Some Machines and Methods For Removal and Control of Brush

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Introduction

Oklahoma has several million acres of land infested with brush. In many areas, brush is increasing in density and is encroaching upon nearby fields and pastures. It is estimated that the productivity of two to five million acres could be increased by brush removal and/or control practices.

The density, height and species of brush encountered in the state is extremely variable. The capabilities or potential of this brush covered land is equally variable, but inherent capability should be the basis upon which brush removal decisions are made. Knowledge of topography, soil type (erodability), and fertility will generally determine the productive potential of the cleared land.

Because of the variability of brush covered land, there is no one (best) method of brush control to fit all circumstances. Effective brush control will generally be the result of a combination of methods and machines. This combination will be determined by the type of brush, topography, soil type, and the selection of equipment available.

Clearing and Control Methods Tested

Brush removal or land clearing is commonly thought of as removal of all the brushy growth. This involves the removal and disposal of the large trees, which is both difficult and expensive. A system of selective removal, wherein only the smaller sizes of trees and brush are removed, may provide some advantage over complete removal. Following selective removal, the area should be clear enough to allow equipment to move among the remaining trees to perform the desired tillage, fertilizing or seeding operations. The remaining trees can be poisoned or removed individually if necessary. The overall effects of selective removal are to reduce the size of equipment needed to clear the land as well as to reduce the cost of the operation.

This bulletin contains the description, method of use, and results of tests made with several machines. All work was done on land covered with brushy growth consisting largely of blackjack and post oak.

Blower-Sprayer

The main use for blower-sprayers is in applying spray materials to tree foliage. As the name implies, blower-sprayers utilize a high velocity air stream to carry the spray droplets to the foliage. A schematic diagram of the experimental blower-sprayer used in the tests is shown in Figure 1.

A 30-horsepower, four-cylinder, air-cooled engine supplied power to the fan and piston pump. The

45-inch diameter centrifugal fan delivered air at an average velocity of 13,000 feet per minute against a static pressure of one inch of water. The fan was mounted so that the discharge could be turned through 120 degrees to provide control of the air stream direction. Adequate ground clearance, compactness, and suitable shielding were features incorporated to facilitate maneuverability of the machine in the brush.

A series of 40 x 40 foot plots with a ten-foot strip between each plot was laid out and access alleys cut to permit sprayer movement. Spray materials were applied on the plots in February, March, May, and June to check the effect of time of application. Machine variables for each time of application included the rate of carrier material (5, 10, and 20 gallons of diesel oil per acre) and operating pressure (100, 250, and 400 pounds per square inch). A mixture of ⅔ 2,4-D and ⅓ 2,4,5-T was applied at the rate of three pounds per acre. All plots were sprayed in 1951. Two plots of each series of three were retreated in 1952, and one-half of these plots were retreated in 1953.

Evaluation and Results

Treatments were evaluated on the basis of regrowth, sprouting, and percent kill. The applications

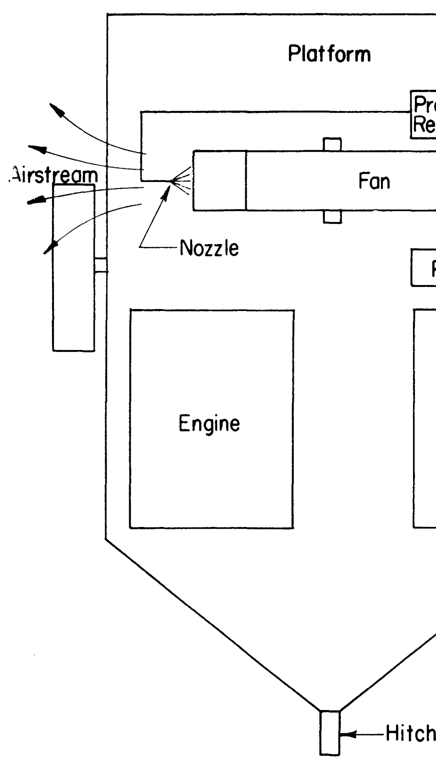

Fig. 1. Schematic diagram of the blower sprayer.

made during February and March showed little or no evidence of controlling the brush. Slightly better results were obtained from the May application. The best results were obtained from the late June application. The June application did not produce a complete kill, but some individual trees and parts of trees were killed.

Resprouting was in evidence on all of the plots. No important difference was found among the various carrier rates and operating pressures as they influenced the control of brush. Observations on the plots retreated in 1952 and 1953 showed an increase in the amount of dead brush. Complete kill was not effected, however, even with three successive treatments. Resprouting remained a serious problem.

Conclusions.

Satisfactory foliage coverage can be obtained 40 to 50 feet from the machine, depending upon the density of the foliage. Because complete kill was not obtained, periodic retreatments would be necessary to control the resprouting. In order to spray a large area covered with a dense uniform growth, it would be necessary to cut access paths about 75 feet apart for the machine to follow. No specific recommendations can be made regarding the best combination of pressure and carrier rate.

Wood Chipper

A study of the portable wood chipper was initiated to evaluate the labor requirement, machine requirement, cost and technique of operation when used as a means of brush disposal for land clearing purposes.

A cylinder-type wood chipper (Figure 2) was used in these studies. The knives were mounted on a cylinder that rotates at approximately 2200 RPM. Each blade cuts a slice from the wood being fed into the machine. As the cutting by one blade occurs, the wood is drawn into the machine and engaged by the next blade. Thus, a piece of wood that was engaged by the cutting knives would be drawn into the chipper and the chips discharged through a chute to the side or rear of the machine. The throat opening determines the maximum tree size which can be chipped.

The main adjustment on the chipper was the knife setting which regulated the chip size (thickness) produced. The maximum knife

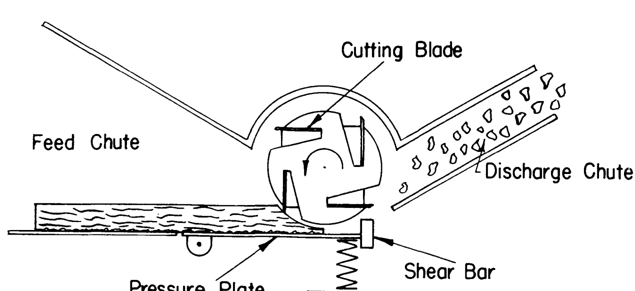

Fig. 2. Schematic diagram of the wood chipper.

setting or length of knife exposed above the surface of the cylinder was 3/16 inch. Proper tension of the pressure plate springs was important for automatic feeding of different sizes of wood.

The chipper was mounted on the front of a 40-horsepower (belt) row-crop tractor. Power was supplied through a V-belt drive from the tractor belt pulley. Chips were discharged to the side of the unit.

Preliminary tests with the chipper were concerned with determining the machine performance under different operating conditions.

The chipper was found to be inconsistent in its ability to draw trimmed poles into the machine automatically using knife blades ground to a 45-degree angle. Wear was observed on the heel of the blades, indicating that the wood was not advancing far enough into the chipper to be engaged solidly by the next knife. The results of a test using blades with 30-, 40- and 45-degree angles showed that the blades with the 40-degree bevel performed the best and remained keen the longest when chipping poles. There was no difference in performance among blade angles when chipping brush trimmings. Regardless of the condition of the knives, if the brush was properly trimmed, it would be drawn into the machine once it was engaged by the knives. When chipping brush, careful trimming was necessary to eliminate branches that projected at right angles to the main stems. Considerable time was lost trying to get poorly trimmed brush to feed automatically.

A two-man crew feeding the chipper proved to be the most effective. One man feeding the chipper had to work steady to keep it busy; and if he had to carry the wood any distance to the machine, the chip production rate would decrease appreciably. With more than two men feeding, interference and delay resulted in poor labor efficiency.

Because considerable dust was produced while the chipper was working, it was necessary for the crew to wear goggles. In some instances dust respirators were used when the wind would not blow the dust away from the machine. Each man was equipped with gauntlet gloves and wore a long-sleeved shirt to prevent the brush from scratching the hands, wrists and arms.

Field testing of the chipper consisted of selective clearing operations and chipping on thirteen 0.1 acre plots. Brush and small trees (up to about 4 inches diameter) on the plots were sawed, trimmed and processed through the chipper.

The plots selected for the tests were paired, with each pair having about the same type and amount of growth. Plot selection was based upon the tree counts on the areas and the estimated amount of chippable wood available. Table I.

The plots were sawed with a portable circular saw mounted on wheels and equipped with a power drive. Two men were required for this operation. All trimming was done with hand axes. Care was taken during trimming to remove any side branches that would interfere with the feeding of the chipper. The brush and trimmed poles were piled separately and oriented to minimize the picking and carrying time when feeding the chipper and to decrease the number of moves the chipper would have to make.

TABLE I—Summary of Chipper Field Tests

Plot	Tree Count— Number of Stems per 1/10 Acre: Original Stand 1*	2*	3*	After Chipping 1*	2*	3*	Chip Yield tons/acre	Prepara ion Labor Man Hours Per Acre: Saw	Trim	Chipping Man Hours Per Acre	Total Labor Man Hours Per Acre	Average Chip Production Rate-Tons/Hr.
M-3	21	20	25	0	6	25	2.01	2.30	1.00	7.00	10.30	.575
M-6	31	15	23	0	0	11	1.52	1.67	2.33	5.33	9.33	.570
K-1	102	21	21	3	7	17	3.47	5.00	1.83	11.67	18.50	.595
L-8	93	19	21	9	1	14	4.08	7.83	9.00	15.67	32.50	.520
L-4	84	29	19	0	5	15	2.82	3.67	6.67	13.70	24.04	.411
J-4	90	30	27	0	11	24	2.01	5.00	9.33	6.16	20.49	.654
M-7	100	38	25	11	5	16	4.07	4.33	11.33	11.67	27.33	.735
L-1	125	38	23	3	1	22	4.79	7.33	13.33	13.00	33.66	.737
I-2	150	54	45	0	16	21	3.32	6.67	9.00	5.63	21.30	1.180
I-5	140	52	32	1	9	18	6.19	8.00	12.67	12.13	32.80	1.020
J-11	69	95	52	9	49	36	11.90	16.00	35.00	17.87	68.87	1.330
I-11	78	102	50	4	49	23	9.15	13.00	26.00	18.40	57.40	.995
J-3	131	60	26	0	8	12	12.39	----	58.33	37.33	95.66	.664

* Numbers refer to size class as follows:
1 = 0 — 2″ diameter
2 = 2 — 4″ diameter
3 = 4″ and over in diameter

On several plots, the sawing, trimming and chipping was done simultaneously. This did not work satisfactorily for two reasons. First, it was found that the chipper was able to process the brush faster than it could be sawed and trimmed; and, second, a crew of six was necessary for the operation. On the remaining plots, sawing and trimming operations were done separately and more care was taken in clean trimming and careful piling.

Results of Field Tests.

Chip yield, chip production rate, labor and machine requirements are shown in Table I. The chip production rate shows a marked increase for the plots with most growth. The low production rate for some plots was due to chipping a greater proportion of small stems and brush trimmings. On other plots, the growth was largely tall, slender trees with few side branches. The wood chipped from these plots consisted of trimmed poles (which chip rapidly) and a small amount of trimmings. Plot J-3 shows high machine and labor requirement because of the nature of the growth and the method of piling. Much of the growth on this plot consisted of small trees (of a chippable size) with considerable side branching. Thus, a greater proportion of trimmings was processed which slowed the chipping operation. Also, the trimmings and trimmed poles were piled together, a factor that slowed the operation further.

Samples of chips produced from trimmed poles and brush trimmings are shown in figure 3. The trimmed pole chips shown would be satisfactory for mulching purposes but are probably too coarse

Fig. 3. Samples of chips produced from trimmed poles (left) and brush trimmings (right).

and thick to make good livestock bedding. The chips from brush trimmings would be unsatisfactory for bedding purposes because of the sharp-pointed ends of the twigs and because of the low absorbency. The best use for these chips would be as mulch or as a source of soil organic matter. The chips were not produced in sufficient quantities during the tests to make utilization studies. Thus, no information is available as to the actual or potential value of the chips.

Conclusions.

The main factor limiting the use of the chipper for brush disposal was the amount of labor necessary to saw, trim and pile the brush for chipping. Wood chip utilization may justify part of the high labor input for this method.

Heavy Duty Stalk Shredder

A heavy duty stalk shredder was evaluated as a means of selective brush removal. A tractor-mounted shredder (Figure 4) was selected for this work because of its maneuverability. A blade carrier supported four twelve-inch blades. The two blades on each end of the blade carrier were spaced six inches apart vertically. The blade tip circle measured 57 inches in diameter. Power was supplied to the blades from the tractor power-take-off shaft through universal joints and a 1 to 1 gear box. Height of cut was controlled by both the hydraulic lift and the setting of the shredder gauge shoes.

Several modifications were made

Fig. 4. Tractor mounted shredder unit.

on the original shredder to make it more effective for this work. Part of the shielding at the rear of the shredder was cut away so that the unit could move backward as well as forward without the shielding bending inward and becoming fouled in the blades. A bumper was added to the shredder to push and bend the growth when backing. This bumper was attached to the rear axle housing on the tractor and was supported by guides at the rear of the shredder. The method of attaching the lower blades to the blade carrier was revised. In some preliminary work

brush would pass into the shredder more readily.

Two different tractors were used to power the shredder during operation. A summary of the operating characteristics of these tractors is shown in Table II.

The advance per knife cut with tractor A was fixed as this tractor did not have a "live" power-take-off (PTO). Tractor B, however, was equipped with a "live" PTO and the advance per knife cut could be varied from 0 to 0.9 or 1.2 inches.

Tractor A was used to remove

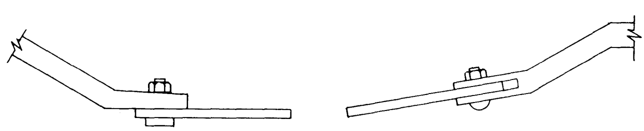

Fig. 5. Schematic diagram of blade mounting systems.

with the shredder, frequent stoppage was necessary because of failure of the bolts attaching the blades to the blade carrier. The original offset knife blade mounting was replaced by a yoke arrangement. (Figure 5). The blade was inclined at an angle of 15° which provided clearance for the bolt head.

Suitable shielding was provided on the tractor around the operator to protect against wood fragments that would occasionally come out of the front of the shredder and from branches when moving through dense growth.

Other tractor shielding included a front bumper, radiator shield, and valve stem protectors. Rear wheel spacing was increased so shreddable growth from 13 one-tenth acre plots. Plot selection was based on counts (Table III) and observations as to the distribution and arrangement of the larger growth. Because of the arrangement of the larger growth, four plots were sawed first and then shredded. On these plots, the growth was either in clumps with 4 to 8 stems per clump or was so dense that the tractor and shredder were not able to get through the growth. After trees too large for the shredder were sawed, it was thought that the shredder could be effectively used to dispose of

TABLE II—Operating Characteristics of the Tractors Used With the Shredder.

Tractor	Gear	PTO (rpm)	Ground Speed (mph)	Shredder Advance per knife cut (inches)	Shredder Blade Tip Speed (ft/min.)
A	Low-Forward	690	3.25	2.5	10,300
	Reverse	690	3.41	2.6	10,300
B	Low-Forward	720	1.23	0.9	10,700
	Low Reverse	720	1.64	1.2	10,700

the small brush, limbs and tops of the trees.

Tractor B was used with the shredder to remove the shreddable growth from a two acre plot.

Results of Shredder Tests.

The effectiveness of the shredder was reduced because tractor A did not have sufficient power to maintain blade speed and to propel the unit under difficult conditions. When traveling up a slope or when pushing over the growth, most of the tractor's power was used to move the tractor and shredder. As a result, the engine speed and knife speed would decrease and the engine would stall unless declutched. With the inadequate power supply, it was difficult to keep the blades rotating at a speed where good cutting and shredding action was obtained. With the shredder advancing 2.5 inches per blade cut, the resistance of the wood was larger than the force available to carry the blade through the cut. In heavy cutting, this reduced the blade speed rapidly. High impact loading on the power train along with poor cutting action resulted from slow blade speed.

Maneuvering among trees too large to shred was not difficult with this unit. The shielding and bumpers on the tractor offered adequate protection to both the operator and tractor.

No blade carrier bolt failures have occurred since installing the yoke type of blade mounting, although some blade breakage has been experienced.

A summary of the plots shredded with Tractor A is shown in Table III.

To clear the plots of the shreddable growth required an average of 6 shredder-hours per acre. About 50 percent of the operating time was spent in idle travel (turning, backing, gaining position), starting the stalled engine, and removing stems lodged in the shredder blade carried. The majority of the growth shredded was under four inches in diameter. In general, anything that was pushed over by the tractor was shredded. On the larger growth, the shredding consisted mainly of removing the top and side branches, leaving the limbed trunks on the ground. The stumps were left fractured and split near the ground line.

Conclusion

Sawing the growth, then shredding, did not prove satisfactory. The tractor and shredder were not

TABLE III—Summary of Plots Shredded

A. With Shredder Only

Plot	Tree Stands* Original 1 - 2 - 3	Tree Stands* Final 1 - 2 - 3	% of Unproductive Time	Shredder Hours Per Acre **
I-4	269-33-17	6-16-14	53.9	4.33
K-2	152-37-32	5-16-24	43.0	9.50
I-1	215-29-28	3- 7-18	42.4	5.50
J-5	109-27-20	1- 4-16	50.0	5.00
L-7	169-40-31	3- 8-22	60.0	4.17
J-2	119-41-31	4- 8-29	49.0	7.84
I-3	139-43-27	1-11- 9	50.0	6.34
M-1	180-93-36	20-44-24	53.3	5.00
M-2	117-69-45	20-22-13	58.6	5.84

B. Plots Sawed Then Shredded

Plot	Tree Stand* Original 1 - 2 - 3	Tree Stand* Final 1 - 2 - 3	Saw Hrs/Acre	Saw & Trim Man Hours Per Acre	Shredder Hour Per Acre**
J-1	123-39-35	0-0-15	7.00	18.00	5.00
I-9	123-23-34	0-2-10	6.34	36.66	2.17
I-10	215-29-34	0-0-14	6.00	35.00	2.33
J-7	85-79-30	0-0-15	4.34	23.33	1.33

* Refers to the number of trees in each plot of the size classes as follows:
1 = 0 — 2 inches in diameter
2 = 2 — 4 inches in diameter
3 = 4 and over inches in diameter
** Not including breakdown time.

able to get over, around, or through the fallen growth to shred the limbs. Thus, on these plots hand trimming was necessary to remove the branches from the large trees. Once the trees were trimmed, the brush was easily and quickly shredded.

Although the use of tractor B, with a "live" PTO and slower ground speeds, improved the versatility of the shredder, the overall productive capacity was not materially increased. Several factors might account for this. Because of the improved performance of the shredder, a greater percentage of the brush was shredded. Also, more time was spent in complete fragmentation of tree tops and trunks. The slower ground speeds may have contributed to the time lost in turning and gaining position. When tractor B was used on the two-acre plot, 6 shredder hours per acre were required to dispose of the shreddable growth. This is comparable to the performance of tractor A.

Tree Pulling

Three men, a 27-horsepower (drawbar) tractor and a one-half inch chain 25 feet long were used to uproot trees on a 1/4 acre plot. The chain was attached to the trees as high as the crew men could reach. The traction of the rear tractor tires was reduced by attaching high on the trees, but they could be uprooted with less pull on the chain. After clearing, the area was divided into plots to determine the effect of tillage treatments on resprouting. Treatments included disk harrowing, disk plowing, and a check area.

Ten hours were required to clear the 1/4 acre of brush which averaged 1,892 trees per acre ranging in size from two to eight inches in diameter. About 25 percent of the trees broke above or at the ground surface. These stumps were removed by sawing. Most effective pulling can be accomplished when the soil moisture conditions are such that sufficient traction can be obtained and when the roots will pull easily. Pulling brush with a tractor is slow, tedious, and expensive. The high labor requirement of this method limits its usefulness as a means of brush removal.

The results of the tillage treatments on resprouting are shown in the following table:

Treatment	Sprouts Per Acre	% of Untreated
Untreated	18,200	100.0
Disk Harrowed	17,500	96.0
Disk Harrowed & Disk Plowed	7,210	39.6

Bulldozer

A bulldozer with a ten-foot blade was used for clearing three acres of blackjack and post oak brush. This area had an average of 1,808 trees per acre, varying from one to fourteen inches in diameter. The land was cleared in six and one half hours at a cost of $50.

It was difficult to uproot trees under three inches in diameter with the bulldozer. These smaller trees bent and broke rather than being uprooted. The larger trees were uprooted without difficulty and were pushed into a windrow around the perimeter of the cleared area. The ground was left in a very rough condition after the trees had been removed. Considerable soil was attached to the tree roots and mixed in among the trees in the windrow. It has been found elsewhere that twice as much time is required for windrowing as is required for uprooting (1).

The cleared area was divided into five plots to study the effect of tillage methods on resprouting. Four of the plots were disk harrowed twice with a tandem disk harrow, while the fifth plot was

(1) Hall, R. A., "Brush Control With Heavy Machinery," Agricultural Engineering Journal, Vol. 27, No. 10, October 1946.

left undisturbed. Disk harrowing leveled the surface. Two of the plots were then plowed with a disk plow and disk harrowed again. During the middle of the growing season following the clearing, sprout counts were made on the plots and the results are listed in the following table:

Treatment	Sprouts Per Acre	% of Untreated
Untreated	17,100	100.0
Disk Harrowed	11,250	65.8
Disk Harrowed & Disk Plowed	6,360	37.2

Tree Shear

A shear powered by a hydraulic cylinder was used to cut trees. A diagram of the tree shear used is shown in figure 6.

The hydraulic cylinder was used to push the blade horizontally through a tree. From laboratory experiments, it was found that 6,000 to 8,000 pounds of force were required to push a ½ inch blade with a 45-degree bevel, through green blackjack and post oak poles three to four inches in diameter.

Limitations found in the use of the shear were (a) insufficient operating pressure of the tractor hydraulic sysetms, (b) lack of a rapid means of getting the shear into operating position and (c) portability. Considerable development would be required on a blade design, an automatic latching mechanism, and method of transporting the shear before it would be practical.

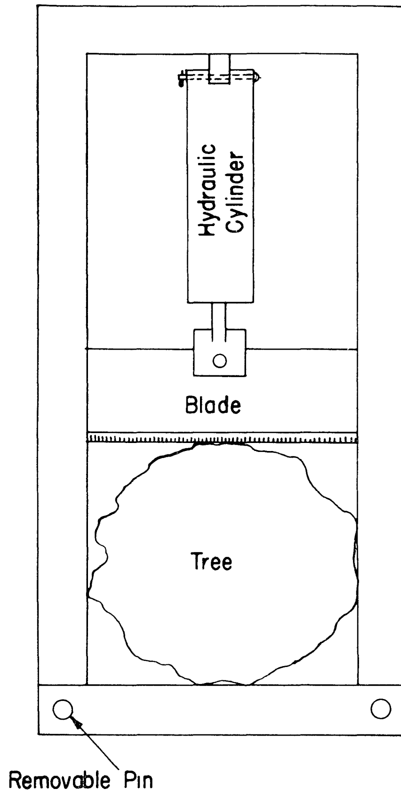

Fig. 6. Schematic diagram of a tree shear.

Broach

Broaching was tried as a means for cutting trees. The operation of broaching consists of removing material by pushing or pulling a tool across a surface. The tool is called a broach and has a number of teeth or cutting edges, each tooth being slightly longer than the preceding. As the broach crosses the surface, each tooth removes a chip of material. Broaching differs from sawing in that all the cutting is done in one pass of the tool.

A tree broaching device was designed and constructed as shown in figure 7. The tooth spacing and side bar angle were designed so that each tooth would remove approximately the same volume of wood when passing through a tree. The space between the teeth provided a place for the removed wood to accumulate. The teeth were flared out at the tip to provide relief for the tooth body and side bar.

In preliminary field tests, the broach was pulled with a tractor. It was found that the unit was not self-centering. The teeth on one side digging deeper into the tree than the teeth on the other side caused the side bars to be bent. Better results were obtained when broaching from only one side of the tree.

Because the use of this device did not show particular promise without a considerable amount of development, further work was discontinued.

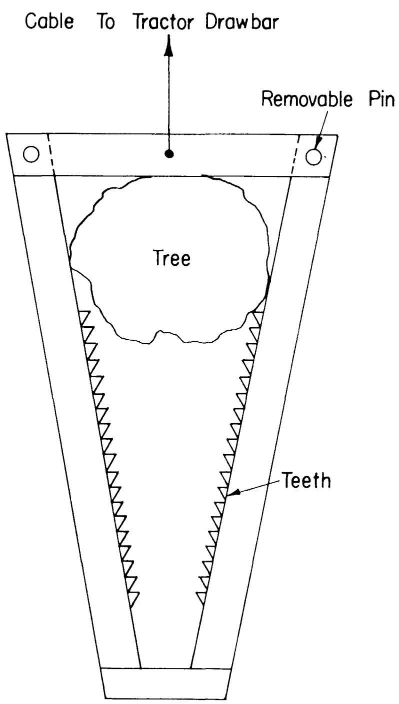

Fig. 7. Schematic diagram of a tree broach.

Boomless Sprayer

Preliminary investigations were made in developing a tractor mounted boomless-type foliage sprayer to simulate airplane spraying.

The tractor mounted sprayer was constructed as shown in figure 8. The sprayer consisted essentially of two boomless-type nozzles attached to the top of a 15-foot pipe mounted on the rear of a tractor. The spray solution moved up the pipe under pressure to the nozzles. Shielding was provided for the tractor, operator and nozzles to facilitate movement in dense growth. Both spray nozzles were mounted to discharge on the same side of the tractor and were adjustable to produce different spray patterns.

Preliminary field work with the sprayer showed the maneuverability to be good with little trouble occurring due to the nozzles and the top of the mast becoming entangled in branches. It was soon apparent that the nozzles were not mounted high enough to apply the spray to the taller trees. Observation of the areas where chemical (2,4,5-T at 3 pounds per acre in fifty gallons per acre of diesel oil) had been applied showed the sprayer to be quite ineffective in distributing the spray. No difference was observed as a result of different nozzle positions. Penetration of the spray into the foliage was slight and areas where the spray had apparently missed the foliage were

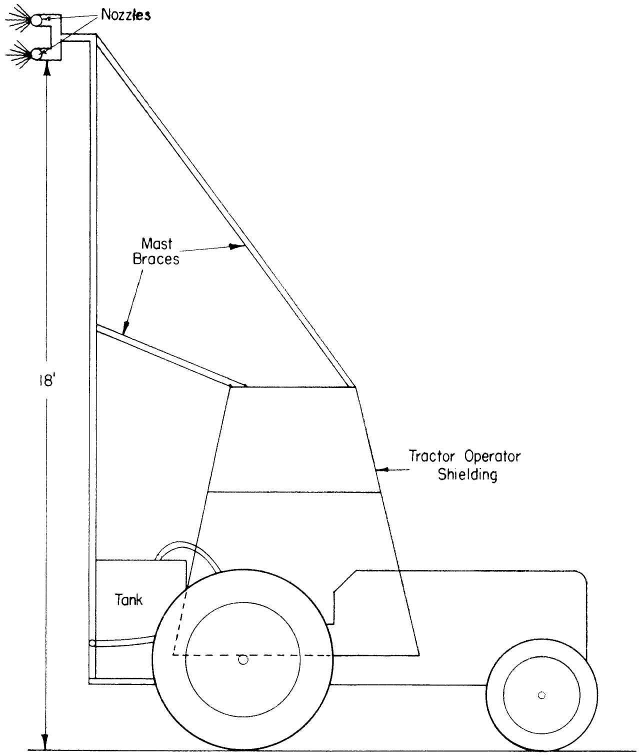

Fig. 8. Schematic diagram of the boomless sprayer.

frequent. The effective swath width was approximately fifteen feet (on one side of the tractor) with a nozzle pressure of sixty pounds per square inch.

The results of these preliminary tests did not show sufficient promise to warrant further development.

Portable Circular and Chain Saws

Both circular- and chain-type saws were used where sawing was required in the test work. No measurements were taken on the performance of these saws. The information reported here is based on observation and experience in using the saws.

The productive capacity of both types of saws depends largely on the type and amount of growth, and the skill and stamina of the operators. The presence of small brushy growth among the larger trees hinders the sawing operation. These machines can be used to the best advantage where the underbrush has been removed prior to sawing. Keeping the cutting edges of the saws sharp will help to prevent excessive strain

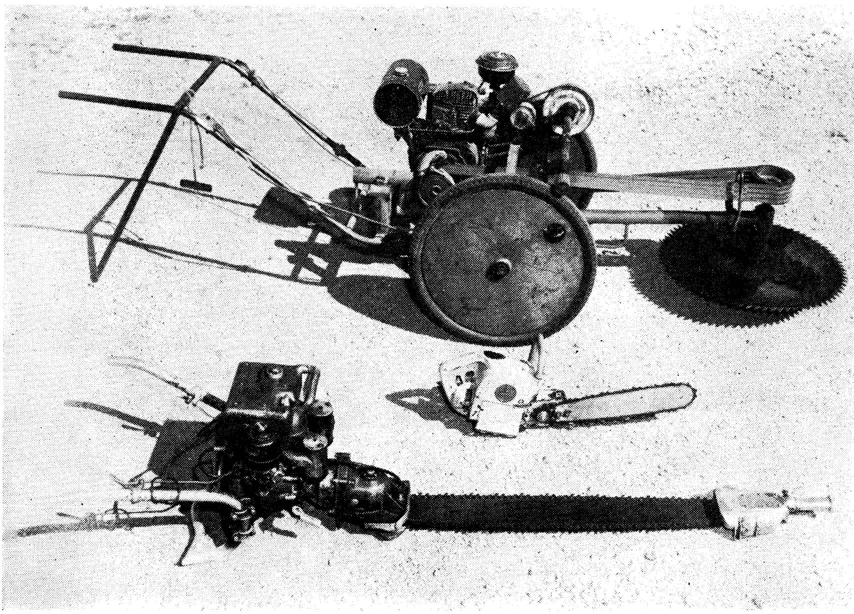

Fig. 9. Three saws used in brush control work, are portable circle saw, top, one man chain saw, center, and two man chain saw, bottom.

on both the equipment and the operators.

The use of a portable circular saw is essentially a two-man job. One man is required to operate the saw and another man to aid in felling the tree. Cox (1) found the labor requirement to vary from 22.7 to 35.5 man hours per acre using a portable circular saw and a four-man crew. Caution must be exercised by the helper to keep well away from the rotating saw blade. A long pole will aid in felling the trees away from the saw. The trees should be felled away from the uncut growth, providing an uncluttered space for maneuvering the saw.

A ground wheel power drive system is helpful to the operator if the saw is heavy and the terrain uneven. Some care in properly orienting the saw to a tree before starting to saw will aid in preventing the blade from pinching. Pinching not only slows the operation, but also takes the set out of the saw teeth. It is difficult to keep the blade of a circular saw sharp and in good condition when operating close to the ground where dirt and stones may be encountered.

Effective operation of a chain saw will develop naturally as the

(1) Cox, M. B., "Small Machines for Removing Trees and Brush," Agricultural Engineering Journal, Vol. 27, No. 7, July 1946.

operator learns how to control the saw, i.e., to let the saw do the work. As with any kind of saw, sharp teeth with the proper set will help the saw perform as it should. Pinching the chain should be carefully avoided. To prevent excessive chain wear, the operator should frequently check the chain oiling system to see that it is functioning properly.

Cost Estimates

The method of determining the cost of operation for the machines is given in the appendix. It should be emphasized that the costs reported are estimates of the actual costs involved for a particular operating circumstance and may be different as conditions change. Cost information is not available for the blower-sprayer, tree shear, broach, and boomless sprayer.

Woodchipper. The cost of removing the chippable wood from the plots studied was found to range from $15 per acre for areas with small brushy growth to over $100 per acre for dense stands of brush and small trees. About half of the cost of clearing land by this method is the cost of preparation prior to chipping. To clear an acre of scattered small growth would require two men for about one-half day. An acre of the dense growth could be cleared of the chippable wood by two men in about three days. Chips were produced at a cost of $7.50 to $14.00 per ton at the chipping site. The main factor influencing this cost is the type of material being chipped. Trimmings have the least potential value and cost the most to process.

Shredder. To remove the small growth from dense stands of brush required an average of six shredder-hours per acre. The cost of removing this growth ranged from $10 to $20 per acre, depending largely upon the arrangement of the trees.

Pulling. The labor and machine requirements for the area pulled amounted to about 120 man-hours per acre and 40 tractor-hours per acre. With labor at $1.00 per hour and the tractor at $1.00 per hour, the cost to pull an acre would amount to about $160.

Bulldozer. The cost of bulldozing may vary considerably depending upon the size of dozer used, skill and technique of the operator, and upon the amount and type of growth to be removed. In the bulldozer study reported, six and one-half hours were required to clear three acres at a cost of $50. This amounted to an hourly rate of about $8.00 per hour or approximately $16 per acre.

Portable Saws. The estimated cost of using the portable circular saw was $.40 per hour. The two-man chain saw was estimated to cost $.65 per hour. These figures do not include labor.

Treatment After Clearing

After an area has been cleared, seedbed preparation and the establishment of native or improved grasses and legumes must follow to hold the soil in place and to get the land into production as soon as possible. In the test areas cleared, seedbed preparation generally consisted of disk plowing one or more times, primarily for root cutting purposes, followed by disk harrowing to level and firm the soil prior to seeding. Improved grass and legume species successfully established on these cleared areas were weeping lovegrass, Bermudagrass, King Ranch bluestem, big and little bluestem, lespedeza, and sudan grass.

Because resprouting has occurred on all the areas mechanically cleared, subsequent maintenance measures have been necessary. Periodic mowing with the shredder has been used as a means of controlling the regrowth. The shredding has generally been done biennially and at a time when the pasture forages would not be injured.

Summary and Conclusion

Selective brush removal offers the opportunity for clearing land with farm-sized equipment at a reasonable cost. Selective clearing reduces equipment maneuverability only slightly when tillage and seeding operations are performed among the remaining trees.

A heavy-duty stalk shredder has been effectively used to clear land of brush and small trees when the large trees have been arranged so that a tractor-shredder unit could move among them. An average of six shredder hours per acre was required to remove the shreddable growth. The cost of this operation ranged from $10 to $20 per acre depending largely on the growth arrangement. For maximum shredder effectiveness, the powering tractor should be equipped with a "live" PTO shaft.

A portable wood chipper was investigated as a method of disposing of woody growth for land clearing purposes. Field operations on 0.1-acre plots required from $15 to $100 per acre to process the chippable wood. The main factor contributing to the cost of this operation was the preparation labor required to saw, trim, and pile the brush for chipping. Wood chip utilization as mulches or bedding offer possibilities to offset part of the cost of the clearing operation.

The blower-sprayer could be used most effectively where the brush to be treated is in small groves not over 100 feet across. This type of growth would allow movement of the sprayer among the trees without having to cut paths through the growth for the machine to follow. No specific recommendations can be made regarding the best combination of pressure and carrier rate. Complete brush kill was not observed on any plots treated with this machine. Periodic retreatments would be necessary to control the regrowth and resprouting.

Tillage and seeding operations must follow mechanical land clearing to encourage and stimulate the growth of grasses to hold the soil in place and to return the areas rapidly to a high level of production. Because little brush killing is done in a mechanical clearing operation, periodic retreatments are necessary to check resprouting.

Appendix

Cost Determination of Equipment Used

Tractor (for Wood Chipper)

New Cost Approximately—$2,600
Total Estimated Annual Use—1,000 hours
Estimated Service Life—10 years
Interest on Investment at 5%

Fixed Costs (Cost of Owning)

Depreciation— $\frac{\$2600—260}{10}$	$234.00
Interest on Investment $\frac{(2600+260)}{2}$ $.05	71.50
Repairs, Housing, Insurance, Taxes and Daily Service (7-¾% of New Cost)	201.50
Total Annual Fixed Costs=	$507.00

Fixed Costs Per Hour of Use=$507÷1000=$.51/hour

Operating Costs

Fuel—2¼ gal/hour at $.185/gal.	$	.42/hour
Oil (including changes) 2 qts./8 hours at $.40/qt.		.10/hour
Total Operating Costs=	$	.52/hour

Total Cost of Owning and Operating Per Hour (Not including labor)= $.51 + .52 = $1.03 per hour

The costs of using the following equipment were determined by the same method and do not include labor:

Wood Chipper=$1.11/hour
Portable Circular Saw=$0.40/hour
Two-man Chain Saw=$.65/hour
Tractor (for shredder)=$.97/hour
Shredder=$.54/hour

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