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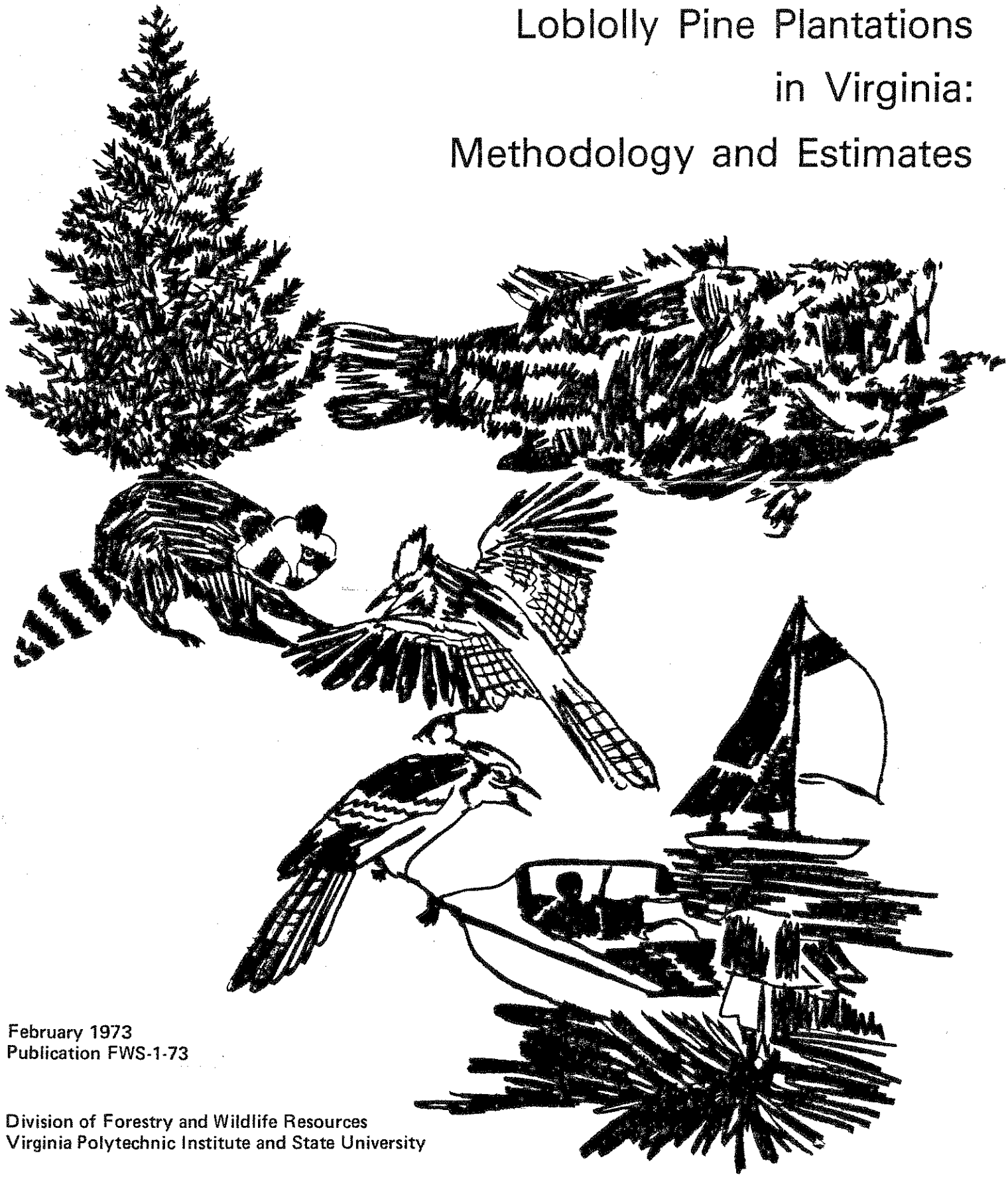

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COSTS OF ESTABLISHING LOBLOLLY PINE PLANTATIONS IN VIRGINIA: METHODOLOGY AND ESTIMATES

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Forest regeneration decisions are among the most important that foresters make. In many instances, the cost of regeneration may be the largest cost item incurred in producing a timber crop. Accordingly, information on the cost of establishing satisfactorily stocked stands is a necessary ingredient for effective forestry decision making. This report presents a method for obtaining such information and provides cost estimates for establishing loblolly pine (Pinus taeda L.) plantations in Virginia.

Problem and Procedures

Other studies (2, 3, 6, 7) have obtained data which estimate the cost of performing an establishment operation, e.g., drum chopping followed by burning and hand planting. What is now needed is a cost estimate for obtaining a satisfactorily established stand. This latter estimate, which we call expected cost, recognizes and includes the chance that regeneration will have to be repeated. It can be thought of as the total cost which a landowner can expect to spend to achieve successful regeneration. Expected cost is defined mathematically as the sum of all possible costs, times their associated probability of occurrence.

Given estimates of (1) the cost of performing various regeneration operations and (2) the probability of the specific operation resulting in a satisfactorily established stand, expected cost (EC) may be estimated as follows:

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$$EC = (c_0)(p_0) + (c_0 + \frac{c_1}{(1+i)^n})(q_0)(p_1) + (c_0 + \frac{c_1}{(1+i)^n} + \frac{c_2}{(1+i)^{2n}})(q_0)(q_1)(p_2) + (c_0 + \frac{c_1}{(1+i)^n} + \frac{c_2}{(1+i)^{2n}} + \frac{c_3}{(1+i)^{3n}})(q_0)(q_1)(q_2)(p_3) + \ldots \quad (1)$$

Where:

c_0 = initial regeneration cost, c_1 = the added cost of repeating regeneration once, c_2 = the added cost of repeating regeneration twice, etc.

p_0 = probability of regeneration success on initial attempt, p_1 = probability of regeneration failure on first repeat, etc.

i = appropriate interest rate

n = interval between regeneration attempts

If, in equation (1), it can be assumed that:

1. $p_0 = p_1 = \ldots = p_k = p$; that is, probability of success does not vary with regeneration attempt, and

2. cost reductions due to discounting are offset by generally rising regeneration costs, so that, effectively,

$$c_0 = \frac{c_1}{(1+i)^n} = \frac{c_2}{(1+i)^{2n}} = \frac{c_3}{(1+i)^{3n}} = \ldots = c$$

equation (1) reduces to:

$$EC = c(p) + 2c(p)(q) + 3c(p)(q^2) + 4c(p)(q^3) + \ldots \quad (2)$$

The sum of the infinite series given by equation (2) is

$$EC = c/p \quad (3)$$

Equation (3) will be used to estimate expected costs in this report. However, an individual landowner may prefer to use his own data and/or assumptions, and calculate expected cost from equation (1).

To illustrate equation (3), if performing a specific regeneration operation costs $40 per acre and the operation has an 80 percent probability of success, the expected cost is 40/.80 = $50 per acre. That is, over many trials the estimated average cost of achieving a satisfactorily stocked stand is 50 dollars per acre.

Seven, large, integrated forest products corporations, all involved and experienced in establishing loblolly pine plantations in Virginia, cooperated by supplying data for the study. The study procedures included two personal interviews with each cooperating firm. The interviews were conducted during the summer and early fall, 1970, and all data reflect 1969 cost levels. All interviews were conducted by the same person.

The purpose of the first interview was to identify the major regeneration techniques for establishing loblolly pine plantations currently being employed in Virginia (Table 1), and the major factors affecting the probability of these techniques achieving successful regeneration. For purposes of this study, successful regeneration was defined as 500 or more free-to-grow seedlings two years after establishment. Regeneration techniques and opportunities were recorded separately for the Virginia Piedmont and the Virginia Coastal Plain (Fig. 1). Regeneration opportunities in both the Piedmont and Coastal Plain were differentiated, by the degree of hardwood brush and/or pine reproduction competition, as either low, medium, or heavy at the time site preparation was begun.[1/] Opportunities in the Piedmont were further differentiated as having favorable or unfavorable topography.[2/] In the Coastal Plain, opportunities were categorized by the time of year site preparation was begun. Three categories, which roughly correspond to: (1) winter; (2) summer; (3) spring and fall, were recognized.

Data collection forms, based upon information from the initial interview, were mailed to the cooperating firms prior to the second interview. They were, however, filled out by the interviewer during the second personal interview. Between receiving the forms and having the second interview, the cooperating personnel were asked to bring together all the information they had about the requested

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[1/] Low indicates zero to 25 percent of the area occupied, medium is 26 to 50 percent, and heavy is more than one-half of the area occupied by competition.

[2/] Favorable topography is land which averages less than 20 percent slope and has a minimum of rock outcroppings. Unfavorable topography is land which averages more than 20 percent slope and/or has several rock outcroppings.

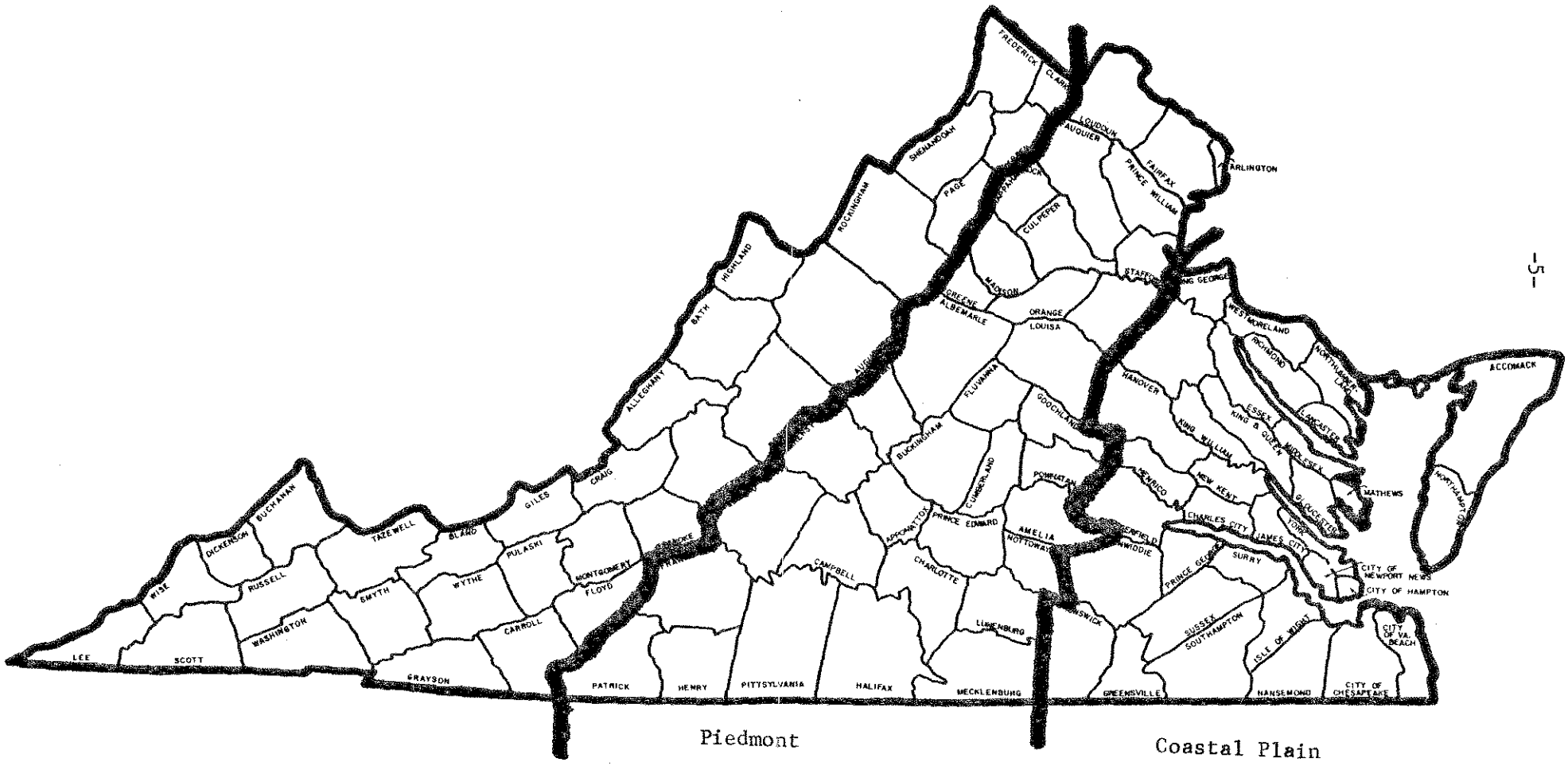
Table 1. Regeneration techniques currently employed in the Virginia Piedmont and Virginia Coastal Plain to establish loblolly pine plantations

Piedmont	
Hand poison and hand or machine plant	Burn and hand or machine plant
Scalp and machine plant	Chop, burn, and hand or machine plant
Burn and hand or machine plant	Double chop and hand or machine plant
Chop, burn, and hand or machine plant	Chop, disc and hand or machine plant
Shear, rake, pile, disc, and hand or machine plant	Double disc and hand or machine plant

data. Their information included records on costs and plantation success as well as their personal estimates of these factors. In general, the data obtained were personal judgments based upon experience and professional knowledge and backed up, whenever possible, with corporate records.

The second interviews, which lasted approximately one hour each, were all conducted on an individual basis. Whenever more than one employee of a cooperating firm participated in the study, separate interviews were conducted with each person. In total, eleven industrial foresters and one accountant participated in the study. The final portion of each interview was concerned with assuring that comparable costs were obtained from each firm. Each interviewee was specifically asked whether the cost estimates he had furnished included: seedlings, equipment depreciation, interest on equipment investment, equipment repairs, insurance, overhead costs, employment fringe benefits, direct operating costs, and transportation to and from work areas. When one of these components was not included, the estimates were adjusted, to the best of the interviewee's ability, to reflect the missing component.

Figure 1. Map showing the areas defined as the Virginia Piedmont and Virginia Coastal Plain



Results and Discussion

Average expected costs, calculated from equation (3) for those regeneration technique-opportunity combinations for which four or more cost-probability estimates were obtained, are presented in Table 2 and Table 3. A complete listing of the raw data obtained in the study is available elsewhere (1). The results give the forest landowner an indication of what he can expect to spend for loblolly pine plantation establishment.3/

When examining Tables 2 and 3, the reader may wonder why, for a given opportunity, the less expensive techniques are not used exclusively. To help explain this question, consider the opportunity: Piedmont - favorable topography, low brush, and the two techniques (1) burn-hand plant and (2) chop-burn-hand plant. The average expected costs for these two techniques are $25.15 and $44.43 per acre respectively. These costs would seem to indicate that chopping is not an economically justified regeneration technique. But, chopping is a popular technique in the Virginia Piedmont.

Part of the apparent discrepancy can be explained because it may not be possible to obtain an acceptable burn without chopping. Also, many foresters appear to believe that more intensive site preparation will result in higher yields at harvest. Examination of the data suggests at least one more possible reason (Table 4).

The data in Table 4 indicate that while it obviously costs more to include chopping in the site preparation treatment, chopping does increase the estimated probability of obtaining a successful stand. It may very well be that the inconvenience or loss of prestige associated with having to go back and re-treat an area is quite large. That is, the additional benefits associated with the higher probability of success outweigh the added costs. These benefits are, of course, difficult to quantify.

The use of management's subjective judgment as a procedure for obtaining data may be questioned. However, the alternative of collecting empirical data would have been very costly in terms of both time and money. The quantification of subjective judgment

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3/ It is interesting that in an area and an era where the use of fire and chemicals as forest management tools are becoming suspect, 17 of 24 techniques listed in Tables 2 and 3 include fire and/or chemicals. The other 7 techniques are, for the most part, either restricted to limited use or quite expensive. It would appear that the loss of fire and chemicals as forest management tools would lead to significantly increased establishment costs.

appears a reasonable avenue to obtaining data necessary for management decisions. It is particularly appropriate in those areas where empirical data are very expensive to obtain and/or tend to become out-dated rather quickly. However, additional research into procedures for obtaining such data for forestry decisions is warranted.[4/]

[4/] For a more complete discussion of the current status of developing and using subjective judgment and probability distributions see (4) and (5).

Table 2. Average expected costs, in dollars per acre, for the most frequent regeneration technique-opportunity combinations in the Piedmont

Technique--opportunity combination	Cost
Favorable topography - low brush	
Scalp and plant*	19.63
Burn and machine plant	24.75
Burn and hand plant	25.15
Hand poison and hand plant	30.76
Chop, burn, and hand plant	44.43
Chop, burn, and machine plant	47.68
Shear, rake, disc, and hand plant	83.72
Favorable topography - medium brush	
Hand poison and hand plant	41.48
Chop, burn, and hand plant	49.50
Chop, burn, and machine plant	54.26
Shear, rake, disc, and hand plant	91.42
Favorable topography - heavy brush	
Chop, burn, and hand plant	61.46
Chop, burn, and machine plant	62.12
Shear, rake, disc, and hand plant	98.36

*Generally considered applicable on the most favorable sites, such as old fields.

Table 3. Average expected costs, in dollars per acre, for the most frequent regeneration technique-opportunity combinations in the Coastal Plain

Technique-opportunity combination	Cost
Low brush - May 15-Oct. 15	
Burn and hand plant	30.51
Chop, burn, and hand plant	42.27
Medium brush - May 15-Oct. 15	
Chop, burn, and hand plant	45.79
Heavy brush - May 15-Oct. 15	
Chop, burn, and hand plant	52.00
Low brush - Mar. 1-May 15; Oct. 15-Jan. 1	
Chop, burn, and hand plant	41.06
Medium brush - Mar. 1-May 15; Oct. 15-Jan. 1	
Chop, burn, and hand plant	54.42
Heavy brush - Mar. 1-May 15; Oct. 15-Jan. 1	
Chop, burn, and hand plant	76.22
Low brush - Jan. 1-Mar. 1	
Double mechanical*, hand plant	39.37
Medium brush - Jan. 1-Mar. 1	
Double mechanical, hand plant	43.24
Heavy brush - Jan. 1-Mar. 1	
Double mechanical, hand plant	60.67

*Double chop, chop and disc, double disc.

Table 4. Estimates for costs and probability of success and expected costs for burn-hand plant and chop-burn-hand plant under favorable topography and low brush conditions in the Virginia Piedmont

Burn-hand Plant			Chop-burn-hand Plant		
Cost	Prob. of Success (percent)	Expected cost	Cost	Prob. of Success	Expected cost
16.62	95	17.49	4.12	95	43.28
16.62	65	25.57	41.12	99	41.55
16.62	90	18.47	41.12	95	43.28
16.62	60	27.70	41.12	100	41.12
30.00	75	40.00	53.38	100	53.38
19.91	100	19.91	43.35	98	44.24
20.00	60	33.33	40.00	80	50.00
25.75	100	25.75	42.15	100	42.15
20.50	90	22.77	35.28	97	36.37
20.50	100	20.50	37.33	80	46.66
			37.33	80	46.66
Averages					
20.31	83	25.15	41.21	93	44.43

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