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LOW-IMPACT, SELECTIVE CONTROL OF MESQUITE ON RIGHTS-OF-WAY

Objective 1. Economic Thresholds for Honey Mesquite Regrowth Control with Selected Individual Plant Treatments

Submitted to

THE TEXAS DEPARTMENT OF TRANSPORTATION

by

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16. Abstract

Honey mesquite regrowth on highway rights-of-way was treated with four individual plant treatments (stem spraying with Pathfinder II or 15% Garlon 4 + 85% diesel; leaf spraying with 0.5% Garlon 4 + 0.5% Transline using backpack sprayers or an all-terrain vehicle-sprayer) to determine the economic feasibility and labor requirements of these methods. Mesquite density accounted for 95% or more of the variability in total cost/acre for all four methods. Mesquite densities on highway rights-of-way were highly variable (average = ± 324 plants/acre; range = 18 to >1,000 plants/acre). For the average mesquite density scenario, all four methods, even at a labor cost of $20.71/hour, would substantially reduce right-of-way maintenance costs, compared to annual mowing, over a 10-year planning horizon. Total costs, labor requirements, and herbicide deposition in the environment would be greatly minimized by selection of the leaf spray methods. The variability in labor costs for highway maintenance personnel among counties and the variability in mesquite densities suggest that several methods, including broadcast spraying, may be viable treatment alternatives for long-range right-of-way maintenance programs.

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EXECUTIVE SUMMARY

Honey mesquite regrowth on highway rights-of-way was treated with four individual plant treatments (stem spraying with Pathfinder II or 15% Garlon 4 + 85% diesel; leaf spraying with 0.5% Garlon 4 + 0.5% Transline using backpack sprayers or an all-terrain vehicle-sprayer) to determine the economic feasibility and labor requirements of these methods. Mesquite density accounted for 95% or more of the variability in total cost/acre for all four methods. Mesquite densities on highway rights-of-way were highly variable (average = ± 324 plants/acre; range = 18 to >1,000 plants/acre). For the average mesquite density scenario, all four methods, even at a labor cost of $20.71/hour, would substantially reduce right-of-way maintenance costs, compared to annual mowing, over a 10-year planning horizon. Total costs, labor requirements, and herbicide deposition in the environment would be greatly minimized by selection of the leaf spray methods. The variability in labor costs for highway maintenance personnel among counties and the variability in mesquite densities suggest that several methods, including broadcast spraying, may be viable treatment alternatives for long-range right-of-way maintenance programs.

INTRODUCTION

Honey mesquite (Prosopis glandulosa var. glandulosa) is a major problem on the Texas Department of Transportation's (TxDOT) highway rights-of-way (R.O.W.) in the western two-thirds of the State. Mowing, TxDOT's standard R.O.W. maintenance practice, currently costs about $18/acre, and only temporarily suppresses mesquite. The thorns produced by regrowth mesquite puncture tires of TxDOT vehicles and those of motorists, resulting in considerable expense and a safety hazard to TxDOT personnel and the public in general. TxDOT manages about 1.4 million acres of highway R.O.W., hence the expense of mowing is a substantial outlay of tax-payer dollars which is not considered cost-efficient relative to mesquite management. TxDOT's management objective for its highway R.O.W. is to create and maintain the native prairie plant community for the region and to eliminate mowing on a large proportion of the R.O.W. in rural areas. Achieving this objective hinges upon development and implementation of effective and cost-efficient technology to control the mesquite infestation.

Low-volume basal application of Pathfinder II is the only herbicide treatment currently recommended by TxDOT's Vegetation Management staff for mesquite control on Texas highway R.O.W. This ready-to-use formulation, containing the butoxyethyl ester of triclopyr in a vegetable oil carrier, must be applied as an individual plant treatment by ground crews using pressurized garden sprayers or backpack sprayers. TxDOT's Vegetation Management staff reported 95% control of mesquite following applications of Pathfinder II. Individual plant treatments currently used for mesquite control on Texas rangelands include low-volume basal bark applications of 15% Remedy herbicide + 85% diesel fuel, and foliar sprays of 0.5% Remedy + 0.5% Reclaim. Remedy and Reclaim are the same herbicides as Garlon 4 and Transline, respectively, and the latter two products are registered for use on highway R.O.W. The active ingredient in Garlon 4 is also the butoxyethyl ester of triclopyr. These individual plant treatments, when properly timed and applied, are considered to be highly effective (> 80% root kill), very cost efficient, and ecologically sound for maintenance mesquite control on rangelands. They are highly selective and result in insignificant collateral damage to desirable, non-target species such as wildflowers. Also, when properly applied, these methods usually reduce herbicide use by 50 to 95% compared to conventional broadcast spraying methods.

Labor-intensive individual plant treatments for mesquite control are a concern to TxDOT's management since the agency is currently downsizing. Research appeared warranted to determine the labor requirements and total costs for using the above-mentioned individual plant treatments for mesquite control on highway R.O.W. This information should be a valuable decision aid for TxDOT management in determining the economic feasibility of using "tactical" mesquite control technology on highway R.O.W. Objective No. 1 of Project No. 7-2953 was developed to address this issue.

Statement of Objective No. 1

To develop economic thresholds for honey mesquite regrowth control in highway R.O.W. for low-volume basal bark spraying and for high-volume foliar spraying methods.

METHODS

Mesquite in 29 plots within highway R.O.W. were treated during September - October 1995 by 2-or 3-man crews using the following treatments:

1. Low-volume basal bark applications (stem sprays) of Pathfinder II using backpack sprayers (8 plots);

2. High-volume foliar applications (leaf sprays) of 0.5% Transline + 0.5% Garlon 4 + 5% diesel fuel using backpack sprayers (9 plots); or

3. High-volume foliar applications (leaf sprays) of 0.5% Transline + 0.5% Garlon 4 + 5% diesel fuel using an all-terrain vehicle (ATV) equipped with a power sprayer (12 plots).

The stem sprays of Pathfinder II were applied by ground crews using backpack sprayers (Solo) equipped with 5500-X1 adjustable cone nozzles (Spraying Systems Co.) set to deliver a fine mist in a narrow, cone-shaped pattern. The lower 12 inches of all stems were sprayed on all sides to the point of runoff. Leaf sprays were applied by ground crews using: (1) backpack sprayers equipped with 5500-X8 adjustable cone nozzles set to deliver a coarse mist; or (2) an all-terrain vehicle (Polaris) equipped with a 25-gallon tank, a 1.4-gpm, 12-volt electric pump, and three handguns with 5500-X8 nozzles. The sprays were applied till the mesquite leaves and stems were wet, but not to the point of runoff. Plots were measured and delineated with wire flags prior to treatment.

Data recorded for each plot included: the number of mesquite treated; man-hours of labor; ATV hours; and the total volume of spray utilized. Plots were generally 3 acres in size, except that some were smaller where mesquite densities were excessively high. Our values for labor were considered 100% efficient since there was no allowance for driving time (i.e. to and from the site), rest breaks, or refilling spray tanks. Actual labor values were multiplied by a factor of 1.2 to adjust for approximately 1 hour/day driving time, 0.5 hour/day for breaks, and 0.1 hour/day for refilling spray tanks, repairs, etc. (1.6 hr non-productive time/8 hr day = 20% non-productive time). The adjusted labor values were used in all further analyses.

Data from each of the three treatment methods were then subjected to separate regression analysis to quantify the relationship between labor requirements (man-hours/acre) and mesquite density (plants/acre) for each method. Data on 1995 costs for labor, herbicides, ATV, and spray ingredients (Table 1) were then integrated into the data sets to calculate cost/acre for each plot treated. Costs for vehicles to transport workers to work sites were not included.

Table 1. Cost input information used in this study.

Item	Cost	Source
Pathfinder II herbicide	$27.18/gal.	TxDOT/San Angelo
Transline herbicide	$250.00/gal.	TxDOT/San Angelo
Garlon 4 herbicide	$87.50/gal.	TxDOT/San Angelo
Diesel fuel	$0.70/gal.	local retailer
Triton X-100 emulsifier	$20.00/gal.	local retailer
HiLite blue dye	$36.60/gal.	local retailer
Leaf Spray mixture	$1.83/gal.	calculation
Garlon 4 + Diesel stem spray mixture	$13.73/gal.	calculation
Minimum Wage + 33%	$5.67/hr.	Texas Employment Commission
TxDOT (low county)	$12.05/hr.	TxDOT/San Angelo
TxDOT (average)	$16.43/hr.	TxDOT/San Angelo
TxDOT (high county)	$20.71/hr.	TxDOT/San Angelo
All-terrain vehicle	$2.50/hr.	Ueckert/McGinty

Cost/acre data were calculated for each of the plots treated at each of four labor cost scenarios ($5.67, $12.05, $16.43, and $20.71/hr) to reflect labor cost differences among TxDOT's County Maintenance personnel as well as the cost that could be expected if minimum wage workers could be utilized during the summer season (e.g. college students as part-time student workers).

Costs were also generated for a fourth method, stem sprays of 15% Garlon 4 + 85% diesel fuel, by using the cost of this mixture ($13.73/gallon) for the eight field plots where Pathfinder II was actually applied. This mixture contains 0.60 lb acid equivalent (a.e.) of triclopyr per gallon, whereas Pathfinder II contains 0.75 lb a.e. of triclopyr per gallon. Each of the four data sets were then subjected to regression analysis to quantify the relationship between cost ($/acre) and mesquite density.

Budgets were generated to compare the cost/acre of TxDOT's current R.O.W. mesquite management practice, mowing once per year, to those for each of the four alternative mesquite control methods at each labor cost scenario over a 10-year planning horizon. Cost estimates were generated from the regression equations discussed above (and shown in Table 3). The budgets assumed a 3% annual rate of inflation. The budget for the current procedure allowed for one mowing each year. Budgets for the 16 alternative methods/labor cost scenarios assumed an initial mesquite density of ± 324 plants/acre (the average density on the 29 plots treated) would be treated by the respective method in year 1, with re-treatment scheduled in year 5 on a density of 100 plants/acre and in year 10 on a density of 50 plants/acre by the same method. The mesquite numbers projected to be treated in years 5 and 10 were based on assumptions that about 20% of the mesquite would survive the treatments, and that about 5 to 10 new plants/acre would establish from seed each year. Budgets for all alternative mesquite control practices assumed that mowing would be discontinued on the treated R.O.W. acreage. Total cost over the 10-year planning horizon for each method and the savings for each alternative method

compared to the current practice were calculated. Similar budgets were prepared for initial mesquite densities of 100 and 1,000 plants/acre.

RESULTS AND DISCUSSION

Mesquite density in the 29 plots averaged 324 plants/acre (median = 228; range = 18 - 1,388; s.d.= 354). The plots were not randomly selected, but rather were selected to represent the array of mesquite densities that occur in highway R.O.W. in the western two-thirds of the state. These statistics are only an approximation, but give insight as to the severity and variability of the mesquite infestation. The most severe mesquite infestations encountered in this study were along Hwy. 67 in Reagan County and Hwy. 163 in Irion County.

Data on mesquite densities, actual man-hours labor/acre (100% efficiency), ATV time, and gallons of spray utilized/acre for each treatment are shown in Table 2. Average mesquite densities were similar for the three treatments (320, 323, and 328/acre for stem sprays, leaf spray/backpack sprayers, and leaf spray/ATV, respectively). The average labor requirement/acre for stem sprays (1.67 man-hr/acre) was about 2X greater than for leaf sprays/backpack sprayers (0.82 man-hr/acre) and about 2.6X greater than for leaf sprays/ATV (0.64 man-hr/acre). In contrast, the average total volume of spray applied by the leaf spray/ATV (3.90 gal/acre) was about 1.5X greater than for leaf sprays/backpack sprayers (2.53 gal/acre) and about 2.8X greater than for stem sprays (1.41 gal/acre). The average total amount of herbicide applied per acre was 1.06, 0.09, and 0.14 lb acid equivalent per acre for stem sprays, leaf sprays/ backpack sprayers, and leaf sprays/ATV, respectively. These data indicate significant advantages of the leaf spray methods in that labor requirements and herbicide usage were lower compared to the stem spray method.

Relationship of Herbicide Usage to Mesquite Density

Averaged over all treated plots, herbicide usage (acid equivalent basis) for stem spraying with Pathfinder II was 112% greater than the rate normally applied in broadcast sprays (0.5 lb a.e./acre) on adjacent rangeland. In contrast, herbicide usage for leaf sprays/backpack sprayers and for leaf sprays/ATV sprayer was 82% and 72% less than the normal broadcast application rates, respectively. The relationships between herbicide usage and mesquite density for all four treatments are shown graphically in Appendix A. Those concerned about pesticide deposition and the environment would very likely look more favorably upon TxDOT adopting technology that minimizes herbicide usage (i.e. the leaf spray methods). Furthermore, the leaf spray method would minimize the potential hazard of damage to susceptible crops or landscape plants via herbicide volatilization because less herbicide would be used.

Table 2. Mesquite densities, labor, ATV time, and volume of spray applied for three mesquite control practices utilized on highway R.O.W. during September and October 1995.

Mesquite Density (plants/acre)	Labor[1] (man-hr/acre)	A.T.V. (hr/acre)	Spray Volume (gal./acre)
Stem Sprays			
29.7	0.32	-----	0.21
36.5	0.38	-----	0.30
166.1	0.89	-----	0.79
169.1	1.35	-----	0.77
186.5	1.37	-----	1.13
227.8	1.62	-----	1.20
356.7	1.58	-----	1.50
1,388.0	5.87	-----	5.40
Avg. 320.1	1.67	-----	1.41
Leaf Sprays/Backpack sprayers			
18.0	0.28	-----	0.23
94.3	0.67	-----	0.96
111.3	0.52	-----	0.73
155.3	0.75	-----	1.75
162.0	0.84	-----	1.92
241.7	0.80	-----	1.85
294.3	0.83	-----	2.42
485.7	0.97	-----	2.57
1,340.6	1.71	-----	10.30
Avg. 322.6	0.82	-----	2.53
Leaf Sprays/ATV sprayers			
18.7	0.30	0.1	0.50
65.0	0.38	0.13	1.08
94.7	0.30	0.15	1.25
148.3	0.65	0.22	2.42
247.3	0.63	0.21	3.75
271.7	0.51	0.26	3.08
303.7	0.60	0.20	3.16
363.3	0.78	0.26	3.92
400.0	0.68	0.23	3.33
472.3	0.87	0.29	5.33
520.0	0.75	0.25	5.42
1,032.7	1.17	0.39	13.50
Avg. 328.1	0.64	0.22	3.90

[1]100% efficiency values.

Relationship of Labor Requirement to Mesquite Density

The linear relationships (Y = a + bX) of mesquite density with labor requirements (adjusted by 1.2X) for the three mesquite control methods were:

Stem Sprays/backpack sprayers $Y = 0.4888 + 0.0047\ X$ $(r^2 = 0.98)$

Leaf Sprays/backpack sprayers $Y = 0.6283 + 0.0011\ X$ $(r^2 = 0.90)$

Leaf Sprays/ATV sprayers $Y = 0.4289 + 0.0010\ X$ $(r^2 = 0.86)$

where Y = labor (man-hr/acre x 1.2), and
X = mesquite density (plants/acre).

The high r^2 values for these regression equations indicate that 86 to 98% of the variability in labor may be associated with variability in mesquite density for the three mesquite control methods. The greater regression coefficient ("b" value) for stem spraying (0.0047) indicates that the labor requirement for this method increases about 4 to 5 times more for each mesquite plant treated compared to the leaf spray methods (b = 0.0010 and 0.0011). The low constant ("a" value) and low regression coefficient for leaf spraying with ATV sprayers suggest this method be used if the primary criterion for selection was to minimize the labor requirement. These relationships are shown graphically in Appendix B.

Relationship of Total Cost to Mesquite Density

Components of total cost included labor, herbicide + other spray ingredients, and machine (ATV) time (where applicable). On average, cost for herbicide and other spray ingredients generally comprised most of the total cost/acre when workers were paid minimum wage. In contrast, labor was the major cost component for all methods at the high labor cost of $20.71/hr (Appendix C). Cost for the ATV averaged $0.56/acre (range $ 0.25 - $0.98/acre), which was a minor component of total cost at all labor cost scenarios.

The relationships between total cost (Y) ($/acre) and mesquite density (X) (plants/acre) for all mesquite control method/labor cost scenarios were linear (i.e. Y = a + bX) (Table 3, Appendix D). The high r^2 values (0.946 - 0.994) suggest that about 95% or more of the variability in total cost was associated with variability in mesquite density. Slightly lower r^2 values for the two leaf spray methods indicate that variability in other factors (probably mesquite canopy height or volume) also influenced total cost. Increases in labor costs caused major increases in the constants ("a" values) and regression coefficients ("b" values) within each mesquite control method, as would be expected. The higher costs for herbicides used as stem sprays and the lower labor efficiency for this method are reflected in greater constants and regression coefficients for the stem spray methods compared to the leaf spray methods. These differences are reflected in higher costs for stem spray methods at all mesquite densities and in

steeper slopes of the regression lines for stem spray methods compared to leaf spray methods (Appendix D).

Table 3. Relationships of Total Cost (Y) to Mesquite Density (X) for Four Control Methods.

Labor Cost	Method	r^2
($/hr)	Stem Sprays/Pathfinder II	
$5.67	Y = 8.519 + 0.129 X	0.994
$12.05	Y = 11.64 + 0.159 X	0.993
$16.43	Y = 13.78 + 0.180 X	0.992
$20.71	Y = 15.87 + 0.200 X	0.992
	Stem Sprays/15% Garlon 4 + 85% Diesel	
$5.67	Y = 5.675 + 0.078 X	0.993
$12.05	Y = 8.793 + 0.109 X	0.991
$16.43	Y = 10.93 + 0.130 X	0.990
$20.71	Y = 13.03 + 0.150 X	0.989
	Leaf Sprays/Backpack sprayers	
$5.67	Y = 3.851 + 0.020 X	0.968
$12.05	Y = 7.860 + 0.027 X	0.957
$16.43	Y = 10.612 + 0.031 X	0.951
$20.71	Y = 13.301 + 0.036 X	0.946
	Leaf Sprays/ATV sprayers	
$5.67	Y = 2.623 + 0.029 X	0.963
$12.05	Y = 5.36 + 0.035 X	0.959
$16.43	Y = 7.238 + 0.040 X	0.954
$20.71	Y = 9.074 + 0.044 X	0.949

The leaf spray methods were definitely found to be the least cost alternatives for mesquite control in highway R.O.W. Leaf spraying with the ATV sprayer tended to cost less than leaf spraying with backpack sprayers at low mesquite densities, whereas leaf spraying with backpack sprayers tended to be the least cost method at high mesquite densities (Appendix D). Mixing Garlon 4 with diesel fuel for stem spraying greatly reduced predicted total costs compared to those for stem spraying with Pathfinder II.

Comparative Budgets for Alternative Mesquite Management Practices

The budgets for the 324 mesquite/acre scenario suggest that all four alternative mesquite control practices, even at the high labor cost of $20.71/hr., would result in considerable savings over the 10-year period ($52 to $154/acre) to TxDOT compared to the current practice of mowing annually. The 10-year total savings to TxDOT would be considerably greater ($113 to $184/acre) if the work could be accomplished by summer workers hired at minimum wage ($5.67/hr.). The projected 10-year savings would always be maximized within any labor cost scenario by selection of the leaf spray methods. The leaf spray methods always minimized total costs and maximized total savings over the 10-year planning horizon for this hypothetical mesquite density scenario of 324 plants/acre.

Many of the alternative mesquite control practices had high initial treatment costs in year 1 compared to the cost for mowing. The only alternative treatments that resulted in year 1 costs less than that for mowing were leaf spraying (backpack or ATV sprayers) at the two lowest labor costs ($5.67 and $12.05/hr.). To reduce total year 1 costs the initial treatment can be applied to only a portion of the total R.O.W. acreage in year 1, with similar portions receiving the initial treatment in subsequent, consecutive years. A long-range plan for controlling mesquite on all highway R.O.W. acreage over a 5- or 10-year period may be preferable to a short-term plan, especially if the work must be done entirely with the current labor force.

The budgets (Table 4) should be applicable to most counties in the western two-thirds of Texas. However, one should not expect the data to apply to any particular highway R.O.W. or to any particular segment of a highway R.O.W. because of the inherent spatial variability in mesquite densities. Estimated budgets for low (100 mesquite/acre) and high (1,000 mesquite/acre) mesquite density situations are presented in Appendix E and F, respectively. Budgets for the low-density mesquite situation (100/acre) (Appendix E) indicate that many treatments which may have high costs in year 1 where mesquite densities were 324/acre will have considerably lower costs where densities are lower. Budgets for high-density mesquite (1,000/acre) (Appendix F) suggest that broadcast herbicide treatments, similar to those currently used on adjacent rangelands should be considered as an alternative method for mesquite control on highway R.O.W. with severe infestations. We estimate that broadcast sprays of Garlon 4 + Transline could be applied for about $31/acre (¼ lb a.e. of each herbicide) to $58/acre (½ lb a.e. of each herbicide). Broadcast spraying could be a viable alternative for R.O.W. with dense mesquite infestations adjacent to rangelands, such as those in the western counties. If properly timed, broadcast sprays of these herbicides would pose no hazard to most wildflowers in R.O.W.

Table 4. Comparative budgets (cost in $/acre) over a 10-year planning horizon[1].

	Year											
Method/Labor Cost	1[2]	2	3	4	5[3]	6	7	8	9	10[4]	10-Yr. Total Cost	10-Yr. Saving
Mow Annually	$18	$19	$19	$20	$20	$21	$22	$22	$23	$23	$207	----
Stem/PFII @ $20.71/hr	$81				$40					$34	$155	$52
Stem/G4D @ $20.71/hr	$62				$32					$21	$115	$92
Leaf/BP @ $20.71/hr	$25				$19					$20	$64	$143
Leaf/ATV @ $20.71/hr	$23				$15					$15	$53	$154
Stem/PFII @ $16.43/hr	$72				$36					$30	$138	$69
Stem/G4D @ $16.43/hr	$53				$27					$23	$103	$104
Leaf/BP @ $16.43/hr	$21				$15					$16	$52	$155
Leaf/ATV @ $16.43/hr	$20				$13					$12	$45	$162
Stem/PFII @ $12.05/hr	$63				$31					$26	$120	$87
Stem/G4D @ $12.05/hr	$44				$22					$19	$85	$122
Leaf/BP @ $12.05/hr	$17				$12					$12	$41	$166
Leaf/ATV @ $12.05/hr	$17				$10					$9	$36	$171
Stem/PFII @ $5.67/hr	$50				$24					$20	$ 94	$113
Stem/G4D @ $5.67/hr	$31				$15					$13	$59	$148
Leaf/BP @ $5.67/hr	$10				$7					$6	$23	$184
Leaf/ATV @ $5.67/hr	$12				$6					$5	$23	$184

[1] All values rounded off to nearest dollar.
[2] Mesquite density 324/acre.
[3] Mesquite density 100/acre.
[4] Mesquite density 50/acre.

CONCLUSIONS

Mesquite densities on highway R.O.W. are highly variable. While the average density may be about 324 plants/acre, densities range from only a few to > 1,000 plants/acre. This high level of spatial variability in mesquite abundance suggests that several alternative mesquite control practices should be considered in developing long-range mesquite management plans. Practices that are highly effective and cost efficient for controlling low-density mesquite infestations will not likely also be cost efficient for controlling high-density infestations. Also, practices that are not considered cost efficient for initial treatments may be highly acceptable for follow-up, maintenance control operations. Single-treatment approaches rarely provide the most cost-efficient, long-range solutions to any brush problem!

The high level of public concern about pesticides in the environment dictates that State agencies should utilize mesquite management practices that are environmentally friendly. This study showed that herbicide use (acid equivalent basis) could be minimized by using leaf spray methods compared to stem spray methods. We recognize that the efficacy of the leaf spray used in this study has not been scientifically documented for control of ≤ 1-year-old mesquite regrowth (this aspect is to be addressed in Objective 2 of Project 7-2953). However, herbicide usage in leaf sprays containing 2X the concentrations of Transline and Garlon 4 used in this study would be considerably less than that commonly used on adjacent rangeland.

This study strongly considered TxDOT management's concern about the labor-intensive nature of hand spraying individual mesquite plants. We found that labor requirements were 4 to 5 times greater for stem spraying than for leaf spraying methods. Of the three basic methods evaluated, leaf spraying with ATV sprayers was identified as the treatment of choice relative to minimizing labor inputs. The cost for operating the ATV sprayer averaged only about $0.56/acre (range $0.25 - $0.98), which was a very minor component of total cost. Our experience has shown that work crews greatly prefer to spray with the ATV sprayer compared to using backpack sprayers. The ATV sprayer is only one of several innovations that make hand spraying easier and less laborious. Objective 3 of this project will develop and/or evaluate other innovations to further minimize the labor-intensive nature of selective mesquite control.

Mesquite density accounted for ≥95% of the variability in total cost/acre for selective mesquite control using stem or leaf sprays. Total costs were higher for stem spraying than for leaf spraying because the method is less labor efficient, results in much greater application rates of herbicide (acid equivalent basis)/acre, and because the herbicide costs for this method are much greater than for leaf spraying. Stem spraying of mesquite that has been frequently mowed is very labor intensive because the mowing stimulates basal sprouting from dormant, belowground buds, and each sprout (stem) must be sprayed to kill the mesquite plant's root system.

Labor costs were a major component of total cost/acre for all four mesquite control methods evaluated in this study. Consequently, total cost for mesquite control in highway R.O.W. will

vary greatly from county to county depending upon the total labor cost/hr for TxDOT maintenance personnel in the respective counties. Mesquite control practices that are viewed as acceptable in one county may not be acceptable in an adjacent county. The leaf-spray methods appeared to be the least cost alternatives of the four methods evaluated. The use of minimum wage, seasonal workers minimized total cost/acre for all four mesquite control methods considered. Counties with lower labor costs will likely have more potential mesquite control alternatives from which to choose.

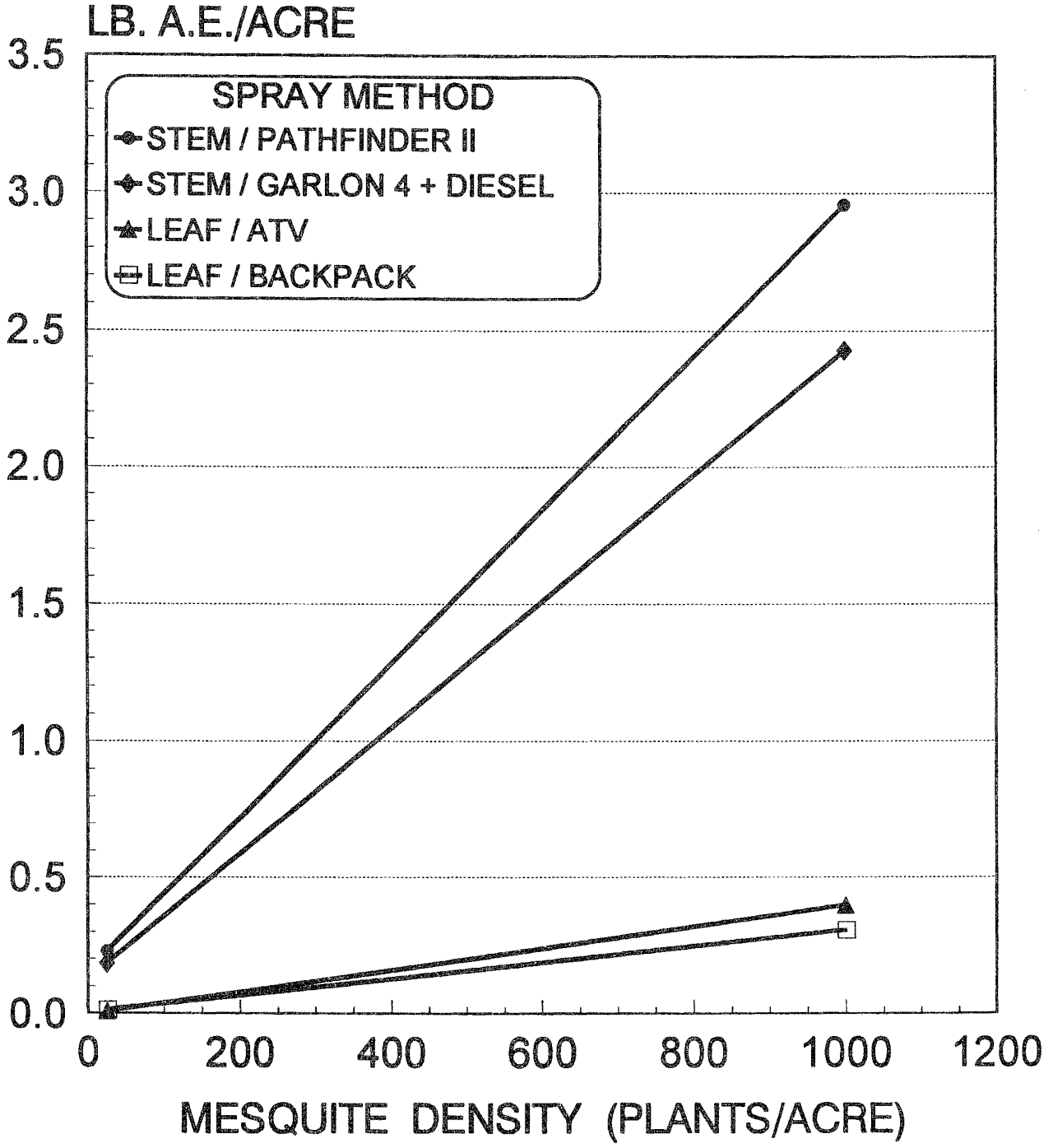
Mesquite can not be eradicated! Furthermore, a single treatment will not provide long-term control. Economically and ecologically sound mesquite management requires long-term planning. Follow-up, maintenance control treatments should be selected, scheduled, and budgeted for prior to installation of the initial control treatment. Initial and follow-up treatments should be selected after long-range budgets have been developed and carefully analyzed to select the treatments and treatment sequencing to maximize the probability of achieving the management objectives. Budgets prepared over a 10-year planning horizon indicated that all four alternative mesquite control methods could reduce TxDOT expenditures for R.O.W. maintenance over a 10-year period. Savings could be maximized by selecting the mesquite leaf spray methods and by utilizing minimum-wage, seasonal employees to conduct the operations. Counties with high labor costs and/or high mesquite densities may have to spread their initial mesquite control operations out over a 5- to 10-year period because of high initial treatment costs. All counties may have to consider this approach if the existing labor force must install the mesquite control treatment(s).

None of the four treatments evaluated in this study should be ruled out as a viable mesquite control alternative. Methods that are obviously not viable alternatives for moderate- or high-density mesquite infestations may be found to be highly acceptable for follow-up, maintenance control in later years or for initial treatments on segments of highway R.O.W. with low mesquite densities. Broadcast applications of Garlon 4 + Transline should be considered as an alternative method for mesquite control where mesquite densities and labor costs are high.

APPENDIX A

Relationships between herbicide use and mesquite density for four individual plant treatments on highway rights-of-way.

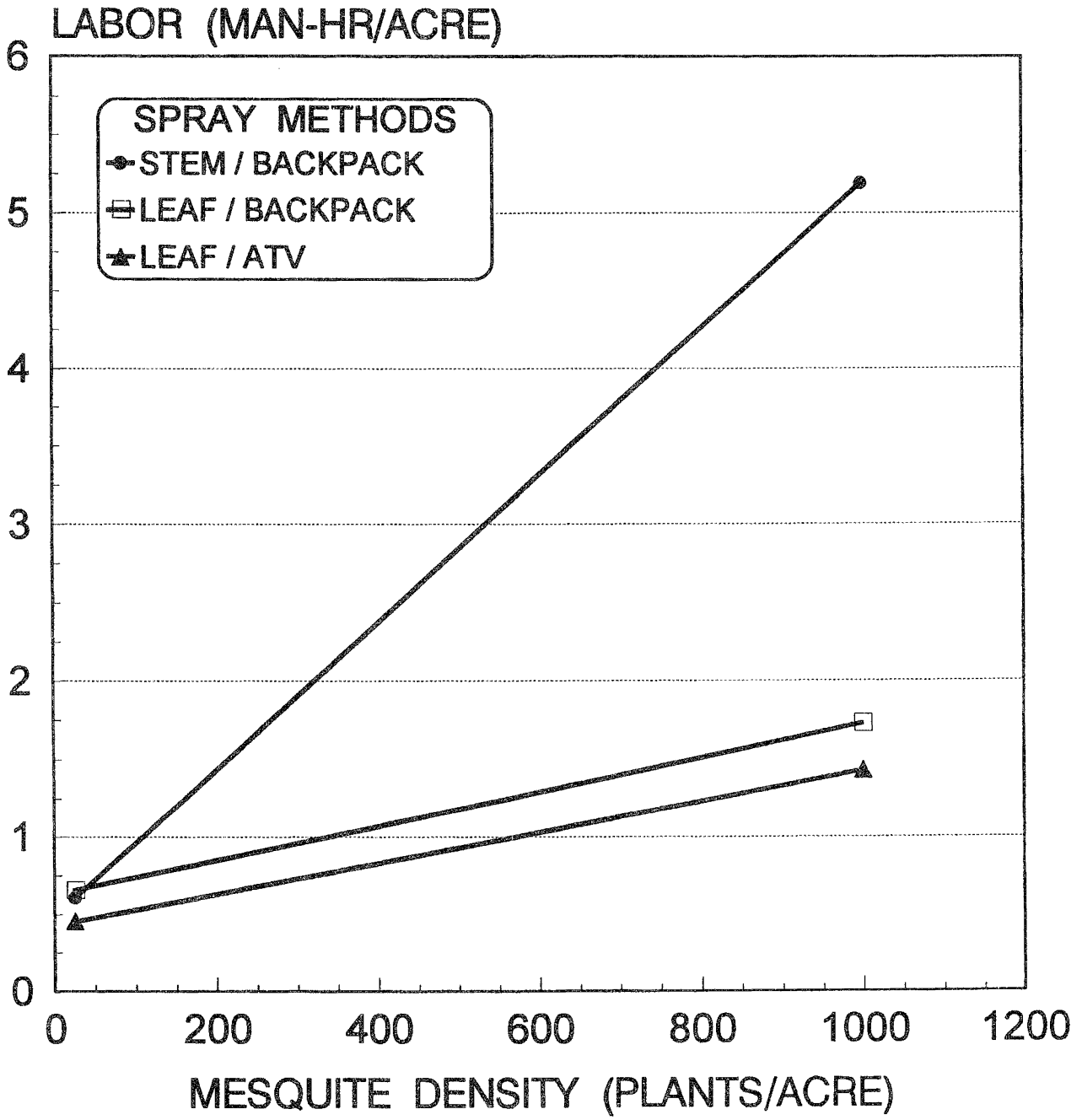
RELATIONSHIP OF HERBICIDE USE (LB. A.E./ACRE) TO MESQUITE DENSITY BY 4 SPRAY METHODS



APPENDIX B

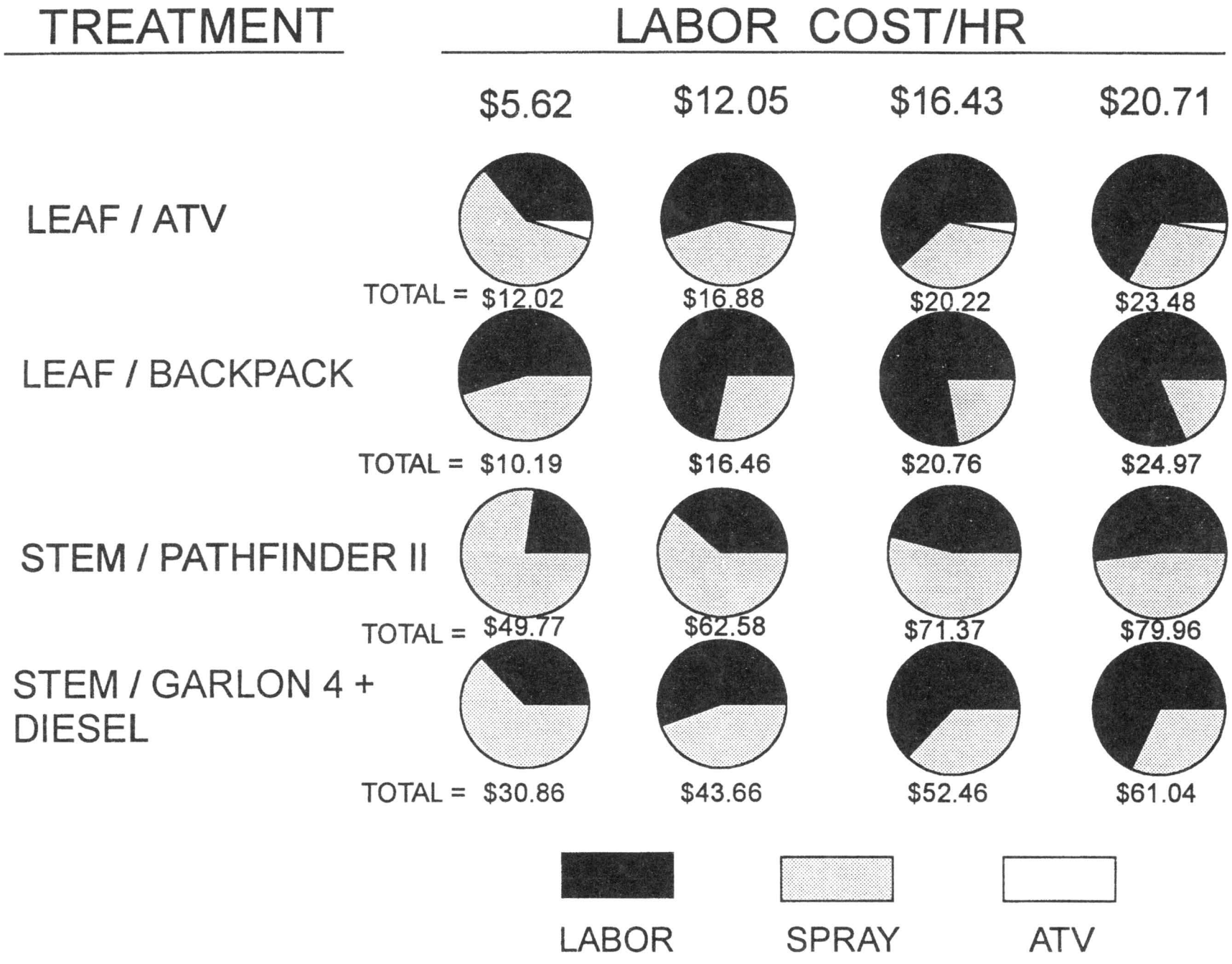
Relationships between labor requirements and mesquite density for three individual plant treatments on highway rights-of-way.

LABOR ESTIMATES (MAN-HR/ACRE) FOR MESQUITE CONROL USING 3 SPRAY METHODS



APPENDIX C

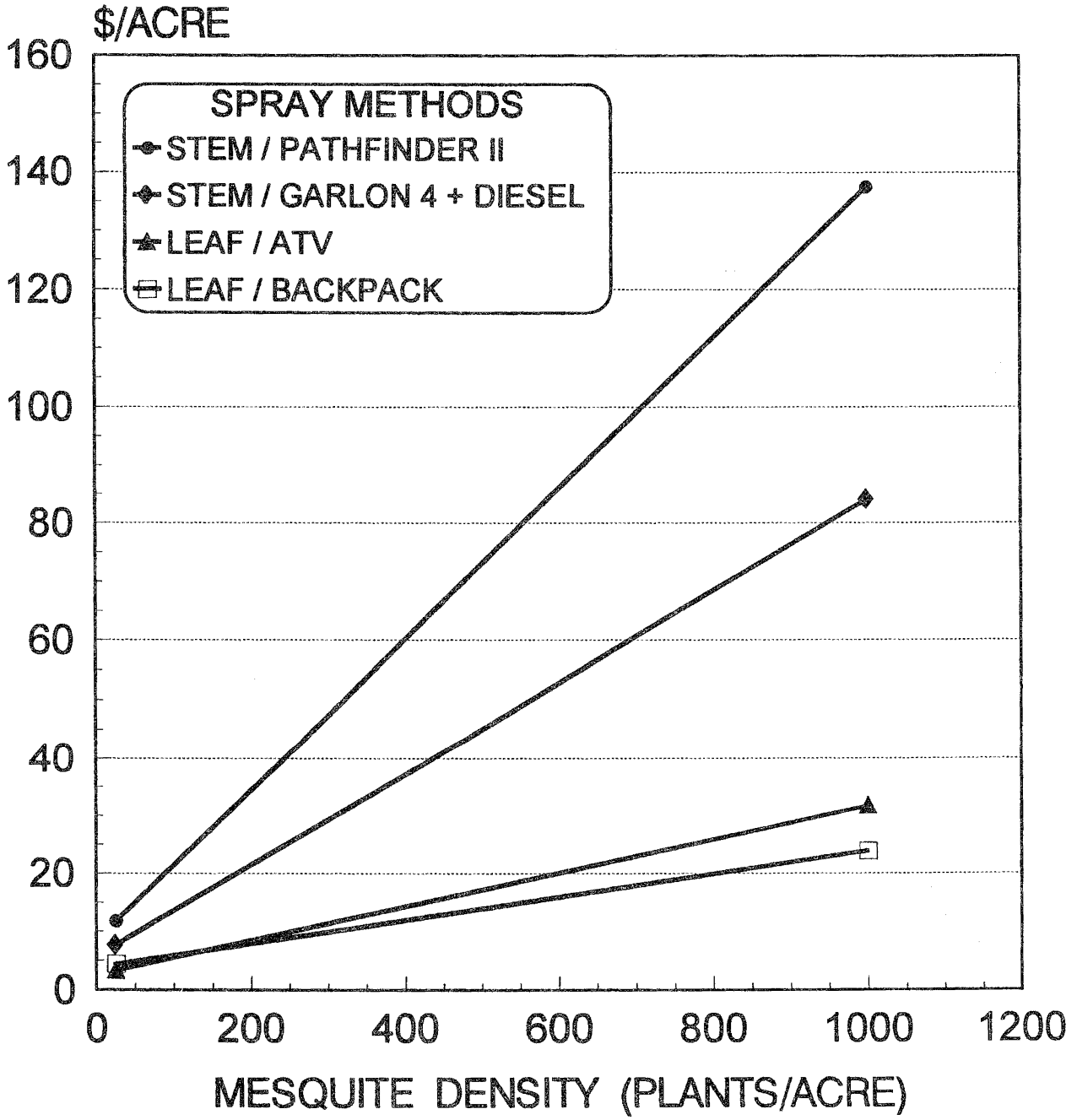
Components of total cost ($/acre) for four mesquite control methods each at four labor cost scenarios. These data represent averages for the field plots treated (average mesquite density ± 324 plants/acre).


TREATMENT
LABOR COST/HR
$5.62
$12.05
$16.43
$20.71
LEAF / ATV
TOTAL = $12.02
$16.88
$20.22
$23.48
LEAF / BACKPACK
TOTAL = $10.19
$16.46
$20.76
$24.97
STEM / PATHFINDER II
TOTAL = $49.77
$62.58
$71.37
$79.96
STEM / GARLON 4 + DIESEL
TOTAL = $30.86
$43.66
$52.46
$61.04
LABOR
SPRAY
ATV

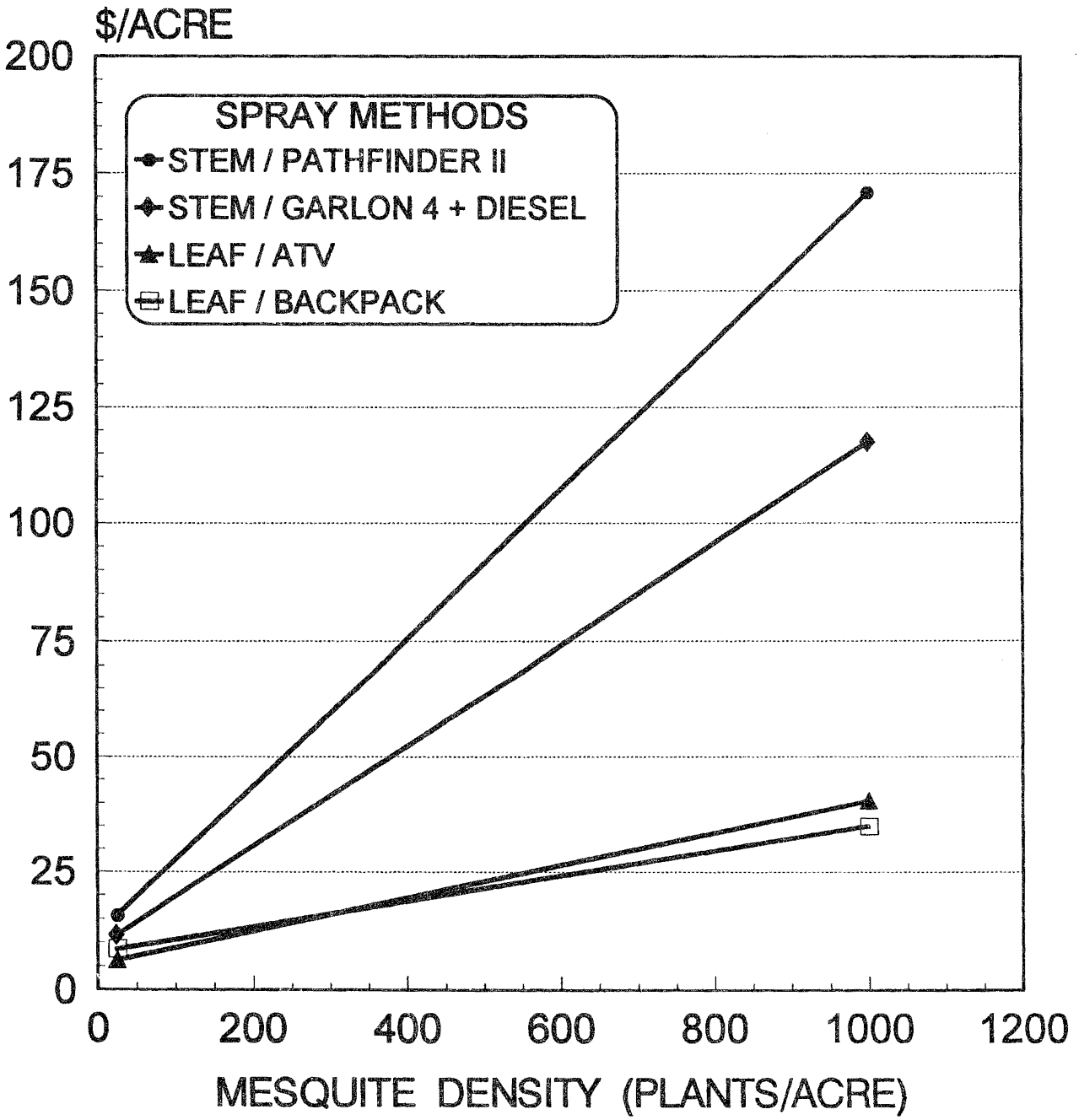
APPENDIX D

Relationships between total costs and mesquite density for four individual plant treatments at each of four labor cost scenarios.

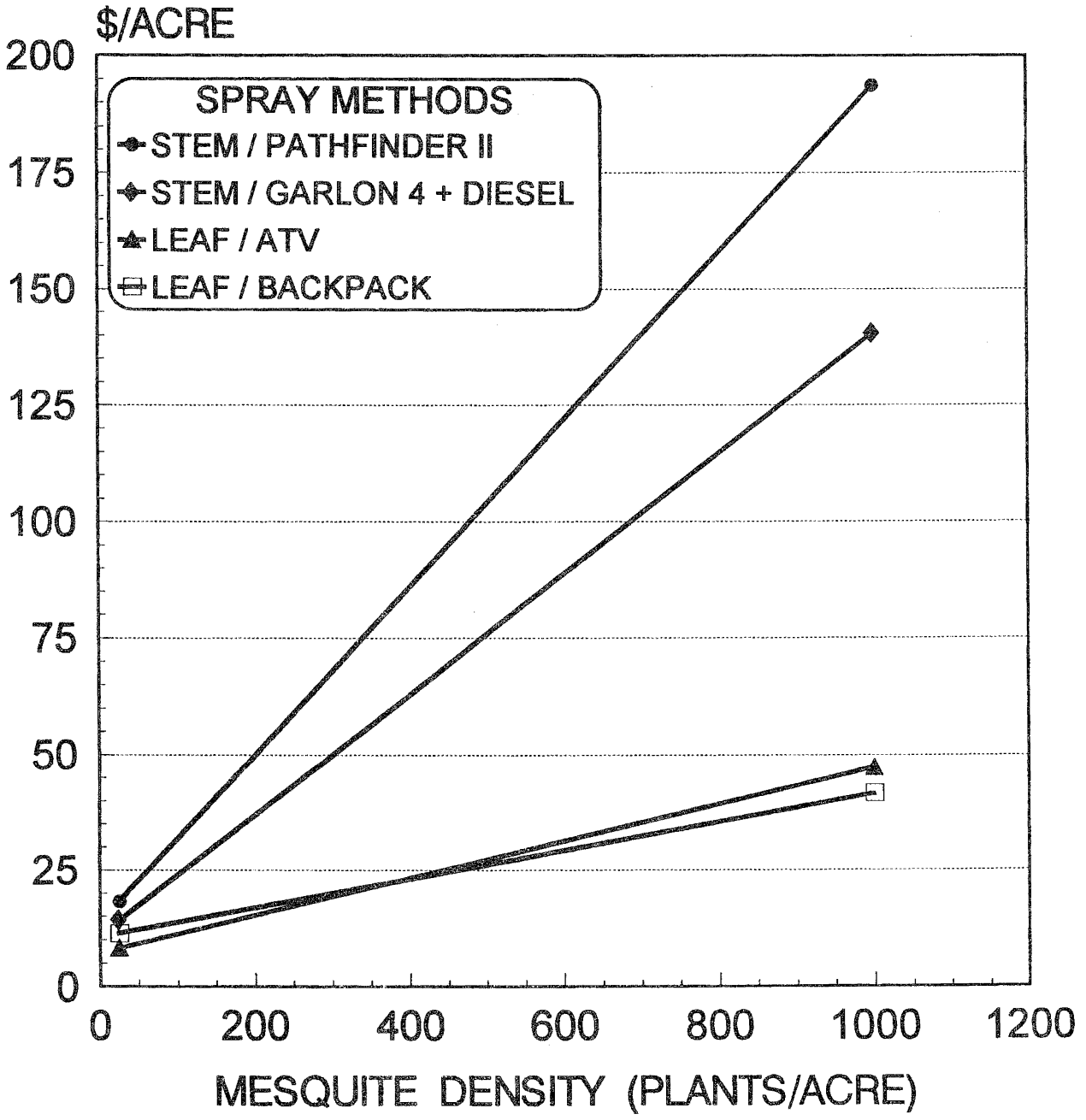
TOTAL COST ($/ACRE) FOR MESQUITE CONTROL USING DIFFERENT METHODS @ $5.67/HR LABOR COST



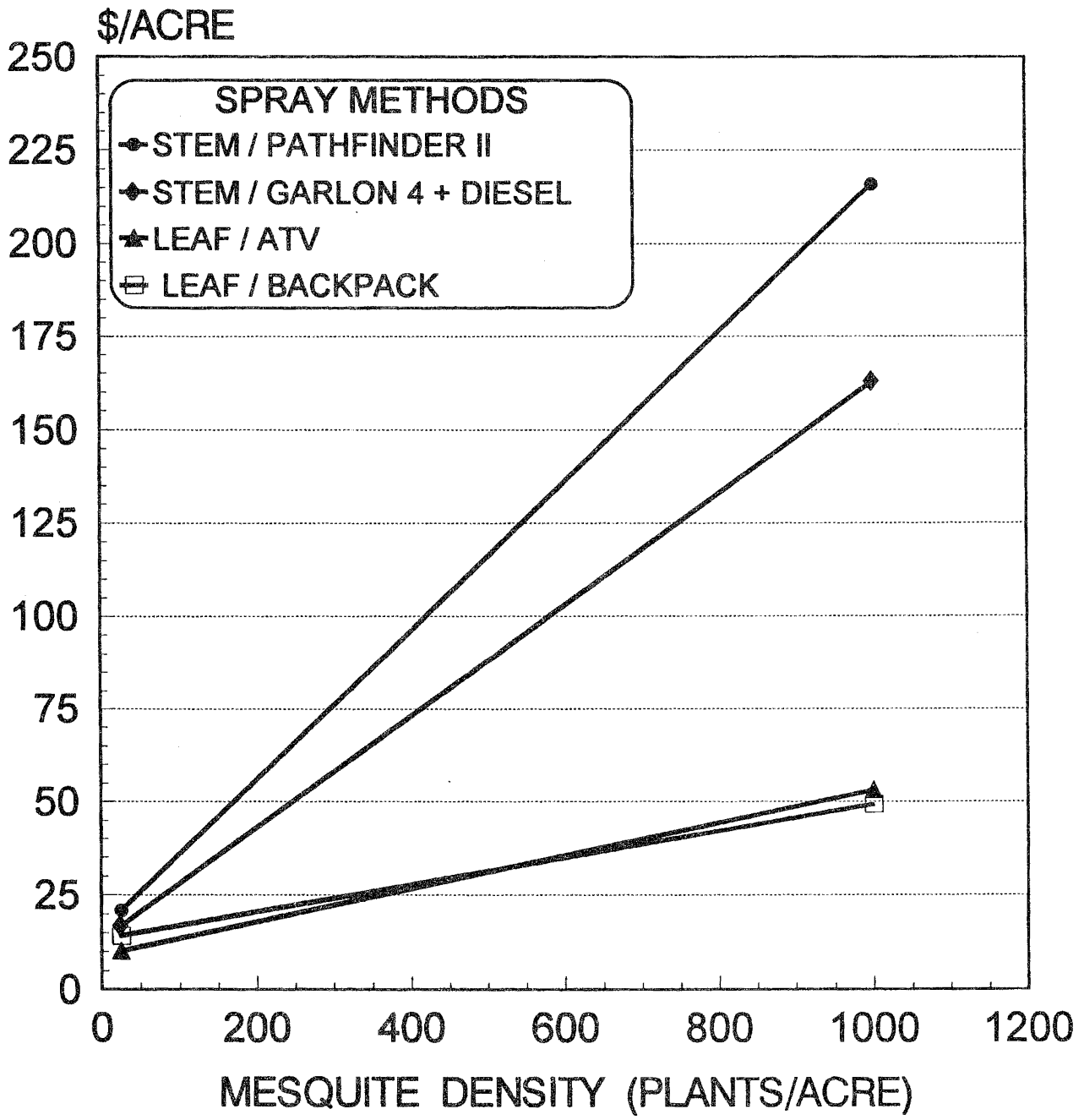
TOTAL COST ($/ACRE) FOR MESQUITE CONTROL USING DIFFERENT METHODS @ $12.05/HR LABOR COST



TOTAL COST ($/ACRE) FOR MESQUITE CONTROL USING DIFFERENT METHODS @ $16.43/HR LABOR COST



TOTAL COST ($/ACRE) FOR MESQUITE CONTROL USING DIFFERENT METHODS @ $20.71/HR LABOR COST



APPENDIX E

Budgets for four mesquite control methods at each of four labor cost scenarios over a ten-year planning horizon. Initial mesquite density 100 plants per acre. Retreat 25 plants per acre in year 5 and 25 plants per acre in year 10.

Comparative budgets (cost in $/acre) over a 10-year planning horizon[1].

	Year											
Method/Labor Cost	1[2]	2	3	4	5[3]	6	7	8	9	10[4]	10-Yr. Total Cost	10-Yr. Saving
Mow Annually	$18	$19	$19	$20	$20	$21	$22	$22	$23	$23	$207	----
Stem/PFII @ $20.71/hr	$36				$24					$27	$87	$120
Stem/G4D @ $20.71/hr	$28				$19					$22	$69	$138
Leaf/BP @ $20.71/hr	$17				$16					$19	$51	$155
Leaf/ATV @ $20.71/hr	$13				$11					$13	$38	$168
Stem/PFII @ $16.43/hr	$32				$21					$24	$76	$130
Stem/G4D @ $16.43/hr	$24				$16					$18	$58	$148
Leaf/BP @ $16.43/hr	$14				$13					$15	$41	$165
Leaf/ATV @ $16.43/hr	$11				$9					$11	$31	$175
Stem/PFII @ $12.05/hr	$28				$18					$20	$66	$141
Stem/G4D @ $12.05/hr	$20				$13					$15	$48	$159
Leaf/BP @ $12.05/hr	$11				$10					$11	$31	$175
Leaf/ATV @ $12.05/hr	$9				$7					$8	$24	$182
Stem/PFII @ $5.67/hr	$21				$13					$15	$50	$156
Stem/G4D @ $5.67/hr	$14				$9					$10	$32	$174
Leaf/BP @ $5.67/hr	$6				$5					$6	$16	$190
Leaf/ATV @ $5.67/hr	$5				$4					$4	$14	$193

[1] All values rounded off to nearest dollar.
[2] Mesquite density 100/acre.
[3] Mesquite density 25/acre.
[4] Mesquite density 25/acre.

APPENDIX F

Budgets for four mesquite control methods at each of four labor cost scenarios over a ten-year planning horizon. Initial mesquite density 1,000 plants per acre. Retreat 250 plants per acre in year 5 and 100 plants per acre in year 10.

Comparative budgets (cost in $/acre) over a 10-year planning horizon[1].

	Year											
Method/Labor Cost	1[2]	2	3	4	5[3]	6	7	8	9	10[4]	10-Yr. Total Cost	10-Yr. Saving
Mow Annually	$18	$19	$19	$20	$20	$21	$22	$22	$23	$23	$207	----
Stem/PFII @ $20.71/hr	$216				$74					$47	$337	-$130
Stem/G4D @ $20.71/hr	$163				$57					$37	$257	-$150
Leaf/BP @ $20.71/hr	$50				$25					$22	$97	$110
Leaf/ATV @ $20.71/hr	$53				$23					$18	$94	$113
Stem/PFII @ $16.43/hr	$194				$66					$41	$301	-$94
Stem/G4D @ $16.43/hr	$140				$49					$31	$220	-$13
Leaf/BP @ $16.43/hr	$42				$21					$18	$81	$126
Leaf/ATV @ $16.43/hr	$46				$19					$15	$80	$127
Stem/PFII @ $12.05/hr	$171				$58					$36	$265	-$58
Stem/G4D @ $12.05/hr	$117				$40					$26	$183	$24
Leaf/BP @ $12.05/hr	$35				$16					$14	$65	$142
Leaf/ATV @ $12.05/hr	$40				$16					$12	$68	$139
Stem/PFII @ $5.67/hr	$137				$46					$28	$211	-$4
Stem/G4D @ $5.67/hr	$84				$28					$18	$130	$77
Leaf/BP @ $5.67/hr	$24				$10					$8	$42	$165
Leaf/ATV @ $5.67/hr	$31				$11					$7	$49	$158

[1] All values rounded off to nearest dollar.
[2] Mesquite density 1,000/acre.
[3] Mesquite density 250/acre.
[4] Mesquite density 100/acre.