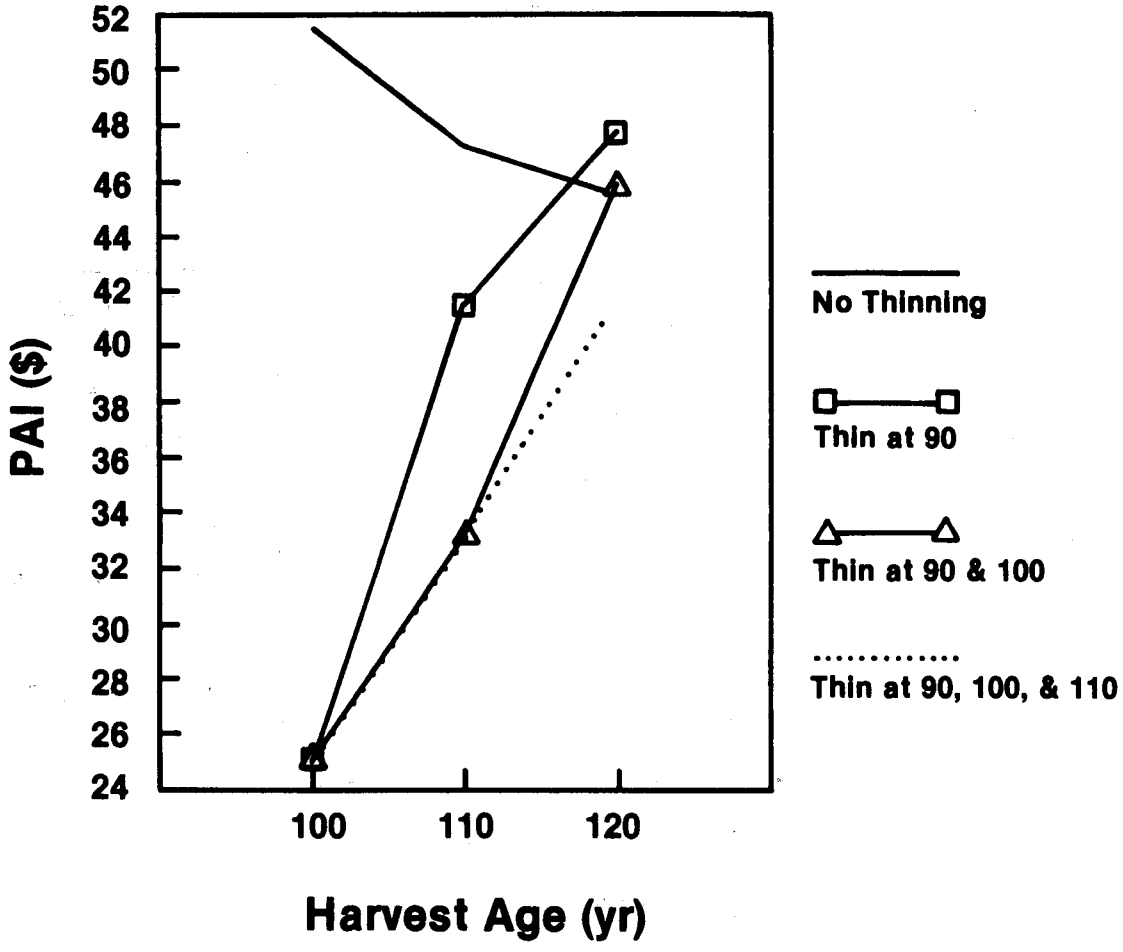

Figure 24. Periodic Annual Increment in Total Value Per Acre for Age 90, Site Class 45 by Thinning Regimen and Harvest Age

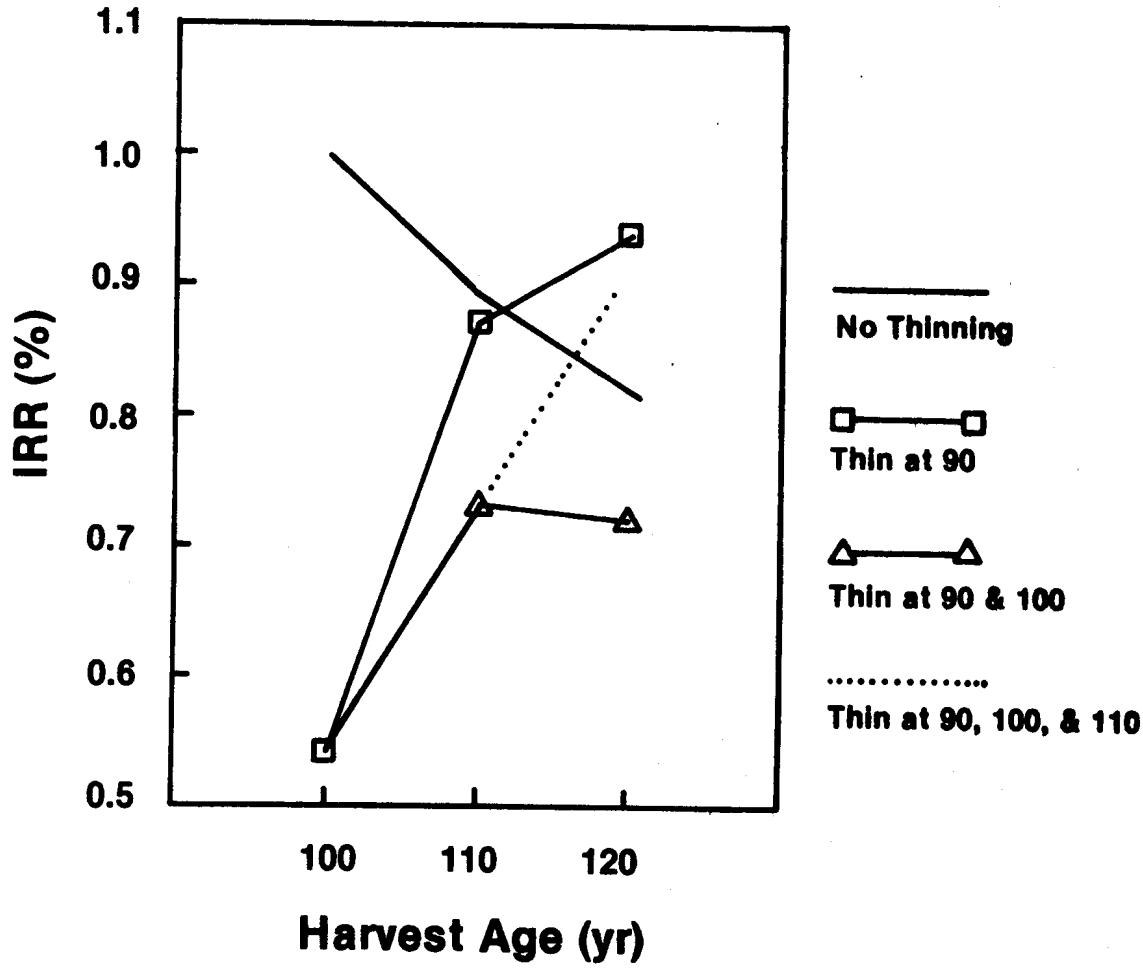

Figure 25. Internal Rate of Return for Age 90, Site Class 45 by Harvest Age and Thinning Regimen

The "Internal Rate of Return" for the 30 year period from age 90 to age 120 appears to be sensitive to the level of residual growing stock and the time since last thinning because the rates of return for the three thinning regimens are 0.9, 0.7, and 0.9 percent (0.9%, 0.7% and 0.9%) respectively This compares to 0.8 percent (0.8%) for the unthinned example.

SUMMARY AND CONCLUSIONS

Summary. Over the range of stand conditions and thinning treatments examined in this paper the thinning treatments reduced total yield (including thinnings) per acre at age 100 from zero to four (0 - 4) cunits. Periodic annual increment in these same examples is also reduced from zero to three (0 - 3) cubic feet per acre per year.

In terms of value, under the conditions of this analysis, the results are quite different. In the stands with initial ages of 30, 40, and 50 years the increases in the value of total yield at age 100 range from one to eight thousand dollars ($1,000 - $8,000) per acre In the case of the 90 year old stand the value of the total yield at age 100 is reduced by three thousand ($3,000) dollars per acre. This is due to the inability of the stand to make up the reductions resulting from the heavy thinning at age 90. Observe the trends in Figure 23. The trends in periodic annual value increment per acre are similar. In the stands with initial ages of 30, 40, and 50 the increases range from two to twenty four dollars ($2 - $24) per acre per year. In the 90 year old stand the periodic annual value increment was reduced by $26 per acre per year for the same reason that the value of the total yield was reduced.

The trends for "Internal Rate of Return", a measure of the efficiency of invested growing stock, are similar to the trends for the value of total yield and value increment. In the stands with initial ages of 30, 40, and 50 the increases in IRR ranged from 0.2 percent to 0.9 percent (0.2% - 0.9%). The IRR in the 90 year old stand was reduced by 0.5 percent (0.5%) following thinning.

Conclusions. The major consideration in the economics of stand management for shortleaf pine is the value of the growing stock required to produce the growth desired. In the examples considered in this analysis that investment ranged from $1,400 to $5,000 per acre. This exceeds by orders of magnitude any other investment in forest management during the life of the stand. Because of the size of this element of the forest management investment it is important to look beyond the cash flows in the economic evaluation of forest management and concentrate on treatments to increase the efficiency of invested growing stock.

One of the most important forest management tools available to increase the efficiency of invested growing stock in forest management are thinnings expressly designed to concentrate the growth on the tallest and best formed individual trees. In the examples, examined, in this paper there were reductions in total yield and periodic annual increment as a result of the thinning regimens simulated. However, there were also increases in the value of total yield and the periodic annual increment in value following thinning if there was sufficient time for the stands to create the more highly valued volume following treatment.

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Edited by

Paul A. Murphy
Southern Forest Experiment Station
U.S. Department of Agriculture, Forest Service
Monticello, Arkansas

Symposium Coordinator

R. Larry Willett
Extension Forester
Arkansas Cooperative Extension Service
Monticello, Arkansas

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