A USER-ORIENTED MODEL FOR INCORPORATING RISK INTO SHORT-RUN DECISIONS*

Kim B. Anderson and John Holt

Decision makers, comparing production alternatives and faced with risk, normally utilize a large amount of information from many sources [3]. To compare alternatives, information must be organized and net returns calculated. Techniques producing single value estimates, such as partial budgeting, do not adequately utilize available information, produce enough information to facilitate an adequate comparison of alternatives, or account for risk and uncertainty [11]. Furthermore, single value techniques fail to take into account skewed probability distributions of various alternative outcomes. Decision makers need methods to analyze data when making specific recurring short-run decisions in a risky and uncertain environment.

This paper describes a simple model extension specialists can use with farmers in organizing data, analyzing information and producing easily understood results applicable to specific recurring management decisions. Decision trees are used as the basis for organizing data and producing results [8]. The model can be used with portable computer terminals, giving farmers and specialists in the field access to large computers. It can also be used by teachers and researchers to analyze decision alternatives and as a teaching aid.

The model is illustrated by analyzing alternatives available to northcentral Oklahoma wheat farmers during the October to May period. The assumption is made that wheat has been planted and the farmer has the following five production alternatives: (1) November to March stockers, (2) March to May stockers and harvest some of the wheat, (3) sell November to March stockers and harvest all wheat, (4) harvest wheat only or (5) purchase March stockers and grazeout. Each decision alternative will be analyzed to demonstrate the model's applications, its versatility, and how risk is incorporated into the decision process.

DECISION TREE

Risk is incorporated into a decision by estimating probability of each factor affecting the decision and simulating possible value combinations for each factor to determine the range of possible outcomes and probability associated with each possible outcome [5]. Two major factors affecting a wheat farmer's decisions are production yields and prices for wheat and stockers. Decision trees provide a method of incorporating estimated ranges of factors and their probabilities into the decision process. In the model, three yield levels, three price levels and corresponding yield and price probabilities are required to produce a nine-limb decision tree with nine levels of income (Figure 1). Yields and prices are assumed to be independent events.[1]

Information produced with the decision tree technique allows decision makers to consider a range of incomes and corresponding probabilities—probabilities of obtaining various target incomes, as well as the expected income value [6]. Expected

Kim B. Anderson is Extension Associate, Farm Management, Department of Agricultural Economics, Oklahoma State University; and John Holt is Extension Farm Management Economist, Food and Resource Economics Department, University of Florida.

*The authors benefited from suggestions made by Gerald Doeksen, Cecil Maynard and John Ikerd. This work was supported by an ERS-USDA special project "Wheat Farm Management in an Environment of Risk and Uncertainty."

[1] Wheat prices are determined at the national level. A localized poor wheat yield would not necessarily affect price. However, stocker prices are partially locally determined; therefore, a "flooded" market caused by poor forage yields (synonymous with poor gains and grazing days) could depress local stocker prices. The model could be modified to incorporate different prices on each set of limbs, but the authors feel the gain in reality is not worth the loss in simplicity.

Yield bu.	Yield Probability %	Sell Price $	Price Probability %	Net Income $	Joint Probability %
		2.40	(30)	76.30	7.50
37	(25)	2.20	(50)	68.90	12.50
		2.00	(20)	61.50	5.00
		2.40	(30)	59.50	18.00
30	(60)	2.20	(50)	53.50	30.00
		2.00	(20)	47.50	12.00
		2.40	(30)	42.70	4.50
23	(15)	2.20	(50)	38.10	7.50
		2.00	(20)	33.50	3.00

Expected Value=$50.57

FIGURE 1. EXPECTED WHEAT INCOMES WITH RANGE OF YIELDS, PRICES AND THEIR PROBABILITIES CONSIDERED, NORTHCENTRAL OKLAHOMA

value is defined as the long run average income if the decision was made many times with the same set of conditions. Expected values reflect a point estimate of income which is the typical result of budgeting techniques. By using the range of incomes and their probabilities, the chance and magnitude of losses and gains can also be quantified. Target income may be the specified income a decision maker selects based on his individual situation.

Subjective probabilities are used in the analyses; however, objective probabilities, if available, could be used just as easily. Most decision makers are neither familiar with nor have access to rigorous methods for calculating objective probabilities of yields and prices, but they can use farm records, outlook, futures market and other sources of information, including past experience, to estimate required subjective probabilities. Decision makers can also estimate subjective probabilities based on previously obtained objective evidence [12, p. 9]. Candler, Boehlje and Saathoff contend that decision makers give more credence to results when they provide data instead of using unfamiliar data [2, p. 73]. Lin supports this view and stresses that, in certain cases, objective probabilities are not accepted at face value by the decision maker [9]. Halter, Dillon and Makeham postulate that subjective probabilities are "the only correct approach because, after all, decision makers are individuals" [4].

THE MODEL AND ITS APPLICATION

A nine-limb decision tree representing one alternative can be solved without strenuous calculations. However, when more than one alternative is analyzed or the alternative (e.g., grazing and harvesting) is a combination of activities, calculations are cumbersome. Portable remote terminals make it possible to organize large amounts of data on the computer via telephone hookups. Consequently, analyses can be made at an individual's home, at a meeting or anywhere a telephone is available.[2] Delay between data input and availability of a suggested solution is minimal.

Computer language PL/1 was used to develop a Conversational Programming System model (software) for calculating and organizing results [7]. The model was constructed based on the following considerations: decision makers tend to utilize both essential and non-essential information [10], information required and results must be easily understood, results must be quickly obtained [2] and computer cost is minimized.[3] The model and technique presented were field tested and revised until they met these requirements.[4]

Two matrices were developed to facilitate input of data-probabilities and costs, and two routines were designed to calculate results [1]. The two routines, one for calculating returns from crops (Harvest Only) and one for calculating returns from livestock or combinations of crops and livestock (Graze, Harvest), are illustrated in the following section.

Data and probabilities for determining returns are shown in the data-probabilities matrix (Table 1). A set of coefficients is stored with the program and can be used as a guide; but the decision maker must provide input data for his specific resource situation. Rows one and two contain data and probabilities for the harvest only routine, and rows three through six contain data and probabilities used in the graze-harvest routine. Good, fair and poor values are

[2]Actual telephone hookup time is less than 15 minutes for most decision analyses consisting of alternatives presented in this paper.

[3]Actual computer cost was $1.80 for hookup and disconnect, and approximately $2.00 per hour computer use. Actual cost varies according to amount of data read in and number of computations made.

[4]The model was presented to seven different groups including farmers, extension management specialists, bankers and a commodity group's board of directors. Modifications were made after the first three outings. Evaluation forms were handed out during the last four meetings involving approximately 178 farmers. Sixty-one farmers completed the forms. Of these, 64 percent felt joint probabilities were "the strong point of the program," and only five percent did not understand joint probabilities. Twenty-five percent felt the decision tree technique was the strong point and three percent did not understand decision trees. At one meeting (24 farmers filled out the evaluation), 42 percent said the analysis "convinced them to keep stockers." Farmers' acceptance and utilization of the model and portable terminal facilities were above the authors' expectations. The teaching technique used with this type model and farmers' responses are explained in detail in an article by Holt and Anderson [6].

TABLE 1. EXAMPLE DATA-PROBABILITIES AND COST MATRICES FOR HARVEST ONLY vs. NOVEMBER TO MARCH STOCKERS, NORTHCENTRAL OKLAHOMA

Item	DATA GOOD	DATA FAIR	DATA POOR	PROBABILITIES GOOD	PROBABILITIES FAIR	PROBABILITIES POOR
1 Crop Yield	37.00	30.00	23.00	0.250	0.600	0.150
2 Crop Price	2.40	2.20	2.00	0.300	0.500	0.200
3 Grazing Days	105.00	95.00	80.00	0.400	0.350	0.250
4 Ave. Daily Gain	1.40	1.35	1.25	0.000	0.000	0.000
5 # Stockers/Ac	0.45	0.40	0.35	0.000	0.000	0.000
6 Stocker Sell Price	44.00	41.50	39.00	0.250	0.500	0.250
7 % Acres Harvested	0.00	0.00	0.00	0.000	0.000	0.000

COST	PRICE
1 Stocker Buy Price	$ 43.000
2 Hay	$ 6.000
3 Feed	$ 5.500
4 Vet & Med	$ 6.500
5 Haul & Market	$ 5.500
6 Fert,Spray-Graze	$ 5.000
7 Interest Rate-Decim	$ 0.100
8 Fert,Spray-Harv	$ 0.000
9 Harvest Cost	$ 12.500

estimated for each "Item" in the data matrix. Probabilities are required only for crop yields, crop prices, beef production and stocker sell prices (rows 1, 2, 3 and 6). Beef production probabilities including grazing days, average daily gains and stocking rates, are entered in row 3.

Net returns per acre are gross returns minus costs implemented via the cost matrix (Table 1). Rows one through seven contain stocker costs and rows eight and nine show crop costs. Stocker buy price is either price paid for stockers or opportunity cost for keeping them. Stocker assembly costs are entered on a per-head basis and fertilizer, spray costs allocated to wheat for harvest or grazing are entered as per-acre cost. If the decision maker desires, costs other than those listed can be entered in rows two through five, eight and nine.

Decision-maker input is also required for net return per acre from stockers, beginning stocker weight and percent death loss. Net return per acre from stockers is used when they are transferred from one activity to another (i.e., November to March stocker activity to the March to May stockers and harvest wheat activity), or when sold in March and all the wheat is harvested. Beginning stocker weight is per-head poundage. Percent death loss is loss of revenue due to stocker death, i.e., one percent death loss would be entered as 1.

Stockers — November to March?

Returns to fall (November to March) stockers are derived with the graze-harvest routine. Coefficients supplied by the decision maker in rows three through six of the data-probabilities matrix are beef production and price coefficients. Rows one through seven in the cost matrix show production cost (Table 1). The producer planned to purchase 420-pound steers in October and anticipated a two percent death loss. Beginning stocker weight and percent death loss were not entered in the input matrices, but were entered directly into the analysis as shown in Table 2.

Expected value per acre for fall stockers was \$3.83 with an expected stocking rate of .4 head and an expected steer weight of 549 pounds (Table 2). Returns per acre ranged from \$—5.19 to \$13.28. Expected value per head can be obtained by dividing expected value per acre by expected stockers per acre (\$3.83 ÷ .4 = \$9.58). Net return per head is included in the results because some decision makers think in a per head framework.

Stockers — March to May?

The above analysis implied that a positive net return is expected from fall stockers. In northcentral Oklahoma, if all wheat is harvested, stockers would be sold about March 15.[5] If fall stockers are grazed out, per-acre stocking rate increases and requires less total acres of wheat; therefore, remaining wheat can be harvested. The manager must make a decision: to graze or not to graze.

Data, probabilities and costs for the two alternatives obtained from the decision maker (to sell fall stockers and harvest all wheat, or to carry stockers over and harvest part of the wheat) are entered in the input matrices simultaneously (Table 3).

The graze-harvest routine calculates returns for a nine-limb decision tree if grazing alone is utilized; however, if returns are from both grazing and

TABLE 2. EXAMPLE ANALYSIS OF NET RETURNS TO NOVEMBER TO MARCH STOCKERS, NORTHCENTRAL OKLAHOMA

Enter Beginning Stocker Weight
BSW
?420

Enter Percent Death Loss
PDL
?2

Enter Net Return per acre for stockers.
NRS
?0

GRAZEOUT,HARVEST

GAINS YIELD	STOCKER PRICE	VALUE GRAIN	STOCKER WEIGHT	STOCKER INCOME/HD	INCOME PER AC	JOINT PROBABILITY
GOOD	GOOD	\$ 0.00	567	\$ 29.52	\$ 13.28	10.00%
GOOD	FAIR	\$ 0.00	567	\$ 15.63	\$ 7.03	20.00%
GOOD	POOR	\$ 0.00	567	\$ 1.74	\$ 0.78	10.00%
FAIR	GOOD	\$ 0.00	548	\$ 21.99	\$ 8.80	8.75%
FAIR	FAIR	\$ 0.00	548	\$ 8.56	\$ 3.42	17.50%
FAIR	POOR	\$ 0.00	548	\$ -4.87	\$ -1.95	8.75%
POOR	GOOD	\$ 0.00	520	\$ 10.65	\$ 3.73	6.25%
POOR	FAIR	\$ 0.00	520	\$ -2.09	\$ -0.73	12.50%
POOR	POOR	\$ 0.00	520	\$ -14.83	\$ -5.19	6.25%

Exp. Value/Ac=\$ 3.83 Exp. Stocker Wgt.= 549 Exp. Stocker/Ac= 0.4

[5]March 15 is a rule of thumb used by farmers. Technically, the stockers must be removed before the wheat plant starts jointing.

TABLE 3. EXAMPLE DATA-PROBABILITIES AND COST MATRICES FOR SELL FALL STOCKERS—HARVEST ONLY vs. GRAZEOUT FALL STOCKERS PLUS HARVEST REMAINING WHEAT, NORTHCENTRAL OKLAHOMA

Item	DATA GOOD	DATA FAIR	DATA POOR	PROBABILITIES GOOD	PROBABILITIES FAIR	PROBABILITIES POOR
1 Crop Yield	37.00	30.00	23.00	0.250	0.600	0.150
2 Crop Price	2.40	2.20	2.00	0.300	0.500	0.200
3 Grazing Days	70.00	60.00	50.00	0.250	0.375	0.375
4 Ave. Daily Gain	1.90	1.80	1.70	0.000	0.000	0.000
5 # Stockers/Ac	0.40	0.40	0.40	0.000	0.000	0.000
6 Stocker Sell Price	46.00	42.50	39.50	0.300	0.500	0.200
7 % Acres Harvested	0.80	0.77	0.73	0.000	0.000	0.000

COST	PRICE
1 Stocker Buy Price	$ 41.500
2 Hay	$ 2.500
3 Feed	$ 2.500
4 Vet & Med	$ 1.000
5 Haul & Market	$ 0.500
6 Fert,Spray-Graze	$ 0.000
7 Interest Rate-Decim	$ 0.100
8 Fert,Spray-Harv	$ 0.000
9 Harvest Cost	$ 12.500

harvesting, as in the grazeout plus harvest alternative, the decision tree will have 81 limbs. A matrix with 81 levels of income loses clarity and ease of understanding. Consequently, two measures are taken to maintain these features. Outcomes are reduced by constructing the model to calculate a weighted crop price (sum of crop prices times their respective probabilities). Based primarily on a survey by Walker and Plaxico [13] and supplemented with simple correlations of grain and forage yields from limited experimental data, wheat yields are assumed to be directly linked to grazing yields.[6] Thus, in the stocker graze out and harvest alternative, probabilities for grain yield and beef production are equivalent and are entered in row 3 (Table 3). Weighted harvest income is added to the stocker income.

The data, probabilities and cost coefficients for keep stockers and harvest remaining wheat are presented in Table 3. Returns per acre are calculated by developing a representative acre including both stockers and wheat. Percent acre harvested, row 7 of Table 3 in the data-probabilities matrix, is calculated by using the equation: % Acres Harvested = (Potential Stocking Rate − # Stockers Grazed/Acre) ÷ Potential Stockers/Acre. Potential spring stocking rates are 2, 1.75 and 1.5 head per acre for good, fair and poor years, respectively. The # Stockers Grazed/Acre is .4. For example, percent acres harvested in a good year are: $.8 = (2-.4) \div 2$. Fair and poor values are calculated in the same manner. A representative acre is defined as .4 stockers, and percent of acres harvested: .8, .77 or .73 for good, fair and poor, respectively. Beginning stocker weight, stocking rate and net return per acre for spring stockers are obtained from fall stocker analysis (Table 2). Beginning stocker weight is obtained from expected stocker weight (549 pounds) and stocking rate (.4) is obtained from expected stockers per acre.

Expected value per acre from the fall stocker analysis is entered as net return from stockers in the March to May graze, harvest analysis. Net return to stockers is return above the October purchase price and assembly and marketing costs for fall stockers when they are sold for $41.50/cwt. Thus, to account for variable costs incurred from November to May, $41.50/cwt. is entered as an opportunity cost for the 549-pound stockers. Then, only additional costs are entered in the March to May analysis. Net return to stockers is an optional entry. If it is excluded from the stocker plus harvest analysis, it must be excluded from the sell fall stocker and harvest only analysis. Total returns are obtained only when net return to stockers is entered in both analyses.

Returns from spring stockers and harvest of remaining wheat are shown in Table 4. Returns are presented for value grain, stocker income per head and income per acre. Value grain is the weighted income from wheat production. Stocker income per head represents returns from stockers. Income per acre is per-acre sums of returns from grain and stockers. Range of incomes per acre is from $36.63 to $88.87 and expected value is $60.59.

The data, probabilities and cost coefficients for sell stockers and harvest wheat analysis are shown in the decision tree, Figure 1. However, expected value from selling stockers in March (Table 2) is added to the harvest net return (Table 5). The output matrix shows yield, price level, quantity yield, actual crop

TABLE 4. EXAMPLE ANALYSIS OF NET RETURNS TO MARCH TO MAY STOCKERS PLUS HARVEST REMAINING WHEAT

Enter Beginning Stocker Weight
BSW
?549

Enter Percent Death Loss
PDL
?.5

Enter Net Return per acre for stockers.
nrs
?3.83

GRAZEOUT,HARVEST

GAINS YIELD	STOCKER PRICE	VALUE GRAIN	STOCKER WEIGHT	STOCKER INCOME/HD	INCOME PER AC	JOINT PROBABILITY
GOOD	GOOD	$55.71	682	$ 82.90	$ 88.87	7.50%
GOOD	FAIR	$55.71	682	$ 59.15	$ 79.37	12.50%
GOOD	POOR	$55.71	682	$ 38.79	$ 71.23	5.00%
FAIR	GOOD	$41.66	657	$ 72.10	$ 70.50	11.25%
FAIR	FAIR	$41.66	657	$ 49.22	$ 61.34	18.75%
FAIR	POOR	$41.66	657	$ 29.61	$ 53.50	7.50%
POOR	GOOD	$28.15	634	$ 62.21	$ 53.03	11.25%
POOR	FAIR	$28.15	634	$ 40.13	$ 44.20	18.75%
POOR	POOR	$28.15	634	$ 21.21	$ 36.63	7.50%

Exp. Value/Ac=$ 60.59 Exp. Stocker Wgt.= 655 Exp. Stocker/Ac= 0.4

[6] This assumption could not be tested for statistical significance because of lack of data. Had data been available to determine true relationships, the grain yield could have been averaged out and folded back as was done with wheat prices.

TABLE 5. EXAMPLE ANALYSIS OF NET RETURNS TO SELL FALL STOCKERS AND HARVEST ONLY

Enter Net Return per acre from stockers.
NRS ·
?3.83

HARVEST CROP

	VOLUME	CROP SELLPR	CROP INCOME/A	INCOME PER AC	JOINT PROBABILITY
GOOD Yield, GOOD Price	37.0	$ 2.40	$ 76.30	$ 80.13	7.50%
GOOD Yield, FAIR Price	37.0	$ 2.20	$ 68.90	$ 72.73	12.50%
GOOD Yield, POOR Price	37.0	$ 2.00	$ 61.50	$ 65.33	5.00%
FAIR Yield, GOOD Price	30.0	$ 2.40	$ 59.50	$ 63.33	18.00%
FAIR Yield, FAIR Price	30.0	$ 2.20	$ 53.50	$ 57.33	30.00%
FAIR Yield, POOR Price	30.0	$ 2.00	$ 47.50	$ 51.33	12.00%
POOR Yield, GOOD Price	23.0	$ 2.40	$ 42.70	$ 46.53	4.50%
POOR Yield, FAIR Price	23.0	$ 2.20	$ 38.10	$ 41.93	7.50%
POOR Yield, POOR Price	23.0	$ 2.00	$ 33.50	$ 37.33	3.00%

Expected Value/Ac=$ 59.48

price, crop income per acre, income per acre and joint probability for each level of income. Income per acre is crop income per acre plus expected value from fall stockers. As indicated, net returns for selling fall stockers and harvesting only range from $37.33 to $80.13. The expected value is $59.48.

Decision Summary

Four common alternatives, including the two described above, are summarized in Table 6. All four alternatives depend on the fall stocker decision (shown in Table 2). If fall stockers are not grazed, the decision maker chooses between alternatives one and two: if they are grazed, the spring decision is between alternatives three and four.

Depending on financial condition, risk preference and goals of the decision maker, any alternative can be selected. Expected values and a desired income level $\geq$ $60 (target income) indicate that fall stocker and graze out plus harvest alternative should be utilized. If fall stockers are not grazed, the production alternative is between harvest only and purchase March stockers. In this case, harvest only offers highest expected value. However, spring purchased stockers to graze out all wheat offers highest possible return and largest percent chance to obtain $60 per acre.

SUMMARY

Integrating the decision tree technique, portable remote computer terminals and computer software offer a versatile, easily understood approach to incorporating risk into the decision process. The package presented provides a computerized method for arranging data, doing arithmetic, and organizing output. No attempt was made to develop an absolute decision criterion since the final decision always depends on the individual's willingness and ability to bear risk. Rather, the package aids decisions by assembling information which can be used by decision makers with different objectives and different decision criteria resulting from different risk situations and preferences. Data requirements and results are simplified to:

a. Possible yield levels and an estimate of how likely they were
b. Possible price levels and how likely they might be
c. Possible range of incomes, given risk associated with changing yields and prices
d. Probability of receiving different income levels and
e. Expected value of the enterprises.

The major point is that more information is given by the decision tree technique and all information can be applied to the decision. Thus, to the extent that more and better information results in more profitable decisions, this model makes possible better decisions than do methods producing only single value point estimates. Managers with differing risk preferences, financial conditions and production capabilities can each obtain information which permits a clearer comparison of the production alternatives they face as individual decision makers.

TABLE 6. EXPECTED VALUES, INCOME RANGES AND PROBABILITIES OF MAKING MORE THAN $60 PER ACRE FROM WHEAT AND STOCKER ALTERNATIVES, NORTHCENTRAL OKLAHOMA

Decision	Expected Value	Range of Incomes	Probability Receiving > $60
1. Harvest Only	55.65	33.50 to 76.30	25
2. Purchase March Stockers	51.40	-2.30 to 108.06	42.5
3. Sell Fall Stockers & Harvest Only	59.48	37.33 to 80.13	38
4. Grazeout Fall Stockers & Harvest	60.59	36.63 to 88.87	60

REFERENCES

[1] Anderson, Kim B. and John Holt. "A Model for Incorporating Risk and Uncertainty into Crop and Grazing Decisions," Agricultural Economics Paper A. E. 7706, Stillwater: Department of Agricultural Economics, Oklahoma State University.

[2] Candler, Wilfred, Michael Boehlje and Robert Saathoff. "Computer Software for Farm Management Extension," *American Journal of Agricultural Economics*, Volume 52, No. 1, February 1970, pp. 71-80.

[3] Eisgruber, Ludwig M. "Managerial Information and Decision Systems in the U.S.A.: Historical Developments, Current Status, and Major Issues," *American Journal of Agricultural Economics*, Volume 55, No. 5, December 1973, pp. 930-937.

[4] Halter, A. N., John L. Dillon and J. P. Makeham. *Best-Bet Farm Decisions*, Professional Farm Management Guide Book, No. 6, Corvallis: Department of Agricultural Economics, Oregon State University, 1969.

[5] Hespos, Richard F. and Paul A. Strassmann. "Stochastic Decision Trees for the Analysis of Investment Decisions," *Management Science*, Volume 11, No. 10, August 1965, pp. B-224-B-259.

[6] Holt, John and Kim B. Anderson. "Teaching Decision Making Under Risk to Farmers," Agricultural Economics Paper A. E. 7704, Stillwater: Department of Agricultural Economics, Oklahoma State University, March 1977.

[7] IBM. *Conversational Programming System (CPS) Terminal User's Manual*, Program No. 360D-03.4-016, First Edition, White Plains, New York: IBM Corporation, January 1970.

[8] Kohls, Richard L. "Economic Research and Education for Commercial Agriculture," *American Journal of Agricultural Economics*, Volume 56, No. 5, December 1974, pp. 1009-1013.

[9] Lin, Wen-Rong. "Decisions Under Uncertainty: An Empirical Application and Test of Decision Theory in Agriculture," Unpublished Ph.D. thesis, University of California, Davis: Agricultural Economics, 1973.

[10] McCarl, Bruce A., Wilfred V. Candler, D. Howard Doster and Paul R. Robbins. "Experiences with Farmer Oriented Linear Programming for Crop Planning," *Canadian Journal of Agricultural Economics*, Volume 25, No. 1, February 1977, pp. 17-30.

[11] Swirles, John and Peter A. Lusztig. "Capital Expenditure Decisions Under Risk and Uncertainty," *Cost and Management*, September 1968, pp. 13-19.

[12] Walker, Odell L. and A. Gene Nelson. *Agricultural Research and Education Related to Decision-Making Under Uncertainty: An Interpretive Review of Literature*, Research Report P-747, Agricultural Experiment Station, Stillwater: Oklahoma State University, March 1977.

[13] Walker, Odell L. and James S. Plaxico. "A Survey of Production Levels and Variability of Small Grain Pastures in Oklahoma," Stillwater: Department of Agricultural Economics, Oklahoma State University Processed Series P-336, November 1959.