FEASIBILITY OF HAND APPLICATION OF UREA TO FOREST LAND IN WESTERN WASHINGTON

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ABSTRACT

A large scale pilot study to determine the potential of hand fertilizing forest stands in western Washington was undertaken by the Department of Natural Resources in 1976. Tests were conducted in two major stand types of Douglas-fir (juvenile stands with voids and openings and older open grown stands), where two hand spreading techniques (broadcast and individual tree fertilization) and two types of work crews (contract and DNR) were evaluated. During the study manhours of the various job-related activities were recorded and costs determined. A total of 634 acres was treated and costs ranged from $36.95 to $126.42 per acre and averaged $81.74 per acre (1976 dollars). Costs varied because of stand type which influenced the fertilizer rate and crew type which influenced the application cost. Based on units treated in this study and assuming similar conditions, estimates of hand fertilization costs for an operational fertilization project where stand conditions would allow for a reduced fertilizer rate (individual tree fertilization) would be approximately $52 per acre at the rate of 330 pounds of urea and $42 per acre at the rate of 220 pounds of urea. This compares to costs of $61 per acre for hand broadcast application at 440 pounds of urea and $56 per acre for aerial application at the same rate. Therefore, where stand conditions allow for a reduced rate of fertilizer, hand application could be a more inviting alternative to the normal procedure of aerial application.

INTRODUCTION

In the Pacific Northwest, aerial application of urea fertilizer by helicopter has become a standard practice on many forest ownerships. The Department of Natural Resources (DNR) has been actively involved in aerial fertilization since 1968, and has fertilized over 170,000 acres during the last 10 yr. Although aerial application has been efficient, hand spreading may be desirable under certain conditions. Such conditions may be where fertilizer units are small, scattered geographically, or remotely located from access roads, thus making helicopter application costs high, or where stands are understocked or open grown and helicopter application could result in wasted fertilizer.

To determine the potential of hand fertilizing forest stands in western Washington, a large pilot study was conducted by the DNR during the fall of 1976. The hand application procedures consisted of developing a grid layout for a particular unit, flagging locations for stock piling the fertilizer, placement of the 80-lb fertilizer bags, and spreading the fertilizer.

In this study, urea fertilizer was applied to 634 acres of Douglas-fir. Variables studied were two hand spreading techniques, two types of work crews, and two stand types.

The specific objectives of the study were to record manhours involved in the various job-related aspects of hand fertilization and to determine costs.

METHODS

STAND TYPE

Tests were conducted in two extensive stand types of Douglas-fir; juvenile stands (10–30 yr) with numerous voids and openings, and older open grown stands of a commercially thinnable age (40–70 yr). These stand types were selected because their open grown condition provided accessibility and broadcast application by helicopter would be less efficient. The range of physical characteristics of the units treated in this study can be seen in Table 1.

CREW TYPE

Two types of labor were used; DNR employees and contract crews. Contract crews were responsible for moving the fer-

Table 1. Range of physical characteristics of treated units.

Unit size (acres)	Age (yr)	Trees/acre (No.)	Slope (%)
4–72	10–65	45–650	0–30
Brush and/or slash condition		Little to heavy	

tilizer bags from railroad cars at several railheads to either centrally located storage areas, or directly to the fertilizer units. Placement of the fertilizer bags at the units and fertilizer application was done by either DNR or contract crews.

FERTILIZER

Urea (46% N) was used and was delivered in 80-lb bags of 6-mil polyethylene which was heat sealed.

STAND SURVEY

Prior to establishing the specific units included in this hand fertilizer trial, candidate areas were surveyed to determine unit size, number of stems to be fertilized, and equipment accessibility problems within the unit. Based on this initial survey, the type of hand spreading technique to be utilized was determined, and the amount of fertilizer required to accomplish the job was calculated.

GRID LAYOUT

Each unit was flagged in a uniform pattern. Unit boundaries were flagged as well as interior grid lines. Drop points for fertilizer were designated at this time.

PLACEMENT METHODS

The 80-lb fertilizer bags were next placed at the designated grid points. A number of alternative methods were employed. These were:

1. The use of a small tractor with a wheel trailer. The tractor and trailer followed the predetermined grid lines, where fertilizer sacks were hand carried to the flagged bag drops. The tractor and trailer was capable of carrying 25 to 30 bags per trip and experienced little difficulty in maneuvering through dense stands.
2. Use of a small tractor with a front end scoop. This equipment was capable of carrying five to six bags per trip. The fertilizer bags were hand carried to the drop points.
3. Use of a small tractor with a sled. Two different sleds were designed by the Department that were capable of carrying 20 to 30 bags per trip. However, because of design problems, these sleds consistently would hang up in the brush or debris on a fertilizer unit, and their use was discontinued early in the study.
4. A helicopter using a specially designed sling capable of carrying six bags per trip was evaluated on several units. The fertilizer bags were dropped at marked spots and then hand carried from the drop location to the flagged grid points. This technique was evaluated because of concerns of ground equipment causing excessive stand damage. However, the usual procedure would be to aerially apply the fertilizer if a helicopter was available.
5. Another method utilized trucks to haul the fertilizer bags along an existing road system within the unit and the fertilizer was hand carried from the road edge to the flagged grid points.
6. Although not utilized in this study, the use of a tree toter by the Department in earlier trials with hand fertilization showed that under some conditions (relatively flat terrain, little slash or debris on the ground, etc.) this equipment could be modified to haul 15 to 20 fertilizer bags per trip.

SPREADING THE FERTILIZER

Special equipment was designed for spreading the fertilizer. Tree planting bags were modified to hold 20 to 30 lb of urea. Small scoops were utilized for actual spreading. These scoops carried approximately ¼ lb of fertilizer and provided a calibrated amount when individual trees were fertilized. Although not used in this study, earlier hand fertilization trials by the Department had made use of a backpack whirlybird spreader. This was not utilized in the present study, however, because of past experience with down time and equipment maintenance problems.

Two types of spreading techniques were followed; broadcast and individual tree fertilization. Broadcast fertilization was utilized if the stand was fully stocked and/or the canopy would close in 5 yr or less. This involved evenly distributing the fertilizer over the unit at the rate of 440 lb urea/acre.

Individual tree fertilization was utilized if the stand was understocked, had numerous voids and openings, and/or had a large amount of variation in the size of the trees in the stand. Individual tree fertilization resulted in a reduced rate of fertilizer from the broadcast rate of 440 lb urea/acre. In individual tree fertilization, the rate of urea per tree was based on the tree diameter (dbh). For example, trees 4–7 in. dbh would require 1 lb urea/tree, while trees 14–19 in. dbh would require 4 lb urea/tree. The fertilizer was uniformly distributed in the area formed by the crown drip line and the tree stem.

COSTS

In order to determine the cost effectiveness of hand fertilization, accurate records of manhours were kept for both DNR and contract crews. These were broken down by the time spent in surveying the stands, grid layout, fertilizer placement, spreading the fertilizer, and administrative costs such as compliance, meetings, office calculations, etc. Fertilizer and equipment costs were also recorded.

RESULTS AND DISCUSSION

Of the 634 acres fertilized in this study, 303 acres were in the young age class and 331 acres were in the older age group.

Individual tree fertilization was done on 252 acres and 382 acres were broadcast fertilized.

The breakdown of manhours and costs associated with the various job categories is shown in Table 2. This shows that actual working time spent in hand fertilization was 4.53 manhours/acre and increased to 6.14 manhours/acre when travel time and rest breaks were included (nonproductive time). Total cost average $81.74/acre with labor (total manhour/acre) and fertilizer costs included.

The change in manhours spent in fertilizer placement and spreading between total manhours and working manhours is accounted for by the greater amount of time required to do these two jobs and, therefore, the greater time required traveling to the units to accomplish these jobs. For example, placement of fertilizer required twice the amount of time when travel was added to working time, 0.63 manhours/acre working time versus 1.21 manhours/acre total time (Table 2).

The costs of hand application by job categories does not follow the trend of project breakdown by manhours (Table 2). The percentage breakdown changes with costs, compared to manhours, because of equipment costs associated with fertilizer placement. Thus, while spreading took by far the most manhours to perform, fertilizer placement was the greater part of the application cost. When introducing the cost of fertilizer into the picture, the percentage breakdown again changes. The cost of the fertilizer accounts for 46% of the project costs.

The average cost of hand fertilization as well as the range in cost, based on all units, can be seen in Table 3. Total costs (including fertilizer) ranged from $36.95 to $126.24/acre, and averaged $81.74/acre (1976 dollars).

The type of placement crew (DNR vs. contract) affected the cost of hand fertilization (Table 4). Although the costs for contract placement crews was higher than DNR crews, the manhours spent by the two crew types varied little; 1.27 manhours contract, 1.17 manhours DNR. This cost difference was due to (1) excessive travel distance between units for contract crews, (2) uncertainties as to the amount of time each unit would take to complete as well as unforeseen down time, and (3) no real precedent for costs associated with this type of job, which is reflected in the bid price from the contractor. Helicopter placement was competitive with crew placement, although previous estimates by the Department would indicate that the helicopter would be an expensive means for fertilizer placement (Table 4).

Based on the units treated in this study and assuming similar conditions, an estimate of manhours and costs can be made for

Table 2. Manhours and costs by job categories. Average of all treatments. Costs in 1976 dollars.

	Labor				Costs			
	Actual working time[a] MH/acre	%	Total MH/acre	%	Labor and equipment $/acre	%	Total $/acre	%
Survey	0.13	3	0.20	3	0.95	2	0.95	1
Layout	0.65	14	0.87	14	5.36	14	5.36	7
Placement	0.63	14	1.21	20	17.05	44	17.05	24
Spreading	2.91	64	3.60	59	13.90	35	13.90	19
Admin.	0.21	5	0.26	4	1.97	5	1.97	3
Fertilizer							32.51	46
Total	4.53	100%	6.14	100%	$49.23	100%	$81.74	100%

[a]Total manhours less travel and rest breaks.

Table 3. Hand fertilization cost summary of all units. Cost per acre in 1976 dollars.

	Low	Average	High
Application	$19.53	$49.23	$76.76
Fertilizer	17.42	32.51	49.66
Total	36.95	81.74	126.42

Table 4. Cost summary by type of fertilizer placement (1976 dollars).

Type	Application cost $/acre
Contract crew	$53.87
DNR crew	23.72
Helicopter	47.62

an operational project (Table 5). This shows that a typical job would require approximately 4.15 manhours/acre and cost approximately $23.75/acre (1976 dollars).

Since the rate of fertilizer has a significant effect on the total cost of fertilization, then those stand conditions which allow for a reduction in the amount of fertilizer, such as individual tree fertilization, make hand application a more inviting alternative compared to an aerial application (Table 6). In these cases the cost of fertilization could be reduced by approximately $13.00/acre. if the fertilizer rate utilized in a hand fertilization project was reduced to 220 lb urea/acre.

We conclude then that in some situations, hand fertilization could be a practical, economical, and operationally feasible technique for fertilizing forest stands in western Washington.

Table 5. Estimated manhours and costs per acre for an operational hand fertilization project based on moderate size units of about 40 acres.

Job category	Manhours/acre	Cost/acre[a]
Stand survey	0.15	$ 0.75
Grid layout	0.50	3.00
Placement	0.75	10.00
Spreading	2.50	8.00
Administration	0.25	2.00
Total	4.15	23.75

[a]Includes labor and equipment costs.

Table 6. Estimated total cost per acre for an operation-fertilization project.

Fertilization technique	lb urea/acre[a] 220	330	440
Hand broadcast[b]			$61.15
Individual tree[b]	$42.45	$51.80	
Aerial broadcast[c]			55.55

[a]Urea at $0.085/lb. [b]Application costs based on figures shown in Table 5. [c]Cost of aerial application calculated for a large scale project conducted by DNR during the 1976–1977 season.