Economic Evaluation of Chemical Mesquite Control Using 2,4,5-T

D.E. ETHRIDGE, B.E. DAHL, AND R.E. SOSEBEE

Abstract

Honey mesquite (Prosopis glandulosa var. glandulosa) represents the most severe brush problem in the Texas Rolling Plains. Substantial research has been conducted on control methods, but economic analysis has been limited. The purpose of this study was to develop an evaluation model and evaluate the economic feasibility of 2,4,5-T (2,4,5-trichlorophenoxy acetic acid) for honey mesquite control in the Rolling Plains. The model is used to estimate the net present value of added grass production from treatment with 2,4,5-T over the life of the treatment; the central part of the model is the estimated herbage yield response function. The gross value of treatment with 2,4,5-T was estimated using different combinations of livestock price, top kill, canopy cover, and discount rate. Of the situations analyzed, gross value of mesquite control varied from a low of $32/ha to over $73/ha. These returns compare to current treatment costs of $22-25/ha.

Infestation with honey mesquite (Prosopis glandulosa var. glandulosa) constitutes the single most severe deterrent to range production in the Texas Rolling Plains. Almost 4.8 million hectares of the 5.6 million hectares of native rangeland in the Texas Rolling Plains are infested with mesquite (Whitson and Scifres 1980). Osborn and Witkowski (1974) estimated that mesquite decreased economic activity in Texas by $429 million to $832 million in 1967 dollars; adjusting to 1981 dollars with the Gross National Product implicit price deflator, the cost becomes $1.05 billion to $2.04 billion.

The decision to invest in mesquite control, or any other form of brush control measure, is complex. A major factor contributing to this complexity is that results of a control measure extend over a period of time, the length of which may vary. Some factors may be unknown or not well understood, and others may be known or understood but beyond the decision maker's control. Another major factor is the uncertainty associated with important economic variables, such as livestock prices and production costs, through time.

A substantial amount of research has been conducted on both mechanical and chemical control of mesquite; however, economic research on the various methods has been limited. Several studies have evaluated costs with little or no emphasis on benefits. Boykin (1960) estimated the costs of root plowing and reseeding in the Rio Grande Plains. Wiedemann and Cross (1975) considered costs of grubbing small trees. Freeman et al. (1980) estimated costs of harvesting mesquite in the Texas Rolling Plains using mechanical methods. In a study evaluating costs and returns, Freeman et al. (1978) studied the effects of cattle prices and levels of mesquite control on ranch organization and income in the Texas Rolling Plains. In the linear programming analysis, they assumed that forage production would increase by 31% in each year from year 2 through year 7 after treatment from spraying mesquite with 2,4,5-T (2,4,5-trichlorophenoxy acetic acid); lower response rates were also assumed to test for sensitivity. Workman et al. (1965) conducted a study of costs and returns from spraying in which they attempted to determine the longevity of chemical treatment in a survey by asking ranchers to estimate the life of treatment. Sharp and Boykin (1967) evaluated returns from mesquite control using a dynamic programming model in which they assumed a distribution of added forage production over a 10-year planning horizon. Whitson and Scifres (1981) conducted an extensive economic study of different methods of controlling mesquite in several regions of Texas. Their study provided recommendations for control on a regional basis; it was not addressed to specific situations or to the most efficient method of control in most instances. Among procedural problems they recognized was that long-term response data were lacking because of cost, personnel changes, and short-term research goals. Consequently, they assumed a 20-year production response for each region in their study.

The general objective of this study was to develop a procedure for evaluating the economic feasibility of honey mesquite control on rangeland with which decision makers can consider (1) variations in effectiveness of control in terms of longevity and (2) variations in economic variables affecting returns from the control technique through time. The specific objective was to evaluate the economic feasibility of 2,4,5-T for control of honey mesquite in the Texas Rolling Plains.

Analytical Framework

Purchasing mesquite control is fundamentally different from purchasing production inputs, such as supplemental feed, which are used in a single production period. Mesquite control by chemical or mechanical means constitutes a capital investment. The major expenditure occurs at a point in time and the effects of the control extend for some period of time into the future, usually several production periods. Since the treatment is expected to last for several years, there is more uncertainty and more production risk than with the one-period production input. Sources of risk are of two types: (1) biological variation, of which the impact of weather is an example, and (2) economic uncertainty, arising mostly from variations in product (livestock) prices.

The effectiveness of mesquite control treatments over time, in conjunction with certain economic variables, largely determines the feasibility of treatment. A treatment which reduces mesquite and its impact on rangeland and productivity for 10 years is more likely to be economically feasible than a treatment which diminishes the mesquite infestation for fewer years. Although the time pattern of control is an important element of economic feasibility (Whitson and Scifres 1980, Freeman et al. 1978), little empirical analysis exists on the longevity of treatments on control of mesquite; little data have existed with which to establish longevity.

The conceptual model developed for this analysis consists of
several generalized relationships. The basic relationship on which
the other relationships depend is a herbaceous yield response function
which relates grass production resulting from treatment of mes-
quite with the herbicide to time and other variables.

\[ \text{MP}_G = f(X_1, X_2, \ldots, t) \]  
where \( \text{MP}_G \) = additional grass production per unit of land
associated with the mesquite control treatment,
\( t \) = time, and
\( x_i \) = other explanatory variables.

It is expected that \( \text{MP}_G \) declines over time because mesquite re-
establishes after the initial damage from treatment and conse-
quentially decreases the added grass production as reinfection
occurs.

Added grass production is not directly marketable, but it may be
converted to a product which is marketed—livestock. This relation-
ship can be expressed as:
\[ \text{MP}_L = k(\text{MP}_G) = g(f(X_1, X_2, \ldots, t)) \]
where \( \text{MP}_L \) = additional livestock production per unit of land
associated with the mesquite control treatment, and
\( k \) = units of livestock produced per unit of grass; a
conversion factor for converting grass to meat.

Equations (1) and (2) are biological relationships. No purely
economic factors have been introduced. Equation (2) is transformed
into an economic relationship as follows:
\[ \text{VMP} = \text{MP}_L (P_L) = g(X_1, X_2, \ldots, t) \]
where \( \text{VMP} \) = value of the additional production per unit
of land, and
\( P_L \) = price (net) of the livestock produced.

The ranch manager cannot affect the price of the livestock, thus
price is determined outside his influence. However, price may not
remain constant over time. The VMP is the additional revenue
from the mesquite control treatment, and there is VMP each year
during which the treatment has an impact on grass (and livestock)
production. If it is assumed that all costs of treatment occur at the
time of treatment, the stream of additional returns must be
discounted in order to place them on an equivalent basis with the
costs (Whitson and Scifres 1980). Thus,
\[ \text{PV}_{\text{VMP}} = \sum_{t=1}^{\infty} \frac{\text{VMP}_t}{(1 + r)^t} \]
where \( \text{PV}_{\text{VMP}} \) = present value of the added revenue from mesquite
control treatment,
\( \text{VMP}_t \) = added revenue from treatment in year \( t \), and
\( r \) = discount rate, i.e., the price of the capital used for the
treatment.

Equation (4) shows that the longer the life of the treatment \( t \)
and the lower the discount rate \( r \), the greater the present value of the
revenue generated from mesquite control.

For the manager, the decision criterion is: If \( \text{PV}_{\text{VMP}} \) is greater
than or equal to the cost of treatment, the treatment is economi-
ically feasible. Otherwise, the added costs exceed the added
revenues. This is a modification of the marginal analysis principle
explained by Whitson and Kay (1978) and numerous other
authors. To make reliable estimates of the appropriate costs and
returns, several things must be known: (1) the nature of the \( \text{MP}_G \)
and/or the \( \text{MP}_L \) relationship, (2) the price of livestock, and (3) the
cost of mesquite control treatment. Item (3) is relatively easy to
determine with a small margin of error. Item (2) is extremely
difficult to forecast, especially with a high degree of precision and
over a long period. There are, however, ways to use alternate
assumptions regarding livestock prices to facilitate analysis and
decisions. Item (1) requires identification of factors which affect
productivity of the treatment and quantification of impacts of those factors.

Methods and Procedures

The source of data for this analysis was a 6-year plot study at 7
locations in the Rolling Plains treated with 0.55 kg 2,4,5-T/ha. The
sites were located in Kent, Lynn, and Tom Green counties. Details of
applications of treatments are reported in Dahl et al. (1978) and grass response
data were from those experiments.

The first question relating to equation (1) in the previous section
was: What are the variables which affect the grass response from
treatment with 2,4,5-T (i.e., what are the \( X_1 \)'s which impact
on \( \text{MP}_G \))? The experimental results clearly indicated that initial mes-
quite infestation (measured as canopy cover or number of trees
/ha) and top kill (the percentage of trees unsprouted at the end of
the first year) were explanatory variables. The study also implied
that soil type might be an explainable variable. It was hypothe-
ized that climatic factors (rainfall and temperature) also affect
additional grass production and that location may also have an
impact. It was further assumed that the relationship between \( \text{MP}_G \)
each of the independent variables except time was linear and
relationship to time was hypothesized to be in semi-log form. The
mathematical model formulated was:

\[ \text{MP}_G = \text{B}_0 + \text{B}_1 X_1 + \text{B}_2 X_2 + \text{B}_3 X_3 + \text{B}_4 X_4 + \text{B}_5 t + \text{B}_6 D_1 + \text{B}_7 D_2 + \text{B}_8 D_3 + \text{B}_9 D_4 \]

where \( \text{MP}_G \) = added grass production from treatment (kg/ha),
\( X_1 \) = mesquite canopy cover prior to treatment (%),
\( X_2 \) = top kill measured as percent of trees unsprouted at the
end of the first year,
\( X_3 \) = rainfall during the Sept.–Mar. period prior to the grow-
ing season (cm),
\( X_4 \) = rainfall during the April–Aug. growing season (cm),
\( X_5 \) = number of days during the year with the high temper-
   ature >37.8°C,
\( t \) = natural logarithm of year following treatment (1 = year
   of treatment),
\( D_1 \) = location dummy variable; \( D_1 = 1 \) if site in Tom Green
   County, 0 otherwise,
\( D_2 \) = location dummy variable; \( D_2 = 1 \) if site in Lynn
   County, 0 otherwise,
\( D_3 \) = soil type dummy variable; \( D_3 = 1 \) for Redland, 0
   otherwise, and
\( D_4 \) = soil type dummy variable; \( D_4 = 1 \) for valley soil, 0
   otherwise, and
\( D_5 \) = soil type dummy variable; \( D_5 = 1 \) for hardland.

Data on rainfall and temperature were obtained from secondary
sources (U.S. Dep. Commerce). For the Kent County site, climato-
 logical data for Jayton was used. For the Lynn County site, aver-
ages of observations for Fost and Tahoka were used and for the
Tom Green County site, averages of Water Valley and San Angelo
Airport observations were used. Ordinal least squares was used to
estimate parameters of equation (5).

Once the \( \text{MP}_G \) relationship was established, conversion to \( \text{MP}_L \)
was accomplished as follows. It was estimated that for the Rolling
Plains areas in the study 9,525.5 kg of grass were required annually
to support one animal unit (AU); this allowed for trampling and
restoring vigor. It was assumed that the livestock enterprise would
consist of a cow-calf operation and that one animal unit consists of
a 453.6-kg cow, one 18 1.4-kg calf, a 5% of a 725.8-kg bull, and 14%
heifer replacement. A calving rate of 90% and marketing of calves at 18 1.4 kg was assumed. Thus, under

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decisions. Item (1) requires identification of factors which affect
productivity of the treatment and quantification of impacts of those factors.
livestock. The value of livestock marketed was calculated as:

\[ P_c = P_e - V_{Cc} \]  
\[ \text{(6)} \]

where \( P_c \) = market price of 181.4 kg calves in dollars/kg, and \( V_{Cc} \) = variable cost of producing 181.4 kg calves in dollars/kg.

Variable costs consist of supplemental feed and minerals, veterinarian costs, fuel, lubrication, and repair costs on equipment, marketing cost, depreciation, taxes, and insurance on livestock, interest on operating capital, and interest on investment in the cows, bulls, and replacement heifers. Variable costs in this case excluded land costs and overhead costs and the value of cull cows, a function of cow prices, was subtracted to make calf costs a net cost estimate. Cost estimates were derived from enterprise budgets by the Texas Agricultural Extension Service (1982). The \( V_{Cc} \) was estimated to be $.55/kg. The market price for calves, \( P_e \), was obtained from Texas Department of Agriculture (1982).

**Results and Interpretation**

Estimation of equation (5) yielded the following relationship:

\[ M_{Po} = 11.48 + 19.15X_1 + 23.72X_2 - 15.56X_3 - 13.50X_4 - 31.14X_5 \]

\[ -625.6 \ln t \]

\[ (01) \quad (00) \quad (05) \quad (12) \quad (12) \]

\[ (04) \]

Numbers in parentheses below the estimated regression parameters represent the probability of an equal or greater \( t \)-value associated with the parameter (the significance level). The \( F \)-statistic for the model was 4.89 and \( R^2 \) was .607. The location and soil type dummy variables were insignificant; i.e., with the data used, location, and soil type had no significant effect on the added grass production from treatment of mesquite with 2,4,5-T. Canopy cover, top kill, pre-season rainfall, and time were highly significant explanatory variables; growing season rainfall and temperature were less significant. Negative signs for coefficients at \( X_3 \) and \( X_4 \) indicate that treatment of mesquite with 2,4,5-T adds less to grass production in high rainfall years than in low rainfall years, as expected. When there is sufficient soil moisture for both the mesquite and the grass, damaging the mesquite does not benefit the grass to the same extent as when mesquite and grass are more competitive for soil moisture.

To facilitate interpretation, several variables in equation (7) were fixed at some value(s) to produce a grass yield function with added grass yield as a function of time. If all independent variables except time are held constant at their mean values (Table 1), then equation (6) becomes

\[ M_{Po} = 1048.6 - 625.6 \ln t \]

\[ \text{(8)} \]

shown graphically (Fig. 1). This relationship indicates that with normal (average) temperature and rainfall conditions, a 26% initial canopy cover, and a 75% top kill, treatment with 2,4,5-T would produce 1.049 kg more grass per hectare the first year after treatment, 615 kg the second year, 361 kg the third, 181 kg the fourth, and 42 kg the fifth year. After year five, the effect of the treatment is negligible.

![Fig. 1. Estimated grass yield functions with independent variables at mean values and canopy cover varying one standard deviation.](image-url)

The greater the top kill the greater the added production per year and the longer the life of the treatment. This demonstrates the effect of proper application methods, spraying under good environmental conditions, and other management practices which affect top kill.

\[ M_{Po} = 1389.2 - 625.6 \ln t \]

\[ \text{(9)} \]

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To convert the added grass production to added beef production, the factor of 1 kg of grass = .0145 kg of marketable calf was used. To convert to dollar values, the estimated added cost of producing the marketable calf of $.5467/kg was used. The price of beef is subject to variation from numerous sources, but for purposes of this analysis, the price quotations for the San Angelo
market for medium frame #1 feeders, 136.1–181.4 kg and 181.4–226.8 kg reported on June 12, 1982, were used (Texas Dep. Agr.). Based on those prices, a calf price of $1.62/kg was assumed. Thus, \( P_c = 1.62 \times 0.5467 = 0.973 \), or an additional kg of marketable beef produces $0.973 income above added costs. Each added kg of grass produced thus has a value of \( 0.0145 \times 0.973 = 0.01556 \).

If average conditions hold and the above production cost and market price conditions hold, derivation of the present value of mesquite treatment with 2,4,5-T are shown (Table 2). A discount rate of 10% was assumed over the 5-year life of the treatment. Under these conditions, the treatment would produce a present value of additional income of $29.85/ha. If the treatment cost is less than $29.85/ha, investment in the treatment is economically feasible because the expected additional revenue from treatment exceeds the expected additional costs. If it cost more than $29.85/ha to treat, the treatment is not economically feasible. Cost of treatment with 2,4,5-T in the Texas Rolling Plains is about $22/ha.

As any changes in the physical conditions occur, the economic feasibility may change. Consider a greater-than-average initial mesquite infestation. If all conditions are the same as above except the infestation is increased to 40.83% canopy cover (one standard deviation above the mean), the \( PV_{MP} \) increases from $29.85 to $52.90/ha. Thus, the manager could invest up to $52.90/ha for treatment under these conditions. This increase in value results from greater additional grass production and a longer life of return from the treatment. Since rangeland is a dynamically changing resource and mesquite infestation tends to increase over time, treatment which is not feasible under a set of conditions at one point in time may be feasible under the same set of conditions at a later time.

Consider also the effect of a greater-than-average top kill on the economic returns. Factors such as spraying under more advantageous soil moisture, atmospheric temperature, etc., conditions may affect top kill and are under control of the ranch manager. If all conditions are average except for top kill, which is at 89.12% (one standard deviation above the mean), then \( PV_{MP} \) increases from $29.85/ha to $42.72/ha.

As with changes in the physical conditions, changes in economic condition likewise affect the economic feasibility. Economic factors which affect beef prices, costs of producing beef, and discount rates may have a substantial effect on the returns from and feasibility of mesquite control (Table 3). The data indicate that the value of mesquite control with 2,4,5-T in the Texas Rolling Plains increases as beef prices increase, decrease as discount rates increase, increase as the initial canopy cover increases, and increase as the percentage top kill increases. The price of culled cows, included in the calculation of \( VC_c \), was assumed to be constant in this analysis. To the extent the cow prices vary directly with calf prices, the discounted values (Table 3) are under-estimated at higher calf prices.

### Table 2. Calculation of value of added grass production.

<table>
<thead>
<tr>
<th>Additional Year</th>
<th>Value of additional grass production</th>
<th>Discounted value of additional grass production</th>
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</thead>
<tbody>
<tr>
<td>kg/ha</td>
<td></td>
<td>$/ha</td>
</tr>
<tr>
<td>1</td>
<td>1048.8</td>
<td>16.63</td>
</tr>
<tr>
<td>2</td>
<td>615.0</td>
<td>9.76</td>
</tr>
<tr>
<td>3</td>
<td>361.4</td>
<td>5.73</td>
</tr>
<tr>
<td>4</td>
<td>181.4</td>
<td>2.87</td>
</tr>
<tr>
<td>5</td>
<td>41.8</td>
<td>0.67</td>
</tr>
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<td>2246.4</td>
<td>35.66</td>
<td>29.85</td>
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1. Assumes 9.526 kg grass produces 137.9 kg of calf for market, variable calf production cost of $5.55/kg, and calf market price of $1.62/kg.

### Table 3. Discounted present values of additional grass production ($/ha) under alternative situations.

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<th>Calf price ($/kg)</th>
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1. Conditions: 25 cm pre-season rainfall, 34.3 cm growing season rainfall, 9 days/year with high temperature >37.8°C, production >37.8°C,
2. 25% initial canopy cover, 75% top kill,
3. 25% initial canopy cover, 75% top kill,
4. 25% initial canopy cover, 85% top kill.

### Implications

The economic feasibility of controlling mesquite with 2,4,5-T in the Rolling Plains of Texas depends on many variables; some are environmental, some are economic and some may be influenced or manipulated by managers. Among the environmental variables which affect added grass and beef production, and therefore, economic feasibility associated with mesquite control are initial canopy cover, degree of top kill achieved with treatment, pre-season and growing season rainfall, and number of high temperature summer days. Of these variables, ranch management may manipulate initial canopy cover by choosing the time to engage in spraying and influence top kill by choosing conditions at the time of spraying which promote high top kill. Among the economic variables which affect economic feasibility are livestock prices, costs of production, and discount rates. While an individual ranch manager is quite limited on the degree to which he may influence these variables, some impact on them through livestock production management, financial management, and marketing strategies may occur. This analysis shows the relative magnitudes of effects from the various factors on the economic returns from treatment of mesquite with 2,4,5-T. To determine economic feasibility, the discounted added returns from treatment must be compared to the added costs of treatment. Economic feasibility may, therefore, vary with time, among ranches, and among pastures within ranches. The MP\(_o\) relationship estimated in this study is believed to be generally reliable for the Rolling Plains region. The appropriate values of the variables within the relationship, the appropriate factor to convert to marketable product, and the appropriate values for the economic variables will vary from one situation to another. The analytical framework, along with the MP\(_o\) relationships, should be applicable to individual decision situations.

### Literature Cited


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