

To the Graduate Council:

I am submitting herewith a thesis written by Dale Vincent Dunlap entitled "Resource Management Guidelines for the Norris Watershed: An Analysis of Harvest Scheduling Alternatives." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

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Thesis

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RESOURCE MANAGEMENT GUIDELINES FOR THE NORRIS WATERSHED:

AN ANALYSIS OF HARVEST SCHEDULING ALTERNATIVES

A Thesis

Presented for the

Master of Science

Degree

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Dale Vincent Dunlap

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ABSTRACT

The objectives of this study were to identify multiple-use management goals through a public participation program and to develop management guideline proposals for the Norris Watershed. The goals and guidelines were applied to an interrelated problem involving the scheduling of the decadal harvest of the area. An opportunity cost approach was used to consider conflicting objectives.

Scheduling alternatives that were developed for harvesting the merchantable stands on the watershed included:

1. Scheduling to maximize present value.
2. Scheduling to provide an annual even flow of sawtimber volume and concomitantly maximize present value.
3. Scheduling to improve forage production capacity.
4. Scheduling to minimize visual impact of timber harvesting.
5. Scheduling to retain the most mast production capability.
6. Scheduling to minimize present value.
7. Price response scheduling.

These alternatives were compared on the basis of present value of future gross receipts generated from timber sales, total gross receipts generated over the harvest period, and

sawtimber volume removals. Analysis showed that in terms of present value the opportunity costs of implementing a particular scheduling option were less than expected.

However, some scheduling options were found to be more desirable in terms of annual budget planning. The price response scheduling alternative was found to have potentially desirable effects by maximizing the present value and the total gross receipts from future sales, and by holding volume removals to a minimum estimated allowable cut.

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CHAPTER I

INTRODUCTION

The objectives of this study were to identify multiple-use management goals through a public participation program and to develop management guideline proposals for the Norris Watershed. Management guidelines are important to any public area where the objective is to integrate timber, wildlife, recreation, and water uses. In 1978, the members of the Norris (Tennessee) Watershed Board proposed the development of a set of guidelines for a 10-year planning period (1979-1989) which would integrate these multiple uses of the watershed to best meet the goals and the interests of the citizens of Norris. The management guidelines presented herein are the result of the Watershed Board members working with representatives of the Tennessee Valley Authority (TVA), Division of Land and Forest Resources, and the Forestry, Wildlife and Fisheries Department of the University of Tennessee.

The Norris Watershed comprises 2,307 acres of forestland located in Anderson County, Tennessee. In 1954, 1,854 acres of this tract were acquired by the city of Norris by transfer and the remaining 453 acres by long-term lease from TVA. Reasons for the transfer and lease were to provide inexpensive public recreation and a sustained clean water supply

for the Norris community. Full recognition was also given to the importance of timber production and wildlife management. The agreement stipulated that 15 percent of the gross receipts from timber sales would go to TVA through 1993 as payment for the property and the remainder would be spent for management of the watershed and to provide other multiple-use benefits desired by the citizens of Norris.

Thus, the Norris Watershed represents a complex forest planning and management situation because the area is characteristic of a public forest in that its available resources must be used to achieve multiple and often noncompatible goals. Operating and maintenance funds must be generated primarily through timber sales because no appropriations are made by the city of Norris for this purpose. The watershed forest must therefore be managed as a sound economic enterprise.

The forest management operations which are undertaken on the watershed probably represent the greatest elements of change and environmental impact confronting future direction of the area. Timber harvesting operations are not only of paramount importance in providing income for over-all watershed management but also affect wildlife habitat, water quality control, and recreational amenities (particularly visual quality). The implementation of a timber harvesting program may determine the extent to which

some multiple benefits can be attained. Therefore, production and marketing of timber is necessary for maintaining the watershed on a sound financial basis while providing other benefits to the Norris community.

Because the timber stands available for harvesting during the 10-year period differ in size, volume available for cutting, growth, wildlife habitat capability, and visual impact, the actual harvesting schedule applied to the stands may have very different benefits and impacts on the watershed. For this reason, the study was divided into two interrelated parts: (1) the establishment and definition of the policy objectives of the Watershed Board through a public participation process and the subsequent development of proposed management guidelines related to these objectives referred to as "The Planning Process," and (2) a problem analysis of one particular pressing problem involving the scheduling of the harvest of the watershed over the next 10 years (decadal harvest). The policy objectives and management guidelines developed within the planning process established criteria by which to judge alternative courses of action for the timing of the harvests. The study identified some conflicting objectives and calculated opportunity costs of giving more or less weight to any one objective to assist final decision-making by the Watershed Board.

CHAPTER II

THE WATERSHED AREA

A. Historical Use and Development

The area that is now encompassed in the Norris Watershed consisted of marginal farmland prior to the 1930's. It was characterized by eroded fields, poor pastures, and over-cut woodlands. Early settlers and farmers relied on Clear Creek spring for drinking water and four water-powered mills have utilized the creek to grind meal.

TVA acquired this property in 1933 in conjunction with the Norris Dam project. Clear Creek spring furnished water for the nearby village which later became the city of Norris. The water supply system which is still used today was constructed by TVA and utilizes a pumping station that raises water almost 500 feet into an underground reservoir atop of what is now known as Reservoir Hill, allowing gravity flow to serve the community.

While under TVA ownership from 1935 to 1954, the area was protected from fire and grazing and timber harvests were limited to light selection cuts. Additionally, recreational improvements such as trails and picnic facilities were made.

In 1954 when the watershed was acquired by the city of Norris, a memorandum of understanding with TVA was

developed by the city council which stipulated that TVA's Division of Forestry Development would provide the city with technical advice on management of the watershed. In turn, TVA was permitted use of the area for research, education, and demonstration purposes.

In 1959 a city ordinance was adopted that transferred management and administration of the area from the city council to a Watershed Board. While this is the decision-making body responsible for operating and managing the area, work plans and budgets must be approved by the city council. This keeps control in the council but gives the Watershed Board the authority and flexibility to manage the area.

B. The Watershed Today

Under city ownership and board management recreational facilities have been added and maintained. There are over 22 miles of roads and trails throughout the watershed area and a nature trail is under development. Both an archery range and a rifle range are available to those who enjoy the shooting sports. Over 120 birds and mammal species are represented on the area including deer, squirrel, and grouse as well as song and predatory birds. Small game hunting is permitted under state regulations except on the area south of Clear Creek which has been designated a wildlife sanctuary. Additionally, historic sites have been identified and marked for public information.

Since maintaining a clean water supply is an imperative aspect of management, no practices are undertaken that would harm water quality.

Forest cover on the watershed consists primarily of upland hardwood and mixed pine-hardwood stands. Approximately 130 acres along Clear Creek have been reserved from cutting. The Continuous Forest Inventory (CFI) employed on the remainder of the watershed forest showed the composition of sawtimber-size trees to be predominantly white oak and yellow poplar.

The present sawtimber volume is 10.1 million board feet (Log Rule—International 1/4") and the projected growth for the next 10 years is 2,269 board feet per acre for hardwoods and 596 board feet per acre for softwoods. The total projected decadal increase in volume is approximately 6 million board feet.

In addition to the marketing of sawtimber products, the forest is a highly utilized source of firewood for Norris residents. Permits are issued by authorization of the Watershed Board for firewood cutting on designated areas of the watershed.

CHAPTER III

THE PLANNING PROCESS

A. Participants and Their Roles in Planning

The Watershed Board members were invaluable contributors to the process of developing management guidelines through their monthly board meetings held between January 1978 and April 1979. Initially, the meetings concerned developing a public participation procedure for determining watershed management goals and their relative priorities. Subsequent meetings were concerned with making tentative decisions regarding the management direction for timber, wildlife, and recreation.

TVA staff members provided input to the planning process by supplying background information on the watershed area and also by aiding in the public participation program. Responsibilities of the writer toward developing management guidelines included:

1. Aiding in the establishment of goals, and in the development of a public participation program.
2. Aiding in the establishment of criteria in order to evaluate the type and form of data needed for developing management guidelines.
3. Assimilating and analyzing data.

4. Coordinating the needed input from various disciplines, i.e., wildlife, forestry, and recreation.
5. Aiding in the development of alternative management strategies.
6. Writing management guideline proposals for the Norris Watershed.

B. Goal Development

Although past policies and institutional guidelines provided a framework for future watershed management, the importance of involving the residents of Norris in developing more contemporary management goals was recognized by the Watershed Board members. Therefore, a public participation program was used to obtain information from the residents to aid in the development of goals. The following procedure was used: a fact sheet describing uses and characteristics of the watershed and an announcement of a public meeting was distributed via the "Norris Bulletin" (a local news sheet) to Norris residents. The meeting was held on March 30, 1978.

The information gathered at the meeting was listed in written form and given to each Watershed Board member for reference. Later, this information was reorganized into an evaluation form and each member evaluated and assigned priorities to the issues expressed at the meeting by ranking

their importance on a scale of one to five with five indicating the highest priority rating and one the lowest rating (Appendix A). Finally, the individual evaluations and open discussions among the board members resulted in a set of broadly defined management goals.

C. Sources of Natural Resource Information

The goal development process provided a framework for determining the types and scope of natural resource information that was necessary to develop management guidelines. The information that was needed included various maps showing road and trail locations as well as maps illustrating the location and boundaries of the timber types on the watershed area. Other sources of information included data from the CFI system employed on the area as well as additional information gathered in the field specifically for the project. The CFI data that were used included the total volume of sawtimber present on the watershed in 1978 and the projected decadal increase in volume for the entire area. This information was used to determine the allowable cut for the 10-year planning period.

For previous management purposes a TVA forester had mapped stand types on the watershed. Stand classes mapped were: large sawtimber, small sawtimber, pole timber, regeneration areas, and miscellaneous. Eleven large sawtimber

stands were selected as candidates for future timber harvests. Each tract was inventoried by the writer and a TVA forester to determine the total sawtimber volume, partial cut volume, and preliminary silvicultural prescriptions (Figure I). Cruise lines and sample points were established on each tract and total volumes were determined by tallying all trees greater than 10 inches diameter breast height (DBH) as indicated by a basal area factor 10 prism wedge. Partial cut volumes were determined by tallying only those trees that would be harvested on the basis of maturity, poor form or quality, and evidence of expected mortality.

The development of preliminary silvicultural prescriptions was based on procedures outlined by Roach and Gingrich (1). These procedures were used primarily to determine whether the large sawtimber stands should be harvested by employing either regeneration cuttings or intermediate cuttings.

Wildlife habitat information collected for each tract in conjunction with the forest inventory field work included the basal area of mast producing species and the forage production capacity. The forage production capacity of each tract was estimated by using procedures and a graph illustrated in the U.S. Forest Service Handbook—2609.23R (2).

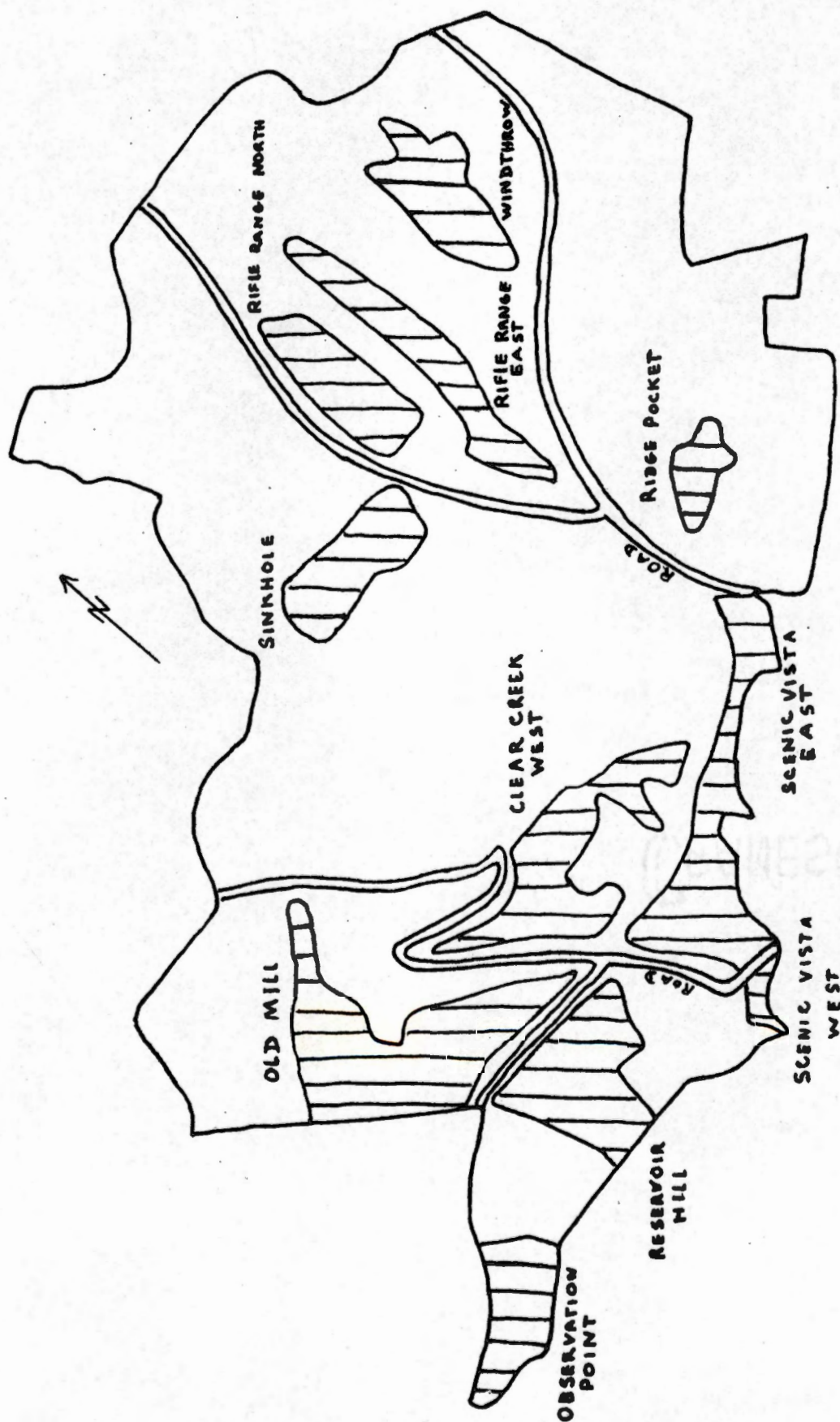


Figure I. Location of the large sawtimber stands on the Norris Watershed.

D. Management Goals and Guidelines

The final phase of the planning process was to develop management guidelines by considering the broadly defined management goals that had been established, analyzing and utilizing necessary natural resource information and by drawing upon suggestions and recommendations provided to the writer by representatives of TVA and the U.T. Department of Forestry, Wildlife, and Fisheries. The following management goals and guidelines evolved from this planning process.

1. General use guidelines

Norris Watershed use will be primarily for Norris area residents, and nonresident use will be restricted to non-consumptive uses such as education, demonstration, and in some cases group camping. Multiple-use management will be practiced and no management practices will be undertaken that would adversely affect water quality.

When it is financially possible, employment opportunities for Norris youths will be provided in conjunction with work projects on the area. Additionally, public labor forces such as the Youth of America Conservation Corps will be utilized as needed.

Future increase in police patrol will be dependent upon its need and effectiveness in protecting the resources of the area.

2. Forest management goals and guidelines

- Harvest and market only the timber that is necessary to meet the financial requirements of the watershed.
- Minimize logging damage during harvesting operations.
- Practice sustained-yield forestry (maintain a sustained supply of merchantable sawtimber).
- Outline a harvest schedule for the period 1979-1989.
- Harvest timber in an ecologically acceptable manner with due consideration to stand condition and harvest impact. This can include utilizing buffer strips when clearcutting, avoiding logging operations during poor weather conditions, minimizing the time to complete a harvest, and seeding road beds.
- Identify and reserve from cutting more unique natural areas if the utilization of these area would destroy their desired qualities.

Forest inventory results and preliminary silvicultural prescriptions for each of the 11 large sawtimber tracts are shown in Table 1. The prescriptions are only tentative and the areas will require a more detailed analysis at the time of harvest. The preliminary recommendations were made by a

TABLE 1. Inventory Summary of 1978 and Tentative Harvest Recommendations for Potential Sale Areas

Tract	Acres	Volume/Acre MBF		Volume/Tract MBF		Type Cut Recommended	
		Clear cut	Partial cut	Clear cut	Partial cut	Regeneration	Intermediate
Old Mill	78	8.2	5.1	642	399	Clearcut or Shelter- wood cut, lower slope	Improvement Upper slopes
Sink Hole	30	10.3	5.0	308	150	Clearcut West section	Improvement East section
Ridge Pocket	10	11.0	4.9	119	48		Thinning/Improvement
Rifle Range North	34	7.2	4.7	246	161	Clearcut lower slopes	Thinning, Upper slopes
Rifle Range East	36	9.8	5.7	352	204	Clearcut lower slopes	Thinning, Upper slopes
Windthrow	39	6.3	3.4	246	133	Clearcut	
Clear Creek West	52	11.4	7.0	592	364	Small clearcuts	Thinning/Improvement
Reservoir Hill	60	6.2	2.5	371	150		Thinning/Improvement
Scenic Vista	30	11.8	5.5	354	165	Possible Clearcut Mid and lower slopes	Thinning/Improvement
Scenic Vista East	30	8.7	4.8	261	142	" " " "	" "
Observation Point	30	7.5	2.4	225	72	Cut not recommended	

TVA forester. Continuing consultation with TVA foresters concerning the implementation of silvicultural prescriptions will be of great value to the Watershed Board.

The determination of future volume removals (allowable cut) should be dependent upon the capability of the forest to produce merchantable sawtimber. The following procedures were used to estimate future harvest volumes:

Allowable cut:

Two estimation procedures are illustrated below to determine harvest levels:

- a. allowable cut may be equivalent to one-third of the projected growth for the planning period.

Projected growth on the watershed is 6 million board feet. Thus one-third of 6 million shows the allowable cut as 2 million board feet over the next 10 years (200,000 board feet annually).

- b. The allowable cut may be expressed as a function of total growing stock in the forest using the following formula by von Mantel as described by Matthews (3):

$$\text{Cut} = \frac{2(\text{Growing Stock})}{\text{Rotation Age}}$$

The present growing stock on the watershed is approximately 10 million board feet. A rotation age of 100 is assumed. Thus,

$$\text{Cut} = \frac{2(10,000,000)}{100} = 200,000 \text{ board feet annually.}$$

A harvest of 200,000 board feet annually for 10 years is equivalent to 2 million board feet.

Both of these procedures show that the watershed can supply at least 2 million board feet for the 10-year planning period. Harvests based on these allowable-cut guidelines would result in a net increase of about 4 million board feet in sawtimber during the next decade.

Economic considerations:

The present monetary requirements for watershed management are approximately \$10,000 annually. Present hardwoods stumpage prices are in the range of \$50 per thousand board feet.

Therefore, if a budget requirement of \$10,000 annually is to be maintained, it would be necessary to harvest 200,000 board feet annually.

Changes in budget requirements and stumpage prices may also be a consideration in planning timber sales. Marketing timber and planning harvests on a periodic basis rather than on a strictly annual basis would provide the flexibility needed to obtain higher stumpage prices.

3. Wildlife management goals and guidelines

- Recognize the importance of wildlife resources to the area and coordinate wildlife management with other uses.
- Emphasize nonconsumptive (nonhunting) use of wildlife (wildlife observation).

- Ban the use of high-powered rifles for any type of hunting.
- Permit small game hunting.
- Allow bow and arrow hunting for deer.
- Minimize deer poaching.

Two wildlife management options were considered. These were featured species management and management for habitat diversity. Featured species management is the selection of one or two species and management to fulfill the habitat needs of those species. This system is usually implemented where recreational hunting is important and where the population maximization of a particular game species is desired. This type of wildlife management program is not considered appropriate for the watershed since hunting is of minimal importance. The more flexible wildlife habitat diversity approach which attempts to achieve a range of ecological conditions that favor a large variety of wildlife species is considered more compatible with other watershed uses. Proponents of this system recognize that the habitat manipulation resulting from timber harvesting operations is an effective means for maintaining wildlife habitat diversity.

The following guidelines were designed to show how wildlife and timber management can be coordinated. These proposed guidelines were based on a management guide that was developed in 1973 by the U.S. Forest Service for

coordinating wildlife and timber resources on the national forests in Missouri (4).

Old Growth—Ten percent of the management area may be retained in old growth by extending the rotation period or by reserving the area from timber harvest. On the watershed approximately 200 acres would be retained in this condition. Tree species, stand condition, and risk should be considered in working toward this objective. Economic maturation and rotation age should be given less consideration.

Mast—Forty percent, or 800 acres, of the watershed may be maintained in mast producing species. This acreage would represent about one-half of the pole and all the small sawtimber stands on the area.

Forage—Twenty percent of the watershed, or approximately 400 acres, may be maintained in the forage condition. Forage is all of the herbaceous and woody material utilized by wildlife for food. The forage objective may be worked toward and maintained by the following procedures:

- Timber harvesting operations utilizing clearcuts, shelterwood cuts, thinnings, and improvement cuts. The quality and amount of forage production will vary according to the type of harvest and the amount of overstory removed. Clearcuts have

the potential of producing the best forage conditions even though partial cutting methods will contribute also to forage production.

- Direct habitat improvements such as food plots and small clearings.

These guidelines represent management targets and do not necessarily have to be achieved to their fullest extent in order to have a successful wildlife management program. However, they do represent a way in which a wildlife management program may be integrated with forestry operations on the watershed.

4. Recreation management goals and guidelines

- Watershed will be used primarily for passive nature-oriented recreation.
- Emphasize trail use and dispersed recreation.
- Short connecting trails and trail spurs only will be added to the existing trail system.
- Only minimal facilities will be provided for nondispersed recreation, such as picnicking.
- Establish watershed as plant sanctuary.

In order to maintain a quality area for passive and nature-oriented recreation, timber harvests should be planned in order to preserve the aesthetic qualities of the watershed. This can be accomplished by considering both the location of future timber harvests as well as the type of silvicultural system prescribed for the stands.

The present trail system can be used with only short connecting trails or trail spurs being considered for future construction. Roads that are constructed in connection with timber harvests may be seeded and closed to motorized vehicles to serve as foot and horse trails.

Establishment of the watershed as a plant sanctuary could help to insure that unique or endangered species are not destroyed. Additionally, future identification and location of unique forest stands and wildflower habitats may help to determine impacts from harvesting operations.

CHAPTER IV

TIMBER HARVEST SCHEDULING ALTERNATIVES

A. Importance of Scheduling Timber Harvests to the Watershed Management Goals

Planning timber harvests is not, of course, the only problem that will be encountered in the future management of the watershed. However, since timber sales represent the primary source of income for the watershed management and maintenance and because harvests may affect the attainment of multiple uses, the timing and management of the harvests do represent major problems that will be encountered in the future and the harvests should be planned in a way that will meet management goals of the watershed.

Examination of the priorities given the various management goals (Appendix A) showed that most board members agreed that timber harvesting should be limited to only that which is necessary to produce income for management and maintenance. Additionally, high priority was given to maintaining the area with a minimum amount of visual impact from harvests for passive nature-oriented recreation. Most board members agreed that nonconsumptive wildlife uses should be emphasized and habitat diversity should be considered for all wildlife species. Therefore, various timber harvest scheduling alternatives were developed for these goals

and the opportunity costs of giving either more or less emphasis to each of these goals was measured in monetary terms.

The scheduling alternatives that were developed include:

- Scheduling to maximize present value.
- Scheduling to provide an annual even flow of sawtimber volume and concomitantly maximize present value.
- Scheduling to improve forage production capacity.
- Scheduling to minimize visual impact of timber harvesting.
- Scheduling to retain the most mast production capability.
- Scheduling to minimize present value.
- Price response scheduling.

B. Development of Growth Model

The assessment of the environmental and economic impacts of harvesting the 11 large sawtimber stands over the planning period required the evaluation of the relative differences in sawtimber growth and the value of that increase in volume for each tract and for each year of the planning interval. Of the factors necessary to evaluate the stands for scheduling (size, volume available for cutting, growth, wildlife habitat capability, and visual impact) growth for each stand was the only factor not readily available. In order to make

the necessary growth predictions for the stands, procedures outlined by Meyer, Recknagel, Stevenson and Bartoo (5) were used.

An uneven-aged stand structure has tree frequency and diameter distribution that yields an "inverted" J curve similar to the one illustrated in Figure II. An analysis of the entire watershed forest diameter distribution obtained from the CFI information and the analysis of diameter distributions for the 11 large sawtimber tracts based on stand tables developed from the field inventory showed curves similar to the inverted J type. Thus, the watershed forest and the 11 stands were considered to be of uneven-aged stand structure. Further, Meyer, et al. (5) showed that for an uneven-aged stand the gross volume increase in percent (compound growth rate) can be determined by using the formula:

$$\text{Gross volume increase (\%)} = (Q^{I/A} - 1) \cdot 100$$

The variable "Q", which represents stand structures, is a quotient calculated from any stand table by dividing the number of trees in a diameter class by the number of trees in the next higher diameter class. The variable "A" represents the width of the diameter class and the variable "I" is the average annual diameter growth (increment). In application, lower Q values yield a lower compound growth rate where increment is constant.

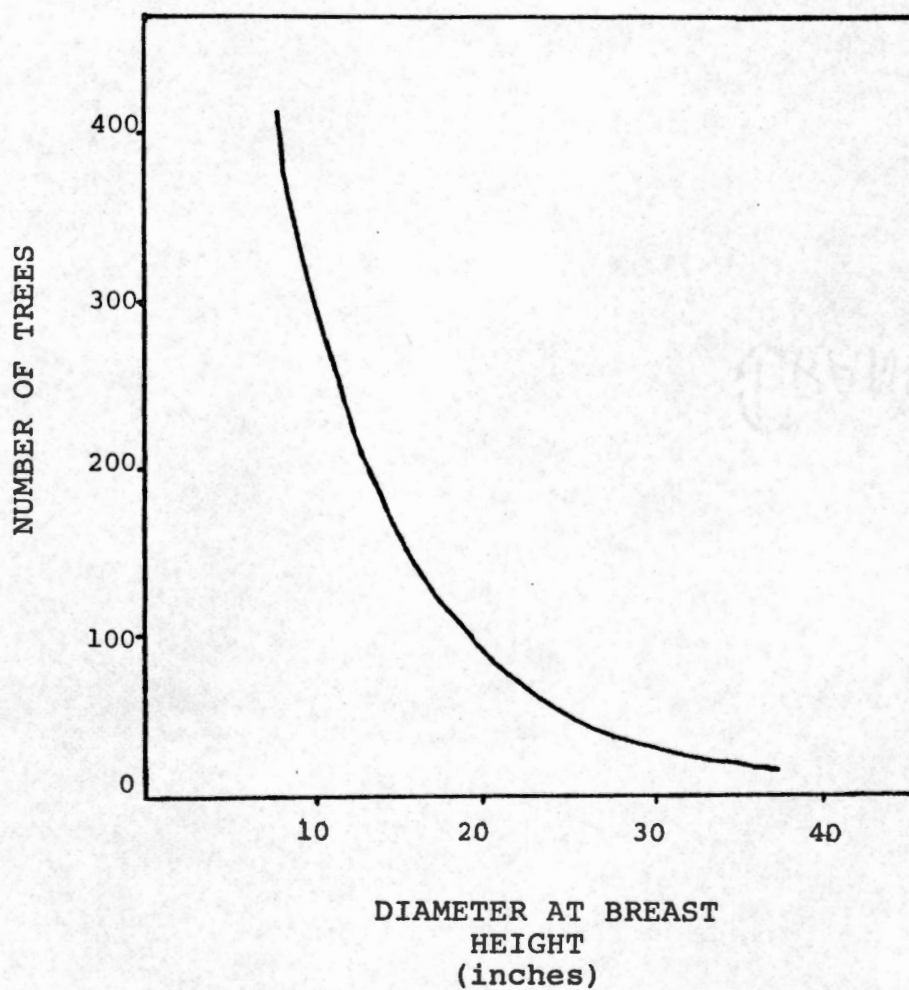


Figure II. Theoretical diameter distribution of uneven-aged stands.

Source: Meyer, H. A., A. B. Recknagel, D. D. Stevenson, and R. A. Bartoo, 1961. Forest Management. Ronald Press, New York, p. 97.

The formula was applied to the hardwood component of the watershed by determining the average watershed Q variable and the average increment for all diameter classes; the resulting compound growth rate was approximately 5 percent. This growth rate was essentially the same as that determined by TVA foresters using another procedure (stand projection table). Hence, the same method prescribed by Meyer, et al. (5) was applied to each of the 11 sawtimber stands to determine estimates of their individual growth rates.

No increment information was taken during the field inventory for the 11 large sawtimber stands scheduled for harvest. These stands comprised the areas of the watershed having the greatest frequency and volume in the large diameter classes. Therefore, an assumption was made that the stands should increase in volume at a rate slower than the "average" acre (5 percent) of the watershed forest. By using this assumption and by calculating the average Q variable for each of the large sawtimber tracts a compound growth rate was determined for the stands based on their stand structures using the following procedures:

The average Q-factor was calculated for each stand.

The mean for all stands was determined, and 95 percent confidence limits were established. The Sinkhole tract stand structure was significantly different from the other stands and the difference indicated a slower

growth rate. The compound growth rate was 3.1 percent. The Reservoir Hill tract had a Q value significantly greater than the average; its compound growth rate was determined to be 6.3 percent. Stand structures in the remaining stands were not significantly different; their growth rate was 3.9 percent.¹

The merchantable sawtimber volume (available from thinnings and improvement cuttings) and the total sawtimber volume for each stand was projected. The yearly monetary value of each stand was determined using the increase in volume and a constant stumpage price of \$50 per thousand board feet (Tables 1-11, Appendix B).

C. Description of Scheduling Alternatives

Scheduling to Maximize Present Value

Present value as used in this scheduling analysis was the estimated income (gross receipts) to be derived from future timber sales discounted to 1979. A conservative discount rate of 5 percent was selected. It was equivalent to the compound growth rate of the "average" acre for the hardwood stands on the watershed. The conservative rate was selected because the management goals emphasized that no

¹The 3.9 percent was derived by considering the formula, the slow growth assumption, and setting the Q factors of the stands not significantly different from each other equal to the lower confidence limit value of the population mean.

more volume should be harvested than necessary to generate annual operating expenditures. This limits alternative investment opportunities.

It is obvious that harvesting the entire decadal allowable cut during the first year of the planning interval would be the best financial alternative assuming the watershed board has an investment option greater than 5 percent. However, this alternative was not considered because it would greatly conflict with the multiple-use goals identified due to the massive harvesting impact on the watershed.

The tracts were scheduled to maximize present value by comparing the compound growth rate of the monetary value of the stands at the end of a 10-year period with the alternative growth rate of 5 percent. Since all of the tracts except Reservoir Hill had a growth rate less than 5 percent, the analysis showed the other tracts would represent a financial loss compared to the return of the "average" watershed acre if allowed to remain for 10 years. Therefore, the tracts were scheduled so that the stands representing the greatest financial losses would be harvested and sold first (Table 1, Appendix C).

Scheduling to Provide an Annual Even Flow
of Sawtimber Volume and Concomitantly
Maximize Present Value

The even-flow schedule was developed to illustrate a method by which, as nearly as possible, an annual cut of

200,000 board feet could be sold by harvesting preferably one and a maximum of three stands in any year with stands representing the greatest financial losses harvested first. Thus, stands having available 200,000 board feet were scheduled early in the planning period and the other stands were allowed to remain until their increase in volume available from thinnings and improvement cuttings approached the annual allowable cut (Table 2, Appendix C).

Scheduling to Improve Forage Production Capacity

Forage production (measured as thousands of twigs per acre) was based on a stand's basal area. A graph illustrated in Forest Service Handbook—2609.23R (2) was used to determine estimates of forage production following harvest for each stand.

The per acre estimates were converted to total estimates for each tract and the areas were scheduled so that the tracts having the greatest capacity following a harvest would be harvested first (Table 3, Appendix C).

Scheduling to Minimize Visual Impact of Timber Harvesting

In order to minimize visual impact, the tracts were scheduled so that the ones with the most trail and road frontage would be harvested later in the planning period.

Using road and trail maps of the watershed area, the promixity and distance in thousands of feet of these travel

routes were determined for each tract. The tracts were then scheduled so that the areas with the least frontage would be harvested before areas with greater frontage (Table 4, Appendix C).

Scheduling to Retain the Most Mast Production Capability

This option was based on the concept of harvesting the stands so that the total present basal area of mast producing species (measured as basal area) would be reduced by the least amount. This was done by scheduling first for harvesting those stands where the fewest mast producing species would be removed. It was a schedule of harvesting based on the inverse of basal area of mast producing species to be cut by tract (Table 5, Appendix C).

Scheduling to Minimize Present Value

This scheduling option is exactly the opposite of the schedule to maximize present value. It was included to show the maximum opportunity cost of implementing the least desirable economic alternative.

Price Response Scheduling

Price fluctuations in the market may be a consideration in scheduling. The concept of price response scheduling is to sell more volume during periods of high stumpage prices and to sell little or no volume in periods when prices are low.

While it is impossible to predict with certainty the future timing and magnitude of stumpage price fluctuations, it is reasonable to assume that the cyclical nature of stumpage prices exhibited in the past will likely continue in the future. Therefore, the previous 10-year price fluctuations were used to illustrate the price response cutting alternative. The results are not intended to propose the exact timing of the future timber harvests, but rather to show the possible ramifications of making price fluctuations a consideration in planning the harvests.

The stumpage price trends that were used in the analysis are based on hardwood lumber price data obtained from the Fingertips Facts and Figures publication (6). Stumpage price fluctuations should be reflected in hardwood lumber price trends in competitive markets. Therefore, the hardwood lumber price trend curve was used to develop stumpage price trends by indexing the curve on the basis of the present stumpage prices of \$50 MBF (Figure III).

The schedule was developed by harvesting the accumulated allowable cut from any of the large sawtimber tracts at the high price years.

D. Methods of Comparison for the Scheduling Alternatives

Each of the eleven large sawtimber tracts were considered as candidates for future timber harvests and sales. They were

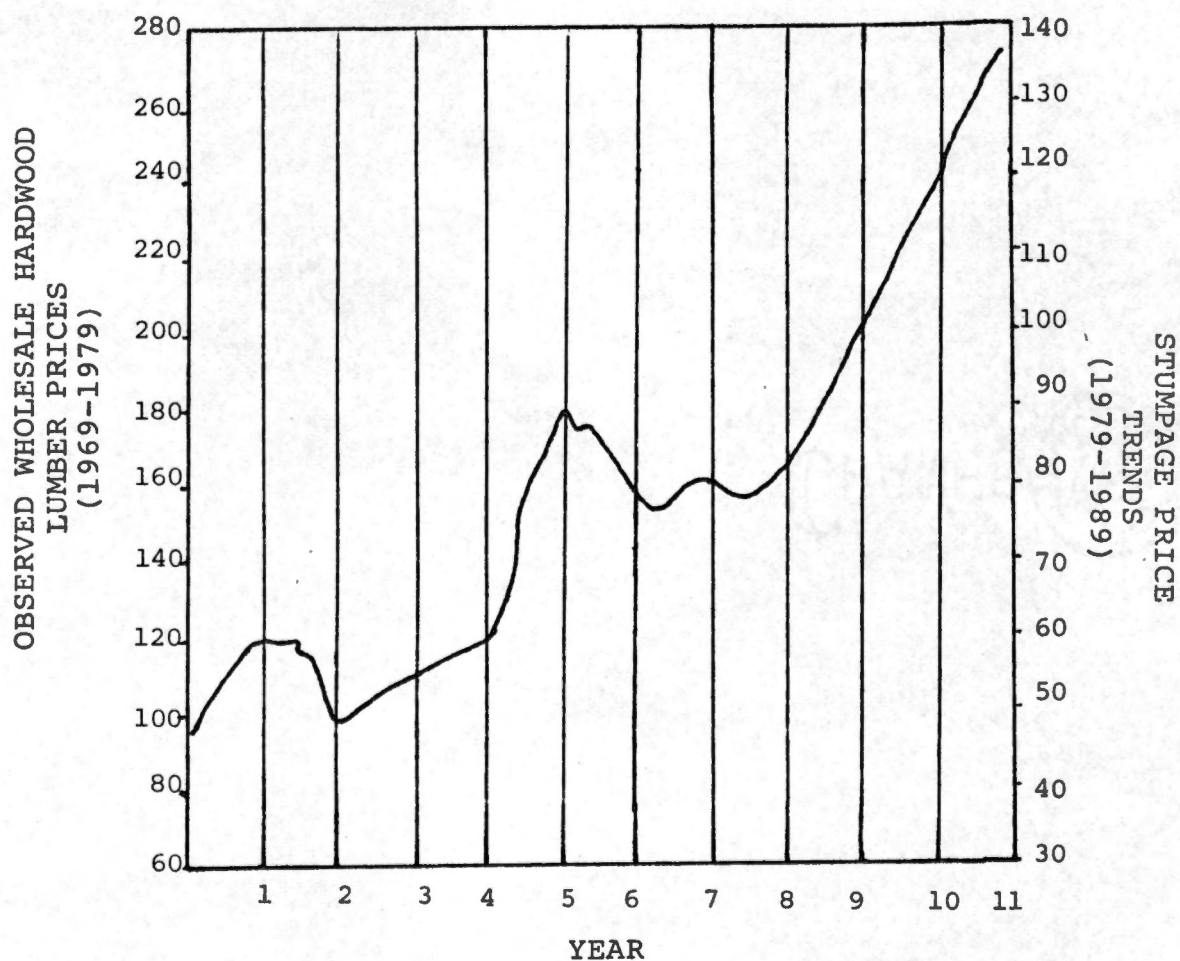


Figure III. Observed wholesale hardwood lumber prices 1969-1979 and calculated stumpage price trends 1979-1989.

Source: National Forest Products Association. March 1979. Fingertips facts and figures. Washington, D.C., p. 3.

scheduled on the basis that each tract would be operated individually and that only one tract would be harvested in any single year, except in the even-flow and price response schedules which allowed more than one tract to be harvested in some years. Because the eleven tracts were treated as individual units for harvest operations, the seven scheduling alternatives provide an analysis for eleven timber sales for the period 1979 through 1989.

The factors that were used to compare the scheduling alternatives included a measure of opportunity cost in terms of the total present value of gross receipts from future timber sales, the total gross receipts generated from the decadal sales, and the total decadal volume harvested.

The total present value of the gross receipts generated through the implementation of each scheduling alternative was calculated by first discounting the gross receipts received from the sale of each individual tract at its scheduled year and then summing the discounted values. A 5 percent discount rate was used.

The total gross receipts generated from the implementation of each scheduling alternative was calculated by summing the gross receipts from the sales of each individual tract. This was not the same as discounted value because of the differential in growth rates of the stands and the timing of the income to be received.

Total harvest volumes were calculated by summing the merchantable sawtimber volumes that would be sold from each tract by implementing the schedule.

CHAPTER V

RESULTS

A. Present Value

The appraisal of present value for the scheduling alternatives, based on holding future stumpage prices constant at \$50 per thousand board feet, showed that the greatest value obtainable by implementing the schedule to maximize present value to be \$101,358. Appraisal of the other scheduling alternatives based on holding stumpage prices constant (even-flow, forage improvement, minimized visual impact, mast production and minimized present value), showed the present values to be \$101,138, \$99,152, \$97,817, \$96,828 and \$96,267, respectively (Figure IV, Tables 2-7).

Thus, the results indicated that the opportunity costs among the scheduling alternatives are almost negligible (\$5,086 between the maximum and minimum) when considered over the entire scheduling period. Therefore, the watershed management goals may be more important factors in scheduling future timber harvests and sales than economic consideration based on the appraisal of present value.

Analysis of the price response scheduling alternative, which assumed variable stumpage prices in the future based on past trends, showed the appraised present value to be

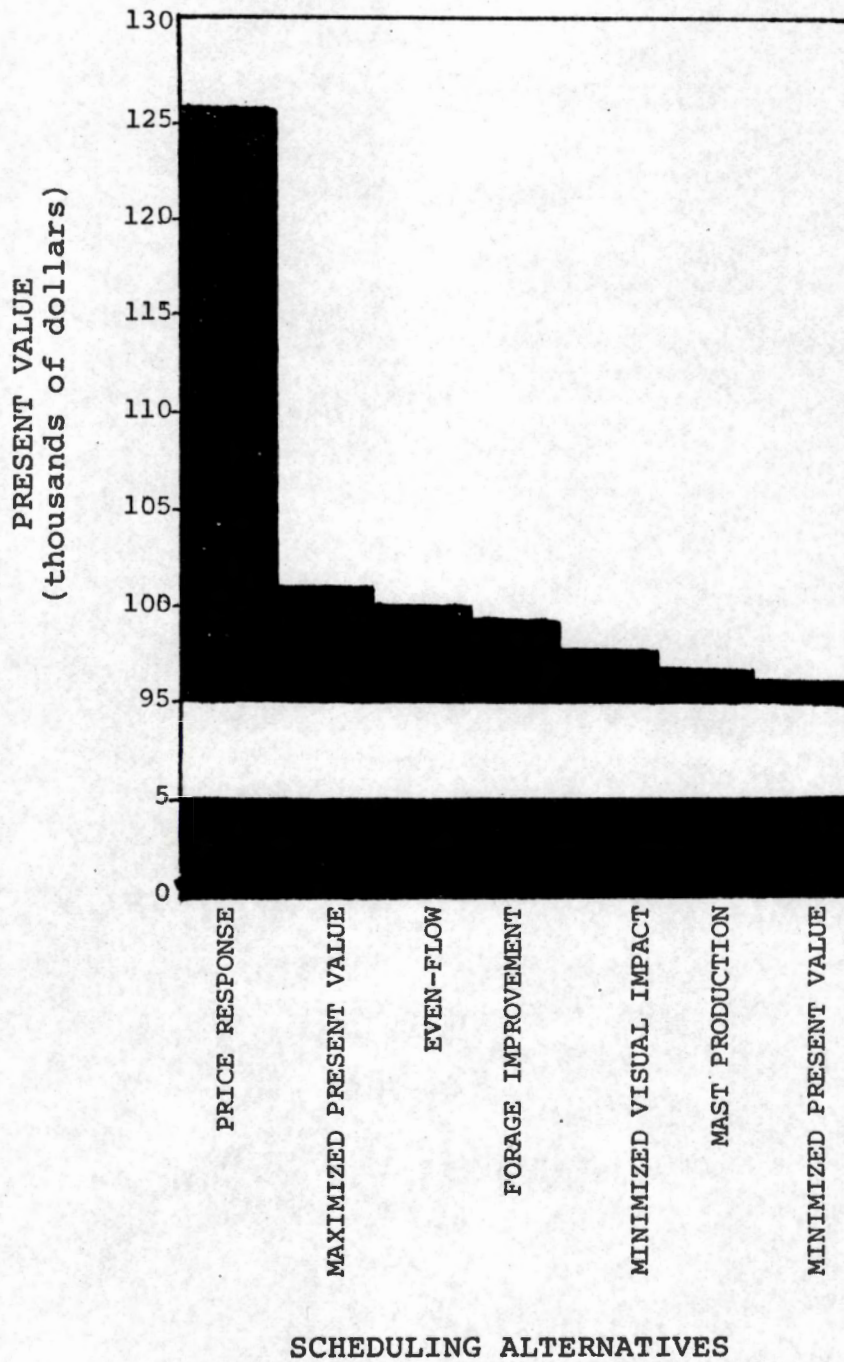


Figure IV. . Present value of the harvest scheduling alternatives.

TABLE 2. Harvesting Schedule to Maximize Present Value

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Gross Receipts	Present Worth
1	1979	Old Mill	414,124	\$ 20,706	\$ 20,706
2	1980	Clear Creek West	392,945	19,647	18,711
3	1981	Sinkhole	164,386	8,219	7,454
4	1982	Rifle Range East	237,874	11,893	10,273
5	1983	Scenic Vista	200,147	10,007	8,232
6	1984	Rifle Range North	202,317	10,115	7,925
7	1985	Scenic Vista East	185,689	9,293	6,934
8	1986	Windthrow	180,801	9,004	6,339
9	1987	Observation Point	101,595	5,079	3,437
10	1988	Ridge Pocket	71,251	3,562	2,296
11	1989	Reservoir Hill	294,810	14,745	9,051
Total			2,445,319	\$122,270	\$101,358

TABLE 3. Harvesting Schedule to Provide an Even Flow of Sawtimber and Concomitantly Maximize Present Value

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Gross Receipts	Present Worth
1	1979	Old Mill	414,124	\$ 20,706	\$ 20,706
2	1980	Old Mill			
3	1981	Clear Creek West	408,270	20,413	18,514
4	1982	Clear Creek West			
5	1983	Sinkhole/ Rifle Range East	421,887	21,093	17,353
6	1984	Sinkhole/ Rifle Range East			
7	1985	Scenic Vista	216,063	10,803	8,061
8	1986	Rifle Range North	218,405	10,920	7,760
9	1987	Scenic Vista East	200,615	10,032	6,789
10	1988	Windthrow	194,401	9,720	6,265
11	1989	Reservoir Hill/ Observation Point Ridge Pocket			
Total			478,612	23,929	14,690
			2,552,377	\$127,616	\$101,138

TABLE 4. Harvesting Schedule to Improve Forage Production Capacity

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Gross Receipts	Present Worth
1	1979	Old Mill	414,124	\$ 20,706	\$ 20,706
2	1980	Reservoir Hill	170,173	8,508	8,103
3	1981	Clear Creek West	408,270	20,413	18,514
4	1982	Windthrow	154,527	7,726	6,673
5	1983	Rifle Range North	194,723	9,736	8,009
6	1984	Observation Point	90,578	4,528	3,547
7	1985	Rifle Range East	266,805	13,340	9,954
8	1986	Scenic Vista	224,490	11,224	7,976
9	1987	Sinkhole	197,452	9,871	6,680
10	1988	Scenic Vista East	208,475	10,423	6,718
11	1989	Ridge Pocket	74,029	3,701	2,272
Total			2,400,626	\$120,176	\$ 99,152

TABLE 5. Schedule to Minimize Visual Impact of Timber Harvesting

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Gross Receipts	Present Worth
1	1979	Sinkhole	154,649	\$ 7,732	\$ 7,732
2	1980	Windthrow	143,144	7,157	6,816
3	1981	Ridge Pocket	54,510	2,725	2,471
4	1982	Rifle Range East	237,874	11,893	10,273
5	1983	Observation Point	87,178	4,358	3,585
6	1984	Reservoir Hill	217,282	10,864	8,511
7	1985	Rifle Range North	210,207	10,510	7,842
8	1986	Scenic Vista East	193,118	9,655	6,861
9	1987	Scenic Vista	233,245	11,662	7,892
10	1988	Clear Creek West	533,650	26,682	17,199
11	1989	Old Mill	607,135	30,356	18,635
Total			2,671,992	\$133,594	\$ 97,817

TABLE 6. Harvesting Schedule to Retain the Most Mast Production Capability

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Gross Receipts	Present Worth
1	1979	Ridge Pocket	50,495	\$ 2,524	\$ 2,524
2	1980	Observation Point	77,725	3,886	3,701
3	1981	Reservoir Hill	180,894	9,044	8,202
4	1982	Windthrow	154,527	7,726	6,673
5	1983	Scenic Vista	200,147	10,007	8,232
6	1984	Rifle Range North	202,317	10,115	7,925
7	1985	Clear Creek West	475,784	23,789	17,751
8	1986	Scenic Vista East	193,118	9,655	6,861
9	1987	Sinkhole	197,432	9,871	6,680
10	1988	Rifle Range East	299,254	14,962	9,644
11	1989	Old Mill	607,135	30,356	18,635
Total			2,638,828	\$131,935	\$ 96,828

TABLE 7. Harvesting Schedule to Minimize Present Value

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Gross Receipts	Present Worth
1	1979	Reservoir Hill	160,087	\$ 8,004	\$ 8,004
2	1980	Ridge Pocket	52,464	2,623	2,498
3	1981	Observation Point	80,756	4,037	3,661
4	1982	Windthrow	154,527	7,726	6,673
5	1983	Scenic Vista East	172,177	8,608	7,081
6	1984	Rifle Range North	202,317	10,115	7,925
7	1985	Scenic Vista	216,063	10,803	8,061
8	1986	Rifle Range East	277,210	13,860	9,850
9	1987	Sinkhole	197,432	9,871	6,680
10	1988	Clear Creek West	533,650	26,682	17,199
11	1989	Old Mill	607,135	30,356	18,635
Total			2,653,818	\$132,685	\$ 96,267

\$125,925 (Figure IV, Table 8). While this scheduling option did not specify the harvesting order of the tracts, the analysis did show that harvesting the allowable cut and more than one tract during peak stumpage price periods, yielded a higher appraisal of present value than the other scheduling alternatives. This result, therefore, indicates that it may be desirable to consider the concept of price response scheduling in planning future timber sales. Implementation of this concept could be accomplished in conjunction with one of the other scheduling alternatives by harvesting the tracts in the relative order specified by the particular schedule chosen, and yet harvesting the number of tracts necessary to yield the desired amount of volume to be sold during periods in which high stumpage prices occur.

Identification of peak price periods in the future would be difficult, if not impossible, to determine exactly beforehand. Criteria for judging whether it is desirable to sell more volume could be established by considering percentage price increases. For example, if prices given for stumpage sales in the region are greater by 20 percent than in previous years, it may be desirable to market more volume. If, however, prices do not increase by a 20 percent margin, an increase in harvest volume may not be desirable. Withholding volume during periods of either weak bidding or otherwise depressed markets would be easier to accomplish in practice.

TABLE 8. Price Response Harvesting Schedule

Order	Year	Tract	Volume Int. 1/4" bd. ft.	Price/ MBF	Gross Receipts	Present Worth
1	1979	No cut		\$ 50.00		
2	1980	Any tract	400,000	60.00	\$ 24,000	\$ 22,857
3	1981	No cut		50.00		
4	1982	No cut		55.00		
5	1983	No cut		65.00		
6	1984	Any tract	800,000	90.00	72,000	56,412
7	1985	No cut		75.00		
8	1986	No cut		75.00		
9	1987	No cut		80.00		
10	1988	No cut		95.00		
11	1989	Any tract	800,000	120.00	76,000	46,656
Total			2,000,000		\$172,000	\$125,925

B. Gross Receipts

The alternatives based on constant stumpage prices that would produce the most income (minimized visual impact, minimized present value, and mast production) would produce total gross receipts of \$133,594, \$132,685, and \$131,935 respectively. The schedules to maintain even flow, maximize present value and improve forage would yield total gross receipts of \$127,616, \$122,270, and \$120,176 respectively (Tables 2-7).

The first three above alternatives all produced similarly high gross receipts. These alternatives all scheduled the largest tracts with the most volume later in the scheduling period. This, of course, allows these tracts to grow and thereby increase in volume and merchantable value. Examination of the alternatives (Tables 5, 6, 7) indicated that even though they produce more revenue, most of the money would be obtained in the later years. These alternatives may be considered undesirable if obtaining annual operating expenditures of \$10,000 is considered highly important because most of the tracts scheduled in the initial years of the scheduling period (1979-1983) would yield substantially less revenue than needed. However, the even-flow schedule (Table 4) would produce revenue at levels necessary to meet operating expenditures of \$10,000 annually and could be desirable from that standpoint.

The schedule to maximize present value (Table 2, page 36) would yield more revenue than is necessary to meet operating expenditures in the initial years of harvesting (1979-1980) and less in some of the later years (1987-1988). Because this option would produce revenue in excess of that needed to meet the operating expenditures, the remaining revenue could be invested at a rate of return greater than the forest stands are increasing in value. The money received as interest on this investment could contribute to future operating expenditures. The schedule to improve forage production (Table 4, page 38) also would produce revenue in excess of that needed in the earlier years (1979-1981) thereby providing a similar investment opportunity.

The results showed that implementation of the price response alternative (with perfect foresight) would generate gross receipts totaling \$172,000 (Table 8). This result again indicates that considering price fluctuations in planning future timber sales can have economic advantages. However, based on past price trend data, the analysis showed that the cash flow associated with this alternative may not be desirable for planning annual budgets. In fact, it would be impossible to obtain necessary operating expenditures through the years 1979-1983 if price fluctuations occur throughout the next decade exactly as they did during the past decade. Therefore, practical application of this

concept probably would entail some harvesting on either an annual or biannual basis the tracts and volume necessary to meet operating expenditures regardless of stumpage prices until prices rose to such a level that it would be desirable to harvest significantly greater volumes than necessary to meet budget requirements.

C. Harvest Volume

The results showed that implementing any of the scheduling alternatives (except the even-flow schedule) based on holding prices constant would entail harvesting more volume than is represented in the allowable cut guidelines (200,000 board feet annually). Two factors are responsible for this. First, the scheduling analysis actually concerns eleven different sales between 1979 and 1989, thus "allowing" 2,200,000 board feet to be harvested. Secondly, the growth that occurs in the stands increases the volume of that growing stock which is presently available for harvesting. If the stands are harvested in the future, removing the present merchantable growing stock plus this growing stock's increase in volume, the allowable cut would be slightly exceeded. However, procedures which were used to determine allowable cut in the management guidelines are gross estimators. Volume removals based on these cut guidelines would result in an increase of approximately 4 million

board feet of sawtimber on the watershed. It is, therefore, doubtful that the capacity of the watershed to provide a sustained yield of merchantable sawtimber would be reduced greatly by implementing any schedules that exceeded the allowable cut estimated for the forest.

Examination of the even-flow schedule (Table 3, page 37) shows this option could be implemented in a way that the allowable cut would not be exceeded through the year 1988. Implementation of the schedule would provide approximately 200,000 board feet for harvesting and gross receipts of about \$10,000 on an annual basis. The decadal cut would be approximately 2 million board feet and the total gross receipts would be approximately \$100,000.

The price response schedule, however, showed that a total of \$172,000 could be generated by marketing only 2,000,000 board feet over the 11-year period (Table 8). This comparison again shows the potential economic benefits of considering stumpage price changes.

CHAPTER VI

CONCLUSIONS

1. The opportunity costs among the scheduling alternatives was small as measured by present value. One exception was the price response option which increased present value by about 25 percent above other schedules.
2. The scheduling alternatives differ in respect to the total gross receipts that can be generated and also in respect to the annual gross receipts available to fulfill yearly budget requirements. If it is highly desirable to have available equal annual operating expenditures of \$10,000, the even-flow schedule would most nearly achieve this. If maximizing the total gross receipts is highly desirable, implementation of the price response, visual impact, mast production, or minimized present value alternatives should be considered.
3. With the exception of the price response and even-flow scheduling alternatives, the decadal allowable cut guidelines would be exceeded if the tracts were operated as indicated in the scheduling alternatives. However, net growth would still exceed cut in the watershed forest.
4. The price response schedule can have desirable effects by maximizing the present value of monies derived from future timber sales, maximizing total gross receipts

generated, and holding volume removals to a minimum estimated allowable cut.

5. The study results are somewhat sensitive to the discount rate assumed.

a. Opportunity costs will directly increase.

Alternative investment rates greater than 5 percent would enlarge the opportunity costs among the alternatives but would not change their relative order.

b. The present value maximization alternative will change. The scheduling order of the tracts that maximize present value would be expected to change with alternative investment rates greater than 5 percent. When the alternative rate exceeds the growth rates of the stands by any appreciable amount, the timing of the income stream becomes more important in determining the order selected within this alternative.

CHAPTER VII

RECOMMENDATIONS

The management guidelines and scheduling analyses presented herein are intended to aid the watershed board in future decision making. However, because the environmental, economic, and sociological factors affecting the utilization of the watershed as a public forest are not static, a continuing assessment of the goals and guidelines should be made throughout the planning period. This may call for additional public comment periodically to determine if the presently established goals are still relevant, and changes in management direction if they are not.

The scheduling alternatives and analyses are intended to provide within the realm of multiple-use management a broader perspective by which to plan future timber harvests. They are not intended, however, to provide a rigid schedule for planning these harvests. It should be recognized that the scheduling alternatives are based upon predictive data and the analysis results are estimations of what will occur if a particular schedule is implemented. Development of the growth model was based upon the assumption that all merchantable growing stock would survive and increase in volume and, as such, does not include an assessment of mortality. Because the large sawtimber stands have much of their merchantable

volume in the larger diameter classes, some risks exist in holding tracts throughout the scheduling interval. Therefore, another factor to be considered in planning future harvests is the relative risk associated with expected mortality.

It also should be recognized that the assessments of the scheduling alternatives were based on harvesting only that sawtimber (and its increase in volume) that would be removed in partial cuttings by employing thinnings and improvement cuttings (defined as merchantable sawtimber). However, the actual marketable sawtimber volume available by clearcutting is much greater for each tract. Utilization of the clearcutting system could have the following advantages:

- Scheduling with greater flexibility.
- Harvesting less watershed acreage in order to market the volume necessary to produce operating and maintenance expenses.
- Leaving the areas where clearcutting is recommended in a more productive condition for regeneration rather than as an under-stocked stand.

The primary disadvantage of utilizing clearcutting is that of visual impact.

Implementation of any of the scheduling alternatives identified in the study probably will require assessment of the alternatives and their implications and a more definitive board decision concerning goal priorities in the near future.

Additionally, it may be desirable to gather more environmental resource information throughout the planning period. Utilization of interested citizens for identifying unique areas such as unusual forest stands and wildflower habitats may be helpful in making final decisions regarding location and timing of the harvests.

If a particular scheduling option is tentatively chosen, it cannot be too strongly stressed that considerations of changing factors, timely recommendations by the managing forester and other environmental specialists, and considerations of contemporary developments at the time of harvest, also must be weighed.

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APPENDICES

APPENDIX A

WATERSHED CONCERNS

The following is a list of issues, goals and policies that have been rated previously by the Watershed Board members. The list has been reorganized to aid final evaluation. Five indicates high priority and one indicates low priority.

The first seven issues initially were given high priority. They also could be expensive to achieve.

- 45545 Increase patrol and enforcement.
- 53455 Minimize deer poaching.
- 44555 Litter (cleanup and prevention).
- 54445 Summer employment opportunities for Norris youth.
- 54454 Create permanent openings.
- 23444 Dredge ponds for fishing by children.
- 54345 Improve present road system.

GENERAL USE

Policies

- 15555 Use of Watershed primarily by Norris area residents.
- 55453 Restrict nonresident use to nonconsumptive uses, i.e., education/demonstration, group camping areas and passive recreation.
- 52555 Protection of water supply.
- 54455 Multiple-use management.
- 55533 Utilization of public labor forces—YACC.
- 33333 Minimize maintenance costs.

- 13111 Use municipal funds to support Watershed.
- 00111 Use funds derived from timber sales for other city projects.

Goals

- 45545 Increase patrol and enforcement.
- 54445 Summer employment opportunities for Norris youth.

FOREST MANAGEMENT

Policies

- 35535 Harvest timber for income.
- 44155 Produce income for Watershed maintenance only.
- 54555 Maintain visual quality during harvesting.
- 44555 Minimize damage during harvesting.
- 33552 Do not consider potential 10-year extension of timber contract as planning constraint.

Goals

- 33454 Timber harvest through group selection and single tree selection.
- 13114 Timber harvest through clear-cutting techniques.
- 55555 Sustained yield forestry.
- 54525 Preserve more unique natural areas.
- 43454 Outline a long-ranged cutting schedule (10 years).
- 41553 Feasibility study of city-owned firewood business.

Forest Management Concerns—Initially given low priority

- 32322 Maximize profits from forest products.
- 53223 Increase cost of firewood cutting permits.

- 31211 Designate commercial forest area and manage only that area for wood production.

WILDLIFE MANAGEMENT

- 54455 Nonconsumptive use of wildlife.
- 13311 Consumptive use of wildlife.
- 55334 Increase forest rotation age to favor old growth stands for certain wildlife species.

Hunting

- 53312 Permit small game hunting.
- 33314 Allow deer hunting only as population control.
- 53411 Allow bow and arrow hunting of deer.
- 55555 Ban use of high-powered rifles for any type of hunting.
- 53455 Minimize deer poaching.
- 53255 Limit hunting near firewood cutting areas.

Manage Watershed for particular wildlife species

- 54415 Deer.
- 54525 Small game—squirrel, rabbit.
- 55555 Songbirds.
- 51235 Reptiles, amphibians.
- 54355 Upland game—quail, grouse.

RECREATION

Policies

- 54455 Use of Watershed for passive, nature-oriented recreation.
- 34255 Watershed as plant sanctuary by Federal park guidelines.
- 55455 Emphasize trails and dispersed recreation.

Policies given low priority

- 11111 Use of Watershed for developed recreation (tennis courts, swimming pools, etc.)
- 13332 Emphasize nondispersed recreation—picnicking.

Goals

- 54454 Create permanent openings.
- 44555 Litter (cleanup and prevention).
- 55545 Mark large trees and incorporate in trails system.
- 23444 Dredge ponds for fishing by children.
- 44112 Locate new trails to encounter diverse vegetative cover types.
- 44314 Increase age class structures of vegetative cover.
- 14131 Expand trail system.

Motorized recreation

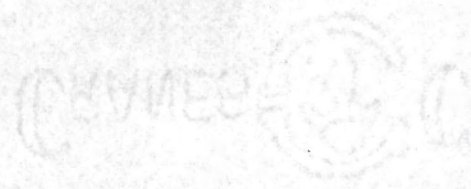
- 41354 Designate motorcycle trails.
- 11453 Designate area for motorcycles.
- 55155 Minimize noise.

Camping

- 53255 Regulate/designate areas.
- 43225 Require permit for any type camping.
- 45555 Formulate camping policy.

ACCESS TO WATERSHED

- 11315 Provide general access to the area.
- 55515 Secure access by trail through the Norris Corporation lands.
- 54345 Improve present road system rather than expanding the road system.



APPENDIX B

TABLE B-1. Old Mill Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	667,786	\$33,389	414,124	\$20,706
1980	693,829	34,691	430,275	21,513
1981	720,889	36,044	447,056	22,352
1982	749,003	37,450	464,491	23,224
1983	778,214	38,910	482,606	24,130
1984	808,565	40,428	501,428	25,071
1985	840,099	42,004	520,983	26,049
1986	872,863	43,643	541,302	27,065
1987	906,904	45,345	562,413	28,120
1988	942,274	47,113	584,347	29,217
1989	979,020	48,451	607,120	30,356

TABLE B-2. Clear Creek West Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	615,378	\$30,768	378,195	\$18,909
1980	639,378	31,968	392,945	19,647
1981	664,314	33,215	408,270	20,413
1982	690,222	34,511	424,193	21,209
1983	717,141	35,857	440,736	22,036
1984	745,109	37,255	457,925	22,896
1985	774,169	38,708	475,784	23,789
1986	804,361	40,218	494,340	24,717
1987	835,731	41,786	513,619	25,680
1988	868,325	43,416	533,650	26,682
1989	902,180	45,109	554,460	27,723

TABLE B-3. Sinkhole Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	317,651	\$15,882	154,649	\$ 7,732
1980	327,498	16,374	159,444	7,972
1981	337,650	16,882	164,386	8,219
1982	348,117	17,405	169,482	8,474
1983	358,909	17,945	174,736	8,736
1984	370,035	18,501	180,153	9,007
1985	381,506	19,075	185,738	9,286
1986	393,333	19,666	191,496	9,574
1987	405,526	20,276	197,432	9,871
1988	418,098	20,904	203,553	10,177
1989	431,040	21,552	209,860	10,493

TABLE B-4. Rifle Range East Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	365,437	\$18,271	212,080	\$10,604
1980	379,689	18,984	220,351	11,017
1981	394,497	19,724	228,445	11,447
1982	409,882	20,494	237,874	11,893
1983	425,867	21,293	247,151	12,357
1984	442,476	22,123	256,790	12,839
1985	459,733	22,986	266,805	13,340
1986	477,662	23,883	277,210	13,860
1987	496,291	24,814	288,021	14,401
1988	515,647	25,782	299,254	14,962
1989	535,740	26,787	310,920	15,546

TABLE B-5. Scenic Vista Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	368,741	\$18,437	171,746	\$ 8,587
1980	383,122	19,156	178,444	8,922
1981	398,063	19,903	185,540	9,270
1982	413,588	20,679	192,634	9,631
1983	429,718	21,485	200,147	10,007
1984	446,477	22,323	207,953	10,397
1985	463,889	23,944	216,063	10,803
1986	481,981	24,099	224,490	11,224
1987	500,778	25,038	233,245	11,662
1988	520,309	26,015	242,341	12,117
1989	540,600	27,030	251,792	12,589

TABLE B-6. Rifle Range North: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	356,113	\$12,805	167,091	\$ 8,354
1980	266,101	13,305	173,608	8,680
1981	276,479	13,823	180,379	9,018
1982	287,262	14,363	187,414	9,370
1983	298,465	14,923	194,723	9,736
1984	310,010	15,505	202,317	10,115
1985	322,200	16,110	210,207	10,510
1986	334,765	16,738	218,405	10,920
1987	347,821	17,391	226,923	11,346
1988	361,386	18,069	235,773	11,788
1989	375,480	18,774	244,960	12,248

TABLE B-7. Scenic Vista East Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	271,178	\$13,558	147,745	\$ 7,387
1980	281,754	14,087	153,507	7,675
1981	292,743	14,637	159,494	7,974
1982	304,160	15,208	165,714	8,285
1983	316,022	15,801	172,177	8,608
1984	328,347	16,417	178,892	8,944
1985	341,153	17,057	185,869	9,293
1986	354,458	17,722	193,118	9,655
1987	368,281	18,414	200,650	10,032
1988	382,644	19,132	208,475	10,432
1989	399,560	19,878	216,600	10,830

TABLE B-8. Windthrow Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	256,092	\$12,804	137,771	\$ 6,888
1980	266,080	13,304	143,144	7,157
1981	276,457	13,822	148,727	7,436
1982	287,239	14,361	154,527	7,726
1983	298,441	14,922	160,554	8,027
1984	310,080	15,504	166,815	8,340
1985	322,174	16,108	173,321	8,666
1986	334,738	16,736	180,081	9,004
1987	347,793	17,389	187,104	9,355
1988	361,357	18,067	194,401	9,720
1989	375,440	18,772	201,980	10,099

TABLE B-9. Observation Point Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	234,710	\$11,735	74,807	\$ 3,740
1980	243,863	12,193	77,725	3,886
1981	253,374	12,668	80,756	4,037
1982	263,256	13,162	83,906	4,195
1983	273,523	13,676	87,178	4,358
1984	284,190	14,209	90,578	4,528
1985	295,273	14,763	94,111	4,705
1986	306,789	15,339	97,781	4,889
1987	318,754	15,937	101,595	5,079
1988	331,185	16,559	105,557	5,277
1989	344,100	17,205	109,660	5,483

TABLE B-10. Ridge Pocket Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of yield	Merchantable Volume Int. 1/4" bd. ft.	Value of yield
1979	124,056	\$ 6,202	50,495	\$ 2,524
1980	128,894	6,444	52,464	2,623
1981	133,921	6,696	54,510	2,725
1982	139,144	6,957	56,636	2,831
1983	144,571	7,228	58,845	2,942
1984	150,209	7,510	61,140	3,057
1985	156,067	7,803	63,525	3,176
1986	162,154	8,107	66,002	3,300
1987	168,478	8,423	68,576	3,428
1988	175,049	8,752	71,251	3,562
1989	181,875	9,093	74,029	3,701

TABLE B-11. Reservoir Hill Tract: Projected Growth and Yearly Value of Yield

Year	Total Volume Int. 1/4" bd. ft.	Value of Yield	Merchantable Volume Int. 1/4" bd. ft.	Value of Yield
1979	394,798	\$19,739	160,087	\$ 8,004
1980	419,670	20,983	170,173	8,508
1981	446,109	22,305	180,894	9,044
1982	474,214	23,710	192,290	9,614
1983	504,090	25,204	204,404	10,220
1984	535,847	26,792	217,282	10,864
1985	569,606	28,480	230,971	11,548
1986	605,491	30,274	245,522	12,276
1987	643,637	32,181	260,990	13,049
1988	684,186	34,209	277,432	13,871
1989	727,280	36,364	294,900	14,745

APPENDIX C

TABLE C-1. A Schedule of Harvesting to Maximize Present Value by Harvesting First the Tracts that Represent Greater Financial Losses

Order	Tract	Present Market Value	Market Value in Ten Years	Discounted Value ¹	Financial Loss ²
1	Old Mill	\$20,706	\$30,356	\$18,635	\$2,071
2	Clear Creek West	18,909	27,723	17,019	1,890
3	Sinkhole	7,732	10,493	6,441	1,291
4	Rifle Range East	10,604	15,546	9,543	1,061
5	Scenic Vista	8,587	12,589	7,728	859
6	Rifle Range North	8,354	12,248	7,519	835
7	Scenic Vista East	7,387	10,830	6,648	739
8	Windthrow	6,888	10,099	6,199	689
9	Observation Point	3,740	5,483	3,366	374
10	Ridge Pocket	2,524	3,701	2,272	252
11	Reservoir Hill	8,004	14,745	9,051	+1,047 ³

¹Discounted at 5 percent rate to 1979.

²Difference between present market value and discounted value.

³Reservoir Hill represented a financial gain.

TABLE C-2. A Schedule of Harvesting to Provide an Annual Even Flow of Sawtimber and Concomitantly Maximize Present Value

Order	Year	Tract	Merchantable Volume Int. 1/4" bd. ft.	Annual Harvest Int. 1/4" bd. ft.
1	1979	Old Mill	414,000	±200,000
2	1980	"	"	±200,000
3	1981	Clear Creek West	408,000	±200,000
4	1982	"	"	±200,000
5	1983	Sinkhole/Rifle Range East	424,000	±200,000
6	1984	"		±200,000
7	1985	Scenic Vista	216,000	±200,000
8	1986	Rifle Range North	218,000	±200,000
9	1987	Scenic Vista East	200,000	±200,000
10	1988	Windthrow	194,000	±200,000
11	1989	Reservoir Hill Ridge Pocket Observation Point	478,612	±200,000

TABLE C-3. A Schedule to Most Improve Forage Production Capacity Following a Harvest by Tract

Order	Tract	Capacity	Increase in Capacity Following a Harvest	Total Capacity Following a Harvest
1	Old Mill	1950*	2730*	4680*
2	Reservoir Hill	2100	2100	4200
3	Clear Creek West	1560	2600	4160
4	Windthrow	1950	1950	3900
5	Rifle Range North	1190	1700	2890
6	Observation Point	1200	1200	2400
7	Rifle Range East	790	1370	2160
8	Scenic Vista	660	1290	1950
9	Sinkhole	750	750	1500
10	Scenic Vista East	660	390	1050
11	Ridge Pocket	250	350	600

*Thousand twigs per tract.

TABLE C-4. A Schedule Based on Harvesting Tracts with Less Road and Trail Frontage Before Tracts with Greater Frontage

Order	Tract	Road and Trail Frontage (Feet)
1	Sinkhole	0
2	Windthrow	100-500
3	Ridge Pocket	100-500
4	Rifle Range East	1,500
5	Observation Point	1,700
6	Reservoir Hill	3,500
7	Rifle Range North	3,500
8	Scenic Vista East	4,000
9	Scenic Vista	4,500
10	Clear Creek West	7,000
11	Old Mill	8,750

TABLE C-5. A Schedule of Harvesting Based on the Inverse of Basal Area to be Cut of Mast Producing Trees by Tract

Order	Tract	Present Basal Area Sq. Ft.	Residual Basal Area Sq. Ft.	Cut Basal Area Sq. Ft.
1	Ridge Pocket	935	530	405
2	Observation Point	1395	900	495
3	Reservoir Hill	1200	540	660
4	Windthrow	1755	975	780
5	Scenic Vista	1950	1140	810
6	Rifle Range North	1615	697	918
7	Clear Creek West	3926	2886	1,040
8	Scenic Vista East	1740	690	1,050
9	Sinkhole	1950	810	1,140
10	Rifle Range East	2340	1098	1,242
11	Old Mill	4290	1198	3,096

VITA

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