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Profitability and Nitrate Leaching Effects of Possible Farming Practice and System Changes over South Dakota's Big Sioux Aquifer:
Case Farm No. 3 Summary

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ECONOMICS DEPARTMENT
South Dakota State University
Brookings, South Dakota

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CASE FARM NO. 3 SUMMARY

Introduction

The overall goal of the SARE/Water Quality project was to determine whether economic incentives offered by recent environmental provisions of the Federal farm program are sufficient to induce Western Corn Belt/Northern Great Plains farmers in environmentally sensitive areas to adopt sustainable farming practices and systems. To attain this goal, four case farms were chosen to be involved in this study based on their size, soil types, cropping systems, topography, and management in the Big Sioux Aquifer study area.

Description of the Case Farm

Baseline System: Before

Case Farm No. 3 is located in Minnehaha County and has corn, soybeans, oats, alfalfa, and clover. It is a dryland operation that uses conventional tillage. The total operation consists of 168 acres, with 108 of the acres under the Water Quality Incentive program (WQIP) being focused on in the study. The acres are divided into two separate fields that are managed differently. A corn/soybean rotation is followed on the lower field and inorganic fertilizers were used. The upper field contains two different rotations. One rotation is a corn/oats,clover rotation and the other is a corn/oats,alf/alf/alf/alf/alf rotation. The majority of the soils on the lower field under WQIP are a combination of medium (Brandt), and coarse-textured (La Prairie) soils. Both of these soils overlay a shallow drinking water aquifer. The upper field was mostly Moody soils (medium-textured). These soils don't overlay an aquifer, but contribute to the runoff onto the lower field.

All machinery operations, inputs, etc. used in the baseline system were entered into a program called CARE (Cost and Return Estimator) to generate crop budgets. The figures from these crop budgets were compiled into an economics summary spreadsheet to show economic performance before WQIP enrollment (Table 1). The first row shows the number of acres for each crop based on the rotation followed. The next line shows the yield for each crop. Net returns are calculated by subtracting operating costs, such as fertilizer, pesticide, fuel, labor, machinery, and other costs, from total receipts (crop revenue + deficiency payments). These operating costs include such costs as depreciation, interest on machinery, and family labor (i.e., certain "fixed" costs).

Baseline System: After

The WQIP program incorporates pest and nutrient management, crop selection and rotation, and conservation measures into a more comprehensive management program than is usually associated with Agricultural Conservation Program[1] cost share. Practices may include soil and tissue testing, field

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[1] The WQIP uses many different practices that are similar to ones administered through the USDA's Agricultural Conservation Program (ACP).

scouting, cover crops, green manures, improved rotations, composting, and other techniques for reducing the use of agrichemicals.

Enrollment in the WQIP program began in 1992 for Case Farm No. 3. Pesticides used on corn changed from Dual 8E and 2,4D to Dual 25G and Accent after enrolling in the WQIP program. Also, inorganic fertilizers were eliminated from the corn crop on the upper field. Case Farm No. 3 received incentive payments to help pay for crop consulting. The total projected WQIP payments to be received each year in the program were $865.20 for the first year and $715.20 for the other two years, or $2,295.60 for the 3-year contract. The average payment/year was projected to be $765 for 108 WQIP acres. This means that Case Farm No. 3 was projected to receive an annual average of approximately $7 per acre enrolled in the WQIP. Practices that are being followed but are not receiving incentive payments are conservation cropping sequence and crop residue. The economics summary spreadsheet for the "after" scenario is shown in Table 2. Costs for the crop consultant were considered "pass-throughs" and neither crop consultant costs nor WQIP payments were included on the economic summary spreadsheet.

Major Simulated Changes

Description of Practice Changes

In this study, we also performed profitability analyses for possible additional **practice** changes. These are "what if" scenarios that are not actually being used at this time, but are possible management alternatives for this case farm. The key in Table 3 shows a complete list of the different alternatives analyzed for Case Farm No. 3.

The practice changes for Case Farm No. 3 involved banding fertilizer on the lower field (Alternative #3), and splitting the nitrogen application on the lower field into two operations (Alternative #4). No inorganic nitrogen on the lower field (Alternative #6) and no moldboard plow (Alternative #12) are other practice changes that are discussed in a later section of this paper.

Description of System Changes

Additional **systems** with more diverse crop rotations were analyzed to compare economic and environmental results with the results from the baseline "before" and "after" scenarios. The diverse rotations include oats (as a nurse crop for alfalfa), alfalfa (harvested for 2 years after seeding), soybeans, and corn. In one rotation, soybeans are grown 2 years out of 6 and corn is only grown 1 year (Alternative #9); in the other, soybeans are grown 1 year and corn is grown 2 years (Alternative #10). These rotations are more diverse than the corn/soybean rotation that was used on the lower field in the baseline "after" scenario. These diverse rotations were used only on the lower field. The rotation from the baseline "after" was used on the upper field.

Alternative #17 used a low-intensity crop, sudan grass, for the lower field. The rotation from the baseline "after" was used on the upper field. This alternative system is discussed more in a later section of this paper. Table 4 shows the yield estimates for the baseline "before", baseline "after", and the alternative practices and systems under different climate scenarios.

Input Expenditure Summary Comparison

Input expenditure comparisons were made between the baseline systems and the alternatives with other practice or system changes, which are for the "typical" climate scenario. These comparisons were categorized into fertilizer, pesticide, fuel, labor, machinery, and other (seed cost, trucking, etc.) expenses and were put into individual bar charts (Figures 1-6). There was little change in the input expenditures between the different alternatives, except for the pesticide expenditures, where Alternatives #9 , #10, and #17 were considerably lower than the other alternatives. This can be attributed to the diverse rotations used on the lower field for Alternatives #9 and #10 and the use of the low-intensity crop (sudan grass) for Alternative #17. Fertilizer expenditures also dropped considerably from the baseline "before" to the baseline "after". This can be attributed to the elimination of inorganic fertilizer from the upper field.

Nitrate Leaching Comparisons

The nitrate leaching estimates were made using the computer model NLEAP (Nitrogen Leaching and Economic Analysis Package). This model is a general use model designed for use by land owners/operators/managers to help in deciding which farm management practices may impact groundwater quality (nitrates) under various rotational cropping systems over several years of simulation.

Case Farm No. 3 had two soils on the lower field analyzed for nitrate leaching with different management alternatives (Table 3). The "whole-farm" nitrate leaching is dependent upon how many acres of each soil are used in the analysis. As an example, if there were 10#/Ac nitrate leached on 40 acres of a coarse-textured soil out of a 100 acre parcel, and 20#/Ac on 60 acres of a fine-textured soil, the whole-farm nitrate leaching would be 16#/Ac ((10*40/100) + (20*60/100) = 16). **The nitrogen leaching amounts given in pounds/Ac (Figures 7-9) are whole-farm leaching annual averages.** The nitrogen leaching values should not be compared to those for any other case farms, since soils, crop practices and systems may be quite different. The nitrate leaching values can be used as indicators of what the magnitudes of nitrate leaching might be on typical farms in the Big Sioux Aquifer area.

The leaching values derived from the model were done only on the soils overlying the aquifer. The upland soils would contribute runoff to the lower field, but the additional run-on water from the upland field is not included in these leaching values. The upland glacial till subsoil field would not have sufficient leaching through the soil profile to impact any surrounding aquifer.

Profitability/N Leaching Results

Three different precipitation situations (typical, wet, and dry) were examined to see how the different alternatives would be affected economically and environmentally under different moisture conditions. Each alternative was based on the average 6-year rotation with the simulated climate for all 6 years. These different conditions had varying effects on the economic and environmental results for the different alternatives. The results were put into charts with increasing economic returns extending vertically up the left side of the chart and increased nitrogen leaching extending horizontally to the right along the bottom of the chart. Points were plotted for each alternative based on their economic and environmental results (stated in annual averages), illustrating tradeoffs and complements for each precipitation situation (Figures 7-9). Generally, this farm had lower N leaching values for all climate scenarios than did the other case farms. This probably was due to the lower input of inorganic nitrogen to fields of this farm.

In the "typical" year (Figure 7), profitability was slightly greater for banding fertilizer ($101.54/acre) and splitting nitrogen applications ($102.06/acre) when compared to the baseline "after" scenario ($100.81/acre). The alternative systems had significantly greater economic returns ($109.49/acre for the O/A,A,A,S,C,S rotation and $111.37/acre for the O/A,A,A,C,S,C rotation) than the baseline systems and the alternative practices. Environmental results for splitting nitrogen application showed a slight increase in the amount of nitrogen leached, rising to 4.0 lbs/acre from 3.8 lbs/acre for the baseline system. The amount of nitrogen leaching for banding fertilizer was at the same level as the baseline "after" system. As expected, the alternative systems showed a decrease (3.4 lbs/acre for the O/A,A,A,S,C,S rotation and 2.8 lbs/acre for the O/A,A,A,C,S,C rotation) in the amount of nitrogen leached.

In the "wet" year (Figure 8), the profitability rankings changed, with the alternative systems being less profitable ($118.47/acre for the O/A,A,A,S,C,S rotation and $117.96/acre for the O/A,A,A,C,S,C rotation) than the other systems. This may be attributed to the fact that the oats/alfalfa and the alfalfa crops contributed roughly $50 to $100 less per acre to whole farm profitability than in the typical year, due to the assumption that alfalfa would have lower yield as a result of some drowning out on the lower field. Environmental results showed that the alternative systems had the lowest level of nitrogen leaching (3.7 lbs/acre for the O/A,A,A,S,C,S rotation and 3.1 lbs/acre for the O/A,A,A,C,S,C rotation).

In the "dry" year (Figure 9), the profitability rankings were the same as the "typical" year, except that the alternative systems reversed ranking, with the O/A,A,A,S,C,S rotation being the most profitable followed by the O/A,A,A,C,S,C rotation. However, nitrogen leaching rankings changed, with the alternative systems having higher levels of nitrogen leached (0.7 lbs/acre for the O/A,A,A,S,C,S rotation and 0.8 lbs/acre for the O/A,A,A,C,S,C rotation) than the alternative practices and the baseline "after" system.

The profitability figures for the "wet" and "dry" scenarios were affected by yield estimates based on how "wet" or "dry" conditions were assumed to affect different crops for each alternative on the different soils that were being dealt with on this case farm (Table 4). Nitrogen leaching figures were determined by running the nitrogen leaching model with appropriate precipitation levels for the "wet" and "dry" scenarios. The results showed that no one system is most beneficial in the context of profitability and nitrogen leaching under all climate scenarios.

It should be emphasized that the nitrogen leaching calculated by the model was only to the nearest pound, but the 6-year annual average is given in tenths of pounds to help the reader establish trends.

Sensitivity Analyses

In addition to the simulated practice and system changes, some sensitivity analyses were done with alfalfa prices and yields. For these analyses, whole farm net returns were recorded for the baseline systems and the alternative systems which included alfalfa as alfalfa prices or alfalfa yields were decreased. The purpose of these analyses was to determine how sensitive the rankings of the different alternatives were to assumed alfalfa prices and yields. Figure 10 shows how profitability for different systems changes as the alfalfa price decreases. Similarly, Figure 11 shows how profitability for the different systems changes as alfalfa yield decreases. Prior to the analysis, Alternative #10 had the highest profitability, followed by Alternative #9, Alternative #4, Alternative #3, and the baseline "after" system. It appears that alfalfa price or yield estimates would need to be lowered by one-third or more for the diverse rotations (Alternatives #9 and #10) to be less profitable than the baseline "after" system when weather is "typical". Such large decreases indicate that the results for this case farm are not very sensitive to either alfalfa price or alfalfa yield. The decrease in alfalfa prices or yields required to change profitability rankings may not have been as extreme if the baseline system were not already using alfalfa in the rotation.

In addition to alfalfa sensitivity analyses, selected analyses were conducted to explore policy alternatives to green payments (such as WQIP payments) to induce more diverse rotations. A "free market" policy and a "normal crop acreage" policy were examined. In the "free market" scenario, set-aside acres and price supports (i.e., deficiency payments) would be dropped and crop mixes would be more influenced by market price. In the "normal crop acreage" scenario, the deficiency payments were decoupled from the crops grown (i.e., a flat payment equivalent to that in the "after" baseline scenario was assumed) and overall set-aside acreage was left the same as in the "after" baseline (for all practices and systems). These analyses were done only for the "after" baseline and alternatives with a rotational change--to determine the relative profitability of different systems under these policy options, compared to provisions of the farm program in 1993. The "free market" and "normal crop acreage" scenarios did not change the profitability rankings for Case Farm No. 3 (Figure 12). Since this farm had a somewhat diverse rotation in the baseline "after" system, there was less of a dependence on government payments than on some other farms. Thus, these alternative policies did not have enough impact to change the profitability rankings.

Selected Other "Practice" and/or "System" Changes

Other practices were analyzed but were not included in earlier explanations since they were not part of the primary focus. One of these practices was the use of a field cultivator instead of a moldboard plow (Alternative #12). This practice increased profitability compared to the baseline "after", but there was no change in the amount of nitrogen leached for all climate scenarios.

Another practice change included not using any inorganic nitrogen on either the upper or the lower fields (Alternative #6). This alternative practice decreased profitability compared to the baseline "after", but was able to decrease the amount of nitrogen leaching for all climate scenarios.

Another analysis was performed to compare to the baseline "after". This analysis consisted of using a low-intensity crop, in this case sudan grass, on the lower field (33 acres) to determine the amount of stewardship payment needed to make the low-intensity system equally profitable to using a corn/soybean rotation on that field as in the "after" baseline. The result of switching the lower field to sudan grass (Alternative #17) was about a $25 drop in whole-farm profitability per acre, from $100.81 to $76.14. Consequently, this alternative system appears to have little chance of viability for voluntary, cost-shared adoption.

Methodological Notes

In some situations, we were unable to model both economic and environmental implications of an alternative. For Case Farm No. 3, there was not enough information to enable us to model the impact of switching to a low-intensity crop (sudan grass) on nitrogen leaching. The analysis of that alternative is based solely on economic returns.

Table 1. CARE Budget Spreadsheet: Case Farm #3 - Before Program

	Corn1*	Soybeans*	Corn2a**	Corn2b**	Oats/clo**	Oats/alf**	Alfalfa**	Set aside*	WHOLE FARM
Units	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Tons	Tons	
Acres	13	16.5	13	8	13	8	33	3.5	108
Yield/ac	110	29	115	115	75	75	4	5	
Defc. Pmts./ac	$33.60	$0.00	$33.60	$33.60	$0.00	$0.00	$0.00	$0.00	
Total Receipts ($/acre)	$253.60	$159.50	$263.60	$263.60	$198.75	$198.75	$220.00	$75.00	
Operating Costs ($/acre)	$147.85	$114.34	$143.24	$154.00	$101.86	$129.75	$99.34	$88.97	
Returns to Land & Management ($/acre)	$105.75	$45.16	$120.36	$109.60	$96.89	$69.00	$120.66	($13.97)	
Net Returns ($/acre)	$105.75	$45.16	$120.36	$109.60	$96.89	$69.00	$120.66	($13.97)	
********** **********	**********	**********	**********	**********	**********	**********	**********	**********	**********
Total Crop Returns ($/crop)	$1,374.75	$745.14	$1,564.68	$876.80	$1,259.57	$552.00	$3,981.78	($48.90)	$10,305.83
								$/ac =	$95.42

*-denotes crops on lower field
**-denotes crops on upper field

Table 2. CARE Budget Spreadsheet: Case Farm #3 - After Program

	Corn1*	Soybeans*	Corn2a**	Corn2b**	Oats/clo**	Oats/alf**	Alfalfa**	Set aside*	WHOLE FARM
Units	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Tons	Tons	
Acres	13	16.5	13	8	13	8	33	3.5	108
Yield/ac	110	29	115	115	75	75	4	5	
Defc. Pmts./ac	$33.60	$0.00	$33.60	$33.60	$0.00	$0.00	$0.00	$0.00	
Total Receipts ($/acre)	$253.60	$159.50	$263.60	$263.60	$198.75	$198.75	$220.00	$75.00	
Operating Costs ($/acre)	$140.54	$114.34	$119.64	$130.40	$101.86	$130.81	$99.34	$88.97	
Net Returns ($/acre)	$113.06	$45.16	$143.96	$133.20	$96.89	$67.94	$120.66	($13.97)	
Total Crop Returns ($/crop)	$1,469.78	$745.14	$1,871.48	$1,065.60	$1,259.57	$543.52	$3,981.78	($48.90)	$10,887.98
								$/ac =	$100.81

*-denotes crops on lower field

**-denotes crops on upper field

Table 3. Baseline Systems and Other Possible Practice and System Changes, Case Farm No. 3.

Key #	Alternative Description
1	Baseline (Before)
2	Baseline (After)
3	Banding fertilizer
4	Splitting N application
6	No inorganic N
9	O/A,A,A,S,C,S rotation*
10	O/A,A,A,C,S,C, rotation**
12	Use field cultivator, no moldboard plow
17	Whole field to sudan grass

*-Oats/Alfalfa,Alfalfa,Alfalfa,Soybeans,Corn,Soybeans rotation

**-Oats/Alfalfa,Alfalfa,Alfalfa,Corn,Soybeans,Corn rotation

Table 4. Yield Estimates for Various Management Practices with Different Climates for Case Farm #3.

System, field rotation and soils	Corn Yields in bu/ac			Soybean Yield in bu/ac			Oat Yield in bu/ac			Alfalfa Hay in tons/ac			Forage Sorghum; tons/Ac		
	Average	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet
"Before"(baseline)															
Lower fields															
C,S rotation															
Brandt soil	110	80	115	29	25	32									
La Prairie soil	110	70	120	29	22	35									
Setaside: Brandt soil													5	2.5	7
Upper fields															
C,O/A,A,A,A,A rotation															
Moody soil	115	80	95				75	60	55	4	2	6			
C,O/Clover rotation															
Moody soil	115	80	95				75	60	55						
"After"															
Lower fields															
C,S rotation															
Brandt soil	110	80	115	29	25	32									
La Prairie soil	110	70	120	29	22	35									
Setaside: Brandt soil													5	2.5	7
Upper fields															
C,O/A,A,A,A,A rotation															
Moody soil	115	80	95				75	60	55	4	2	6			
C,O/Clover rotation															
Moody soil	115	80	95				75	60	55						
Crop rotation w/no inorganic N															
Lower fields															
O/A,A,A,S,C,S rotation															
Brandt soil	110	80	95	29	25	32	60	45	30	5	3	3			
La Prairie soil	110	70	95	29	22	35	60	45	30	5	3	3			
Crop rotation w/no inorganic N															
Lower fields															
O/A,A,A,C,S,C rotation															
Brandt soil	105	75	90	29	25	32	55	35	25	5	3	3			
La Prairie soil	105	65	90	29	22	35	55	35	25	5	3	3			
Tillage Change: Plow to Field Cult.															
Lower fields															
C,S rotation															
Brandt soil	110	80	115	29	25	32									
La Prairie soil	110	70	120	29	22	35									
Banding Fertilizer @planting															
Lower fields															
C,S rotation banding fert. 50#N															
Brandt soil	112	82	117	29	25	32									
LaPrairie soil	112	72	122	29	22	35									
Splitting N Applications															
Lower fields															
C,S rotation															
Brandt soil	115	85	120	29	25	32									
LaPrairie soil	115	75	125	29	22	35									
Corn-Soybean rotation															
Lower fields															
C,S rotation w/no inorg. N															
Brandt soil	75	55	65	29	25	32									
LaPrairie soil	70	50	60	29	22	35									
Setaside: Brandt soil													4	2.5	5.5

Figure 1a.

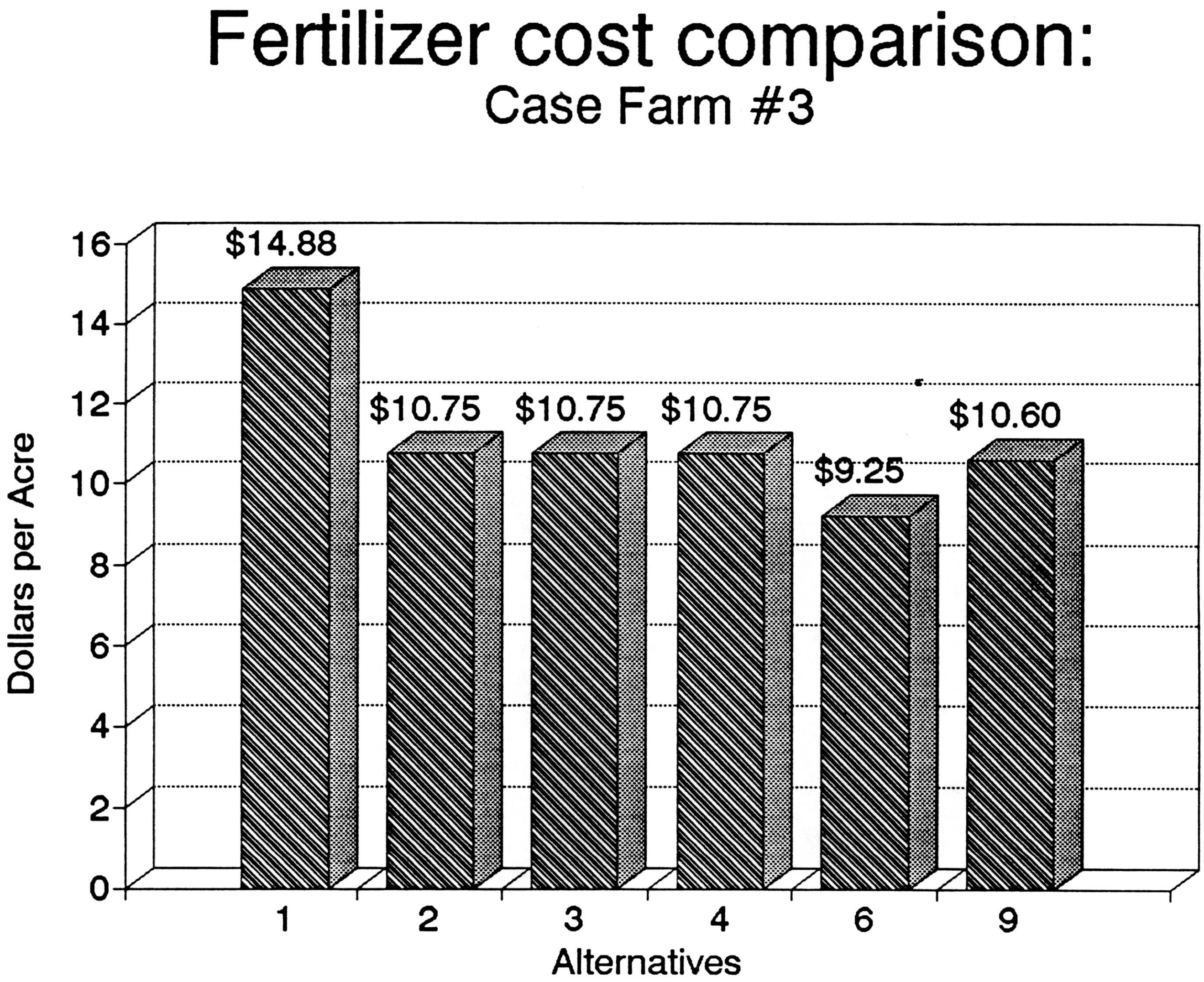

Fertilizer cost comparison:
Case Farm #3
Dollars per Acre
0
2
4
6
8
10
12
14
16
$14.88
$10.75
$10.75
$10.75
$9.25
$10.60
1
2
3
4
6
9
Alternatives

Figure 1b.

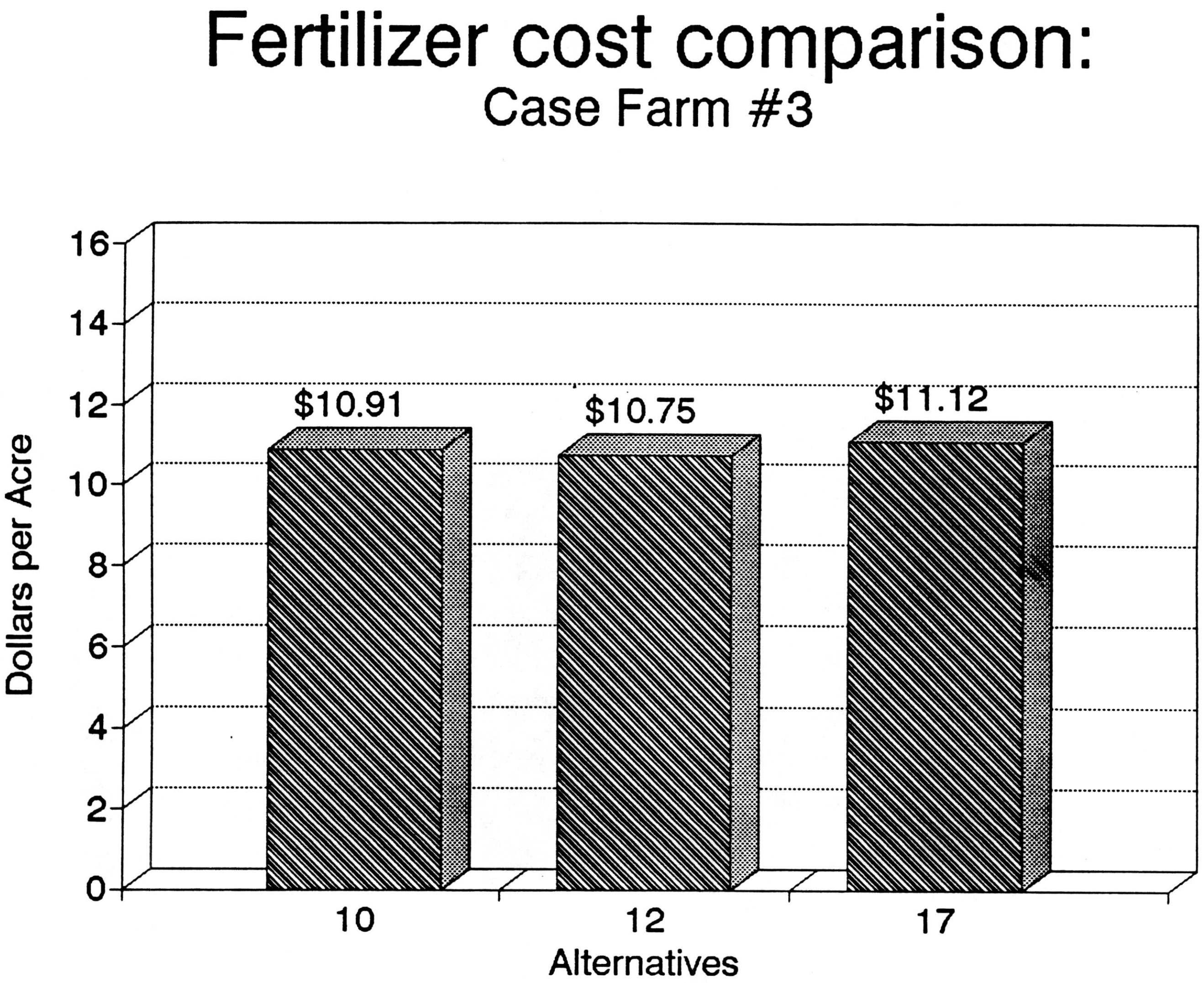

Fertilizer cost comparison:
Case Farm #3

Figure 2a.

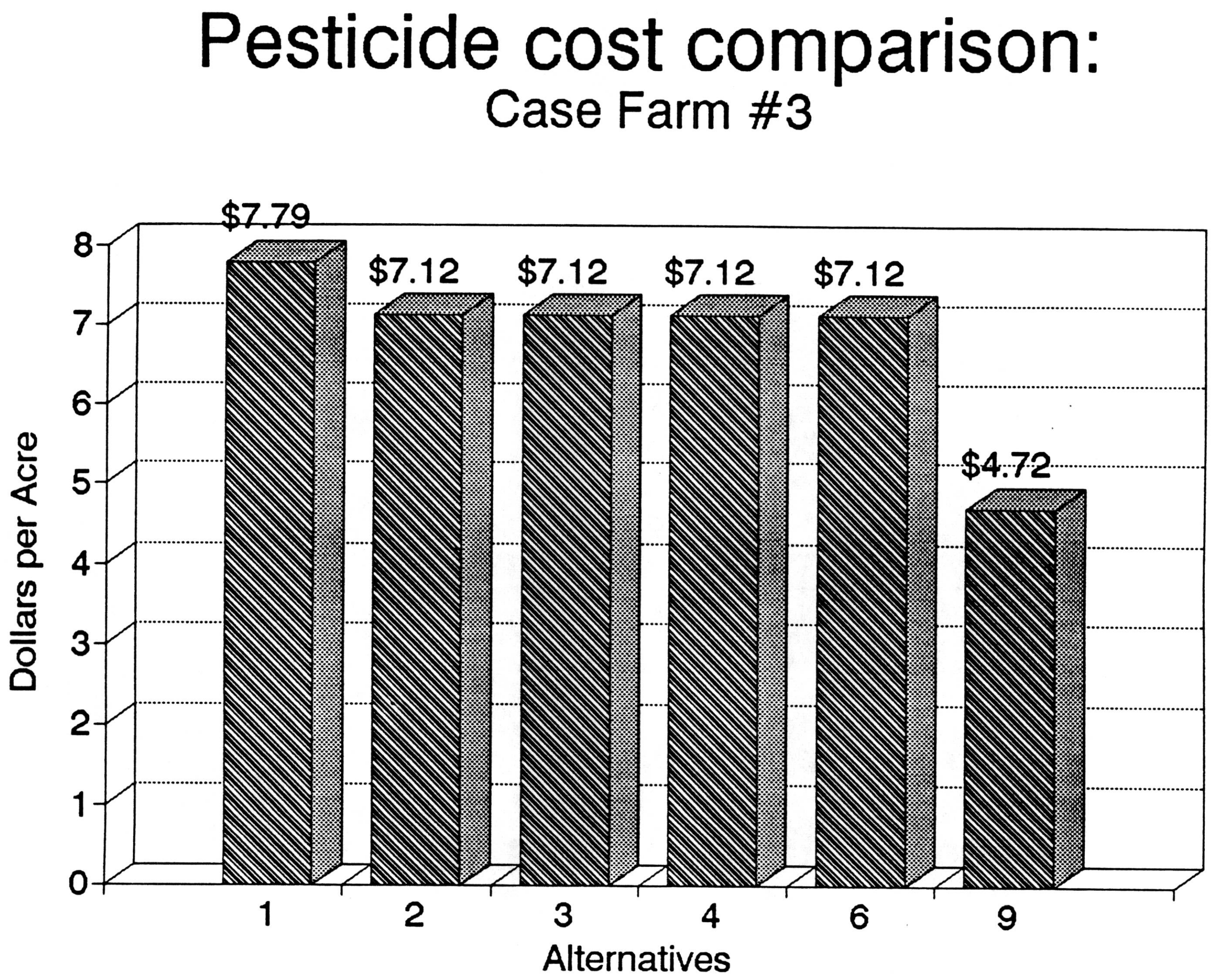
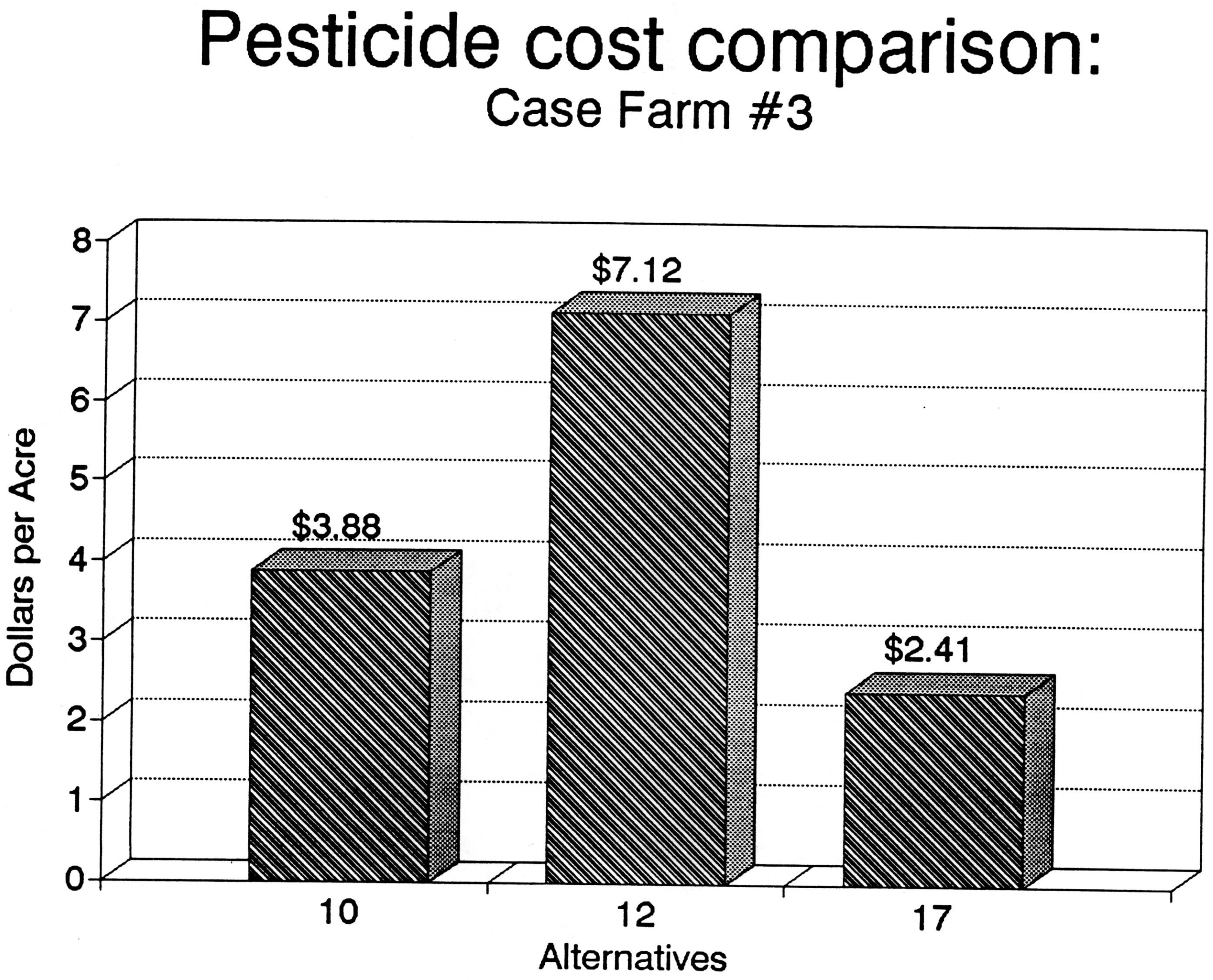

Pesticide cost comparison:
Case Farm #3
Dollars per Acre
0
1
2
3
4
5
6
7
8
$7.79
$7.12
$7.12
$7.12
$7.12
$4.72
1
2
3
4
6
9
Alternatives

Figure 2b.



Pesticide cost comparison:
Case Farm #3

Figure 3a.

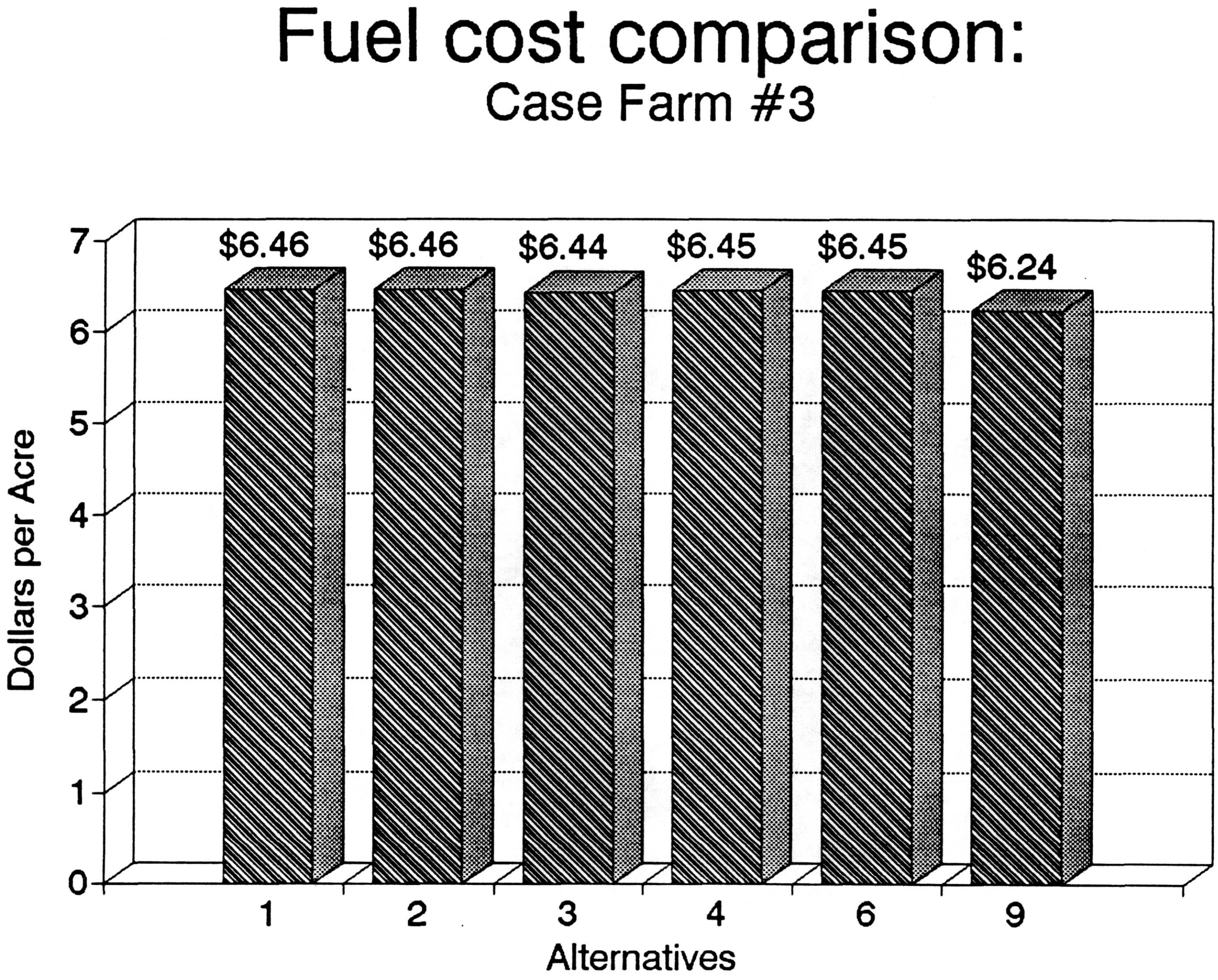

Fuel cost comparison:
Case Farm #3
Dollars per Acre
0
1
2
3
4
5
6
7
$6.46
$6.46
$6.44
$6.45
$6.45
$6.24
1
2
3
4
6
9
Alternatives

Figure 3b.

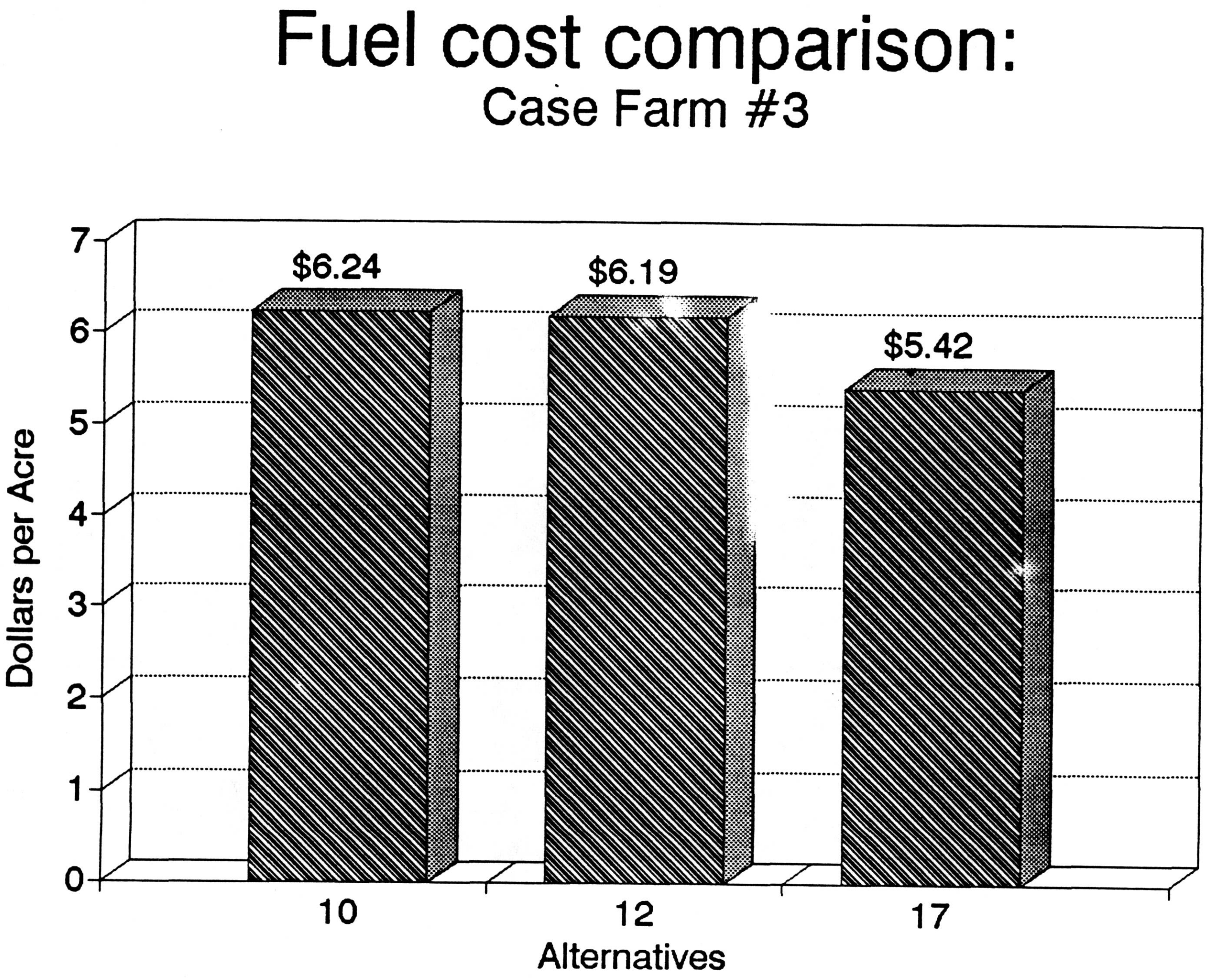
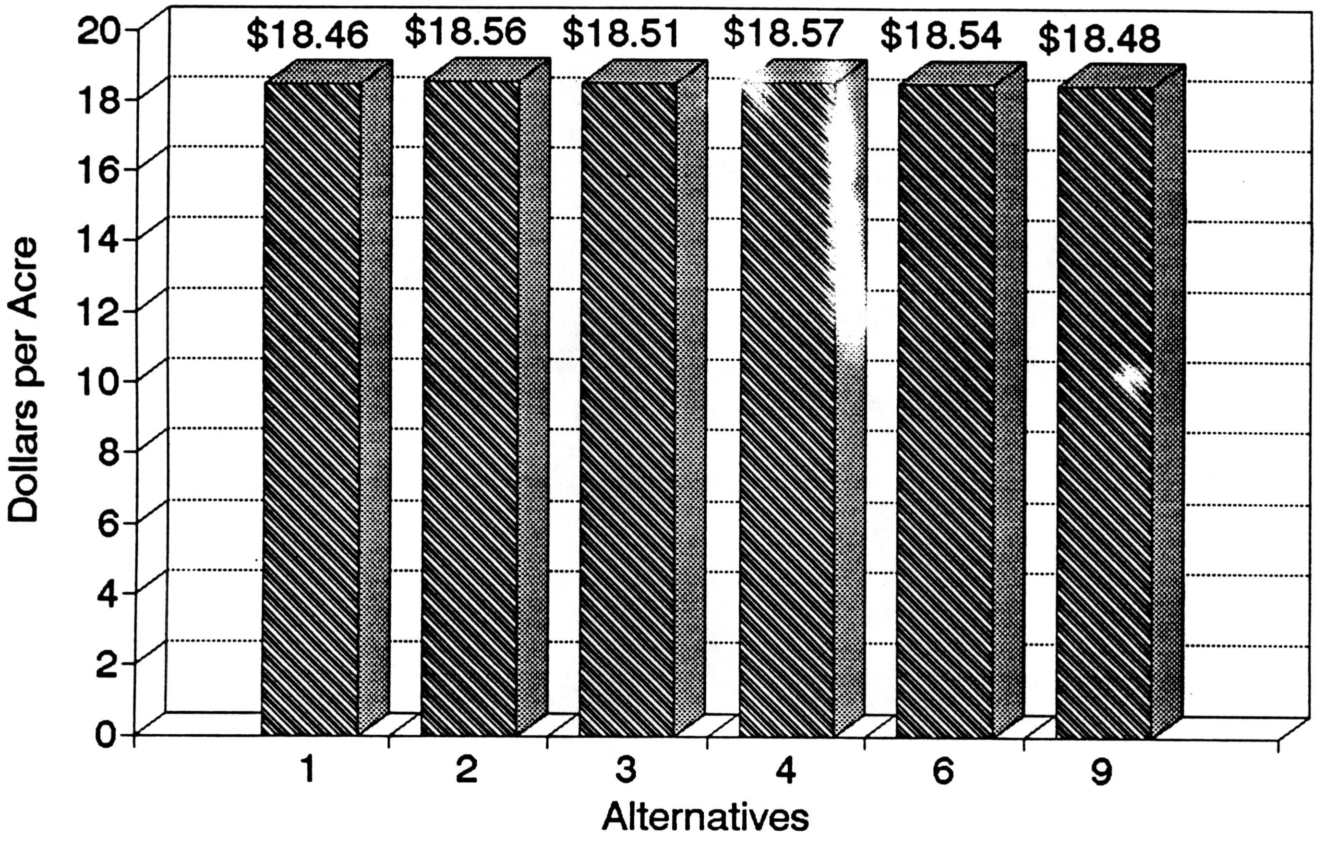

Fuel cost comparison:
Case Farm #3
Dollars per Acre
0
1
2
3
4
5
6
7
$6.24
$6.19
$5.42
10
12
17
Alternatives

Figure 4a.



Labor cost comparison:
Case Farm #3

Figure 4b.

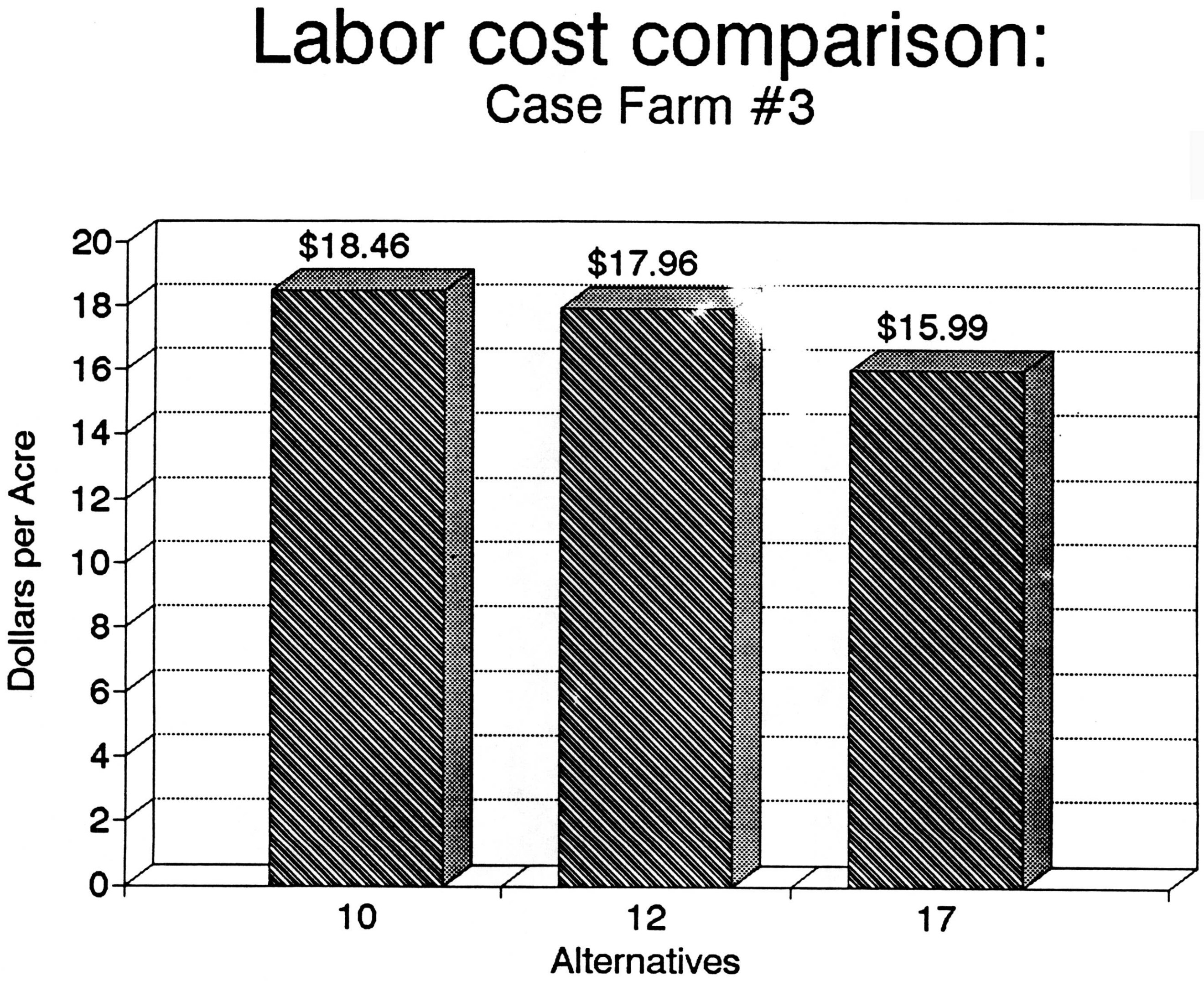
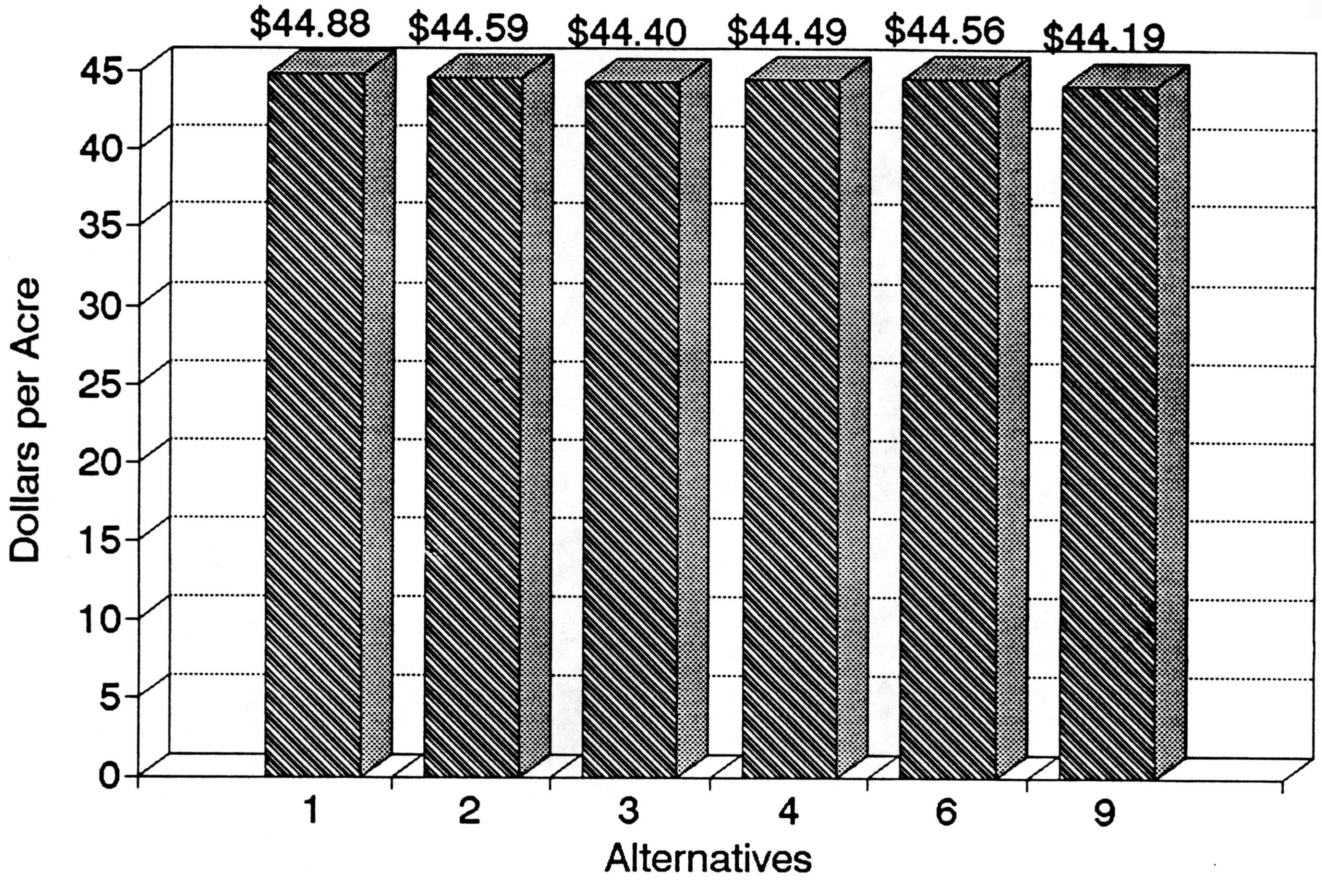

Labor cost comparison:
Case Farm #3
Dollars per Acre
0
2
4
6
8
10
12
14
16
18
20
$18.46
$17.96
$15.99
10
12
17
Alternatives

Figure 5a.



Machinery cost comparison:
Case Farm #3

Figure 5b.

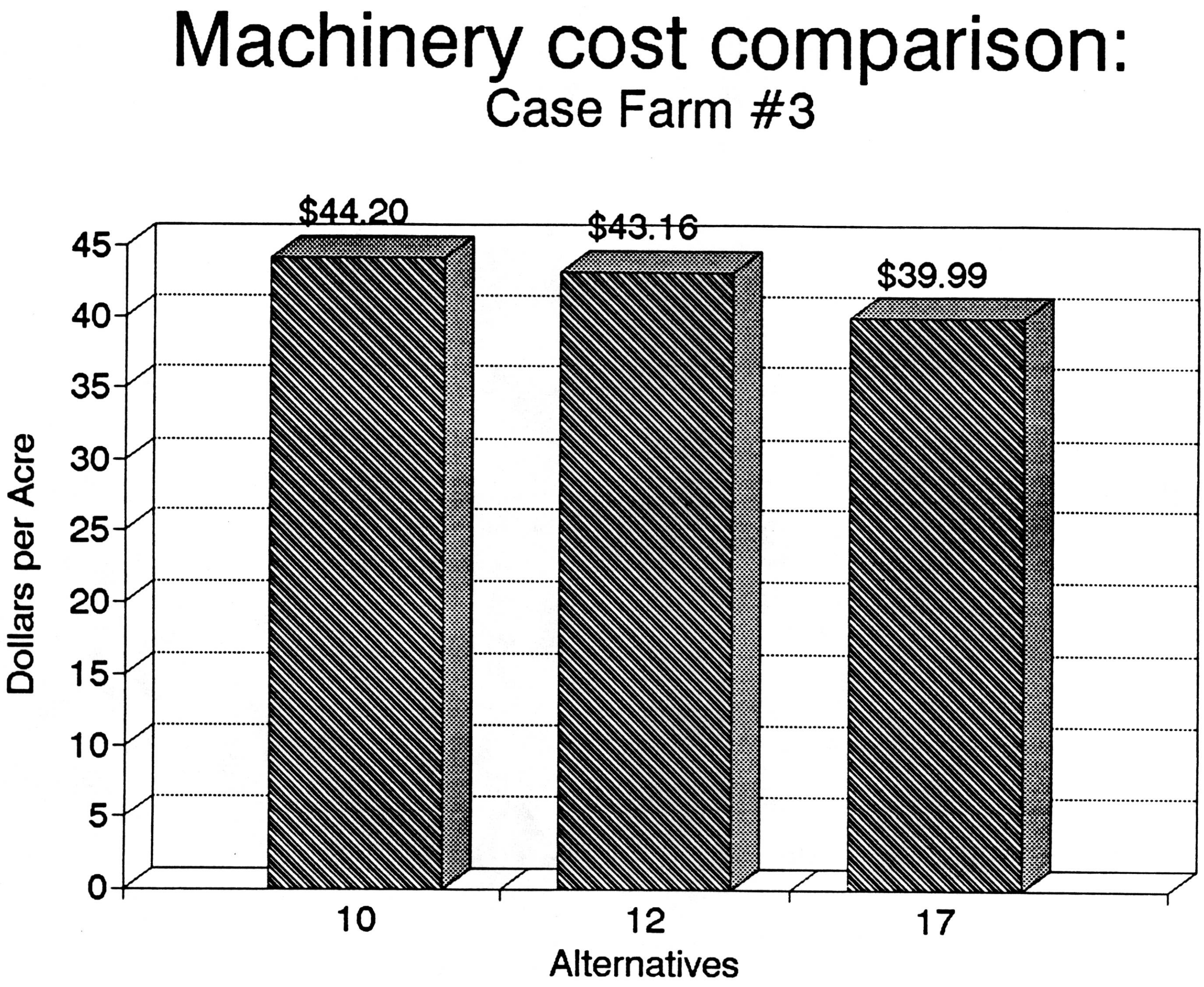

Machinery cost comparison:
Case Farm #3
$44.20
$43.16
$39.99
45
40
35
30
25
20
15
10
5
0
Dollars per Acre
10
12
17
Alternatives

Figure 6a.

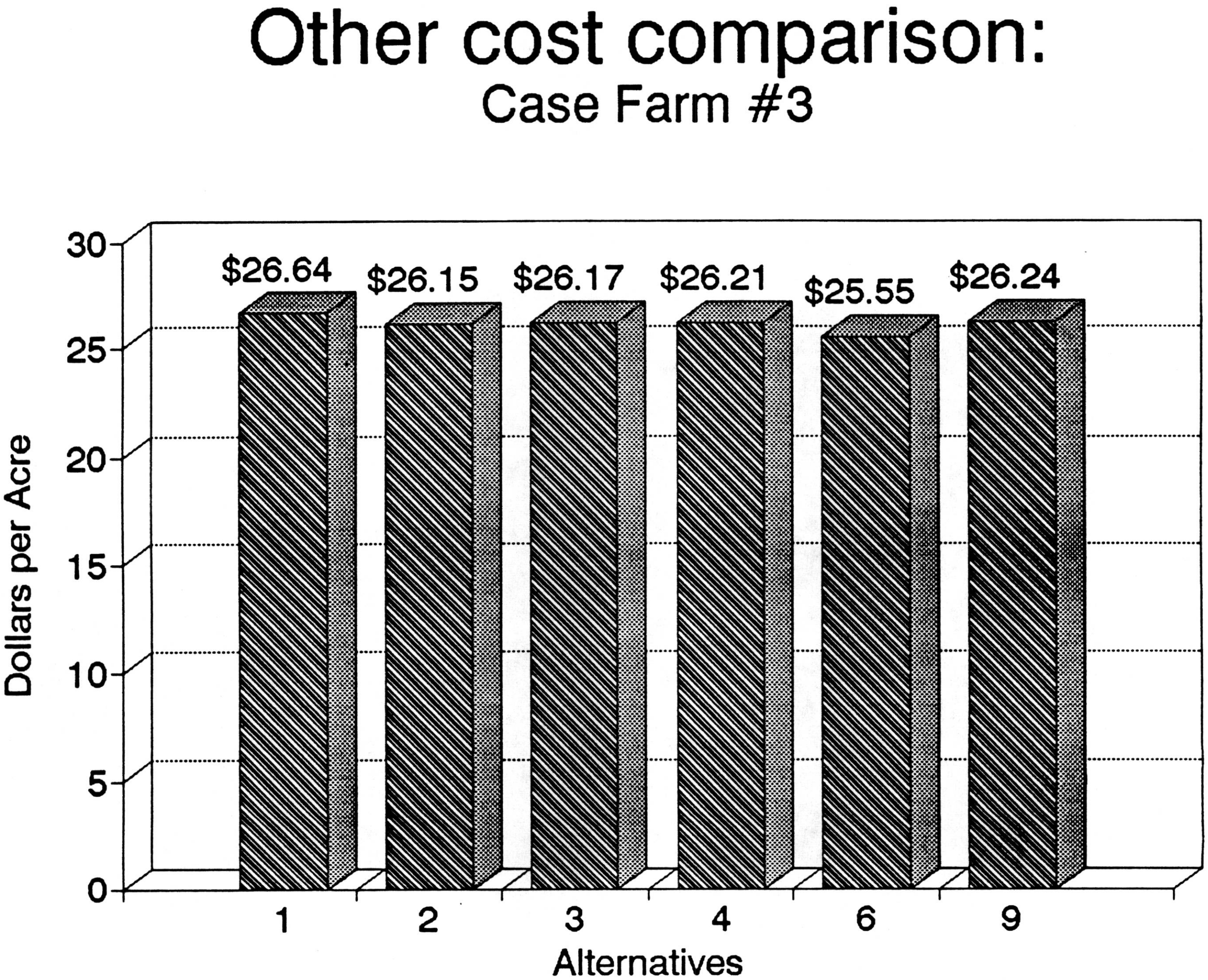

Other cost comparison:
Case Farm #3
Dollars per Acre
0
5
10
15
20
25
30
$26.64
$26.15
$26.17
$26.21
$25.55
$26.24
1
2
3
4
6
9
Alternatives

Figure 6b.

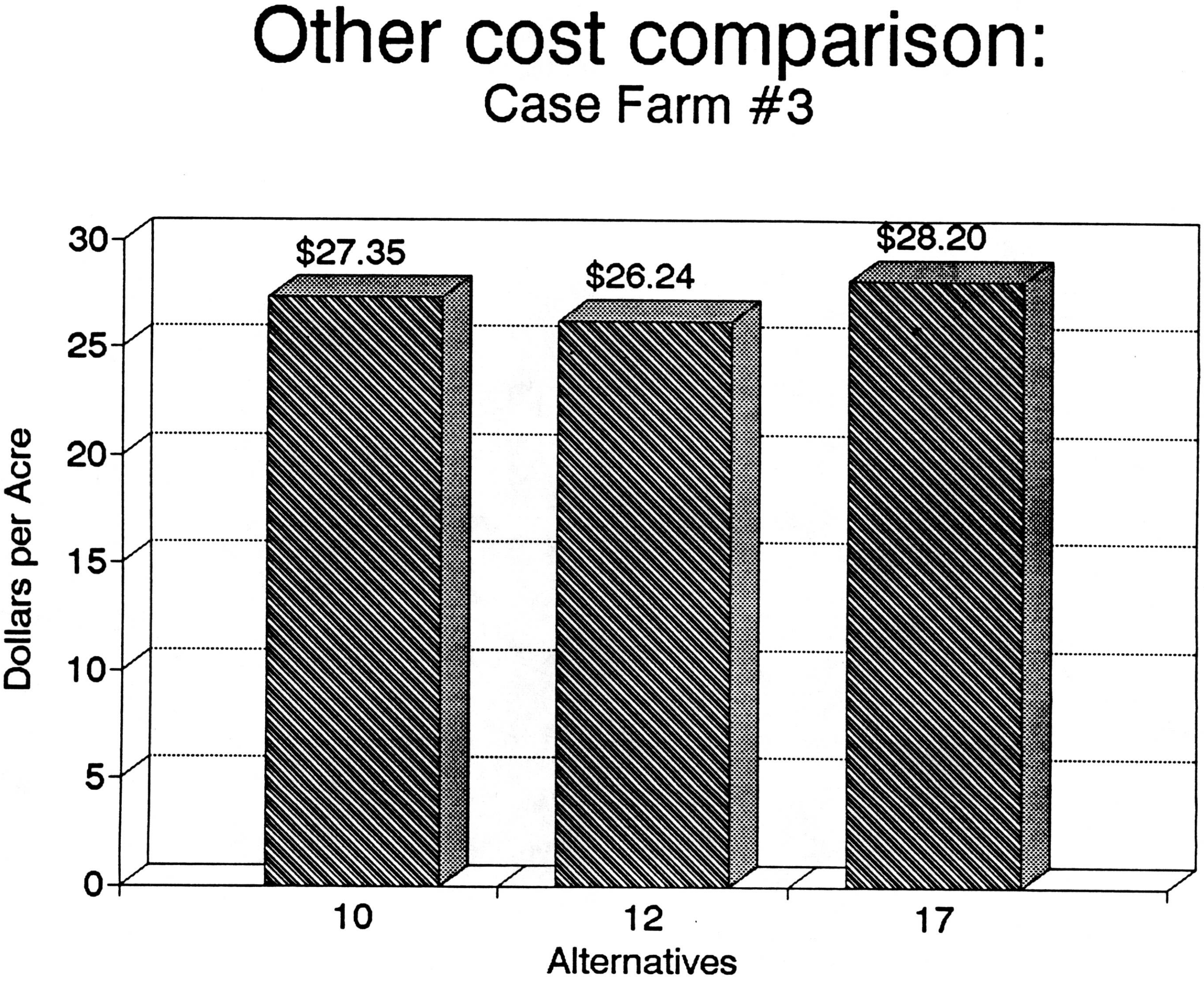

Other cost comparison:
Case Farm #3
Dollars per Acre
0
5
10
15
20
25
30
$27.35
$26.24
$28.20
10
12
17
Alternatives

Figure 7.

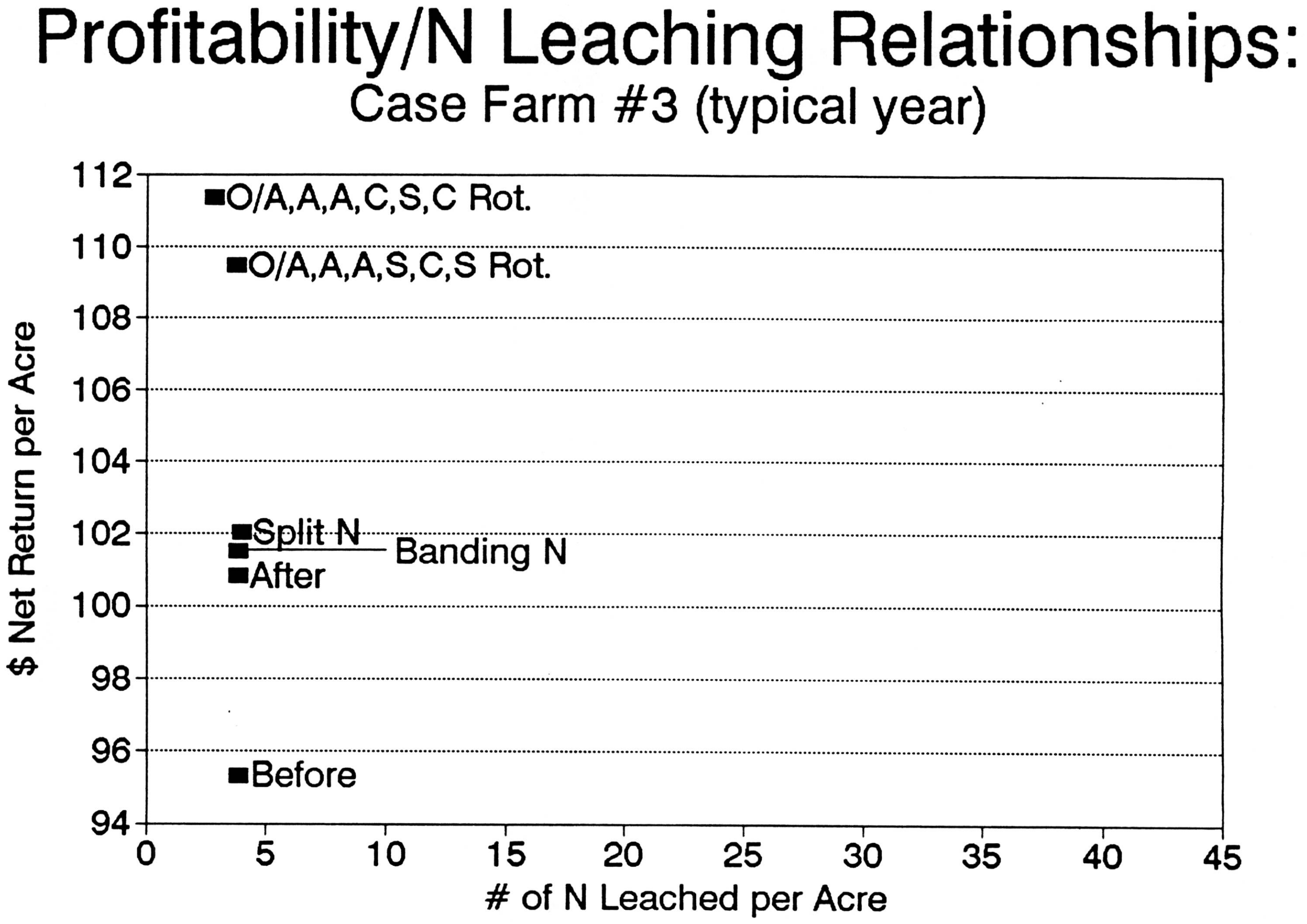
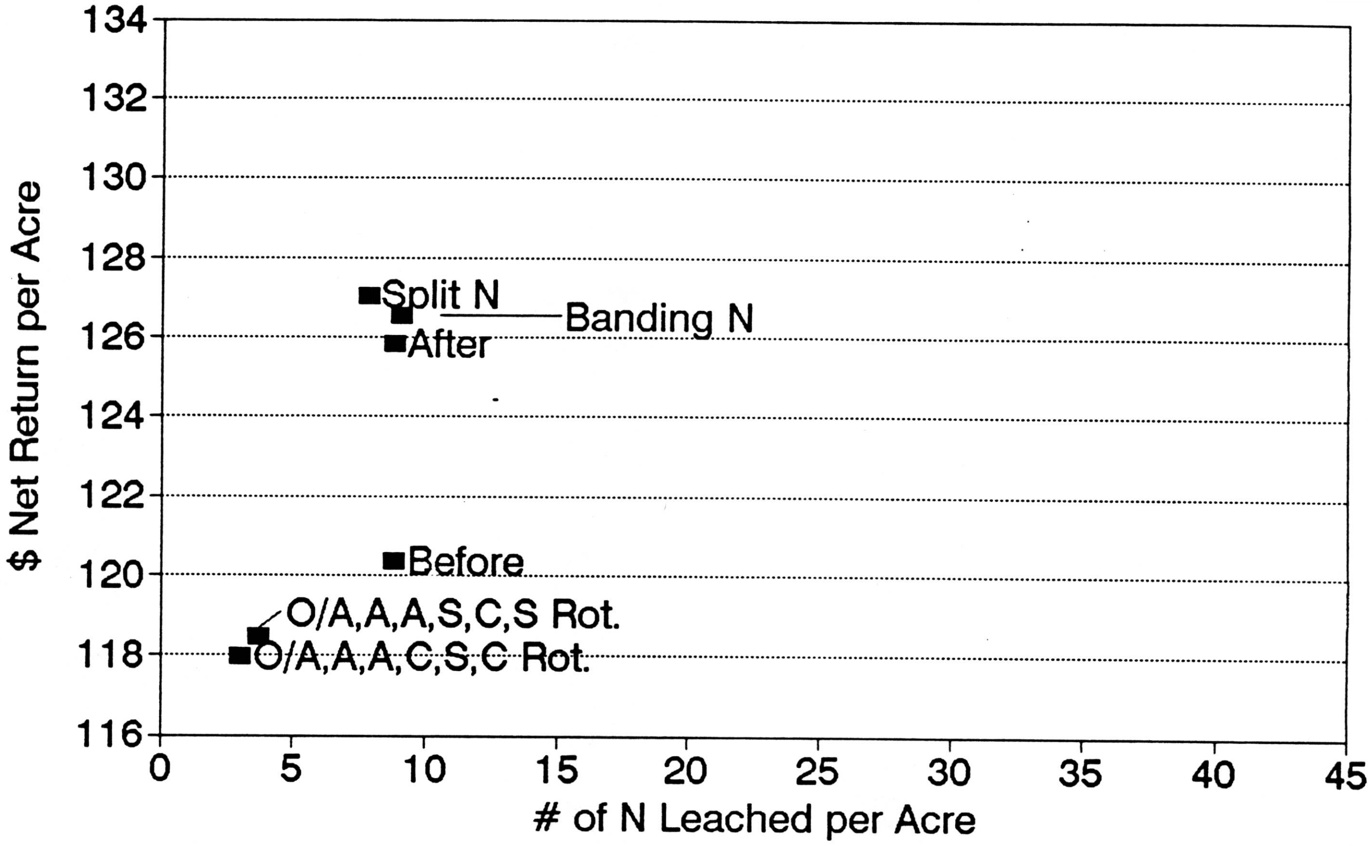

Profitability/N Leaching Relationships:
Case Farm #3 (typical year)
$ Net Return per Acre
# of N Leached per Acre
112
110
108
106
104
102
100
98
96
94
0
5
10
15
20
25
30
35
40
45
O/A,A,A,C,S,C Rot.
O/A,A,A,S,C,S Rot.
Split N
Banding N
After
Before

Figure 8.



Profitability/N Leaching Relationships:

Case Farm #3 (wet year)

Figure 9.

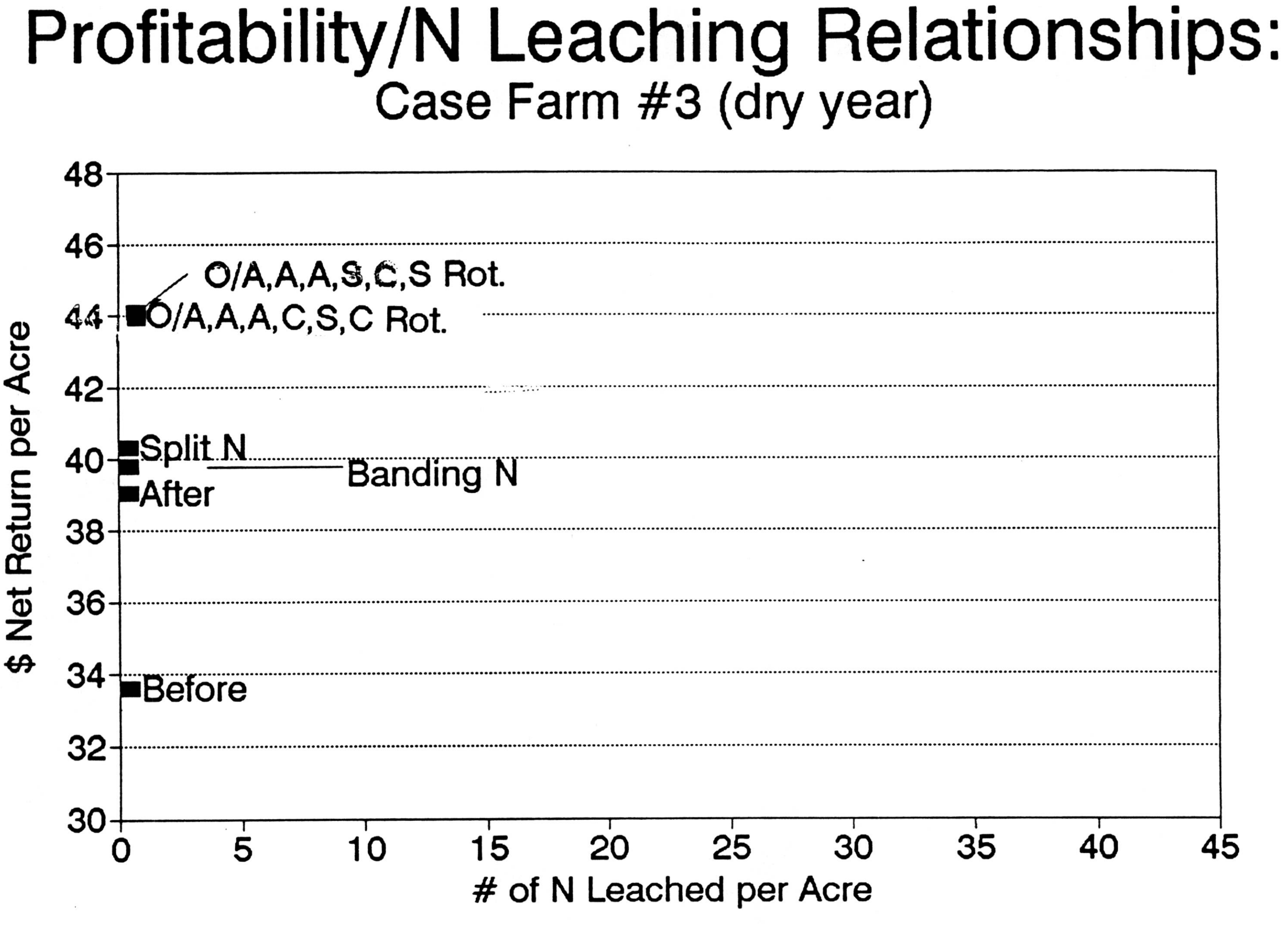

Profitability/N Leaching Relationships:
Case Farm #3 (dry year)
$ Net Return per Acre
# of N Leached per Acre
48
46
44
42
40
38
36
34
32
30
0
5
10
15
20
25
30
35
40
45
O/A,A,A,S,C,S Rot.
O/A,A,A,C,S,C Rot.
Split N
Banding N
After
Before

Figure 10.

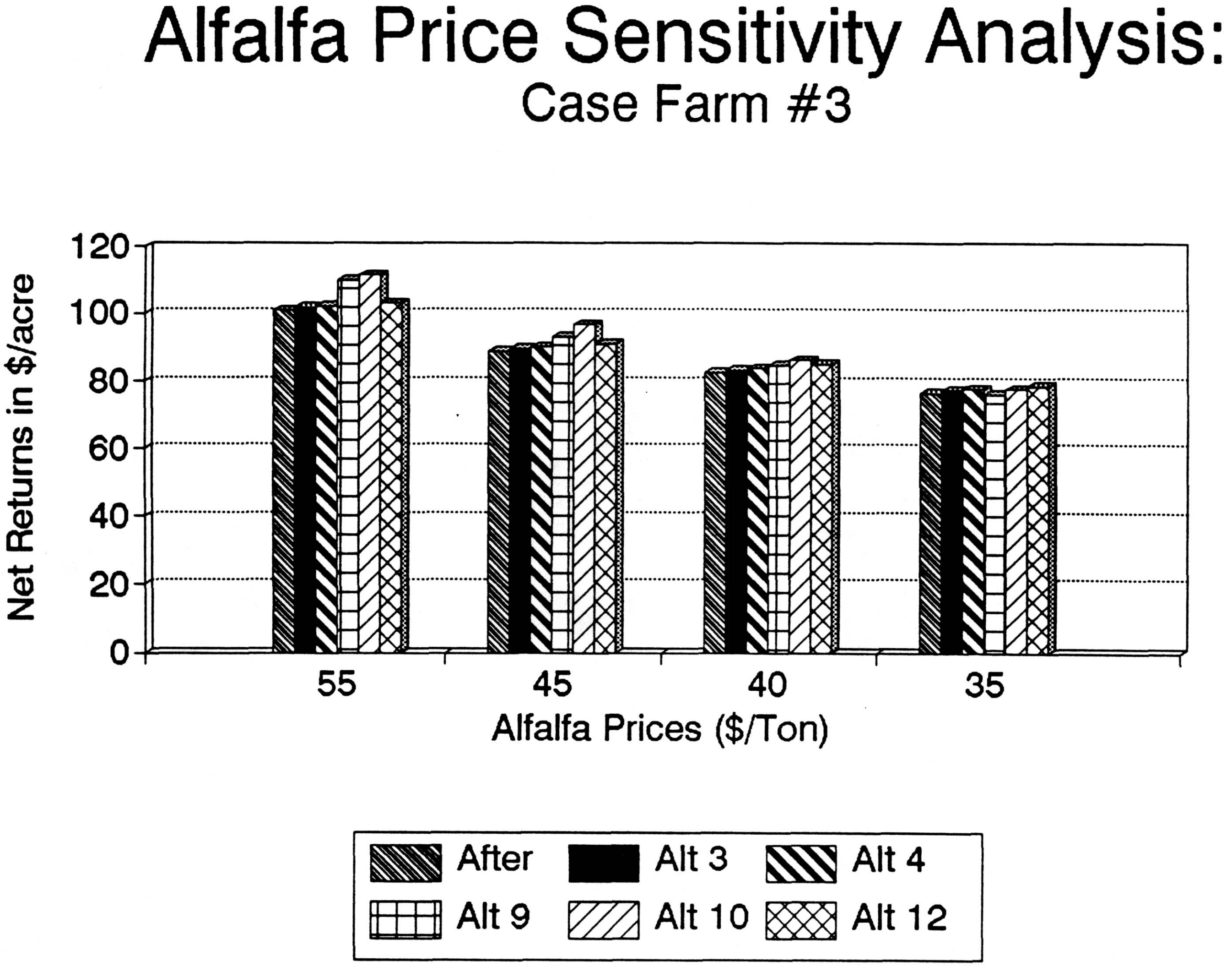

Alfalfa Price Sensitivity Analysis:
Case Farm #3
Net Returns in $/acre
120
100
80
60
40
20
0
55
45
40
35
Alfalfa Prices ($/Ton)
After
Alt 3
Alt 4
Alt 9
Alt 10
Alt 12

Figure 11.

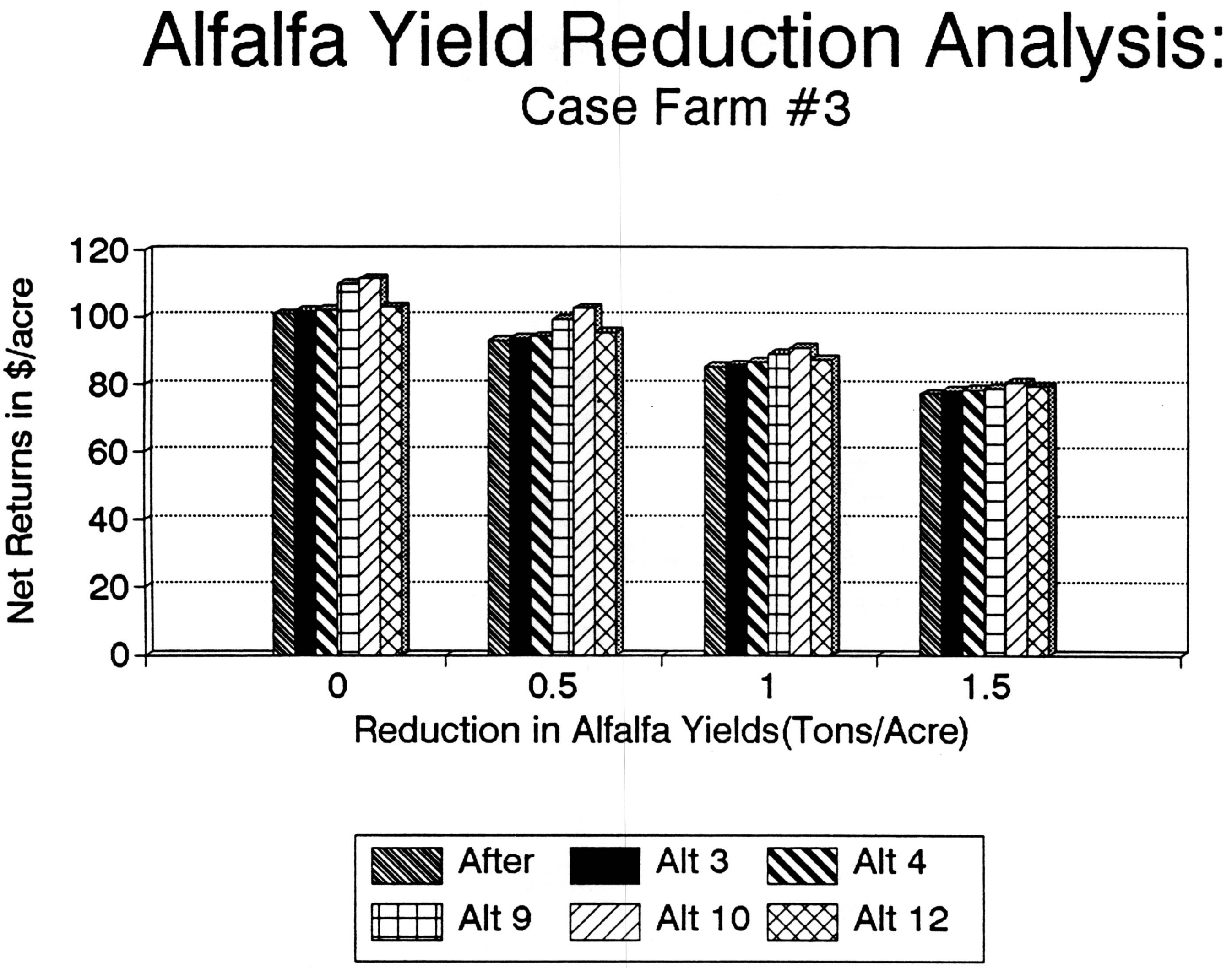
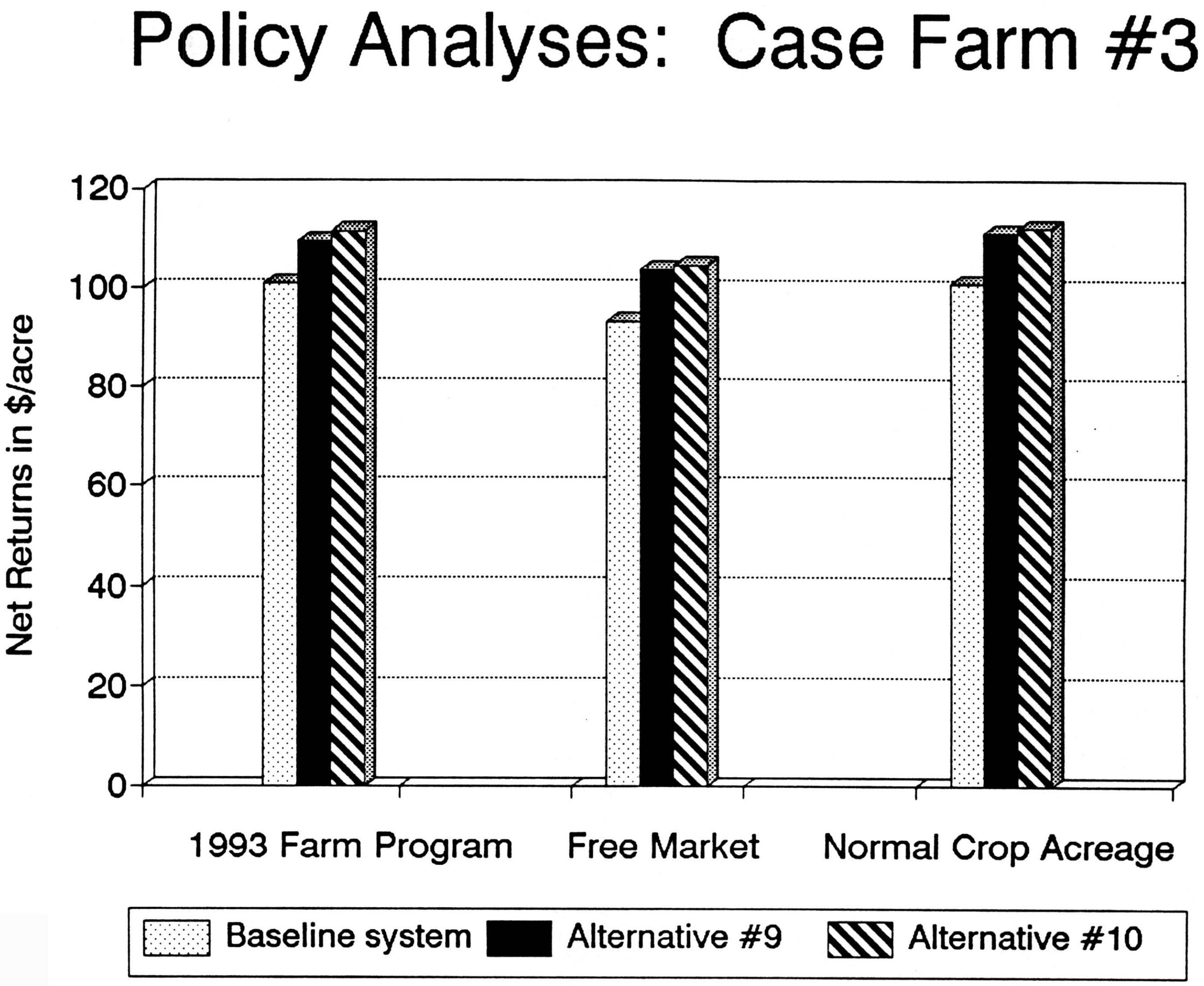

Alfalfa Yield Reduction Analysis:
Case Farm #3
Net Returns in $/acre
0
20
40
60
80
100
120
0
0.5
1
1.5
Reduction in Alfalfa Yields(Tons/Acre)
After
Alt 3
Alt 4
Alt 9
Alt 10
Alt 12

Figure 12.


Policy Analyses: Case Farm #3
Net Returns in $/acre
0
20
40
60
80
100
120
1993 Farm Program
Free Market
Normal Crop Acreage
Baseline system
Alternative #9
Alternative #10