AN ABSTRACT OF THE THESIS

Jonathan D. Bates for the degree of Master of Science in Agricultural and Resource Economics presented on July 7, 1989.

Title: A Comparative Assessment of Four Winter Cattle Feeding Programs for Spring Calving Cow-calf Ranches in the Harney Basin, Oregon.

Abstract approved: Redacted for Privacy
Fred Obermiller

The objective of this thesis is to assess four winter feeding programs of spring-calving brood cows that may improve profitability to ranching operations of the Harney Basin, Oregon. The four feeding strategies include strip grazed rake-bunched hay, supplemented range grazing, strip grazed meadow pasture, and baled hay feeding. These first three alternatives were compared to baled hay feeding, the preferred practice of the region, in terms of profitability to the operation and management requirements.

To evaluate the alternatives a deterministic biophysical-economic simulation model was constructed. The biophysical model simulates relationships between (1) the physiological status and nutritional requirements of mature gestating cows, (2) the forage base being utilized, and (3) the effects of the physical environment upon the nutritional requirements of cows and their ability to forage successfully for food. The biological simulation is designed to provide, as output, measures of cow reproductive performance and

forage utilization. This information is integrated into herd and pasture management subroutines to yield measures of herd production, and pasture and feed utilization. An economic subroutine uses results from the herd production and forage utilization subroutines to estimate costs and net returns to each feeding strategy.

Risk is introduced into the simulation by varying the climatic components of the physical environment. Four winter scenarios are represented, ranging from mild to very severe. Probabilities are assigned to each winter scenario for each feeding program. The probabilities under each alternative for each of the four climate scenarios are combined to yield estimates of the expected net return of the feeding strategy.

Analysis of the results indicate that raked-bunched hay is the best alternative to baled hay feeding. Returns are substantially higher as a result of reduced wintering costs. Cow performance factors remain nearly identical to hay fed cows, and management of the winter operation is simplified. In addition, there appears to be little risk associated with management of the raked hay alternative.

The range grazing program also yields superior economic results to the operation when compared to baled hay feeding. Although there is considerable variation in net returns to the alternative over the climate scenarios, the expected return to range grazing is substantially higher than the baled hay strategy. Variability in net returns to range grazing is due to effects of ground snow depth levels which may prevent cows from feeding on range forages. When these conditions occur emergency hay feeding is required. Management of the operation is intensified, increasing with the severity of the winter.

Based upon the economic results of the simulation it appears that range grazing is a promising alternative to baled hay. However, because empirical data are limited regarding the adaptability of this alternative in the Harney Basin, more information is needed regarding (1) ground snow depth level effects upon the feeding success of cows, and (2) reproductive performance of cows following severe winters.

The results of the meadow grazing alternative indicate that this strategy is not a viable alternative to baled hay feeding. Returns to the operation are reduced as the result of poor cow reproductive factors, and the vulnerability of this strategy to relatively shallow snow cover requiring large amounts of emergency feeding.

A Comparative Assessment of Four Winter Feeding Programs for Spring Calving Cow-Calf Ranches in the Harney Basin, Oregon

by

Jonathan D. Bates

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed July 7, 1989

Commencement June 1990

APPROVED:

Redacted for Privacy

Professor of Agricultural and Resource Economics in charge of major

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Date thesis is presented: July 7, 1989

Typed for Jonathan D. Bates by: Jonathan D. Bates

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A COMPARATIVE ASSESSMENT OF FOUR WINTER FEEDING PROGRAMS FOR SPRING CALVING COW-CALF RANCHES IN THE HARNEY BASIN, OREGON

CHAPTER I

INTRODUCTION

The past 15 years has seen the development of a farm financial crisis of historic dimensions across the various sectors of United States agriculture (Melichar, 1984). Between 1972 and 1979-80 farm producers enjoyed a period of high commodity prices, rising incomes, and elevated land values. Between 1980 and 1988 falling farm commodity prices coupled with rising input costs resulted in reduced farm incomes (Table 1.1). In addition, the combination of rising interest rates and declining farm real estate values placed many agricultural producers in conditions of severe financial stress (Hughes et al., 1985; Hewlett, 1987). Although income cycles have been a characteristic in United States agriculture, the length and breadth of the recent downturn in farm financial health has been unusually severe (Melichar, 1984).

Western cattle operations have not been immune to the financial problems besetting the country's agricultural industry. Between 1980 and 1987 cattle ranching operations also suffered from declining incomes and enterprise profitabilities (Bartlett, 1983; USDA, 1988). Four major factors worked in concert to reduce ranch returns and net

Table 1.1: United States Gross Farm Income, Production Expenses and Net Income, 1972-1987.

Year	Gross Farm Income	Production Expenses	Net Income Current Dollars	Net Income 1982 Dollars
	------ billion dollars ------			
1972	71.1	51.7	19.5	41.8
1973	98.9	64.6	34.4	69.4
1974	98.2	71.0	27.3	50.5
1975	100.6	75.0	25.5	43.1
1976	102.9	82.7	20.2	32.0
1977	108.8	88.9	19.9	29.1
1978	128.4	103.3	25.2	34.9
1979	150.7	123.3	27.4	34.9
1980	149.3	133.1	16.1	19.8
1981	166.3	139.4	26.9	28.6
1982	163.5	140.0	23.5	23.5
1983	153.1	140.4	12.7	12.2
1984	174.7	142.7	32.0	29.6
1985	166.0	133.7	32.3	29.0
1986	159.5	122.7	37.5	32.8
1987	168.5	123.0	46.3	39.3

Source: USDA, Agricultural Statistics, 1988.

incomes during the recent downturn: (1) ranch input prices increasing relative to prices received for marketed output, or as Gray (1968) terms a classic "cost-price squeeze", (2) Federal policies to control inflationary pressures in the early 1980s (Hughes and Pensch, 1985; Hewlett, 1987), (3) declining land values (Taylor and Nelson, 1987; *Oregon Public Lands Rancher*, 1987), and (4) demand and supply conditions in the Nation's consumer market (Bartlett, 1983; Melichar, 1984; Taylor, 1984).

Impact of the Cattle Industry on State and Local Economies

The condition of the cattle industry has important economic repercussions for the western states where cattle sales constitute a large percentage of the total agricultural sales. In Oregon, ranch gate receipts for beef cattle sales consistently rank as the top agricultural producer on a yearly basis (Extension Economic Information Office, 1973-1987). Since 1973, beef cattle sales have made up an average of 16.8 percent of the state's agricultural sales. Locally, cattle sales in several Oregon agricultural districts comprise the bulk of all agricultural receipts. This is particularly true of the counties located in the southeast and South-central portions of the state. For instance, between 1973 and 1986 cattle sales in Harney county averaged 82 percent of total agricultural sales in the county.

Economic multipliers (sales and employment) for the Oregon cattle industry have consistently ranked at the top of various agricultural sectors and the entire economy at state and county levels (Obermiller et al., 1982). Elsewhere, Utah State University economists found that the meat animals sector in general exhibited the largest multipliers for both sales and employment (Synder et al., 1985).[1] It can be concluded that the economic vitality of many local communities is dependent upon the financial success and/or survival of ranching operations.

Challenge to the Western Cattle Sector

Recently, the financial outlook for western United States ranchers has improved (USDA, February 1989). Cattle prices have increased since the first quarter of 1987, although in terms of real prices, they are still relatively low. Combined with reduced and/or stable input costs, forecasts of the financial performance of the ranch community suggest continued improvement over the next few years (USDA, November 1988).

These developments in the ranch outlook do not reduce incentives to develop more efficient and productive means of operating profitable ranch enterprises. On the contrary, the risks imposed as a consequence of national and international economic policies and conditions, as demonstrated by the events of the preceding decade, require ranch managers to seek alternatives that lead not only to increased incomes but also to enhanced financial stability in their operations.

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[1] This sector includes sheep, cattle, and hogs.

The alternatives available to U.S. ranchers cover a wide spectrum. However, because ranch characteristics vary throughout the West, the usefulness of an alternative or combination of alternative practices may not be applicable on a regional basis, or to specific locations within a given locality. Operations are influenced by a host of variables, including land and capital resources, forage resources, climate, and particular management plans and objectives (Workman, 1986).

Suggested alternatives are numerous, but center around a common focus of restoring and/or improving ranch net returns. Bartlett (1983), in broad terms, has recommended strategies (1) to increase income in the short term, (2) to reduce cash outlays, (3) to seek out new marketing opportunities, and (4) to improve productivity of ranch enterprises. Hewlett (1987) investigated and assessed federal, state, and local policy alternatives and management strategies that may serve to reduce financial stress on Oregon agricultural producers. These strategies included reducing debt, reducing interest rates, deferring debt, selling assets with lease back and no lease back provisions, and various equity infusions.

Thesis Purpose and Scope

The purpose of this thesis is to assess economically four feeding strategies for wintering brood cows that may assist ranchers in reducing production costs and thereby improving the profitability of their cattle enterprises. The assessment is based upon recently concluded and ongoing experiments conducted by researchers at the

Squaw Butte Agricultural Experiment Station based in Burns, Oregon. The expressed purpose of these experiments are to assist ranchers in developing cost reducing production strategies. In addition, cow performance in regard to calf production, conception rates, and cow condition are examined in order to determine the feasibility of alternative strategies.

The thesis focus is on the Harney Basin region since the feeding trials have been performed within that locale. In addition, since experiments have used only mature spring calving cows, the thesis limits attention to spring calving cow-calf enterprises. Another reason for limiting the scope of the thesis is that the bio-physical simulation developed to analyze the feeding regimes is based heavily upon (1) cow production data collected during the trials, and (2) winter weather conditions characterizing the region. However, the simulation model is adaptable to other cattle producing regions of the western United States provided necessary adjustments are made, given the data base being utilized.

Objectives

The primary objective of the thesis is to assess the economic feasibility of alternative winter feeding programs for beef cattle in the Harney Basin region of eastern Oregon in order to identify alternatives that have the greatest potential to maximize economic returns above variable costs to ranch operators. To realize this objective, four supporting goals are defined:

1. To identify and describe the winter feeding alternatives in financial, biological, and management terms for the cow-calf operations in the Harney Basin.

2. To assess the sensitivity of gestating brood cows to weather risks and nutritional constraints associated with winter feeding conditions that affect cow reproductive factors (i.e. calf production, and conception rates).

3. To construct a biological-economic simulation model interfacing cow nutritional requirements, climate effects, herd management strategies, and ranch land usage allocations to provide cow reproductive factors, determine net returns above variable costs to the ranch, and measure associated risks to each feeding alternative.

4. To estimate the financial impacts of introducing winter feeding alternatives to cow-calf operations in the Harney Basin region.

Organization of the Thesis

The remainder of the thesis has been organized into six chapters. In Chapter II, the cow-calf and cow-calf-yearling operations in the Harney Basin are described. Common wintering programs for gestating brood cows are presented. The methods and risks associated with each winter feeding alternative being examined at the Squaw Butte Experiment Station are discussed. Information regarding winter weather conditions in the Basin is provided and the forage base available in the region is discussed. Information on the nutritional requirements of gestating cows and how those requirements are affected by environmental conditions is presented in Chapter III. The goals of agricultural operators and approaches in the literature for constructing bio-physical, economic simulation models are canvassed in Chapter IV. In addition the model developed to analyze the alternative feeding regimes at Squaw Butte is described and information on the data used to perform the simulation is presented. Chapter V is used to describe in detail the results obtained from the bio-economic simulation. Recommendations regarding the most viable alternatives are furnished. In Chapter VI the project and its results are summarized and conclusions are drawn. Limitations to the thesis are acknowledged, and future research possibilities building upon the study are suggested.

CHAPTER II

HARNEY BASIN RANCH, CLIMATE, AND FORAGE CHARACTERISTICS, AND ALTERNATIVE WINTER FEEDING REGIMES

The Harney Basin is located in the High Desert region of south-central Oregon that encompasses Malheur, Harney, Lake, and parts of Klamath County. The High Desert represents the northern most extension of a larger desert environment that stretches southward into Nevada, Utah, Arizona and westward into Idaho, Wyoming, and Colorado. This area, referred to as the Intermountain (or Great Basin) region, is characterized by desert shrub-grassland ecosystems interspersed by forested mountain ranges (Stoddart et al., 1975). The region also contains extensive riparian areas and valley flood meadows. The northern Intermountain region alone contains nearly one million acres of native flood meadow bordering local streams and lakes. Approximately 350,000 acres of these native meadows are found in Oregon (Cooper, 1956a).

The climates of the Intermountain region are fairly homogeneous, being characterized by cold winters, hot summers, and low precipitation levels arriving mainly during the winter months. On average, only 25 percent of the annual precipitation arrives during the growing season in the spring and early summer (Gomm, 1979). The combination of late spring and early fall frosts with limited amounts of precipitation during the warmer months result in short growing seasons (Gomm, 1979). These climatic characteristics, coupled with generally poor soil attributes, limit the production of crops to forages, and some grains and vegetables that can grow under these conditions. Most of the forage produced is utilized as winter feed for cattle and sheep that are raised locally.

The Harney Basin covers an area of approximately 9,840 square miles comprising the northern two-thirds of Harney and Malheur Counties (Gomm, 1979). Elevations in the basin range from 4,100 feet near the region's two central lakes, to 4,600 feet in the surrounding desert plains and foothills. Topographically, the area is characterized primarily by rolling plain, interspersed with volcanic rock formations rising abruptly from the desert floor. The plains and foothills fall off sharply onto bottomland flats found along stream valleys and surrounding lake shores. The area's watershed is confined within the Basin as all the rivers and streams ultimately drain into Malheur Lake and Harney Lake.

Winter Climate Conditions of the Harney Basin

Late fall and winter weather of the Basin is highly variable, particularly with respect to precipitation patterns and snow-depth levels. Temperatures will vary from seasonally, but to a much lesser degree than precipitation, snowfall, and snow-depth amounts.

It is not unusual for summer type conditions to persist through the first half of October. By November winter type temperatures usually arrive. Between November and March average daily temperatures in the Basin hover near freezing although diurnal temperature fluctuations can be quite large. The coldest period of the winter occurs between December and mid-February and the greatest temperature variabilities occur during December and January. Average monthly temperatures from October through March between 1950-51 and 1986-87 are presented in Table 2.1. Temperature means, variances, minimums, and maximums are also listed for each month over the 37 year period.

Winter precipitation amounts averaged 20.4 centimeters (8.0 inches) between 1950-51 and 1985-86 (Table 2.2). A low of 4.6 centimeters (1.8 inches) was recorded in 1976-77, and highs of 29.2 centimeters (11.5 inches) were reported in 1981-82 (Table 2.2). Generally the month of January receives the largest amount of winter precipitation. Greatest variability in precipitation occurs in December and January.

Average snow depth levels are presented on a weekly basis between October and March for the years 1950-51 through 1985-86 in Tables 2.3 and 2.4. Earliest snow accumulations have been recorded in October, though significant and sustained accumulation rarely begins until late November and early December. Snow generally remains on the ground through February and occasionally into the first weeks of March. The highest average weekly snow accumulations occur in January, which is the month of heaviest snowfall.

Total winter snow accumulations have been as low as 10.2 centimeters in 1966-67, and as high as 429.3 centimeters (179 inches) in 1951-52 (Table 2.5).

Table 2.1: Monthly Temperature Means, Burns Oregon, 1950-1986.

	Temperature, (C)					
Year	Oct.	Nov.	Dec.	Jan.	Feb.	Winter Average
1950-51	9.78	3.67	1.17	-4.50	0.00	2.02
1951-52	7.17	0.89	-4.33	-6.11	-3.83	-1.24
1952-53	12.22	0.39	-3.17	1.94	1.39	2.56
1953-54	9.28	4.56	-0.67	-0.50	2.56	3.04
1954-55	8.28	5.06	-3.00	-6.06	-3.83	0.09
1955-56	9.72	0.33	-1.61	-3.33	-4.72	0.08
1956-57	7.61	2.33	-1.33	-7.67	-0.78	0.03
1957-58	7.56	1.22	-0.39	-2.17	2.67	1.78
1958-59	10.94	3.22	1.67	0.44	0.39	3.33
1959-60	9.11	2.89	-2.94	-5.17	-2.39	0.30
1960-61	8.50	1.39	-2.00	-1.06	2.28	1.82
1961-62	7.72	0.89	-3.22	-6.11	-1.50	-0.44
1962-63	9.00	3.39	0.44	-3.72	4.61	2.72
1963-64	10.17	2.50	-2.44	-3.56	-2.78	0.78
1964-65	9.94	0.89	-1.61	-1.89	1.44	1.76
1965-66	10.61	3.11	-3.22	-2.72	-1.44	1.27
1966-67	7.28	2.61	-1.17	-0.50	1.61	1.97
1967-68	7.89	3.39	-3.61	-2.78	3.83	1.74
1968-69	7.44	2.17	-2.06	-3.39	-3.22	0.19
1969-70	5.72	2.78	-0.56	-1.28	2.72	1.88
1970-71	6.61	2.67	-5.61	-1.17	0.61	0.62
1971-72	6.61	1.56	-4.50	-4.78	-0.72	-0.37
1972-73	9.06	1.78	-6.28	-3.83	-1.00	-0.06
1973-74	7.44	0.89	-0.67	-3.00	0.50	1.03
1974-75	9.00	2.50	-2.00	-3.56	1.22	1.43
1975-76	8.06	1.44	0.22	-2.44	-0.94	1.27
1976-77	9.00	4.94	-1.22	-7.11	1.83	1.49
1977-78	9.22	1.50	-0.11	-1.06	-0.11	1.89
1978-79	10.33	0.44	-5.67	-9.00	-0.44	-0.87
1979-80	10.56	0.00	-1.22	-3.78	1.72	1.46
1980-81	6.94	2.11	-1.67	-1.06	-1.56	0.96
1981-82	5.72	2.00	-1.61	-7.78	-1.56	-0.64
1982-83	6.39	3.89	-5.11	-2.67	0.50	0.60
1983-84	8.44	2.06	-5.67	-7.83	-4.94	-1.59
1984-85	4.28	0.61	-7.28	-8.39	-5.28	-3.21
1985-86	5.44	-6.17	-11.17	-2.56	0.56	-2.78
Mean	8.31	1.94	-2.60	-3.61	-0.29	0.75
Std. Error	1.72	1.88	2.56	2.62	2.44	1.54
Minimum	4.28	-6.17	-11.17	-9.00	-5.28	-3.21
Maximum	12.22	5.06	1.67	1.94	4.61	3.33

Source: National Oceanic and Atmospheric Administration.

Table 2.2: Average Monthly Precipitation, Burns Oregon, 1950-86.

	Precipitation (cm)						
Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Winter Total
1950-51	4.3	3.9	6.6	4.0	4.5	3.0	26.2
1951-52	0.0	2.8	5.6	5.0	2.3	1.8	17.5
1952-53	1.1	6.9	4.0	2.6	0.6	2.6	17.8
1953-54	0.4	2.4	3.0	1.5	0.5	1.2	9.0
1954-55	1.0	4.8	6.3	10.1	1.9	0.9	24.7
1955-56	0.9	0.6	2.6	3.5	5.9	5.5	18.9
1956-57	2.6	1.8	4.0	6.0	5.8	2.3	22.6
1957-58	0.9	1.9	1.9	2.5	2.3	3.2	12.7
1958-59	2.6	0.3	1.6	5.3	5.3	5.1	20.2
1959-60	0.5	5.3	2.1	1.8	3.1	4.5	17.2
1960-61	2.3	2.5	5.7	2.0	5.4	3.1	21.0
1961-62	9.4	3.1	2.6	3.6	2.9	2.9	24.5
1962-63	0.8	4.7	2.6	5.3	0.6	2.2	16.2
1963-64	0.5	5.1	13.9	6.1	0.6	0.5	26.7
1964-65	0.4	4.5	2.1	2.0	1.9	2.0	12.7
1965-66	0.8	5.2	5.0	5.5	1.1	6.2	23.8
1966-67	3.1	2.1	2.6	2.5	4.1	0.3	14.8
1967-68	1.8	5.6	4.6	8.1	3.7	0.8	24.7
1968-69	2.6	1.2	7.9	14.6	1.8	1.1	29.2
1969-70	3.1	8.1	6.4	4.5	1.2	5.1	28.4
1970-71	1.3	4.1	5.2	5.3	2.5	4.7	23.0
1971-72	0.8	3.3	5.4	3.4	1.1	1.1	15.2
1972-73	1.6	6.8	6.2	2.2	2.1	6.2	25.0
1973-74	0.9	0.3	3.5	3.9	4.5	4.3	17.4
1974-75	3.4	2.1	4.2	3.8	3.7	1.1	18.3
1975-76	0.3	0.8	0.0	1.8	1.1	0.7	4.6
1976-77	1.1	5.3	5.9	6.5	3.6	4.0	26.0
1977-78	0.0	3.1	1.4	7.5	4.4	2.5	18.9
1978-79	2.6	4.9	4.1	4.0	5.1	1.6	22.3
1979-80	2.2	1.5	3.5	2.0	2.3	4.1	15.6
1980-81	3.4	6.7	10.0	2.9	4.3	2.0	29.1
1981-82	3.6	2.8	6.5	2.6	5.4	6.8	27.7
1982-83	2.7	6.2	7.9	0.5	1.9	4.3	23.6
1983-84	2.6	6.9	2.2	0.2	1.2	2.6	15.8
1984-85	2.1	2.5	1.9	3.1	8.9	2.4	20.8
1985-86	0.9	0.8	0.7	- -	- n.a -	- -	
Mean	1.9	3.6	4.4	4.2	3.1	2.9	20.4
Std. Error	1.7	2.1	2.7	2.8	1.9	1.8	5.7
Minimum	0.0	0.3	0.0	0.2	0.5	0.3	4.6
Maximum	9.4	8.1	13.9	14.6	8.9	6.8	29.2

Source: National Oceanic and Atmospheric Administration

Table 2.3: Weekly Snow Depth Accumulations, November 12-January 6, Burns, Oregon, 1950-1986.

	Snow depth (cm)							
	Nov.			Dec.			Jan.	
Year	12-18	19-25	26-2	3-9	10-16	17-23	24-30	31-6
1950-51	0.0	2.5	0.0	0.0	5.1	0.0	0.0	12.7
1951-52	0.0	5.1	0.0	10.2	7.6	5.1	25.4	25.4
1952-53	0.0	0.0	0.0	17.8	12.7	5.1	20.3	20.3
1953-54	0.0	0.0	0.0	0.0	7.6	5.1	2.5	2.5
1954-55	0.0	0.0	0.0	5.1	0.0	12.7	7.6	7.6
1955-56	0.0	10.2	17.8	0.0	17.8	7.6	15.2	15.2
1956-57	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0
1957-58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958-59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6
1959-60	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0
1960-61	0.0	7.6	2.5	0.0	0.0	0.0	0.0	0.0
1961-62	0.0	0.0	2.5	0.0	0.0	15.2	17.8	15.2
1962-63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963-64	5.1	0.0	0.0	7.6	0.0	7.6	0.0	0.0
1964-65	5.1	0.0	10.2	0.0	5.1	0.0	5.1	15.2
1965-66	0.0	0.0	5.1	2.5	0.0	0.0	15.2	12.7
1966-67	0.0	0.0	2.5	5.1	5.1	2.5	7.6	5.1
1967-68	0.0	0.0	5.1	12.7	2.5	17.8	10.2	2.5
1968-69	0.0	5.1	0.0	0.0	5.1	20.3	15.2	5.1
1969-70	0.0	0.0	0.0	0.0	7.6	0.0	5.1	5.1
1970-71	0.0	0.0	5.1	10.2	5.1	7.6	25.4	20.3
1971-72	0.0	0.0	10.2	15.2	15.2	30.5	25.4	25.4
1972-73	0.0	0.0	0.0	10.2	17.8	17.8	20.3	7.6
1973-74	0.0	2.5	5.1	2.5	2.5	0.0	5.1	5.1
1974-75	0.0	0.0	0.0	2.5	0.0	5.1	2.5	2.5
1975-76	0.0	0.0	0.0	0.0	0.0	15.2	7.6	5.1
1976-77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977-78	25.4	12.7	0.0	0.0	15.2	15.2	17.8	20.3
1978-79	0.0	0.0	0.0	0.0	10.2	2.5	5.1	7.6
1979-80	0.0	17.8	15.2	2.5	0.0	27.9	22.9	20.3
1980-81	0.0	0.0	12.7	0.0	0.0	0.0	0.0	0.0
1981-82	0.0	7.6	7.6	0.0	5.1	15.2	25.4	53.3
1982-83	2.5	2.5	0.0	0.0	5.1	5.1	15.2	15.2
1983-84	2.5	5.1	5.1	17.8	22.9	15.2	22.9	20.3
1984-85	0.0	0.0	5.1	0.0	0.0	10.2	7.6	12.7
1985-86	5.1	15.2	15.2	25.4	22.9	20.3	17.8	17.8
Mean	1.3	2.5	3.7	4.1	5.6	7.6	10.4	11.0
Std. Error	4.3	4.6	5.1	6.5	6.8	8.3	9.3	10.7
Maximum	25.4	17.8	17.8	25.4	22.9	30.5	25.4	53.3

Table 2.4: Weekly Snow Depth Accumulations, January 7-March 3, Burns, Oregon, 1950-1986.

	Snow depth (cm)							
	Jan.				Feb.			Mar.
Year	7-13	14-20	21-27	28-3	4-10	11-17	18-24	25-3
1950-51	25.4	22.9	15.2	15.2	7.6	0.0	0.0	0.0
1951-52	35.6	40.6	43.2	35.6	30.5	35.6	43.2	33.0
1952-53	12.7	5.1	2.5	0.0	0.0	0.0	0.0	0.0
1953-54	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0
1954-55	7.6	17.8	10.2	15.2	10.2	2.5	0.0	0.0
1955-56	17.8	30.5	45.7	45.7	38.1	30.5	17.8	0.0
1956-57	0.0	0.0	15.2	20.3	17.8	15.2	2.5	0.0
1957-58	0.0	10.2	15.2	20.3	20.3	15.2	2.5	0.0
1958-59	7.6	10.2	10.2	15.2	10.2	7.6	0.0	0.0
1959-60	17.8	27.9	25.4	25.4	22.9	20.3	5.1	5.1
1960-61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961-62	5.1	7.6	20.3	10.2	5.1	5.1	0.0	0.0
1962-63	0.0	0.0	15.2	7.6	0.0	0.0	0.0	0.0
1963-64	0.0	7.6	15.2	12.7	15.2	10.2	5.1	0.0
1964-65	27.9	22.9	20.3	15.2	0.0	0.0	0.0	0.0
1965-66	2.5	5.1	2.5	0.0	7.6	0.0	0.0	2.5
1966-67	0.0	2.5	15.2	10.2	5.1	0.0	5.1	0.0
1967-68	0.0	0.0	2.5	2.5	0.0	0.0	0.0	0.0
1968-69	5.1	15.2	20.3	27.9	25.4	27.9	27.9	20.3
1969-70	15.2	15.2	5.1	0.0	0.0	0.0	0.0	0.0
1970-71	15.2	15.2	15.2	0.0	0.0	2.5	0.0	0.0
1971-72	15.2	5.1	17.8	17.8	12.7	12.7	7.6	0.0
1972-73	0.0	15.2	0.0	0.0	0.0	2.5	0.0	0.0
1973-74	5.1	7.6	0.0	0.0	0.0	5.1	0.0	0.0
1974-75	25.4	22.9	20.3	12.7	12.7	5.1	0.0	0.0
1975-76	17.8	15.2	15.2	10.2	5.1	0.0	5.1	0.0
1976-77	15.2	15.2	10.2	7.6	2.5	0.0	0.0	0.0
1977-78	15.2	17.8	12.7	10.2	0.0	0.0	5.1	0.0
1978-79	25.4	35.6	35.6	35.6	17.8	15.2	20.3	10.2
1979-80	15.2	10.2	2.5	2.5	5.1	0.0	0.0	7.6
1980-81	0.0	0.0	5.1	5.1	7.6	5.1	0.0	0.0
1981-82	48.3	45.7	40.6	38.1	35.6	25.4	15.2	2.5
1982-83	7.6	7.6	7.6	15.2	7.6	7.6	5.1	2.5
1983-84	20.3	20.3	25.4	15.2	17.8	17.8	17.8	17.8
1984-85	10.2	10.2	10.2	22.9	17.8	12.7	2.5	0.0
1985-86	17.8	17.8	17.8	15.2	15.2	12.7	12.7	0.0
Mean	12.1	14.2	14.9	13.6	10.4	8.2	5.6	2.9
Std. Error	11.4	11.3	11.8	11.9	10.5	9.8	9.4	7.0
Maximum	48.3	45.7	45.7	45.7	38.1	35.6	43.2	33.0

Table 2.5: Total Monthly Snow Depth Accumulations, Burns, Oregon, 1950-1986.

	Snow Depth (cm)						
Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Winter Total
1950-51	0.0	2.5	5.1	91.4	7.6	12.7	119.4
1951-52	0.0	5.1	48.3	180.3	142.2	53.4	429.3
1952-53	0.0	0.0	55.9	40.6	0.0	0.0	96.5
1953-54	0.0	0.0	15.2	10.2	0.0	2.5	27.9
1954-55	0.0	0.0	25.4	58.4	12.7	0.0	96.5
1955-56	0.0	27.9	40.6	154.9	86.4	0.0	309.9
1956-57	0.0	0.0	2.5	35.6	35.6	0.0	73.7
1957-58	0.0	0.0	0.0	45.7	38.1	0.0	8.8
1958-59	0.0	0.0	0.0	50.8	17.8	0.0	68.6
1959-60	0.0	0.0	7.6	96.5	48.3	5.1	157.5
1960-61	0.0	10.2	0.0	0.0	0.0	0.0	10.2
1961-62	0.0	2.5	33.0	58.4	10.2	5.1	109.2
1962-63	0.0	0.0	0.0	22.9	0.0	0.0	22.9
1963-64	0.0	5.1	15.2	35.6	30.5	0.0	86.4
1964-65	0.0	15.2	10.2	101.6	0.0	0.0	127.0
1965-66	0.0	5.1	17.8	22.9	10.2	0.0	55.9
1966-67	0.0	2.5	20.3	33.0	10.2	12.7	78.7
1967-68	0.0	5.1	43.2	7.6	0.0	0.0	55.8
1968-69	0.0	5.1	25.4	83.8	101.6	10.2	226.1
1969-70	0.0	0.0	12.7	40.6	0.0	0.0	53.3
1970-71	0.0	5.1	48.3	66.0	2.5	0.0	121.9
1971-72	0.0	10.2	86.4	81.3	33.0	0.0	210.8
1972-73	0.0	0.0	66.0	22.9	2.5	0.0	91.4
1973-74	2.5	7.6	10.2	17.8	5.1	5.1	48.3
1974-75	0.0	0.0	10.2	83.8	17.8	20.3	132.1
1975-76	0.0	0.0	22.9	63.5	10.2	5.1	101.6
1976-77	0.0	0.0	0.0	48.3	2.5	5.1	55.9
1977-78	0.0	38.1	48.3	76.2	5.1	2.5	170.2
1978-79	0.0	0.0	17.8	139.7	63.5	0.0	221.0
1979-80	0.0	33.0	53.3	50.8	12.7	2.5	152.4
1980-81	0.0	12.7	0.0	10.2	12.7	2.5	38.1
1981-82	0.0	15.2	45.7	226.1	78.7	2.5	368.3
1982-83	0.0	5.1	25.4	53.3	22.9	0.0	106.7
1983-84	0.0	12.7	78.7	101.6	71.1	27.9	292.1
1984-85	2.5	5.1	17.8	66.0	33.0	27.9	152.4
1985-86	0.0	35.6	86.4	86.4	40.6	0.0	248.9
Mean	0.1	7.4	27.6	65.7	26.8	5.6	133.4
Std. Error	0.6	10.4	25.0	48.6	33.1	10.9	97.1
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	10.2
Maximum	2.5	38.1	86.4	226.1	142.2	53.3	429.3

Wind speeds in the Basin are relatively insignificant, as the winter months are the calmest periods of the year. Seventy-five percent of the time wind speeds are between zero and fourteen kilometers per hour (Table 2.6). The average wind speed between October and March is just over 4.5 kilometers per hour (3 miles per hour). As a consequence windchill effects in the region are less important.

Ranch Forage Resources and Forage Characteristics

Typically, cattle ranches of the Harney Basin, and high desert in general, rely on dryland range for spring through early fall grazing and on native meadow hays for winter feed supplies (Castle et al., 1961). There are four principal forage sources that are utilized for feeding beef cattle in the region. Listed in order of total production of animal unit months (AUMs) they include (1) dryland range, (2) irrigated and flood meadow pasture, (3) floodmeadow hay, and (4) dryland hay and grain aftermaths (Schmissuer and Holst, 1979; Table 2.7).

Specific characteristics of dryland range and the floodmeadows of the Basin are discussed in the following two subsections. Since dryland hay and grain aftermath represent a relatively insignificant amount of the total forage production, characteristics of these sources are not reviewed (Schmissuer and Holst, 1979).

Table 2.6: Monthly Wind Velocities, Burns, Oregon (50-year average).

Wind Velocity (mph)	Number of days per month					
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
0-3	5.43	7.80	9.46	9.08	6.07	4.81
4-9	18.20	16.11	15.69	15.57	15.49	15.81
10-15	5.95	4.56	4.15	4.59	4.75	7.72
16-20	1.09	1.14	1.33	1.28	1.29	2.04
21-26	0.28	0.33	0.28	0.38	0.31	0.50
27-32	0.05	0.06	0.09	0.07	0.06	0.09
33-38	0.00	0.00	0.00	0.03	0.03	0.03
Total Days	31.00	30.00	31.00	31.00	28.00	31.00
Average Wind Velocity	5.40	4.80	4.50	4.60	5.20	6.30

Source: Oregon State Climatological Center.

Table 2.7: Forage Production, High Desert Region, Oregon.

	Normal Year (AUMs)	1977 Drought Year (AUMs)
Range grazing	1,728,936	922,196
Irrigated pasture	926,061	601,806
Irrigated and dryland hay	1,296,663	760,029
Grain aftermath	102,060	52,175

Source: Holst and Schmissuer, June, 1979, Schmisseur and Holst, September, 1979.

Dryland Range

Dryland range comprises the major portion of the Basin land area. These areas are composed of native perennial bunchgrass-sagebrush ecosystems and/or introduced perennial and annual grass species. Principal native grass species are Bluebunch Wheatgrass (*Agropyron spicatum*), Idaho Fescue (*Festuca idahoensis*), Sandberg Bluegrass (*Poa sandbergii*), Squirreltail (*Sitanion hystrix*), and several species of Needlegrasses (*Stipas* spp.). Introduced grass species include Crested Wheatgrass (*Agropyron desertorum*), and Cheatgrass (*Bromus tectorum*).[1] The grasses of the high desert are classified as cool season grasses due to their dependence upon winter and early spring precipitation and onset of warmer temperatures to begin growth in the spring (Stoddart et al., 1975). Growth lasts into July and August depending on the forage species, precipitation patterns, and elevation of the site (Cook and Harris, 1968).

Shrubs form a major component of desert range vegetation. Wyoming Big Sagebrush (*Artemesia tridentata wyomingensis*) is the dominant climax shrub species of the region. Other shrubs found in the region include several other Sagebrush subspecies (*Artemesia tridentata* spp.), Bitterbrush (*Purshia tridentate*), Green Rabbitbrush (*Chrysothamnus viscidiflorus*), and Gray Rabbitbrush (*Chyrsothamnus*

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[1] Bromus tectorum, an annual grass, was introduced in the Palouse region of eastern Washington in the 1890's. As a forage source, the plant is not considered to be desirable as cattle feed due to extreme variability in biomass production and a relatively short useful life. However, it will provide an excellent source of early spring forage in years of good precipitation.

nauseous). In general, except for Bitterbrush the shrub species found in the basin are not palatable to cattle.

Although total AUM production on dryland range is the highest among the forage sources, production per acre is lower than the other forage sources and will vary considerably between years, and over different locales. Average forage production on the grassland-sagebrush ranges can be as high as three acres per AUM, and as low as 20-25 acres per AUM. Differences in forage production are due to a variety of factors including species composition, previous grazing patterns, soil conditions, and precipitation levels (Raleigh, 1970). Annual fluctuations in precipitation alter production of annual forage species up to 19 times and of perennial grass species up to three times (Stoddart et al., 1975).[2] Strong correlations between precipitation amounts and forage production in the Intermountain region have been documented by Sneva and Hyder.

In general, energy, protein, mineral, and vitamin contents of the forages are adequate to meet nutritional needs of cattle during the plant's period of growth and maturation. However, as forage species mature, digestibility and nutritional quality decline rapidly, particularly in forage protein, vitamins, and mineral amounts (Wallace et al., 1964; Raleigh, 1970). Crude protein levels of Intermountain forage species fall off rapidly to between three and

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[2] Annual grasses exhibit greater variability in production than native and introduced perineal grass species. For example, at the Squaw Butte experiment range, Bromus tectorum (Cheatgrass) production varied from 17 pounds per acre (44 acres per AUM) during the drought year of 1977 to 260 pounds per acre in a normal year (3 acres per AUM) (Ganskopp and Bedell, 1979).

four percent by late July and early August. Unless rains arrive early enough in the fall to induce plant regrowth, protein and other nutrient levels will remain at low levels until the following year's growing season (Cook and Harris, 1968).

A vast amount of empirical evidence has documented changes in range forage nutritional and digestibility characteristics through the season. Wallace et al. (1964), using *in vitro* techniques, measured cellulose digestibility coefficients of six range grasses of the Harney Basin. All six grasses exhibited declining digestibility and crude protein values as plants matured (Appendix A). Crampton and Harris (1968) determined energy content and crude protein percentages of several Intermountain forage species. Results again showed declining nutritional content in the forages as plants matured (Appendix A). Other researchers e.g., Skovlin (1967), Hickman (1966), and Hilken (1983), have measured similar nutritional and digestibility trends in their research (Appendix A).

The suitability of winter grazing cattle in the Intermountain region varies depending upon location and forage resources (Stoddart et al., 1975). Generally speaking, cattle grazing Harney Basin ranges during winter are unable to meet nutritional needs unless provided with (1) an energy-protein supplement to compensate for the poor quality of the range grasses, and (2) emergency feed supplies in the event of substantial snow accumulation. Deep snows may hinder the animals ability to procure enough food to satisfy intake and nutritional requirements since grasses are flattened to the ground, making it difficult for cows to reach buried forages.

Native Flood Meadows

Native meadows of the Harney Basin are found along the areas streams and on the floodplains adjacent to Malheur and Harney Lakes. The meadows are primarily utilized for the production of hay for feeding cattle through the winter. The meadows are flooded for 6 to 12 weeks, generally between April 1 to July 1, resulting primarily from natural occurrences, but some man-made irrigation also takes place (Gomm, 1979). The growing season on the meadows roughly coincides with the flood period. Depth of water and length of the flooding vary according to the time and amount of run-off from adjacent watersheds in the foothills to the north and Steens mountains to the south (Cooper, 1956a).

Harvesting of hay begins in July at the end of the flood period and coincides with maximum dry matter production on the meadows (Rumberg, 1972). The meadows also provide fall grazing of hay aftermaths and plant regrowth following hay harvesting (Cooper, 1956a). However, the amount of regrowth is negligible due to the lack of significant precipitation the remainder of the growing season.

Though vegetation of native meadows consists of as many as 85 species, the meadows are largely composed of rushes (*Juncus* spp.) and sedges (*Carex* spp.) (Cooper, 1956b; Rumberg, 1972). These species represent from 70 to 80 percent of the meadow forage biomass (Cooper, 1956b; Rumberg, 1972). The principal sedge species is Rusty sedge (*Carex subjuncea*) and the dominant rush species is Baltic rush

(*Juncus balticus*). The other 20 to 30 percent of the meadow vegetation consists of short and dense-growing grass and clover species (Rumberg, 1972). The most abundant grasses are Nevada bluegrass (*Poa nevadensis*), Meadow foxtail (*Alopercurus pratensea*), Meadow barley (*Hordeum brachyantherum*), and Beardless wild-rye (*Elymus triticoides*) (Cooper, 1956a; 1956b). The principal clover species is annual White-tip clover (*Trifolium variegatum*).

Natural forage production on the meadows averages 0.75 ton to one ton per acre (Cooper, 1956a; Raleigh, 1970). In addition to the influences of precipitation amounts and the length of the flooding period, hay yields and quality vary depending upon cutting heights and levels of fertilization. Lowering the cutting height increases forage yields but results in reduced protein content of the hay (Table 2.8).

Nitrogen fertilization has been demonstrated to (1) increase hay yields and (2) change the vegetative make-up of the meadows. Increases of meadow production will vary depending upon the time and rate of application (Cooper, 1956b; Rumberg and Cooper, 1961; Wallace et al., 1964; Rumberg, 1972; Figure 2.1). In general, larger amounts of nitrogen increase meadow forage production, although the marginal increases in production tend to decline rapidly after applications greater than 150 pounds per acre. Nitrogen fertilization alters vegetative composition by increasing the percentage of grasses, while decreasing the amount of rushes, sedges and meadow clover (Rumberg and Cooper, 1961; Wallace et al., 1964). The decrease in meadow clover composition results in reduced protein content of meadow

Table 2.8: Yields of Hay in Tons Per Acre, and Average Crude Protein Content as Influenced by Cutting Height and Year, 1951-1954.

Cutting height	Year, tons per acre 1951	1952	1953	1954	Average tons	% cp
2 inches	1.69	1.75	1.59	1.21	1.56	6.15
4 inches	1.01	1.06	1.07	0.60	0.94	6.46
6 inches	0.30	0.34	0.53	0.14	0.33	6.68
Average	1.00	1.05	1.06	0.65		

Source: Cooper, 1956b.

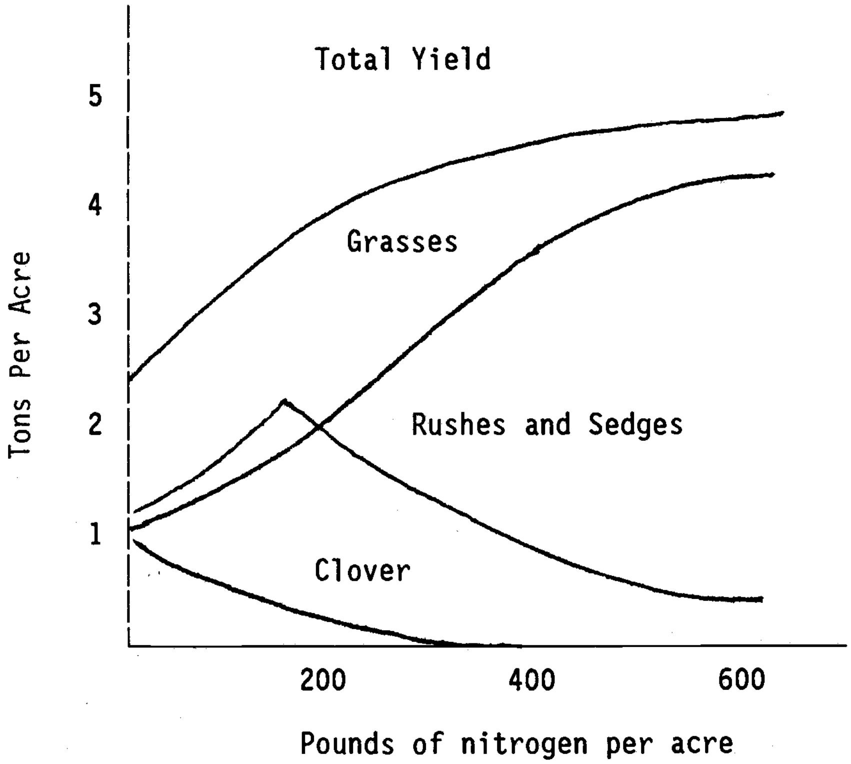

Figure 2.1: Yields of Hay and Species Composition in Response to Nitrogen

Source: Rumberg and Cooper, 1961.

forages and lowers hay quality (Cooper and Rumberg, 1961). Fertilizing with phosphorus gives the opposite effect by improving hay quality and increasing the clover composition (Cooper, 1956b; Cooper and Rumberg, 1961; Rumberg, 1972).

Forage nutritional content patterns of meadows are similar to grasses found on surrounding rangelands. As meadow forages mature through spring and early summer, quality and digestibility coefficients decline (Table 2.9). Protein quality after maturity declines daily at a rate of 0.05 percent per day before leveling off between 2.0 to 3.5 percent in September. Digestibility of energy declines but to a lesser degree than protein. Forage energy values generally remain at levels high enough to meet requirements of ranch or range livestock (Raleigh and Wallace, 1963).

Cattle production experiments performed on Harney Basin flood meadows concluded the most important factor influencing production was the decline in protein content and digestibility (Raleigh and Wallace, 1963). Poor quality forage tends to reduce forage intake by cattle although during periods of cold weather mature cows usually increase intake levels enough to meet their nitrogen requirements when fed lower quality hay (National Research Council, 1981). Yearling and weaner calves will not be able to meet requirements by feeding exclusively on meadow hay unless the hay is cut early in the season when protein content is high. Since meadows are often flooded at this time and forage production for winter feed reserves would be greatly reduced, harvesting at this time is not practical. Hence,

Table 2.9: Energy and Protein Digestibility, and Energy and Protein Content of Native Meadow Hay Harvested at Four Dates, Burns, Oregon.

Harvest date	Digestibility		Nutrient Content	
	Dry Matter	Protein	Energy	Protein
	%	%	mcal/kg	%
June 9	61.76	63.02	1.22	6.36
June 28	56.60	60.24	1.07	4.94
July 17	51.73	48.37	0.92	2.80
August 4	49.16	35.20	0.84	1.65

weaners and yearlings are provided protein supplementation when fed meadow hay or are fed higher quality hays such as alfalfa.

Ranching Characteristics

Ranch characteristics of the Harney Basin are typical of the High Desert region of Oregon. The primary ranching enterprises are cow-calf and cow-calf yearling operations with a small percentage of outfits managed exclusively for weaners (stockers) or purebreds (Table 2.10).[3] Size appears to dictate the type of cow-calf operation (Schmisseur and Holst, 1979). Ranches with cow herd sizes of less than 200 head are predominately cow-calf operations, while herds larger than 200 brood cows are primarily cow-calf yearling operations.

The majority of the operations manage their herds to calve in the spring, though it is not uncommon for a ranch to operate with both spring and fall calving programs (Table 2.11). Herd sizes in the High Desert region average nearly 500 brood cows per operation in 1979 (Schmisseur and Holst, 1979).

The ranches in the region follow a fairly typical schedule indicative of western cattle operations. The spring calving period, normally 60 to 75 days in length, begins in late February and runs through late April or early may (Williams, 1986). Cattle are generally taken off winter programs by March-April and turned out on

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[3] Many High Desert cow-calf ranchers also purchase weaners to supplement incomes. In 1979 twenty-three percent of High Desert ranchers purchased an average of 704 weaners. (Schmissuer and Holst, 1979).

Table 2.10: Eastern Oregon Cattle Operation Types, By Region

Region	Cow-calf	Cow-calf yearling	Stocker	Other
	- - - - - - - -	percent	- - - - - - - -	
Central	48.4	50.3	0.0	1.3
High Desert	34.6	58.7	4.5	2.2
North Central	68.9	29.6	0.0	1.5
Northeast	40.2	56.8	0.0	3.0

Source: Schmisseur and Holst, 1979.

Table 2.11: Calving Seasons of Eastern Oregon Ranches.

Region	Fall	Spring	Fall and Spring
	- - - - - -	percent	- - - - - -
Central	8.9	73.3	17.8
High Desert	2.7	68.1	29.2
North Central	17.1	68.1	14.8
Northeast	10.0	78.5	11.5

Source: Schmisseur and Holst, 1979.

dryland range and/or pasture where they will remain through September.

In general, spring calving cows begin cycling by June 1st signaling the start of the breeding period. The breeding period ideally runs 45 days, but commonly extends to 60 days concluding during the first week of August.

The fall feeding (or early winter) program runs through October and mid November. Cows are fed during this time in a variety of ways depending upon the ranch forage resource base. Common feed sources includes dryland range, meadow and hay aftermath, baled hay, rake bunched hay, and to a lesser extent grain aftermath.

Calves are generally weaned between September 1st and before the winter feeding programs begin in November. Depending upon the operation, calves are either sold in the fall or retained as yearlings for sale the following year (Williams, 1986). In addition, 10 to 15 percent of the heifers are generally retained for herd replacement.

The winter feeding program begins between October 1st and November 15th depending on weather conditions and the ranch forage base. The length of the wintering period varies between 150 and 180 days, ending in late March or early April, again determined by weather and range forage conditions.

Alternative Winter Feeding Regimes: Experimental Methods and Results

In response to the rancher's desire to reduce cattle production expenditures, research staff at the Squaw Butte Agricultural Experiment Station, Burns, Oregon are assessing three winter feeding programs for mature, gestating cows. The goals of the studies are (1) to find methods to reduce dependency on feeding out hay to wintering cows and (2) to achieve acceptable cow production performance at reduced costs.

The alternative feeding programs include (1) strip grazing rake-bunched hay, (2) strip grazing standing meadow forage, and (3) grazing local range grassland. A control group of cows was fed baled hay in order to compare production factors and costs among the alternatives being tested and current feeding methods.

The experiments were performed in two stages. The first set of experiments covered the winters of 1982-83, 1983-84, and 1984-85 and assessed the raked-bunched hay and standing forage alternatives. Cows entered the winter period in the second trimester of pregnancy on October 1st. The winter programs concluded during the last trimester of gestation. For the calving season, cows were returned to range on March 1st where they remained through the month of September. Calves were weaned by the middle of September before beginning the wintering program in October.

The second set of trials was conducted over the winters of 1986-87 and 1987-88. These trials evaluated the use of rangeland as a source of winter feed. Cows wintered on range from October through February and remained on range through the month of July. From August 1 through September 30, cow-calf pairs were moved to native flood meadows and fed rake-bunched hay, and allowed to graze meadow aftermath. Calves were weaned in September on the meadows.

All experiments measured cow performances in terms of conception rates, cow weight, cow condition scores, calf birth and weaning weights, calf birth dates, calving intervals, and attrition rates for each of the alternatives. In addition, variable costs of production for the alternatives were calculated on a per head basis.

The type of cows used were three years and older, spring calving, Hereford-Angus crosses. The Hereford-Angus cross is the prevalent cattle type found on western ranches (Sanders and Cartwright, 1979b; Ensiminger, 1976). Other cattle types, fall calving cows, weaners, replacement heifers, yearlings, and first calf heifers would not perform well on the treatments unless substantially supplemented, hence their exclusion from the trials.

In the following sections each alternative is addressed in greater detail with respect to particular management practices and associated risks and uncertainties. At the conclusion of these descriptions, test results of the trials are presented. These sections are largely based upon two published articles by H. A. Turner and R.F. Angell (1984 and 1987), conversations with Turner, and unpublished Squaw Butte data.

Winter Rake-Bunched Hay

Rake-bunched hay has been utilized as a feed source over much of the west where hay is harvested. However, this method has been used primarily for fall feeding of cows prior to the arrival of winter. The concept of feeding rake-bunched hay over the winter is relatively new and in some respects still being perfected.

Methods of hay harvest are identical for the fall and winter rake-bunched feeding regimes. The meadows are cut in early to mid-July and the hay allowed to dry. The hay is then raked into bunches of between One hundred to one hundred and twenty pounds using a dump and/or tumbleweed rake. Ranchers could also rake the hay into rows using a side delivery rake. The bunches and/or rows are then left on the meadows to await the arrival of the cows returning from summer range in October.

At this point, similarities between the two rake-bunch regimes end. The fall feeding cows are turned out on the meadows and allowed to feed by free choice. They remain on the meadows from four to six weeks depending upon forage availability or before the arrival of winter snows. The method of feeding rake-bunched hay over the winter, originated and tested at the Squaw Butte Experiment Station, is of an entirely different approach. The management practices that make this treatment unique and applicable to winter feeding are twofold. First, New Zealand type electric fences are used to force cows to strip graze the rake-bunched hay on the meadows in sections.[4] Second, the cows graze these sections on a weekly basis. Weekly feed requirements are estimated using observed cow intake levels from previous years. The cows are forced to clean up each strip before the fence is moved and the animals permitted to feed on new sections

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[4] The fences consist of two strands of polywire strung on fiberglass (or steel) stepdown posts set at 30 ft. intervals. Power to generate electric current is provided by a twelve volt car battery.

of the meadow. The reasons for limiting feed to one week's allowance is to control intake levels and deter cows from poorly utilizing feed which tends to happen when cows are given unlimited access on the meadows.[5]

There are three major advantages of winter rake-bunch programs when compared to the common practice of feeding baled hay on a daily basis. First, harvesting costs are reduced since no baling is performed. Second, labor costs are cut significantly since feeding hay is not required during the winter except in cases of very heavy and iced over snow cover. The only labor required in managing the rake-bunched treatment occurs when the fence is moved weekly. According to Squaw Butte records, a half mile of the New Zealand type fence can be moved by one man within fifteen to thirty minutes. Third, forage waste was minimal (1-4 percent), with cows cleaning up bunches in the spring that were missed during the winter, including bunches under as much as 15 cm of water. Cows also exhibited a preference for rake-bunched hay, selecting the bunches when given a choice of baled hay. In contrast, cows on baled hay systems generally waste 15 percent of the forage fed to them.

Nutritional quality of rake-bunched hay is similar to that of baled meadow hay. For the trials, protein content of the rake-bunched hay averaged 7.5 percent. Energy content was roughly 1.10 megacalories (Mcal) of net energy per kilogram of hay.

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[5] Cows tend to bed upon, trample, and deposit their excrement on the hay during periods of snow cover. This reduces utilization, increases levels of forage wasted, and results in increasing feed costs.

Risks associated with rake-bunching are minimal as cows appear to be adept in finding and digging through snow to reach the hay bunches. During the trials depths as great as 61 cm (2 feet) failed to inhibit cows from finding the hay bunches and meeting their intake and nutritional requirements. Cows learned to associate humps on snow covered fields with the presence of hay bunches. In addition, portions of the bunches tend to stay exposed because of their height above the ground surface. Furthermore, the bunches appear to undergo some ensilaging, generating enough heat to melt the snow cover.

One risk that surfaced during the trials, which would skew test results, occurred during the winter of 1983-84. Deep snow cover was followed by freezing rains that formed an ice crust several inches thick on lower elevation meadows. The ice crust prevented cows from digging through the snow and feeding on the bunches. After an unsuccessful attempt to force the cows through on these meadows, feeding baled hay became necessary for a 49 day period in January and February. Subsequent evaluations indicate that by improving management practices this situation could have been prevented or minimized. Higher elevation portions of the meadows did not experience the ice crust as severely as the lower meadows. Therefore, putting cows on the lower meadows earlier and later during the winter period while saving the higher meadows for mid-winter feed would have helped eliminate or reduce emergency feeding. In addition, it was observed that more compact and slightly larger bunches remained accessible even during the worst conditions. Raking hay into taller more compact bunchs in subsequent years has helped cows access hay more easily.

Standing Meadow

Cows on this treatment are placed on uncut meadow pasture in October and remain on the pasture until calving. Pastures are strip grazed using New Zealand type electric fence. As in the winter rake-bunch program the fence is moved weekly. In this system cows require a protein supplement to meet nutritional requirements. In the Squaw Butte trials the protein supplement consisted of a weekly ration of seven pounds of cottonseed meal. The supplement was fed three times a week rather than daily to reduce labor costs. Experiments have shown feeding protein supplements every other day does not reduce cow performances significantly (Raleigh et al., 1971).

Cows were placed on a higher quality meadow with crude protein content averaging 4.3 percent over the trial.[6] In general, most cured meadow in the area is lower in crude protein, averaging between 2 and 3.5 percent over the winter period (Sneva and Turner, 1977).

Advantages to the system are elimination of harvesting forage to feed cows during the winter and reduced labor costs. Labor costs are confined to moving fence each week and providing protein supplement three times per week. Although these advantages appear to

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[6] Grass with a protein content of 4.3 percent is still a poor quality forage. To meet maintenance protein requirements without supplementation cows should be feeding on grass with a minimum 6 percent protein content. The higher protein content on the experiment meadow may not be accurate either. Sampling occured at ground level where some material could have been picked up, experienced some microbial action, thereby increasing protein levels of the forage samples.

result in significant cost savings, test trials at Squaw Butte do not support this conclusion. Once significant snow cover was received, forage on the meadows was flattened to the ground preventing cows from feeding efficiently and receiving an adequate level of nutrition. As a result, cows had to be fed baled hay an average of two months during each of the three winters. Costs associated with the standing forage trials were found to be nearly identical to cows wintered on baled hay.

Winter Range Grazing

Cows on this treatment are on range for ten months from October 1 through July 31. Between August 1 and September 30 cows are placed on flood meadows and allowed to feed free choice on rake-bunched hay. Calves are weaned around the first week of September.

Forage quality is low on Basin winter range, averaging 2 to 3.5 percent crude protein and 0.80 Mcal net energy per kilogram of forage. Because of low forage quality cows are provided with a protein/energy supplement. The supplement consists of 85 percent cottonseed meal (41 percent protein) and 15 percent barley (13 percent protein). During the trials cows were given one pound of cottonseed meal and barley mix over the winter of 1986-87, and 1.5 pounds of mix for the winter of 1987-88. Supplement was provided every other day, between October 1 and the beginning of the calving season in March.

There are two advantages to winter range grazing making this system an attractive alternative to ranchers. First, cows are taken off range when forage quality has diminished and put on better quality rake-bunch hay in the late summer. The cows are able to gain significant amounts of weight during the two month period before being returned to range in the fall. Because cows are placed on higher quality feed, calves are able to realize better late summer gains than calves that remained out on range. Studies undertaken by Vavra and Raleigh (1976) and Bedell (1980) reveal that cow-calf pairs remaining on range through the late-summer and early-fall suffer from reduced performance. Cows lose weight and condition, and calf average daily gains decline significantly (Vavra and Raleigh, 1976; Bedell, 1980).

Disadvantages to winter range grazing primarily result from the risks of severe winter weather conditions. Deep and prolonged snow cover (15-20 centimeters or greater) will hinder the cows ability to acquire enough feed to satisfy intake and nutritional requirements (Senft et al., 1985; Carr, 1989; Turner, 1988). Therefore, substantial quantities of emergency hay should be available for quick access. Given weather patterns in the Basin, approximately six to ten weeks of hay should be set aside for emergencies.

Because winter ranges cover large areas, and given the generally poor forage conditions on Basin grasslands, special care must be taken to assure an adequate emergency hay supply. It is not uncommon for forage production on Basin ranges to be over ten acres per AUM. One cow grazing ten acre per AUM locations will require fifty acres to meet its winter nutritional needs. In a larger context, a herd of 400 cows under identical range conditions will require 20,000 acres from October 1st to March 1st (31 square miles). Emergency supplies should be placed strategically on the particular range site or be available nearby in order to (1) minimize distances cattle would have to travel to feed sites, and/or (2) facilitate transportation and feed of hay to livestock.

The particular range being utilized for winter grazing needs to be managed to provide enough feed for the cow herd. Grazing the range only during the winter or grazing the area early in the spring and taking the cows off to allow plants to regrow are two strategies that would provide sufficient winter feed.[7]

Baled Hay

The control group of cows in the trials was managed according to practices commonly used by area ranches. Cows were on fall feed for 4 to 6 weeks in October and November. Fall feed consisted of rake-bunched hay, aftermath, and regrowth available free choice to the cows. The rest of the winter feeding period cows were fed baled hay on a daily basis.

As mentioned previously, the nutritional components of baled hay are similar to that of rake-bunched hay. Protein content over the trial was 7.2 percent in baled hay samples compared to 7.5 percent in the rake bunched hay samples. This difference is attributed to the rake bunched hay being cut a couple of days earlier than hay that was baled.

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[7] During a drought year lowered range forage production may require ranchers to provide supplemental hay to cows on winter range regardless of winter weather conditions.

Feeding hay daily is the least risky of the alternatives. Cows are not required to search for food when snow is on the ground and ranchers are able to control daily intake. However, this method of feeding is the most time consuming and on paper the most expensive. Loading and feeding hay to a large herd of 500 cows will, depending upon equipment used, take one to two men up to five hours per day.

Trial Results

Test results included cow production measurements and economic costs of the treatments. Cow production measurements include conception, attrition, calving, and calf death loss rates, and cow and calf weights.

Of the cow production components, cow conception rates are one of the most important measurements. Higher conception rates within a confined breeding season are an indication of a healthy breeding herd and will translate into higher ranch revenues (Ensiminger, 1976). During the first set of trials the baled hay group of cows had the highest conception rate at 86 percent followed by the rake-bunched group at 79 percent, and the standing meadow group at 73 percent (Table 2.12). Although the rake-bunched group of cows conception rate was lower over the trial period, this apparently resulted from the attempt to force cows through the winter of 1983-84 without providing emergency feed (Turner and Angell, 1987). As noted previously, this skewed results for the entire trial period. Conception rates were similar during the other two years. Prior experiments at Squaw Butte demonstrated rake-bunched fed cows

Table 2.12: Results of Squaw Butte Feeding Trials for Baled Hay, Rake-Bunched Hay, and Meadow Grazing Alternatives, 1982-1985.

	Baled Hay	Meadow Grazing	Rake-bunch Hay
Conception rate (%)	86.0	73.0	79.0
Calving rate (%)	95.6	91.9	98.2
Attrition rate (%)	19.9	33.6	21.0
Calf death loss (%)	5.0	2.1	6.8
Calving interval (days)	371	372	375
Weaning weight (lbs)	346	346	344
Cow weight change (lbs)	34	0	44
Winter costs ($/cow)	50.40	48.07	21.78

Source: Turner, 1987.

achieved similar conception rates to cows fed baled hay. Unpublished results show cows on rake-bunched hay to have achieved 86 percent conception rates and those on baled hay 89 percent over a six year period.

During the second set of trials conception rates of the range grazing cows was 92 and 88 percent for 1986-87 and 1987-88, respectively. Over the same period conception rates of baled hay and rake-bunched hay groups of cows averaged 91.2 and 90.5 percent, respectively (Table 2.13).

Attrition rates measure both death loss of the cows and culling of open cows in the fall (Table 2.12). Attrition rates where highest for the standing meadow group at 33.6 percent. The baled hay group had attrition rates of 19.9 percent during the first set of trials, and 8.7 percent in the second set of trials. Rake-bunched groups had attrition rates of 21.2 and 9.5 percent during the first and second set of trials, respectively. Range grazing cows had attrition rates of 10.0 percent (Table 2.13).Calving percentage was highest for the rake-bunched group at 98.2 percent (Table 2.12). The baled hay and standing groups had calving percentages of 95.6 and 91.9 percent, respectively. Calf death loss was 6.8, 5.0, and 2.1 percent, for the rake-bunched, baled hay, and standing meadow groups, respectively. Calving rate and calf death loss rates were not compiled in the second set of trials.

Weaning weights were nearly identical among the first trial test herds (Table 2.12). Weaning weights stood at 157 kg (346 lb) for calves in both standing and baled hay treatment groups, and 156

Table 2.13: Results of Squaw Butte Feeding Trials for Baled Hay, Rake-Bunched Hay, and Range Grazing Alternatives, 1986-1988.

	Baled Hay	Range Grazing	Rake-bunch Hay
Conception rate (%)	91.2	90.0	90.5
Calving rate (%)	100.0	100.0	100.0
Attrition rate (%)	8.7	10.0	9.5
Calf death loss (%)	8.0	0.0	2.0
Calving interval (days)	360	361	360
Weaning weight (lbs)	388	395	382
Cow weight change (lbs)	- - - not available - - -		
Winter costs ($/cow)	- - - not available - - -		

Source: Turner, 1988.

kg (344 lb) for calves in the rake-bunched group. Weaning weights during the second feeding trials averaged 176 kg (388 lb) for the baled hay group, 172 kg (379 lb) for the rake bunch-group, and 180 kg (397 lb) for the range grazers (Table 2.13). Cows on standing forage maintained their weight over the course of each winter while cows on the other two treatments gained weight (Table 2.12).

Cows on rake-bunch put gained an average of 44 kg (97.0 lb) during the trial and cows on baled hay gained an average of 34 kg (75.0 lb). Again, weight gains per cow on the rake-bunched treatment were skewed because of the winter of 1983-84. Cow weight change over the winter was not performed in the second set of trials.

Variable costs among the treatments were lowest for the rake-bunched method. Costs varied over the three years between $20-28 per head. Variability was due to the type of fence materials used and emergency feeding in 1983-84. Costs on the baled hay group varied from $46-55 per head, depending upon the length of fall feeding programs and winter severity. Costs on the standing hay ran from $38-57 per head, nearly as expensive as the control group. Costs were not compiled for the second set of trials, although the costs of feeding the baled and rake-bunch groups during this period can be assumed to be similar to previous years expenditures.

Based upon these results it appears that rake-bunch hay feeding is the best alternative to baled hay feeding over the winter. The rake-bunch treatment is cheaper and cattle performance criteria are comparable to baled hay fed cows. Range grazing is a promising alternative since cattle performance on winter range has been good.

If not much emergency feeding is required and protein supplementation can be minimized range grazing may also prove to be a cost effective alternative to baled hay feeding in the Harney Basin. High costs combined with reduced performance indicate that the use of standing forage is probably not a desirable alternative to present feeding practices.

CHAPTER III

COW NUTRITIONAL REQUIREMENTS: PHYSIOLOGICAL AND ENVIRONMENTAL FACTORS AND EQUATIONAL RELATIONSHIPS

The primary goal of cow-calf operators is to maximize net income to the operation (Workman, 1986). To accomplish this goal, it is necessary to produce as many pounds of beef per cow-calf unit as economically efficient as possible (Lewis). The means by which this is achieved in cow-calf or cow-calf-yearling operations will depend upon proper management of the brood cow herd. For either operation, production in the herd is measured by the number of calves produced and their sale weights as weaners or yearlings. Therefore, three major objectives of the cow-calf operation are (1) producing as large a calf crop as feasible, (2) weaning as heavy a calf as feasible, and (3) achieving these two goals in the most economically sound manner.

Many factors are interwoven in establishing an efficient and productive brood cow program. These factors include the genetics of the herd, proper nutrition, range and pasture management, disease prevention and treatment, monitoring and evaluating the operation, and management flexibility in adopting necessary changes to the operation (Lewis).

The main focus of this chapter is to examine the nutritional requirements of wintering pregnant cows as they relate to (1) the physiological stage of the cow and (2) the environmental influences on cow nutritional requirements and forage acquisition. To achieve high calf crops in the spring and successfully re-breed the cows over the summer breeding season, cows must be maintained in healthy and vigorous condition through the winter (Ensminger, 1976). By understanding physiological and environmental factors that influence nutritional requirements of cows, productive brood herds can be achieved and maintained.

Management Considerations

Mature cows pass through two reproductive states during a year's production cycle--gestation and lactation. Each of these physiological states requires careful management of the cows feed intake and feed quality. For instance, cows in the first 3 to 4 months of lactation require nearly a 50 percent increase in dietary levels of energy and protein in comparison to cows in maintenance (NRC, 1984). Cows during the nine months of pregnancy require increasing amounts of energy and protein to compensate for fetal calf development and growth.

During the wintering period spring calving cows will be passing through their second and third trimesters of pregnancy. Cow herds in the High Desert region normally enter winter programs in the 60th-120th day of pregnancy and leave the program during the 220th-283rd day of pregnancy.[1] This is a critical period during the cows production cycle. Cows must delegate an escalating level of nutrients to the development of the unborn calf. Second, cows must

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[1] The gestation (or pregnancy) period will last approximately 283 days from conception.

remain in good condition in order to raise a healthy calf following parturition and breed back during the summer (Salisbury and Van Demark, 1961; Ensminger, 1976). Hence, the measure of a sound, economically viable wintertime nutritional program is two-fold. First, cows should be fed adequately to maintain their condition and body weight.[2] Secondly, additional feed must be provided for growth and development of the calf within the mother.

Ideally cows should be managed to maintain or lose no more than five to ten percent of their own weight (Lewis). Assuming average condition, cows losing over five to ten percent of their body weight during pregnancy generally experience reduced reproductive performances (Lewis; Ensminger, 1976). Reproductive problems include reduced calf crops, deficient milk production, higher calf mortality, lengthened calving intervals, lowered conception rates, and greater numbers of services to achieve conception (NRC, 1984; Wiltbank et. al., 1962; 1964). In addition, calf weaning weights may be reduced if cows are fed limited rations during pregnancy.

Although cows are fed to maintain their own body weight they should be managed to gain weight during the period to compensate for the development of the calf inside the mother (NRC, 1984; Ensminger, 1976). By the time cows are ready to calve, the fetus, amniotic fluid, fetal membrane, and cow uterus will weigh approximately 45 to 68 kilograms (100-150 pounds) (Lewis; Salisbury and Van Demark,

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[2] This assumes cows are in good breeding condition. If not, cows should be fed to put on weight in order to bring them up to condition.

1961). Hence, operators target cows to gain between 45-68 kilograms to compensate for calf development and growth (Lewis; Ensminger, 1976). However, if cows have extra weight on them before the winter begins cows can lose weight without harming reproductive performance (Lewis). Phillips and Vavra (1981) compared production factors between good condition, pregnant cows losing small amounts of metabolic weight (four percent) and cows gaining large amounts of weight (ten percent) during the last two months of pregnancy. Results showed no significant differences in calf crops, calving intervals, or conception rates between the two test groups.

Assuming cows in average condition, most compensatory weight should be put on during the last trimester of gestation, since 70-80 percent of calf growth occurs during this period. Cows should be gaining 0.40 to 0.90 kg/day otherwise the cow will catabolize her body fat reserves (Lewis). Catabolizing body fat reserves leads to the cow losing weight and condition, subsequently reducing reproductive performances and diminishing calf production factors.

Effects of Nutrient Deficiencies on Cow Reproductive and Production Performance

Nutrients that are of primary concern in meeting a pregnant cows feed requirements are energy, protein, phosphorus, and vitamin A (Ensminger, 1976). Energy is considered the most important nutrient for two reasons. First, deficient energy levels during gestation and lactation are the most frequently cited factor linked to reproductive failures (Ensminger, 1976). Secondly, other nutrients essential to the cows diet will not be fully utilized unless energy requirements are satisfied, further exacerbating problems in cow reproductive performance criteria (NRC, 1984).[3]

A large number of experiments have been conducted to measure the influence of insufficient or excessive dietary energy levels of cows on their reproductive and production performances. Knox and Watkins (1958) determined insufficient energy intake by cows grazing desert grasslands before and after pregnancy was responsible for lowered calf crops. Pinney et al. (1962), found wintering beef cows fed inadequate amounts of energy had lowered calf crops, depressed milk production following calving, and weaned lighter calves. Moreover, cows that were placed on very high planes of nutrition also experienced lower calf crops and depressed milk production. It was determined that cows put on medium to high planes of nutrition were the most economical per dollar of input. Larger calf crops were realized and bigger calves were weaned.

Wiltbank et al. (1962) fed wintering gestating cows different levels of energy and protein before and after pregnancy to test reproductive and productive performance. Results were similar to observations made by Pinney et al. (1962). In addition to decreased calf crops and depressed milk production, pregnant cows receiving deficient energy and protein levels suffered delayed estrus and lengthened calving intervals. Furthermore, deficient levels of

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[3] Note, low levels of crude protein in poorer quality forages will reduce dry matter intake by cows (Campling et al., 1962). This results in diminishing energy uptake, further exacerbating problems of nutrient utilization by cows.

energy and protein during lactation yielded lighter calves and reduced conception rates (Wiltbank et al., 1962; 1964).

Bellows and Short (1978) found cows fed inadequate amounts of energy during the precalving period experienced reduced conception rates. In examining data from the test groups at Squaw Butte it appears there is a strong correlation between low conception rates and inadequate energy levels during pregnancy (Turner, 1988). Weight changes over the winter were significantly different between the experimental groups. This indicates that nutrient intake for some test groups was inadequate, while for other groups intake was sufficient. Cows receiving inadequate levels of nutrition included the rake-bunch hay test group in the winter of 1983-84 and the standing pasture groups during the winters of 1982-83, 1983-84, and 1984-85. The groups on medium nutritional planes included the test groups fed baled hay and the rake-bunched hay fed groups in the winters of 1982-83 and 1984-85. Cows on low planes of nutrition had lower conception rates in comparison to cows receiving adequate nutritional levels. Since the groups were all grazing an identical forage base from March through September, it seems safe to assume that the particular winter program the cows were put on largely influenced conception rate among the test groups.

Severe shortages of crude protein in the diet also lead to problems in cow reproductive and production performance (NRC, 1984). Normally, forage fed to pregnant cows should contain between 6 and 6.5 percent protein to meet dietary requirements. Symptoms of protein deficiency include delayed estrus and lighter calf weaning weights. Protein deficiencies usually are a result of inadequate dry matter intake due to poor forage quality.

Poor quality forage (low percentages of forage crude protein) leads to energy deficiencies in the diet by depressing intake (Campling et al., 1962). Campling et al. (1962) found cows receiving less than six percent protein in the diet reduced forage intake amounts. Sanders and Cartwright (1979b), derived intake levels from the results obtained by Campling et al. (1962). Intake levels of forages were calculated to be 100, 90, 78, 66, 52, and 34 percent for forages containing protein contents of 6 (or greater), 5, 4, 3, 2, and 1 percent respectively.

Cows fed poor quality forage can be supplemented to compensate for protein deficiencies. Rittenhouse et al. (1970) found wintering cows supplemented to meet protein requirements achieved adequate dry matter and energy intake. However, cows given excessive amounts of protein experienced depressed intake levels and reduced performance (Rittenhouse et al. (1970); NRC, 1981).

Major indications of phosphorus deficiencies in the pregnant cow include irregular breeding and depressed milk production (Ensminger, 1976; NRC, 1984). Large areas of the west, including the Oregon High Desert, possess phosphorus deficient soils. As a result rangeland forages, particularly following maturity, do not contain adequate phosphorus levels to meet cow requirements. Deficiencies can be corrected through supplementation. Protein supplements such as cottonseed or soybean meal serve as excellent sources of phosphorus. Another common form of supplementation is mixing a phosphorus source such as dicalcium phosphate with free choice salt (Taylor, 1984). Ranchers mixing their own supplements find this to be cheaper than purchasing commercially produced sources.

Severe shortages of vitamin A can lead to birth of smaller calves, increased incidence of stillborn calves, and higher calf mortalities (Ensminger, 1976; NRC, 1984). The vitamin A requirement for pregnant cows is 2800 IU per kilogram dry feed (Church et al., 1956; Meacham et al., 1970). Vitamin A is synthesized during the cows digestive processes by the splitting of carotene molecules contained in green forages.

Carotene is acquired by cows in the natural state when animals are grazing on green forage. When forages are exposed to sunlight, high temperatures, experience drought conditions, and as they mature, forage carotene is rapidly depleted which can lead to deficiencies of vitamin A in the cow diet. However, cows possess internal biological mechanisms to provide vitamin A during these periods. Cows are able store large amounts of vitamin A in the liver for periods of 2-4 months (Hayes et al., 1967). During periods of feeding on forage deficient in carotene, hepatically stored vitamin A can be utilized by the cow to compensate for the low levels of dietary carotene.

Deficiencies of vitamin A in the diet can be corrected by providing higher quality forage or hay, hand fed vitamin supplements, and vitamin A injections (NRC, 1984). Perry et al. (1967) determined that injected vitamin A is more efficiently used by cows than supplements and management time is reduced.

Nutrient Requirements of Pregnant Cows

The level of nutrition required by a mature pregnant cow is primarily dependent upon the size and weight of the cow and the stage of pregnancy.[4] The nutrient load for maintenance increases the larger the size of the cow (Ensminger, 1976). As the pregnancy period advances nutrient requirements increase on a daily basis, accelerating daily during the third trimester as parturition nears (Sanders and Cartwright, 1979b; NRC, 1984). Nutrient requirements according to cow size and stage of gestation are provided in Tables 3.1 and 3.2. Table 3.1 provides the nutrient requirements of cows during maintenance and second trimester of gestation. Table 3.2 provides the average nutritional requirements of cows during the third trimester of pregnancy.

Differences in the nutritional requirements between cows in maintenance or second stage of pregnancy and the third trimester are For example, a 500 kg cow increases intake by 10.7 percent, energy

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[4] Other elements influencing nutritional requirements include the cow's condition, age, the individual animal and environmental conditions (Ensiminger, 1976). In general the poorer the condition of the cow the greater the amount of nutrients per unit of cow weight are required (Thompson et al., 1983; Klosterman et al., 1968). Nutrient requirements increase as cows mature, to provide for the animals growth and increasing maintenance load. Cows reach maturity by three years of age where growth ends and maintenance requirements level off for several years. After the cow reaches eight years of age maintenance requirements decline by 3% per year (Sanders and Cartwright, 1979b). Individual animals will exhibit different metabolic rates and require varying levels of nutrients. A wide range of environmental factors are involved in influencing cow nutritional needs. These environmental factors will be discussed in the following section of the chapter.

Table 3.1: Daily Nutrient Requirements of Breeding Cattle for Maintenance.

Weight (kg)	Net energy (Mcal)	Protein (gms)	Phosphorus (gms)	Vitamin A (1000's IU)
350	6.23	478	12	19
400	6.89	525	13	21
450	7.52	570	15	23
500	8.14	614	17	25
550	8.75	657	18	27
600	9.33	698	20	28

Source: NRC, 1984.

Table 3.2: Daily Nutrient Requirements of Breeding Cattle During the Last Trimester of Pregnancy.

Weight (kg)	Net energy (Mcal)	Protein (gms)	Phosphorus (gms)	Vitamin A (1000's IU)
350	8.38	609	15	21
400	9.04	657	16	23
450	9.67	703	18	24
500	10.29	746	20	27
550	10.90	790	21	29
600	11.48	832	23	30

Source: NRC, 1984 apparent.

requirements by 27.4 percent, and protein requirements by 25 percent between the middle third of pregnancy and the last trimester of gestation. Note that the cows in the last trimester are being fed to gain 0.4 kg per day to compensate for fetal development. To achieve this level of gain the National Resource Council recommends cows be provided with an extra 2.15 Mcal of energy, and 55 grams of protein per day. Although cow requirements are higher during the last trimester, Jordan et al. (1973) and Campling (1966) showed that pregnant cows may reduce dry matter intake by as much as 12 to 13 percent during the last weeks of gestation.

Researchers have estimated equational relationships for determining energy, protein, and phosphorus requirements essential to the bovine diet. The relationships relate weight, skeletal size, and physiological state of the animal to determine the specific nutrient requirement. Calculations are first made to discover the maintenance requirements of the cow. Nutritional requirements are then adjusted depending upon the physiological condition of the cow, whether it be growth and development of young animals, pregnancy, or lactation.

Several methods are used to determine maintenance energy requirements including digestible energy (DE), metabolized energy (ME), net energy for maintenance (NEm) (NRC, 1984). The net energy relationship is the most useful system for two reasons (NRC, 1984). First, unlike other energy determinants, energy requirements in the NEm system do not need to be adjusted for varying diets of roughage or roughage-concentrate mixes. Secondly, requirements for maintenance are estimated independently from feed used for production functions such as pregnancy. This is because energy efficiency varies between maintenance and other physiological stages such as pregnancy or lactation. The equational form to calculate maintenance energy requirements of cows is based upon knowledge of the cows live weight (Lofgreen and Garrett, 1968). The condition used to estimate NEm for cows is:

$$NEm = .077 \times W^{0.75} \qquad (3.1)$$

where:

NEm = Net energy for maintenance in Mcal/day.

W = Cow weight (kg)

Source: NRC, 1984

Because equation 3.1 assumes cows are in good condition, and at genetic weight potentials, adjustments to the equation have been recommended to reflect cows being in varying levels of condition. Klosterman et al. (1968) recommended that Lofgreen and Garrett's equation be corrected for the cow's condition. Klosterman et al. (1968) showed that cows below genetic weight potential have higher maintenance requirements per unit of weight. Hence, a fairly involved corrective factor was added to the above equation to take into consideration the condition of the cow. However, Sanders and Cartwright (1979b), using Klosterman's results, fitted a multiplicative relationship into an equation that not only is easier to use but more adequately describes effects of condition upon cow maintenance energy requirements.[5] The following equation presents the adjusted maintenance energy relationship as interpreted by Sanders and Cartwright (1979b):

$$NEm = .077 \times (W^{0.75}) \times [(WM/W)^{0.5}] \tag{3.2}$$

where WM = Genetic potential weight (kg).

Comparing the two equations for a cow suffering a five percent weight loss shows significant differences between the two interpretations maintenance requirement estimates. Using the Sanders and Cartwright (1979b) interpretation, a five percent loss of weight will decrease total cow energy requirements by 0.7 of a percent, but increase maintenance energy requirements per unit weight by 4.3 percent. The Lofgreen and Garrett (1968) equation shows a decrease in total energy requirements by 3.8 percent but only a 1.2 percent increase in energy level per unit of weight.

As stated previously, net energy requirements of the conceptus accelerate as the pregnancy period advances (NRC, 1984; Salisbury and Van Demark, 1961). Numerous studies have documented the increasing energy load of pregnancy. Ferrell et al. (1976) determined the

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[5] Sanders and Cartwright (1979b) also determined an additional multiplicative factor that considers conditional effects for degrees of maturity of the animal. Young animals have higher metabolic rates requiring higher maintenance requirements per unit of weight. Therefore, changes in the body size and composition are taken into account by this factor. The adjusted equation calculates maintenance energy as:

$$(3.3) \quad NEm = .077 \times (W^{0.75}) \times [(WM/W)^{0.5}] \times [(WMZ/W)^{0.15}]$$

deposition of energy in the conceptus of the cow increased during the pregnancy period. Salisbury and Van Demark (1961) compiled U.S.D.A. data to estimate weight gain in the conceptus of the cow on a monthly basis (Table 3.3, Figure 3.1). Other studies have recorded similar observations relating conceptus development to cow weight changes (Silvey and Haydock, 1978; Eley et al., 1978).

The relationship used to calculate NE requirements for pregnant cows is based upon the energy deposition studies performed by Ferrell et al. (1976). The equation estimates daily NE requirements of pregnancy based upon the expected birth weight of the calf and the particular day of gestation (NRC, 1984). Using an exponential expression to reflect the escalating energy requirements of pregnancy the equation is:

$$NEp = CW \times (0.0149 - 0.0000407 \times t) \times e^{z} \qquad (3.3)$$

where:

NEp = Net energy for pregnancy

CW = Calf birth weight

t = Day of pregnancy

e = Natural log (2.714)

z = $(0.05883 \times t) - (0.0000804 \times t^2)$

Source: NRC, 1984

Table 3.3: Weight Changes of the Cow Uterus and Uterus Content During Pregnancy.

Stage of gestation (days)	Total: Uterus and contents Weight (kg)	Fetus Weight (kg)	Amniotic fluid Weight (kg)	Fetal membrane Weight (kg)	Empty uterus Weight (kg)
0-30	0.91	.0005	---	0.005	0.91
31-60	1.60	.0059	0.18	0.050	1.36
61-90	2.31	.0726	0.59	0.150	1.50
91-120	3.95	.3311	1.63	0.259	1.72
121-150	10.11	1.63	4.99	0.73	2.77
151-180	14.60	3.81	4.99	1.27	4.08
181-210	23.81	9.52	6.35	2.49	5.44
211-240	37.32	17.69	9.98	2.40	7.26
241-270	53.70	28.57	11.79	3.36	9.98
271-300	67.76	39.91	15.42	3.81	8.62

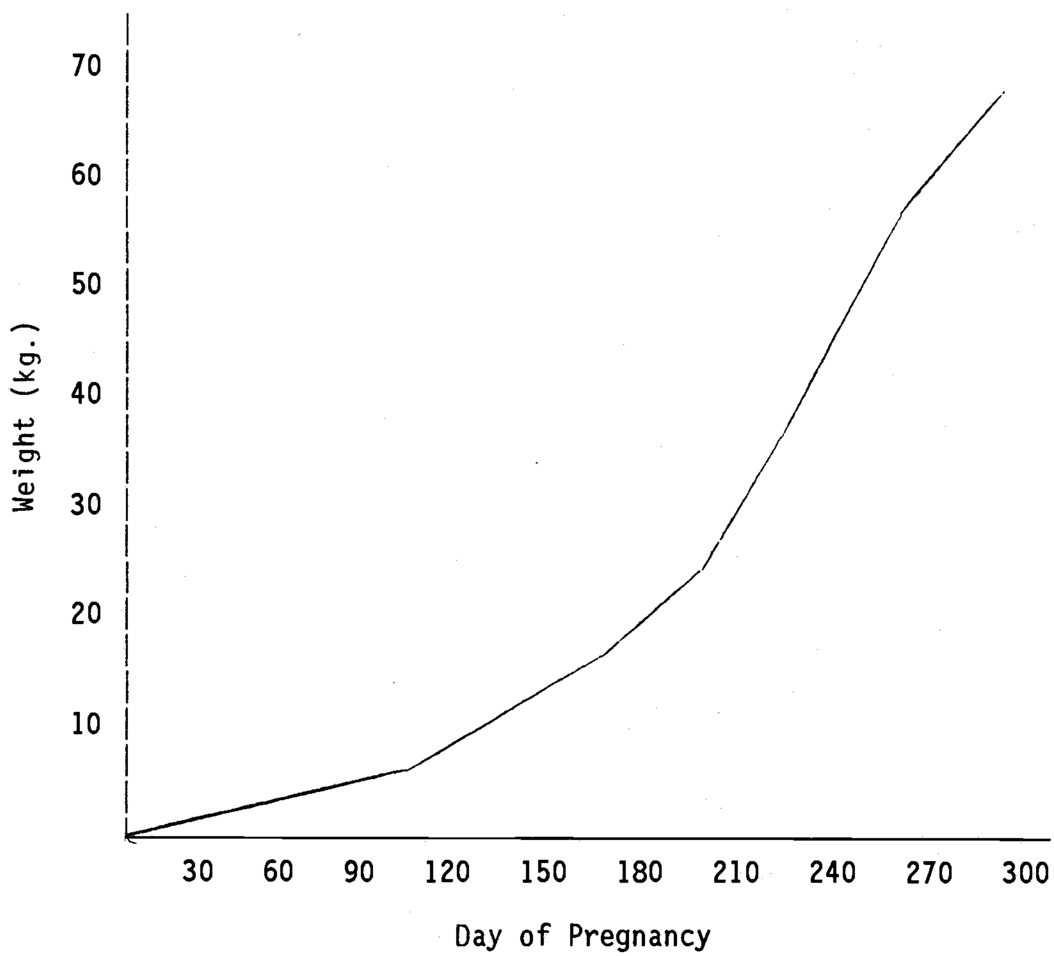

Figure 3.1: Conceptus Weight Gain in the Cow

Table 3.4: Average Daily Energy and Protein Requirements of Pregnancy, for a Cow Producing a 34 Kilogram Calf

Week	Net Energy (mcal)	Protein (gm)	Week	Net Energy (mcal)	Protein (gm)
1	0.00	0.02	22	0.34	8.42
2	0.00	0.02	23	0.42	10.33
3	0.00	0.03	24	0.51	12.57
4	0.00	0.05	25	0.62	15.15
5	0.00	0.07	26	0.74	18.09
6	0.00	0.10	27	0.87	21.40
7	0.01	0.14	28	1.02	25.09
8	0.01	0.19	29	1.19	29.13
9	0.01	0.27	30	1.37	33.50
10	0.01	0.36	31	1.56	38.14
11	0.02	0.50	32	1.75	43.00
12	0.03	0.67	33	1.96	47.98
13	0.04	0.90	34	2.16	52.99
14	0.05	1.19	35	2.36	57.89
15	0.06	1.57	36	2.55	62.55
16	0.08	2.05	37	2.72	66.82
17	0.11	2.65	38	2.88	70.52
18	0.14	3.40	39	3.00	73.51
19	0.18	4.32	40	3.08	75.63
20	0.22	5.44	41	3.13	76.71
21	0.28	6.80			

In Table 3.4 changes in energy (and protein) requirements can be observed during the forty weeks of pregnancy. In the example the calf is estimated to weigh 34 kilograms (75 pounds).

The equation used to calculate protein requirements of pregnant cows is composed of a number of secondary relationships that measure the animals protein metabolic costs, and factors (NRC, 1984). These subdivisions include metabolic fecal loss, scurf loss, endogenous urinary loss, tissue growth, fetal growth, and milk produced (NRC, 1984). These terms are added together and divided through by a biological factor and true protein digestibility (NRC, 1984). The biological value equals retained plus metabolic and endogenous losses of protein divided through by the cows true protein digestibility factor. The condition used for determining protein requirements for pregnant cows is (NRC, 1984):

$$CP = \frac{F + S + U + C}{D * BV} \qquad (3.5)$$

where

CP = Crude Protein, g/day

F = Metabolic fecal protein loss = 3.34% dry matter intake

S = Scruf protein loss = $0.2 * W^{0.6}$

U = Endogenous urinary protein loss = $2.75 * W^{0.5}$

C = Conceptus, average of 55 g/day, third trimester

D = True protein digestibility = 0.90

B = Biological value = 0.66

Source: NRC, 1984

Protein requirements of cows based upon their weight and stage of pregnancy are provided in Tables 3.1 and 3.2.[6]

Phosphorus requirements for cows are estimated similarly to energy and protein needs. Cow weight serves as the basis for calculating maintenance requirements. Additional factors are added to adjust phosphorus requirements for different physiological stages. The equation for calculating phosphorus requirements for pregnant cows is:

$$\text{Phosphorus, g/day} = \frac{(0.0280 \times W) + (0.0076 \times FG)}{0.85} \qquad (3.6)$$

where

W = Cow weight in kilograms

FG = Fetal growth, gm/day

Source: NRC, 1984.

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[6] The growth and milk protein requirements have been left out of equation (4) since the cows in the study have reached maturity are no longer growing, and are not in the lactation state. These factors would be included if the animals were still growing or if the cows were lactating. To calculate the tissue protein deposition (G) the following relationship is used:

G, Tissue protein deposition (in grams) =
(268 - 29.4 x energy content of gain, Mcal/kg)

Milk protein production (M) is calculated using:

M (in grams) = 33.5 x milk production in kg

For further explanation of the derivation of the factors to calculate cow protein requirements, refer to <u>Nutrient Requirements of Beef Cattle, 1984. sixth revised edition, National Academy Press, Washington D.C.</u>

The first calculation made in the equation provides the cows maintenance requirement and the second corrects for additional phosphorus required by the conceptus.

The vitamin A requirement of pregnant beef cows is 2800 IU per kg of forage (Meacham et al., 1970). Requirements for maintenance, and during pregnancy are shown in Tables 3.1 and 3.2.

In conclusion, the preceding relationships used to estimate nutrient requirements of cows assume ideal environmental conditions. In most cases, cows wintering on western ranges or feed grounds are subject to severe environmental stresses affecting the level of nutrients required by the cow, feeding behavior of the cows, and feed availability. Influences of the winter environment upon cow nutrition and behavior will be discussed in the next section. In addition, nutritional adjustments due to environmental conditions are provided.

Environmental Factors

Environmental conditions are the second critical factor influencing the nutrition of wintering pregnant beef cows. Winter weather conditions affect beef cattle by two means. First, the thermal environment directly effects the maintenance energy requirement of cows. Second, environmental factors influence cow behavior, effecting forage acquisition and dry matter intake of the animal.

The physical effects of the environment upon wintering cows vary depending upon factors that the animals possess to moderate winter type conditions and management of the brood herd during periods of environmental stress (Ames, 1986). Factors that influence the ability of cows to lessen the effects of winter environmental stresses include the animals insulating capacity, condition, age, breed, physiological state, and degree of acclimization to the environment (Ames and Insley, 1975; NRC, 1981). Management of cows during the winter include providing shelter for animals, adjusting the dietary needs of cows to compensate for the effects of winter environmental stresses, and providing emergency rations during periods of inclement weather.

The environmental variables playing a role in altering cow nutritional needs and intake levels are air temperature, wind velocity, percent snow cover, snow depth, humidity, and rain (NRC, 1984). The most important impact these variables have on cow nutrition and behavior is the effect on the thermal environment as sensed by the animal (NRC, 1981). Cows, being homeothermic organisms, must maintain fairly constant body core temperatures for survival. This is done by balancing heat produced by the body's metabolic functions and heat lost or gained from the thermal environment (NRC, 1981). During periods of cold temperatures cows can become cold stressed, experiencing increased heat dissipation from the body. Cold stress induces cows to raise their rate of metabolism--i.e. increase metabolic heat production--to compensate for heat lost to the environment. Elevating metabolic heat production requires an increase in the energy intake of the cows diet.

Of the environmental factors attributable to cold stress air temperature and wind velocity are the most thoroughly documented. They are also the only weather conditions to be quantified into equational relationships estimating cow nutritional requirements. The influence of the other environmental variables on cow dietary needs and behavior, although acknowledged by empirical observation, have yet to be quantified into workable relationships. Therefore, the following sections concentrate attention on the effects of wind and temperature induced cold stress upon the nutrition of wintering cows.

Air Temperature

Cold stress is experienced by cows when effective air temperature falls below the animal's thermoneutral zone (TNZ).[7] The TNZ is defined as the temperature zone where cows are able to maintain homeothermic conditions without adjusting their basal metabolic activity (NRC, 1981). The TNZ of beef cows is found between 15 and 25°C (NRC, 1981). To estimate cold stress in cows the NRC (1981) recommended using a temperature of 20°C as a basis for

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[7] Effective air temperature (EAT) is an index measuring the environmental heat demand to an animal. In addition to air temperature, temperature as sensed by animals is altered by wind velocity, humidity, precipitation, terrestrial radiation, precipitation, and solar radiation (NRC, 1981). EAT attempts to describe the effects of other environmental variables on the temperature sensed by animals. For example, animals experience a 3 to 5° C increased EAT when exposed to sunlight (solar radiation) and when combined with cold temperatures, wind, precipitation, and humidity an animals EAT is lowered, and may adversely upset the heat balance of an animal (NRC, 1981).

calculations. Therefore, when temperature falls below 20°C cows are assumed to become cold stressed and must increase their metabolic rate to maintain homeothermic conditions (Young, 1981; Webster, 1970).

Cold stress upon cows increases the further away effective air temperature is from the equilibrium temperature of 20°C. Acute cold stress occurs when cows are exposed to temperatures below their lower critical temperature (LCT) (NRC, 1981). The LCT is dependent on the individual animal, age, condition, breed, time after feeding, and degree of acclimatization to cold (Ames, 1986; Table 3.5). In general, mature beef cows in good condition experience the least discomfort to cold temperatures in comparison to other cattle types. Younger animals and cows in poor condition are more susceptible to cold stress since they generally have higher LCTs (NRC, 1981).

As cows become acclimatized to cold temperatures the LCT of the cows usually decreases as long as the animals remain in good condition (Webster, 1970). Webster found that the LCT of wintering pregnant cows fell from 11° C in the early stages of winter to -23°C later in the season (Table 3.6).

The LCT of an animal is also affected by wind, and/or rain conditions (Webster, 1970). For instance, feeder steers were found to have an LCT of -33°C when the air was dry and still. However, during conditions of ten mile-per-hour winds and ten mile-per-hour winds combined with rain, the feeder's LCTs rose to 8.9°C and 11.3°C, respectively (Webster, 1970). Pregnant beef cows were found to have an LCT of -25°C when exposed to dry, low wind conditions, but rose to

Table 3.5: Critical Temperatures of Beef Cow Types

Type	Temperature (°C) LCT	HCT
Mature Beef Cow	-10	20
8mm hair*,		
Fasting	18	- - -
Maintenance	7	- - -
Full feed	-1	- - -
Summer coat or wet coat, maintenance*	15	- - -
Fall coat, maintenance*	7	- - -
Winter coat	-10 to -25	- - -
Maintenance*	0	
Heavy coat, maintenance*	-7	
Beef Calves	-4	19
Yearlings	-9	17
Fat, 0.8-1.5 kg gain/day	-36	- - -

Source: NRC, 1981 ; * Ames, 1986

Table 3.6: Changes in Cow Lower Critical Temperatures with Winter Acclimatization

Month	Cow Type		
	Pregnant Cows	Calves	Yearlings
	- - -	Temperature (°C)	- - -
November	-11	-17	-31
December	-16	-19	-33
January	-18	-19	-48
February	-20	-21	-41
March	-23	-16	-38

Source: Webster, 1970

-7.3°C when subjected to conditions of wet snow in conjunction with ten mile-per-hour winds (NRC, 1981).

The effects of cold temperatures on cows has received extensive study. In Young's (1981) review of the literature, cold stress was concluded to effect the nutritional requirements of beef cows in four ways: (1) increasing the cow's resting metabolic rate, (2) energy requirements for maintenance are higher and increase as temperatures drop, (3) escalating the rate of passage of digesta, and (4) stimulating dry matter intake (Ames and Insley, 1975; Hironaka and Peters, 1969; Wiltbank et al., 1962; Milligan and Christianson, 1974). Failing to adjust for increased energy demands during periods of cold stress may lead to the reproductive and productive problems described in preceding sections of the chapter.

Cold stress effects upon other cow dietary requirements such as protein, minerals, and vitamins are not well understood (NRC, 1981). Studies have determined that as long as total protein levels are sustained no adverse affects upon the cow performance and production are noticeable (Ames et al., 1980; Rittenhouse et al., 1970). Cows can usually satisfy protein requirements on lower quality roughages during periods of cold stress since intake levels are elevated enough to bring protein levels up to requirements (Ames et al., 1980). Some evidence indicates that vitamin A requirements increase as effective temperature falls (NRC, 1981).

Cold stress due to cold temperatures also affects the behavior of range cows. Cows on winter range have been observed to decrease food gathering activities and increase the amount of time spent idly during days of bitter cold (Malechek and Smith, 1976). During warmer days, especially when sunny, the opposite occurred with greater amounts of time spent grazing. Malechek and Smith (1976) surmised from this behavior, that cows adjusted grazing activity according to levels of cold stress as a form of energy conservation. By increasing idle time during days of cold, cows were estimated to expend 14 percent less energy than they normally expended while feeding on warmer days.

Wind Chill Factors

Effective air temperature measures the relative cooling or heating strength of the physical environment as sensed by animals. When wind velocities increase above five kilometers-per-hour (three miles-per-hour) animals exposed to the environment no longer sense actual air temperatures but rather the effective air temperatures (Ames and Insley, 1975). For example, cows exposed to a temperature of 10°C with wind velocities of ten mph will sense the effective temperature of 4°C instead of the dry bulb temperature of 10°C.

The combination of dry bulb air temperatures and wind velocity is commonly referred to as the wind-chill effect. Wind-chill is felt by animals because as wind driven, colder air contacts the skin, the insulating layers of warmer air adjacent to the body are blown away (Ames and Insley, 1975). As a result heat is removed from the body surface making the animal feel colder. Heat removal will increase as wind velocities increase.

To measure wind-chill, indexes have been estimated relating wind speeds and dry bulb air temperatures. The first acceptable wind-chill index was developed by Sipple and Passle in 1945 (NRC, 1981). Unfortunately, the index measured wind-chill only as it applied to humans and is not considered an acceptable means of estimating wind-chill effects on other animals.

Empirical evidence and observation demonstrated that humans and most animals experience differing levels of heat loss when exposed to identical environmental conditions (Ames and Insley, 1975). Dissimilarities in heat loss patterns result primarily from differing external insulatory properties animals possess, such as wool, hair, or fur to moderate conditions of cold EATs.

Until recently, relationships between rates of heat loss and wind velocity for animals such as cows did not provide satisfactory estimates of wind-chill (Ames and Insley, 1975). These models failed to take into account the insulatory properties of animals while assuming quadratic relationships similar to those used to calculate the wind-chill effects on humans. As a result, the estimates failed to fit the entire spectrum of empirical data.

Ames and Insley (1975) largely solved the problem of estimating heat loss of animals by predicting wind-chill response curves of cows and sheep using cubic relationships. The relationship takes into consideration (1) the greater external insulatory capacity of cows and sheep when wind speeds are below 40 kilometers per hour (25 mph) and (2) corrects for the loss of these insulatory properties when wind velocities exceed 40 kilometers per hour. Ames and Insley (1975) demonstrated that wind speeds greater than 40 kilometers per-hour exposed the skin of cows and sheep thereby negating the insulatory properties of their hair and wool. As wind velocity increases above 40 kilometers per-hour the heat loss per unit of area from cows and sheep will exceed the heat loss of humans.

Calculating the wind-chill, or effective temperature, requires knowledge of the dry bulb temperature and wind velocity. The following condition is used for calculating the wind-chill temperature (or EAT) for cows with winter coats:

$$C = (0.996 \times T) - (0.811 \times W) + (0.028 \times W^2) - (0.00077 \times W^3) \quad (3.7)$$

where

C = Windchill temperature

T = Dry bulb air temperature (C)

W = Wind velocity (mph)

Source: D. R. Ames, 1988.

Wind-chill temperatures for wintering cows for varying wind speeds and air temperatures are provided in Table 3.7.

Nutritional Adjustments to Cold Stress

Adjustments developed to reflect cold induced changes in the nutrient requirements of beef cattle have been estimated for (1) dry matter intake, (2) maintenance energy requirements, and (3) the nutritional value of the forage consumed (NRC, 1981; 1984). Except

Table 3.7: Wind Chill Temperatures For Beef Cattle in Heavy Winter Coat.

Wind Velocity (mph)	Temperature (°C)										
	-30	-25	-20	-15	-10	-5	0	5	10	15	20
0	-30	-25	-20	-15	-10	-5	0	5	10	15	20
5	-33	-28	-23	-18	-13	-8	-3	2	7	11	16
10	-36	-31	-26	-21	-16	-11	-6	-1	4	9	14
15	-38	-33	-28	-23	-18	-13	-8	-3	1	6	11
20	-41	-36	-31	-26	-21	-16	-11	-6	-1	4	9
25	-45	-40	-35	-30	-25	-20	-15	-10	-5	0	5
30	-50	-45	-40	-35	-30	-25	-20	-15	-10	-5	0
35	-57	-52	-47	-42	-37	-32	-27	-22	-17	-12	-7
40	-67	-62	-57	-52	-47	-42	-37	-32	-27	-22	-17
45	-80	-75	-70	-65	-60	-55	-50	-45	-40	-35	-30

Source: Ames, 1988.

for intake, the adjustments provide rectilinear estimates based upon effective air temperatures.

Intake follows a fairly rectilinear pattern for beef cows down to -15°C. Intake increases by approximately 0.37 percent per degree temperature decrease from 20 to -15°C. Once past this point intakes are more difficult to predict. In some cases intakes will be depressed for a number of days until cows are acclimated to the thermal environment. Predictable food intakes also vary in accordance with breed, animal condition, acclimatization of the animal to the environment, fluctuations in diurnal temperatures and the forage quality (NRC, 1981; Williams, 1986). Recommended intake adjustments based upon effective air temperature have been compiled by NRC researchers (Table 3.8). Cow intakes are also affected when periods of cold temperatures combine with rain, wet snow, or severe storms. Intakes are usually depressed during these periods, but again, predictable responses are highly variable (NRC, 1981).

Maintenance energy requirements of beef cattle in the winter are temperature influenced by immediate cold stress caused by rapid changes in environmental air temperature below the cow's LCT and acclimatization to long periods of relatively stable thermal conditions (NRC, 1981). Rapid temperature changes below the cow's LCT stimulates immediate responses by cattle. When temperatures suddenly drop well below an animals critical temperature the animal will immediately increase the metabolic rate to maintain its body temperature. To increase metabolic activity the cow requires increased energy intake which is met by either increasing intake of

Table 3.8: Dry Matter Intake Adjustments by Beef Cows due to Effects of the Thermal Environment.

Temperature (C)	Cow Intake Response
> 35	--intake depressed, especially with high humidity, and/or high levels of solar radiation. Effects mitigated by shade or other forms of cover and low fiber diets.
	--10-35 percent depression of intake on full feed.
	--5-20 percent depression, maintenance.
25 to 35	--intake depressed 10 percent.
15 to 25	--preferred temperature range, intake level normal.
5 to 15	--intake increases 2-5 percent.
-5 to 5	--intake increases 3-8 percent.
-15 to -5	--intake increases 5-10 percent.
< -15	--intake increases 8-25 percent.
	--during extreme cold (< -25) and during blizzards or storms intake may be depressed.
	--intake of roughages may be limited by bulk and ruminal capacity.
Other Conditions;	
Rain	--intake may be depressed by 10-30 percent.
Mud	
10-20 cm. deep	--intake depressed 5-15 percent.
20-60 cm. deep	--intake depressed 15-30 percent.

Source: NRC, 1981.

its present feed source and/or consuming feed with higher energy content.

Calculations of the increase in energy requirements are made based upon knowledge of the animal's LCT, tissue insulation, external insulation (hair thickness), heat loss, surface area of the cow, and effective ambient temperature. In general, this calculation is rarely applicable for estimating energy requirements of mature beef cows due to their cold hardiness and the absence of long term conditions of temperatures below the LCT of the animals (NRC, 1981). Cows acclimated to the thermal environment also require higher energy intake due to increased basal metabolic rates in response to cold temperatures (NRC, 1981). This relationship has been quantified into an equation that measures increases of the cows basal energy requirement during cold stress. Similarly to intake adjustments, the changes in energy requirements are based upon the 20°C thermoneutral point for cows. The equation, estimated by the NRC (1981), is an aberration of the Lofgreen and Garrett (1968) estimate for calculating a cows energy requirement under ideal thermal conditions. The net energy requirement of maintenance for cows under conditions of cold stress is estimated from the equation:

$$NEm = a \times W^{0.75} \qquad (3.8)$$

where:

NEm = net energy maintenance

a = .077 + .0007 * (20 - T)

T = Effective air temperature, C°

W = Cow live weight (kg)

Source: NRC, 1981

Equation 3.8 adjusts basal net energy requirements in the equation by changes in effective air temperature below the 20°C thermonuetral point (T). For each change in degree centigrade the value of the coefficient (a) changes by .0007. Therefore, to reflect increased net energy requirements as effective temperature falls the coefficient (a) increases. For example at 10°C and -10°C the coefficient is valued at .084 and .098, respectively. For a 500 kg cow, daily net energy requirements at these temperatures increases by 16.7 percent, from 8.88 Mcal to 10.36 Mcal.

The final temperature influenced adjustment adjusts the nutrient values of consumable roughages. During periods of cold weather, roughages tend to be less digestible as evidenced by decreased ability of cows to digest these feed sources and faster passage rates through the digestive system (NRC, 1981; Young, 1981). The adjustment is made for forage dry matter, energy content, protein content, and percentage of acid detergent fiber (ADF). The forage adjustment is made using the following condition:

$$A = B + B \times [C_r \times (T-20)] \qquad (3.9)$$

where

A = Value adjusted forage factor (energy, protein, dry matter, or ADF)

B = Forage component value

C_f = Forage correction factor[8]

T = Environmental temperature (C)

Source: NRC, 1981.

Utilizing Equation 3.9, Table 3.9 provides an example of forage quality changes of native grass hay due to the effect of the thermal environment. As temperature decreases from the neutral point to 10°C and 0°C, nutrient values are adjusted downward accordingly. In terms of determining the impact of forage quality decline in the cow's diet, a 500 kg cow consuming native grass hay would need to increase intake by 1.1 and 2.0 percent at 10°C and 0°C, respectively, to meet energy and protein requirements. Equation 3.9 is only applicable to evaluating roughages as a workable. It has not been developed to adjust nutrient values offeed concentrates (NRC, 1981).

In summary, temperatures below the thermoneutral point affects cattle dietary requirements by increasing intake and energy requirements to maintain homeothermic conditions. Unless adjustments are made to increase the maintenance requirements, the pregnant cow's productive and reproductive performances can be negatively affected.

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[8] The correction factor for the diet components are: dry matter (0.0016), energy (0.0010), ADF (0.0037), and crude protein (0.0011) (NRC, 1981).

Table 3.9: Temperature Induced Forage Quality Changes of Native Grass Hay.

Air Temperature (C)	Net Energy (mcal/kg)	Crude Protein (gm/kg)
25	1.106	74.41
20	1.100	74.00
15	1.095	73.59
10	1.089	73.18
5	1.084	72.78
0	1.078	72.37
-5	1.073	71.97
-10	1.067	71.56
-15	1.062	71.16
-20	1.056	70.75
-25	1.051	70.35

Effects of Other Environmental Factors: Rain, Storms, and Snow Conditions

The other factors of winter environmental conditions that effect beef cattle nutrition and behavior are limited in terms of quantifiable relationships (NRC, 1981). This is due to (1) the variability and complexity of single and combined effects of weather factors upon cows, and (2) the variability in the response of cows to these conditions (NRC, 1981). Although specific relationships have yet to be correlated, empirical and practical observations have explained some of the effects these factors have on cow nutrition intake, and grazing behavior.

Rain, storms, and blizzards generally will depress dry matter of cows temporarily (NRC, 1981). During blizzards and storms intakes may be reduced by as much as 25 percent from normal. Rain reduces cow intakes by ten to thirty percent depending on rainfall intensity, and ambient air temperatures.

Snow, collected on the ground, can inhibit cows from grazing range or pasture, depending on the depth, type of snow, and percentage of snow cover on the ground. When deep and extensive blankets or crusted snow occurs, grasses are flattened to the ground, prohibiting cows from grazing and satisfying nutrient requirements. When lighter, shallower, and less extensive snow cover occurs grazing may be inhibited but cows will generally meet dietary requirements, assuming forage quality is adequate or the animals are supplemented.

Cows grazing range are able to graze more successfully than on pasture when snow is present. This is due to the shrub component which aids in disrupting the collection of snow on the ground. Shrubs inhibit the formation of thick, even blankets of snow, leaving patches of grass around and beneath shrubs open to grazing (McCormack, 1988). Malechek and Smith (1974) reported that cows were able to graze winter range when snow depths where as high as 25.4 centimeters (10 inches). Other estimates of grazing success on snow covered range average around 20.3 centimeters (8 inches) (Turner, 1988; McCormack, 1988). On pasture or shrub less range, snow depth levels of greater than 12.7 centimeters (five inches) are estimated to inhibit grazing (Turner, 1988). Senft et al. (1985) observed that cows successfully grazed areas of shortgrass steppe when completely covered by snows of ten and 15 centimeters in depth.

Cows appear to reduce grazing time and intake levels during snow storms and while feeding on ground covered by deeper snows. Rittenhouse et al. (1970) and Malachek and Smith (1971) observed that cow intakes was depressed and idle time increased.

Grazing patterns are influenced by snow depth, percentage snow cover, and range topography (Senft et al., 1985). When range was covered by a blanket of snow during the winter (10-15 cm), cows increased time spent grazing ridgetops, south-facing slopes, and north-facing slopes relative to the growing season. Preferences to grazing lowlands and along fence lines were reduced due to deeper snow accumulation in these areas. When snow cover was light or patchy, grazing preferences of cows remained basically identical to range use during the growing season with cows concentrating grazing activities on the lowlands.

When cows no longer are able to meet intake and nutritional needs due to snow conditions, emergency feed supplies must be provided. For example, during the Squaw Butte feeding trials, emergency feed was required during all three winters for cows grazing uncut pastures due to deep snows. Cows on rake-bunched hay were able to feed through snows over 60 centimeters (2 ft), except when the snow became crusted over with ice. When this occurred during part of the winter of 1983-84, the cows had to be emergency fed.

CHAPTER IV

MODEL DEVELOPMENT AND SIMULATION BASE INPUTS

The purpose of the thesis is to assess the economic impact to ranches in Oregon's Harney Basin upon the adoption of three alternative feeding strategies for wintering spring-calving brood cows. These strategies are compared to the common practice of feeding hay daily in the region. To perform the research a biophysical-economic simulation model has been constructed. The biophysical portion of the simulation integrates relationships between the physiological status and nutritional requirements of mature gestating cows, the forage base being utilized, and the effects of the physical environment upon wintering cows. Information on cow reproductive performance resulting from the biophysical segment is then interfaced with the economic subsection of the simulation to provide expected costs and returns for each winter feeding strategy. Results from the economics subsection will serve to identify the alternative or alternatives that produce the greatest return to a typical ranch cow-calf enterprise of the region.

To describe the model in further detail the chapter is organized into three sections. First, the objectives of the simulator model are defined using principles established in economic theory, risk management, and from empirical studies investigating farm operator goals. Second, methodological approaches used to simulate beef production systems are reviewed from the literature. In the final section, a detailed description of the simulator used in the study is provided.

Simulation Objectives

Over the past two decades advances in understanding and quantifying biological and biophysical relationships of beef cows has fostered an increased use of simulation to estimate these systems in ranch production settings. Simulation modeling has a number advantages over traditional methods of economic analysis when investigating and assessing farm and ranch production enterprises.[1] Simulation's strongest attributes are that it adds greater realism to the models and affords additional flexibility for adjusting variables within the model (Musser and Tew, 1984). In addition, the sequential nature of these models also allows impacts to be traced throughout the stages of the model (Whitson and Kay, 1978).

Traditional economic theory and optimization procedures are appropriate to many related agricultural applications, particularly for making marketing, investment, and financial decisions. However, traditional approaches have been unable to adequately incorporate complex biological relationships of beef cattle production processes into conventional model designs (Spreen and Laughlin, 1986; Trapp and Walker, 1986). Traditional agricultural production techniques, as related by Heady and Dillon (1961), are wedded to the use of single

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[1] One major drawback of simulation is its non-optimizing nature, providing qualitative information to "analyze decision alternative"s, rather than analytical derivations of the optimal input level" (Boggess, 1984). In response to this limitation, a number of recent simulations incorporate math programming techniques into the overall model to provide optimal solutions.

equation production function models to describe biological systems.[2] Since biological relationships usually consist of a number of events linked through a variety of feedback mechanisms, single production equations used to assess biological systems are often too simplified to provide meaningful results. Hence, the traditional approaches suffer from a number of constraints when applied to biophysical production processes. Two limiting factors most frequently cited by agricultural economists are: (1) the assumptions made in constructing models are often simplistic and unrealistic which can result in questionable economic results and unreliable management recommendations and (2) the conventional models fail to provide flexibility to the biological system being assessed (Trapp and Walker, 1986).

However, when developing and using simulation models to evaluate economic ramifications to agricultural production enterprises, the goals formulated by economic theory continue to serve as important guides in delineating the objectives of these models.[3] In perfectly competitive markets, as is assumed for most agriculturally related enterprises, a primary goal of the operator is to maximize enterprise profits (Doll and Orazem, 1984; Heady and Dillon, 1961; Workman 1986). To maximize their profits or returns, firms in competitive markets attempt to achieve the highest degree of

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[2] Traditional production economics theory also covers the use of statistical production functions, multiple products, economies of size and scale, and math programming (Trapp and Walker,1986)

[3] Assuming Neo-Classical interpretations of the firm.

efficiency possible given their productive resources. This is accomplished by equating the marginal costs (MC) of production with the marginal revenue (MR or price, P) of the product marketed by the business (Doll and Orazem, 1984; Heady and Dillon, 1961; Figure 4.1). Firms operating at this point, MC = MR, are also considered to be in an equilibrium position. Profit maximization is achieved at the equilibrium position when the difference between total receipts received by the firm and the total costs of production are maximized. Profits will continue to accrue to the business as long as the intersection point of the marginal cost and marginal revenue (price) curves remains above the average total cost (ATC) curve of the firm.

A second goal relates to the business entity's ability to survive in the market under conditions of financial stress in short-run situations (Doll and Orazem, 1984). When prices received for an operation's product falls below its average total cost curve, firms suffer economic losses and become financially stressed (Hewlett, 1987). Although the firm's fixed costs may not be covered at this point the firm will continue to operate. Since the fixed costs must be paid regardless of the firms operating level, the firm minimizes its losses by remaining in operation.[4] However, once the

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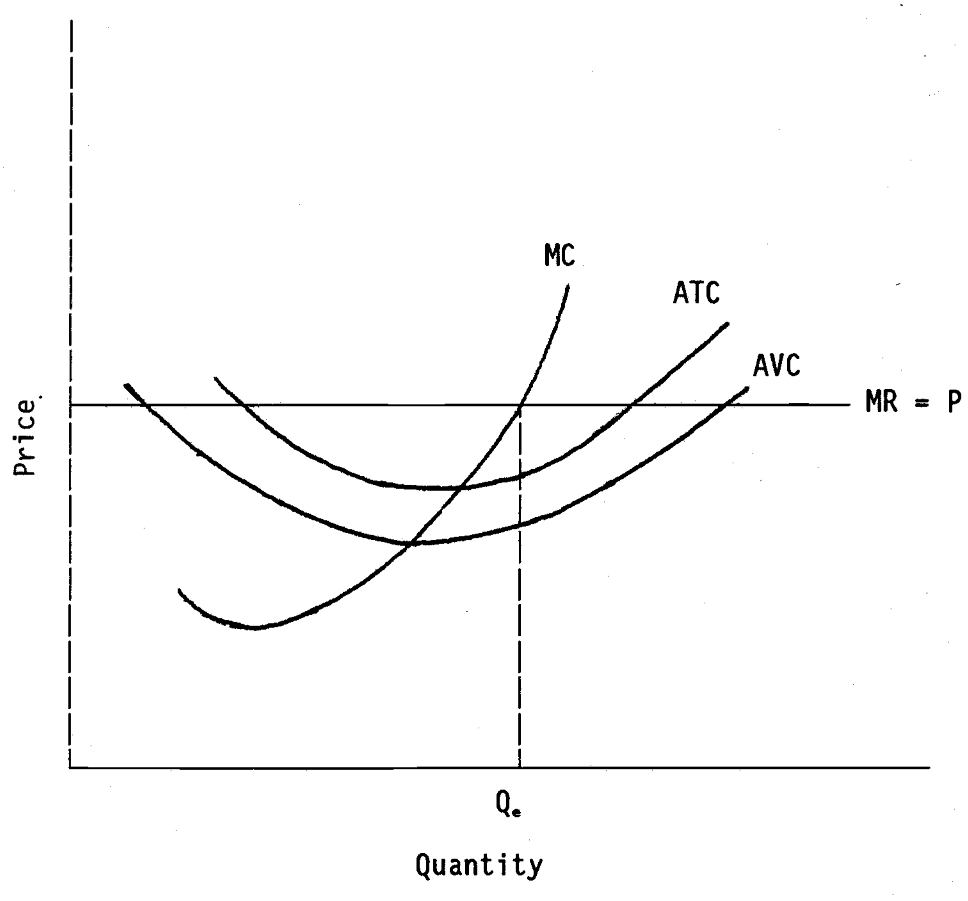
[4] In long-run situations all costs are variable. To remain in operation, a firms marginal revenue must be greater or equal to the average total cost of production, otherwise the business will fail. For a more complete discourse of neoclassical theory and information pertaining to this discussion, readers should refer to <u>Production Economics: Theory With Applications, 2nd. edition</u>, by John P. Doll and Frank Orazem, and <u>Agricultural Production Functions</u>, by Earl O. Heady and John P. Dillon.



where, P_e = Equilibrium price
Q_e = Equilibrium quantity
MC = Marginal cost curve
ATC = Average total cost curve
AVC = Average variable cost curve
MR,P = Marginal revenue curve or price curve

Figure 4.1: Profit Maximization, Short Run Equilibrium Position for Firms Under Perfect Competition.

equilibrium position falls below the firms average variable cost (AC) curve the firm will be forced to shut down. In this situation, the firm would not only be unable to cover any portion of its fixed costs, but would suffer additional economic losses by remaining in operation. Therefore, to minimize losses the firm would leave the market.

Risk management is the final component essential to utilizing economic theory as a decision making tool to aid agricultural producers and policy makers.[5] With risk and uncertainty introduced into the production and financial environment of the operation, operators continue to seek a position of profit maximization. However, achieving this end is made difficult by fluctuations and shocks that occur in world and national economic environments as discussed in Chapter I. To be successful, agricultural operators must balance and/or temper profit maximization objectives by managing their business at acceptable risk levels which describe the decision

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[5] The two sources of risk to agricultural producers are business risk and financial risk. Business risk includes (1) production risk, (2) market or price risk, (3) technological risk, (4) legal and social risk, and (5) human (managerial risk). Business risk occurs due to variability in the returns to the operations productive assets primarily as a result of yield and price fluctuations (Barry and Baker, 1984). Financial risk occurs due to financial claims on the operation (Ibid). Financial risk varies according to how the farm operator organizes and manages the business's debt obligations, liquidity, and insurance policies (Hewlett, 1987).

makers risk bearing attitude.[6]

With this objective in mind, agricultural operators attempt to maintain a position of profit maximization or firm survivability in both short-run and long-run situations through organization of the operation's productive resources and financial obligations at an optimal level of risk to the firm. Given this set of conditions, it is useful to organize the goals set in neoclassical theory and risk management into a singular decision rule for business entities. Hewlett (1987) states this decision rule for a firm as follows: that the operation should "maximize the present value of profits subject to survivability of the firm and level of risk relative to its equilibrium position."

The preceding decision rule correlates closely to empirical observations measuring farm and ranch operator goals. Risk management and satisfying security goals are two of the most important factors cited by farmers in running their operations (Harman et al., 1972; Smith and Capstick, 1976; Harper and Eastman, 1980). Patrick and Blake (1981) list a number of farm operator goals obtained in interviews with central Indiana agricultural producers. The most important goal to agricultural operators was being able to meet loan obligations and/or avoiding foreclosure. Other goals included (1) attaining a comfortable and stable level of income, (2)

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[6] An excellent review of risk management as it applies to agriculture may be found in Risk Management in Agriculture, edited by Barry (1986). Foundations and methods of risk analysis are covered, along with specific methodological applications covering production operations and financial management.

increasing the operations net worth, and (3) selecting investments with the highest rates of return.

The combination of theoretical decision making criteria and empirical observations of farmer and rancher goals serve to define the objectives of the simulation model used in this thesis. These objectives are: (1) to produce an economic valuation of the alternatives in order to select winter feeding regimes that will increase enterprise returns above variable costs to ranchers in the Harney Basin of Oregon, and (2) to identify and measure risks associated with each feeding alternative.

Methodological Review

A major goal in agricultural research is to predict beef cattle performance given variable feed resources and changing environmental conditions. Simulation has proven to be a effective method for predicting animal performance in an array of beef production models. Linked to an economic package, simulation serves as a powerful decision making tool when assessing beef production systems. Although a wide variety of beef production models exist, from site specific to generalized models, they all share similar patterns of analysis. First, the production system being assessed is identified, followed by construction of a biological model describing the system. After performing the simulation, costs of the system are computed and output is valued, yielding an estimated return to the production system (Denham and Spreen, 1984).

Currently, the most common methods used to simulate beef production systems are models based upon either the net energy system (NES) or voluntary feed intake systems (VFI). The majority of models using VFI systems are based upon equational relationships drawn from the National Research Council (NRC, 1984) and Agricultural Research Council derivations (ARC, 1980). The two systems differ in several respects. The NRC system predicts intake based upon metabolic body size and the net energy requirement for maintenance (see equation 3.10). In addition, the NRC system corrects intake for the animals frame size, maturity, and sex. The ARC system bases intake on the metabolic body size, the proportion of concentrate in the diet, and energy metabolizability. The ARC system also adjusts intake according to the diet composition, i.e. fine, medium, and coarse.

Voluntary food intake systems have been applied in a number of recent studies. Fox and Black (1977), developed an bio-economic model based upon the NRC system to predict performance of growing and finishing cattle in enclosed environments, fed concentrate rations. Spreen et al. (1985), extended the Fox and Black (1977) model to incorporate production systems using sub-tropical forages as a feed source. In another study, Black (1984) used a complex ruminal sub-routine to predict forage intake and growth of sheep. Although not presently adapted for analyzing beef cattle systems, the Fox and Black (1977) model is unique in its ability to predict forage intake over a variety of roughage and concentrate diets.

The structure of net energy simulation models are based upon Lofgreen and Garrett's (1968) system of equations estimating net energy requirements of cattle. Since the derivation of these relationships, a number of revisions and additional features have been incorporated into the system to improve estimation of cattle energy requirements. The NES system of equations and revisions were extensively reviewed in preceding sections of Chapter III.

One of the earliest models to incorporate the NES system within its framework is the Texas A&M University Beef Production Model (TAMU) developed by Sanders and Cartwright (1979a and 1979b). The model has been used extensively to evaluate cattle production systems in the United States, Africa, and South America. The TAMU also has formed the basis of several other model designs including the Colorado State University model.

Herd performance is measured by the TAMU through relationships estimating calving rate, conception rate, calf and yearling weight gains, and death loss. The original model is entirely deterministic and allowances for risks associated with cattle production systems are not built into the simulation. Later applications using the TAMU model have incorporated risk into the decision process by fitting linear programming routines to the results generated by the biological simulation (Aderogba et al., 1985; Angirasa et al., 1981; Stokes et al, 1981).

The Kentucky Beef-Forage Model (KBFM) is a another net energy based simulation model and is considerably more complex than the TAMU. The model consists of both beef and crop models, accompanied by a fairly extensive economic package. The beef model is composed of four major sub-routines used to estimate forage growth, animal growth and reproduction, energy use and expenditure, and to coordinate various management and economic activities (Loewer and Smith, 1986). Risk can be applied to the model to measure variabilities in animal performance and price fluctuations in the market. In one application of this model, Parsch et al. (1986) evaluated 30 management strategies for a summer steer grazing program as influenced by ten different weather scenarios. Weather scenarios were constructed and assigned probabilities based upon historical data. Animal gains and net returns per head served as management decision making criteria.

A number of other beef production models incorporate risk factors attributable to weather conditions into the yearly production cycle. Beck et al. (1982), used probabilities of three types of seasonal conditions to evaluate stocking strategies in Australian range and pasture improvement programs. Weaning weights of calves, branding rates, and subsequent economic returns given various stocking rates were all found to be influenced by the simulated climate conditions used in the model. Reeves et al. (1974) designed a model to measure the effects of climate variations (good, normal, and drought) on forage conditions, herd performance, ranch selling strategies, and cattle market prices for central Australian ranches. Williams (1986) assessed selling strategies, breeding and calving season, and several forage alternatives for eastern Oregon cattle ranches as influenced by winter length. Winter lengths included one, three, and five month time periods.

Of the two methods for simulating beef production the net energy system is the most common method used in the United States. Information on net energy equational relationships and model applications are readily available and in general more easily accessed in comparison to intake based models. Therefore, the net energy system was chosen to form the basis of the simulation model used in the thesis. Risk is introduced into the model using methodological approaches used by Parsch et al. (1986), Beck et al. (1982), and Reeves et al. (1974).

Beef Production Simulation Model

The simulation model constructed for the purposes of the research is specifically designed to assess winter feeding strategies of spring calving cow-calf operations. The simulation is composed of seven subroutines linked together to yield information on animal reproductive performance, herd production, pasture management and utilization, and economic valuations for each alternative. The subroutines include (1) measuring late-summer feeding intake, (2) inputing climatic variables, (3) determining forage availability and quality, (4) estimating cow nutritional requirements, intake estimates, and weight changes, (5) determining cow and herd reproductive performance, and (6) coordinating herd and pasture management decisions with, (7) the models economic package. A flow chart describing the operation of the model is provided in Figure 4.2.

Risk is introduced into the system by varying inputs to the climate component. Historical climatic data of the Harney Basin was

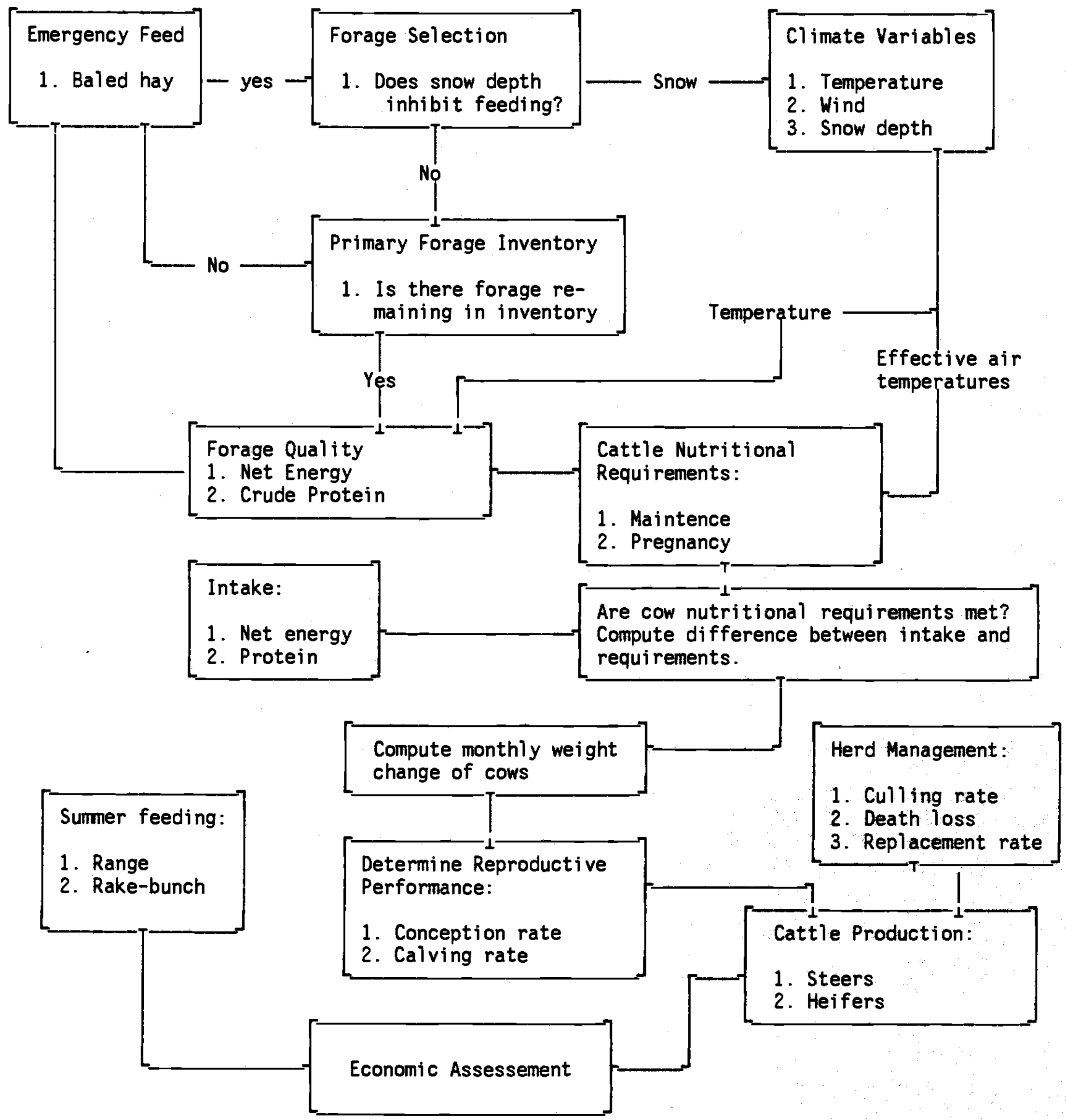

Figure 4.2. Flowchart of Beef Production Simulation Model.

compiled to generate normal and unusual weather patterns. Probabilities were then assigned to describe designated sets of climatic events representing the study area. The probabilities are interfaced with production and economic components to yield the expected net returns to each wintering alternative.

The model includes both (1) a five year time horizon used to assess changes in herd production and compute economic returns, and (2) a seven month time period used to estimate biological and economic performance in the yearly production cycle. The seven month period (August 1 -March 3) is split into a two month late summer grazing and feeding period and a five month winter feeding period. The two month period (August 1 -September 30) is included in the model to reflect differences between alternative late summer feeding programs and incorporate associated costs into the economic subroutine.[7] The actual biological portion of the simulation takes place during the five month winter feeding period, from October 1 through March 3. This part of the simulation is further broken down into 22, week-long intervals.

The model operates on a VP-Planner spreadsheet and uses a number of macro commands and assigned range names to facilitate calculations inside the simulation. The simulation is non-optimizing

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[7] The baled hay, raked bunched hay, and standing meadow alternatives adhere to the traditional practice of grazing cows on range during the summer and feeding the animals near the operation's base facilities during the winter. The range grazing alternative consists of two months of feeding on rake-bunch followed by winter turnout on rangelands. Descriptions of the alternative feeding methods are covered in Chapter II.

which can lead to difficulties in making management recommendations, particularly if there are a large number of alternatives being evaluated. However, because the number of alternative winter feeding programs are few, this limitation will not prohibit recommendations from being made in selecting the best winter feeding regimes.

In the remainder of the chapter, each of the subroutines built into the beef simulation model are examined in greater detail. In addition, linkages coordinating the model's subroutines are discussed in each section.

Summer Feeding Program

The late-summer feeding program covers a nine week period from August 1 through September 30. Cows on rake-bunch hay, baled hay, and meadow feeding systems are on rangelands during this time. Cows on the winter range grazing program are feeding on meadow aftermath and raked hay. Dry matter intake is exogenously determined to be 25 pounds per head, per day for each feeding system.

For the winter grazing alternative, weekly raked hay intake totals are aggregated for the cow herd into tonnage amounts and applied directly into land use input and output subroutines to adjust winter hay production inventories (Table 4.1). In addition, herd hay consumption is inputed into the expenditures portion of the economic assessment.

Range forage consumption for baled hay, meadow, and rake-bunch hay alternatives are aggregated for the herd into animal unit months

Table 4.1: Summer Forage, Dry Matter Basis, Use of Raked Hay, 8/1-9/30; Winter Range Grazing Alternative.

Cow	Herd[a]	
lbs/day	Ton/wk	Total hay usage (tons)
25.00	39.38	354.38

[a] Cow herd size of the ranch brood herd in the simulation numbers 450 animals.

Table 4.2: Summer Forage Use of Range Forage, 8/1-9/30; Baled Hay, Rake-bunch Hay, and Meadow Grazing Alternatives.

Cow		Herd
lbs/day	AUMs	AUMs
25.00	2.0	900

(AUMs) (Table 4.2).[8] The number of AUMs for these alternatives are sent directly to budgets contained in the economic subroutine and valued based upon federal grazing fees.

Winter Climate Factors

Climatic components used in the model include ambient air temperature, wind velocities, and snow depth levels inputed on a weekly basis. The three weather factors are incorporated into the simulation in several ways. Cold temperatures (below 20° C) alone, or combined with wind to produce an effective air temperature (EAT) or wind-chill influence the cows maintenance energy requirements (Ames and Insley, 1975; Young, 1981). To measure EAT, the model uses Ames's (1988) equation for cows in heavy winter coat:

$$\text{(4.1)}\quad EAT\ (C) = (0.996 \times T) - (0.811 \times W) + (0.028 \times W^2) - (0.00077 \times W^3)$$

where, T, dry bulb air temperature (C°)

W, wind velocity (mph)

In the model an EAT is adjusted only when wind velocities exceed three miles per hour. Calculated EAT's are used in the cattle requirements subroutine to calculate cow net energy needs.

Temperatures are also used to adjust forage quality factors in the model. This adjustment is made for forage net energy and protein contents using the following equational relationship (NRC, 1981):

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[8] An AUM is equivalent to feeding a 1000 pound cow 25 lbs of forage daily for a period of one month. The AUM is also the measure by which federal grazing permits are valued and priced.

$$(4.2) \qquad A = B + B \times [C_r \times (T - 20)]$$

where

A = Value adjusted forage factor [net energy (Mcal), and crude protein, (CP)]

B = Forage component value in Mcal or CP

C_r = Forage correction factor
energy, $C_r = 0.0010$
protein, $C_r = 0.0011$

T = Dry bulb air temperature in degrees centigrade (C°)

Empirical evidence and practical observation demonstrate that snow covered range or pasture inhibit or prevent cows from acquiring sufficient amounts of forage to meet nutritional requirements (Malechek and Smith, 1974 and 1976; Turner, 1988; McCormack, 1988; Carr, 1988; and Senft et al., 1985). Unfortunately, there are no exact measurements revealing when, where, and under what type of snow conditions, forage composition, and topographical features cattle can no longer access forage resources. Estimates of when snow depth levels inhibit forage acquisition vary from as low as 13 centimeters (5 inches) on open meadow to almost 30 centimeters (12 inches) on rangelands and over 71 centimeters (2.5 ft.) on rake-bunched hay feed grounds (Turner, 1988; Carr, 1988). The Harney Basin frequently receives moderate to severe winter snow storms that influence the type and amount of a forage source cows will be able to access. The riskiness of snow depth levels as related to forage acquisition by cattle necessitate this factors inclusion in the model. Therefore, assumptions regarding minimum snow depth levels and the ability of cattle to forage are made for each of the alternatives. These assumptions are based upon consultation with Squaw Butte Experiment Station researchers and eastern Oregon extension agents. The baled hay alternative is assumed to be unaffected by snow depth level in the model. Cows feeding on rake-bunched hay are assumed to be affected when snow depth levels exceed 71.6 centimeters (30 inches). Cows placed on range for the winter are assumed to be prohibited from feeding on range grasses when snow depth levels exceed 20.3 centimeters (8 inches). Cows feeding on standing meadow are assumed to be affected when snow depth levels exceed 12.7 centimeters (5 inches).

Four weather scenarios are used in the simulation describing a range of winter climate conditions found in the Basin. Scenarios were developed using (1) historical snow depth level and average daily temperature data covering a 37 year period between 1950-1987 and (2) assumptions made regarding minimum snow depth levels permitting cattle to feed. A single set of wind conditions was used across all scenarios.

The scenarios applied to the alternatives are represented by mild, average, severe, and very severe winter climate conditions. Scenarios are detailed in Tables 4.3, 4.4, 4.5, and 4.6.

For the meadow and range grazing alternatives, scenarios were based upon the number of weeks cows were unable to access the primary feed source due to snow conditions. For the meadow grazing

Table 4.3: Winter Climatic Conditions, Mild Winter, Harney Basin, Oregon.

Week	Ambient Air Temperature (C)	Wind Velocity (mph)	Effective Air Temperature (C)	Snow Depth (cm)
Oct 1-7	12.0	12.0	4.9	0.0
8-14	10.5	6.0	6.4	0.0
15-21	10.0	6.5	5.7	0.0
22-28	7.5	2.0	7.5	0.0
29-4	7.0	2.0	7.0	0.0
Nov 5-11	4.0	5.5	0.2	0.0
12-18	2.0	12.0	-5.0	0.0
19-25	2.0	5.5	-1.7	0.0
26-2	1.0	5.0	-2.5	0.0
Dec 3-9	-2.0	2.0	-2.0	5.0
10-16	-2.0	4.5	-5.1	10.0
17-23	-4.0	5.0	-7.4	0.0
24-30	0.0	11.0	-6.6	5.0
Jan 31-6	-3.0	3.0	-3.0	10.0
7-13	-6.5	5.0	-9.9	18.0
14-20	-3.0	5.5	-6.7	20.0
21-27	0.0	11.5	-6.8	12.0
28-3	1.0	4.5	-2.2	5.0
Feb 4-10	2.0	12.0	-5.0	0.0
11-17	1.0	6.0	-3.0	0.0
18-24	-1.0	3.0	-1.0	3.0
25-3	3.0	6.0	-1.0	0.0

Table 4.4: Winter Climatic Conditions, Average Winter, Harney Basin, Oregon.

Week	Ambient Air Temperature (C)	Wind Velocity (mph)	Effective Air Temperature (C)	Snow Depth (cm)
Oct 1-7	9.5	12.0	2.4	0.0
8-14	8.5	6.0	4.4	0.0
15-21	8.0	6.5	3.7	0.0
22-28	7.5	2.0	7.5	0.0
29-4	7.5	2.0	7.5	0.0
Nov 5-11	4.0	5.5	0.2	0.0
12-18	2.5	12.0	-4.5	0.0
19-25	1.0	5.5	-2.5	0.0
26-2	0.0	5.0	-3.5	2.0
Dec 3-9	-1.0	11.0	-7.6	10.0
10-16	-4.5	4.5	-7.6	10.0
17-23	-1.0	5.0	-4.4	2.0
24-30	-4.0	6.0	-8.0	2.0
Jan 31-6	0.0	3.0	0.0	1.0
7-13	-2.0	5.0	-5.4	11.5
14-20	-7.0	5.5	-10.7	22.0
21-27	-6.5	11.5	-13.3	34.0
28-3	-2.5	4.5	-5.6	30.0
Feb 4-10	-3.0	12.0	-10.0	25.0
11-17	-1.0	6.0	-5.0	18.0
18-24	0.0	3.0	0.0	10.0
25-3	3.0	6.0	-1.0	0.0

Table 4.5: Winter Climatic Conditions, Severe Winter, Harney Basin, Oregon.

Week	Ambient Air Temperature (C)	Wind Velocity (mph)	Effective Air Temperature (C)	Snow Depth (cm)
Oct 1-7	8.0	12.0	0.9	0.0
8-14	8.0	6.0	3.9	0.0
15-21	7.0	6.5	2.7	0.0
22-28	7.0	2.0	7.0	0.0
29-4	6.5	2.0	6.5	0.0
Nov 5-11	5.0	5.5	1.2	0.0
12-18	-1.0	12.0	-8.0	5.0
19-25	1.0	5.5	-2.7	0.0
26-2	-1.0	5.0	-4.4	0.0
Dec 3-9	-1.0	11.0	-12.5	2.5
10-16	-2.0	4.5	-5.1	5.0
17-23	-5.5	5.0	-8.9	20.0
24-30	-6.0	11.0	-12.5	25.4
Jan 31-6	-6.5	3.0	-6.5	40.0
7-13	-7.0	5.0	-10.4	40.0
14-20	-6.5	5.5	-10.2	45.0
21-27	-1.0	11.5	-7.8	35.0
28-3	1.0	4.5	-2.2	10.0
Feb 4-10	-5.0	12.0	-12.0	25.0
11-17	-3.0	6.0	-7.0	24.0
18-24	0.0	3.0	0.0	9.0
25-3	2.0	6.0	-2.0	0.0

Table 4.6: Winter Climatic Conditions, Very Severe Winter, Harney Basin, Oregon.

Week	Ambient Air Temperature (C)	Wind Velocity (mph)	Effective Air Temperature (C)	Snow Depth (cm)
Oct 1-7	7.0	12.0	-0.1	0.0
8-14	6.5	6.0	2.4	0.0
15-21	5.5	6.5	1.2	0.0
22-28	5.0	2.0	5.0	0.0
29-4	3.5	2.0	3.5	0.0
Nov 5-11	0.0	5.5	-3.7	0.0
12-18	2.0	12.0	-5.0	0.0
19-25	-1.0	5.5	-4.7	5.0
26-2	1.0	5.0	-2.5	0.0
Dec 3-9	-6.0	11.0	-12.5	0.0
10-16	-7.0	4.5	-10.1	4.0
17-23	-7.5	5.0	-10.9	13.0
24-30	-9.0	6.0	-13.0	25.5
Jan 31-6	-4.0	3.0	-4.0	25.5
7-13	-3.0	5.0	-6.4	35.5
14-20	-7.0	5.5	-10.7	40.5
21-27	-1.0	11.5	-7.8	43.0
28-3	-6.0	4.5	-9.1	35.5
Feb 4-10	-2.0	12.0	-9.0	30.5
11-17	-7.0	6.0	-11.0	43.0
18-24	-4.0	3.0	-4.0	30.0
25-3	-3.0	6.0	-7.0	22.0

alternative, these scenarios included periods of 11 weeks, 8 weeks, 5 weeks, and 2 weeks of snow cover exceeding 12.7 centimeters (5 inches), representing respectively very severe, severe, average, and mild winter conditions (Table 4.7). The range grazing scenarios included periods of 10 weeks, 7 weeks, and 4 weeks of snow cover exceeding 20.3 centimeters (8 inches) for very severe, severe, average winters, respectively. During the mild winter snow cover does not prevent cows from feeding on range forage. In all scenarios the rake-bunch alternative is unaffected by snow depth levels. Based upon the historical record, average weekly snow depth levels did not exceed 71 centimeters at any time during the 37 year period. Therefore, the rake-bunched alternative is only affected by effective air temperature in the simulation.[9]

Each weather scenario is assigned a probability of occurrence based upon the historical record. Range and meadow grazing alternatives use probabilities of snow depth level in their scenarios, and the rake-bunch and baled hay alternatives use the temperature probabilities. Probabilities of these weather events occurring are provided in Tables 4.8 and 4.9.

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[9] In actual feeding trials, deep snow (1-2.5 ft.), crusted over with a thick coat of ice prevented cows from feeding on rake-bunch hay successfully during the winter of 1983-84. The principal researchers directing the trials believe improved management would have prevented this from happening. It was observed that larger hay bunches and bunches on higher ground remained exposed and accessible to cows. Raking some hay into larger bunches and feeding on lower elevations earlier has been successful in preventing snow conditions from influencing cow forage acquisition. In addition, the winter events of 1983-84, were extremely abnormal. Reliable local sources stated this type of weather had not occurred in the region to the best of their knowledge.

Table 4.7: Number of Weeks of Significant Snow Cover Requiring Emergency Feeding.

Feeding Alternative	Winter Type: Mild	Average	Severe	Very Severe
Baled Hay	0	0	0	0
Range	0	4	7	10
Meadow	2	5	8	11
Rake-bunch	0	0	0	0

Table 4.8: Weather Probabilities for Range and Meadow Grazing Based Upon Historical Snow Depth Levels of the Harney Basin, Oregon.

Winter Type	Probability of Occurrence
Meadow Grazing;	
Mild	0.319
Average	0.417
Severe	0.167
Very Severe	0.097
Range Grazing;	
Mild	0.667
Average	0.222
Severe	0.083
Very Severe	0.028

Table 4.9: Weather Probabilities for Baled Hay and Rake-Bunch Hay Feeding, Based upon Historical Temperature of the Harney Basin, Oregon.

Winter Type	Probability of Occurrence
Mild	0.111
Average	0.750
Severe	0.083
Very Severe	0.056

In summary, climatic factors in the model are applied in the following manner: Temperature and wind velocity combine to yield effective air temperatures, used to aid in measuring weekly cow net energy requirements. Temperature readings are also incorporated into the forage quality subroutine. Energy and protein content are adjusted to reflect quality changes in cattle forages due to environmental temperature changes. The level of snow depth determines if cows on the meadow or range alternative are able to meet intake and nutritional requirements. When snow depth exceeds minimum levels, cows on these two alternatives are unable to secure their nutritional needs and require emergency feeding. Baled hay serves as the source of emergency feed in the model. Procedures for adjusting feed type relative to snow conditions are covered in the following section.

Forage Type, Availability, and Quality Factors

The models input parameters assume that when an alternative is being assessed, that alternative represents the primary winter feed source. When adverse snow conditions are present, and/or forage inventory controls are employed to prevent the primary feed from being used, the model will substitute a secondary or emergency feed source. The secondary feed source is provided by baled hay.

Selecting the forage type to be used, given snow conditions, is performed by a macro-command assigned to each forage alternative. The command checks weekly snow depth level against snow condition restrictions associated with the primary feed source. If snow

Table 4.10: Determination of Feed Type in Relation to Snow Depth for a Range Grazing, Severe Winter Scenario.

Week		Snow Depth (cm)	Feed Type	Forage Nutrient Content: Net Energy (Mcal/kg)	Forage Nutrient Content: Protein (gm/kg)
Oct	1-7	0.0	range	0.80	35.0
	8-14	0.0	range	0.80	35.0
	15-21	0.0	range	0.80	35.0
	22-28	0.0	range	0.80	35.0
	29-4	0.0	range	0.80	35.0
Nov	5-11	0.0	range	0.80	35.0
	12-18	5.0	range	0.80	35.0
	19-25	0.0	range	0.80	35.0
	26-2	0.0	range	0.80	35.0
Dec	3-9	2.5	range	0.80	35.0
	10-16	5.0	range	0.80	35.0
	17-23	20.0	range	0.80	35.0
	24-30	25.4	baled hay	1.10	74.0
Jan	31-6	40.0	baled hay	1.10	74.0
	7-13	40.0	baled hay	1.10	74.0
	14-20	45.0	baled hay	1.10	74.0
	21-27	35.0	baled hay	1.10	74.0
	28-3	10.0	range	0.80	35.0
Feb	4-10	25.0	baled hay	1.10	74.0
	11-17	24.0	baled hay	1.10	74.0
	18-24	9.0	range	0.80	35.0
	25-3	0.0	range	0.80	35.0

conditions fall within the restrictions the primary forage source is selected for the week. Conditions falling outside minimum limits require that the emergency forage source be utilized. An example of the calculations are provided for a range grazing, severe winter scenario in Table 4.10. A list of the macro-commands used are provided in Appendix C.

Calculating forage availability or inventory follows the forage selection routine. The routine calculates inventory changes of the primary feed source based upon output from the forage selection routine. Again, a macro-command is used to facilitate the procedures (Appendix C). As long as conditions permit, the primary forage is used and tonnage amounts consumed by the herd are subtracted from the beginning inventory for that week. However, when adverse snow conditions exist or supplies of the primary forage are completely utilized then cows are fed baled hay. For example, if only 17 weeks of standing meadow are provided and a mild winter (2 weeks of snow) occurs, the supply of meadow pasture will run out in week 19. This will require baled hay to be used the final three weeks of the wintering period regardless of weather conditions. Table 4.11 provides a demonstration of this example.

After establishing the type of forage being used for the week, energy and protein content of the feed are adjusted given the weekly dry bulb air temperature obtained from the climatic table. Equation 4.2 is used in performing the calculations. The adjusted net energy and protein content are then used to determine the nutritional intake of the cows based upon dry matter intake assumptions contained in the

Table 4.11: Calculation of Primary Forage Inventory Changes and Use for Meadow Grazing During a Mild Winter.

Week		Beginning Inventory	Ending Inventory	Change in Inventory	Forage Type used
		- - - - - - -	tons	- - - - - - -	
Oct	1-7	642.6	604.8	37.8	meadow
	8-14	604.8	567.0	37.8	meadow
	15-21	567.0	529.2	37.8	meadow
	22-28	529.2	491.4	37.8	meadow
	29-4	491.4	453.6	37.8	meadow
Nov	5-11	453.6	415.8	37.8	meadow
	12-18	415.8	378.0	37.8	meadow
	19-25	378.0	340.2	37.8	meadow
	26-2	340.2	302.4	37.8	meadow
Dec	3-9	302.4	264.6	37.8	meadow
	10-16	264.6	226.8	37.8	meadow
	17-23	226.8	189.0	37.8	meadow
	24-30	189.0	151.2	37.8	meadow
Jan	31-6	151.2	113.4	37.8	meadow
	7-13	113.4	75.6	37.8	meadow
	14-20*	75.6	75.6	0.0	baled
	21-27*	75.6	75.6	0.0	baled
	28-3	75.6	37.8	37.8	meadow
Feb	4-10	37.8	0.0	37.8	meadow
	11-17**	0.0	0.0	0.0	baled
	18-24**	0.0	0.0	0.0	baled
	25-3 **	0.0	0.0	0.0	baled

* Weeks where snow prevented meadow grazing and emergency hay is required.

** Weeks where baled hay required since inventory of standing meadow has been completely used.

model's input parameter table.

Cow Nutritional Requirements, Intake Estimates, and Winter Weight Changes

The main purpose of the simulation's biological component is to estimate reproductive performance of brood cows. For the rake-bunch hay, standing meadow, and baled hay alternatives this is accomplished by generating weekly weight changes of brood cows, aggregating those changes into monthly weight changes, and finally fitting the monthly weight changes into equations determining herd calving and conception rates. The reproductive performance of cows on the range treatment are exogenously determined using experimental data.

Weight changes of wintering cows are found by comparing the animals daily nutritional requirements versus the cows estimated daily nutritional intake. Estimation of nutritional requirements are based on the net energy system, borrowing primarily from NRC and TAMU equational relationships discussed and presented in Chapter III. Nutritional intake is determined by multiplying the nutritional content of the forage by the estimated dry matter intake of the cow obtained from the input table.

Cow net energy maintenance requirements are estimated using an adjusted TAMU equation which has been converted to metric units. The equation adjusts for effective air temperatures calculated in the climatic subroutine and for cow condition. To adjust for cow condition the weekly metabolic weight of the cow is compared with an ideal metabolic weight based upon assumptions made regarding the cow type and frame size. Cows in the model are assumed to have ideal weight of 480 kg (1058 lb).[10] The modified TAMU equation used is (Sanders and Cartwright, 1979b; NRC, 1984; 1981):

$$(4.3) \quad NE_m = a \times (W^{0.77}) \times [(WM/W)^{0.5}]$$

where,

NE_m = is Net energy for maintenance in Mcal/day

a = 0.077 * (0.0007 * [20 - T]), Temperature correction factor

T = Effective air temperature, (C°)

W = Live weight of the cow, (kg)

WM = Ideal metabolic weight, (kg)

Energy requirements of pregnancy are estimated using an NRC equation. The equation estimates requirements based upon the expected birth weight of the calf and the day of gestation. The model assumes a birth weight of 34 kg (75 lbs), which approximates the average calve birth weights recorded during Squaw Butte feeding trials. The average cow in the brood herd is assumed to enter the winter program on the 102nd day of gestation and leave on the 256th

[10] This metabolic weight corresponds to an average sized Hereford, Hereford-Angus beef cow common to western ranges. The 480 kilogram weight assumes a fat content of 25% of the cow's body weight (Sanders and Cartwright, 1979b). The "ideal" metabolic weight is adjustable in the models input section.

day. Birth weights and day of pregnancy are adjustable in the input table of the simulation. The equation used is:

$$(4.4) \quad NE_p = [CW \times (0.0149 - .0000407 \times t) \times e^z]/1000$$

where,

NE_p = Net energy of pregnancy, Mcal/day

CW = Calf birth weight, (kg.)

t = Day of pregnancy

e = Natural log, 2.714

z = $(0.05883 \times t) - (0.0000804) \times t^2)$

Source: NRC, 1984.

Protein requirements for maintenance are inputed directly into the model using information derived from NRC protein recommendations (NRC, 1984). Protein requirements of pregnancy are also based upon NRC estimates. The NRC recommends that cows conceiving calves weighing 36 kg (80 lb) require, on average, an extra 55 gms of protein daily during the last trimester of pregnancy. This figure is adjusted for the model's assumed calf weight (34 kg) and for the day of pregnancy. A simple ratio calculation using calf weights and the recommended protein amount yielded an average requirement of 52 gms/day during the last trimester. Instead of using the average requirement the model assumes protein levels increase in proportion to energy requirements during pregnancy (Ensiminger, 1976; NRC, 1984). Another ratio, using calculated energy requirements of pregnancy and the base average protein requirement, yields average weekly protein amounts during the winter period.

Following estimation of cow nutritional requirements, the subroutine calculates nutritional intake based upon assumptions made on cow dry matter forage intake for each alternative. Intake assumptions are based upon published and unpublished data from the Squaw Butte Experiment Station. Rake-bunch hay and baled hay intake is assumed to be 11.6 kg (25.5 lb) per day. Dry matter intake of meadow forage is 10.9 kg (24 lb) per day and intake of range forage is 10.0 kg (22 lb) per day. Energy and protein intake is estimated by multiplying assumed dry matter intake levels by the nutritional content of the forage selected from the forage type and availability subroutine. If the alternative requires a protein supplement in the feeding ration, the nutritional content of the supplement is added to the nutritional intake acquired from the forage to provide total net energy and protein intake.

Cow weekly weight changes are determined by (1) estimating changes in cow metabolic weight based upon differences between the animals daily net energy requirement and net energy intake estimates and (2) factoring in weight gains due to growth of the conceptus. The week ending metabolic weight is used to determine maintenance energy requirements of the cow in the following week's energy estimate. The weight gain of the conceptus is added to the new metabolic cow weight to yield the total weight change of the cow during the week. Changes in the cows total weight are used to determine reproductive performance of the cow and of the entire brood herd. A flowchart diagraming the routine is provided in Figure 4.3.

Cow metabolic weight change is determined by subtracting energy requirement computations from energy intake estimates, providing a measure of an animals energy surpluses or deficiencies. If an energy surplus exists cows are assumed to gain weight at a rate of one kilogram per 8.0 Mcal of excess energy (NRC, 1984).[11] If an energy deficiency is present cows are assumed to lose weight at the rate of one kilogram per 6.0 Mcal of energy. This figure represents the amount of energy a dairy cow or elk obtains from catabolizing body fat reserves to serve as an energy source during periods of energy deficiency (Reid and Robb, 1971; Moe et al., 1971; Mautz et al., 1976). The resulting metabolic weight change is then combined with the cow's beginning metabolic weight of the week to yield the week ending cow metabolic weight. As previously mentioned, the ending weight is then used to calculate maintenance requirements of the cow in the following week.

Weight gain of the conceptus is obtained directly from empirical measurements (Salisbury and Van Demark, 1961). Each weeks pregnancy weight gain is added to the cows ending metabolic weight to determine the cows total weight for the week. Weight

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[11] Thin nonlactating mature cows are estimated gain weight at rates of 5.5 and 7.5 Mcal/kg (NRC, 1984). Cows in the model are assumed to be in good condition entering the winter program. Therefore it is assumed that gains occur at a higher energy level of 8.0 Mcal/kg.

depositions during pregnancy were provided in Table 3.3.

Percentage monthly weight changes are then computed for use in determining the calving and pregnancy rates of the cow herd. Weight changes are determined by taking beginning and ending monthly body weights and calculating the percentage change in cow body weight.

Cow and Herd Reproductive Performance

Calf crops and conception rates in the simulation are used to measure productive performance of the brood herd. These two determinants of herd performance provide information used in calculating economic returns to the ranch operation and to assess the relative merits of an alternative to management of the brood herd.

The rake-bunch hay, standing meadow, and baled hay winter feeding strategies use percentage changes in cow monthly body weights to determine the herd's calving rate in the spring and conception rate in the summer breeding season. Based upon experimental data for the Squaw Butte feeding trials, regression equations were developed to measure calving and conception rates for cow herds placed on these particular feeding strategies. The data used in the regressions consisted of pooling individual cow data into herd averages and totals for each feeding strategy, in each of the three winters covered during the experimental period, 1982-1985. The aggregated data are composed of percentage monthly weight changes, herd calving rates, and herd conception rates.

The basis for constructing these equations is derived from empirical observation linking cow reproductive performance with

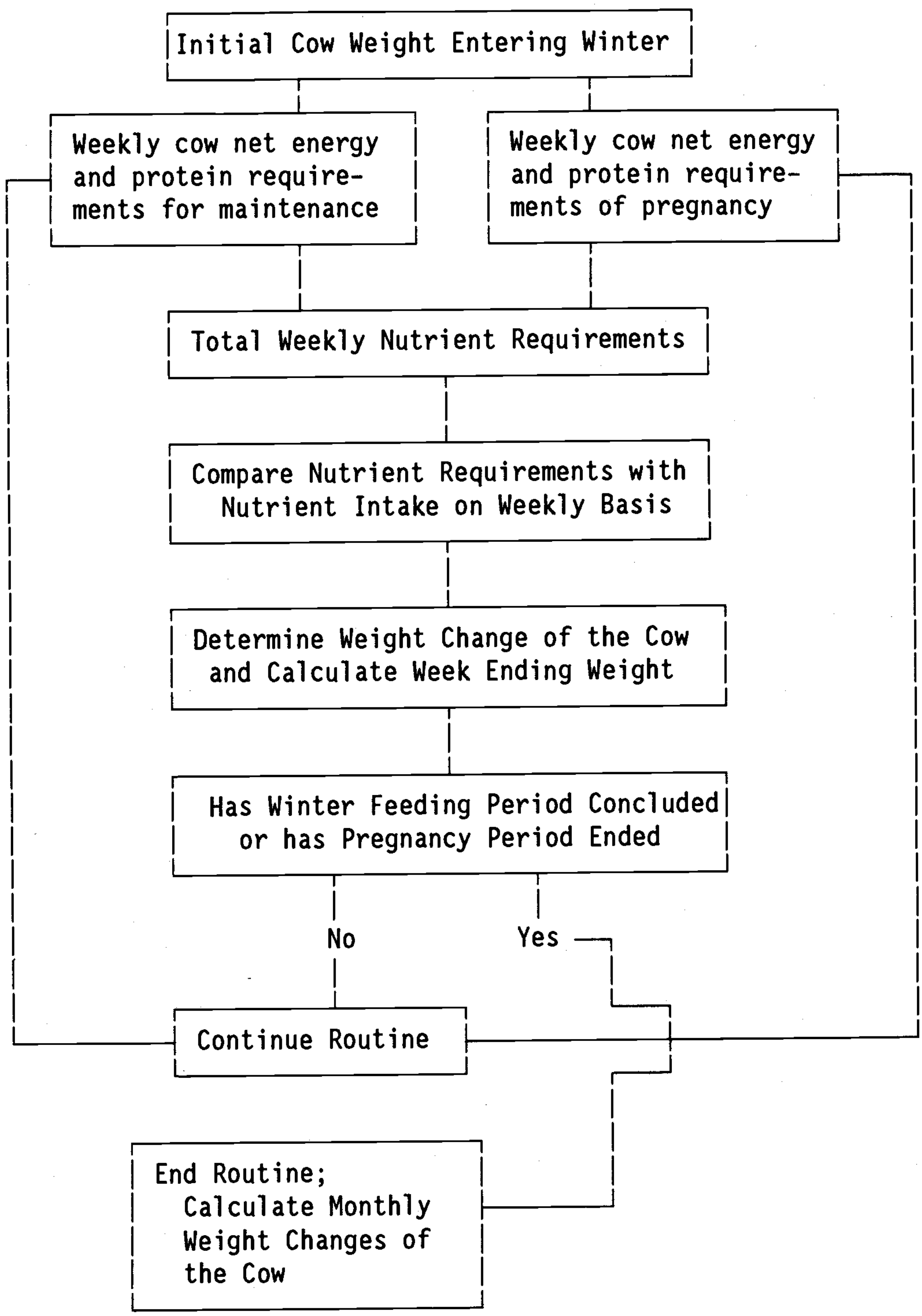

Figure 4.3: Estimation of Cow Winter Weight Changes.

nutritional aspects of the diet. Empirical evidence demonstrates that cow reproductive performance depends upon the animals receiving (1) an adequate level of nutrients for body maintenance and (2) necessary amounts of nutrients to compensate for higher dietary requirements during pregnancy or lactation periods (Lewis; Ensiminger, 1976). Studies have shown that cows losing significant levels of weight (and condition) during gestation suffer reduced calf crops and conception rates (Pinney et al., 1962; Wiltbank et al, 1962; 1964; Bellows and Short, 1978). Results from the winter feeding trials conducted at Squaw Butte indicate that cows losing condition or weight suffer reduced calf crops and conception rates. Consequently, the equations derived and used to estimate calving and conception rates in the model are based upon correlating winter weight (or condition) changes with cow reproductive performance. The method of analysis used in estimating equations measuring cow calving and conception rates consists of regressing pregnancy and calving rates against cow winter-time weight changes.[12]

The equation used to estimate calving rate regressed trial herd calving rates against percentage monthly weight changes of the cows. Using ordinary least squares, corrected for autocorrelation the equation derived to predict calf crop percentage is:

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[12] Other factors, cow age, calve birth dates, calving intervals, May and September cow weights, and calf weaning weights were also regressed. These regressions were not used either because of poor results, and/or the coefficients measured occurred outside the time period being simulated.

$$(4.5)\ CA = 94.947 + (1.095 \times Nov) + (1.026 \times Dec) - (0.522 \times Feb)$$

$$\begin{array}{cccc} (0.979) & (0.541) & (0.388) & (0.305) \\ (96.979) & (2.026) & (2.641) & (1.708) \end{array}$$

Adjusted R^2 = 35.1 Durbin-Watson statistic = 1.88

where CA = Calving rate, Nov = November percentage weight change, Dec = December percentage weight change, and Feb = February percentage weight change. The parenthesed numbers respectively represent the standard errors of the coefficients and student-t statistics (Table 4.12). The t statistics are significant to the 0.05 level for the intercept, Nov, and Dec coefficients, and at the 0.10 level for the Feb coefficient. The Durbin-Watson test indicates no autocorrelation present at the 0.05 significance level. The R^2 of the regression was 59.4, but after adjustment fell to 35.1, indicating a fairly high degree of variance in the results. This indicates that several other factors are also involved in determining calving success. One such factor is that cows will carry calves through to parturition even though they may suffer significant weight loss or reduced condition. As indicated by the data used in the regressions, cows on the meadow trials lost more weight in comparison to the baled and rake-bunch hay treatments. However, calving rates were reduced by only 6.1 percent, while conception rates are reduced by 15.4 percent, when comparing meadow grazing with an average of the other two alternatives.

The equation used to estimate conception rates regressed conception rate against the estimated calving rate (equation 4.6), and winter percentage weight changes. Using ordinary least squares,

Table 4.12: Value of Coefficients, Standard Errors, and Student t Statistics for the Cow Calving Rate Regression Equation.

Coefficient	Value of Coefficient	Standard Error	Student t Statistic
Intercept	94.947	0.979	96.979***
Nov	1.095	0.541	2.026**
Dec	1.026	0.388	2.641**
Feb	-0.522	0.305	1.708*

$R^2 = 59.4$ Adjusted $R^2 = 35.1$

* significant at the 0.10 level
** significant at the 0.01 level
*** significant at the 0.001 level

corrected for autocorrelation, the equation found to predict conception rates is:

$$(4.6)\ \text{Preg} = 149.85 - (0.801 \times \text{CA}) + (0.793 \times \text{Oct}) + (3.761 \times \text{Nov}) + (2.938 \times \text{Dec}) + (2.856 \times \text{Jan}) - (2.536 \times \text{Feb})$$

Adjusted R^2 = 77.54 Durbin-Watson = 1.948

where CA = calving rate, and Oct, Nov, Dec, Jan, and Feb represent percentage monthly weight changes of the cow. Except for the coefficient Oct the equation meets standard measures of fit. The t statistics of the other coefficients are all significant (Table 4.13). The Durbin-Watson test indicates no autocorrelation present at the 0.05 significance level and the coefficient of determination (R^2) is high.

For the range grazing alternative, calving and conception rates are estimated directly from experimental data. In the simulation, calving and conception rates are assumed to be 97 percent and 88 percent for normal and above average winters. During the severe and very severe winters the calving and conception rates are assumed to be 96 percent and 86.5 percent.

The main reason for using two different methods for determining calving and conception rates are that winter, range grazing cows enter the winter period in better condition than cows on the other alternatives. This is because the range grazing cows are on a superior winter preconditioning program, i.e. rake-bunch hay during August and September. Although weight losses of the range cows are similar to weight losses of meadow grazing cows, cows on range can

Table 4.13: Value of Coefficients, Standard Errors, and Student t Statistics for Cow Conception Rate Regression Equation.

Coefficient	Value of Coefficient	Standard Error	Student t Statistic
Intercept	149.850	47.997	3.122**
CA	-0.801	0.501	1.599*
Oct	0.793	0.677	1.172
Nov	3.761	1.117	3.367**
Dec	2.938	1.101	2.668**
Jan	2.886	0.673	4.242***
Feb	-2.536	0.574	4.420***

R^2 = 90.22 Adjusted R^2 = 77.54

* significant at the 0.10 level
** significant at the 0.01 level
*** significant at the 0.001 level

afford to lose weight given their better condition without adversely affecting reproductive performance. This is confirmed through analysis of the first two winters of experiment data. Range grazing cows lost substantial amounts of weight during the winter, however calving and conception rates were comparable to cows on baled and raked hay systems. Using the regression equations to calculate range grazing cow reproductive performance would yield results similar to that experienced by meadow grazing cows which would not agree with test trial data.[13] Therefore, the reproductive performance of range grazing cows had to be exogenously determined using test trial data.

Herd Management

The herd management subroutine uses estimates of cow reproductive performance to determine marketable beef production over a five year time horizon. This is accomplished by interfacing calf crop and conception rate percentages with total cow herd size, herd culling procedures, and estimated cow and calf death losses.

The procedure to determine marketable beef production is outlined as follows (Figure 4.4). First, the number of cows and incoming replacement heifers in the herd are multiplied by the year's conception rate. The two figures are combined to yield the number of cows that are pregnant following the breeding season. Second, the number of cows pregnant in the herd is multiplied by the

[13] In addition, regression equations could not be constructed for the range grazing systems because of the limited number of observations.

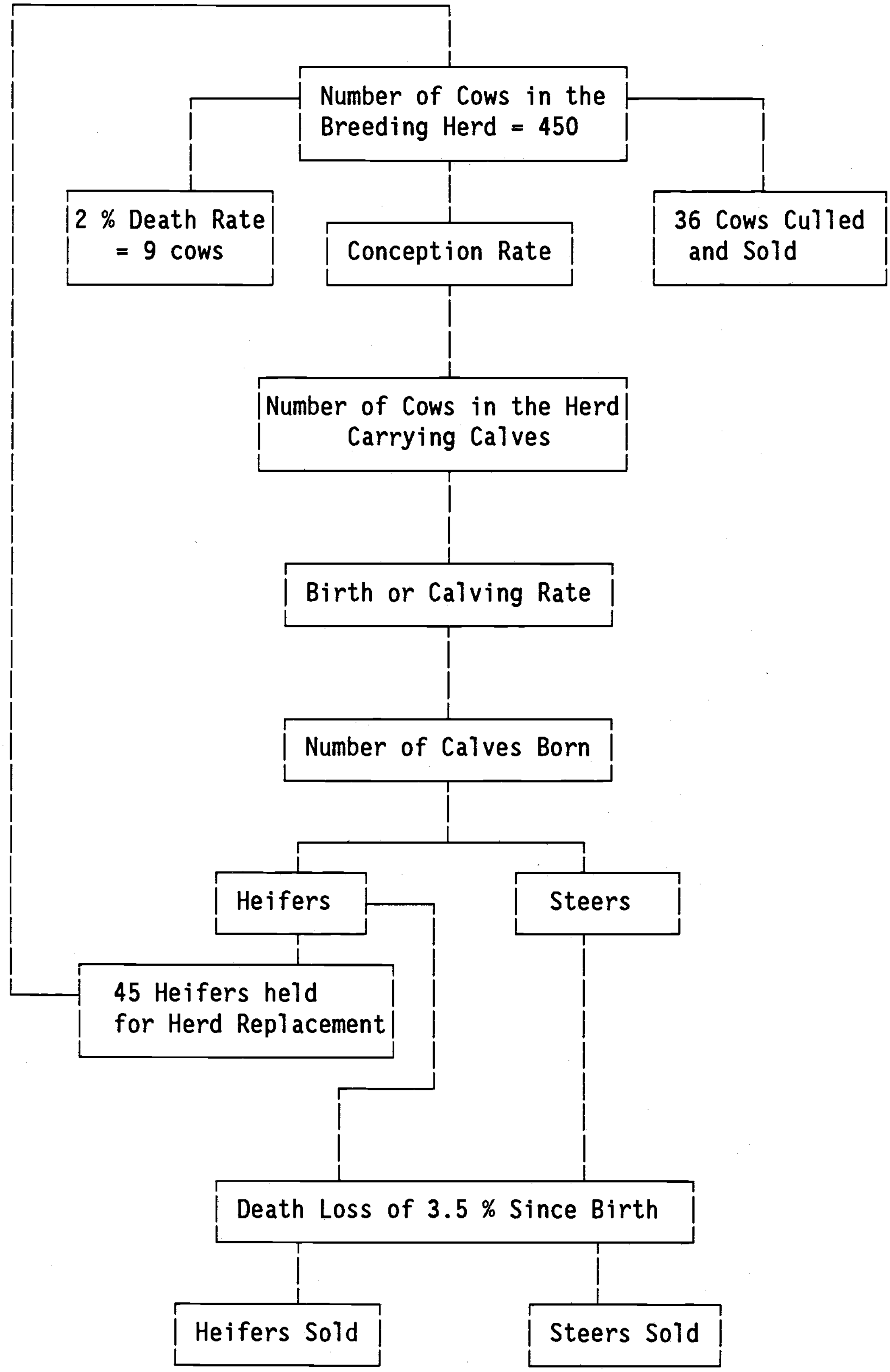

Figure 4.4: Cow Production Flow-chart for Cow-calf Ranch Unit.

estimated calving rate, yielding the number of calves produced for the year. The number of calves are halved to yield the number of heifers and steers in the calf crop.

The replacement rate of the cow herd is equal to the combined culling and cow death loss rate to maintain the size of the breeding herd. The replacement rate in the model is assumed to be 10 percent of the herd total. Culling rate and cow death loss are assumed to be eight and two percent respectively.[14]

The number of animals sold is determined by taking the number of heifers, steers, and cull cows and multiplying each by assigned survival rates. Cows have a survival rate of 98 percent, reflecting the 2 percent death loss rate suffered by the herd. Heifers and steers are assumed to have a 96.5 percent survival rate--i.e. 4.5 percent death rate from the time of birth (Hewlett et al., 1987). The number of animals available for sale are used in calculating returns to the operation for each alternative and corresponding climate scenario.

Land Usage

The land use subroutine uses a complex system of equations and assigned range commands to link herd intake estimates, forage

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[14] The ten percent replacement rate is assumed in a number of Oregon State Agricultural Extension Service publications, hence its adoption to the simulation (Hewlett et al., 1987a and 1987b). However, culling and replacement rates are adjustable in the input section of the simulation to expand the number of options available to management of the system.

inventories, imputed land use requirements, and winter snow condition criteria to determine forage production and forage utilization. The system operates in four stages: (1) determination of forage production and land use, (2) estimation of forage utilization of both primary and emergency feed sources, (3) estimation of forage not utilized, and (4) calculating the amount of recoverable forage.

The routine begins by designating the number of weeks of primary feed and emergency hay the ranch will allocate to the winter period (refer to Tables 4.23 and 4.24). The number of weeks required for each forage type are then interfaced with herd weekly dry matter intake requirements to yield the tonnage amounts produced for the primary and emergency hay resources.[15] Excess amounts of meadow hay not retained are assumed to be sold as baled hay following hay harvest. Harvest is assumed to occur in the second week of July.

Forage utilization is determined by winter severity scenarios. The primary feed is used when snow conditions do not restrict forage access by the cows. When restrictive snow conditions are present, emergency hay (baled) reserves are accessed. If the stocks of retained baled hay should run out then the simulator assumes emergency feed is purchased from outside sources.

In terms of recoverability, only baled hay is assumed to be salvagable. Unutilized rake-bunch hay, rangeland, and standing meadow are assumed to be lost and are costed accordingly in the economic subroutine. Excess baled hay remaining at the conclusion of

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[15] The range grazing component converts tonnage amounts to acres per AUM and total rangeland acreage required.

the winter period is assumed to be sold in the spring. It should be pointed out that in many cases ranches would not have excess forage available for sale. In addition, there may be difficulty selling excess hay in the spring. Ranches could convert hay fields into pasture or use the excess forage in some other phase of the operation. Under these conditions economic returns to an operation would be affected differently.

As an example of the routine, the following description is provided. A rancher, with 1100 acres of flood meadow decides to provide 17 weeks of standing meadow as the primary winter feed source for the 450 cows in the brood herd (Table 4.14). Production on the meadows is 1 ton of forage per acre. The remainder of the meadow is harvested as baled hay of which 7 weeks of forage is retained to serve as an emergency and complementary feed source during the 22 week winter period. The excess amount of baled hay is sold following harvest totaling 4.5 weeks of forage. Weekly herd intake is 37.5 tons when the cows are on standing meadow and 40 tons when the cows are fed baled hay. During the winter, nine weeks of snow prohibit use of the standing meadow resulting in only 13 weeks of the primary feed source being utilized. The remaining four weeks of standing meadow is treated as waste. In this example, all reserve baled hay stocks are consumed requiring emergency hay purchases to be made for the remaining two weeks of the winter period.

Economic Assessment

The economic subroutine uses a set of partial budget statements

Table 4.14: Estimation of Forage Use and Waste for Winter Meadow Grazing.

Winter Length = 22 weeks	Standing Meadow	Baled Hay
	- - - weeks - - -	
Meadow Production	17	11.5
Pre-winter Sale	0	4.5
Beginning winter inventory	17	7
Number of weeks of winter preventing use of meadow	9	NA
Total Forage Utilization	13	NA
Weeks of Emergency Feed		
Owned	NA	7
Purchased	NA	2
Remaining Forage	4	none

to calculate returns and variable costs to each alternative under the four winter condition scenarios.[16] Output consists of total returns above variable costs, net returns above variable costs per cow, and net returns above variable costs per pregnant cow, to compare the relative economic benefits of each system.

Risk is addressed in the routine in a similar fashion to procedures applied in previous beef production studies. Parsch et al. (1986) estimated returns to a alternative steer management strategies for a summer grazing program as influenced by a range of climate conditions. Expected net returns where calculated based on the probability of the weather events occurring. In addition, income variances were computed to provide the relative risk associated with each management alternative. Reeves et al. (1974) and Beck et al. (1982) used similar procedures to assess biological and financial performances of Australian cattle ranches under the influence of several weather scenarios. The thesis simulation applies these concepts in the form of a payoff matrix yielding expected net returns above variable costs for each feeding alternative.[17] Expected returns above variable costs for the alternatives are calculated in

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[16] The simulation assumes short-term conditions. Therefore budgets are constructed so that only those costs and returns associated with the alternative feeding programs are tabulated. Other costs are assumed fixed and/or identical for the alternatives.

[17] This criteria is identical to the concept of profit maximization contained in economic theory. With risk applied, theory assumes that decision makers attempt to maximize expected profit. Expected profit is the sum of possible profit levels multiplied by their respective probabilities (Shelly, 1984).

two steps. First, returns to each of the alternative scenarios are multiplied by the corresponding weather event probability. Second, the adjusted returns are added together providing the expected net return above variable costs for the alternative.

A number of sources were used to construct scenario budgets. Oregon State University Extension Service publications, University of Idaho cow-calf enterprise budgets, and Oregon State Extension Service and USDA price records provided the bulk of the information utilized. Other data sources included consultation with ranch operators, eastern Oregon extension agents, farm and ranch supply employees, and range researchers.

Prices received for marketed cattle were obtained from Extension Service price records for each cattle type. The model uses October 1988 cattle prices for the economic assessment. Prices received for marketed hay used the average 1988 prices for hay sold in Oregon.

Forage expenses varied depending on the alternative being assessed. Hay harvest expenses and hauling costs were obtained from a recently compiled survey of expenses charged for the performance of custom agricultural services (Cross, 1989). Baled hay costs were assumed to be $27 per ton. This included swathing, baling and stacking procedures. Raked hay was assumed to cost $11 per ton. Hauling costs were $12 per ton for the first 50 miles. No harvest or production costs were assigned to standing meadow forage sources.

Grazing fees on rangelands were determined using the 1988 fee schedule. A price of $1.50 per AUM is charged in the budgets

(Collins, 1988). Other costs associated with range grazing are applied as miscellaneous costs. The winter range grazing alternative is assumed to have higher incidental costs since cows on this alternative are on range three months longer than cows in the other alternatives.

Costs of protein supplements, salt, and minerals were obtained from USDA price reports (USDA, 1988) and from local farm supply stores in Harney County (Table 4.15). The costs of the New Zealand fence system used in the standing meadow, and rake-bunch alternatives is amortized over the five year period using an interest rate of 10 percent. Material costs to the system were obtained from Harney County farm suppliers (Table 4.16). The ranch was assumed to require a half mile of two strand fence with fiberglass step posts placed every 30 feet. Labor required to move fence was estimated at 0.5 hours per man per half mile of fence on a weekly basis. Standing and range grazing alternatives require feed troughs for feeding protein-energy supplements. The feed bunks are also amortized over five years using an interest rate of 10 percent (Table 4.17). Feed bunks are 15 feet long and the fiberglass inserts are replaceable. One bunk can service 25 cows.

Ranch labor costs are valued at $5/hour (Hewlett et al., 1987a and 1987b; Smathers et al., 1989). Feeding baled hay requires 2 persons working at a rate of two tons/hr on ranch feeding grounds or meadow and 1.5 tons/hr for range grazing to reflect travel time to range sites. The feeding of protein-energy supplements takes two workers, working at the rate of one ton of supplement per hours for

Table 4.15: Costs of Beef Cattle Feed Concentrates, and Their Nutrient Composition, Cost per Mcal of Net Energy Maintenance, and Cost per Kilogram Crude Protein.

Feed Type	Sale Unit	Cost ($)	NEm (Mcal/kg)	Crude Protein (%)	Cost per: Mcal of NEm ($/Mcal)	Cost per: Kg. of Protein ($/kg)
Barley						
Grain	ton	120.00	2.12	10.80	.06	1.23
Corn						
gluten, meal	bu	10.70	2.12	46.80	.22	1.01
grain, grade 2	bu	4.00	2.24	10.10	.08	1.75
Cottonseed						
meal, 41% cp						
mechanical						
extract	cwt	17.30	1.88	44.30	.20	0.86
solvent ext.	cwt	17.30	1.82	45.20	.21	0.84
Soybean						
meal,						
mechanical	cwt	21.50	2.09	47.70	.22	0.99
solvent ext.	cwt	18.00	2.06	49.90	.19	0.80
Sunflower						
meal	ton	300.00	1.90	38.00	.17	0.87

Table 4.16: Material Costs for a Half Mile of New Zealand Fence.

Fence Component	Unit	$/unit	Number of units	Unit Cost
Poly wire	1000 ft.	19.95	6	119.70
Step Post	20 ea.	21.95	5	109.75
Battery - 12 volt	1 ea.	70.00	2	140.00
Charger	1 ea.	245.00	1	69.95
Porta-reel	1 ea.	75.00	1	75.00
Wire clips	100 ea.	4.00	2	8.00
Insulators	20 ea.	3.25	9	29.25
Total Cost				551.65
Yearly cost at ten percent interest rate				143.40

Table 4.17: Costs of Feed Bunks.

Component	Unit	$/unit	Number of units	Unit Cost
11 ft. Feed bunk	1 ea.	145	18	2610.00
Total Cost				2610.00
Yearly cost at ten percent interest rate				688.51

the meadow grazers and 1.5 hours for the range grazing system (Turner, 1988). Machinery expenses are costed per hour using Oregon State University Enterprise budgets for cow-calf, and cow-calf-yearling enterprises in Lake County, Oregon (Hewlett et al., 1987a and 1987b).

Cattle Ranch Base Inputs

The cattle ranch used in the simulation represents a typical owner-operated cow-calf operation found in the Harney Basin. The cow breeding herd consists of 450 animals replaced at rate of ten percent per year. Land resources available for winter feeding include 1100 acres of native grass flood meadows yielding an average of one ton of harvestable forage per acre. Winter hay is harvested by custom operation using conventional baling techniques. For winter range grazing, 22,500 acres are considered to be available on public land administered by the Bureau of Land Management. The winter range is assumed to be within 50 miles of the ranch unit. Production on rangelands averages ten acres/AUM.

Cattle ranch base inputs are organized in five sections describing (1) herd forage intake levels, (2) land allocation, (3) animal and herd characteristics, (4) winter snow conditions, and (5) computation of protein-energy supplement rations. Inputs to the simulation and to the individual alternatives are provided in Tables 4.18 through 4.22, respectively.

Cow dry matter intake was estimated from data found in Squaw Butte Experiment Station publications and records (Turner, 1988, Sneva and Turner, 1977). The section also factors in waste associated with feeding. The baled hay alternative is assumed to suffer a 15 percent loss when feeding out hay (Cross, 1989). Significant feeding loss associated with the rake-bunched hay alternative was not observed by Squaw Butte staff during the trials. Estimates range between one and five percent. In the simulator, rake bunch feeding loss is assumed to be 2.5 percent. Feeding waste is not computed for either meadow or range grazing alternatives. Waste is measured for meadow and range grazing by the amount of forage not utilized during the winter.

Cow intake after computing feed waste for rake-bunch and baled hay alternatives is assumed to be 25.5 lb per day (Turner, 1988). Range grazing and meadow grazing cow dry matter intake are assumed to be 22 lb and 24 lb per day, respectively (Turner, 1988). The lower intake levels for range and meadow grazing reflect the poorer quality of the forages and acquisition difficulties that reduce cow forage intake.

Total weekly herd forage consumption is computed by multiplying individual cow dry matter intake levels by the herd size and converting the value into tonnage units. The expected herd dry matter consumption level for the entire winter is computed by multiplying weekly intake by the number of weeks allocated to the forage source. Again intake amounts are converted to a tonnage amount. The meadow grazing scenarios allocate 17 weeks of meadow and 9.5 weeks of baled hay for winter forage supplies (Table 4.23). The baled hay alternative allocates 6 weeks of rake-bunch hay for

Table 4.18: Cattle Ranch Base Inputs.

Forage Resources:

	Acres	Production (tons)
Native Meadow	1100.0	
tons/acre	1.0	1100.0

	Acres	AUMs
Winter Range	22,500.0	
acres/AUM	10.0	2250.0

Animal and Herd Characteristics:

Herd Size	450	Cows
Cow Ideal Metabolic Weight	480	kilograms
Entering Winter Weight of Cows;		
Range graze	500	kilograms
Baled hay	453	kilograms
Raked hay	453	kilograms
Meadow graze	453	kilograms
Calf Birth Weight	34	kilograms
Cow Weight Gain	8.0	Mcal/kg
Cow Weight Loss	6.0	Mcal/kg
Supplement Waste	0.10	
Raked-Hay Waste	0.02	
Baled Hay Waste	0.15	
Herd Replacement Mode	1.0	
Herd Replacement Number	45.0	Cows

Winter Conditions:

Weeks of snow	see table 4.5, varies with winter scenario and
Weeks of no snow	forage alternative
Weeks in winter	22

Sale Weights Of Cattle:

Baled, Raked, and Meadow Grazing;			Range Grazing;		
Cows	1000.0	pounds	Cows	1125	pounds
Steers	365.0	pounds	Steers	380	pounds
Heifers	350.0	pounds	Heifers	365	pounds

Table 4.19: Base Inputs for Baled Hay Feeding Alternative.

Forage Resources:	Acres	Production (tons)
Hay Meadow	1100.00	1100.00
Bale Hay	854.11	
tons/acre	1.00	854.11
Rake Hay	245.89	
Summer Use	0.00	
tons/acre	1.00	0.00
Winter Use	245.89	
tons/acre	1.00	245.89
Meadow Graze	0.00	
tons/acre	1.00	0.00
Winter Range		(AUMs)
Acres	0.00	
Acres/Aum	10.00	0.00

Winter Forage Resources:

Baled Hay weeks 16

Unit	Fed lb/day	Utilization lb/day	kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	30.00	25.50	11.56	1.10	74.00	1295.24
	ton/wk	ton/wk	ton/season			
herd	47.25	40.16	756.00			

Raked Hay weeks 6

Unit	Fed lb/day	Utilization lb/day	kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	26.02	25.50	11.56	1.10	74.00	485.71
	ton/wk	ton/wk	ton/season			
herd	40.98	40.16	245.89			

Table 4.20: Base Inputs for Rake-Bunch Hay Feeding Alternative.

Forage Resources:	Acres	Production (tons)
Hay Meadow	1100.00	1100.00
Bale Hay	198.44	
tons/acre	1.00	198.44
Rake Hay	901.56	
Summer Use	0.00	
tons/acre	1.00	0.00
Winter Use	901.56	
tons/acre	1.00	901.56
Meadow Graze	0.00	
tons/acre	1.00	0.00
Winter Range		(AUMs)
Acres	0.00	
Acres/Aum	10.00	0.00

Winter Forage Resources:

Baled Hay weeks 2

Unit	Fed lb/day	Utilization lb/day	Utilization kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	30.00	25.50	11.56	1.10	74.00	161.84
	ton/wk	ton/wk	ton/season			
herd	47.25	40.16	80.32			

Raked Hay weeks 22

Unit	Fed lb/day	Utilization lb/day	Utilization kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	26.02	25.50	11.56	1.10	74.00	1780.24
	ton/wk	ton/wk	ton/season			
herd	40.98	40.16	883.52			

Table 4.21: Base Inputs for Meadow Grazing Alternatives.

Forage Resources:	Acres	Production (tons)
Hay Meadow	1100.00	1100.00
Bale Hay	457.40	
tons/acre	1.00	457.40
Rake Hay	0.00	
Summer Use	0.00	
tons/acre	1.00	0.00
Winter Use	0.00	
tons/acre	1.00	0.00
Meadow Graze	642.60	
tons/acre	1.00	642.60
Winter Range		(AUMs)
Acres	0.00	
Acres/Aum	10.00	0.00

Winter Forage Resources:

Baled Hay weeks 9.5

Unit	Fed lb/day	Utilization lb/day	kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	30.00	25.50	11.56	1.10	74.00	769.05
	ton/wk	ton/wk	ton/season			
herd	47.25	40.16	448.88			

Meadow weeks 17

Unit	Fed lb/day	Utilization lb/day	kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	24.00	24.00	10.88	0.76	41.00	1295.24
	ton/wk	ton/wk	ton/season			
herd	37.80	37.80	642.60			

Table 4.22: Base Inputs for Range Grazing Alternatives.

Forage Resources:	Acres	Production (tons)
Hay Meadow	1100.00	1100.00
Bale Hay	738.54	
tons/acre	1.00	738.54
Rake Hay	361.46	
Summer Use	361.46	
tons/acre	1.00	361.46
Winter Use	0.00	
tons/acre	1.00	0.00
Meadow Graze	0.00	
tons/acre	1.00	0.00
Winter Range		(AUMs)
Acres	22500.00	
Acres/Aum	10.00	2250.00

Winter Forage Resources:

Baled Hay weeks 8

Unit	Fed lb/day	Utilization lb/day	Utilization kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	30.00	25.50	11.56	1.10	74.00	647.62
	ton/wk	ton/wk	ton/season			
herd	47.25	40.16	378.00			

Raked Hay weeks 22

Unit	Fed lb/day	Utilization lb/day	Utilization kg/day	NE/kg	CP gm/kg	Maximum Cow Intake kg/season
cow	22.00	22.00	9.98	0.80	35.00	1536.51
	ton/wk	ton/wk	ton/season			
herd	34.65	34.65	762.30			

early fall feeding (Oct 1-Nov 15) and 16 weeks of baled hay for the remainder of the winter period. The raked-bunch hay alternative provides 22 weeks of raked hay and 2 weeks of emergency baled hay for winter forage supplies. The range grazing alternative uses nine weeks of raked hay during the summer period. In the winter the range alternative allocates eight weeks of baled hay for emergency winter supplies during the five months the cows are on rangelands.

The number of weeks of feed sequestered to each alternative is used in the land allocation input table to determine forage tonnage production on the meadows and winter AUM and acreage requirements on rangelands (Table 4.24). The tonnage amounts computed in the table are used in forage inventory control and to assess forage utilization, waste, and recovery calculations.

Also included in the cow intake input section are forage net energy and crude protein content. Crude protein contents of the alternative forages are determined from Squaw Butte records and the trial data. Dry matter energy digestibility estimates obtained from Squaw Butte Experiment Station publications and forage sample records were used to derive forage net energy content. Energy content of meadow hay, meadow grasses, and range forage were estimated using a dry matter digestibility-energy conversion, developed by Rittenhouse et al. (1971). The conversion estimates digestible energy in kilocalories per gram of forage using the following relationship:

$$DE = a + b \times DMD \tag{4.7}$$

where,

Table 4.23: Weeks of Feed Allocation for the Winter Feeding Alternatives by Season and Feed Type.

Primary Winter Feed	Allocated Weeks	Emergency, or Complementary Feed and Summer Use				
		Baled Hay	Range Grazing Summer	Range Grazing Winter	Rake Bunch Summer	Rake Bunch Winter
Meadow	17	9.5	9	0	0	0
Range	22	8	0	---	9	0
Bale	16	---	9	0	0	6
Rake	22	2	9	0	0	---

Table 4.24: Tonnage Feed Allocation for the Winter Feeding Alternatives by Season and Feed Type,

Primary Winter Feed	Allocated Feed	Emergency, or Complementary Feed and Summer Use				
		Baled Hay	Range Grazing Summer	Range Grazing Winter	Rake Bunch Summer	Rake Bunch Winter
	tons	tons	- - AUMs - -		- - - tons - - -	
Meadow	642.60	448.88	900	0	0	0
Range	2250 AUMs	378.00	0	---	361.46	0
Bale	756.00	---	900	0	0	245.89
Rake	901.56	94.50	900	0	0	---

DE = Digestible energy in kcal/gm forage

DMD = Percent dry matter digestibility

a = 0.18 +/- 0.07

b = 0.038 +/- 0.001

R^2 = .891 SD = 0.195

Source: Rittenhouse et al., 1971.

Net energy content is determined from digestible energy values using standard energy conversion equations (NRC, 1984; Appendix D). Forage net energy content for the alternatives used in the simulation are shown in Tables 4.19, 4.20, 4.21, and 4.22. Net energy and crude protein content is used to determine nutritional intakes of the cows based upon intake assumptions.

Cow and herd input factors include the number of cows in the herd, average fall weight of the cows, ideal metabolic cow weight, calf birth weight, rate of weight gain and loss for the cows, herd replacement mode, and sale weights of heifers, steers, and cull cows (refer to Table 4.18). The number of cows in the herd has been determined to number 450 brood cows. Average fall weights of the cows are based upon the experiment records. Baled, rake-bunch, and meadow grazing cows come into the winter program at 453 kg and the range grazing cows weigh 510 kg. Calf birth weight and ideal metabolic weights are 34 and 480 kg as established earlier in the text. Cows are determined to gain weight and lose weight at the rate of 8 Mcal/kg and 6 Mcal/kg, respectively. The replacement mode for the herd is ten percent of the herd total, equaling 45 cows per year. Sale weight of cattle types were based upon calf weaning weights in the trials and the average fall weight of the cows. The winter range grazed group had heavier calf and cow weights in the fall than the other test groups. This is most likely due to their being on higher quality forage (rake-bunch hay and aftermath) in the late summer. Cows on the rake-bunch, baled hay, and standing meadow groups were grazing on native sagebrush-grasslands which decline in nutritional quality during this period (Vavra and Raleigh, 1976; McInnis and Vavra, 1987). As a consequence, fall weights of both cows and calves were lighter than the range group. Sale weights of cattle on the range alternative are assumed to weigh 365, 380, and 1125 pounds for heifers, steers, and cows, respectively. Sale weights for the other alternatives are assumed to be 350, 365, and 1000 pounds for heifers, steers, and cows, respectively.

As discussed earlier in the chapter, the feeding alternatives are exposed to four winter types. Winter scenarios consist of mild, average, severe, and very severe winters. Winter weather scenarios, based upon the number of weeks of snow cover prohibiting use of forages are used in the input tables for computing forage utilization for the meadow and range grazing alternatives. In the simulation only meadow and range grazing alternatives is affected by deep snow conditions. The baled hay and rake-bunch hay regimes are affected only by temperature and wind conditions associated with these winter types.

Protein supplements are fed to cows in the range and meadow grazing alternatives. The amount of supplement fed to cows in the simulation were determined directly from rations fed to cows in the Squaw Butte trials. Meadow grazers are fed an average ration of 0.454 kg (1 lb) of cottonseed meal per day (Table 4.25). A feeding waste of 10 % is inputed to the system resulting in cows consuming only 0.41 kg of the ration. Range grazing cows are ed an average daily ration of 0.68 kg (1.5 lb) of 15 percent barley and 85 percent cottonseed meal (Table 4.25). The nutritional components of the supplements were obtained from NRC nutritional tables for concentrate feeds (NRC, 1984).

Table 4.25: Daily Protein Supplement Rations for Cows on Meadow, and Range Grazing Winter Feeding Alternatives.

Feed supplement	Nutrient Content		Ration Formula		Nutrient Content of Ration	
	Protein (%)	NE (Mcal/kg)	Percent of ration	Amount (kg)	Protein (%)	NE (Mcal/kg)
Meadow Grazing:						
Cottonseed meal	44.30	1.88	100.0	0.454	201.12	0.85
Range Grazing:						
Cottonseed meal	44.30	1.88	85.0	0.578	256.16	1.09
Barley grain	13.50	2.12	15.0	0.102	13.77	0.22
Total			100.0	0.680	269.93	1.31

CHAPTER V

SIMULATION RESULTS AND OUTPUT

The simulator generates ranch partial budgets, measurements of cow reproductive performance, herd production performance, and forage utilization for each alternative. Due to the large amount of material produced by the simulation, the output presented in the chapter has been condensed to facilitate interpretation. Examples of the stimulations complete output are provided in Appendices E and F.

Output from each alternative is organized and presented in four separate sections. Economic results are reported in terms of the program costs, wintering costs, net returns, and expected net returns on a per-cow basis. Program costs include costs associated with the wintering period, fall and spring hay sale costs, and summer grazing costs. Wintering costs include only those expenditures associated with the winter feeding time period. This provides a better accounting of the costs of the winter program.

Calving and conception rates for the alternatives and scenarios are presented along with tables summarizing management of the breeding herd. In addition, the number and type of cattle marketed is also included in the tables. Hay, meadow and range forage production, utilization, waste, and forage recovered are provided in tonnage and acreage amounts.

At the conclusion of the chapter alternatives will be compared to assess their impact to the profits of the operation and the affects to management of the breeding herd. Recommendations for adoption of an alternative for the ranch types are also discussed.

Baled Hay Alternative

Net returns to the baled hay alternative did not exhibit much variation across the four climatic scenarios (Table 5.1). This resulted from a combination of (1) fairly constant ranch output factors and (2) stable costs over both the total program and winter periods. The variability in ranch returns that occurred resulted from small changes in the breeding herds calving percentages and conception rates due to temperature induced influences upon the cows. Net returns in year one were \$235.01, \$235.19, \$234.72, and \$234.36 for the mild, average, severe, and very severe winters, respectively (Table 5.1). Net returns per year increased during years two through five to \$235.67 and \$235.36 for the mild and average winter scenarios. Returns decreased during this period for the severe and very severe winters to \$233.88 and \$234.07, respectively.

Herd production characteristics remained relatively constant although minor differences existed for calving and conception rates between each scenario (Tables 5.2 and 5.3). Calving rates for the herd were 98.6, 98.7, 98.5, and 98.4 percent and conception rates were 89.1, 89.0, 88.6, and 88.8 percent during the mild, average, severe, and very severe winters, respectively Table (5.2 and 5.3). The differences in reproductive characteristics are a result of differential cow winter weight changes as influenced by temperatures used in the four climate scenarios.

Table 5.1: Per Cow Net Returns, Total Program Costs, and Winter Costs: Baled Hay Feeding.

Winter Type	Year	Total Cost	Winter Cost	Net Return
Mild	1	75.25	66.36	235.01
	2-5	75.25	66.36	235.67
Average	1	75.25	66.36	234.88
	2-5	75.25	66.36	235.18
Severe	1	75.25	66.36	234.72
	2-5	75.25	66.36	233.89
Very Severe	1	75.25	66.36	234.36
	2-5	75.25	66.36	234.07

Table 5.2: Cow Herd Performance Factors and Herd Production Figures, Baled Hay, Mild and Average Winters.

Mild Winter Type:
Calving Percentage 98.6 %
Conception Rate 89.1 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.6	98.6	98.6	98.6	98.6
Number of Calves	439	439	439	439	439
Heifers	219	220	220	220	220
Steers	219	220	220	220	220
Pregnancy Rate	89.1	89.1	89.1	89.1	89.1
Cows pregnant	401	401	401	401	401
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	167	167	167	167	167
Steers (3.5 %)	212	212	212	212	212

Average Winter Type:
Calving Percentage 98.6 %
Conception Rate 89.0 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.6	98.6	98.6	98.6	98.6
Number of Calves	439	439	439	439	439
Heifers	220	220	220	220	220
Steers	220	220	220	220	220
Pregnancy Rate	89.0	89.0	89.0	89.0	89.0
Cows pregnant	400	400	400	400	400
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	167	167	167	167	167
Steers (3.5 %)	212	212	212	212	212

Table 5.3: Cow Herd Performance Factors and Herd Production Figures, Baled Hay, for Severe and Very Severe Winters.

Severe Winter Type:
Calving Percentage 98.6 %
Conception Rate 88.6 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.6	98.6	98.6	98.6	98.6
Number of Calves	439	439	439	439	439
Heifers	219	219	219	219	219
Steers	219	219	219	219	219
Pregnancy Rate	88.6	88.6	88.6	88.6	88.6
Cows pregnant	399	399	399	399	399
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	167	166	166	166	166
Steers (3.5 %)	212	211	211	211	211

Very Severe Winter Type:
Calving Percentage 98.4 %
Conception Rate 88.8 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.4	98.4	98.4	98.4	98.4
Number of Calves	438	438	438	438	438
Heifers	219	219	219	219	219
Steers	219	219	219	219	219
Pregnancy Rate	88.8	88.8	88.8	88.8	88.8
Cows pregnant	400	400	400	400	400
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	166	166	166	166	166
Steers (3.5 %)	211	211	211	211	211

Depending upon the winter scenario, the number of calves marketed varied from 211 to 212 steer calves and 166 to 167 heifer calves sold during the years production cycle (Table 5.2 and 5.3). Thirty-six (eight percent of the herd total) are culled and sold each year in each scenario. Forty-five heifers are retained as replacements to the breeding herd. Cattle death rates are provided in the parentheses adjacent to the type of animal being sold.

Winter land usage remained the same over each scenario, providing 6 weeks of rake bunch hay (245.89 tons), and 16 weeks (756 tons) of baled hay being utilized (Table 5.4). As indicated all forage is completely consumed during the winter.

The expected profit for the alternative is estimated by multiplying scenario net returns by the corresponding winter temperature probability and summing the products (Table 5.5 and 5.6). Expected net return to the ranch is \$235.42, and \$235.20 per year for years one and years two through five, respectively. Variability in the expected net returns negligible. In year one, the variance of the expected net return is 0.162, and for years two through five, the variance equals 0.260 (Table 5.5 and 5.6).

Table 5.4: Native Meadow and Rangeland Usage: Baled Hay Feeding for Mild, Average, Severe, and Very Severe Winters

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	854.11	854.11
Hay retained	756.00	756.00
Fall hay sale	98.11	98.11
Raked Hay		
Summer use	0.00	0.00
Winter use	245.89	245.89
Standing Pasture	0.00	0.00
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Utilization:		
Baled Hay		
Hay retained	756.00	756.00
Purchased hay	0.00	0.00
Raked Hay		
Summer use	0.00	0.00
Winter use	245.89	245.89
Standing Pasture	0.00	0.00
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Waste:		
Baled Hay	0.00	0.00
Raked hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Winter use	0.00	0.00
Recovered:		
Baled hay		
Spring hay sale	0.00	0.00

Table 5.5: Expected Net Returns for Baled Hay Feeding, Year One, Based Upon Winter Temperature Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net Return ($)	Adjusted Net Return ($)
1	Mild	.111	235.01	26.09
1	Average	.750	235.19	176.39
1	Severe	.083	234.72	19.25
1	Very severe	.056	234.36	13.12
Expected Net Return, year 1				234.85

Variance = 0.162

Table 5.6: Expected Net Returns for Baled Hay Feeding, Year 2-5, Based Upon Winter Temperature Probabilities of the Harney Basin, Oregon,

Year	Winter Type	Probability	Net Return	Adjusted Net Return
2-5	Mild	.111	235.67	26.16
2-5	Average	.750	235.36	176.52
2-5	Severe	.083	233.88	19.41
2-5	Very severe	.056	234.07	13.11
Expected Net Return, year 2-5				235.20

Variance = 0.260

Rake-Bunched Hay

Net returns to the rake-bunch hay feeding system are approximately $38 higher per cow than cows on the baled hay system. Net returns to the raked-hay system are extremely stable, centering around $282 per head over the four scenarios (Table 5.7). This is due to constant cost levels, and stable cow reproductive characteristics across the scenarios (Tables 5.7, 5.8, and 5.9).

Calving rates for the cows in the mild, average, severe, and very severe winter types, measured 98.7, 98.7, 98.6, and 98.4 percent, respectively (Table 5.8 and 5.9). In the same order, conception rates were 89.2, 89.1, 88.7, and 88.8 percent (Table 5.8 and 5.9). These simulated reproductive measurements are comparable to actual test trial results for the raked hay alternative over the past three winters.

The number of calves sold in the fall numbered between 211 to 212 steer calves and 166 to 167 heifers, depending upon the year of sale and climate scenario. Culled cows number 36 animals and 45 heifers are retained as replacements. Utilization of the rake-bunched hay for each climatic scenario is 100 percent since snow depth levels did not interfere with cow feeding activities (Table 5.10). The two weeks of emergency hay keep on hand is recovered and sold in the spring.

The expected net returns to the rake-bunch scenario are $282.65 dollars in year one and increases to $283.07 dollars per year for years two through five (Table 5.11 and 5.12). These returns are close to $48 higher than returns to the baled hay feeding system.

Table 5.7: Per Cow Net Returns, Program Costs, and Winter Costs: Rake-bunched Hay Feeding.

Winter Type	Year	Total Cost	Winter Cost	Net Return
Mild	1	41.43	25.77	282.68
	2-5	41.43	25.77	283.48
Average	1	41.43	25.77	282.72
	2-5	41.43	25.77	283.27
Severe	1	41.43	25.77	282.39
	2-5	41.43	25.77	281.69
Very Severe	1	41.43	25.77	281.99
	2-5	41.43	25.77	281.70

Table 5.8: Cow Herd Performance Factors and Herd Production Figures, Raked-bunched Hay, Mild and Average Winters.

Mild Winter Type:
Calving Percentage 98.7 %
Conception Rate 89.2 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.7	98.7	98.7	98.7	98.7
Number of Calves	439	440	440	440	440
Heifers	220	220	220	220	220
Steers	219	220	220	220	220
Pregnancy Rate	89.2	89.2	89.2	89.2	89.2
Cows pregnant	401	401	401	401	401
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	167	167	167	167	167
Steers (3.5 %)	212	212	212	212	212

Average Winter Type:
Calving Percentage 98.8 %
Conception Rate 89.1 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.8	98.8	98.8	98.8	98.8
Number of Calves	439	440	440	440	440
Heifers	220	220	220	220	220
Steers	219	220	220	220	220
Pregnancy Rate	89.1	89.1	89.1	89.1	89.1
Cows pregnant	401	401	401	401	401
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	167	167	167	167	167
Steers (3.5 %)	212	212	212	212	212

Table 5.9: Cow Herd Performance Factors and Herd Production Figures, Raked-bunched Hay, Severe and Very Severe Winters.

Severe Winter Type:
Calving Percentage 98.6 %
Conception Rate 88.7 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.6	98.6	98.6	98.6	98.6
Number of Calves	439	438	438	438	438
Heifers	220	219	219	219	219
Steers	219	219	219	219	219
Pregnancy Rate	88.7	88.7	88.7	88.7	88.7
Cows pregnant	399	399	399	399	399
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	167	167	167	167	167
Steers (3.5 %)	212	211	211	211	211

Very Severe Winter Type:
Calving Percentage 98.4 %
Conception Rate 88.8 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	98.4	98.4	98.4	98.4	98.4
Number of Calves	438	438	438	438	438
Heifers	219	219	219	219	219
Steers	219	219	219	219	219
Pregnancy Rate	88.8	88.8	88.8	88.8	88.8
Cows pregnant	400	400	400	400	400
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	166	166	166	166	166
Steers (3.5 %)	211	211	211	211	211

Table 5.10: Native Meadow and Rangeland Usage: Rake-bunch Hay Feeding for Mild, Average, Severe, and Very Severe Winters.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	198.4	198.4
Hay retained	94.5	94.5
Fall hay sale	103.9	103.9
Raked Hay		
Summer use	0.0	0.0
Winter use	901.6	901.6
Standing Pasture	0.0	0.0
Range Forage		
Summer use	9,000.0	337.5
Winter use	0.0	0.0
Utilization:		
Baled Hay		
Hay retained	0.0	0.0
Purchased hay	0.0	0.0
Raked Hay		
Summer use	0.0	0.0
Winter use	901.6	901.6
Standing Pasture	0.0	0.0
Range Forage		
Summer use	9,000.0	337.5
Winter use	0.0	0.0
Waste:		
Baled Hay	94.5	0.0
Raked hay		
Winter use	0.0	0.0
Standing Pasture	0.0	0.0
Range Forage		
Winter use	0.0	0.0
Recovered:		
Baled hay		
Spring hay sale	94.5	0.0

Table 5.11: Expected Net Returns for Raked Hay Feeding, Year One, Based Upon Winter Temperature Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net return ($)	Adjusted Net Return ($)
1	Mild	.111	282.68	31.38
1	Average	.750	282.72	212.04
1	Severe	.083	282.39	23.44
1	Very severe	.056	281.99	15.79
Expected Net Return, year 1				282.65

Variance = 0.034

Table 5.12: Expected Net Returns for Raked Hay Feeding, Years 2-5, Based Upon Winter Temperature Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net return ($)	Adjusted Net Return ($)
2-5	Mild	.111	283.48	31.47
2-5	Average	.750	283.27	212.45
2-5	Severe	.083	281.69	23.38
2-5	Very severe	.056	281.70	15.77
Expected Net Return, year 2-5				283.07

Variance = 0.312

Variance of the returns to the rake-bunched hay alternative are 0.034 in year one, and 0.312 during years two through five, respectively. Therefore, besides having higher returns than the baled hay system, the low variance in expected returns indicates the rake-bunched system is a relatively risk less feed alternative to traditional baled hay feeding programs.

Meadow Grazing

Net returns to the meadow grazing system are lower in comparison to the raked and baled hay systems and also vary substantially across the four climate scenarios (Table 5.13). Ranch net returns also fall off significantly in each scenario after the first year of production. This is primarily a result of reduced herd conception rates in year one which lowers calf crops in subsequent years (Table 5.14 and 5.15). The largest drop in net returns occur over the mild and average winter type scenarios. Net returns fall off by $48.39 for the mild winter and $48.09 for the average winter. Net returns decrease by $23.14 and $37.45 for the severe and very severe winters, respectively.

Net returns in year one are highest for the mild and average winters at $250.38 and $248.41, respectively. Returns to the severe winter and very severe winter in year one are $239.11 and $217.04. In years two through five, yearly returns are $201.99, $202.21, $215.97, and $179.59 dollars for the mild, average, severe, and very severe winters.

Total program costs, and wintering costs are highest for the

Table 5.13: Per Cow Net Returns, Program Costs, and Winter Costs: Meadow Feeding.

Winter Type	Year	Total Cost	Winter Cost	Net Return
Mild	1	60.76	44.49	250.38
	2-5	60.76	44.49	201.99
Average	1	60.72	44.45	250.30
	2-5	60.72	44.45	202.21
Severe	1	58.28	55.28	239.11
	2-5	58.28	55.28	215.97
Very Severe	1	66.18	62.67	217.04
	2-5	66.18	62.67	179.59

Table 5.14: Cow Herd Performance Factors and Herd Production Figures, Meadow Feeding, Mild and Average Winters.

Mild Winter Type:
Calving Percentage 93.2 %
Conception Rate 71.5 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	93.2	93.2	93.2	93.2	93.2
Number of Calves	415	342	342	342	342
Heifers	208	171	171	171	171
Steers	207	171	171	171	171
Pregnancy Rate	71.5	71.5	71.5	71.5	71.5
Cows pregnant	322	322	322	322	322
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	155	120	120	120	120
Steers (3.5 %)	200	165	165	165	165

Average Winter Type:
Calving Percentage 93.2 %
Conception Rate 71.6 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	93.2	93.2	93.2	93.2	93.2
Number of Calves	415	342	342	342	342
Heifers	208	171	171	171	171
Steers	207	171	171	171	171
Pregnancy Rate	71.6	71.6	71.6	71.6	71.6
Cows pregnant	322	322	322	322	322
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	155	120	120	120	120
Steers (3.5 %)	200	165	165	165	165

Table 5.15: Cow Herd Performance Factors and Herd Production Figures, Meadow Feeding, Severe and Very Severe Winters.

Severe Winter Type:
Calving Percentage 95.2 %
Conception Rate 80.7 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	95.2	95.2	95.2	95.2	95.2
Number of Calves	423	389	389	389	389
Heifers	212	195	195	195	195
Steers	211	194	194	194	194
Pregnancy Rate	80.7	80.7	80.7	80.7	80.7
Cows pregnant	363	363	363	363	363
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	159	142	142	142	142
Steers (3.5 %)	204	187	187	187	187

Very Severe Winter Type:
Calving Percentage 93.7 %
Conception Rate 75.5 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	93.7	93.7	93.7	93.7	93.7
Number of Calves	417	360	360	360	360
Heifers	209	180	180	180	180
Steers	208	180	180	180	180
Pregnancy Rate	75.5	75.5	75.5	75.5	75.5
Cows pregnant	340	340	340	340	340
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle Sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	156	129	129	129	129
Steers (3.5 %)	201	174	174	174	174

very severe winter scenario because of greater emergency hay requirements (Table 5.14). Total costs are lowest for the severe winter scenario as a result of lower protein supplement use and hay interest expense. Average and mild winters have the lowest wintering costs among the scenarios totaling \$44.45 and \$44.49, respectively.

The greater yearly decreases between ranch net returns during the mild and average winters, relative to the severe and very severe scenarios, is due to significantly lower cow conception rates under these climate types. Conception rates are 71.5 and 71.6 percent in the mild and average winter scenarios, while conception rates of 80.7 and 75.5 percent are achieved during the severe and very severe winters (Table 5.14 and 5.15). This disparity has occurred because during the two milder winter types cows are feeding on lower quality meadow grasses for longer periods of time than during the severe winters.[1] As a result these cows lose significantly more weight than cows supplemented with greater amounts of emergency feed during the severe winters. Since cow monthly weight changes during gestation have been determined to affect cow conception rates, the greater weight losses for cows in the milder winters translate into lower conception rates over these scenarios (Equation 4.7).

Calving rates for the cows in the mild, average, severe, and very severe winter types measured 93.2, 93.2, 95.2, and 93.7 percent,

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[1] Cows feed on meadow for 17 weeks during thé mild and average winters. During the severe winter cows feed on meadow during 14 weeks of the winter period, and during the very severe winter cows feed on the meadows only 111 weeks out of the winter.

respectively (Table 5.14 and 5.15). Again, meadow grazing cows exposed to the severe winters have better reproductive responses than cows exposed to milder winters. The number of calves sold in the fall were highest for the severe winter scenario with 159 heifers and 204 steers sold in year one and 142 heifers and 187 steers sold during years two through five. The number of calves marketed for the very severe winter are 156 heifers and 201 steers in year one and 129 heifers and 174 steers for years two through five. The mild and average winter types have identical numbers of calves sold. In year one 155 heifers and 200 steers are marketed and in years two through five 120 heifers and 165 steers are sold each year.

Utilization of the meadow forage varied over the climatic scenarios. Each scenario begins the winter with 642.6 tons of meadow forage, and 448.88 tons of baled hay for supplemental, and emergency feed supplies. Of the 642.6 tons of meadow allocated to the system, all the forage was utilized during the mild and average winter scenarios with 236.35 tons of baled hay also being consumed (Tables 5.16 and 5.17). A total of 8.53 tons of hay is sold in the fall and 212.62 tons of hay is recovered and sold in the spring.

In the severe winter and very severe winters, 529.2 and 415.8 tons of meadow forage are utilized for the respective winters (Tables 5.18 and 5.19). Wasted meadow forage totaled 113.4 tons in the severe winter and 226.8 tons in the very severe winter. Baled hay consumption totaled 378 tons in the severe winter with the

Table 5.16: Native Meadow and Rangeland Usage: Meadow Feeding System for a Mild Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	457.40	457.40
Hay retained	448.88	448.88
Fall hay sale	8.53	8.53
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	642.60	642.60
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Utilization:		
Baled Hay		
Hay retained	236.35	236.35
Purchased hay	0.00	0.00
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Waste:		
Baled Hay	212.62	212.62
Raked Hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Winter use	0.00	0.00
Recovered:		
Baled Hay		
Spring hay sale	212.62	212.62

Table 5.17: Native Meadow and Rangeland Usage: Meadow Feeding System for an Average Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	457.40	457.40
Hay retained	448.88	448.88
Fall hay sale	8.53	8.53
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	642.60	642.60
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Utilization:		
Baled Hay		
Hay retained	236.35	236.35
Purchased hay	0.00	0.00
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Waste:		
Baled Hay	212.62	212.62
Raked Hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Winter use	0.00	0.00
Recovered:		
Baled Hay		
Spring hay sale	212.62	212.62

remaining 71.88 tons of hay being sold in the spring. Baled hay consumption for the very severe winter totaled 448.88 tons, of which 71.88 tons were purchased from outside sources to meet feed requirements.

Using snow depth level probabilities, the expected net returns to the meadow grazing alternative are estimated to be $245.23 in year one, decreasing to $202.24 per year for years two through five (Table 5.20 and 5.21). Variance of the meadow grazing returns are 102.354 for year one, and 81.265 for years two through five. The lower variance in years two though five reflect a greater concentration of scenario net returns about the expected net return for the alternative. This is due to several reasons. In each scenario all cows are assumed to possess the ability to calve in the spring following the first winter period. Since the disparity in calving rate is fairly small, fall calf sales among the scenarios are approximately the same the first year. However, better reproductive performances by cows in the severe and very severe winters in comparison to cows in the mild and average winters translate into higher cattle sales during the severe winter scenarios in subsequent years. As a consequence, the drop in revenues to the ranch in the severe winter types is less than the reduction of receipts during the mild and average winter types. This results in reduced variability in net returns among the scenarios.

Table 5.18: Native Meadow and Rangeland Usage: Meadow Feeding System for a Severe Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	457.40	457.40
Hay retained	448.88	448.88
Fall hay sale	8.53	8.53
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	642.60	642.60
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Utilization:		
Baled Hay		
Hay retained	378.00	378.00
Purchased hay	0.00	0.00
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	529.20	529.20
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Waste:		
Baled Hay	0.00	0.00
Raked Hay		
Winter use	0.00	0.00
Standing Pasture	113.40	113.40
Range Forage		
Winter use	0.00	0.00
Recovered:		
Baled Hay		
Spring hay sale	70.88	70.88

Table 5.19: Native Meadow and Rangeland Usage: Meadow Feeding System for a Very Severe Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	457.40	457.40
Hay retained	448.88	448.88
Fall hay sale	8.52	8.52
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	642.60	642.60
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Utilization:		
Baled Hay		
Hay retained	448.88	448.88
Purchased hay		70.88
Raked Hay		
Summer use	0.00	0.00
Winter use	0.00	0.00
Standing Pasture	415.80	415.80
Range Forage		
Summer use	9,000.00	337.50
Winter use	0.00	0.00
Waste:		
Baled Hay	0.00	0.00
Raked Hay		
Winter use	0.00	0.00
Standing Pasture	226.80	226.80
Range Forage		
Winter use	0.00	0.00
Recovered:		
Baled Hay		
Spring hay sale	0.00	0.00

Table 5.20: Expected Net Returns for Meadow Feeding, Year One, Based Upon Winter Snow Depth Level Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net Return ($)	Adjusted Net Return ($)
1	Mild	.319	250.38	79.87
1	Average	.417	250.30	104.38
1	Severe	.167	239.11	39.93
1	Very severe	.097	217.04	21.05
Expected Net Return, year 1				245.23

Variance = 102.354

Table 5.21: Expected Net Returns for Meadow Grazing, Year 2-5, Based Upon Winter Snow Depth Level Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net Return ($)	Adjusted Net Return ($)
1	Mild	.319	201.99	64.43
1	Average	.417	202.21	84.32
1	Severe	.167	215.97	36.07
1	Very severe	.097	179.59	17.42
Expected Net Return, year 2-5				202.24

Variance = 81.265

Range Grazing

Net returns to the range grazing alternative vary to a large degree across the four climate scenarios, but variability between years one and two through five for each scenario is relatively low (Table 5.22). The variability of ranch net returns between the scenarios is a result of differing requirements concerning emergency hay feeding, hay hauling costs, and the amount of spring hay sales.

Net returns are highest for the mild winter type, benefiting from greater spring hay sales. Net returns in year one are \$304.07 and \$301.07 for years in years two through five (Table 5.22). Net returns for the average, severe and very severe winter scenarios, ranked in decreasing dollar amount, are \$278.09, \$254.09, and \$233.63 per cow in year one, and \$275.40, \$246.96, and \$226.50 in years two through five.

In general total program and wintering costs increase with the severity of the winter (5.22). Per cow wintering costs escalate from \$53.17 in the mild type winter to \$90.32 in the very severe winters. Wintering costs for the average and severe winter types are \$64.44 and \$72.81 per cow, respectively. Total program cost decrease over the average and severe winter types, from \$106.32 to \$106.11 per cow, but increase to \$121.04 in the very severe winter due to outside purchases of emergency hay. The decrease in total costs between the average and severe winters results from lower hay interest costs.

Conception and calving rates were exogenously determined using Squaw Butte data. Cows in the mild and average winters had

Table 5.22: Per Cow Net Returns, Program Costs, and Winter Costs: Range Grazing.

Winter Type	Year	Total Cost	Winter Cost	Net Return
Mild	1	106.32	53.17	304.07
	2-5	106.32	53.17	301.37
Average	1	106.25	64.44	278.09
	2-5	106.25	64.44	275.40
Severe	1	106.11	72.81	254.09
	2-5	106.11	72.81	246.96
Very Severe	1	121.04	90.32	233.63
	2-5	121.04	90.32	226.50

conception rates of 88 percent and calving rates of 97.5 percent (Table 5.23). Conception and calving rates for the severe and very severe winters are 86.5 and 96.0 percent respectively (Table 5.24).

The number of calves sold in the fall are highest during the mild and average winters, with 164 heifers and 209 steers sold in year one, and 162 heifers and 207 steers sold during years two through five (Table 5.23). The number of calves marketed for the severe and very severe winters are 161 heifers and 206 steers in year one and 156 heifers and 201 steers for years two through five (Table 5.24).

Utilization of rangeland and meadow hay resources during the winter varies depending upon the climatic scenario. Each scenario begins the winter with 8 weeks of baled hay equaling 378 tons and 22 weeks of range forage equaling 762.3 tons. In each scenario 360.54 tons of hay are sold in the fall and two months of rake-bunched hay, totaling 361.46 tons, is consumed during the summer.

In the mild winter all range forage is utilized and all the retained hay is sold in the spring (Table 5.25). During the average winter 623.7 tons of range forage is used leaving 138.6 tons un-utilized (Table 5.26). Four weeks of baled hay is required (189 tons) with the remainder sold in the spring (189 tons). In the severe winter 519.75 tons of range forage is consumed, leaving 242.55 tons unused (Table 5.27). Seven weeks of baled hay are used, leaving 47.25 tons of hay for spring sale. Only 415.8 tons of range forage is utilized during the very severe winter with 346.5 tons remaining unused. Cows require 10 weeks of emergency feed in the

Table 5.23: Cow Herd Performance Factors and Herd Production Figures, Range Grazing, for Mild and Average Winters.

Mild Winter Type:
Calving Percentage 97.5 %
Conception Rate 88.0 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	97.5	97.5	97.5	97.5	97.5
Number of Calves	434	430	430	430	430
Heifers	217	215	215	215	215
Steers	217	215	215	215	215
Pregnancy Rate	88.0	88.0	88.0	88.0	88.0
Cows pregnant	396	396	396	396	396
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	164	162	162	162	162
Steers (3.5 %)	209	207	207	207	207

Average Winter Type:
Calving Percentage 97.5 %
Conception Rate 88.0 %

Herd Characteristic	Year 1	2	3	4	5
Breeding herd size	450	450	450	450	450
Calving rate	97.5	97.5	97.5	97.5	97.5
Number of Calves	434	430	430	430	430
Heifers	217	215	215	215	215
Steers	217	215	215	215	215
Pregnancy Rate	88.0	88.0	88.0	88.0	88.0
Cows pregnant	396	396	396	396	396
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	164	162	162	162	162
Steers (3.5 %)	209	207	207	207	207

Table 5.24: Cow Herd Performance Factors and Herd Production Figures, Range Grazing, Severe and Very Severe Winters.

Severe Winter Type:
Calving Percentage 96.0 %
Conception Rate 86.5 %

Herd Characteristic	Year 1	2	3	4	5
Breeding herd size	450	450	450	450	450
Calving rate	96.0	96.0	96.0	96.0	96.0
Number of Calves	427	417	417	417	417
Heifers	214	209	209	209	209
Steers	213	208	208	208	208
Pregnancy Rate	86.5	86.5	86.5	86.5	86.5
Cows Pregnant	389	389	389	389	389
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	161	156	156	156	156
Steers (3.5 %)	206	201	201	201	201

Very Severe Winter Type:
Calving Percentage 96.0 %
Conception Rate 86.5 %

Herd Characteristic	Year 1	2	3	4	5
Breeding Herd Size	450	450	450	450	450
Calving Rate	96.0	96.0	96.0	96.0	96.0
Number of Calves	427	417	417	417	417
Heifers	214	209	209	209	209
Steers	213	208	208	208	208
Pregnancy Rate	86.5	86.5	86.5	86.5	86.5
Cows pregnant	389	389	389	389	389
Cows culled	45	45	45	45	45
Cows retained	405	405	405	405	405
Replacement heifers	45	45	45	45	45
Cattle sold (death loss)					
Cull cows (2.0 %)	36	36	36	36	36
Heifers (3.5 %)	161	156	156	156	156
Steers (3.5 %)	206	201	201	201	201

Table 5.25: Native Meadow and Rangeland Usage: Range Grazing System for a Mild Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	738.54	738.54
Hay retained	378.00	378.00
Fall hay sale	360.54	360.54
Raked Hay		
Summer Use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	0.00	0.00
Winter use	22,250.00	762.30
Utilization:		
Baled Hay		
Hay retained	0.00	0.00
Purchased hay		0.00
Raked hay		
Summer use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	22,250.00	762.30
Winter use	0.00	0.00
Waste:		
Baled Hay	378.00	378.00
Raked hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Winter use	0.00	0.00
Recovered:		
Baled hay		
Spring hay sale	378.00	378.00

Table 5.26: Native Meadow and Rangeland Usage: Range Grazing System for a Average Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	738.54	738.54
Hay retained	378.00	378.00
Fall hay sale	360.54	360.54
Raked Hay		
Summer Use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	0.00	0.00
Winter use	22,250.00	762.30
Utilization:		
Baled Hay		
Hay retained	189.00	189.00
Purchased hay		0.00
Raked hay		
Summer use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	0.00	0.00
Winter use	18,409.10	623.70
Waste:		
Baled Hay	189.00	189.00
Raked hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Winter use	4,090.90	138.60
Recovered:		
Baled hay		
Spring hay sale	189.00	189.00

Table 5.27: Native Meadow and Rangeland Usage: Range Grazing System for a Severe Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	738.54	738.54
Hay retained	378.00	378.00
Fall hay sale	360.54	360.54
Raked Hay		
Summer Use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	0.00	0.00
Winter use	22,500.00	762.30
Utilization:		
Baled Hay		
Hay retained	330.75	330.75
Purchased hay	0.00	0.00
Raked hay		
Summer use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage (AUMs)		
Summer use	0.00	0.00
Winter use	15,341.00	519.75
Waste:		
Baled Hay	47.25	47.25
Raked hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage (AUMs)		
Winter use	7,159.00	242.55
Recovered:		
Baled hay		
Spring hay sale	47.25	47.25

Table 5.28: Native Meadow and Rangeland Usage: Range Grazing System for a Very Severe Winter.

Forage Unit	Land Area (acres)	Forage Production (tons)
Production:		
Baled Hay	738.54	738.54
Hay retained	378.00	378.00
Fall hay sale	360.54	360.54
Raked Hay		
Summer Use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	0.00	0.00
Winter use	22,500.00	762.30
Utilization:		
Baled Hay		
Hay retained	378.00	378.00
Purchased hay		94.50
Raked hay		
Summer use	361.46	361.46
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Summer use	0.00	0.00
Winter use	12,272.73	415.80
Waste:		
Baled Hay	47.25	47.25
Raked hay		
Winter use	0.00	0.00
Standing Pasture	0.00	0.00
Range Forage		
Winter use	10,227.27	346.50
Recovered:		
Baled hay		
Spring hay sale	0.00	0.00

scenario. Since all eight weeks of emergency stocks are used, an outside purchase of 94.5 tons of hay is required to cover the remaining two weeks.

Expected net returns to the range grazing alternative equal $292.18 in year one and $288.97 per year for years two through five (Table 5.29 and 5.30). These represent the highest returns among the four feeding alternatives given the assumptions used to assess the range grazing program. The variances estimated for the returns are 354.776 in year one and 399.120 for years two through five, indicating a high degree of variability in the return to the range grazing alternative.

Discussion

The main objective of the thesis has been to identify alternative winter cattle feeding programs that have the potential to increase net returns to cow-calf operations of the Harney Basin compared to traditional practices of feeding baled hay. Comparing the alternatives with each other and the baled hay practice will be achieved through assessment of expected net returns to each feeding program and evaluating the risks associated with the alternatives. Additional economic measures used in the evaluation include the costs to individual feeding programs, the sources of income to the alternatives, and the relative proportion of total revenue attributed to hay and cattle sales for each feeding system. Other important considerations in adopting an alternative are cattle production characteristics and the ease or difficulty of implementing the

Table 5.29: Expected Net Returns for Range Grazing, Year One, Based Upon Winter Snow Depth Level Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net return ($)	Adjusted Net Return ($)
1	Mild	.667	304.07	202.81
1	Average	.222	278.09	61.74
1	Severe	.083	254.09	21.09
1	Very severe	.028	233.63	6.54
Expected Net Return, year 1				292.18

Variance = 354.776

Table 5.30: Expected Net Returns for Range Grazing, Year 2-5, Based Upon Winter Snow Depth Level Probabilities of the Harney Basin, Oregon.

Year	Winter Type	Probability	Net Return ($)	Adjusted Net return ($)
2-5	Mild	.667	301.37	201.01
2-5	Average	.222	275.40	61.12
2-5	Severe	.083	246.96	20.50
2-5	Very severe	.028	226.50	6.34
Expected Net Return, year 2-5				288.97

Variance = 399.190

system to the management strategy of a particular ranch unit.

The range grazing and rake-bunch hay alternatives generated the highest expected returns while the baled hay and meadow grazing alternatives produced significantly smaller returns. Expected returns to the baled hay alternative are $50 to $60 below the range grazing and rake-bunch alternatives. After the first year, expected returns to the meadow grazing system are $85 to $90 below the range and rake-bunch methods and approximately $33 below baled hay feeding. Expected net returns to the rake-bunch hay alternative are about $10 less in year one, and about $5 less per-cow than the range grazing system. However, the program has higher returns during the average, severe, and very severe winters (Tables 5.31 and 5.32).

Program and wintering costs are lowest for the rake-bunched hay alternative. In addition, costs to the rake-bunched system remain unchanged across the weather scenarios indicating that the feeding system is generally unaffected by winter weather conditions found in the Basin. Costs to the meadow grazing alternative are next lowest among the scenarios. However, costs increase with the severity of the winter as determined by the number of weeks of significant snow depth level.[2] Total program costs are highest for the range grazing alternative followed by the baled hay alternative. For the wintering period, costs to the baled hay program are lower during

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[2] Although some costs decrease, such as the amount of protein supplement required and labor and machinery requirements of feeding supplement, the overall costs increase due to higher costs associated with emergency hay feeding.

Table 5.31: Net Returns to Feeding Alternatives by Winter Type Year 1.

	Mild	Average	Severe	Very Severe	Expected Return
Rake-bunch Hay	282.68	282.72	282.39	281.99	282.65
Range Grazing	304.07	278.09	254.09	233.63	292.18
Baled Hay	235.01	235.19	234.72	234.36	234.85
Meadow Grazing	250.38	250.30	239.11	217.07	245.23

Table 5.32: Net Returns to Feeding Alternatives by Winter Type Years 2-5

	Mild	Average	Severe	Very Severe	Expected Return
Rake-bunch Hay	283.48	283.27	281.69	281.70	283.07
Range Grazing	301.37	275.40	246.96	226.50	288.97
Baled Hay	235.67	235.36	233.88	234.07	235.20
Meadow Grazing	201.99	202.21	215.97	179.59	202.24

the severe and very severe winters than those of the range grazing alternative. During the two milder winters, costs of the baled hay program are higher than the range grazing option. Winter costs of the range grazing program are higher in the severe winters due to greater emergency hay costs, labor requirements, and hay hauling costs.

In terms of proportions of ranch sales revenue, the range grazing system is heavily dependent upon hay sales to generate the high returns associated with the two milder winter types (Tables 5.33 and 5.34). Even during the severe winter scenarios, income derived from hay sales helps to offset the higher program expenses and wintering costs associated with the alternative. The greater dependence upon hay sales of the program make it vulnerable to the effects of winter snows. As winter severity increases the amount of hay sold decreases, thereby reducing ranch revenues and net returns. In contrast, cattle production and associated sales play a greater role in producing income to the rake-bunch, meadow grazing, and baled hay options. In addition, because the baled and rake-bunch hay alternatives are not influenced by snow depth, the amounts of hay sold for these programs remains unaffected.

Production risks as measured by scenario expected net returns and variances to the expected net return indicate that the least risky alternatives are the rake-bunch hay and baled hay feeding programs. Very little variation in income occurs over a scenarios five year time horizon or across the four climate scenarios of each alternative. Although the range grazing provides the greatest

Table 5.33: Percentage of Cattle Sales and Hay Sales In Ranch Revenue by Forage Type and Winter Scenario, Year 1.

	Mild	Average	Severe	Very Severe
Rake-Bunch Hay				
Cattle Sales	91.6	91.6	91.6	91.5
Hay Sales	8.4	8.4	8.4	8.5
Range Grazing				
Cattle Sales	75.2	80.3	84.4	85.7
Hay Sales	24.8	19.7	15.6	14.3
Baled Hay				
Cattle Sales	95.6	95.6	95.6	95.6
Hay Sales	4.4	4.4	4.4	4.4
Meadow Grazing				
Cattle Sales	90.2	90.2	96.3	99.6
Hay Sales	9.8	9.8	3.7	0.4

Table 5.34: Percentage of Cattle Sales and Hay Sales In Ranch Revenue by Forage Type and Winter Scenario, Year 2-5.

	Mild	Average	Severe	Very Severe
Rake-Bunch Hay				
Cattle Sales	91.8	91.6	91.5	91.5
Hay Sales	8.2	8.4	8.5	8.5
Range Grazing				
Cattle Sales	75.0	80.2	84.1	85.4
Hay Sales	25.0	19.8	15.9	14.6
Baled Hay				
Cattle Sales	95.7	95.6	95.6	95.6
Hay Sales	4.3	4.4	4.4	4.4
Meadow Grazing				
Cattle Sales	88.4	88.4	96.0	99.5
Hay Sales	11.6	11.6	4.0	0.5

expected return, income to this system is the most variable compared to the other feeding alternatives. This is demonstrated by the large differences in net returns occurring between scenarios (or the high variances in the expected net returns of the alternative). As indicated previously variability in expected returns of the range grazing alternative, result from differences in (1) the amount of hay sold and (2) the level of emergency feeding required between scenarios as dictated by winter severity. Returns to the meadow grazing alternative are also dependent upon winter severity. However, variability in net returns occurs not only across scenario types, but between the first and second through fifth years of production of each scenario. Variability in expected net return is caused by (1) different reproductive characteristics which affect cattle production figures and the numbers of animals sold yearly and (2) the amount of emergency hay required.

Acceptable measurements of cow reproductive factors and numbers of cattle produced for sale are achieved in the simulation for both rake-bunched hay and baled hay feeding. The simulation results correlate with recent test data monitoring the systems. The range grazing alternative, as explained in Chapter IV, does not use the simulator to provide cow reproductive measurements. Instead a conservative estimate using Squaw Butte trial data is used to calculate ranch cattle production.

Cow reproductive performance and cattle production for the meadow grazing simulation are significantly lower than the other alternatives. As a result, cattle sales are substantially lower for the meadow grazing alternative than the other programs. Cow reproductive performance for the meadow grazing simulation fit test trial data for the mild and average winter scenarios, but over all are slightly higher than the actual data. This may be due to the model not forcing cows through on meadows as in the test trials during the severe winters, but immediately providing emergency feed as soon as adverse snow conditions occur. In general, cows in the simulation put on more weight than cows in the actual trials for these winter types. In addition, there may be biological factors not corrected by the model that explains the generally lower performance of cows in the test trials.

Conclusions and Recommendations

Based upon the results provided by the simulation, conclusions and recommendations can be made regarding the feeding alternatives. In general, these conclusions and recommendations support those arrived at by Squaw Butte researchers.

It is evident from the results that the meadow grazing alternative is not an adequate substitute to baled hay feeding. Cow reproductive performance is poor, lowering yearly cattle production and reducing revenues from cattle sales to the operation. Besides having lower net returns than baled hay program, the alternative is risky as demonstrated by the variability in net returns between the winter scenarios. The program is costly from the standpoint of emergency hay requirements and unutilized meadow forage in severe winters. Bringing cow reproductive performance up to the level achieved by feeding baled hay and increase calf production would require additional amounts of protein supplement. This would drive meadow grazing costs above expenditures required for baled hay feeding and nullify any benefits achieved through increased cattle production.

Compared to traditional methods of feeding out baled hay over the winter, results indicate that both rake-bunched hay feeding and range grazing programs provide ranchers with the means to improve net returns to the operation. There are five major advantages of the rake-bunched feeding in relation to the baled hay method. First, although revenues to the rake-bunch hay and baled hay systems are approximately equal, significantly lower costs in rake-bunch feeding result in higher net returns to the program. The difference in costs between the two systems is approximately $41 per head, which is about $10 more than earlier estimates made at Squaw Butte. This difference is attributed to calculating a 15 percent feeding waste to the baled hay system. Second, since cows are able to successfully feed through abnormally deep snows, there appears to be little risk of the system failing due to snow conditions. This is confirmed by low variances to the expected net return of the rake-bunch alternative. Third, the program can be easily adapted to most cow-calf operations in the region. Investment in materials is low and management of the system can be easily incorporated and administered by most ranch operations. Investment requirements are limited to the purchase and erection of low cost, moveable New Zealand type electric fence. Management requires moving the fence once a week to allow cows to feed on rake bunches section by section.[3] Fourth, since the owner-operator is assumed to provide much of the winter labor the savings in labor requirements not only reduce labor costs but provide the manager with additional time to be used as he or she may chose. The additional time could be used by the operator in a variety of ways such as earning extra income (non-farm), repairing machinery, or making improvements to the operation. For comparative purposes, Table 5.35 provides labor requirements for each alternative, totaled and averaged over the 22 week winter period. Fifth, a support system and technical expertise is available in the region to aid ranchers in introducing rake-bunch methods to their operations. Support and technical assistance can be provided by personnel at the Squaw Butte Experiment Station and through county extension offices.

Advantages of the range grazing alternative compared to baled hay feeding are similar to the rake-bunch alternative. Except for the very severe winter, range-grazing generates higher returns than baled hay feeding. Even in the very severe scenario net returns are only $4 less per cow than the baled hay group. Cow performance factors are similar, although calves are generally heavier due to better late summer nutrition of the mother cows. The management of the program may be more intensive. Besides the requirements of the actual wintering program (feeding of supplement every other day or

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[3] The time period for moving fence can vary from a few days to a maximum of two weeks depending upon management choice.

Table 5.35: Total Winter and Average Weekly Number of Hours Required by Feeding Alternatives as Influenced by Winter Conditions.

Feed Alternative	Winter Labor Hours							
	Mild		Average		Severe		Very Severe	
	Total	Week	Total	Week	Total	Week	Total	Week
Rake-bunch	11	0.5	11	0.5	11	0.5	11	0.5
Baled hay	756	34.4	756	34.4	756	34.4	756	34.4
Meadow grazing	313	14.2	317	14.4	441	20.6	570	25.9
Range grazing	256	11.6	471	21.4	632	28.7	793	36.0

providing emergency hay) the rangeland used for grazing must be managed to provide enough forage to feed the cows through the winter. This is partially accomplished by removing cows from rangeland during August and September in the feeding program. The program will most likely require deferred grazing during the spring and summer of locales to be grazed over the winter or removing cows from the area in the early spring to allow for enough plant regrowth. Resting range during the growing season could have advantages in terms of improving range conditions to an area. Allowing range grasses to grow and set seed could increase forage production on sites, providing better forage conditions for cattle, reducing erosion and the loss of top-soil. Investment are limited to the purchase of feed troughs for feeding supplement. As with the fencing requirements for the rake-bunch and meadow grazing alternatives this is a fairly low cost expenditure.

Winter grazing of rangeland is used extensively on a number of ranches in the High Desert with excellent results. The Hatfield Ranch near Brothers, Oregon is one example and there are several ranches in the Harney Basin and in Lake County that also winter graze. However, the areas used by these ranches for winter grazing do not receive extensive amounts (if any) of snowfall as may be experienced by the study area or are not in higher elevation areas of the Basin.

Disadvantages of the range grazing system center around the high variability in net returns making this a risky alternative, although the expected return is still higher than baled hay feeding.

Risk to the system occurs due to snow depth levels reducing the ability of cows to feed on range forages. Since the alternative depends heavily on spring hay sales to offset the higher costs to the program, increases in winter severity reduce those hay sales and returns to the operation fall off correspondingly.

The alternative, at least initially, requires different and more intensive management. This could be viewed as a disadvantage by some operators. Two management factors include: (1) organizing emergency feeding procedures and (2) coordinating grazing plans of the operation with owned land resources, public land agencies, and/or private land owners to provide enough winter forage.

As addressed earlier in the thesis, there remain several questions regarding when snow depth levels prohibit cattle from foraging for food. The array of estimates on snow depth and when it restricts cattle feeding, make it difficult to fully predict cattle response and to accurately predict economic consequences. In addition, the type of snow, composition of the site vegetation, terrain factors, and elevation will influence where cattle may feed over the winter. All these factors must be considered when developing a winter grazing plan.

When comparing rake-bunch hay with range grazing it appears that rake-bunch feeding is the best alternative to baled hay for ranch operations in the Harney Basin at this time. Although expected net returns to rake-bunch hay feeding are smaller (about 2.0 %) than the range grazing alternative, the rake-bunch feeding is relatively risk free compared to the the range grazing system.[4] This is demonstrated by the extremely low variances to expected net returns for the rake-bunch hay system, while variability in returns to range grazing is high. Cows feeding on rake-bunch are essentially unaffected by excessive snow depth levels that may occur in the area.

Management time and effort is reduced by the rake-bunched hay system while the range grazing alternative requires considerably more effort in execution (Table 5.35). During mild winters the difference in average weekly management time is 11 hours but increases to 35.5 hours in very severe winters. Management time and costs of planning a winter grazing program was not measured in the simulation but should be considered when assessing this alternative. The range grazing system is still a promising alternative as demonstrated by the high returns to the program in the simulation. However, the data used in the simulation to assess the range system is not as complete as information regarding the other feeding alternatives. Only two years of data was available compared to almost ten years of data for the rake-bunch and baled hay systems. More information is needed to assess; (1) effects of snow on this method of feeding cattle over the winter (2) range improvement possibilities that may exist due to different grazing strategies being implemented and (3) areas in the region need to be identified that offer the possibility of winter

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[4] The difference in expected net returns between range grazing and rake-bunch hay would be affected if forage resources where utilized differently in the simulation. Instead of selling excess forage as hay, forage could be used as pasture in the spring and summer for the cow herd or a yearling operation. This may change the conclusions reached in the thesis.

grazing with reduced risks of heavy snows occurring and/or have better forage quality to reduce or eliminate supplemental feeding.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

United States agriculture has suffered severe financial difficulties in the 1980's. Falling commodity prices coupled with rising costs to agricultural operations has depressed farm incomes. In addition, rising interest rates and declining land values has further increased the level of financial stress experienced by agricultural operators. This has made it difficult for operators to finance operations and/or meet loan obligations. Western cattle operations have not been immune to the financial problems besetting the United States agricultural industry. Between 1980 and mid-1987 cattle ranch operations suffered from declining incomes and enterprise profitabilities (Bartlett, 1983; Hewlett, 1987). A combination of four factors have been responsible for creating the financial crisis in ranch communities. These factors include (1) ranch input prices increasing relative to prices received for marketed output, (2) Federal government policies to control inflationary pressures and stimulate economic growth simultaneously in the early 1980's, (3) declining land values, and (4) demand and supply conditions (in general) in the United States consumer market.

Since the fall of 1987, the economic outlook for ranches in the western United States has improved. Cattle prices have increased and returns to cattle enterprises have been steadily improving (USDA, 1989). Future forecasts of the financial performance in the ranch community suggest continued improvement over the next few years (USDA, 1989).

However recent improvements in the economic outlook for the cattle industry do not reduce incentives to develop more efficient and productive strategies for operating profitable ranch enterprises and building financial stability. The risks of future financial shocks to United States agriculture resulting from national and international economic policies and conditions require managers to develop strategies that not only increase ranch incomes but reduce financial risk to the operation. Recommended strategies include reducing ranch input expenses, expanding existing markets and/or developing new market niches, improving ranch productivity, and restructuring financial obligations and capital holdings.

The purpose of this thesis has been to assess the economic and managerial feasibility of introducing three alternative winter feeding programs to cattle operations in the Harney Basin, Oregon. The primary objective has been to identify from the assessment those alternatives that have the greatest potential to increase returns above variable costs to a typical cow-calf operation found in the Basin. The three feeding alternatives evaluated include strip grazed rake-bunch hay, strip grazed uncut native meadow, and range grazing. These alternatives are compared to baled hay feeding, the prevalent winter feeding practice of the region

A biophysical, economic simulation model was constructed to evaluate the feeding alternatives. The model design is based upon an extensive review of the literature pertaining to relationships linking cow nutritional requirements with cow physiological status, the effect of the physical environment on wintering cows, and recent models used to simulate beef production systems.

Observations from the literature yielded a number of important considerations in construction of the model. First, nutrition during pregnancy influences the calving and re-breeding success of cows. Unless cows enter the winter period in exceptionally good condition, poor nutrition during middle and late gestation often will result in reduced calf crops and lower conception rates in the breeding herd (Wiltbank et al., 1964; Bellows and Short, 1978). In general, to achieve high calf crops and conception rates, cows must maintain or increase condition through the winter months (Lewis).

Environmental conditions play a critical role in influencing the nutrition and feeding success of wintering beef cows. Major environmental determinants include effective air temperature, diurnal temperature fluctuations, snow depth, and the frequency of severe storms. Effective air temperature (EAT) is the most prevalent climate factor affecting beef cattle. When EAT falls below a cows thermonuetral zone, cows must increase maintenance energy intake to maintain homeostatic conditions. This generally requires increased dry matter intake of roughage. A number of variables work in combination with ambient air temperature to affect the cow's thermal environment. These factors include wind velocity, humidity, solar radiation, and rain. Environmental conditions also affect cow behavior influencing dry matter intake, and the cow's ability to successfully forage for food. These variables include snow depth, rain, sudden changes in effective air temperature, and storms. In the thesis snow depth affects the foraging ability of cows on range and uncut meadows.

The simulation model integrates a system of seven subroutines to yield information on cow reproductive performance, cattle production, forage utilization, and economic valuations for each feeding program. The subroutines include (1) calculation of late summer feeding costs, (2) inputing climatic variables, (3) determination of forage availability and quality, (4) estimation of cow nutritional requirements, intake, and monthly weight changes, (5) measurement of cow and herd reproductive performance, (6) determination of herd production and forage utilization, and (7) calculation of the net returns to the feeding systems.

The biophysical portion of the simulation uses a net energy system of equations to measure monthly weight changes of wintering cows based upon differences between a cows net energy intake and net energy requirements. The system of equations reflect the influences of the thermal environment, snow conditions, forage quality factors, and physiological status on cow nutritional requirements and intake levels. Monthly weight changes of the cows are used in determining calving and conception rates of the ranch herd.[1] Information on cow reproductive performance is used to estimate ranch cattle production

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[1] Rake-bunch, meadow grazing, and baled hay alternatives use estimated equations based upon winter weight changes to determine reproductive performance. The reproductive performance of winter range grazing cows is estimated from trial results.

which is interfaced with forage utilization estimates in the economic subsection to yield net returns to the feeding programs.

Risk is introduced into the simulation by varying temperature and snow depth climatic components. Each feeding program has four weather scenarios representing mild, average, severe, and very severe winters.[2] The climatic scenarios were constructed based upon historical weather data of the region and assumptions regarding minimum snow depth levels preventing cattle feeding for each alternative. Probabilities were assigned to each scenario and are integrated with corresponding economic valuations to yield expected net returns to each feeding programs. The degree of variability to the expected net returns indicates the relative level of risk associated with the individual feeding strategies.

Analysis of the results indicates raked-bunched hay is the best alternative to baled hay feeding. Returns to the rake-bunch hay alternative are nearly $50 per cow higher than the baled hay program. This is accomplished by a substantial reduction in wintering costs since cow reproductive factors and cattle production are nearly identical to the baled hay alternative. There appears to be little risk associated with management of the raked hay alternative. This is demonstrated by a relatively constant level of net returns and costs occurring across the four winter scenarios. Management of the winter operation is simplified. The ranch operator spends about 34 hours less per week managing the brood herd on rake-bunch than on

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[2] The range grazing winters represented are average, above average, severe and very severe.

feeding out baled hay. This additional time could be used in a number of ways, from repairing ranch equipment to earning extra income of the operation.

Overall, results from the simulation indicate range grazing is a promising alternative to baled hay. The expected net returns are higher and cow production performance, judging from the Squaw Butte feeding trials, was acceptable during the first two years of trials (1986-87 and 1987-88). However, the simulation identifies a number of problems when cows are grazed on range during the winter. Although the range grazing program yields superior economic returns to the operation, variability in those returns is much higher than either the baled hay or rake-bunch strategies. When deep snows inhibit cattle from acquiring adequate amounts of feed on range, cows must be fed baled hay. Since the alternative depends to a large extent on hay sales to offset the higher costs of the strategy, deep and prolonged snows require greater amounts of emergency feed. As hay requirements increase, ranch revenues are correspondingly reduced since hay available for sale in the spring is used up as emergency feed. Consequently, there is considerable variation in ranch net returns across the climate scenarios using this strategy.

Management of the operation varies in intensity depending upon winter severity. As winter severity increases labor requirements will increase due to emergency feeding. In all scenarios labor required for rake-bunch hay feeding is significantly lower than range grazing. A number of management costs or requirements are not accounted for in the study. The operation requires development of emergency feeding procedures for cows on winter range in case of prolonged periods of severe weather In addition, greater attention must be placed on planning yearly grazing plans to provide enough forage over the winter period. This would involve adjusting use of the ranch's land resources and/or negotiation with both public and private land owners for winter grazing use.

Empirical evidence is limited regarding the effects of snow depth on the ability of cows to forage successfully on range during severe winters. Complete measures of cow performance and adaptability to severe winters while wintering on high desert rangelands is lacking. This calls into questions the accuracy of input assumptions regarding minimum snow depth levels and cow reproductive measurements. Therefore, more information is needed regarding the effects of snow depth level upon the feeding success of cows on winter range and the reproductive performance of cows following severe winters.

The results of the meadow grazing alternative indicate this strategy does not present itself as a viable alternative to baled hay feeding. Returns to the operation are low as a result of (1) poor cow reproductive performance, subsequently reducing cattle production and (2) the vulnerability of this strategy to relatively shallow snow cover requiring large amounts of expensive and labor intensive emergency hay feeding.

Limitations

Modeling biological systems such as beef cattle production is a difficult task due to a variety of factors. These factors include changing forage quality and environmental conditions, accurately estimating cow nutrient requirements and intake as influenced by physiological and environmental relationships, and measurement of cow reproduction performance. For the purposes of the thesis the simulation has worked reasonably well in identifying the best alternatives and/or most promising alternatives to baled hay feeding. However, a number of factors found in the design features and input assumptions of the model impose some limits to the findings of the thesis. Moreover, the model is not adaptableat present to other beef production systems without extensive re-adjustment.

A major design limitation is the method used to estimate the reproductive success of the cows. Calving and conception rates are estimated using two regression equations. These equations are based upon monthly weight changes of the cows during the five month winter period. These relationships work when comparing alternatives but are dependent upon two assumptions. First, cows in each alternative must enter the winter period in similar condition (i.e. having similar winter preconditioning programs during August and September). Second, cows must then be on similar forage types during the other seven months of the year (March - September). These conditions are met when comparing baled hay feeding with rake-bunched hay and meadow grazing programs. The range grazing alternative does not meet these conditions since these cows enter the winter in better condition and are on a different forage type during 60 days of the seven month non-winter period (i.e. rake-bunched hay from August through September. Using the equations to calculate reproductive performance of range grazing cows would yield results similar to that experienced by meadow grazing cows. This would not agree with test trial data. In the trials, weight losses for range grazing cows were similar to weight losses of meadow grazing cows. However, cows on range could afford to lose weight over the winter given their better condition without adversely affecting reproductive performance. As a result, reproductive performance of range grazing cows had to be exogenously determined using test trial data. Therefore, the estimation of reproductive performance in the simulation for comparing alternatives is limited to programs with similar feeding schedules and where cows begin the winter program in approximately identical condition (or weight given similar frame size).

A second limitation involves accurately determining the effects of snow depth on the foraging and feeding ability of wintering cows. It is fairly clear from the feeding trials that relatively light snows prevent cattle from feeding successfully on uncut meadows. Baled hay and rake-bunch feeding cows are unaffected by deep snows. However, an accurate measure of when and under what terrain conditions and vegetation composition cows on range are affected by snow depth is less clear. Cows on range trials enjoyed relatively mild winters during the first two years of testing. Calving and rebreeding success were good and comparable to baled hay and rake-bunch hay control groups. This past winter was fairly severe and as indicated by higher calve mortality this spring the program did not perform as well as the previous years. Since the criteria for determining reproductive success of range grazed cows in the simulation was based upon milder winters conditions the accuracy of these assumptions can be questioned. Until more complete data becomes available regarding cow productive performance on rangelands following severe winters, the management assessment and economic valuation of the range grazing alternative suffers.

A third limitation to the findings include not economically accounting for the benefits or costs of management time involved in imputing and operating the alternatives when compared to baled hay programs. For instance, range grazing operations will require considerable planning to implement successfully. Another benefit not measured may be improved range condition due to deferring grazing on wintering grounds during the growing season.

Only one type of cow-calf ranch was assessed in the simulation. Differences in ranch operational policy such as calving season, culling procedures, methods and costs of baling hay, and use of available land resources would affect thesis findings to some extent.[3] For example, instead of selling off excess hay ranchers

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[3] The thesis assumed haying was done by custom operation. Cost differences in hay harvest would exist if the owner-operator performed this function. In addition only one type of haying operation was assessed, i.e. harvesting and feeding of 100-130 lb bales. Other systems such as large round bales and stacked hay loafs were not assessed. Besides harvest costs there would be differences in feeding costs, capital expenditures, and depreciation schedules between the different baled hay systems.

could convert this forage source to pasture to add or expand a yearling operation. However, it is believed that rake-bunched hay would remain the best alternative to baled hay feeding in the Harney Basin given changes to the model assumptions.

The model assumes that all costs and revenues accrue to the ranch at the end of the year. In actuality, costs and revenues are payed for and received over the course of the yearly operation, varying in amount depending upon the time of year. For instance, there are large cash expenses involved in hay harvest in the summer and a major portion of ranch revenues typically arrive in the fall when calves and yearlings are sold. Differences in cash flows could influence management acceptance of an alternative. In addition, except for an interest expense assigned to hay left over for spring sale, the model fails to use discounting procedures to correct for differences in monthly or weekly cash flows between alternatives.

The last major limitation is that the simulation does not contain a method of discovering optimal solutions. Since the number of alternatives in the study are few in number, assessing and comparing the feeding programs is not a difficult task. However, the non-optimizing nature of the simulation prevents the model from evaluating a large number of comparable beef production systems and optimizing the operation of a single production system given an array of strategies regarding management of the cattle herd, labor inputs, and use of the resource base.

Recommendations for Future Research

From review of the thesis limitations, recommendations for future research become evident. Recommendations include not only those that improve the methodology and findings of the thesis but also enhance modeling of the total ranch operation. Recommendations center around expanding and improving biological production relationships, developing a broader array of forage base alternatives, and adapting a number of economic valuation techniques to improve management decision making aids.

Many of these improvements could be achieved by expanding the model into a yearly beef production and total ranch management simulation. For instance a major limitation of the thesis is determining cow conception rate given a different winter pre-conditioning programs of pregnant cows. Estimation of cow breeding performance can be accomplished a number of ways in a year long model. One of the better approaches is used in the Texas A&M Beef Production Model (TAMU) (Sanders and Cartwright, 1979b). The TAMU measures cow fertility by combining relationships of cow condition, current weight gain of the cow, lactation status, and the time since calving. This system is adaptable to the present simulation model after expansion to a year-long model.

A yearly production model would also permit the introduction of greater flexibility to the biological and forage base inputs, and factors used and measured in the simulator. This would enable expansion in the number of management strategies and alternatives that could be assessed. For example, the simulator could be adjusted to evaluate fall calving operations and the performance and management of calves and yearlings.

Other management dimensions that could be evaluated are culling strategies, preconditioning of calves and yearlings, land and water improvements, and alternative haying practices. Costs and revenues need to be documented on a weekly or monthly basis and discounted over specified time periods. This would identify cash flow changes and differences between alternative management strategies. Expanding the simulation to a yearly model would require enlarging current budget statements, adding depreciation schedules and income statements, and provide for investment options.

Improvements in forage base options include evaluation of summer grazing programs to determine range carrying capacities based upon forage production-precipitation relationships and terrain factors. In addition, forage nutritional factors could be imputed based upon the seasonal change in range forage quality. This would aid in determining weight gains of calves and yearlings over the summer period given a number of grazing options to a ranch unit. McInnis et al. (1986) have developed a simulation model that determines beef production and optimal carrying capacity for eastern Oregon summer ranges. It may be possible to incorporate methods used in this simulator with the thesis model to develop a year long ranch production setting.

The yearlong model would permit a number of business and market risks to be included in management assessments. For example, drought conditions have profound impacts on forage production and carrying capacity of rangelands. The risk of drought and its effects on various management strategies could be modeled in similar fashion to the thesis interpretations of winter weather risks.

Optimization of simulator output, using linear or quadratic programming, would be useful in whole ranch planning situations, particularly if a large number of options were evaluated. Optimization can be used to evaluate a number of ranch scenarios such as developing calf or yearling marketing strategies, determining efficient carrying capacity of rangelands, developing cost efficient feeding rations, and discovering an efficient set of E-A frontiers for a ranch unit. The advantage of an optimization routine is that it provides a more quantitative assessment for decision making purposes.

As pointed out in the chapter summary, more information is needed regarding snow depth level effects upon the feeding success of cows on range and reproductive performance of these cows following severe winters. This would improve knowledge regarding the limitations of wintering cows on range. This information could be used in combination with climatic data to identify areas in Oregon that may serve as suitable wintering grounds for ranch cow herds.

LITERATURE CITED

Aderogba, K.A., G.M. Sullivan, R.R. Harris, and N.R. Martin Jr. "Gulf Marketing Strategies for Livestock Producers in Alabama: Interfacing a Bioeconomic and Linear Programming Model." American Agricultural Economics Association annual meetings, Iowa State University, Ames, 1985.

Agricultural Research Council. The Nutrient Requirements of Ruminant Livestock. Commonwealth Agricultural Bureau, Surry: The Gresham Press, 1980.

Ames, D.R. "Thermal Environment Affects Livestock Performance." BioScience, 30(1980):457-461.

Ames, D.R. "Assessing the Impact of Climate." In: Limiting the Effects of Stress on Beef Cattle, G. Mobers (ed)., and L.W. Sorenson and J. Weilbald (assoc. eds.). Western Resource Research Project. Bulletin 609 and Utah Agricultural Extension Service Bulletin 512. 1986.

Ames, D.R. Personnel correspondence 1988.

Ames, D.R., and L.W. Insley. "Wind Chill Effect for Cattle and Sheep." Journal of Animal Science, 40(1975):161-165.

Ames, D.R., D.P. Brink, and C.L. Willms. "Adjusting Protein in Feedlot Rations During Thermal Stress." Journal of Animal Science, 50(1980):1-6.

Angirasa, A.K., C.R. Shumway, T.C. Nelson, and T.C. Cartwright. "Integration, Risk, and Supply Response: Simulation and Linear Programming Analysis of a East Texan Cow-Calf Producer." Southern Journal of Agricultural Economics, 13(1981):89-98.

Barry, P.J., and C.B. Baker. "Financial Response to Risk in Agriculture." In Risk Management in Agriculture, P.J. Barry (ed.). Ames, Iowa. Iowa State University Press, 1984.

Bartlett, V.V. (ed.). "Opportunities for Survival and Success in Ranching." Society for Range Management. Denver, Colorado. 1983.

Beck, A.C., I. Harrison, and J.H. Johnston. "Using Simulation to Assess the Risks and Returns from Pasture Improvement for Beef Production in Agriculture by Underdeveloped Regions." Agricultural Systems, 8(1982):55-72.

Bedell, T.E. "Range Nutrition in Relation to Management." Extension Service Circular of Information 1045, Department of Rangeland Resources, Oregon State University, Corvallis. 1980.

Bellows, R.W., and R.E. Short. "Effect of Pre-Calving Feed Level on Birth Weight Calving Difficulty and Subsequent Fertility." Journal of Animal Science, 46(1978):1522-1528.

Black, J.L. "The Integration of Data for Prediction of Feed Intake, Nutrient Requirements, and Animal Performance." In, Herbivore Nutrition in the Subtropics and Tropics, p. 648. F.M.C. Gilchrist and R.J. Mackie (eds.), The Science Press, 1984.

Boggess, W.G. "use of Biophysical Simulation in Production Economics." Southern Journal of Agricultural Economics. 16(1984):87-90

Bond, J., and J.M. Wiltbank. "Affect of Energy and Protein on Estrus, Conception Rate, Growth and Milk Production of Beef Females." Journal of Animal Science, 30(1970):438-444.

Campling, R.C. "A Preliminary Study of the Effect of Pregnancy and Lactation on the Voluntary Intake of Food by Cows." British Journal of Nutrition, 20(1966):25-30.

Campling, R.C., M. Freer, and C.C. Balch. "Factors Affecting the Voluntary Feed Intake of Food by Cows: The Effect of Urea on the Voluntary Intake Oat Straw." British Journal of Nutrition, 16(1962):115-120.

Carr, J. Personal conversations. 1988 and 1989.

Castle, E.N., J.P. Wallace, and R. Bogart. "Optimum Feeding Rates for Wintering Weaner Calves." Oregon Agricultural Experiment Station Technical Bulletin 56, Oregon State University. 1961.

Christopherson, R.J. "Effects of Prolonged Cold and the Outdoor Winter Environment on Apparent Digestibility in Sheep and Cattle." Canadian Journal of Animal Science, 56(1976):201-212.

Church, D.C., L.S. Pope, and R. MacVicar. "Effect of Plane of Nutrition of Beef Cows on Depletion of Vitamin A During Gestation and on Carotene Requirements During Lactation." Journal of Animal Science, 23(1956):1078-1088.

Collins, A. Personal conversation. 1988.

Cook, C.W., and L.E. Harris. "Nutritive Value of Seasonal Ranges." Utah State Agricultural Experiment Station Bulletin 472, 1968, 55 pp.

Cooper, C.S. "The Effect of Service Rate and Time of Nitrogen Application Upon the Yields, Vegetative Composition, and Crude Protein Content of Native Meadow Hay in Eastern Oregon." Agronomy Journal, 48(1956a):543-547.

Cooper, C.S. "The Effect of Time, and Height of Cutting on the Yield, Crude Protein Content, and Vegetative Composition of a Native Flood Meadow in Eastern Oregon." Agronomy Journal, 48(1956b):257-258.

Crampton, E.W., and L.E. Harris. Applied Animal Nutrition. California: W.H. Freeman and Company, 1969.

Cross, T.L. "Custom Rates for Oregon Agriculture, 1988." Oregon Agricultural Experiment Station Special Report 835, Oregon State University, Corvallis. 1989.

Denham, S.C., and T.H. Spreen. "Introduction to Simulation of Beef Cattle Production." In Simulation of Beef Cattle Production Systems and Its Use in Economic Analysis. pp. 39-62. T.H. Spreen and D. Laughlin (eds.,), London: Westview Press. 1986.

Dikeman, M.E. 1984. "Cattle Production Systems to Meet Future Consumer Demand." Journal of Animal Science, 59(1984):1631-1643.

Doll, J.P., and F. Orazem. Production Economics: Theory With Applications. 2nd edition. New York: John Wiley and Sons. 1984.

Eley, R.M., W.W. Thatcher, F.W. Bazer, L.J. Wilcox, R.B. Becker, H.H. Head, and R.W. Adkinson. "Development of the Conceptus in the Bovine." Journal of Dairy Science, 42(1978):467-473.

Ensiminger, M.E. Beef Cattle Science. 5th Edition. Danville, Iowa: The Interstate Printers and Publishers, Inc. 1976.

Extension Economic Information Office. "Oregon Gross Farm Sales." Oregon Agricultural Extension Service, Oregon State University. Years 1973-1987.

Ferrell, C.L., W.N., Garrett, and N. Hinman. "Growth, Development, and Composition of the Udder and Gravid Uterus of Beef Heifers During Pregnancy." Journal of Animal Science, 42(1976):1477-1489.

Fox, P.G., and J.R. Black. "A System for Predicting Body Composition and Performance of Growing Cattle." Journal of Animal Science, 58(1977):725-739.

Ganstropp, D.C., and T.E. Bedell. "Cheatgrass and Its Relationship to Climate: A Review." Oregon Agricultural Experiment Station, Oregon State University, Corvallis, 1979.

Gomm, F.B. "Climate and Agriculture of Malheur-Harney Basin, Oregon." Oregon Agricultural Experiment Station Special Report 530, Oregon State University, Corvallis. 1979.

Gray, J.R. Ranch Economics. Ames, Iowa: Iowa State University Press, 1968.

Harman, W.L., R.E. Hatch, V.R. Eidman, and P.L. Claypool. "An Evaluation of Factors Affecting the Hierarchy of Multiple Goals." Oklahoma Agricultural Experiment Station Technical Bulletin T-134, 1972.

Harper, W.H., and C.E. Eastman. "An Evaluation of Goal Hierarchies for Small Farm Operators." American Journal of Agricultural Economics, 52(1980):742-747.

Hayes, B.W., G.E. Mitchell, and C.O. Little, and H.B. Sevell. "Turnover of Vitamin A in Steers." Journal of Animal Science, 16(1967):855-857.

Heady, E.O., and J.L. Dillon. Agricultural Production Functions. Ames, Iowa: Iowa State University Press. 1961.

Hewlett, J.P. "The Effect of Various Management Policy Options on the Financial Stress Situation of Oregon Grain and Cattle Producers." Unpublished M.S. thesis, Oregon State University, Corvallis. 1987.

Hewlett, J.P., T.L. Cross, and J. Carr. "Enterprise Budget. Native Hay Production Costs, Lakeview Area." Oregon State University Extension Service. Oregon State University. January 1987.

Hewlett, J.P., T.L. Cross, and J. Carr. "Enterprise Budget. Cow-Calf, Lakeview Area." Oregon State University Extension Service. Oregon State University. June 1987.

Hickman, O.E. "Seasonal Trends in the Nutritive Content of Important Range Forage Species Near Silver Lake, Oregon." Unpublished M.S. thesis, Oregon State University, Corvallis. 1966.

Hidirolgou, M., and J.R. Lessad. "Some Effects of Fluctuating Low Ambient Temperature on Beef Cattle." Canadian Journal of Animal Science, 51(1970):111-120.

Hilken, T.C. "Feed Habits and Diet Quantity of Deer and Cattle and Herbage Production of Sagebrush-Grass Range." Unpublished M.S. thesis, Oregon State University, Corvallis. 1980.

Hironaka, R., and H.R. Peters. "Energy Requirements of Wintering Mature Pregnant Beef Cows." Canadian Journal of Animal Science, 49(1969):323-330.

Hobbs, N.T., D.L. Baker, J.E. Ellis, D.M. Swift, and R.A. Green. "Elk-Range Carrying Capacity." Journal of Wildlife Management, 46(1982):12-21.

Holst, D., and E. Schmisseur, "Effects of the 1977 Drought on Eastern Oregon Ranches." Oregon State University Extension Service Special Report 555, Oregon State University, Corvallis. June, 1979.

Hughes, D.W., and J.B. Penson Jr. "Effects of Selected Macroeconomic Policies on Agriculture, 1984-1990." Agricultural Financial Review, 45(1985):81-91.

Hughes, D.W., J.W. Richardson, and M.E. Rister. "Effects of Sustained Financial Stress on the Financial Structure and Performance of the Farm Sector." American Journal of Agricultural Economics, 67(1985):1116-1122.

Jordan, W.A., E.E. Lister, J.M. Wauthy, and J.E. Comeau. "Voluntary Roughage Intake by Nonpregnant and Pregnant or Lactating Beef Cows." Canadian Journal of Animal Science, 53(1973):733-740.

Klosterman, E.W., C.C. Stanford, and C.F. Parker. "Effect of Cow Size and Condition and Ration Protein Content Upon Maintenance Requirements of Mature Beef Cows." Journal of Animal Science, 27(1968):242-246.

Knox, J.H., and W.E. Watkins. "Supplements for Range Cows." New Mexico Agricultural Experiment Station Bulletin 425, 1958.

Lewis, L.D. "Range Cattle Feeding, Management, and Disease Interrelationships." Department of Clinical Sciences, Colorado State University, Ft. Collins, CO. 1980.

Loewer, O.S., and E.M. Smith. "The Kentucky Beef-Forage Model." In Simulation of Beef Cattle Production Systems and Its Use in Economic Analysis, pp. 63-100. T.H. Spreen and D. Laughlin (eds.), London: Westview Press. 1986.

Lofgreen, G.P., and W.N. Garrett. "A System of Expressing Net Energy Requirements and Feed Values for Growing and Finishing Cattle." Journal of Animal Science, 27(1968):793-806.

Malechek, J.C., and B.M. Smith. "Range Cow Behavior and Energy Conservation." Utah Science, 35(1974):103-104.

__________. "Behavior of Range Cows in Response to Winter Weather." Journal of Range Management, 29(1976):9-12.

Mautz, W.W., H. Silver, J.B. Holter, H.H. Haynes, and W.E. Urban, Jr. "Digestibility of Deer Browse." Journal of Wildlife Management, 40(1976):630-638.

McCormack, B. Personal interview. May, 1988.

McInnis, M.L., T.M. Quigley, and M. Vavra. "Using Computer Simulation to Estimate Grazing Capacity and Beef Production." Research in Rangeland Management, Oregon Agricultural Experiment Station Special Report 773, Oregon State University. 1986.

McInnis, M.L., and M. Vavra. "Beef Cattle Production on Western Juniper Rangelands." Agricultural Experiment Station Special Report 803, Department of Rangeland Resources, Oregon State University. 1987.

Meacham, T.N. K.P. Bovard, B.M. Priode, and J.P. Fontenot. "Effect of Supplemental Vitamin A on the Performance of Beef Cows and Their Calves." Journal of Animal Science, 31(1970):428-433.

Melichar, E. "A Financial Perspective on Agriculture." Federal Reserve Bulletin, 70/1(1987):1-13.

Milligan, J.D., and G.I. Christianson. "Effects of Severe Winter Conditions on Performance of Feedlot Steers." Canadian Journal of Animal Science, 54(1974):605-610.

Moe, P.W., H.F. Tyrell, and W.P. Flatt. "Energetics of Body Tissue Mobilization." Journal of Dairy Science, 54(1971):548-551.

Musser, W.N., and B.V. Tew. "Use of Biophysical Simulation in Production Economics." Southern Journal of Agricultural Economics, 16(1984):77-86.

National Oceanic and Atmospheric Administration, Department of Commerce. "Climatological Data for the U.S. by Sections, Oregon." National Climatic Data Center, Ashville, North Carolina. Years 1950-1986.

National Oceanic and Atmospheric Administration, Department of Commerce. "Climatological Data for the U.S. by Sections, Oregon." National Climatic Data Center, Ashville, North Carolina. Years 1950-1987.

National Research Council. Effect of Environment on Nutrient Requirements of Domestic Animals. Washington, DC: National Academy Press. 1981.

__________. Nutrient Requirements of Beef Cattle. Sixth revised edition. Washington, DC: National Academy Press. 1984.

Obermiller, F.W., S.D. Miles, B.A. Weber, and J.C. Cornelius. "Agriculture and Oregon's Economy." Department of Agricultural and Resource Economics, Oregon State University. 1987.

Oregon Public Lands Rancher. "Eastern Oregon Ranch Values." February 1987, Vol. 2, No. 1, pp. 2-4.

Parsch, L.D., P.S. Lower, and D.H. Laughlin. "Use of the Kentucky Beef-Forage Model in Economic Analysis." In Simulation of Beef Cattle Production Systems and Its Use in Economic Analysis. T.H. Spreen and D. Laughlin (eds.), pp. 137-158. London: Westview Press. 1986.

Patrick, G.F., and B.F. Blake. "Measurement and Modeling of Farmers Goals." Southern Journal of Agricultural Economics, 12(1981):199-204.

Perry, T.W., W.M. Beeson, W.H. Smith, and M.T. Mohler. "Injectable vs. Oral Vitamin A for Fattening Steer Calves." Journal of Animal Science, 26(1967):115-118.

Phillips, R.L., and M. Vavra. "The Effect of Pre-Calving Energy Levels on Cow Performance." Proceedings of Western Section, American Society of Animal Science, 32(1981):117-122.

Pinney, D., L.S. Pope, C.V. Cotthem, and K. Urban. "Effect of Winter Plane of Nutrition on the Performance of Three and Four year Old Beef Cows." pp. 51-53. 36th Annual Livestock Feeders Day, Oklahoma State University, April 21, 1962.

Raleigh, R.J. "Symposium on Pasture Methods for Maximum production in Beef Cattle: Manipulation of Both Livestock and Forage Management to Give Option Production." Journal of Animal Science, 30(1970):108-114.

Raleigh, R.J., L. Foster, and H.A. Turner. "Daily Versus Alternative Feeding Range Supplements." Oregon Agricultural Experiment Station Special Report No. 322, Oregon State University. 1971.

Raleigh, R.J., and D. Wallace. "Digestibility Measurements on Native Meadow Hay and Their Effect on Animal Performance." Agricultural Experiment Station Special Report 145, Oregon State University, Corvallis. 1963.

Reeves, G.W., E.K. Sekavs, D.E. Abel, and I.R. Cottingham. "A Computer Model Simulating Extensive Beef Cattle and Production Systems." Occasional Paper No. 21, Bureau of Agricultural Economics, Canberra. 1974.

Reid, J.T., and J. Robb. "Relationship of Body Composition to Energy Intake and Energetic Efficiency." Journal of Dairy Science, 54(1971):553-564.

Rittenhouse, L.R., D.C. Clanton, and C.L. Streeter. "Intake and Digestibility of Winter-Forage by Cattle With and Without Supplementation." Journal of Animal Science, 31(1970):1215-1221.

_________. "Estimating Digestible Energy from Dry Matter and Organic Matter in Diets of Grazing Cattle." Journal of Range Management, 24(1971):73-75.

Rumberg, C.B. "Yield and N Accumulation of Meadow Forage Fertilized at Advancing Maturity with N." Agronomy Journal, 64(1972):187-189.

Rumberg, C.B., and C.S Cooper. "Fertilizer Induced Changes in Botanical Composition, Yield, and Quality of Native Meadow Hay." Agronomy Journal, 53(1961):255-258.

Salisbury, G.W., and N.L. Van Demark. Physiology of Reproduction and Artificial Insemination of Cattle. Wilt Freeman and Company. 1961.

Sanders, J.O., and T.C. Cartwright. "A General Cattle Production Systems Model. I: Structure of the Model." Agricultural Systems, 4(1979a):217-227.

_________. "A General Cattle Production Systems Model. II: Structure of the Model." Agricultural Systems, 4(1979b):289-309.

Schmisseur, E., and D. Holst. "Characteristics of Eastern Oregon Cattle Operations." Oregon Agricultural Experiment Station Special Report 561, Oregon State University. September, 1979.

Selly, R. "Decision Rules in Risk Analysis". In Risk Management in Agriculture, P.J. Barry (ed.). Ames: Iowa State University Press, 1984.

Senft, R.L., L.R. Rittenhouse, and R.G. Woodnaise. "Factors Influencing Patterns of Cattle Grazing Behavior on Shortgrass Steppe." Journal of Range Management, 36(1985):82-87.

Silvey, M.W., and K.P. Haydock. "A Note on Liveweight Adjustments for Pregnancy in Cows." Animal Production, 27(1978):113-116.

Skovlin, J. "Fluctuation of Forage Quality on Summer Forage in the Blue Mountains." U.S.D.A. Forest Service Publication PRN-44. 1967.

Smathers, R.L., R.R. Loucks, C.W. Gray, and N.R. Rimbey. "1989-90 Livestock Enterprise Budgets. Cow-Calf Private Pasture and Public Range: Winter Feeding Necessary." University of Idaho Extension Service Publication MS 110-8, University of Idaho, January 1989.

Smathers, R.L., R.R. Loucks, C.W. Gray, and N.R. Rimbey. "1989-90 Livestock Enterprise Budgets. Cow-Calf Winter on Public Range." University of Idaho Extension Service Publication MS 110-10, University of Idaho, January 1989.

Smith, B.A., and P.F. Capstick. "Evaluation of Factors Affecting the Ranking of Management Goals by Farm Operators." Arkansas Experiment Station Report 232. 1976.

Sneva, F.A., and D.N. Hyder. "Forecasting Range Herbage Production in Eastern Oregon." United States Department of Agriculture, Agricultural Research Service. 1967.

Sneva, F.A., and H.A. Turner. "Paraquat plus Meadow Equals Winter Grazing." Research in Beef Cattle Nutrition and Management, Oregon Agricultural Experiment Station Special Report 480, Oregon State University, 1977.

Spreen, T.H., and D. Laughlin (eds.). Simulation of Beef Cattle Production Systems and Its Use in Economic Analysis. Westview Press. 1986.

Spreen, T.H., J.A. Ross, J.W. Pheasant, J.E. Moore, and W.E. Kunkle. "A Simulation Model for Back-Grounding Feeder Cattle in Florida." Florida Agricultural Experiment Station Bulletin No. 850, University of Florida, Gainesville. 1985.

Stoddart, L.A., A.D. Smith, and T.W. Box. Range Management. 3rd edition. New York: McGraw-Hill Book Company. 1975.

Stokes, K.W., D.E. Farris, and T.C. Cartwright. "Economics of Alternative Beef Cattle Genotype and Management/Marketing Systems." Southern Journal of Agricultural Economics, 13(1981):1-10.

Snyder, D.L., T.E. Keith, J.C. Mudenson, and C. Diamond. "Determining Agriculture's Contribution to Utah's Economy." Utah Science, 46(1985):86-89.

Taylor, M., and G. Nelson. "Oregon Agricultural Financial Situation: A Survey of Lenders." Oregon Agricultural Experiment Station Special Report 806, Oregon State University. 1987.

Taylor, R.E. Beef Production and the Beef Industry: A Beef Producer's Perspective. Minneapolis, MN: Burgess Publishing Co. 1984.

Thompson, W.R., J.C. Meiske, R.D. Goodrich, J.R. Rust, and F.M. Byers. "Influence of Body Composition on Energy Requirements of Beef Cows During Winter." Journal of Animal Science, 53(1983):1241-1252.

Trapp, J.N., and O. Walker. "Biological Simulation and Its Role in Economic Analysis." p. 13. T.H. Spreen and D. Laughlin (eds.). In Simulation of Beef Cattle Production Systems and Its Use in Economic Analysis. Westview Press. 1986.

Turner, H.A. Personal conversations. 1988.

Turner, H.A., and R.F. Angell. "Systems for Reducing Dependency on Harvested Forage for Wintering Cows." In Proceedings, Western Section, American Society of Animal Science, 39(1987):1-15.

Turner, H.A, R.F. Angell, and M.R. Haferkamp. "Strip Grazing Rake-Bunched Hay and Standing Forage as Alternatives to Wintering Cows on Baled Hay." Oregon Agricultural Experiment Station Special Report No. 714, Oregon State University. 1984.

Turner, H.A., and R.J. Raleigh. "Improved Efficiency After Winter Cows by Feed Rumensin." Oregon Agricultural Experiment Station Special Report 455, Oregon State University, Corvallis. 1977.

United States Department of Agriculture. Agricultural Statistics, 1988. Washington, DC: U.S. Government Printing Office. 1988.

United States Department of Agriculture. Agricultural Prices. National Agricultural Statistics Service, Washington, DC: August 1988 - February 1989.

United States Department of Agriculture. Livestock and Poultry: Situation and Outlook Report. Economic Research Service, Washington, DC: March 1988, November 1988, and February 1989.

Vavra, M., and R.J. Raleigh. "Coordinating Beef Cattle Management with the Range Forage Resource." Journal of Range Management, 29(1976):449-452.

Verme, L.J. "Winter Weather Severity for Northern Deer: An Index." Journal of Wildlife Management, 32(1969):566-574.

Wallace, J.D., C.B.Rumberg, and R.J. Raleigh. "Evaluation of Range and Meadow Forages at Various Levels of Maturity and Level of Nitrogen Fertilization." Oregon Agricultural Experiment Station Technical Paper No. 1426, Squaw Butte Agricultural Experiment Station. Burns, OR. 1964.

Webster, A.J.F. "Direct Effects of Cold Weather on the Energy Efficiency of Beef Produced in Different Regions of Canada." Canadian Journal of Animal Science, 50(1970):563-573.

Williams, J. "Analysis and comparison of Spring vs. Fall Calving in Various Eastern Oregon Environments." Unpublished paper, Oregon State University. 1986.

Wiltbank. J.R., W.W. Rowden, J.E. Ingalls, K.E. Gregory, and R.R. Hoch. "Effect of Energy Level on Reproductive Phenomena of Mature Hereford Cows." Journal of Animal Science, 21(1962):219-225.

Wiltbank. J.R., W.W. Rowden, J.E. Ingalls, and D.R. Zimmerman. "Influence of Post-Partum Energy Level on Reproductive Performance of Hereford Cows Restricted Energy and Intake Prior to Calving." Journal of Animal Science, 23(1964):1049-1053.

Whitson, R.E., and R.D. Kay. "Beef Cattle Forage Systems Analysis Under Variable Prices and Forage Conditions." Journal of Animal Science, 46(1978):823-830.

Workman, J.P. Range Economics. New York: Macmillan Publishing Company. 1986.

Young, B.A. "Cold Stress as It Effects Animal Production." Journal of Animal Science, 52(1981):154-163.

APPENDICES

APPENDIX A:

NUTRIENT CONTENT OF RANGE AND MEADOW FORAGES

APPENDIX A

NUTRIENT CONTENT OF RANGE AND MEADOW FORAGES

I: Rangeland Species

A.) Bluebunch Wheatgrass

Month of growth	Net Energy (Mcal/kg)	Crude Protein (%)
1	1.70	18.6
2	1.42	11.9
3	1.42	10.2
4	1.42	7.2
5	1.34	4.2
6	1.34	2.7
7	1.24	2.0
8	1.16	2.0

Source: Crampton and Harris, 1969

B.) Idaho Fescue

Month of growth	Net Energy (Mcal/kg)	Crude Protein (%)
1	1.42	13.5
2	1.42	12.1
3	2.35	10.3
4	1.70	9.0
5	1.34	6.7
6	1.24	5.8
7	0.66	5.1
8	0.97	3.9

Source: Hickman, 1966; Williams, 1986

C.) Sandberg Bluegrass

Month of growth	Net Energy (Mcal/kg)	Crude Protein (%)
1	1.32	19.6
2	1.42	13.5
3	1.14	7.2
4	1.03	5.9
5	NA	5.6
6	NA	5.4
7	NA	5.0
8	NA	5.0

Source: Hickman, 1966; Hilken, 1980; Williams, 1986

D.) Crested Wheatgrass

Stage of growth	Net Energy (Mcal/kg)	Digestible Protein (%)
Boot	1.11	7.2
Head	1.29	6.3
Dough	1.13	6.4
Seed	1.14	6.7

Source: Cook and Harris, 1968

E.) Cheatgrass

Stage of growth	Net Energy (Mcal/kg)	Digestible Protein (%)
Boot	1.62	10.5
Head	1.66	7.2
Dough	1.11	3.8
Early Seed	0.73	2.8
Late Seed	0.67	1.0

Source: Cook and Harris, 1968

F.) Digestibility and Net Energy Content of Range Forage

Date	Dry Matter (%)	Net Energy** (Mcal/kg)	Nitrogen Digestibility (%)
May 29	62.0	1.23	65.0
June 12	62.0	1.23	64.0
June 26	59.0	1.14	63.0
July 10	57.0	1.08	58.0
July 24	52.0	0.93	44.0
August 7	49.0	0.84	36.0
August 21	48.0	0.81	28.0
September 4	48.0	0.81	26.0

Source: Raleigh, 1970

** Net energy value found using conversion equation by Rittenhouse et. al, 1971

G.) *In Vitro* Dry Matter Digestibility and Net Energy Content, Range Forages; Squaw Butte Experiment Station Range, 1986-87

Date	Dry Matter (%)	Net Energy** (Mcal/kg)
1986		
March 6	54.32	1.00
April 3	52.45	0.94
May 1	63.28	1.26
May 28	50.60	0.89
June 26	53.54	0.98
July 28	45.05	0.71
August 28	48.07	0.81
October 9	46.70	0.76
November 8	51.90	0.93
December 2	47.80	0.80
December 31	47.20	0.78
1987		
January 28	46.40	0.76

Source: Squaw Butte Field Tests, unpublished data, 1988

II: Meadow Forage

A.) Dry Matter Digestibility, Net Energy Content, and Nitrogen Digestibility of Meadow Hay Harvested at Different Date

Date	Dry Matter (%)	Net Energy** (Mcal/kg)	Nitrogen Digestibility (%)
1961			
June 9	61.8	1.22	63.0
June 28	56.6	1.07	60.2
July 17	51.7	0.92	48.4
August 4	49.2	0.84	35.2
1962			
June 21	65.2	1.32	64.1
June 28	65.2	1.32	64.5
July 5	65.7	1.33	64.2
July 12	60.3	1.18	61.0
July 19	61.1	1.20	58.2
July 26	58.7	1.13	53.1
August 2	55.3	1.03	46.7
August 9	51.4	0.91	39.5

Source: Raleigh et al., 1964

** Net energy value found using conversion equation by Rittenhouse et. al, 1971

APPENDIX B:

DATA USED IN DETERMINING COW CALVING AND CONCEPTION RATE REGRESSION EQUATIONS

APPENDIX B

DATA USED IN DETERMINING COW CALVING AND CONCEPTION RATE REGRESSION EQUATIONS

I. Herd Data Used in Thesis, Averaged by Year and Herd Size

Year and Feeding Program	Average Conception Rate	Average Calving Rate	Oct	Average Percentage Weight Changes Nov	Dec	Jan	Feb
	- - - - - - - - - - -	Percent	- - - - - - - - - - -				
Baled Hay							
1982-83	90.3	96.8	5.03	2.86	-2.74	-0.45	-4.06
1983-84	80.6	92.3	6.39	2.57	-0.50	-0.91	0.43
1984-85, 1	88.5	96.4	9.87	-0.99	1.91	0.91	-1.09
1984-85, 2	82.5	97.0	8.83	-0.65	1.33	0.24	-0.19
Rake-Bunch Hay							
1982-83	93.8	100.0	4.84	2.73	-2.55	2.52	-3.53
1983-84	70.0	97.5	5.86	3.02	-0.07	-5.44	2.01
1984-85, 1	85.7	100.0	5.51	2.15	2.83	0.75	2.89
1984-85, 2	75.0	95.4	7.02	1.38	0.55	0.55	3.14
Meadow Grazing							
1982-83	71.0	93.8	1.12	0.06	-3.91	-0.63	-4.54
1983-84	71.0	93.9	0.96	-0.40	-0.58	0.40	1.08
1984-85, 1	83.3	86.4	3.52	0.06	-2.30	2.96	2.62
1984-85, 2	66.7	93.3	2.81	0.49	-3.97	3.87	4.19

II. Other Data

Year and Feeding Program	Percentage Weight Changes Winter	May	Sept	Avg. Weaning Wgt	Begin Winter Cow Wgt	Birth Date	Calving Interval	Cow Age
	- - Percent - -			- Pounds -		- - Days - -		Year
Baled Hay								
1982-83	0.36	-13.24	2.64	383	1081	80	374	5.6
1983-84	8.02	-17.76	4.02	360	1031	87	378	5.7
1984-85, 1	10.64	-5.49	-4.37	338	975	98	362	6.3
1984-85, 2	9.64	-9.47	-1.61	326	956	97	370	4.9
Rake-Bunch								
1982-83	3.79	-13.77	1.62	379	1079	77	375	5.4
1983-84	5.12	-16.20	4.23	362	1005	88	383	5.6
1984-85, 1	14.89	-8.26	-2.39	367	998	94	374	6.4
1984-85, 2	13.14	-12.65	-0.52	328	950	98	375	4.1
Meadow								
1982-83	-7.78	-9.85	6.27	375	1079	80	374	5.4
1983-84	1.46	-15.17	7.07	347	1030	87	378	5.5
1984-85, 1	7.85	-5.89	-0.90	333	1012	97	362	5.9
1984-85, 2	7.36	-10.57	0.77	307	1010	101	372	7.8

APPENDIX C:

LIST OF MACRO-COMMANDS

APPENDIX C

LIST OF MACRO-COMMANDS

1. WEEKLY FORAGE TYPE SELECTION BASED UPON SNOW DEPTH LEVEL MACRO-COMMAND

```
/S    * Go to I61
      {goto}I61~
/D    * Create range name NUM.
      /rncNUM~{backspace}~
      * If NUM is greater than than DEEP then go to A1.  If NUM
        is less than or equal to DEEP continue procedure.  DEEP
        is range name for the minimum snow depth that cows can
        forage for the feed type. DEEP = 12.69 for meadow
        scenarios.  DEEP = 20.31 for range scenarios, and equals
        76.20 for rake-bunch scenarios.
      /xiNUM > +DEEP~/xgA1~
      * Print out forage type, and the forage type energy and
        protein values.  For meadow grazing scenarios routine
        prints "standing", NESTA (energy value of meadow,
        mcal/kg), and CPSTA (protein content of meadow, gm/kg).
        For rake-bunch scenarios routine prints "raked", NERA,
        and CPRA.  For range grazing scenarios routine prints
        "range", NERAN, and CPRAN.
      {right}"feed type"~
      {right}+"energy content of feed in mcal/kg"
      {right}+"protein content of feed in gm/kg"
      * Repeat Procedure
      {left}{left}{left}{down}~
      /xg\D~

/A1   *Space right and print "baled", and nutrient content of
       baled hay
      {right}baled~
      {right}+NEBA~
      {right}+CPBA~
      * Repeat Procedure
      {left}{left}{left}{down}~
      /xg\v~

      * To end routine hit CONTROL/BREAK
```

2. WEEKLY FORAGE INVENTORY CONTROL MACRO COMMANDS

I: Procedure to Select Primary Forage Type for Forage Inventory Control

```
/Z     goto{AC53}~
       * create range name FEED.
       /rncFEED~{backspace}~
       *If FEED equals BAPRO then go to 061 and print BAPRO value.
       *If FEED is not equal to BAPRO then go to R1
       /xiFEED<>BAPRO~/xgR1~
       {goto}061~BAPRO~
       *Quit
       /xq~

/R1    *If FEED equals RAPRO then go to 061 and print RAPRO value.
       *If FEED is not equal to RAPRO then go to S1
       /xiFEED<>RAPRO~/xgS1~
       {goto}061~RAPRO~
       *Go to Inventory Control Macro-Command
       /xg\I~

/S1    *If FEED equals STPRO then go to 061 and print STPRO value.
       *If FEED is not equal to STPRO then go to R2
       /xiFEED<>STPRO~/xgR2~
       {goto}061~STPRO~
       *Go to Inventory Control Macro-Command
       /xg\I~

/R2    *Go to 061 and print RANPRO value.
       {goto}061~RANPRO~
       *Go to Inventory Control Macro-Command
       /xg\I~
```

BAPRO = Tonnage production of baled hay from input table
RAPRO = Tonnage production of rake-bunch hay from input table
STPRO = Tonnage production of meadow grass from input table
RANPRO = Tonnage production of range forage from input table

II: Forage Inventory Control

```
/I    * Go to cell position 061
      {go to}061
      * Create range name FOR.
/V    /rncFOR~{backspace}~
      * If FOR is equal to or less than zero go to EM, emergency
        feed routine. If FOR is greater than zero continue with
        primary routine V. FOR is equal to either RAPRO, STPRO,
        or RANPRO depending on previous macro-command.
      /xiFOR<=0'/xgEM
      * Space right and print the feed type, and its nutrient
        values.  Feed type printed and nutrient values will be
        raked-bunch hay, standing meadow, or range depending
        upon primary forage selection procedure.
      {right}feed type~
      {right}+"energy content of feed in mcal/kg"
      {right}+"protein content of feed in gm/kg"
      * Repeat Procedure
      {left}{left}{left}{down}~
      /xg\V~

/EM   *Space right and print "baled", and nutrient content of
       baled hay
      {right}baled~
      {right}+NEBA~
      {right}+CPBA~
      * Repeat Procedure
      {left}{left}{left}{down}~
      /xg\V~

      * To end routine hit CONTROL/BREAK
```

* FOR in routine can be either RAPRO, STPRO, or RANPRO.
* When forage type is rake-bunch hay, the procedure prints out "raked", and forage nutrient values from the input section. The values have range names of NERA (energy), and CPRA (protein).
* When forage type is meadow forage hay, the procedure prints out "standing", and forage nutrient values from the input section. The values have range names of NESTA (energy), and CPSTA (protein).
* When forage type is range, the procedure prints out "range", and its forage nutrient values from the input section. The values have range names of NERAN (energy), and CPRAN (protein).

APPENDIX D:

LIST OF EQUATIONS

APPENDIX D

LIST OF EQUATIONS

1. Interconversions Between Energy Values of Feedstuffs

a. $$DE = 0.0504 \times CP\% + 0.0770 \times EE\% + 0.0200 \times CF\% + 0.000377 \times NFE^2\% + 0.0110 \times NFE\% - 0.152$$

where, DE = Digestable energy
CP = Crude protein
EE = Ether extract
NFE^2 = Crude fiber
NFE = Nitrogen-free extract

Source: NRC, 1984

b. Metabolizable Energy (ME) = 0.82 x DE

Source: NRC, 1984

c. Net Energy;

$$\text{Maintenance} = 1.37 \times ME - 0.138 \times ME^2 + 0.0105 \times ME^3 - 1.12$$

$$\text{Gain} = 1.42 \times ME - 0.174 \times ME^2 + 0.0122 \times ME^3 - 1.65$$

Source: NRC, 1984

d. Dry Matter Digestibility (DMD) Content to Digestible Energy

$$DE = a + b \times DMD$$

where, DMD = Percent dry matter digestibility
a = 0.18 +/- 0.07
b = 0.038 +/- 0.001

Source: Rittenhouse et al., 1971

2. Nutritional Requirements of Cows:

a. Net Energy Maintenance (NE_m) Requirement, Expressed in mcal/day;

$$NE_m = 0.077 \times W^{0.75}$$

where, W = Cow weight

Source: NRC, 1984

b. Net Energy Requirement for Maintenance, Adjusted for Temperature and Cow Condition:

$$NEm = a \times W^{0.75} \times (WM/W)$$

where, a = 0.077 + 0.0007 x (20 - T)
WM = Cow's ideal metabolic weight
T = Effective air temperature, (°C)

Source: NRC, 1984

c. Weight Gain of Mature Thin Cows:

NE = 5.5 to 7.5 mcal/kg gain (Source: NRC, 1984)

For the thesis:

1 kg. gain = 8.0 mcal NE

d. Weight Loss of Cows and/or Energy Conversion of Body Fat:

NE = 6.0 mcal/kg of fat converted to energy for cow maintenance

Source: Reid and Robb, 1971; Moe et al., 1971; Mautz et al., 1976

e. Energy Requirement of Pregnancy (NE_p) expressed in mcal/day:

$$NE_p = [CW \times (0.0149 - 0.0000407 \times t) \times e^z] \times 1000$$

where, CW = Calf birth weight
t = Day of pregnancy
e = Natural log
$z = 0.05883 \times t - 0.0000804 \times t^2$

Source: NRC, 1984

f. Nutrient intake by cows:

NE (mcal) = Forage Intake (kg) x Forage NE (mcal/kg)

Protein (gms) = Forage Intake (kg) x Forage CP (gms/kg)

3. Effective Air Temperature of Cows in Heavy Winter Coat:

$$EAT = (0.996) \times T - (0.811) \times W + (0.028) \times W^2 - (0.00077) \times W^3$$

where, T = Dry bulb air temperature in degrees celsius
W = Wind velocity (mph)

Source: Ames, 1988

4. Temperature Adjusted Forage Content:

$$A = B + B \times [C_f \times (T-20)]$$

where, A = Value adjusted forage factor -- i.e. -- mcal/day for energy, crude protein content etc.
B = Forage component value in mcal or CP
C_f = Forage correction factor
energy, $C_f = 0.0010$
protein, $C_f = 0.0011$
T = Dry bulb air temperature

Source: NRC, 1981

APPENDIX E:

RANGE GRAZING: BASE INPUTS AND SEVERE WINTER OUTPUT

APPENDIX E

RANGE GRAZING: BASE INPUTS AND SEVERE WINTER OUTPUT

Base Parameters:

1. Forage Resources

	Acres	Production (tons)
Hay Meadow/acre	1100.00	1100.00
Bale/acres	198.41	
Tons/acre	1.00	198.41
Rake/acres	901.59	
Summer/acres	.00	
Tons/acre	1.00	.00
Winter/acres	901.59	
Tons/acre	1.00	901.59
Meadow/acres	.00	
Tons/acre	1.00	.00
Supplement	1.00	
Winter Range		
Acres	.00	
Acres/AUM	10.00	.00

2. Animal and Herd Characteristics

Herd Size	450.00	# cows
Cow weight	480.00	kg.
Calf weight	34.00	Birth weight (kg)
Cow loss	6.00	Mcal/kg of loss
Cow gain	8.00	Mcal/kg of gain
Sup waste	.10	
Rake waste	.02	
Bale waste	.15	
Herd Replacement Mode	1.00	
Herd Replacement Number	45.00	
Sale Weight		
Cows	1000.00	
Steers	365.00	
Heifers	350.00	

3. Winter Conditions

Weeks of snow	0
Weeks of no snow	22
Weeks in winter	22

Winter Forage Resources:

Baled Hay

unit	Fed lb/day	Use lb/day	kg/day	weeks 2 NE/kg	CP gm/kg	Maximum Intake kg/yr
cow	30.00	25.50	11.56	1.10	74.00	161.90

	ton/wk	ton/wk	ton/yr
herd	47.25	40.16	94.50

Raked Hay

unit	Fed lb/day	Use lb/day	kg/day	weeks 22 NE/kg	CP gm/kg	Maximum Intake kg/yr
cow	26.02	25.50	11.56	1.10	74.00	1780.92

	ton/wk	ton/wk	ton/yr
herd	40.98	40.16	901.59

Range

unit	Fed lb/day	Use lb/day	Months 0.00 kg/day	weeks 0.00 NE/kg	CP gm/kg	Maximum Intake kg/yr
cow	22.00	22.00	9.98	.80	38.00	.00

	ton/wk	ton/wk	ton/yr
herd	.00	.00	.00

Meadow

unit	Fed lb/day	Use lb/day	kg/day	weeks 0.00 NE/kg	CP gm/kg	Maximum Intake kg/yr
cow	24.00	24.00	10.88	.76	41.00	.00

	ton/wk	ton/wk	ton/yr
herd	.00	.00	.00

4. Primary Winter Forage

	#weeks	kg/day	ton/wk	ton/yr
Raked	22.00	11.56	40.98	901.59

Table 1.1: Determination of Feed Type in Relation to Snow Depth

(week)	Snow Depth (cm)	Feed Type	Forage Nutrient Content NE (mcal/kg)	Forage Nutrient Content CP (gm/kg)
OCT 1-7	.0	raked	1.10	74.00
8-14	.0	raked	1.10	74.00
15-21	.0	raked	1.10	74.00
22-28	.0	raked	1.10	74.00
29-4	.0	raked	1.10	74.00
NOV 5-11	.0	raked	1.10	74.00
12-18	.0	raked	1.10	74.00
19-25	.0	raked	1.10	74.00
26-2	.0	raked	1.10	74.00
DEC 3-9	2.5	raked	1.10	74.00
10-16	5.1	raked	1.10	74.00
17-23	20.2	raked	1.10	74.00
24-30	25.4	raked	1.10	74.00
JAN 31-6	40.0	raked	1.10	74.00
7-13	40.0	raked	1.10	74.00
14-20	45.0	raked	1.10	74.00
21-27	35.0	raked	1.10	74.00
28-3	10.0	raked	1.10	74.00
FEB 4-10	25.0	raked	1.10	74.00
11-17	24.0	raked	1.10	74.00
18-24	9.0	raked	1.10	74.00
25-3	.0	raked	1.10	74.00

Table 1.2: Determination of Inventory Changes of Winter Forage Resources and Associated Nutrient Contents

DATE (week)	Beginning Stock	Ending Stock (tons)	Change in Stock	Feed Type	Nutrient Content of Forage NE (mcal/kg)	Nutrient Content of Forage CP (gm/kg)
OCT 1-7	901.59	860.61	40.98	rake	1.10	74.00
8-14	860.61	819.63	40.98	rake	1.10	74.00
15-21	819.63	778.65	40.98	rake	1.10	74.00
22-28	778.65	737.67	40.98	rake	1.10	74.00
29-4	737.67	696.69	40.98	rake	1.10	74.00
NOV 5-11	696.69	655.70	40.98	rake	1.10	74.00
12-18	655.70	614.72	40.98	rake	1.10	74.00
19-25	614.72	573.74	40.98	rake	1.10	74.00
26-2	573.74	532.76	40.98	rake	1.10	74.00
DEC 3-9	532.76	491.78	40.98	rake	1.10	74.00
10-16	491.78	450.80	40.98	rake	1.10	74.00
17-23	450.80	409.82	40.98	rake	1.10	74.00
24-30	409.82	368.83	40.98	rake	1.10	74.00
JAN 31-6	368.83	327.85	40.98	rake	1.10	74.00
7-13	327.85	286.87	40.98	rake	1.10	74.00
14-20	286.87	245.89	40.98	rake	1.10	74.00
21-27	245.89	204.91	40.98	rake	1.10	74.00
28-3	204.91	163.93	40.98	rake	1.10	74.00
FEB 4-10	163.93	122.94	40.98	rake	1.10	74.00
11-17	122.94	81.96	40.98	rake	1.10	74.00
18-24	81.96	40.98	40.98	rake	1.10	74.00
25-3	40.98	.00	40.98	rake	1.10	74.00

Table 1.3: Temperature Adjusted Nutrient Values

DATE (week)		Temperature (C)	NE (mcal/kg)	CP (gm/kg)
OCT	1-7	8.0	1.09	73.02
	8-14	8.0	1.09	73.02
	15-21	7.0	1.09	72.94
	22-28	7.0	1.09	72.94
	29-4	6.5	1.09	72.90
NOV	5-11	5.0	1.08	72.78
	12-18	-1.0	1.08	72.29
	19-25	1.0	1.08	72.45
	26-2	-1.0	1.08	72.29
DEC	3-9	-1.0	1.08	72.29
	10-16	-2.0	1.08	72.21
	17-23	-5.5	1.07	71.92
	24-30	-6.0	1.07	71.88
JAN	31-6	-6.5	1.07	71.84
	7-13	-7.0	1.07	71.80
	14-20	-6.5	1.07	71.84
	21-27	-1.0	1.08	72.29
	28-3	1.0	1.08	72.45
FEB	4-10	-5.0	1.07	71.97
	11-17	-3.0	1.07	72.13
	18-24	.0	1.08	72.37
	25-3	2.0	1.08	72.53

Table 1.4: Energy and Protein Requirements of Spring Calving Cows

				Maintence requirements:		Pregnancy Requirements:			Total Daily Requirement	
DATE (week)	TEMP. (C)	Cow wght. (kg)	A (coef.)	NE (mcal)	CP (gm)	Day of pregnancy	NE (mcal)	CP (gm)	NE (mcal)	CP (gm)
OCT 1-7	.9	453.0	.09	9.13	592.0	109	.08	2.05	9.21	594.0
8-14	3.9	455.9	.09	8.93	592.0	116	.11	2.65	9.04	594.6
15-21	2.7	459.0	.09	9.04	592.0	123	.14	3.40	9.18	595.4
22-28	7.0	462.0	.09	8.75	592.0	130	.18	4.32	8.92	596.3
29-4	6.5	465.2	.09	8.80	592.0	137	.22	5.44	9.02	597.4
NOV 5-11	1.2	468.2	.09	9.19	592.0	144	.28	6.80	9.46	598.8
12-18	-8.0	470.9	.10	9.86	592.0	151	.34	8.42	10.20	600.4
19-25	-2.7	472.9	.09	9.49	592.0	158	.42	10.33	9.91	602.3
26-2	-4.4	475.1	.09	9.63	592.0	165	.51	12.57	10.14	604.6
DEC 3-9	-1.0	477.2	.09	9.39	592.0	172	.62	15.15	10.01	607.1
10-16	-5.1	479.3	.09	9.70	592.0	179	.74	18.09	10.44	610.1
17-23	-8.9	481.1	.10	9.98	592.0	186	.87	21.40	10.85	613.4
24-30	-12.5	482.4	.10	10.24	592.0	193	1.02	25.09	11.27	617.1
JAN 31-6	-6.5	483.4	.10	9.82	592.0	200	1.19	29.13	11.00	621.1
7-13	-10.4	484.6	.10	10.10	670.0	207	1.37	33.50	11.47	703.5
14-20	-10.2	485.4	.10	10.09	670.0	214	1.56	38.14	11.65	708.1
21-27	-7.8	486.0	.10	9.92	670.0	221	1.75	43.00	11.68	713.0
28-3	-2.2	486.7	.09	9.52	670.0	228	1.96	47.98	11.48	718.0
FEB 4-10	-12.0	487.6	.10	10.23	670.0	235	2.16	52.99	12.39	723.0
11-17	-7.0	487.6	.10	9.87	670.0	242	2.36	57.89	12.23	727.9
18-24	.0	487.8	.09	9.37	670.0	249	2.55	62.55	11.92	732.6
25-3	-2.0	488.3	.09	9.52	670.0	256	2.72	66.82	12.24	736.8

Table 1.5: Energy and Protein Intake of Cows and Nutrients Available for Maintence

DATE (week)	Daily Requirements NE (mcal)	Daily Requirements CP (gm)	Daily Intake: Roughage: DM (kg)	Roughage: NE (mcal)	Roughage: CP (gm)	Concentrate: (kg)	Concentrate: NE (mcal)	Concentrate: CP (gm)	Total Intake: NE (mcal)	Total Intake: CP (gm)	Nutrients Avaliable for Cow Maintence: NE (mcal)	Nutrients Avaliable for Cow Maintence: CP (gm)
OCT 1-7	9.21	594.0	11.56	12.57	844.5	.00	.00	.00	12.57	844.5	12.48	842.4
8-14	9.04	594.6	11.56	12.57	844.5	.00	.00	.00	12.57	844.5	12.46	841.8
15-21	9.18	595.4	11.56	12.56	843.5	.00	.00	.00	12.56	843.5	12.42	840.1
22-28	8.92	596.3	11.56	12.56	843.5	.00	.00	.00	12.56	843.5	12.38	839.2
29-4	9.02	597.4	11.56	12.55	843.1	.00	.00	.00	12.55	843.1	12.33	837.6
NOV 5-11	9.46	598.8	11.56	12.53	841.6	.00	.00	.00	12.53	841.6	12.25	834.9
12-18	10.20	600.4	11.56	12.45	836.0	.00	.00	.00	12.45	836.0	12.11	827.6
19-25	9.91	602.3	11.56	12.48	837.9	.00	.00	.00	12.48	837.9	12.06	827.6
26-2	10.14	604.6	11.56	12.45	836.0	.00	.00	.00	12.45	836.0	11.94	823.4
DEC 3-9	10.01	607.1	11.56	12.45	836.0	.00	.00	.00	12.45	836.0	11.84	820.9
10-16	10.44	610.1	11.56	12.44	835.1	.00	.00	.00	12.44	835.1	11.70	817.0
17-23	10.85	613.4	11.56	12.40	831.8	.00	.00	.00	12.40	831.8	11.52	810.4
24-30	11.27	617.1	11.56	12.39	831.3	.00	.00	.00	12.39	831.3	11.37	806.2
JAN 31-6	11.00	621.1	11.56	12.38	830.8	.00	.00	.00	12.38	830.8	11.20	801.7
7-13	11.47	703.5	11.56	12.38	830.4	.00	.00	.00	12.38	830.4	11.01	796.9
14-20	11.65	708.1	11.56	12.38	830.8	.00	.00	.00	12.38	830.8	10.83	792.7
21-27	11.68	713.0	11.56	12.45	836.0	.00	.00	.00	12.45	836.0	10.70	793.0
28-3	11.48	718.0	11.56	12.48	837.9	.00	.00	.00	12.48	837.9	10.52	789.9
FEB 4-10	12.39	723.0	11.56	12.40	832.2	.00	.00	.00	12.40	832.2	10.24	779.2
11-17	12.23	727.9	11.56	12.43	834.1	.00	.00	.00	12.43	834.1	10.07	776.2
18-24	11.92	732.6	11.56	12.47	836.9	.00	.00	.00	12.47	836.9	9.92	774.4
25-3	12.24	736.8	11.56	12.49	838.8	.00	.00	.00	12.49	838.8	9.77	772.0

Table 1.6: Cow Weekly Weight Changes and Week Ending Weight

DATE (week)	Beginning metabolic cow wght. (kg)	Difference between Intake and Maintence Requirements: NE (mcal)	CP (gm)	Cow Weight Change (kg/week)	Ending metabolic cow wght. (kg)	Pregnancy Weight Gain (kg/week)	Total Cow Weight (kg)
OCT 1-7	453.0	3.35	250.4	2.93	455.9	.42	456.4
8-14	455.9	3.53	249.8	3.09	459.0	.42	459.9
15-21	459.0	3.38	248.1	2.96	462.0	.42	463.2
22-28	462.0	3.63	247.2	3.18	465.2	.42	466.8
29-4	465.2	3.53	245.6	3.09	468.2	1.51	471.4
NOV 5-11	468.2	3.07	242.9	2.68	470.9	1.51	475.6
12-18	470.9	2.25	235.6	1.97	472.9	1.51	479.1
19-25	472.9	2.56	235.6	2.24	475.1	1.51	482.9
26-2	475.1	2.31	231.4	2.03	477.2	1.09	486.0
DEC 3-9	477.2	2.45	228.9	2.14	479.3	1.09	489.2
10-16	479.3	2.01	225.0	1.75	481.1	1.09	492.1
17-23	481.1	1.55	218.4	1.35	482.4	1.09	494.5
24-30	482.4	1.12	214.2	.98	483.4	1.09	496.6
JAN 31-6	483.4	1.38	209.7	1.21	484.6	2.15	499.9
7-13	484.6	.91	126.9	.79	485.4	2.15	502.9
14-20	485.4	.74	122.7	.64	486.0	2.15	505.7
21-27	486.0	.78	123.0	.68	486.7	2.15	508.5
28-3	486.7	1.00	119.9	.88	487.6	3.51	512.9
FEB 4-10	487.6	.01	109.2	.01	487.6	3.51	516.4
11-17	487.6	.19	106.2	.17	487.8	3.51	520.1
18-24	487.8	.55	104.4	.48	488.3	3.51	524.1
25-3	488.3	.25	102.0	.22	488.5	3.85	528.1

Table 1.7: Monthly Percent Weight Change of Cows and Estimation of Cow Conception and Calving Rate

Date		Cow weight (kg)	Monthly Change (%)
OCT	1-7	456.4	
	8-14	459.9	
	15-21	463.2	
	22-28	466.8	
	29-4	471.4	3.30
NOV	5-11	475.6	
	12-18	479.1	
	19-25	482.9	
	26-2	486.0	3.08
DEC	3-9	489.2	
	10-16	492.1	
	17-23	494.5	
	24-30	496.6	2.18
JAN	31-6	499.9	
	7-13	502.9	
	14-20	505.7	
	21-27	508.5	2.40
	28-3	512.9	
FEB	4-10	516.4	
	11-17	520.1	
	18-24	524.1	
	25-3	528.1	3.86

Conception Rate

= 88.60

Calving Rate

= 98.54

Table 1.8: Herd Production Characteristics

	year 1	year 2	year 3	year 4	year 5
Number of Cows	450	450	450	450	450
Calving Rate	98.54	98.54	98.54	98.54	98.54
Number of calves	439	437	437	437	437
Heifers	219	219	219	219	219
Steers	219	219	219	219	219
Pregnancy Rate	88.60	88.60	88.60	88.60	88.60
# Cows Pregnant	399	399	399	399	399
Culled	45	45	45	45	45
Cows Retained	405	405	405	405	405
Heifers Retained	45	45	45	45	45
Replacements/Oct 1	45	45	45	45	45
# Cows/Oct 1	450	450	450	450	450
Cattle Sold					
Cows	36	36	36	36	36
Heifers	167	166	166	166	166
Steers	212	211	211	211	211

Table 1.9: Winter Land Usage; Hay Meadows

Production:	Land Area (Acres)	Production (tons)
Baled Hay	198.41	198.41
Hay retained	94.50	94.50
Fall hay sale	103.91	103.91
Raked Hay		
Summer Use	.00	.00
Winter Use	901.59	901.59
Standing Pasture	.00	.00
Utilization:		
Baled Hay		
Hay retained	.00	.00
Purchased Hay		.00
Raked Hay		
Summer Use	.00	.00
Winter Use	901.59	901.59
Standing Pasture	.00	.00
Waste:		
Baled Hay		
Hay retained	94.50	94.50
Raked Hay		
Summer Use	.00	.00
Winter Use	.00	.00
Standing Pasture	.00	.00
Recovered:		
Baled Hay		
Spring hay sale	94.50	94.50
Raked Hay		0.00
Standing Pasture		0.00

Table 1.10: Winter Land Usage; Rangeland

Production:	Land Area (Acres)	Production (tons)
Rangeland	0	.00
Utilization:		
Rangeland	0	.00
Waste:		
Rangeland	ERR	.00
Recovered:		
Rangeland		0.00

Table 1.11: Cow Winter Forage Intake

Total Intake:	
Kg/cow	1780.92
Tons/cow	1.96
Tons/herd	883.56
Baled Hay:	
Kg/cow	.00
Tons/cow	.00
Tons/herd	.00
Raked Hay:	
Kg/cow	1780.92
Tons/cow	1.96
Tons/herd	883.56
Range:	
Kg/cow	.00
Tons/cow	.00
Tons/herd	.00
Standing:	
Kg/cow	.00
Tons/cow	.00
Tons/herd	.00
Supplement:	
Kg/cow	.0
Tons/cow	.00
Tons/herd	.00

Table 1.12: Ranch Partial Budget, Rake-bunch Hay, Year 1

Receipts	Unit	$/unit	Number of Units	Total ($)	Per cow ($)
Livestock:					
Steers	cwt.	86.50	772.29	66803.00	148.45
Heifers	cwt.	86.50	583.05	50433.92	112.08
Cows	cwt.	44.90	360.00	16164.00	35.92
Hay:					
Fall sale	ton	62.00	103.91	6442.23	14.32
Spring sale	ton	62.00	94.50	5859.00	13.02
Total Receipts				145702.15	323.78
Variable Costs					
Raked Hay					
Feed and minerals:					
Hay	ton	11.00	901.59	9917.52	22.04
Salt	ton	102.00	1.71	174.42	.39
Minerals	ton	600.00	2.17	1302.00	2.89
Labor:					
Fence move and maintence	hr.	5.00	11.00	55.00	.12
Materials & misc:					
Fence		147.20	1.00	147.20	.33
Emergency Feed:					
Meadow Hay	ton	27.00	.00	.00	.00
Purchased Hay	ton	62.00	.00	.00	.00
Labor	hr.	5.00	.00	.00	.00
Tractor & wagon	hr.	3.93	.00	.00	.00
Harvest Cost:					
Fall hay sale	ton	27.00	103.91	2805.49	6.23
Spring hay sale	ton	27.00	94.50	2551.50	5.67
Interest: Spring hay				341.78	.76
Range Grazing: (2 months, 8/1-9/30)	aum	1.50	900.0	1350.00	3.00
Total Costs				18644.91	41.43
Net Returns				127057.25	282.35
Winter Costs				11937.92	26.53

Table 1.13: Ranch Partial Budget, Rake-bunch Hay, Year 2-5

Receipts	Unit	$/unit	Number of Units	Total ($)	Per cow ($)
Livestock:					
Steers	cwt.	86.50	770.06	66610.10	148.02
Heifers	cwt.	86.50	580.91	50248.95	111.66
Cows	cwt.	44.90	360.00	16164.00	35.92
Hay					
Fall sale	ton	62.00	103.91	6442.23	14.32
Spring sale	ton	62.00	94.50	5859.00	13.02
Total Receipts				145324.29	322.94
Variable Costs					
Raked Hay					
Feed and minerals:					
Hay	ton	11.00	901.59	9917.52	22.04
Salt	ton	102.00	1.71	174.42	.39
Minerals	ton	600.00	2.17	1302.00	2.89
Labor:					
Fence move and maintence	hr.	5.00	11.00	55.00	.12
Materials & misc:					
Fence		147.20	1.00	147.20	.33
Emergency Feed:					
Meadow Hay	ton	27.00	.00	.00	.00
Purchased Hay	ton	62.00	.00	.00	.00
Labor	hr.	5.00	.00	.00	.00
Tractor & wagon	hr.	3.93	.00	.00	.00
Harvest Cost:					
Fall hay sale	ton	27.00	103.91	2805.49	6.23
Spring hay sale	ton	27.00	94.50	2551.50	5.67
Interest: Spring hay				341.78	.76
Range Grazing: (2 months, 8/1-9/30)	aum	1.50	900.0	1350.00	3.00
Total Costs				18644.91	41.43
Net Returns				126679.38	281.51
Winter Costs				11937.92	26.53

APPENDIX F:

RANGE GRAZING: VERY SEVERE WINTER OUTPUT

APPENDIX F

RANGE GRAZING: VERY SEVERE WINTER OUTPUT

Table 1.1: Determination of Feed Type in Relation to Snow Depth

(week)	Snow Depth (cm)	Feed Type	Forage Nutrient Content NE (mcal/kg)	Forage Nutrient Content CP (gm/kg)
OCT 1-7	.0	range	.80	35.00
8-14	.0	range	.80	35.00
15-21	.0	range	.80	35.00
22-28	.0	range	.80	35.00
29-4	.0	range	.80	35.00
NOV 5-11	.0	range	.80	35.00
12-18	.0	range	.80	35.00
19-25	5.0	range	.80	35.00
26-2	.0	range	.80	35.00
DEC 3-9	.0	range	.80	35.00
10-16	5.0	range	.80	35.00
17-23	13.0	range	.80	35.00
24-30	25.5	baled	1.10	74.00
JAN 31-6	25.5	baled	1.10	74.00
7-13	35.5	baled	1.10	74.00
14-20	40.5	baled	1.10	74.00
21-27	43.0	baled	1.10	74.00
28-3	35.5	baled	1.10	74.00
FEB 4-10	30.5	baled	1.10	74.00
11-17	43.0	baled	1.10	74.00
18-24	30.0	baled	1.10	74.00
25-3	22.0	baled	1.10	74.00

Table 1.2: Determination of Inventory Changes of Winter Forage Resources and Associated Nutrient Contents

DATE (week)	Beginning Stock	Ending Stock (tons)	Change in Stock	Feed Type	Nutrient Content of Forage NE (mcal/kg)	Nutrient Content of Forage CP (gm/kg)
OCT 1-7	762.30	727.65	34.65	range	.80	35.00
8-14	727.65	693.00	34.65	range	.80	35.00
15-21	693.00	658.35	34.65	range	.80	35.00
22-28	658.35	623.70	34.65	range	.80	35.00
29-4	623.70	589.05	34.65	range	.80	35.00
NOV 5-11	589.05	554.40	34.65	range	.80	35.00
12-18	554.40	519.75	34.65	range	.80	35.00
19-25	519.75	485.10	34.65	range	.80	35.00
26-2	485.10	450.45	34.65	range	.80	35.00
DEC 3-9	450.45	415.80	34.65	range	.80	35.00
10-16	415.80	381.15	34.65	range	.80	35.00
17-23	381.15	346.50	34.65	range	.80	35.00
24-30	346.50	346.50	.00	baled	1.10	74.00
JAN 31-6	346.50	346.50	.00	baled	1.10	74.00
7-13	346.50	346.50	.00	baled	1.10	74.00
14-20	346.50	346.50	.00	baled	1.10	74.00
21-27	346.50	346.50	.00	baled	1.10	74.00
28-3	346.50	346.50	.00	baled	1.10	74.00
FEB 4-10	346.50	346.50	.00	baled	1.10	74.00
11-17	346.50	346.50	.00	baled	1.10	74.00
18-24	346.50	346.50	.00	baled	1.10	74.00
25-3	346.50	346.50	.00	baled	1.10	74.00

Table 1.3: Temperature Adjusted Nutrient Values

DATE (week)	Temperature (C)	NE (mcal/kg)	CP (gm/kg)
OCT 1-7	7.0	.79	34.50
8-14	6.5	.79	34.48
15-21	5.5	.79	34.44
22-28	5.0	.79	34.42
29-4	3.5	.79	34.36
NOV 5-11	.0	.78	34.23
12-18	2.0	.79	34.31
19-25	-1.0	.78	34.19
26-2	1.0	.78	34.27
DEC 3-9	-6.0	.78	34.00
10-16	-7.0	.78	33.96
17-23	-7.5	.78	33.94
24-30	-9.0	1.07	71.64
JAN 31-6	-4.0	1.07	72.05
7-13	-3.0	1.07	72.13
14-20	-7.0	1.07	71.80
21-27	-1.0	1.08	72.29
28-3	-6.0	1.07	71.88
FEB 4-10	-2.0	1.08	72.21
11-17	-7.0	1.07	71.80
18-24	-4.0	1.07	72.05
25-3	-3.0	1.07	72.13

Table 1.4: Energy and Protein Requirements of Spring Calving Cows

DATE (week)	TEMP. (C)	Cow wght. (kg)	A (coef.)	Maintence requirements: NE (mcal)	CP (gm)	Pregnancy Requirements: Day of pregnancy	NE (mcal)	CP (gm)	Total Daily Requirement NE (mcal)	CP (gm)
OCT 1-7	-.1	500.0	.09	9.43	592.0	109	.08	2.05	9.52	594.0
8-14	2.4	499.5	.09	9.25	592.0	116	.11	2.65	9.36	594.6
15-21	1.2	499.1	.09	9.34	592.0	123	.14	3.40	9.48	595.4
22-28	5.0	498.6	.09	9.06	592.0	130	.18	4.32	9.23	596.3
29-4	3.5	498.4	.09	9.17	592.0	137	.22	5.44	9.39	597.4
NOV 5-11	-3.7	497.9	.09	9.69	592.0	144	.28	6.80	9.97	598.8
12-18	-5.0	496.8	.09	9.78	592.0	151	.34	8.42	10.12	600.4
19-25	-4.7	495.5	.09	9.75	592.0	158	.42	10.33	10.17	602.3
26-2	-2.5	494.1	.09	9.58	592.0	165	.51	12.57	10.09	604.6
DEC 3-9	-12.5	492.9	.10	10.30	592.0	172	.62	15.15	10.92	607.1
10-16	-10.1	490.6	.10	10.11	592.0	179	.74	18.09	10.85	610.1
17-23	-10.9	488.3	.10	10.16	592.0	186	.87	21.40	11.03	613.4
24-30	-13.0	485.9	.10	10.30	592.0	193	1.02	25.09	11.32	617.1
JAN 31-6	-4.0	486.8	.09	9.65	592.0	200	1.19	29.13	10.84	621.1
7-13	-6.4	488.0	.10	9.83	670.0	207	1.37	33.50	11.20	703.5
14-20	-10.7	488.8	.10	10.15	670.0	214	1.56	38.14	11.70	708.1
21-27	-7.8	489.2	.10	9.94	670.0	221	1.75	43.00	11.69	713.0
28-3	-9.1	489.7	.10	10.04	670.0	228	1.96	47.98	11.99	718.0
FEB 4-10	-9.0	489.8	.10	10.03	670.0	235	2.16	52.99	12.19	723.0
11-17	-11.0	489.8	.10	10.17	670.0	242	2.36	57.89	12.53	727.9
18-24	-4.0	489.4	.09	9.67	670.0	249	2.55	62.55	12.22	732.6
25-3	-7.0	489.4	.10	9.88	670.0	256	2.72	66.82	12.61	736.8

Table 1.5: Energy and Protein Intake of Cows and Nutrients Available for Maintence

DATE (week)	Daily Requirements NE (mcal)	Daily Requirements CP (gm)	Daily Intake: Roughage: DM (kg)	NE (mcal)	CP (gm)	Concentrate: (kg)	NE (mcal)	CP (gm)	Total Intake: NE (mcal)	CP (gm)	Nutrients Avaliable for Cow Maintence: NE (mcal)	CP (gm)
OCT 1-7	9.52	594.0	9.98	7.88	344.2	.61	1.17	242.95	9.05	587.2	8.97	585.1
8-14	9.36	594.6	9.98	7.87	344.0	.61	1.17	242.95	9.05	587.0	8.94	584.3
15-21	9.48	595.4	9.98	7.87	343.6	.61	1.17	242.95	9.04	586.6	8.90	583.2
22-28	9.23	596.3	9.98	7.86	343.4	.61	1.17	242.95	9.04	586.4	8.86	582.1
29-4	9.39	597.4	9.98	7.85	342.9	.61	1.17	242.95	9.02	585.8	8.80	580.4
NOV 5-11	9.97	598.8	9.98	7.82	341.5	.61	1.17	242.95	9.00	584.5	8.72	577.7
12-18	10.12	600.4	9.98	7.84	342.3	.61	1.17	242.95	9.01	585.2	8.67	576.8
19-25	10.17	602.3	9.98	7.81	341.1	.61	1.17	242.95	8.99	584.1	8.57	573.8
26-2	10.09	604.6	9.98	7.83	341.9	.61	1.17	242.95	9.00	584.9	8.49	572.3
DEC 3-9	10.92	607.1	9.98	7.77	339.2	.61	1.17	242.95	8.95	582.2	8.33	567.0
10-16	10.85	610.1	9.98	7.77	338.8	.61	1.17	242.95	8.94	581.8	8.20	563.7
17-23	11.03	613.4	9.98	7.76	338.6	.61	1.17	242.95	8.94	581.6	8.06	560.2
24-30	11.32	617.1	11.56	12.35	828.5	.00	.00	.00	12.35	828.5	11.33	803.4
JAN 31-6	10.84	621.1	11.56	12.42	833.2	.00	.00	.00	12.42	833.2	11.23	804.1
7-13	11.20	703.5	11.56	12.43	834.1	.00	.00	.00	12.43	834.1	11.06	800.6
14-20	11.70	708.1	11.56	12.38	830.4	.00	.00	.00	12.38	830.4	10.82	792.2
21-27	11.69	713.0	11.56	12.45	836.0	.00	.00	.00	12.45	836.0	10.70	793.0
28-3	11.99	718.0	11.56	12.39	831.3	.00	.00	.00	12.39	831.3	10.43	783.3
FEB 4-10	12.19	723.0	11.56	12.44	835.1	.00	.00	.00	12.44	835.1	10.28	782.1
11-17	12.53	727.9	11.56	12.38	830.4	.00	.00	.00	12.38	830.4	10.02	772.5
18-24	12.22	732.6	11.56	12.42	833.2	.00	.00	.00	12.42	833.2	9.87	770.6
25-3	12.61	736.8	11.56	12.43	834.1	.00	.00	.00	12.43	834.1	9.70	767.3

Table 1.7: Monthly Percent Weight Change of Cows and Estimation of Cow Conception and Calving Rate

Date		Cow weight (kg)	Monthly Change (%)	
OCT	1-7	499.9		
	8-14	499.9		
	15-21	499.8		
	22-28	500.0		
	29-4	501.1	.25	Conception Rate
NOV	5-11	501.5		
	12-18	501.7		= 86.50
	19-25	501.8		
	26-2	501.7	.11	
DEC	3-9	500.5		
	10-16	499.3		Calving Rate
	17-23	498.0		
	24-30	500.0	-.34	= 96.00
JAN	31-6	503.5		
	7-13	506.7		
	14-20	509.5		
	21-27	512.3	2.46	
	28-3	516.1		
FEB	4-10	519.9		
	11-17	523.2		
	18-24	526.9		
	25-3	530.5	3.56	

Table 1.8: Herd Production Characteristics

	year 1	year 2	year 3	year 4	year 5
Number of Cows	450	450	450	450	450
Calving Rate	96.00	96.00	96.00	96.00	96.00
Number of calves	427	417	417	417	417
Heifers	214	208	208	208	208
Steers	214	208	208	208	208
Pregnancy Rate	86.50	86.50	86.50	86.50	86.50
# Cows Pregnant	389	389	389	389	389
Culled	45	45	45	45	45
Cows Retained	405	405	405	405	405
Heifers Retained	45	45	45	45	45
Replacements/Oct 1	45	45	45	45	45
# Cows/Oct 1	450	450	450	450	450
Cattle sold					
Cows	36	36	36	36	36
Heifers	161	156	156	156	156
Steers	206	201	201	201	201

Table 1.9: Winter Land Usage: Hay Meadows

Production:	Land Area (Acres)	Production (tons)
Baled Hay	745.63	745.63
Hay retained	378.00	378.00
Fall hay sale	367.63	367.63
Raked Hay		
Summer Usage	354.38	354.38
Winter Usage	.00	.00
Standing Pasture	.00	.00
Utilization:		
Baled Hay		
Hay retained	378.00	378.00
Purchased Hay		94.50
Raked Hay		
Summer Use	354.38	354.38
Winter Use	.00	.00
Standing Pasture	.00	.00
Waste:		
Baled Hay		
Hay retained	.00	.00
Raked Hay		
Summer Use	.00	.00
Winter Use	.00	.00
Standing Pasture	.00	.00
Recovered:		
Baled Hay		
Spring hay sale		.00
Raked Hay		0.00
Standing Pasture		0.00

Table 1.10: Winter Land Usage; Rangeland

Production:	Land Area (Acres)	Production (tons)
Rangeland	22500	2250.00
Utilization:		
Rangeland	12273	415.80
Waste:		
Rangeland	10227	346.50
Recovered:		
Rangeland		0.00

Table 1.11: Cow Winter Forage Intake

Total Intake:	
Kg/cow	1647.62
Tons/cow	1.82
Tons/herd	817.43
Baled Hay:	
Kg/cow	809.52
Tons/cow	.89
Tons/herd	401.63
Raked Hay:	
Kg/cow	.00
Tons/cow	.00
Tons/herd	.00
Range:	
Kg/cow	838.10
Tons/cow	.92
Tons/herd	415.80
Standing:	
Kg/cow	.00
Tons/cow	.00
Tons/herd	.00
Supplement:	
Kg/cow	57.1
Tons/cow	.06
Tons/herd	28.35

Table 1.12: Ranch Partial Budget, Range Grazing, Year 1

Receipts	Unit	$/unit	Number of Units	Total ($)	Per cow ($)
Livestock:					
Steers	cwt.	86.50	783.27	67752.96	150.56
Heifers	cwt.	86.50	588.10	50870.87	113.05
Cows	cwt.	44.90	405.00	18184.50	40.41
Hay					
Fall sale	ton	62.00	367.63	22792.75	50.65
Spring sale	ton	62.00	.00	.00	.00
Total Receipts				159601.08	354.67
Variable Costs					
Range Grazing: (5 months, 10/1-3/3)					
Range	aum	1.50	2250.00	3375.00	7.50
Supplement	ton	282.20	28.35	8000.70	17.78
Salt	ton	102.00	1.71	174.42	.39
Minerals	ton	600.00	2.17	1302.00	2.89
Labor:					
Feeding supplement	hr.	5.00	102.06	510.32	1.13
Materials & misc:					
Troughs		38.25	18.00	688.51	1.53
Truck (3/4 ton)	hr.	1.50	146.86	220.29	.49
Loader Tractor (50 hp)	hr.	3.87	10.50	40.64	.09
Miscellaneous				1000.00	2.22
Emergency Feed:					
Meadow Hay	ton	27.00	378.00	10206.00	22.68
Purchased Hay	ton	62.00	94.50	5859.00	13.02
Labor	hr.	5.00	630.00	3150.00	7.00
Tractor & wagon	hr.	3.93	354.38	1392.69	3.09
Hay Hauling	ton	10.00	472.50	4725.00	10.50
Harvest Cost:					
Fall hay sale	ton	27.00	367.63	9925.88	22.06
Spring hay sale	ton	27.00	.00	.00	.00
Interest: Spring hay				.00	.00
Rake Bunch (Aug/1-Sept/30)	ton	11.00	354.38	3898.13	8.66
Total Costs				54468.57	121.04
Net Returns				105132.52	233.63
Winter Costs				40644.57	90.32

Table 1.13: Ranch Partial Budgett, Range Grazing, Year 2-5

Receipts	Unit	$/unit	Number of Units	Total ($)	Per cow ($)
Livestock:					
Steers	cwt.	86.50	764.35	66116.23	146.92
Heifers	cwt.	86.50	569.93	49298.75	109.55
Cows	cwt.	44.90	405.00	18184.50	40.41
Hay:					
Fall sale	ton	62.00	367.63	22792.75	50.65
Spring sale	ton	62.00	.00	.00	.00
Total Receipts				156392.23	347.54
Variable Costs					
Range Grazing: (5 months, 10/1-3/3)					
Range		1.50	2250.00	3375.00	7.50
Supplement	ton	282.20	28.35	8000.70	17.78
Salt	ton	102.00	1.71	174.42	.39
Minerals	ton	600.00	2.17	1302.00	2.89
Labor:					
Feeding supplement	hr.	5.00	102.06	510.32	1.13
Materials & misc:					
Troughs		38.25	18.00	688.51	1.53
Truck (3/4 ton)	hr.	1.50	146.86	220.29	.49
Loader Tractor (50 hp)	hr.	3.87	10.50	40.64	.09
Miscellaneous				1000.00	2.22
Emergency Feed:					
Meadow Hay	ton	27.00	378.00	10206.00	22.68
Purchased Hay	ton	62.00	94.50	5859.00	13.02
Labor	hr.	5.00	630.00	3150.00	7.00
Tractor & wagon	hr.	3.33	354.38	1332.69	3.09
Hay Hauling	ton	10.00	472.50	4725.00	10.50
Harvest Cost:					
Fall hay sale	ton	27.00	367.63	9925.88	22.06
Spring hay sale	ton	27.00	.00	.00	.00
Interest: Spring hay				.00	.00
Rake Bunch (Aug/1-Sept/30)	ton	11.00	354.38	3898.13	8.66
Total Costs				54468.57	121.04
Net Returns				101923.67	226.50
Winter Costs				40644.57	90.32