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Pasture Improvement: An Analysis of Rancher Attributes in Central South Dakota

Herbert R. Allen

Rex D. Helfinstine

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Pasture Improvement

An Analysis of Rancher Attributes in Central South Dakota

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Economics Department
Agricultural Experiment Station
South Dakota State University, Brookings

Pasture Improvement

An Analysis of Rancher Attributes in Central South Dakota

SUMMARY

In the summer of 1965,160 farmers and ranchers in Faulk, Aurora, Hyde, and Gregory counties were interviewed to determine their experience in beef cattle production and pasture management. Fifteen variables were quantified from data obtained in the survey. Simple correlation and multiple correlation analyses were made to identify variables associated with the amount of pasture improvement work undertaken. The correlation analyses were made using all ranchers included in the survey and also using only those ranchers who had done improvement work.

A distinction needs to be made between the *amount* of pasture improvement done and the *decision* to do pasture improvement work in either a small or a large amount. Simple correlation analysis revealed that those who had decided to do pasture improvement work, irrespective of the amount done, tended to have: (1) higher scores in their understanding of pasture improvement technology, (2) a more innovative nature, (3) lower age, (4) higher expectations of success from a new seeding, (5) higher ranking for pasture improvement in terms of profitability, and (6) an opinion that pasture improvement could be done on a small scale basis.

Among those ranchers who have done pasture improvement work, simple correlation analysis revealed that those with high amounts of acres per animal unit and those who were younger in age had done the most pasture improvement work. Among *all* ranchers in the survey, there was a significant association between the amount of pasture improvement work done and innovativeness as well as the degree to which handling of livestock while seeding becomes estabished

was observed as a problem.

Multiple correlation analysis showed that approximately 13% of the variation in the amount of pasture improvement work done can be explained by the variables employed in this study. This is a relatively small amount, but the association of the independent variables with the dependent variable is statistically significant. Those factors that contributed most significantly to the variation in the amount of pasture improvement work done were innovativeness of the rancher, his expectations regarding a satisfactory stand from a new seeding, and his opinion regarding the profitability of range improvement. Among those ranchers who had done pasture improvement work, the factor most closely associated with the amount of pasture improvement work done was the pasture acres per animal unit. Those ranchers with the greater pasture acres per animal unit were the ranchers who had done the most pasture improvement work.

These relationships have implications for both research and Extension work. Research work to develop improved techniques for pasture renovation and to reduce the risk factor in establishing new seedings would aid in getting more pasture improvement work done. Additional studies to provide information on the costs and returns from pasture improvement would also help. Farm and ranch tours to observe successful applications of pasture improvement would aid in developing rancher understanding of the technology involved. Likewise, the use of demonstration plots, information on improved varieties and methods of seeding and other educational activities of this nature can influence the amount of pasture improvement work done.

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Pasture Improvement

An Analysis of Rancher Attributes in Central South Dakota

By
HERBERT R. ALLEN and REX D. HELFINSTINE*

INTRODUCTION

In the summer of 1965 a survey was made of 160 farmers in Faulk, Aurora, Hyde, and Gregory counties to determine their experience in beef cattle production and pasture management. This survey marked the early phase of a joint project of the Departments of Economics, Agronomy, and Animal Science titled "The Efficiency of Beef Cattle Production in South Dakota with Various Methods of Land Use and Cattle Management." The project involves developing new techniques for pasture improvement and testing various management practices.

Previous studies have indicated that tame grass pastures can profitably be included in the land use program of ranches in Central South Dakota (1). However, in this survey only 29 out of 160 farmers and ranchers reported having tame grass pastures as part of their land use program. Fourteen out of the 160 interviewed reported pasture improvement experience involving native pastures. The type of pasture improvements reported included fertilization, resting the range, rotation grazing, new seeding of native grass and interseeding into native grass pastures. The number of ranchers reporting pasture improvement experience is shown in table 1. Sixty-five different farmers and ranchers reported pasture improvement activities. Many of these did pasture improvement work in several of the categories listed in table 1. In view of the importance of high producing grassland for beef production, the results of this survey raise questions as to why more ranchers have not engaged in pas-

*Assistant professor of economics; associate dean of Graduate School and professor of Economics, respectively.

ture improvement work. This publication helps identify some of the factors associated with pasture improvement work by ranchers in Central South Dakota.

Table 1. Number of ranchers reporting pasture improvement experience.

Type of Pasture Improvements	Number of Ranchers Reporting
Tame grass seeding*	47
Native grass seeding†	6
Native pasture fertilized	6
Tame grass fertilized	13
Range rested	2
Rotation grazing on native grassland	4
Interseeding into rangeland	2
Sprayed for weeds	2
Total number of different ranchers	65

*Tame grass includes: bromegrass, tame rye, intermediate wheatgrass, crested wheatgrass, Russian wild rye, reed canary, sudan grass, and various mixtures of these grasses with alfalfa.

†Native grass includes: western wheatgrass, needlegrasses, switchgrass, big bluestem, sideoats grama, and blue grama.

METHOD AND PROCEDURE

Simple linear correlation and multiple correlation analyses were employed in identifying factors associated with the amount of pasture improvement work by ranchers. Fifteen variables were identified for use in the model. These variables are listed in table 2. Variable X_{14} represented total acres of pasture improvement work and served as the dependent variable. Variable X_{15} also served as a dependent variable. The mathematical model may be expressed:

$$X_{14} = a + b_1 X_1 + b_2 X_2 + \dots + b_{13} X_{13}$$

It was not the intent of this analysis to establish associations for predictive purposes. Consequently, interest was centered on the association between variables and the nearness of this association as measured by the coefficient of determination.

Table 2. Variables used in multiple correlation model.

X_1=Net worth
X_2=Expectation of a satisfactory stand from a new seeding
X_3 Risk and uncertainty associated with beef cow herds relative to other enterprises
X_4=Profitability of range improvement relative to other alternatives
X_5=Pasture improvement may be done on a small scale
X_6=Degree to which handling of livestock while seeding is established is observed as a problem
X_7=Pasture acres per animal unit
X_8=Per cent of total land operated that is owned
X_9=Understanding of the technology of pasture improvement
X_{10}=Innovativeness of the rancher
X_{11}=Age of the operator in years
X_{12}=Years of formal education
X_{13}=Total ranch acres
X_{14}=Total acres of pasture improvement work done in a recent 10-year period
X_{15}=Did or did not do any pasture improvement work

Data for quantifying the variables used in this study came from a survey of 160 farmers and ranchers in Faulk, Hyde, Aurora and Gregory counties. This is the survey previously mentioned and will hereafter be referred to as the "survey."

MODEL VARIABLES

Net Worth (X_1)

Net worth for each rancher was arrived at through an inventory of his assets and liabilities obtained in the survey.

Expectation of Satisfactory Stand from New Seeding (X_2)

Ranchers who have a high expectation for a satisfactory stand from a new seeding may be more likely to do pasture improvement work than those who have a low expectation. Seeding failures add to production costs with no addition to returns. A low expectation of success would deter ranch operators from making this type of investment. Each rancher included in the survey was asked to state the number of years out of five that he would expect to obtain a satisfactory stand from: (a) a new seeding of tame grass, (b) a new seeding of native grass, and (c) interseeding a pasture-type alfalfa into a native grass pasture. The rancher's responses to each of the three different types of seeding were totaled for a score. The maximum score attainable was fifteen and the minimum score was zero.

Risk and Uncertainty Associated with Beef Cow Herds Relative to Other Enterprises (X_3)

Beef production is the major livestock enterprise in Central South Dakota. One hundred forty-nine ranchers out of the 160 kept a beef cow herd. This means that a high proportion of grassland production is processed through a beef cow herd. The rancher's beliefs regarding the amount of risk and uncertainty associated with a beef cow herd may influence the amount he is willing to invest in grassland improvement. The risk and uncertainty factor, however, is a relative thing and can be measured only in relation to other alternative enterprises available to the rancher. These would include the more common alternatives of raising sheep or hogs, steer grazing, and crop production. The enterprises listed in table 3 were presented to the ranchers. They were asked to rank them from one to six on the basis of dependability of income.

The ranking which a rancher gave to the cow-calf operation and the cow-yearling operation were added together for a score. A minimum possible score of 3 would indicate that the rancher rated beef cow herds first in dependability of income. A maximum possible score of 11 would indicate that beef cow herds were ranked last in dependability of income. The average score for each enterprise, as shown in table 3, indicates that ranchers considered a cow-calf operation less risky than any of the other enterprises. They considered cash crop production the most risky.

Table 3. Enterprise ranking according to dependability of income.

Enterprise	Average ranking
Cow-calf operation	1.5
Sheep raising	2.9
Cow-yearling operation	3.4
Hog raising	3.7
Yearling steer grazing	4.4
Cash crop production	5.0

Profitability of Range Improvement Relative to Other Alternatives (X_4)

Ranchers were asked to consider the alternative areas of investment presented in table 4.

Table 4. Profitability ranking of various investment alternatives.

Enterprise	Average ranking
Increasing size of beef cow herd	1.83
Investing in another livestock enterprise	2.65
Investing in range improvement	3.03
Investing to increase crop production	3.09
Investing in Government bonds	4.48

Each rancher then ranked the alternatives in order of likely profitability per $100 invested. The range in possible score for any one enterprise would be one to five. If ranchers believe that capital earns a smaller return when invested in range improvement, as compared to other alternatives, they may not invest in range improvement work. The average ranking given to range improvement by 156 ranch operators included in the survey was 3.03. However, investing in crop production was ranked on an equal basis with pasture improvement work as shown in table 4. Ranchers, on the average, would invest to increase the size of the beef cow herd or invest in some other livestock enterprise before investing for range improvement. Government bonds were rated last in relative profitability.

Degree to Which Range Improvement May Be Done on a Small Scale (X_5)

Enterprises or practices that may be conducted on a small scale are conducive to adoption on a trial basis by ranch operators. The use of fertilizer is an example of such a practice. It may be used on one acre of land as a trial or used on all of the land if the rancher so chooses. Some enterprises are not adapted to trial on a small scale. The adoption of a system for grade A milk production would be an example of this. A farmer could not invest a small amount of money and sell part of his milk on the grade A market. He must make considerable investment in milking equipment, pipe lines, bulk cooler, etc. A decision to shift to grade A milk production would come slower than a decision to use weed sprays, fertilizer or any other practice that may be adopted on a small scale. The consequences of a decision on a small scale activity are not as great as for those on a large scale. If pasture improvement work must be carried out on a large scale basis it may be likely to deter investment in this area. Ranchers who believe pasture improvement work must be done on a large scale basis may not be as likely to invest in pasture improvement work as those who do not. Ranchers in the survey were asked whether range improvement could be done a few acres at a time each year or whether it would have to be done a whole pasture at a time. A yes or no response was obtained. This variable was therefore fitted into the model as a dummy variable (3). In the correlation model "1" equals yes and "0" equals no. Out of 156 ranchers included in the survey, 85 answered yes, 61 answered no, and 10 didn't know. A total of 54½% of ranchers surveyed indicated that they believed range improvement work could be conducted on a small scale basis.

Degree to Which Handling of Livestock is Observed as a Problem (X_6)

When pasture improvement work is carried out, it may be necessary to keep livestock off the range for a period of time. This may cause problems in handling livestock. Other pastures on which livestock can graze may not be available. Ranchers in the survey were asked: Do you consider that handling your cattle while reseeding rangeland is

1. No problem?
2. Somewhat of a problem?
3. An important problem?
4. A very important problem?

A score of 4 was given to those respondents who felt that handling of livestock was a very important problem. Those who felt that no problem was involved received a score of one. If a rancher felt that handling livestock while seeding or improving a portion of a rangeland was a very important problem, he would be would be less likely to undertake improvement work. There were 56 respondents who felt that no problem was involved, 41 believed it was somewhat of a problem, 26 regarded it as an important problem, and 33 stated that it was a very important problem.

Current Stocking Rate (X_7)

Those who desire to expand the size of their beef herd may do so by several means: (1) Rent or buy more pasture land, (2) improve their pasture productivity, or (3) increase the stocking rate. A rancher who is currently overstocking his pasture may be more likely to engage in pasture improvement work than one who is not. Data from the survey permitted the computation of total pasture acres and total animal units on pasture during 1965. Acres per animal unit were calculated for each rancher and used as an independent variable in the model.

Per Cent of Total Land Operated that is Owned (X_8)

Ownership may permit greater security of tenure and greater freedom of management. Under these conditions ranch operators may be in a better position to make long time plans for range improvement. The per cent of land owned was computed for each ranch included in the survey and used as an independent variable in the model.

Understanding of the Technology of Pasture Improvement (X_9)

To obtain satisfactory results from pasture improvement it is necessary to use proper technology. This includes use of adapted varieties, use of fertilizer, proper planting methods, and many other practices. If a rancher does not understand this technology he may be reluctant to begin any pasture improvement work. With the assistance of agronomists at South Dakota State University, a set of questions was formulated which would measure a person's understanding of pasture improvement technology. Each question was scored on the basis of the type of response. The set of questions and the technique for scoring is presented in table 5.

A total score was computed for each rancher by summing the scores on each question. The total score was used as an independent variable.

Innovativeness of the Rancher (X_{10})

It was decided in advance of the survey to measure innovativeness by a technique developed by Rogers, Havens, and Cartano (2). Their approach involves determining an innovativeness score for each farmer for the purpose of categorizing adopters of farm practices as to their degree of innovativeness. Innovativeness measures the degree to which an individual is early in adopting practices as compared with other members of his community. Ranchers who are innovative in nature may do more pasture improvement work than those who are not. The method of computing the innovativeness score is presented in the Appendix.

Age of the Operator in Years (X_{11})

Older operators may not be interested in making long time investments in range improvements. Many factors associated with age may act to cause an individual to avoid investments in range improvements. Age was therefore fitted into the model as an independent variable.

Years of Formal Education (X_{12})

Formal education and training may facilitate an understanding of the value of pasture improvement as well as the methods for doing it. Years of formal education were used as an independent variable.

Ranch Size (X_{13})

Operators of large ranches may be more interested in doing pasture improvement work than operators of small ranches. Many factors such as capital position, personal characteristics of the operators, or adequate land for handling livestock while reseeding may cause ranch size to be a factor related to the amount of pasture improvement work done. Total ranch acres were used as an independent variable in the model.

Acres of Pasture Improvement Work Done (X_{14})

The amount of pasture improvement work done was measured in acres. It was the dependent variable in the model. Interviewers asked each rancher in the survey to list any kind of pasture improvement work which had been done within the last 10 years (in this case the 10-

Table 5. Scoring system on familiarity with range improvement technology

Question and Response	Score
1. What fertilizer would you use on native range?	
(a) Use phosphorous or don't know	0
(b) Use a mixed fertilizer or above 40 pounds of nitrogen per acre	1
(c) Use 10-40 pounds of nitrogen per acre	2
(d) Use no fertilizer or would take a soil sample	3
2. What plants would be best for interseeding into native range?	
(a) Don't know or none	0
(b) Any type of clover	1
(c) Alfalfa alone or crested wheat alone	2
(d) Only grass plants	3
(e) Both alfalfa and grass	4
3. How can one best control gum weed and pasture thistle?	
(a) Don't know	0
(b) Mowing	1
(c) Use 2,4-D	2
(d) Specifies rate, time and form of 2,4-D use	3
4. Between what dates are cool season native grasses most productive?	
(a) Don't know or any time previous to May 1	0
(b) May 1 to July 15	1
(c) June 1 to August or September	2
(d) June 1 to July 15	3
5. How can we increase production of green grass early in the season?	
(a) Don't know	0
(b) Apply nitrogen during late fall or in April	1
(c) Use early emerging cool season grass (no species)	2
(d) Refrain from late fall grazing	3
(e) Use crested wheat or Russian wild rye or both c and d are stated	4
(f) Both d and e are stated	5
6. When is supplemental pasture needed with cool season grasses?	
(a) Don't know	0
(b) Other than July 15 to September 15	1 or 2
(c) July 15 to September 15	3
7. What is the best height for first spring grazing of green needlegrass or western wheat grass?	
(a) Don't know	0
(b) 2 to 4 inches or over 10 inches	1
(c) 8 to 10 inches	3
(d) 5 to 7 inches	4
8. What is the best way to improve alkaline or low spots?	
(a) Don't know	0
(b) Plant reed canary or creeping meadow fescue in low spots	1
(c) Seed tall wheatgrass in alkaline spots	2
(d) Both b and c are mentioned	3

year period up to and including 1965). Pasture improvement work included seedings, resting the range, fertilization, weed spraying, and rotation grazing. For purposes of this study, pasture improvement work was defined as "any activity which had as its objective an increase in pasture production per acre." It included the activities presented in table 1.

Pasture acres represent a cumulative total of all improvement activities. For example, if an individual seeded 5 acres of brome-alfalfa for pasture in 1960, 20 acres in 1962, and fertilized 50 acres of native pasture in 1963, he would have a total of 75 acres of pasture improvement work.

Did or Did Not Do Pasture Improvement Work (X_{15})

This was measured by means of a dummy variable. A "1" indicates that pasture improvement work was done and a "0" indicates that no pasture improvement work was done (3).

SIMPLE CORRELATION ANALYSIS

Table 6 presents the zero order correlation coefficients when all ranchers (156) included in the survey were included in the correlation analysis. (Four of the original 160 ranchers in the survey are not included in this analysis because of insufficient information.) The table reveals that the amount of pasture improvement work done was significantly associated with innovativeness of the rancher and the degree of the problem he associated with handling of livestock while seeding becomes established. Table 6 shows a correlation coefficient of –.169 between the amount of pasture improvement work done and the problem of handling livestock. This is significant at a 5% level of probability.The negative association means that those ranchers who rated the handling of livestock as not important have also done more pasture improvement work.

Pasture improvement work was carried out by those individuals who are more innovative in nature. The association between these variables, as shown in table 6, was significant at the 1.0% level of probability.

Table 7 presents the zero order correlation coefficients when only those ranchers who had done pasture improvement work were included in the analysis. Tables 6 and 7 reveal considerable intercorrelation between the variables in the model. However, certain general conclusions regarding pasture improvement work may be drawn from the analysis as follows:

1. Those ranchers who had pasture improvement experience had higher scores in their understanding of pasture improvement technology.
2. Pasture improvement work was done by those ranchers who were more innovative in nature.
3. Those ranchers who rated the handling of livestock (while seeding becomes established) as not an important

Table 6. Simple correlation matrix, 156 observations, all farms and ranches drawn in random sample survey.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	.032	.041	–.003	.031	–.110	.154	.299†	.043	.315†	.205*	.081	.713†	.088	.008
2		1.000	.012	.009	.110	–.034	.022	.084	.177*	.025	–.037	.021	.033	.157	.198*
3			1.000	.039	.081	.126	–.058	.043	–.070	.037	–.073	–.106	–.112	.084	.118
4				1.000	–.165*	.042	.017	–.072	–.113	–.101	.207†	–.059	–.009	–.153	–.183*
5					1.000	–.379†	–.023	–.041	.155	.115	–.099	.080	.068	.109	.187*
6						1.000	–.101	.012	–.172*	–.187*	–.031	–.112	–.160*	–.169*	–.114
7							1.000	.094	–.138	–.054	.182*	–.015	.336†	.063	–.141
8								1.000	–.055	.146	.268†	–.062	.050	.036	.038
9									1.000	.192*	–.245†	.129	–.031	.119	.250†
10										1.000	–.012	.192*	.246†	.241†	.237†
11											1.000	–.255†	.108	–.005	–.236†
12												1.000	.092	.004	.038
13													1.000	.070	.031
14														1.000	.549†
15															1.000

*Significant at .05 level (.157)
†Significant at .01 level (.206)

Table 7. Simple correlation matrix, 64 observations, farms and ranches having done pasture improvement work.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	.233	–.073	.027	.065	–.118	.060	.248*	.000	.377	.378†	.148	.630†	.180	.000
2		1.000	–.089	.085	–.078	–.118	.113	.056	.219	.099	.122	.168	.290*	.100	.000
3			1.000	.445†	–.047	.080	.024	.094	–.396†	.016	.143	–.154	–.141	.042	.000
4				1.000	–.195	.148	–.096	–.104	–.224	–.162	.190	–.257*	.050	–.098	.000
5					1.000	–.276*	.041	.021	.064	.019	.151	.021	.071	.012	.000
6						1.000	–.285*	.028	–.215	–.090	–.195	–.095	–.132	–.208	.000
7							1.000	–.016	–.125	–.037	.101	.057	.334†	.286*	.000
8								1.000	–.174	.199	.238	–.084	–.053	.031	.000
9									1.000	.151	–.245*	.388†	–.110	–.035	.000
10										1.000	.064	.233	.167	.195	.000
11											1.000	–.300*	.173	.259*	.000
12												1.000	.104	–.068	.000
13													1.000	.098	.000
14														1.000	.000
15															.000

*Significant at .05 level (.246)
†Significant at .01 level (.320)

problem have done the greatest amount of pasture improvement work.

4. Those with experience in pasture improvement work were found more frequently among the younger ranchers.
5. Ranchers who had done pasture improvement work had higher expectations of success from a new seeding than those who had not done pasture improvement work.
6. Those ranchers who had done pasture improvement work ranked such a practice higher, in terms of profitability, than did those ranchers who had not done pasture improvement work.
7. Those with experience in pasture improvement work generally held the opinion that range improvement could be done on a small scale basis.
8. Ranchers who had done pasture improvement work and had a low pasture stocking rate (high acres per animal unit) had also done the most pasture improvement work.

MULTIPLE CORRELATION ANALYSIS

The 15 variables previously identified and discussed were included in a multiple correlation analysis in this study. Variable X_{14} measured the amount of pasture improvement work done (acres) and served as a dependent variable. Variable X_{15} was a dummy variable. It measured the presence or absence of experience in pasture improvement work and also was used as a dependent variable in one model.

Three multiple regression models were used. One model employed X_{14} as a dependent variable with X_1 through X_{13} as independent variables. A second model substituted X_{15} for X_{14} as a dependent variable. A third model used only the 64 ranchers who had done pasture improvement work. Variables X_1 through X_{13} were independent and X_{14} was the dependent variable. These models are subsequently referred to as Model A, Model B, and Model C, respectively.

MODEL A

A stepwise multiple regression program for the I.B.M. 1620 electronic computer was used for this analysis. Results of the program are presented in table 8. The table presents the values for R^2 and the computed F level* for testing the significance of R^2. It also shows the F level for testing the additional explained sum of squares due to introducing a specific variable into the problem.†

---

*F $\dfrac{R^2(N\text{-}k\text{-}1)}{(1\text{-}R^2)(k)}$ with n_1 k and n_2 N-k-1

†F $\dfrac{(\text{Explained SS with k var.}) - (\text{Explained SS with k-1 var.})}{(\text{Error SS with k variables}) \div (N\text{-}k\text{-}1)}$

With n_1 1 and n_2 N-k-1

When all 13 variables were included in the regression problem, R^2 was not significant at the 5% level. When variable X_5 (range improvement done on a small scale) was dropped from the problem, and 12 independent variables were used, the value of R^2 still was not significant. However, when 11, or less, independent variables were employed in the model, the value of R^2 became significant at the 5% level. It became significant at the 1.0% level when eight or less independent variables were used in the regression model.

The X_n column in Table 8 identifies the variable to be deleted in the stepwise regression analysis. For example, with 13 independent variables, an R^2 of .13136 was obtained. The variable which reduced the explained sum of squares least (reduce the value of R^2) when removed from the regression problem was variable X_5. The next variable to be removed from the model was X_1. This is the net worth variable. Previous linear programming studies have indicated that a reduction in available capital generally resulted in less pasture improvement work and a smaller cow herd (1). However, in the current regression analysis the capital position (as measured by net worth) was not a limiting factor in pasture improvement work among the ranchers surveyed. But, in terms of optimum organization, if capital is, in fact, a limiting factor it will reduce the amount of pasture improvement work done.

In table 8 when only one independent variable remained in the model, an R^2 of .05785 was obtained. This is the same as the zero order correlation coefficient of determination as presented in table 6 between X_{14} and X_{10}. Variable X_{10} measures innovativeness. It was the variable

Table 8. F level for testing the signficance of R^2 and for testing the significance of an increase in explained sum of squares due to the introduction of an additional variable, 156 observations, acres of pasture improvement work as dependent variable.

(N=Number of Observations k=Number of Independent Variables)

k	N-k-l	R^2	R^2F Level	Xn	Variable F Level
13	142	.13136	1.652	5	0.010
12	143	.13130	1.801	1	0.017
11	144	.13119	1.977†	13	0.044
10	145	.13092	2.184†	11	0.114
9	146	.13024	2.429†	8	0.110
8	147	.12959	2.736*	9	0.262
7	148	.12803	3.104*	12	0.413
6	149	.12560	3.555*	7	0.730
5	150	.12132	4.142*	3	1.581
4	151	.11205	4.764*	6	2.385
3	152	.09803	5.501*	4	2.904§
2	153	.08079	6.724*	2	3.820‡
1	154	.05785	9.456*	10	9.456*

*Significant at the 1% level
†Significant at the 5% level
‡Significant at the 6% level
§Significant at the 10% level

most significantly associated with the amount of pasture improvement work done. When variable X_2 (expectation of satisfactory stand from a new seeding) was added to the model, there was a significant increase in the explained sum of squares, as shown in table 8.

It is also observed in table 8 that variables X_{10}, X_2, and X_4 explain 9.8% of the variation in X_{14}. The explained variation, when 13 independent variables were used in the model, was 13.1%. It can now be seen that the data presented in table 8 may be summarized in two main statements.

1. The independent variables do not explain a very large portion of the variation in the amount of pasture improvement work done by ranchers. However, the multiple coefficient of determination is significantly large when all but X_{13} and X_{12} are included in the model.
2. Most of the variation in the amount of pasture improvement work was explained by a relatively few independent variables. Innovativeness (X_{10}) and expectation of a satisfactory stand from a new seeding (X_2) were the only two variables which added significantly to the explained sum of squares at a 6% level of probability. (The association between variables was not significant at a 5% level of probability but became significant at a 6% level.)

MODEL B

Table 9 presents the values of R^2 and the F level for tests of significance when variable X_{15} was used as the dependent variable. Variable 15 measured whether or not the rancher had done pasture improvement work. When all 13 of the independent variables were included, an R^2 value of .21579 was obtained. This was significant at a 1.0% level of probability. Table 9 shows that all

Table 9. F level for testing the significance of R^2 and for testing the significance of an increase in explained sum of squares due to the introduction of an additional variable, 156 observations, did or did not do pasture improvement work as dependent variable.

(N=Number of Obseravtions k=Number of Independent Variables)

k	N-k-l	R^2	R^2F Level	Xn	Variable F Level
13	142	.21579	3.006*	1	1.326
12	143	.20847	3.138*	13	0.252
11	144	.20708	3.419*	8	0.368
10	145	.20505	3.740*	6	0.703
9	146	.20119	4.086*	12	0.643
8	147	.19767	4.940*	7	1.248
7	148	.19086	5.026*	5	1.177
6	149	.18443	5.616*	3	2.226
5	150	.17220	6.241*	4	2.238
4	151	.15989	7.184*	2	4.561†
3	152	.13452	7.875*	11	6.145†
2	153	.09953	8.456*	10	6.308†
1	154	.0625	10.267*	9	10.250*

*Significant at the 1% level
†Significant at the 5 level

of the R^2 values obtained by reducing the number of independent variables one at a time were significant at a 1.0% level of probability.

Table 9 also shows that X_2, X_9, X_{10}, and X_{11} were the only variables that added significantly to the explained sum of squares. These were the variables with significant partial correlation coefficients. Variables X_9 and X_{11} became significant in Model B, whereas, they were not significant in Model A. Variable X_9 measured understanding of the technology of pasture improvement and X_{11} was the age of the operator. This would indicate that pasture improvement work was carried out by those who were innovative in nature, understood the technology, were younger in age, and had good expectations for a satisfactory stand from a new seeding.

MODEL C

Table 10 presents the results of the correlation analysis when X_{14} (amount of pasture improvement work done) was used as a dependent variable and only the 64 ranchers who did pasture improvement work were included in the analysis. The table shows that a significant value of R^2 was not obtained until five or less independent variables were included in the model. The five variables measured years of formal education, profitability of range improvement, innovativeness, age of the operator, and pasture acres per animal unit.

An F test showed that X_7 (pasture acres per animal unit) was the only independent variable that added significantly to the explained sum of squares. The F value of 5.503 was significant at a 5% level of probability.

This would indicate that, among those ranchers who have done pasture improvement work, the factor most closely associated with the amount of pasture improvement work done is the pasture acres per animal unit. Those ranchers with the greater pasture acres per animal unit were the ranchers who had done the most pasture improvement work.

Table 10. F level for testing the significance of R^2 and for testing the significance of an increase in explained sum of squares due to the introduction of an additional variable, 64 observations, acres of pasture improvement work as dependent variable.

(N=Number of Observations			k=Number of Independent Variables)		
k	N-k-l	R^2	R^2F Level	Xn	Variable F Level
13	50	.22222	1.0988	9	0.006
12	51	.22211	1.2134	2	0.287
11	52	.21773	1.3157	13	0.666
10	53	.20771	1.3894	1	0.212
9	54	.20454	1.5428	3	0.214
8	55	.20139	1.7337	5	0.384
7	56	.19582	1.9480	6	0.282
6	57	.19177	2.2540	8	0.424
5	58	.18576	2.6464†	12	0.497
4	59	.17879	3.2113†	4	0.544
3	60	.17122	4.1318*	10	2.631
2	61	.13487	4.7548†	11	3.762
1	62	.08152	5.5028†	7	5.503†

*Significant at 1% level
†Significant at 5% level

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2. Rogers, Everett M., A. E. Havens, and D. G. Cartano, *The Construction of Innovativeness Scales*, Mimeo Bulletin A. E. 30, Ohio Agricultural Experiment Station, Department of Agriculture Economics and Rural Sociology, Feb. 1962.

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APPENDIX

COMPUTATION OF INNOVATIVENESS SCORES

An innovativeness score for each rancher was determined on the basis of his answers to questions on time of adoption of new practices. Questions were formulated from recommendations of Animal Science and Agronomy Extension Specialists. Nineteen recommended practices, adapted to the area in which the survey was conducted, were selected by using the following criteria:

1. Practices must have been recommended by South Dakota State University specialists.
2. The practices, or new ideas, should be applicable to the ranchers in the survey area and generally not involve large outlays of capital in order to adopt to them.
3. They should be practices most likely to have been adopted within the last 10 years so that farmers could recall the adoption date.

Table A-1 presents the list of practices and per cent of ranch operators who have adopted each practice. Each rancher was asked to state the year in which he began using the practice. Interviewers did not consider a practice adopted unless it was put into permanent practice. Each practice was then categorized in one of three ways: (a) the year in which it was adopted, (b) not adopted at all, or (c) the practice was not applicable to the rancher's situation. This information was obtained from 40 ranchers by a

Table A-1. Adoption of recommended practices by 160 ranchers, to whom practices were applicable, in Central South Dakota.

Practice	Total to whom applicable	Number of adopters	% adopted
1. Use 2,4-D for weed control in small grain	151	113	74.8
2. Use treated seed for seeding small grain	151	55	36.4
3. Test soil for fertilizer requirements	160	46	28.8
4. Plant crested wheat for spring pastures	158	45	28.5
5. Grow Ranger or Vernal Alfalfa for hay	160	65	40.6
6. Cut alfalfa for hay in early bloom	156	141	90.4
7. Frequently purchase certified seed	156	87	55.8
8. Plant sudan grass for supplemental pasture	158	53	33.5
9. Practice rotation grazing on tame pasture	135	60	44.4
10. Use stubble mulch tillage	150	62	41.3
11. Use soil sterilants for noxious weed patches	156	48	30.8
12. Participate in beef performance testing	136	8	5.9
13. Use stilbestrol in beef cattle feeding	118	28	23.7
14. Use Ronnel, Co-Ral, or Rulene for grub control	157	50	31.8
15. Use haylage	160	4	2.5
16. Calve heifers as 2-year-olds	154	126	81.8
17. Adopted a range plan	160	25	15.6
18. Computes nutrients in cattle rations	150	42	28.0
19. Use antibiotics in feed	146	51	34.9
TOTAL	2,872	1,109	38.6

staff of five interviewers in each of the four counties previously mentioned. All five interviewers worked in a single county until the survey was completed.

Analysis of Data

The range of adoption dates was determined for each practice and the dates of adoption were arrayed to show the number of adopters of a practice in each year. When asked for the year in which he first began using a practice, the respondent may have replied that he had always used the practice. When this response was received, the date of adoption was considered to be the year in which he started farming. Table A-2 presents data to illustrate the procedure used in arraying the dates of adoption. Only two practices are presented to serve as an example of the method employed.

Table A-2. Time of adoption and Sten scores assigned for growing Ranger or Vernal alfalfa and using stilbestrol in beef cattle feeding.

Date of adoption	Grow Ranger or Vernal alfalfa: No. adopters each year	Grow Ranger or Vernal alfalfa: Sten score assigned	Use stilbestrol: No. adopters each year	Use stilbestrol: Sten score assinged
1945	2	9	3	9
1946	1	9	1	8
1947	1	9	2	8
1948	0	--	1	8
1949	3	8	0	--
1950	5	8	2	8
1951	0	0	0	0
1952	1	7	0	--
1953	3	7	0	--
1954	1	7	0	--
1955	9	7	2	7
1956	1	6	1	7
1957	2	6	0	--
1958	3	6	3	7
1959	2	6	0	--
1960	5	6	2	7
1961	5	6	1	7
1962	5	6	5	6
1963	6	5	1	6
1964	6	5	1	6
1965	4	5	3	6
Never adopted	95	3	90	4
TOTAL	160		118	
Don't apply	0		42	
Total respondents	160		160	

After establishing the frequency distribution of the time of adoption for each practice, the next step was that of assigning a "sten score." This was done by assigning a score from 0 to 9 based upon the time of adoption and assuming a normal distribution. Past research in the adoption of farm practices indicates that the adoption of a new practice over time will either be normally distributed or else closely approach normality.* Table A-3 is the guide used for assigning "sten scores" for the year of adoption as presented in table A-2. Table A-3 shows that under a normal distribution, 2.3% of the adopters should receive a "sten score" of nine. These would be the earliest adopters. Another 4.4% would receive a score of eight. Under a normal distribution, 68.2% of the adopters would receive a score ranging from three to six.

In assigning scores for the year of adoption, it was necessary to give the same score to all respondents who adopted a practice in any given year. For example, 2.3%, or three of the respondents, to which the practice of using stilbestrol was applicable, are to receive a "sten score" of nine. In table A-2 we see that three respondents adopted the practice in 1945 so all three receive a score of

*Everett M. Rogers, "Categorizing the Adopters of Agricultural Practices," Rural Sociology 23:345-354, 1958.

nine. The next five respondents (4.4%) are to receive a score of eight. However, it is noted that in order to assign a score of eight to exactly five respondents only one of the two who adopted the practice in 1950 should receive a score of eight. There is no basis for distinguishing between the two so both are given a score of eight. This leaves one less respondent to receive a score of seven in the succeeding category. Ten respondents are now to receive a score of seven. Table A-2 shows that if the next 10 respondents are to receive a score of seven, only one of the five who adopted the practice in 1962 should receive a score of seven. Since less than half of those who adopted the practice in 1962 should receive a score of seven, they are all given a score of six. This allocation of scores, according to a normal distribution, is continued for the remaining years. An average score is computed for all the non-adopters. Four (2.3%) of the non-adopters are to receive a low score of zero. The next five are to receive a score of one. The average score is four for all those who never adopted the practice of using stilbestrol in cattle feeding.

Every respondent was next assigned a score for each separate practice according to the date of adoption. An average score was computed for each respondent and this was his innovativeness score as arrived at by the method employed by Rogers, Havens, and Cartano (2).

It is noted that under this technique an individual's innovativeness score is determined by the number of practices he has adopted as well as how early he adopted the practice. Individuals who started farming in recent years could not possibly receive as high a score as those who started farming earlier since they had no opportunity to adopt a practice. In this survey there were 11 respondents who had started farming since 1960. Therefore, it seemed necessary to make an adjustment in the score for the year in which an individual started farming. To do this, a linear regression analysis was run with the innovativeness score as the dependent variable and the year in which one started farming as the independent variable. The estimating equation obtained was*:

$$Y = 4.54176 - .007215X$$

*In testing the hypothesis that $b=0$, a t value of 2.08 was obtained. With 158 degrees of freedom this is significant at the 5% level of probability and the hypothesis is rejected.

Table A-3. Score guide used in converting time of adoption to Sten scores.

Sten score	Percent respondents receiving each Sten score	Number respondents receiving each Sten score when sample size is 160	Number respondents receiving each Sten score when sample size is 118
9	2.3	4	3
8	4.4	7	5
7	9.2	15	11
6	14.9	24	18
5	19.2	30*	22
4	19.2	30*	22
3	14.9	24	18
2	9.2	15	11
1	4.4	7	5
0	2.3	4	3
Total	100.0	160	118

*When rounded to the nearest whole number 19.2% of 160 would be 31. However, the total would then add to 162 so the two largest categories are rounded to 30.

In correcting the scores, each score was reduced by .007215 for each year that the date of starting farming deviated from 1965 and rounded to three digits. Table A-4 presents the adjusted innovativeness score for each farm operator included in the survey. The mean innovativeness score was 4.07 and the range was from 2.85 to 5.75.

Table A-4. Innovativeness scores, corrected for year started farming, for farm operators included in a sample survey of Central South Dakota farm operators.

Farm Number	Innovativeness Score	Farm Number	Innovativeness Score	Farm Number	Innovativeness Score	Farm Number	Innovativeness Score
101	5.00	201	3.53	301	4.36	401	4.09
102	4.34	202	3.61	302	3.85	402	3.43
103	4.05	203	3.57	303	3.70	403	4.02
104	3.28	204	4.27	304	3.74	404	4.78
105	3.40	205	4.46	305	3.46	405	4.72
106	4.19	206	4.41	306	3.14	406	4.52
107	4.25	207	3.85	307	3.97	407	3.01
108	3.25	208	5.72	308	3.69	408	3.70
109	4.68	209	3.26	309	3.46	409	3.83
110	3.65	210	3.79	310	3.73	410	4.48
111	4.21	211	4.39	311	5.62	411	4.30
112	3.57	212	4.80	312	3.59	412	3.70
113	4.56	213	3.50	313	3.41	413	4.65
114	3.38	214	3.71	314	3.49	414	3.75
115	3.56	215	4.66	315	4.56	415	4.20
116	3.59	216	4.70	316	5.24	416	4.06
117	3.88	217	3.83	317	5.01	417	4.26
118	3.55	218	5.75	318	3.00	418	3.69
119	3.86	219	4.14	319	4.57	419	3.92
120	4.10	220	3.94	320	4.02	420	4.60
121	4.80	221	4.48	321	4.04	421	4.31
122	4.80	222	4.49	322	3.70	422	3.04
123	4.75	223	5.06	323	4.49	423	4.17
124	4.21	224	3.97	324	4.25	424	3.93
125	3.47	225	4.51	325	4.67	425	4.24
126	4.60	226	4.25	326	3.57	426	3.05
127	4.16	227	4.78	327	5.07	427	3.61
128	3.61	228	3.91	328	5.32	428	3.79
129	4.30	229	5.72	329	4.14	429	3.78
130	3.95	230	5.48	330	3.71	430	3.91
131	3.44	231	4.28	331	3.67	431	3.16
132	3.80	232	4.81	332	4.43	432	3.59
133	2.98	233	3.62	333	4.04	433	3.94
134	3.45	234	4.51	334	3.54	434	3.86
135	4.43	235	4.12	335	2.85	435	3.61
136	4.46	236	4.58	336	3.52	436	3.69
137	3.43	237	4.26	337	3.68	437	3.53
138	4.02	238	4.44	338	4.14	438	3.86
139	3.57	239	4.95	339	4.78	439	4.33
140	4.06	240	4.78	340	3.92	440	3.82
		Range 2.85 to 5.75		Mean = 4.07			