Assessment of the Economic Efficiency and Environmental Impact of Major Timber Harvesting Systems in Alabama

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Abstract

Increasing environmental concerns have demanded more environmentally sound as well as economically efficient timber harvesting systems. This study aimed to identify the major timber harvesting systems implemented throughout the state of Alabama, and to assess their economic efficiency and environmental impact. Surveys combined with secondary data were used to evaluate the harvesting systems in terms of efficiency, environmental impact, worker safety, and maintenance. Survey questionnaires were mailed to 200 timber harvesting firms throughout the state of Alabama. According to the survey results, clearcutting, selection cutting, seed-tree cutting, and shelterwood cutting were all used within the state of Alabama, while clearcutting and selection cutting were the primarily used harvesting methods. Approximately three quarters of the logging companies surveyed adopted clearcutting or selection cutting. A variety of logging equipment was operated by these firms. Clearcutting displayed advantages in profitability, worker safety, and system maintenance despite its disadvantages with regard to environmental impact, specifically on soil and water quality. The results also showed that the selection cutting method was the most environmentally sound relative to the three other methods. Moreover, for those seeking optimal environmental soundness and economic efficiency, selection cutting was found to be the best harvesting method. Alabama's timber harvesters did not favor seed-tree cutting and shelterwood cutting because of their disadvantages in profit, worker safety, and maintenance.

INTRODUCTION

In the past two decades, the American public has become increasingly concerned about the protection and conservation of our natural environment. There is a growing need for environmental protection measures in all facets of forest operations. The ever increasing focus on ecosystem management and resource protection on public and private forestland in the United States creates challenges for timber harvesting operations. The primary challenge is the implementation of environmentally sound timber harvesting methods, equipment, and management plans. These harvesting methods and equipment must also prove to be economically sound or cost effective.

Timber production provides various economic contributions to the state of Alabama. These contributions include recreational opportunities, various wood products, employment, and increased economic activity within the state. In spite of these many positive contributions of timber production, there are also negative effects, particularly with respect to decreasing soil quality and water quality resulting from mechanized harvesting methods and equipment.

This study examines economically sound and cost effective timber harvesting methods in Alabama. Its specific objectives were: (1) to identify the major timber harvesting methods and equipment currently used in the state of Alabama; (2) to evaluate the economic efficiency of these harvesting methods; (3) to assess the environmental impacts of these harvesting methods and equipment on soil and water quality; and (4) to compare the harvesting methods and equipment using various criteria.

Timber Harvesting Methods

There are a variety of silviculturally based methods of timber harvesting. Those primarily used in the south include: clearcutting, seed-tree, shelterwood, and selection cutting. The first three methods are used to regenerate even-aged stands, while the last is used to regenerate uneven-aged stands.

Clearcutting is possibly today’s most controversial forest management practice. The public often disapproves of the temporary absence of merchantable trees after cutting, the presence of logging slash, and soil disturbance associated with clearcutting (McCool et al. 1986). Timber harvesting through the clearcutting method involves the removal of virtually all of the trees in a stand, both large and small. Clearcutting is applicable in stands where the

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trees are no longer worth keeping for further growth and value increase, as a source of seed, for the protection of new reproduction, or for other silvicultural purposes.

Seed-tree cutting is a form of clear cutting. This method of timber harvesting leaves a few (4 to 10 trees per acre), seed-bearing trees suitably dispersed throughout the harvest area. These trees remain to provide for regeneration of the desired species in a reasonable period of time. This method is used with species that bear seed frequently and abundantly, such as certain pines and prolific hardwoods.

Selection cutting is a complex method of cutting and removing individual trees throughout the stand based upon maturity, growth rate, diameter, and vigor. Trees may be selected throughout the forest each year; or in the case of large tracts, they may be divided into a series of cutting units for efficiency and convenience. The selection method, when used in some areas, tends to control stand composition and hastens hardwood encroachment problems.

Shelterwood cutting is a harvest method whereby only a portion of the stand is removed at any one time. Its purpose is to obtain natural reproduction under the partial shelter of a large number of seed trees. Shelterwood cuttings are divided into two or three stages of tree removal. In a three-stage method, a preparatory cutting is made first, then a seed cutting, and a final harvest (Holland et. al. 1990).

Environmental Impact
Timber harvesting may have adverse effects on the natural environment, particularly on water and soil quality. Damage inflicted upon water quality is often displayed through siltation. Damage caused to soil quality is displayed through soil erosion, rutting, and compaction.

Stream siltation or sedimentation is by far the most difficult to handle of the potential impacts attributed to timber harvesting (Seehorn 1990). Sediment, the nation’s largest single water pollutant by weight or volume, is Alabama’s single largest water quality contaminant (Hairston 1994). Forest management activities have been identified as a cause of stream sedimentation, and the need for regulation has long been recognized. Sediment reduces water’s capacity to sustain life. Sediment clouds the water, reducing light penetration and photosynthesis. More importantly, it alters bottom condition often covering suitable spawning sites and suffocating fish eggs and aquatic insects. This reduces fish, shellfish, and plant populations and decreases the overall productivity of lakes and streams.

The act of cutting trees, whether by selection or clearcut, has little to do with erosion or overland flow in the eastern regions. The source of sediment in regards to timber harvesting is the transportation system including haul roads, skid trails, and log decks. Sediment resulting from harvest sites with poorly designed, located, and maintained roads and skid trails can average as much as 1 ton per acre per year over a 30-year rotation and more than 10 tons per acre during the year following road construction. With good planning, construction, and maintenance, the same timber harvest can be made with no significant increase above the natural erosion rate of 0.1 to 0.25 ton per acre per year (Brinker 1991).

Timber harvesting, particularly the repeated trips of skidders throughout a site may have detrimental effects on the site. Included among these adverse effects are soil rutting, surface soil compaction, soil erosion, and sedimentation. Thus, responsible, environmentally sound timber harvests must be conducted. These harvests require the establishment of a well defined network of skid trails on which skidders must concentrate their travel.

Most forest landowners now recognize that soil compaction can be minimized by adhering to a system of designated skid trails which would be the same regardless of cutting method. Skidders must concentrate travel on these trails which average 100-150 feet apart depending on the size of the tract. This will prevent any compaction except on the skid trails, which if carefully planned amount to approximately 5% of the total area (Seehorn 1990).

Soil erosion may result from timber harvesting operations. Soil erosion is defined as surface denudation, a general term for wearing away of the land. By most accounts, erosion from disturbed as well as carefully managed forestland is 0.05 to 0.10 ton/ac/yr; that is less than the geological norm (0.1 to 0.25 ton/ac/yr) and less than the maximum tolerable rates for agricultural land (1 to 5 ton/ac/yr). All land, even virgin forests, is subject to erosion at some minimal rate; namely the geological norm. The geological norm for the eastern United States is a one foot per 10,000 years (Patric 1976). Logging roads merit special consideration. They are unquestionably the source of most of the soil lost from nonchannel portions of managed forestland in the eastern United States.
METHODS

Logger Survey
Mail surveys were conducted to 200 timber harvesters randomly selected in Alabama. The survey sample was selected from a list of six hundred logging contractors published in the Alabama Forestry Association Forest Industry Directory (1996). The key questions in the survey questionnaire dealt with the primary timber harvesting processes and equipment implemented by the firm, the perceived environmental impacts of the harvesting methods and equipment by timber harvesters, and productivity of the harvesting methods and equipment.

The survey data were collected from September to December, 1998. One and a half months after the first mailing, a second set of the questionnaire was sent again to those harvesters who had not replied. Upon completion of the survey collection, data were compiled and processed.

Data Analysis
The responses on the survey questionnaire were compiled as a database. The descriptive statistics of each variable were calculated. And the Multiple Attribute Assessment was used to compare the harvesting methods.

Multiple Attribute Decision Making refers to making preference decisions over available alternatives that are characterized by multiple, usually conflicting attributes. The term “attributes” may be referred to as goals or criteria (Yoon and Hwang 1995). In this study, the attributes studied were profit, environmental impact, worker safety, and maintenance. Profit was used as a measure of economic efficiency. Environmental impact measured the degree of damage imposed on soil and water quality. Worker safety measured the degree of safety provided to loggers through the use of personal protective equipment and machinery. Maintenance aimed to measure the amount of repair required for harvesting equipment.

This decision making method requires information regarding the relative importance of each attribute. Attribute weights are often used and may be assigned by various methods. Weights may be supplied by a cardinal or ordinal scale, or assigned directly by the decision maker. Attribute weights in this study were assigned after considering various scenarios. There were five scenarios considered in this study. The weights assigned to each attribute in the different scenarios are shown in Table 1.

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The Multiple Attribute Assessment in this study was achieved through the use of the additive utility function:

\[ U(x_1, x_2, \ldots, x_n) = \sum_{i=1}^{n} w_i U(x_i) \]

where: \( x_i \) = the \( i^{th} \) attribute; \( w_i \) = the weight assigned to attribute \( i \); and \( U(\bullet) \) = the utility function.

It is assumed that in discrete choice multiple attribute decision problem outcomes are to be deterministic. The underlying assumption of the additive utility function is that attributes are preferentially independent. Therefore, the decision maker’s preference regarding the value of one attribute is not influenced in any way by the values of the attribute (Yoon and Hwang 1995).

Utility may be defined as a measure of benefits that have absolute numerical measure that may be inadequate. Furthermore, management will need more comprehensive criterion that incorporates relevant intangibles as well as those absolute numerical values. The criterion must also measure the true worth of the outcomes to the decision maker (Firgionne 1996).

In this study utility was calculated using assigned weights and rating values revealed by the loggers surveyed. A utility value was calculated for each of the four harvesting methods in each of the five scenarios.

RESULTS

Of the 200 mailings, thirty-six responses were valid and completed. Twenty-eight surveys were undeliverable by the U.S. Postal Service. Eleven surveys were returned by respondents reporting business closure. Two surveys were returned by respondents who chose not to participate. Five surveys were returned by respondents who processed wood products, but did not harvest timber.
Harvesting Methods
The survey results revealed 77.4 percent of the responding harvesters chose clearcutting as the primary method of timber harvesting. Selection cutting was the second most popular timber harvesting method used by 74.2 percent of the responding harvesters. Seed-tree cutting was favored as the primary timber harvesting method by 12.9 percent of the timber harvesters. There were 6.5 percent of the harvesters who preferred the shelterwood method, and 3.2 percent primarily used other harvesting methods.

The results also indicated an overlap in the primary timber harvesting methods used by the loggers in Alabama. Forty-two percent of the respondents used both clearcutting and selection cutting as primary harvesting methods. Three percent of the respondents implemented clearcutting, selection cutting and seed tree cutting harvesting methods. Six percent of the timber harvesters surveyed implemented clearcutting, selection cutting, seed-tree cutting, and shelterwood cutting methods. And three percent of the respondents chose to use both clearcutting and seed-tree cutting timber harvesting methods.

Equipment Used
Alabama timber harvesters used a variety of equipment to accomplish timber harvesting. For the process of felling, the most favored equipment brand was John Deere. John Deere fellerbunchers were used by 41.9 percent of the responding timber harvesters. The popularly used models of John Deere fellerbunchers were 640D, 643D, and 843. The second most popular fellerbuncher, used by 22.6 percent of the respondents, was the Hydro-Ax brand, models 411Ex, 511Ex, 611Ex, and 711Ex. Sixteen percent of the respondents reported using various brands of chainsaws for felling operations. Other less favored felling equipment used by the timber harvesters included the 321 Hydro-Ax, Franklin Processor, and Bell Ultra-T.

Limbing operations were accomplished primarily through the use of two equipment types, including chainsaws and gate delimiters. Twenty-eight percent of the responding timber harvesters used various brands of chainsaws for limbing operations. Twenty-eight percent used gate delimiters left unnamed by the respondents. Twenty-five percent of the respondents used CTR delimiters, while fourteen percent used Hudson delimiters.

Fourty-two percent of the responding harvesters chose not to buck, or cut logs into various lengths. Of those who did buck logs, thirty-nine percent used various brands of chainsaws, and nineteen percent used CTR brand bucking equipment.

For skidding operations, sixty-four percent of the timber harvesters reported using John Deere brand, rubber-tired, grapple skidders. Models used included 91, 440, 548, 648, 740, and 748. Approximately eighteen percent of the respondents skidded timber using Timber Jack skidders, namely models 360 and 460. Less popularly used skidding equipment included the Caterpillar model 525, and Franklin models 170 and 560.

Loading was reported as being primarily accomplished through the use of Prentice loaders, models 210 and 310. Forty-nine percent of those responding loggers used Prentice equipment. Twelve percent of the respondents used Log Hog loaders, twelve percent used Barko model 160B loaders, and another twelve percent used Timber Jack model 330 loaders. Other less popularly used loaders included the Huskey Brute loader, XL 235 loader, and Ford model 650 loader.

Comparison of Harvesting Methods
The comparisons of the four harvest methods were made using the Multiple Attribute Assessment approach. Each of the four harvesting methods was scored in the four criteria. These scores were assigned by the responding timber harvesters. The scores ranged from 1 to 4, with 1 represented poor performance and 4 representing excellent performance. The calculated utility value for each harvesting method in a specific scenario was represented by corresponding (1 to 4) values.

The first scenario, assigning an equal weight to all the criteria, revealed the clearcutting method as the best. The utility value calculated for clearcutting was 3.15. The selection cutting method ranked second with a value of 3.13. The seed-tree method ranked third and shelterwood ranked fourth, with utility values of 3.03 and 2.70, respectively.

The second scenario assigned the entire weight to the profit criterion. Clearcutting showed to be the most profitable timber harvesting method, with a utility value of 3.60. The seed-tree and selection cutting methods were ranked second and third, with utility values of 2.80 and 2.70, respectively. Shelterwood method was found to be least profitable, with a utility value of 2.20.

The third scenario assigned one hundred percent of weight to environmental impact. The results showed
that selection cutting was the most environmentally sound harvesting method, with a utility value of 3.60. Seed-tree cutting and shelterwood cutting were found to have a similar degree of environmental soundness, with utility values of 3.00 and 3.10, respectively. The clearcutting method, though most profitable, was found to be least environmentally sound.

The fourth scenario assigned fifty percent of total weight to both profit and environmental impact. The results of this scenario were as follows. The selection cutting method seemed to be the best, with a utility value of 3.15. The seed-tree and clearcutting methods ranked second and third, with utility values of 2.90 and 2.80, respectively. The shelterwood method was found to be the worst, displaying a utility value of 2.65.

The fifth scenario assigned profit 40 percent of total weight, and 20 percent each for environmental impact, safety, and maintenance. The clearcutting method was scored the highest. This scenario ranked the selection cutting method second, seed-tree cutting method third, and shelterwood method fourth, with utility values of 3.04, 2.98 and 2.60, respectively (Figure 1).

Figure 1. Utility values of timber harvesting methods under different scenarios.

LITERATURE CITED


