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Growth Potential of Sandhills Ranches Through Irrigation

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by

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SUMMARY

This study evaluated different methods of facilitating growth of small and medium-sized Nebraska Sandhills ranches. Growth was measured in terms of increased net worth, net income, and amount available for family living for a 15-year planning horizon.

The objective was to compare extensive and intensive growth strategies in a dynamic and uncertain environment through simulation models. Extensive growth through land purchase was compared with rental growth. These were then compared to intensive (irrigation) growth. Planning strategies for extensive growth are hindered by uncertainty in availability of land for rent or purchase. Intensive growth through irrigation is not dependent upon acquiring additional real estate.

Variabilities in forage production, livestock production, livestock yields, and livestock prices were included in simulation models. Major decision variables investigated were methods of land acquisition, different levels of beginning owner equity, alternative financial arrangements, and irrigation investments.

The rancher on the typical ranch was assumed to start with a 380-head cow-calf operation with 5,840 acres of non-irrigated hayland and grazing range. This base included 1,540 acres of rented land. A family consumption function assumed a minimum of $5,000 for family living each year.

In the first phase, simulation trials were conducted to determine which variables had the greatest impact on annual net ranch income. Livestock prices of the variables investigated were found to have the greatest effect upon net ranch income. Livestock price movements resulted in the greatest change in net ranch income, both on an annual basis and over the 15-year period.

The variable with the next greatest effect on net ranch income was annual forage production. Annual forage production variability in the study area is largely the result of weather.

Variability in calf-crop percentage ranked third in impact upon net ranch income.

Variability in calf weaning weights had the least effect upon income variation.

Calf-crop percentages and calf weaning weights can be improved by good management practices. Changing the livestock price level is beyond the scope of the individual producer. Improved livestock production and yields are possible. Improved forage production is now an attractive alternative in the Sandhills due to improved center-pivot irrigation systems.

The combination of price and production variables resulted in a wide variation of returns on total assets in the ranching industry. On the basis of the no-growth simulation trials at 80% beginning equity,

return of investment ranged from –1.45 to 4.77% with a 15-year average return of 1.36%.

The next phase of the study compared extensive and intensive growth in light of the low rate of return for no-growth. Extensive growth consisted of two options for growth over the simulated period—either purchasing or renting 1,280 acres and stocking with 70 cows, three times over the 15 years. Both options employed the same price cycle and variable production coefficients and assumed no appreciation in land value. Negative changes in net worth for extensive growth options occurred. The purchase growth option resulted in a –5.0% change in net worth with a –4.6% change in net worth occurring under the rental growth option. Increased family consumption was less when growth was attempted than when the firm did not attempt to grow, with the purchase growth option returning the least amount for family spending.

Intensive growth was investigated on the assumption the firm was lacking in adequate supplemental winter livestock feed. Intensive growth was examined in two segments. The first was to internalize supplemental winter feed expenses by installing a center-pivot irrigation unit the first year of operation and producing 135 acres of alfalfa. This resulted in the elimination of annual forage and protein purchases. An additional 95 cows were added to the unit through this operation. Rate of return averaged 2.79% compared to 2.16% for the extensive purchase option. Net worth increased 36.4% over the 15 years.

The second phase of intensive growth consisted of installing an additional 135 acre center-pivot irrigation unit and raising 90 acres of corn silage and 45 acres of alfalfa to background ranch-produced calves. This resulted in the addition of raising corn silage and a supplemental type enterprise, feeding ranch-produced calves through the winter. The addition of these enterprises resulted in greater growth than any of the previous strategies. The addition of the second irrigation unit resulted in an average 4.77% return on total investment, an increase in net worth of $175,442 (61.2%) over the period and an improved standard of living $25,467 better than the next best alternative.

Trials were conducted assuming growth under different beginning points on the historical livestock price cycle. The trials assumed growth would begin at the low point (1964) in the 1958–71 price cycle, when prices were on an upswing (1968), at the peak (1971), and when prices were on a downswing (1960). Greatest increases in net worth and improved family consumption occurred when growth began when livestock prices were increasing. Poorest growth over the price cycle occurred when growth began when prices were on the downswing. Assuming average prices over the simulation period resulted in

the second-best increase in net worth but the lowest level of family consumption.

Beginning equity trials were conducted to determine the minimum owner equity required for the firm to take advantage of growth opportunities and have a reasonable chance for success. Typical and liberal real estate credit policies were also examined to determine their effect on firm growth.

Extensive growth required beginning owner equities above 80% for successful growth. This high equity requirement precluded the need for liberal credit policies.

Intensive growth (one irrigation system) under alfalfa production occurred at 60% beginning equity starting with the price upswing but growth could not occur with average or other alternative beginning price levels.

A beginning equity of 65% was found necessary for a reasonable chance of successful growth under irrigated alfalfa given the historical price cycle.

When both intensive alfalfa and corn silage growth options were employed, beginning equities of 45% under price upswing, 50% assuming average prices prevailed over the period and 55% when prices were on the downswing allowed growth to occur. Liberal credit policies were found necessary for growth to occur when beginning equity was below 65%.

This study was completed under given land values and assumed costs for cattle production, crop production and irrigation development. In periods of inflation where these values may have changed, conclusions reached in this study may not hold. Hence, expansion decisions in periods of changing prices need to be made considering up-to-date costs and expected cattle price levels. Additional research needs to be completed incorporating the effects of inflation on questions of ranch expansion strategies.

Growth Potential of Sandhills Ranches Through Irrigation

Robert D. Carver and Glenn A. Helmers[1]

INTRODUCTION

Changes in United States agriculture in the Twentieth Century have been phenomenal. Agriculture has changed from an industry largely land and labor based to an industry relying heavily on capital with increasing financial, technological, organizational, and managerial components. One of the more pronounced adjustments in the past 20 years has been the structural change to fewer and larger farms. Farm and ranch numbers in Nebraska, after reaching a peak of 135,000 in 1934, declined to 73,000 in 1970.[2] During this same period, the average size increased from 350 to 659 acres.

Economies of size, income stability, retirement security, capital accumulation or any combination of these are a few of the factors pressuring farmers and ranchers to expand their operating units. Individual operators must make changes in their operations to obtain and maintain adequate living standards and family income.

Ranching enterprises in the Nebraska Sandhills are faced with many of the same problems confronting farm units. Traditionally, however, Great Plains ranching enterprises have trailed farming enterprises in capital intensification and the resulting substitution of capital or labor. This has occurred not because the ranching industry is lacking in innovators but by the very nature of the ranching industry. From the ranching regions of the arid Southwest, the plains of western Kansas, the Sandhills of Nebraska, to the northern regions of Montana and the Dakotas, extensive type operations prevail.

STUDY AREA

The Sandhills of north central Nebraska presents a unique opportunity for the study of firm growth in the ranching industry. The Sandhills is the largest undivided expanse of grassland in the United States combined with the single enterprise production system of cattle ranching (Figure 1). This combination lends itself to the study of "pure" extensive expansion.

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[1] Former Research Assistant, Associate Professor, University of Nebraska, Lincoln, respectively.

[2] Nebraska Agricultural Statistics. State Federal Division of Agricultural Statistics, Lincoln, Nebraska.

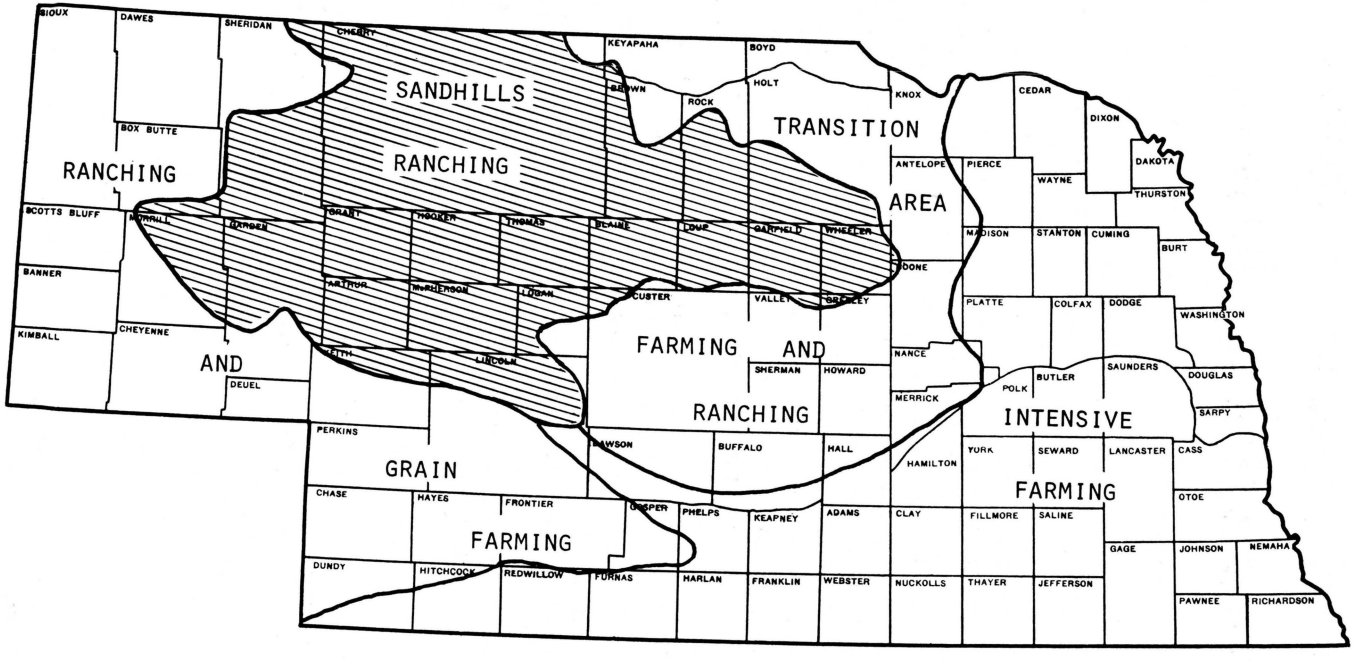

Figure 1. Map of Nebraska showing Sandhills area, major livestock producing areas of the state, and counties included in the study.

Much of the Sandhills has high levels of groundwater storage for irrigation (Figure 2). The use of self-propelled center-pivot sprinkler irrigation systems means firm growth through intensive expansion via irrigation can be examined using a basic ranch unit.

The area chosen for study consists of nine Sandhills counties. The counties are Arthur, Blaine, Cherry, Grant, Hooker, Logan, Loup, McPherson and Thomas (Figure 1). These counties are within the cattle ranching area of Nebraska and the topography, climate and economic base are similar.

Soil material in this nine county Valentine-Dunday soil association is composed of sand and loamy sand. The landscape is a succession of dunes and swales with some narrow elongated dry valleys, scattered shallow lakes and infrequent streams. The cultivated acreage is small and localized along the stream valleys and on less sandy soils. The climate is one of relatively warm summers, cold winters and highly seasonal or periodic moderate precipitation (14–20 inches). The Sandhills counties are known for their abundance of medium and tall warm season grasses. Because of the sandy soils and limited rainfall the area is better suited for grazing than for crop production.

These counties are also similar economically with personal income for the area coming primarily from agriculture. The area exhibits typical extensive ranch type growth problems. Land is not always readily available for rent or purchase. Land going on the market for sale usually occurs when a rancher retires or when sold through an estate. Even when this occurs the land may not be close enough to a rancher interested in growth to make the transfer feasible. The additional unit when purchased results in an investment which is "lumpy" or non-divisible and requires a large amount of investment capital.

PURPOSES AND OBJECTIVES

The purpose of this study was to compare extensive and intensive growth strategies of a typical Nebraska Sandhills ranch in a dynamic and uncertain environment. Study objectives were to:

1. Analyze growth of an average ranch firm of 450 animal units as it grows to 600–900 animal units.

2. Study the effects of an uncertain environment on the long-run growth opportunities of a ranch firm.

3. Compare extensive and intensive growth of a ranch firm.

NATURE OF FIRM GROWTH

Definitions of firm growth generally refer to an increase in physical size and/or increase in the level of output of the firm over time. Therefore, for this study, firm growth was defined as change in net worth (absolute) and income flows allotted for farm family consumption. The assumption followed that the operator was concerned with cur-

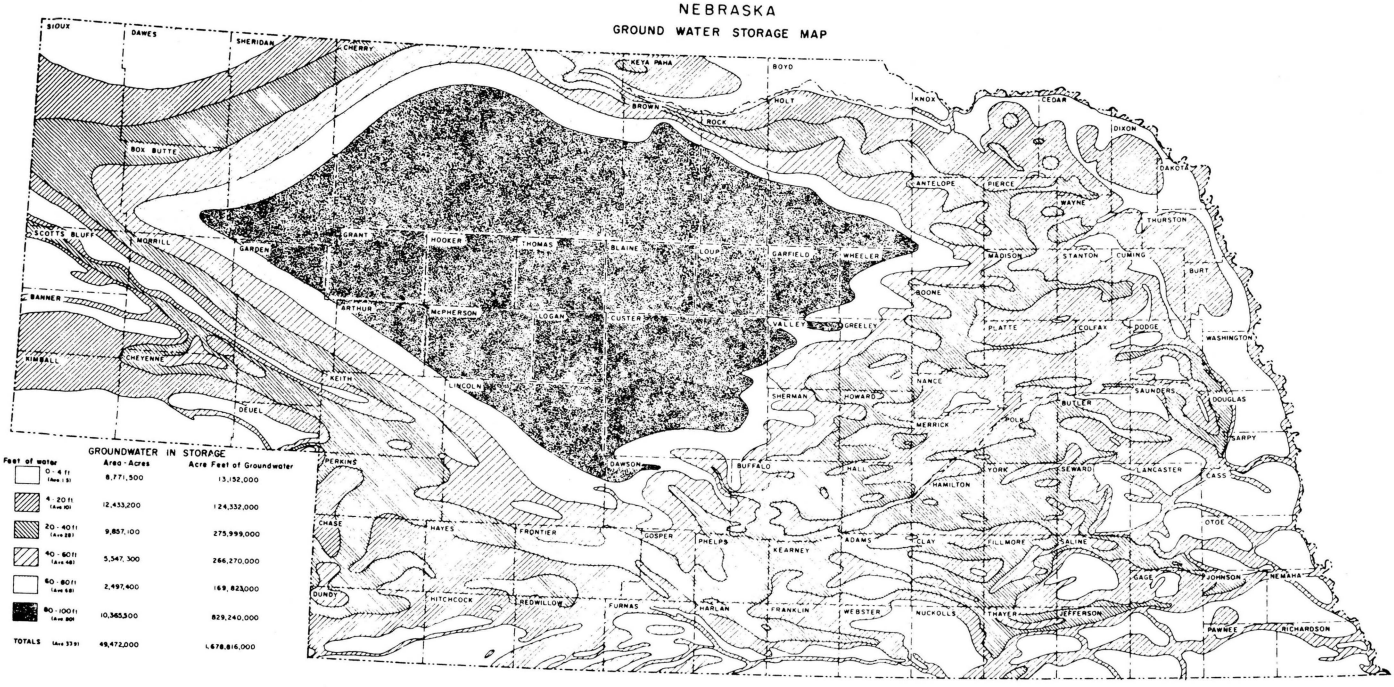

Figure 2. Ground water storage in Nebraska.

rent consumption levels as well as retirement security in the firm-household interrelationship setting.

From a purely operational point of view, ranch operators are primarily interested in controlling the productive power of resources. Productivity depends on the effectiveness with which resources are combined by management. Being free to combine them in an effective manner requires only the control of their use. Ownership of the resources merely establishes how payment for the right to use them will be allocated.

Control through ownership may provide more freedom to select production plans and make operating decisions but this freedom does not guarantee efficient organization of the resources involved. If ownership is to constitute any real asset, acquisitions must be financed from profits generated and retained in the business. This requirement does not preclude the use of credit. Outside funds (inheritance, off-farm earnings and outside investments) can be used to acquire additional resources but such asset growth must not be misinterpreted as a reflection of the firm's ability to support such expansion or its ability to generate profits.

Most means for attaining growth can be reduced to financial strategies which are long-run plans determining the primary source of funds to be employed by the firm and how these funds are to be used. The vast array of financial strategies generally can be reduced to the following four types: internal financing, debt (credit) financing, direct financing (leasing or hiring of resources) and equity financing.

In this study only equity financing was not considered. Primary emphasis was placed upon credit financing and direct financing.

Internal Financing

Internal financing strategies to acquire ownership depend upon earnings being retained in the business. Traditionally, retained profits have been a major means of financing farm business growth. Earnings retained in the business for growth are merely asset transfers and, in the accounting sense, involve neither expenses nor debt obligations. However, such internal funding demands that the cash account be able to support the transaction. The accelerated rate of expansion now taking place throughout agriculture has outstripped most farmer's ability to fund such growth internally, forcing operators to seek credit, the traditional outside source of funding.

Credit Financing

The use of credit financing entails the obligation of a repayment schedule for the principal involved plus interest for the use of the funds. These payments must come from future earnings if ownership growth is to take place.

Firm growth through credit financing involves no immediate increase in ownership equity holdings though the financial structure is altered. The increase in assets is exactly offset by added liabilities. The terms of the debt obligation for an undepreciable asset such as land virtually "lock in" a rate of growth that the business must maintain if it is to remain financially healthy.

Equity Financing

Because of possible incompatibilities between repayment schedules and profit performance, the use of equity financing is gaining acceptance among ranch operators. However, the general use of equity financing on a broad farm basis (through issuance of stock) has not been widely used. Although equity financing avoids fixed charges (principal and interest payments), the profits must be shared with others.

Direct Financing

Renting of land and other resources has long been used to obtain control of resources without ownership. Although it lacks the permanency of control afforded by ownership there are no acquisition payments from future earnings. Renting as a funding strategy involves a fixed charge under a contractual arrangement, on an annual basis.

Factors Limiting Farm Enlargement

While the previous factors encourage farm enlargement there are forces which limit firm growth: managerial limitations, financial limitations, and availability of land limitations.

Managerial Limitations

Management includes supervision and coordination. Supervision involves overseeing firm operations while coordination involves determining types of contracts into which the firm will enter and making adjustments in response to uncertainty and changing conditions. In the agricultural firm, the farm operator typically performs managerial functions of supervision and coordination and also supplies much of the labor. As the farm firm expands the operator can hire more labor and can even hire persons to perform supervisory tasks but he must still act as the coordinator for the entire operation.

Expansion of the farm firm may be limited by the managers ability to coordinate a larger operation. As the farming operation becomes larger and more complex the number of unpredictable situations requiring unique decisions increase. Coordination may become the limiting resource. At this point, the amount of other resources that can profitably be added is limited by the ability of the manager to coordinate the firm's operations.

Financial Limitations

The ability to finance the acquisition of additional resources may be a second limiting factor to expansion. The amount of capital required to gain control over additional resources varies with the type of financing arrangements available but, as a minimum, some type of down payment or collateral is required. The steady increase in land prices has greatly increased the cash outlay required to buy additional land. Even if the additional land is to be rented the operator will still have to make cash outlays to pay for additional quantities of such inputs as livestock, labor, repairs and feed.

Availability of Land Limitations

The third factor that limits farm expansion is the availability of land for rental or purchase. Land differs from the other factors of production in that it is fixed and not capable of being expanded. However, land can be utilized with varying degrees of intensity. The area of land available for a given use such as open range livestock production can change as land is shifted from one use to another. However, such shifts in land use are limited by the constraint imposed by total land area and by the topographic, climatic and locational requirements for land use in a particular area.

The quantity of land transferred by rental or purchase limits the extent to which extensive expansion can occur in a given area during a given time period. If land is fully employed the only way one operator can obtain control of more land is for another operator to give up land in his control. However, all land surrendered by firms leaving the industry will not necessarily become available for expansion of existing firms. Only a fraction of total ownership units is transferred through the markets in any given year and the quantity of land transferred may vary substantially from year to year. Some of these land transfers will be acquired by young men beginning ranching careers.

METHODOLOGY AND ASSUMPTIONS

The model was designed to simulate growth of a ranch firm producing beef cattle and forages in a dynamic and uncertain environment. Important aspects included methods of land acquisition and development, different production plans, prices, yields, levels of beginning equity in the firm and levels of consumption.

The emphasis of this study was to compare extensive growth through land acquisition and intensive growth via irrigation. Land procurement, investment, credit, production, and consumption decisions were governed by data specifications and decision rules within the model. Yearly cash flows were generated to portray linkage of the firm's financial transactions over the years. Resources and products were assumed to be purchased and sold in purely competitive markets.

Operations of the firm were simulated over a 15-year time period to depict the expansionary and varying equity stages of the firm's life cycle. The resource base for year 1 provided the base for the beginning of year 2 and so on. This resource base included land owned and rented, family labor, livestock, carryover forage, machinery, credit and cash savings. A firm solvency test was performed at the end of each year's operation. The firm was required to maintain solvency during each of the years or the program ended.

The simulation model for this study had four main segments—the main program and three major subprograms. The program simulated operation of the ranch firm on an annual basis so cash flows and cattle inventories were subject to minor discrepancies of aggregating data on an annual basis.

The Simulation Program

The main program served as the major source program for the simulation method. The primary input-output coefficients were computed in this segment of the model and it also served as a source for calling the major subprograms. A generalized flow diagram of the main simulation program is shown in Figure 3.

The program began by reading the initial resource base production and cost data and printing out a beginning (January 1) net worth statement. It was assumed that any rental or purchase agreement would be negotiated before the beginning of the production year but after the January 1 net worth statement. The programmer decided before the first replication what years the firm would lease or buy additional land resources. If a buy subroutine was called, a credit check was made to determine if the firm, through available cash and credit, was in a financial position to buy the land and purchase the additional livestock and machinery to operate the additional acreage. If a lease subroutine was called the credit check was made to see if the firm could afford the additional livestock purchases. If these decision points were passed the subroutine then completed the purchase or lease and made the necessary adjustments in cattle and machinery inventory, stocking rates, acres operated, debt structure, etc. If the credit check failed, control was returned to the main program and the model continued to operate with the initial resource base. There was no optimal purchase or lease strategy computed within the program. If the land was available for lease or purchase the model completed the transaction if the firm was in an equity position to do so.

The first major subprogram in the model was the next step. This was the typical extensive type ranch operation before irrigation enterprises. Within this subprogram were determined livestock and forage production, livestock feed and labor requirements and expenses and income for the year's ranch operation. The next two major subpro-

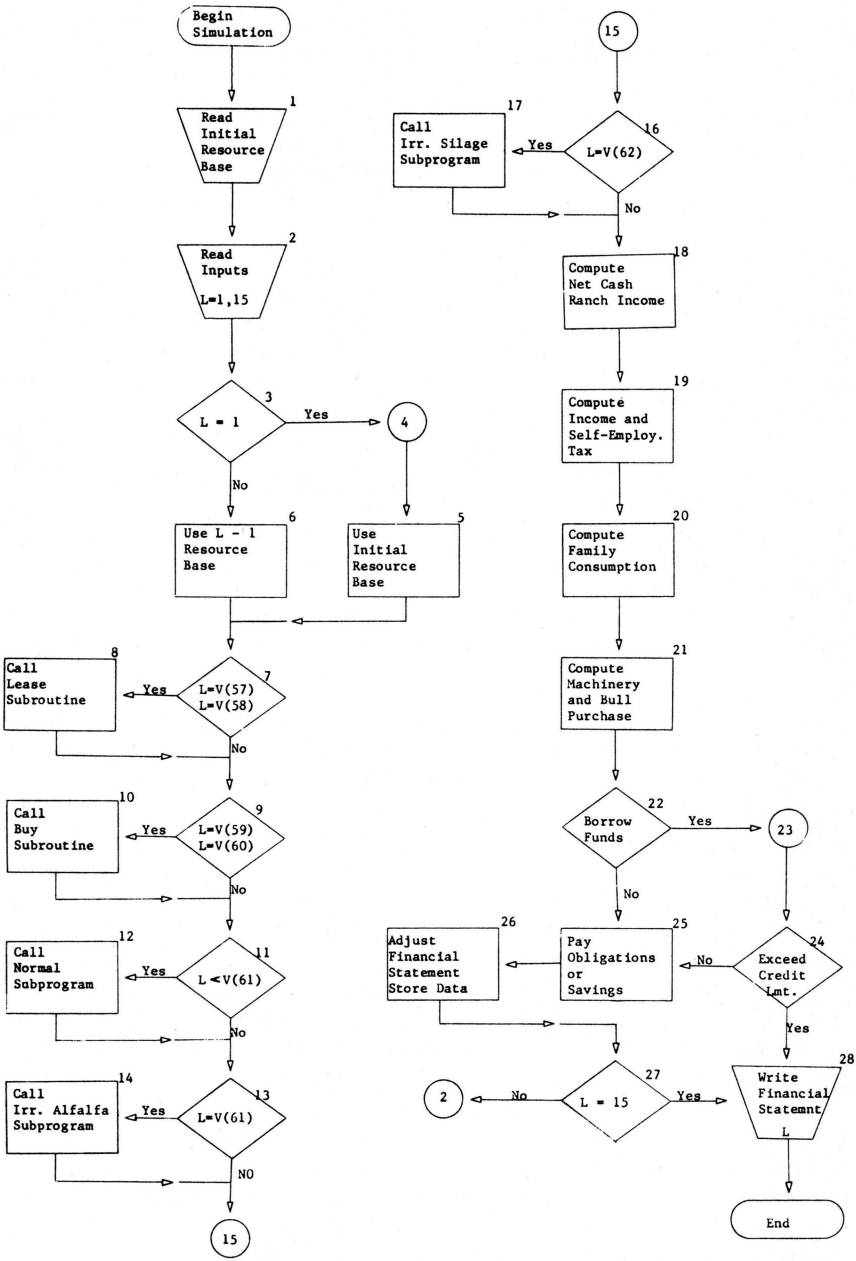

Figure 3. Generalized flow chart of the main simulation program. (L = year)

grams followed the same procedure. The irrigated alfalfa subprogram was designed to add an intensive complementary aspect to the firm and the irrigated corn silage subprogram was designed to add a new supplementary enterprise to the ranch firm. These new enterprises were integrated into the normal firm operation to a level where they competed for resources with other ranch operations. The generalized flow diagram of the operation with corn silage in Figure 4 is an example of one of the major subprograms. The programmer could replicate any one of the subprograms for the entire simulation period or any combination of operations.

After the production aspect of the program was completed in the subprogram, control was returned to the main program for financial completion. Net cash ranch income was determined for the income and expenses computed in the subprogram. Net cash ranch income for purposes of this study was defined as the difference between gross cash ranch income and gross cash ranch expenses.

The next step in the model was to determine income and self employment tax for the year. Income taxes were computed on a cash basis. The family consumption function was computed based on a standard consumption function. This function locked in a "certain" level of consumption plus a percentage of after-tax income. This function was exhibited by the following equation:

$$C = a + bI$$

where C is the family consumption, a is the "certain" level, b is the percentage and I is the after-tax income. Parameters a and b were specified as $5,000 and 25%, respectively.

Machinery and bull purchases were the next step. These purchases occurred every year regardless of ranch firm profit or loss. Machinery purchases were equal to annual machinery depreciation to maintain a constant value for machinery, and bull purchases were based on a culling rate for bulls.

The next step was to determine the amount, if any, of borrowed capital required for the firm's annual operation. Under assumptions of the model the firm had to pay certain fixed obligations every year. The minimum level of family consumption had to be met every year either through generated or borrowed capital. Long-term real estate payments and all interest on borrowed capital had to be paid. If in a poor year the ranch firm failed to generate enough net income to meet these obligations money was borrowed on a short-term basis with short and intermediate-term assets pledged on a chattel mortgage. A solvency check was then run on the firm to determine if it had exceeded the maximum credit limit considering both real estate and chattel credit. If the firm failed this test a final financial statement was written and the program ended. If the firm passed the test, obligations

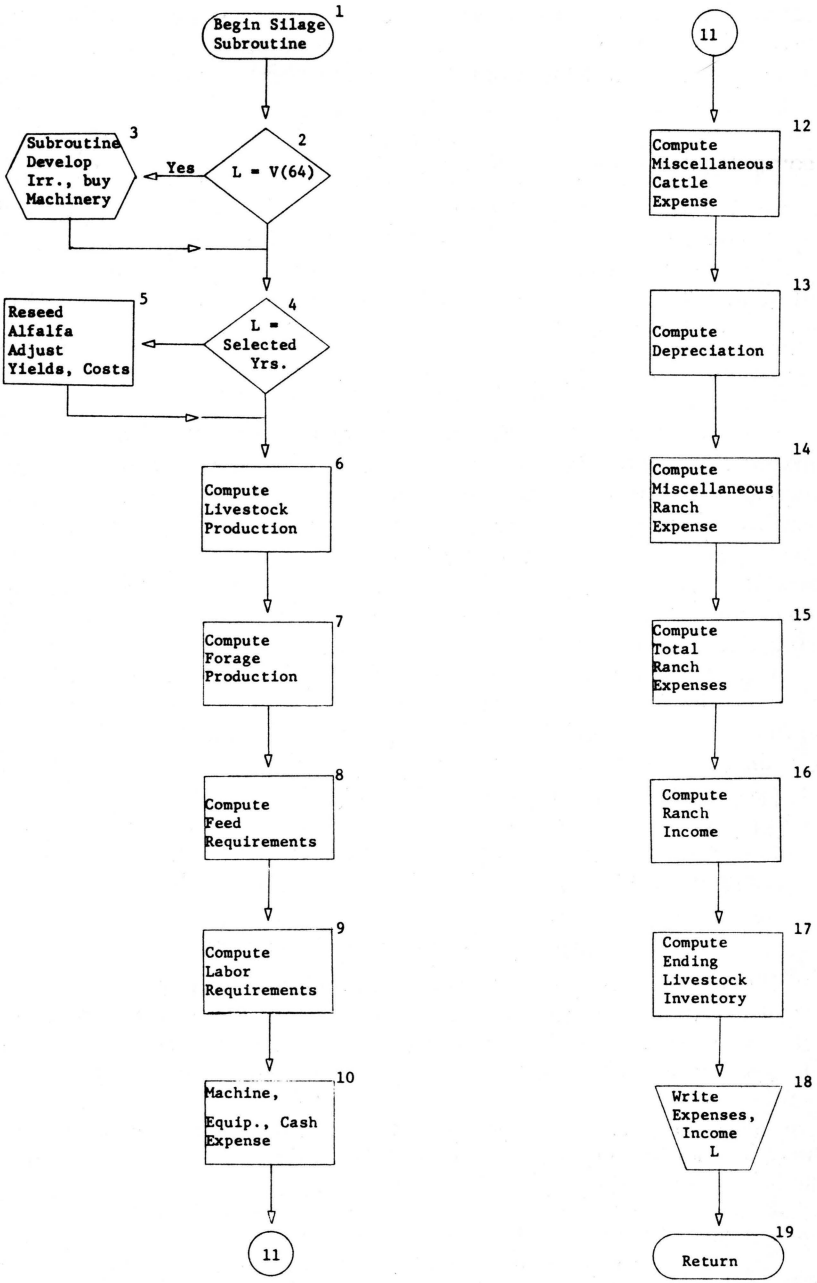

Figure 4. Generalized flow chart of the subprogram to operate the firm with addition of irrigated corn silage. (L = year)

were paid and any excess was deposited in a savings account. The financial and resource adjustments were then made to reflect the year's operation and the model was ready to begin another replication.

Input Data

The second important aspect of the model was the input data. Input coefficients for this simulation model of a ranch firm were based on a combination of survey data and various farm management sources and publications.[3] The simulation model was constructed to allow almost any combination of acres, animal units, costs, operator goals, etc., by changing input data.

Initial Resource Organization

The representative ranch was assumed to be a "typical" small to medium sized cow-calf firm in the central Nebraska Sandhills. Because averaging or grouping ranches tends to reduce accuracy in budgeted ranching research, the representative firm was constructed from records of eight smaller units interviewed during the 1970 Ranch Business Study.[4] This "typical" firm fit very closely the acreage and number of animal units of a ranch in the survey and in this respect almost gave a case study approach to the analysis.

The initial ranch unit consisted of 5,840 acres of which 4,310 acres were deeded and 1,530 acres were leased. There were 220 acres of subirrigated hay meadow. The representative ranch carried about 450 animal units and was operated as a basic cow-calf unit calving in the spring and selling calves in the fall after weaning.[5] This method of operation was chosen on the basis of previous Sandhills livestock systems research that indicated this livestock plan offered one of the best potentials for ranch growth.[6]

Operator Goals and Objectives

The operator of the representative ranch was assumed to be a high school graduate in his early thirties, married, with three children. He was a good to excellent ranch operator with a desire to expand his operation to provide an improved standard of living for his

[3] For detailed aspects of input coefficients and costs see Carver, Robert D. 1972. Simulation analysis of extensive and intensive growth of a Nebraska Sandhills ranch. Ph.D. thesis. Univ. of Nebr.

[4] Epp, A. W. and Robert E. Perry. The Sandhills ranch business in 1970 and comparisons with 1960 and 1965, Nebr. Agr. Exp. Sta. Bul. 525.

[5] Animal unit factors used in this study are as follows: Cows and first-calf heifers, 1 AU; bulls, 1.25 AU; horses, 1 AU; yearlings, .65 AU; weaned calves, .4 AU.

[6] Johnson, G. Robert, 1972. A firm growth study of a Sandhills ranch, M.S. thesis, University of Nebr.

family as well as to build a larger unit to allow inclusion of a son or son-in-law in a partnership arrangement as he approached retirement age.

Irrigation or intensive type agriculture was a relatively new phenomenon in the area. The operator was interested in this type of growth but related any new operation to how it would complement or supplement the present ranch operation or expand his operation along lines that would utilize his present ranching expertise.

There were two possible sites for self-propelled center pivot irrigation systems on the operators deeded land. These two sites were not contiguous and each site would allow about 135 acres to be sprinkler irrigated.

The representative firm, in absence of any irrigation, was short of winter feed. The firm normally purchased additional forage and supplemented livestock through the winter with purchased protein because the native hay was not adequate in this nutrient. The average expense for additional forage and protein supplement per animal unit exceeded $17 per year. The operator would likely look at irrigation as a means of reducing or eliminating his winter feed bill. Linear programming research by Bitney and Perry indicated that protein becomes the limiting factor in trying to internalize feed expenses.[7] Their results showed that this protein deficiency could be alleviated by feeding a good quality alfalfa or similar forage high in protein.

Given the opportunity to expand his operation intensively via irrigation the operator first raised a high quality protein forage for winter feed. This was a complementary operation with respect to internalizing ranch feed costs. Another consideration was that management skill required to raise irrigated alfalfa was not of the magnitude required to begin an intensive row crop enterprise given the delicate soil profile of the Sandhills.

It was logical to assume that after the representative firm was able to raise enough feed to meet its feed requirements it would then look upon irrigation as offering a new type of enterprise. The logical progression was for the firm to feed the livestock produced on the ranch to a heavier sale weight. An economical source of feed raised under irrigation is corn silage, hence it was assumed that the second expansion undertaken by the firm into irrigation was to raise corn silage and background calves. Developing the second irrigation site of 135 acres would allow enough feed raised to background the firm's calves (e.g., 200 days) but would not furnish enough additional feed to finish the cattle to slaughter weight.

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[7] Bitney, Larry L. and Robert E. Perry. Nebraska State Extension Specialist and Area Specialist, respectively. Unpublished research data. 1972.

Table 1. Investment in machinery and equipment.

Description	Investment
	($)
Tractors	
1962 50 hp	1,800
1962 35 hp	1,000
1954 50 hp	1,200
1954 30 hp	400
Pickups	
1968 4 wheel drive ¾ ton	1,600
1971 ½ ton	2,000
Auto (50%)	
1967 sedan	675
Haying equipment	
Double bar mower	500
24 foot rake	200
Stacker	700
Hay sweep	75
Baler (round)	575
Livestock equipment	
2 hay sleds	500
4 wheel wagon	100
Stock trailer	350
2 wheel trailer	150
Portable chute and panel	500
Sprayer	125
Saddle and tack	350
Shop tools and equipment	
2 welders	125
Tools	325
Tanks—gas, propane	320
	$13,570

Raising corn for cash grain or for a full livestock feeding program was not considered in the model. Although increasing amounts of irrigated corn are being raised in the transition areas for cash sale it was not considered a reasonable alternative for the representative firm given the operator's attitudes, lack of marketing facilities, lack of available feed to carry on both the ranching operation and a complete feeding program and the additional capital and management requirements necessary.

It was assumed that the representative firm had an adequate family dwelling, with buildings and equipment to handle the normal ranch operation. Machinery and equipment are shown in Table 1.

Major Program Variables

Land and Forage Use

Sandhills ranches are primarily open range grazing operations with up to 20% of the acreage harvested for winter forage. In addition to

Table 2. Land use and forage production.

Land use	Acres	Average yield/acre	Total AUM's
Owned land (initial)	4,310		
Leased land (initial)	1,530		
Total land	5,840		
Summer graze	3,810	.63 AUM[a]	2,400
Winter feed			2,440
Sub-irrigated hay	220	2.96 AUM[b]	651
Field cleanup	220	.35 AUM	77
Upland hay	490	1.35 AUM[b]	660
Upland hay graze	490	.8 AUM[c]	392
Winter range	825	.8 AUM	660
Roads, bldgs., corrals	5		0
Average annual production of AUM's			4,840

[a] Stocking rate based on Soil Conservation Service site classification of sandy–25%, sands–70% and choppy sands–5% with a range condition class of good.

[b] Average yield, sub-irrigated, 1 ton per acre. AUM equivalent, 675 lb. Average upland yield, .5 ton per acre. AUM equivalent, 742 lb. Upland round bales left in field for grazing. Estimated loss in dry matter digestibility compared to stacked hay is 10%.

[c] Rate of grazing based on supplemental feeding of protein and other critical nutrients.

summer grazing, up to half the total pasture acreage is set aside for winter grazing usually under a deferred grazing or rest-rotation system alternating with summer usage. The land use plan for the representative ranch is shown in Table 2 with yields expressed in AUM.[8]

Feed purchases on Sandhills ranches are a major operating expense and exhibit wide variability from year to year. This is a function of the length of the winter and amount of snow cover but more consistently a result of variability of pasture forage yield and hay production. Variability in pasture forage yield exists although possibly less variation is exhibited in the Sandhills than in the drier hard land range areas of Wyoming, Montana and the Dakotas. Sandhills ranchers typically stock their ranges at a constant conservative rate that allows for excess grazing forage in good production years and still does not abuse the range in dry poorer production years.

Feed expense for the typical Sandhills ranch is the largest cash production expense. The winter feeding program consists of winter grazing, native hay and a protein supplement. The protein supplement is necessary because native hay and sun cured standing grass are deficient in protein. Ranchers typically begin feeding one pound of protein supplement per head per day starting November 1 and supplement through the winter until spring turnout about May 10.

For the representative firm feed was a major expense item as well as a major variable in the ranch operation. Annual variability of forage was input into the model as data. A randomizing technique was

[8] AUM denotes animal unit month. This is the amount of feed required for one animal unit for one month.

Table 3. Annual forage yields used in the simulation model.

Simulation sequence year	Subirrigated hay[a] (tons/acre)	Upland hay[a] (tons/acre)	Irrigated alfalfa-mix[b] (tons/acre)	Irrigated corn silage[a] (tons/acre)
1	1.06	.53	2.00	18.0
2	1.12	.56	4.17	20.0
3	1.04	.52	4.11	17.5
4	.82	.41	3.61	15.0
5	.82	.41	3.51	14.0
6	.97	.48	3.90	16.0
7	.97	.48	3.84	16.0
8	1.12	.56	4.16	19.0
9	.89	.44	3.61	15.0
10	1.19	.60	4.17	22.0
11	.82	.41	3.51	15.0
12	1.12	.56	4.12	19.0
13	.89	.44	3.84	16.0
14	1.12	.56	4.11	18.5
15	1.04	.52	3.96	17.0
Average	1.0	.50	3.77	17.2

[a] Yields derived from Nebraska Agricultural Statistics.

[b] Yields derived from Dreier *et al.*, 1969. Alfalfa variety tests in Nebraska, 1951–1968. Univ. of Nebr. Outstate Testing Cir. 136.

first used to obtain annual subirrigated hay yields. Upland hay, irrigated alfalfa and irrigated corn silage yields were correlated to subirrigated hay yields. Forage yields and sequence used in the model are shown in Table 3. The lower alfalfa yield the first year reflected establishment. The model was programmed so that if there was a hay carryover in excess of 80 tons the excess was sold at $20 per ton.

Livestock Production

Livestock production and operation data were based on survey averages of the 1970 Sandhills Ranch Business Study.[9] A stock cow culling rate of 12% and a 2% annual death loss were assumed. Replacement heifers were raised from the unit's herd at a rate of 14% of January brood cow inventory. A 1.5% death loss was assumed for yearling cattle.

Culling and sale of cull animals were assumed to occur in November after weaning and in May at post-calving. Bulls were culled in the fall after the breeding season and were assumed to have an average five year breeding life.

The second item of variability with a major impact upon costs and returns of the ranch is calving percentage. Calf crop percentages may differ widely between ranches and from year to year on the same ranch due to disease, weather and management factors. This is a major variable because there is a high positive correlation between

[9] Epp, A. W. and Robert E. Perry, *op. cit.*

Table 4. Distribution of calf crop percentage in the simulation model.

Simulation sequence year	January inventory %
1	85
2	87
3	86
4	89
5	89
6	87
7	86
8	91
9	82
10	94
11	81
12	94
13	88
14	86
15	82
Average	87

gross income and calving percentage and only a minor relationship between calving percentage and total ranch costs. There appears to be no single accepted method of determining calving percentages in livestock areas, which causes some confusion in beef performance analysis.

In this study calving percentage was defined as percent of calves weaned from the January 1 bred cow inventory. A normal distribution of calf crop percentages was derived from research data to reflect January bred cow inventory and year to year variability in the model was introduced through a stochastic selection process[10] (Table 4).

Livestock Yields

Another important variability factor that affects ranch income is livestock yield or weight. In a cow-calf operation the heavier the calves at weaning the greater the returns to the ranch. Paralleling livestock production is a positive correlation between ranch income and livestock yield and a lesser relationship between ranch expense and calf weight. However, there may not necessarily be a high correlation between livestock production (calving percentage) and livestock yield (weight). Livestock yields vary annually on the same unit due to average age of cattle, nutrition levels of the brood cow during gestation, length and severity of the winter, summer forage production, age at weaning, heredity factors and presence or absence of diseases.

For the representative ranch, weaning dates were October 21 with

[10] J. N. Wiltbank, J. E. Ingalls, J. A. Rothlisberger and C. W. Kasson, 1967. Reproductive performance in the U.S. Factors affecting calf crop, ed. T. J. Cunha *et al,* University of Florida Press, Gainesville.

Table 5. Annual livestock sale weights and sequence in the simulation model.[a]

Simulation sequence year	Fall weaning sale weight		Spring backgrounded sale weight	
	Steers	Heifers	Steers	Heifers
	(lb)	(lb)	(lb)	(lb)
1	436	408	729	691
2	416	402	736	688
3	417	398	716	682
4	413	398	717	678
5	440	425	713	678
6	421	407	740	705
7	423	408	721	687
8	411	398	723	688
9	435	400	711	698
10	431	417	735	680
11	445	429	731	697
12	431	410	745	704
13	414	404	731	690
14	417	398	714	684
15	440	425	717	678
Average	429	411	729	691
Av. Sale Date	November 1		May 4	

[a] Source: R. M. Koch. 1971. Fort Robinson Beef Cattle Selection Experiment. Unpublished research data. Univ. of Nebr.

calf sales occurring 10 days later—November 1. Calves backgrounded through the winter were sold the first week in May. Steer and heifer weaning weights are given in Table 5. Weaning weights were chosen at random for different years and put in the model as data. Cull cow and bull weights were not assumed subject to annual variation.

Sale weights for the backgrounded steers and heifers were computed by assuming a 1.5 lb per day gain for steers and 1.4 lb per day gain for heifers for a 200-day feeding period. The sale weight became the previous fall weaning weight plus the backgrounding gain (Table 5).

Livestock Prices

Livestock prices presented the greatest variability in the model and had the largest impact upon net ranch income. An examination of the price cycle revealed the historical variability of annual livestock prices (Figure 5). It was assumed that the firm would market its cull livestock through a local livestock auction and the calves sold at weaning time or backgrounded would go directly to feeders.

Livestock prices were derived from a historical 14-year price cycle, 1958 to 1971. To provide 15 years data, the 14-year average price for each class of livestock was added into the cycle between years 1968 and 1969. The 15-year price cycle allowed the programmer to select any beginning point on the price cycle and the remaining cycle of prices

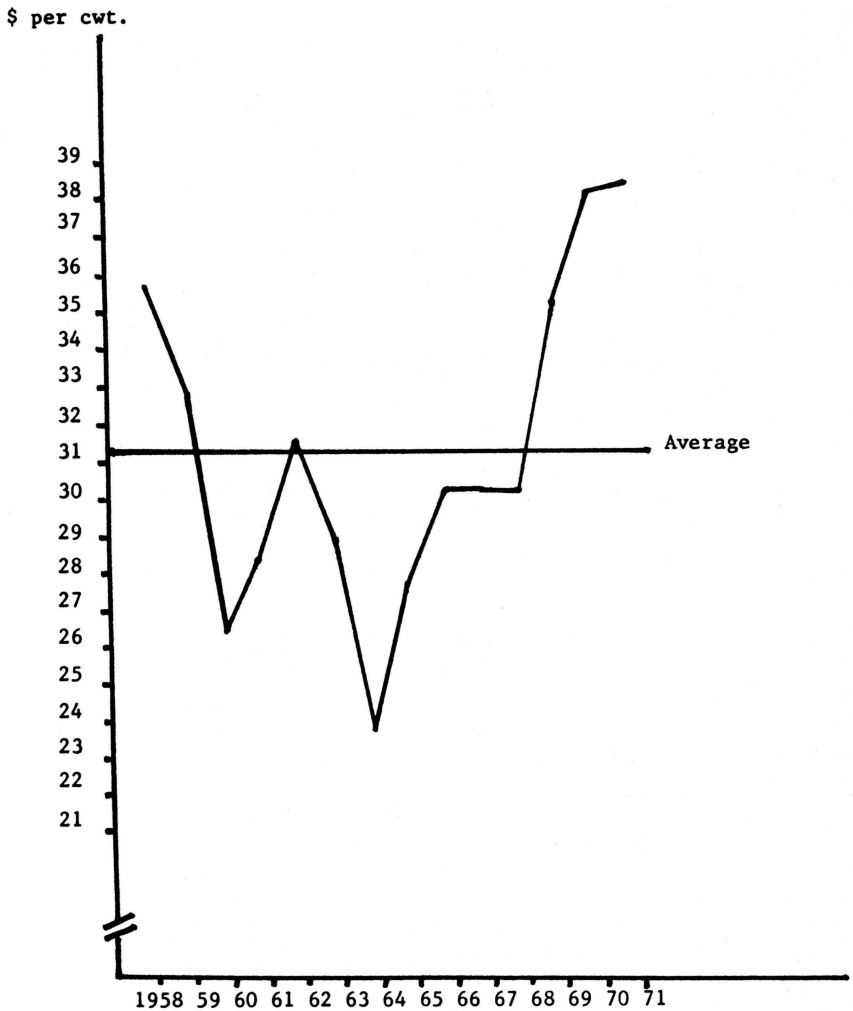

Figure 5. Fourteen-year price cycle for steer calves at Omaha, November prices. (*Livestock Market News,* Livestock Division, Consumer and Marketing Service, USDA)

would fit without a change greater than had existed historically. If the programmer selected a high starting price (1971) the sequence would follow the prie cycle (1971, 1958, 1959, 1960, etc.) without an unrealistic price change from 1971 to 1958. Livestock prices are shown in Table 6.

Extensive Growth

Extensive growth may be accomplished by leasing or buying additional grazing land. Typical real estate transactions for the Sandhills

Table 6. Livestock prices.[a]

Year	Year[b]	1 Feeder steers 300–500 lb	2 Feeder heifers 300–550 lb	3 Feeder steers 500–800 lb	4 Feeder heifers 500–800 lb	5 Feeder steers 800–1050 lb	6 Stock cows[c]	7 Cows utility	8 Bulls utility
		$/cwt.	$/cwt.	$/cwt.	$/cwt.	$/cwt.	$	$/cwt.	$/cwt.
1958	1	35.75	33.00	30.38	27.38	26.59	200	18.08	20.98
1959	2	32.94	30.12	32.56	29.50	27.30	240	14.16	18.95
1960	3	26.44	24.44	28.26	25.50	23.27	200	14.45	17.46
1961	4	28.41	26.14	26.25	23.80	23.97	205	15.01	17.72
1962	5	31.61	28.15	27.31	24.88	25.80	210	14.89	17.70
1963	6	28.95	26.22	25.79	24.36	23.48	210	13.46	16.90
1964	7	23.92	21.51	21.89	20.30	21.45	195	11.97	14.05
1965	8	27.70	24.75	24.29	22.06	24.65	180	13.88	17.25
1966	9	30.38	27.81	28.89	25.88	26.16	200	16.21	20.13
1967	10	30.38	26.31	26.80	24.90	26.25	225	15.74	20.14
1968	11	30.35	27.10	28.30	24.85	26.72	220	16.91	21.89
	12	31.33	28.27	28.91	26.11	26.37	215	16.04	19.79
1969	13	35.30	32.00	34.25	29.31	30.00	230	19.31	23.55
1970	14	38.08	34.50	35.00	32.00	30.81	250	19.04	24.71
1971	15	38.45	35.10	34.75	30.75	32.75	250	21.45	25.69
Av.		31.33	28.37	28.91	26.11	26.37	215	16.04	19.79

[a] *Livestock Market News.* (Livestock Division, Consumer and Marketing Service, USDA), Omaha prices. Columns 1 and 2 are October average prices; columns 3 and 4 are May average prices; column 5 is September average and columns 7 and 8 are November averages. The stock cow price is based on utility cow value for a 1000 lb cow, lagged one year plus $60.

[b] Simulation price year.

[c] Value per cow.

area appear to approach two sections (1,280 acres) per transaction.[11] Assuming about 18 acres per cow, this would allow an additional 70 cows for each 1,280 acres acquired.

One of the assumed growth objectives for the ranch firm was to grow in size from a 450 animal unit firm to one of 600–900 animal units. Participation in three opportunities of land acquisition (rent or purchase) would allow the ranch firm to increase its animal unit size to about 700 animal units or an increase of 55% during the 15-year simulation period. This resulted in an increase from 380 to 590 cows.

The simulation model provided three options to grow during the 15-year simulation period. Because land was not always available for growth a random procedure was used to determine which years it would be possible to purchase or rent land. The sequence and timing of the two growth experimental alternatives became rent-purchase-rent in years 4, 6 and 10 and purchase-purchase-rent in years 4, 6 and 10. Years that the firm rented or purchased land the firm also bought 70 head of young cows and 3 bulls. Cows were purchased after the first of the year at varying prices (Table 6) and were included in the production and feeding process with the rest of the ranch herd. It was assumed that the price of purchased bulls remained constant at $600 per head throughout the simulation period. Because they were assumed to be young cattle they did not undergo a culling process the first year of acquisition.

It was assumed that land purchased had 10% meadowland for additional hay. Those years that land was purchased the firm also bought an additional $2,000 of machinery. Land purchase price was assumed to be $47 per acre for grazing land, $100 per acre for meadowland, and $7.70 per acre for fences, windmills and other improvements. This averaged $60 per acre for purchased real estate resulting in an investment of $76,800 to obtain deeded land to increase the ranch operation 70 head. The purchase of 70 cows and 3 bulls at average prices required an additional $16,850. The total additional capital required to purchase, stock and buy machinery to operate one extensive growth purchase transaction was $95,650. To lease an additional 1,280 acres required only $16,850 plus annual lease payments. Variable costs of operating the additional growth were not included in the above totals.

Intensive Growth

Intensive growth is defined as changes within the basic ranch firm by increased capital investment and/or management strategies that result in increased net farm income. The growth can be complementary

[11] 1967 Annual Report Statistical Supplement. Tax Commissioner. State of Nebraska, pp. 59–60.

(increasing amount of feed raised) or can result in a new, supplemental type of enterprise (backgrounding calves).

It was assumed that intensive growth, unlike extensive growth, could occur at any time the manager desired subject only to the financial and managerial limitations presented by the growth opportunity.

The Irrigation System

The method chosen for intensive growth of the ranch firm was a self-propelled center pivot irrigation investment. This relatively new means of irrigation is easily adapted to many areas of the Sandhills. This overhead sprinkler type of system will operate over uneven terrain and traverse grades up to 15 percent. There is a good porous aquifer that allows water to be pumped from an average depth of 160 feet.

A standard quarter-section center pivot unit will irrigate about 135 acres. It is possible to irrigate as many as 240 acres by adding unit extensions or a lesser amount by subtracting unit extensions. The limiting factors for number of acres irrigated per center pivot unit are available groundwater, terrain and water intake rate of the soil.

It was assumed the center pivot unit was installed during the early spring hence all developmental costs occurred the first year of production. The cost of drilling a well, installing a pump, gearhead and diesel power unit was $10,500. The center pivot unit with pipe, walkers and sprinklers cost $18,500. Additional costs of $3,563 were for a liquid fertilizer injector and fertilizer tank, cross fences to manage cattle within the irrigated acreage, hay-yards, cross fences for meadowland utilized for grazing, and stock water development. The total fixed cost for the installation of one self-propelled, center pivot irrigation system was $32,563. Financing this capital investment was assumed to be obtained by real estate mortgage via conventional long-term credit agencies. Interest costs on this loan were assumed to be 7% with a 20-year amortized peroid.

A 20-year period was chosen because some fixed improvements, such as the irrigation well, fences, fertilizer tank, and livestock watering system, have a depreciable life longer than the 15-year simulation period.

Addition of Irrigated Alfalfa

Because the ranch firm was short of winter feed, the first investment in irrigation was to raise forage. A mixture of alfalfa and smooth bromegrass with a light cover crop of oats was planted. The companion crop of oats was considered necessary to provide a cover for the delicate sandy soil profile. The oat crop was to prevent wind and water erosion until the alfalfa and bromegrass became established. Oats were cut for hay in late June or July. The alfalfa-mix was re-

planted over a period of three years beginning six years after the initial seeding. In years 7, 8 and 9 after the operator began alfalfa production, 45 acres of irrigated land were removed from regular production and replanted. The model allowed for reduced production and the increased costs of replanting this acreage the year that it occurred.

The firm was able to concentrate its haying operation on 135 acres whereas before irrigation it hayed 710 acres. The alfalfa-brome hay was cut twice during the summer whereas the non-irrigated acres had one cutting. Production was far superior under irrigation and there was a 50% net labor savings due to 380 fewer acres harvested. The haying operation under irrigation required more timeliness and, therefore, an additional $6,000 in haying equipment was purchased.

Installation of the irrigation unit to raise high protein alfalfa enabled the firm to produce all the necessary winter forage and to eliminate the annual protein supplement expense. Another important factor is that it freed the previously used hayland for grazing. This increased the firm's animal unit carrying capacity. The firm put the center pivot irrigation unit on land previously used for upland hay production. The additional grazing from upland hay acreage was: 490 upland hay acres minus 135 acres (irrigated) equals 355 acres. At .7 AUM/acre this became 250 additional AUM's. After the first year the firm no longer needed to hay the 220 acres of meadowland; 220 acres at 1.6 AUM/acre equals 352 AUM's. The irrigated alfalfa-brome mix was grazed early in the spring for 15 days and in late fall after the first major frost. This grazing provided 2 AUM/acre or an additional 270 AUM's. It was assumed the firm instituted a new feeding program under irrigation that freed an additional 224 AUM's. The total additional grazing AUM's the second year after installing irrigation and raising alfalfa was 1074. A mature animal unit's annual requirement of 9.5 grazing AUM's allowed the firm to increase its herd size 95 cows. This was accomplished by buying 20 cows and 1 additional bull the year the irrigation system was installed, and 75 cows and 3 bulls the year after installation. Cattle purchases were financed from short-term credit at 7.5% interest.

Addition of Irrigated Corn Silage

The second phase of intensive growth via irrigation was raising irrigated corn silage and backgrounding calves. This was a logical progression of intensive growth for this ranch firm. The flow of benefits to the firm if it installed another irrigation system to raise alfalfa were assumed not nearly as great once the firm's forage and protein requirements were met. The raising of corn silage as a high quality low cost feed gave the firm the opportunity to feed ranch produced livestock to a heavier weight. Backgrounding ranch produced calves offered several advantages over other alternatives. It did not require as large an investment as a cash corn or full feeding operation, made

use of off season labor and did not require the degree of management skill necessary for its success compared to alternative enterprises.

Developmental costs for the corn silage irrigation system were assumed the same as for establishing the alfalfa irrigation system. Additional machinery, however, was required for this new enterprise. It was assumed that the rancher would purchase second-hand machinery to plant, cultivate and harvest his corn silage. Additional costs for these items plus developing an open pit silo were $9,150.

The backgrounding operation consisted of weaning the calves in mid-October, feeding them through the winter and selling them the first week in May, a period of about 200 days. Both the heifers and steers were fed the full period, although heifers held for replacement were fed a different ration so they would not become too heavy. A balanced ration of corn silage and hay was fed for an average gain of 1.5 lb per day for steers and 1.4 lb per day for heifers. A 2% death loss was assumed for backgrounding calves. Fixed costs for the backgrounding operation were $3,740 for feed bunks, loafing shed, etc.

It was assumed that after harvesting the corn silage in late August the firm would seed a cover crop of winter rye. This prevented wind erosion and also served as late fall and early spring grazing. The additional grazing allowed purchase of 20 additional cows.

Financing arrangements were similar to the previous irrigation development. However, it was assumed that costs of development plus initial machinery and equipment purchases were financed with a long-term real estate loan and only cattle purchases were financed with short-term credit. A 7% interest rate was charged for real estate debt assuming a 20-year amortized repayment period. Cattle purchases were financed by chattel mortgage at a 7.5% interest rate.

Depreciation

Depreciation expense for machinery and equipment was based on a standard straight line, 10-year depreciation schedule. Annual replacement payment was equal to depreciation expense which allowed the firm to maintain a constant value for machinery and equipment. When the firm expanded intensively, depreciation expense was 10% on newly purchased items but replacement procedure changed. As the annual value of the newly purchased equipment declined, the depreciated value was reflected in the firm's annual assets. Replacement payments for the new equipment were not made annually but occurred the year of purchase. For example, the irrigation motor was assumed to last 10 years and then was traded in for a new motor. The tenth year after installation the old motor was traded and this was reflected in the firm's payments the year of purchase and the firm's assets the following January 1. The center pivot system was depreciated over 15 years and the well was depreciated for 20 years.

Depreciation and replacement for improvements was computed at 5%. Bull depreciation was $61 per year for five years based on a $600 purchase price and an average salvage value of $296 per head.

Credit and Financing

Financing and credit for the model consisted of short and long-term credit. Short-term credit was advanced on an annual renewal basis with a chattel mortgage given on all short and intermediate-term assets. Short-term lending policies assumed a maximum lending limit of 50% of the current value of machinery and equipment and 75% of the current value of livestock. Real estate was pledged as security for the purchase of other than real estate items, however, purchase of real estate required that only real estate be used for security. An annual finance charge of 7.5% was assumed for short-term credit.

Long-term financing was obtained through conventional long-term credit sources. The maximum lending value was 60% of current real estate market value. It was assumed that the firm began operation with a real estate debt. It was further assumed that this debt was acquired several years before the simulation trials. For this reason beginning real estate debt was charged a 6% finance charge and any newly acquired real estate debt via the simulation experiments was charged a 7% rate to reflect increases in finance charges. A 30-year amortized repayment period was used for real estate purchase and a 20-year amortized payment for real estate (irrigation) development.

The model provided a family savings account for the deposit and withdrawal of excess capital. It was assumed a minimum balance of $500 was kept in this account unless the operation was in danger of termination. A 4.5% return was paid on deposited savings. Because the model focused on ranch adjustments, investment of capital outside the ranch firm was not considered.

To assess ability of the firm to provide for capital withdrawals, the disposition and concept of net income required further explanation. Otherwise it became difficult to reconcile income levels to yearly allocations for family consumption, debt reduction and income and social security taxes.

Ranch improvements were depreciated over a 20-year period and were an expense in determining net income. However, the depreciation was not assumed to be applied to reinvestment in improvements, but rather applied to the reduction of long-term debt. In addition, repair and maintenance charge on improvements was considered a paid expense each year.

In irrigation systems, a similar procedure was used, however the assumption was made that the irrigation system was financed when purchased. Hence, a fund flow occurred each year to finance the system. A depreciation charge was made on the systems affecting net

income but applied to long-term debt reduction. Furthermore, a repair charge was made each year to maintain the irrigation system.

For machinery the more traditional assumption was made that depreciation was used each year for yearly machinery purchases. Thus, the machinery inventory was held constant.

ANALYSIS OF RESULTS

Effects of Selected Variables on Net Ranch Income

One objective of this study was to determine effects of an uncertain environment upon firm growth. Net ranch income was chosen as a measure to appraise the impact of selected variables on firm growth. Net ranch income is defined as net cash ranch income minus depreciation. It is the net return from the ranching business to unpaid labor, management and owner equity in the business. This measure was chosen because it indicates how much money is available at the end of the year to be allocated to income and social security taxes, payments on fixed obligations, carryover debt, family consumption and growth savings.

Earlier firm growth was defined to include absolute increases in net worth plus amounts available for current family consumption. Net ranch income serves as an indicator for the amount of money available for family consumption and internally financed increases in net worth and indicates repayment capacity when attempting to obtain outside credit for growth.

Simulation trials used to determine the relative impact of the four primary variables, forage production, calf-crop, weaning weights and prices were conducted. It was assumed the firm carried a beginning debt load of $12,000 short-term credit and a $61,230 long-term debt that required an annual payment of $2,450 plus interest. A 15-year simulation trial was conducted employing average inputs and not allowing firm expansion. Figures 7–11 show the average net ranch income in an upward trend from $5,248 in year 1, to $8,460 in year 15. This was the result of the firm repaying long and short-term debt. As this outstanding debt was reduced over time interest expense was reduced which resulted in larger net ranch income.

Separately, each of the variables was allowed to vary over the 15-year simulation run while the other variables remained at an average level. Any variation in net ranch income was due solely to the annual variation in the selected variable. This procedure was repeated for each of the selected variables.

Forage Production

Figure 6 shows the annual variation in net ranch income due to hay yields (Table 3). As a result of variability in forage yields, net ranch income varied a year to year maximum of $2,962 between years

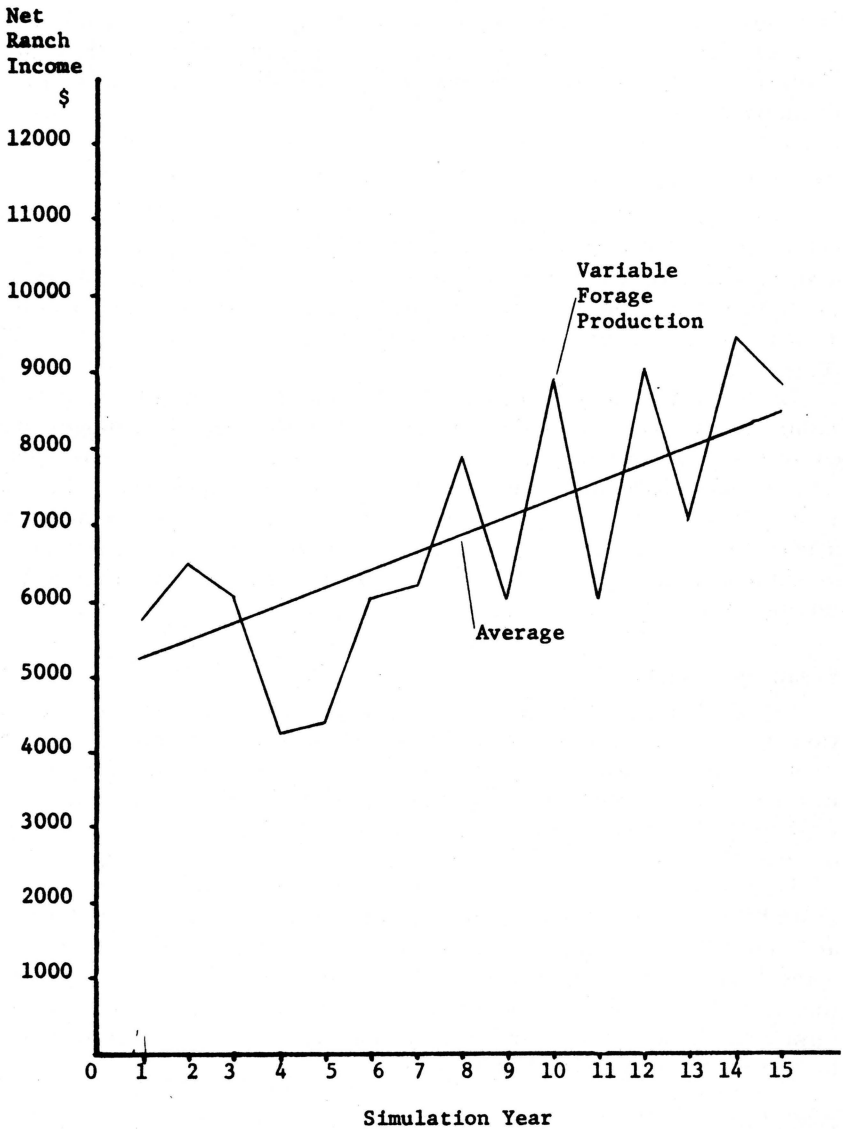

Figure 6. Annual variation in net ranch income due to variable forage production.

11 and 12 in the simulation experiment. Low to high net ranch income ranged from $4,245 in year 4 to $9,415 in year 14.

Exogenous weather factors determine annual variability in forage production in non-irrigated Sandhills haying operations. Economic response to fertilization on subirrigated meadows in the Sandhills area

is erratic and was assumed not to occur on the selected firm's hay ground. Forage production fits into the uncertainty area of the firm's operation and, short of installing irrigation, was beyond the control of management.

Livestock Production

Figure 7 shows the annual variation in net ranch income due to calf-crop percentages (Table 4). Annual net ranch income varied at a year to year maximum of $6,040 between years 11 and 12 as a result of annual variation in calf-crop percentage in the simulation trial. Low to high net ranch income ranged from $4,406 in year 1 to $11,103 in year 12.

Livestock production measured in terms of percent calf crop is a biological function of the breeding herd. Calf crop percentages are subject to improvement by good management practices. However, annual variability will exist under the best of management due to disease factors, weather, labor availability and age of cattle, to mention a few. The annual variation in calf crop percentage for a given level of management has a negligible effect on expenses but a major effect on income.

Weaning Weight

Figure 8 shows the annual variation in net ranch income due to varying calf weaning weights (Table 5). Annual net ranch income varied at a year to year maximum of $2,345 between years 4 and 5 in the simulation run due to annual variation in calf weaning weights. Low to high net ranch income ranged from $4,429 in year 2 to $9,460 in year 15.

Weaning weights vary on an annual basis due to weather, forage availability, average birth dates and heredity characteristics of the sire and dam. Weaning weights are subject to improvement over time as a result of management practice. Herd selection processes, cross-breeding, etc., have proven to be ways by which weaning weights can be improved. Weaning weight improvement over time was assumed not to occur during the simulation trials.

Cattle Prices

Variation in net ranch income due to the historical 14-year price cycle is indicated in Figure 9. This particular 15-year simulation trial used 1964 (Table 6) as the beginning point on the price cycle. Net ranch income varied at a year to year maximum of $6,900 between years 11 and 12 on an annual basis. The low and high cyclical livestock prices for the simulation period resulted in –$5,243 net ranch income in year 1 and $16,900 in year 9.

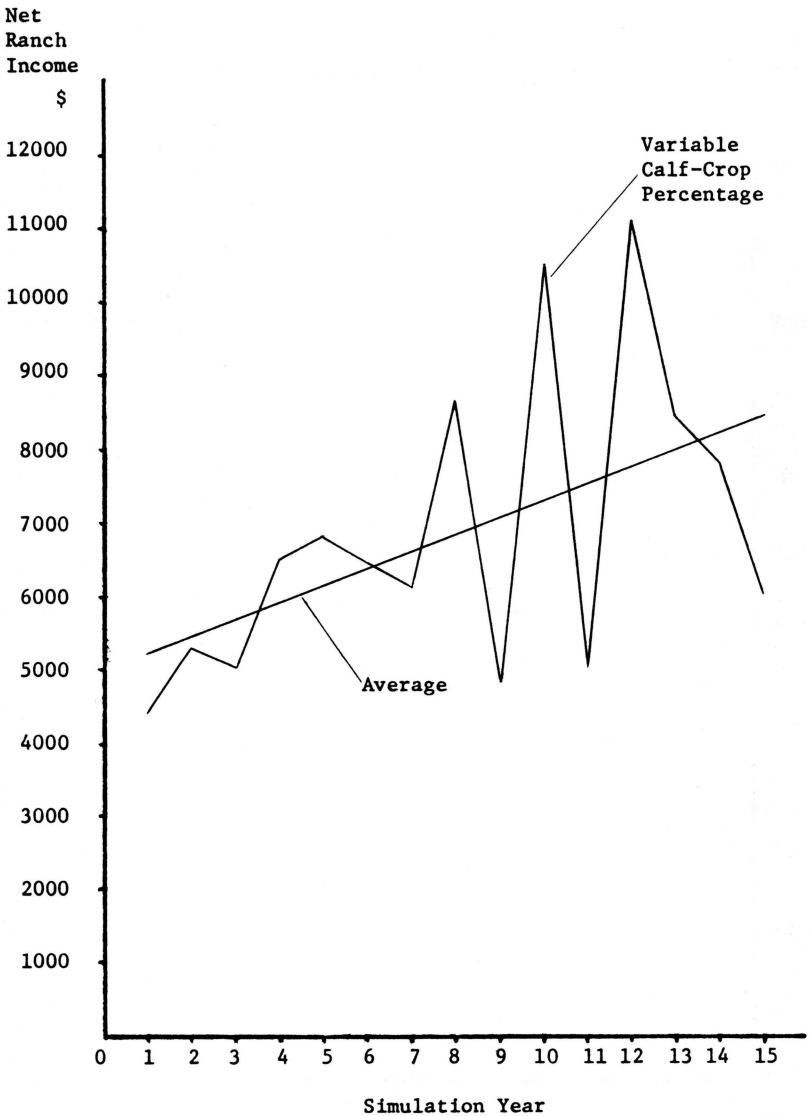

Figure 7. Annual variation in net ranch income due to variable calf-crop percentage.

Normal Operation

Figure 10 reflects the variation in net ranch income when all selected variables were combined and allowed to vary on an annual basis. Within this simulation trial livestock prices followed the cyclical

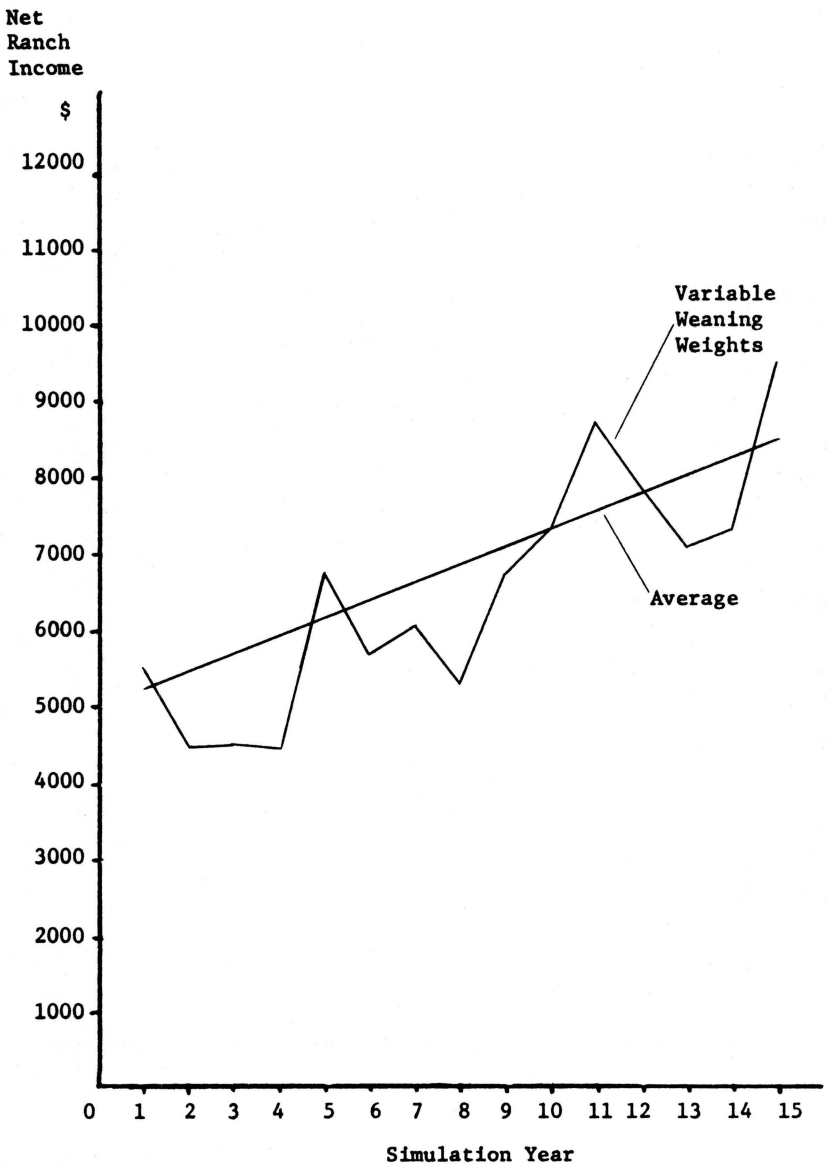

Figure 8. Annual variation in net ranch income due to variable weaning weights.

average beginning with a 1964 price and the remaining variables occurred over the simulation period in the previously demonstrated random fashion. When this procedure was followed, *net ranch income* varied at a year to year maximum of $13,286 between years 10 and 11,

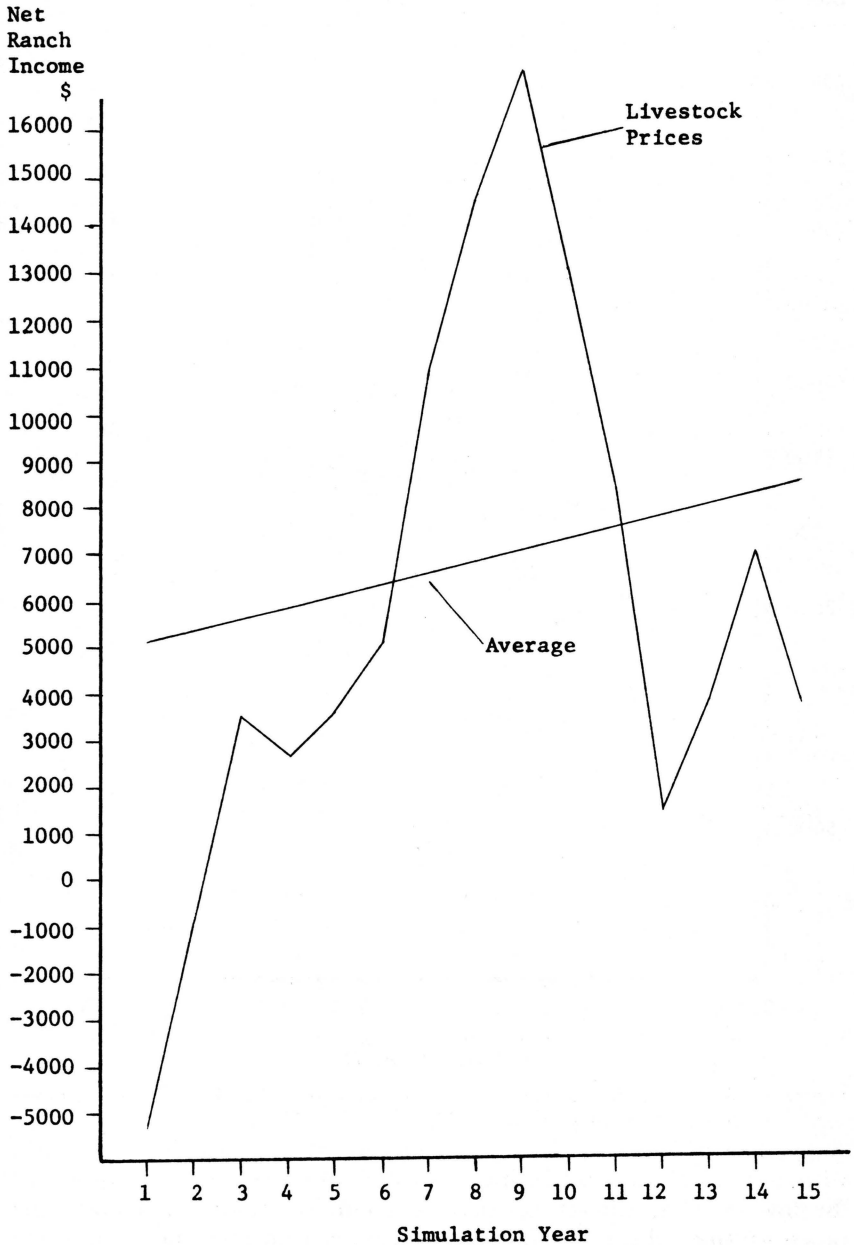

Figure 9. Annual variation in net ranch income due to livestock price cycle (begin 1964).

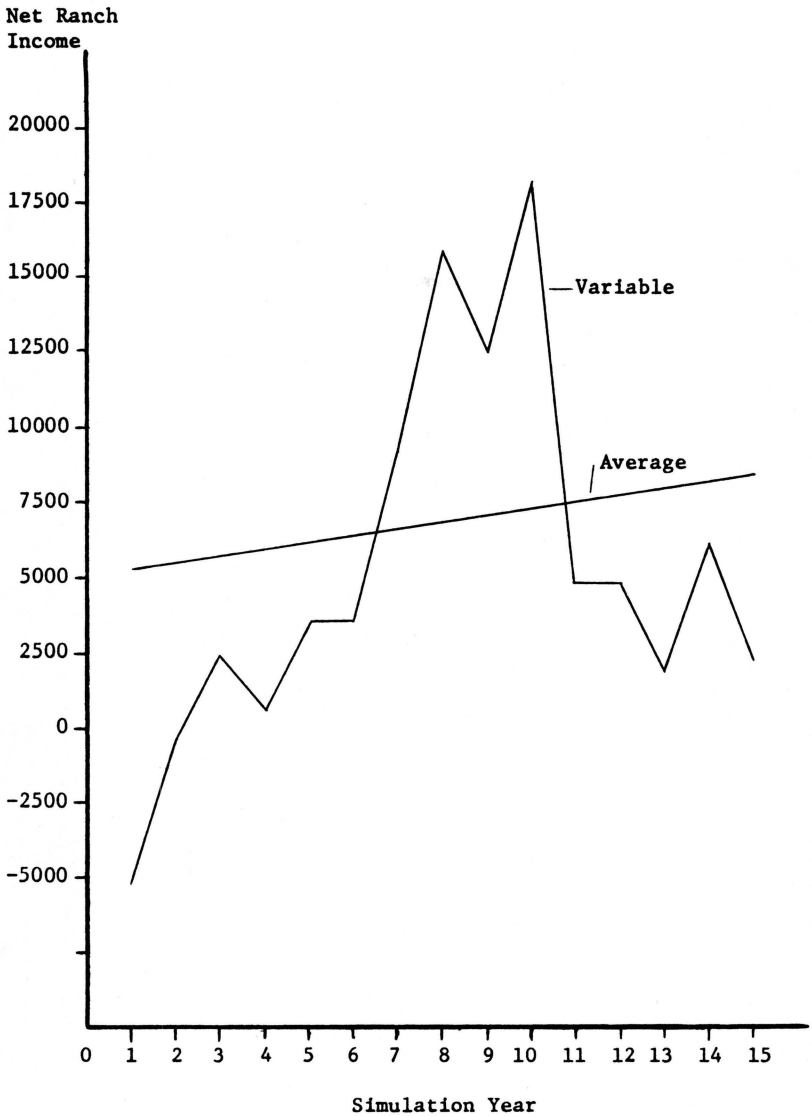

Figure 10. Annual variation in net ranch income when all of the selected variables are allowed to vary.

with a $23,224 net ranch income difference between the high and the low over the simulation period. Comparisons of the average net ranch income exhibited the longer-run impact on the ranch firm when all the variables were allowed to vary (Table 7). Based on the simulated 15-year normal operation there was a $1,500 difference in average

Table 7. Effect of selected variability factors on annual net ranch income, 80% equity, no growth.

Year	Average inputs	Variable forage	Variable calf-crop	Variable weaning weight	Variable prices	All variables inputs
			(dollars)			
1	5,248	5,799	4,406	5,509	–5,243	–5,132
2	5,343	6,483	5,315	4,429	– 730	– 437
3	5,536	6,020	5,025	4,516	3,493	2,455
4	5,747	4,245	6,528	4,452	2,649	559
5	5,971	4,404	6,806	6,797	3,594	3,530
6	6,368	6,024	6,418	5,723	4,649	3,569
7	6,597	6,230	6,170	6,041	10,958	9,357
8	6,843	7,873	8,671	5,322	14,551	15,811
9	7,105	6,049	4,840	6,764	16,900	12,523
10	7,386	8,901	10,510	7,351	12,993	18,092
11	7,686	6,048	5,063	8,739	8,304	4,806
12	8,007	9,010	11,103	7,811	1,400	4,736
13	8,166	7,110	8,526	7,086	3,755	1,887
14	8,313	9,415	7,832	7,293	6,979	6,214
15	8,460	8,828	6,054	9,460	3,745	2,320
Av.	6,852	6,829	6,884	6,486	5,865	5,352

net ranch income using average inputs rather than variable inputs. This occurred because 1964–65 (starting) price levels were below the level required for positive net farm income under the variable trial. The firm had to borrow short-term capital for family consumption and long term debt payment, resulting in a build-up of short-term debt in the early years. The annual interest expense on this debt resulted in lower average income over the period.

Table 7 details the annual net ranch income from the different simulation trials. A study of Table 7 and Figures 6–9 make it clear that livestock prices have major impact upon variation of net ranch income over time. Given climatic and topographical conditions of the study area, alternative enterprises that might approach zero or negative price correlations for diversification purposes to stabilize income were not feasible.

Variability in calf-crop percentage had the next greatest impact upon net ranch income, followed by variability in forage production and weaning weights. Variability on calf-crop percentage and weaning weights can be reduced through improved management practices but this was not attempted within the simulation trials. Forage production was considered to be determined primarily by climatic factors external to the firm. This variability factor may be internalized to some extent by installing an irrigation system. Irrigation will not eliminate and may increase absolute variability in forage production but may reduce relative annual variability. This aspect is taken into consideration in the next section when intensive growth is examined.

Simulation trials were run, viewing what would happen under the "best" and "worst" possible conditions. Assuming the best of all

possible variables resulted in net ranch income of $23,430, a 341% increase over average net income. Assuming the worst possible would occur resulted in net ranch income of –9,881, an income $16,732 less than average.

Beginning Equity for Growth Trials

The simulation trials assumed a beginning owner equity of 80%, consisting of $15,000 short-term debt and $58,590 long-term debt with a fixed annual principal payment of $2,950. The 80% equity was based on average livestock prices. When the simulation trials began at various price levels, beginning equity varied slightly due to valuing the firm's livestock at the price level chosen for the beginning year. A beginning equity level of 80% was chosen because it was felt that this level was as high as could be expected for a young operator to have achieved assuming he had inherited or purchased the unit. Secondly, this level of beginning equity allowed the firm to obtain ample credit to take advantage of the various growth opportunities.

Extensive Growth

Extensive growth consisted of offering the firm three options to grow during the 15 years. Two major growth plans were examined. One growth plan placed major emphasis on growth through land purchase whereas the second plan placed primary emphasis on growth through leasing arrangements. Each rent or purchase opportunity was equal in terms of acres controlled (1,200 acres per opportunity) and additional cattle acquired (70 head per opportunity). However, it was assumed that land purchased consisted of 10% meadowland for haying purposes and rented land was suitable only for grazing. The additional hay land under the purchase option required the firm purchase $2,000 in additional machinery. The simulation trials conducted in this section started with a price cycle beginning in 1964 (Table 6). Because a comparison between strategies was desired, the selected variables varied randomly on an annual basis but varied in the same manner between trials.

The first simulation trial placed primary emphasis on growth through purchasing additional land. The opportunities offered the model were to purchase 1,280 acres and stock with cows in year 4 and similarly in year 6, plus the opportunity to lease 1,280 acres in year 10. There was no optimal purchase or rent strategy programmed.

The second simulation trial was extensive growth of the ranch firm with primary emphasis on leasing activities. The growth opportunities offered the model were to lease 1,280 acres and stock with 70 head of cows in year 4 and similarly in year 10, and a land purchase of 1,280 acres and stock with 70 head of cows in year 6.

Table 8 outlines operational results of extensive growth via purchase and leasing trials. These results were compared with an operation

Table 8. Growth comparisons with emphasis on purchasing land, rental emphasis and no growth.

	No growth $	Buy growth $	Rent growth $
Year 1			
Assets	360,476	360,476	360,476
Short term debt	15,000	15,000	15,000
Long term debt	58,990	58,990	58,990
Net worth	286,486	286,486	286,486
Owner equity (percent)	79.47	79.47	79.47
Family consumption	5,000	5,000	5,000
Net ranch income	–5,223	–5,223	–5,223
Year 5			
Assets	370,050	465,453	386,653
Short term debt	40,101	62,497	60,753
Long term debt	47,190	121,430	47,190
Net worth	282,759	281,526	278,710
Owner equity (percent)	76.41	60.48	72.08
Family consumption	5,000	5,000	5,000
Net ranch income	3,375	772	2,448
Year 10			
Assets	362,778	551,006	472,206
Short term debt	29,258	95,179	79,005
Long term debt	32,440	160,440	99,000
Net worth	301,080	295,387	294,201
Owner equity (percent)	82.99	53.61	62.30
Family consumption	6,799	5,722	6,480
Net ranch income	17,846	17,248	18,100
Year 15			
Assets	360,871	564,314	485,514
Short term debt	31,011	180,005	146,251
Long term debt	17,740	112,020	65,940
Net worth	315,120	272,289	273,323
Owner equity (percent)	87.32	48.25	56.30
Family consumption	5,000	5,000	5,000
Net ranch income	1,939	–8,889	–7,440
Change in net worth (percent)	10.0	–5.0	–4.6

where no growth was allowed. Changes in net worth were absolute changes, i.e., appreciation in land and improvements not considered. Year 15 reflected end of the year financial statements whereas the other yearly comparisons reflected beginning of the year situations. Purchase price of land was $60 per acre and rental costs were $2.80 per acre. The final asset position shown in year 15 reflected the same livestock prices as year 1 for asset valuation purposes.

The criterion for measuring growth is an increase in absolute net worth and increasing family consumption. The simulation trials showed that when "growth" or increased acreage was not experienced a 10% increase in net worth resulted (Table 8). When extensive growth with emphasis on purchasing additional land was simulated, a 5% decrease in net worth resulted. When extensive growth with emphasis on renting additional land was simulated, a 4.6% decrease in

net worth occurred. Similar results became evident when examining increases in family consumption over time. The program assumed a minimum of $5,000 per year would be spent by the operator's family. Because housing and income taxes were separate, this amount was essentially non-housing disposable income. The amount spent for family consumption over the 15-year simulation period showed an additional $3,450 above the minimum $5,000 when no growth was considered, $931 additional when emphasis on purchase growth was considered and $2,425 additional when growth by renting was emphasized.

Beginning at the low point on the livestock price cycle, criterion for growth shows that limiting extensive growth rather than attempting extensive growth is a superior strategy. This is not surprising when the average rate of return on investment in the ranching industry is examined.[12] The annual rates of return on total investment under the three simulated growth strategies are detailed in Table 9. Annual rate of return on investment is computed by:

$$R = \frac{(Y + V + i - D - L)}{\text{Total Assets)}}$$

where

R = annual rate of return
Y = net cash ranch income
V = value of inventory changes
i = interest paid on borrowed capital
D = depreciation
L = family labor at $2.00/hr.

An average rate of return over the simulated period of less than 3% does not allow a firm to rationally employ financial leverage for growth through debt financing.

Extensive growth via debt financing has taken place and will continue to occur in the ranching industry although it does not make "economic sense" to borrow capital at 7% interest and receive a 2% return. There are several reasons why debt financed growth is occurring. When studying the growth of firms in an industry, a representative or typical firm is analyzed for growth potential. There are firms within the industry that exceed the typical firm's management and organizational structure. Superior management results in lower costs

[12] Based on the market prices of bona fide commercial ranches, the following studies report computed net returns to capital and management range from a negative figure to a positive 1 to 2 percent. Alan R. Dickinson and William E. Martin. 1967, Organization, Costs and Returns for Arizona Cattle Ranches. Univ. of Ariz., Dept. of Agricultural Economics File Report 67-6; Regional Research Project W-79, "Economic Analysis of Ranch and Ranch Management Decisions on Western Livestock Ranches" (Western Agricultural Experiment Stations *et al.*, 1968),

Table 9. Annual rate of return on total investment for the 15-year simulation period comparing the two extensive growth options with the no growth option.

Year	No growth	Purchase emphasis	Rent emphasis
	(percent)	(percent)	(percent)
1	−1.4525	−1.4525	−1.4525
2	.0091	.0091	.0091
3	.8899	.8899	.8899
4	.3925	.9545	− .0525
5	1.2507	1.9458	1.4387
6	1.2460	2.2593	1.8175
7	2.7665	3.7760	3.5903
8	4.2741	5.1735	5.1359
9	3.2462	4.2375	4.1705
10	4.7664	5.6950	5.6988
11	.8771	1.9553	1.5726
12	.8346	2.0192	1.4711
13	.0374	1.2167	.6631
14	1.2227	2.3789	1.8952
15	.1074	1.2910	.6754
Simple av.	1.3645	2.1566	1.8349

and greater returns from a given set of resources. Superior management will be in a better position to acquire capital for growth.

Secondly, it is virtually impossible for growth studies to anticipate the year to year expectations of the firm manager. Ranchers are quite often optimists. Ranchers and farmers alike are termed "next year" businessmen, always assuming that "next year" nature will be more kind to them in increasing production and that "next year" prices will remain stable if they are currently high or improve if they are low. Therefore, average returns over the simulation period may not be an adequate expectation on which to finance growth.

As data presented in Table 7 indicate, uncertainties result in major differences in annual net ranch income. These historical uncertainties will continue to exist in the foreseeable future. The optimism inherent in many ranch operators leads them into externally financed firm growth based on a "next year" philosophy. If future profits are less than expected the operator will usually pay his annual credit payment at the expense of his depreciation account. Firm growth and accounting studies assume that the firm annually reinvests into the business an amount equal to the annual depreciation on equipment and improvements. However, what usually occurs is that the amount programmed for this reinvestment is diverted to family living and debt payment in low profit years. Machinery replacement and upkeep of permanent improvements are postponed until profits go up and/or the firm's debt load is decreased.

Finally, the simulation trials looked at only absolute net worth figures and did not consider appreciation in land and improvements.

County census data for the study area indicated a yearly $2 per acre average increase in the value of agricultural land from 1954 through 1969. If this rate of appreciation was applied over the simulation period, the equity position of the firm would be greatly enhanced. There is, of course, the possibility that real estate values may depreciate. However, this is considered a remote possibility in the Sandhills study area.

Intensive Growth

For a firm interested in growth the alternative to extensive growth is intensive growth. The intensive growth trials simulated consisted of installing center pivot irrigation systems. The first trial involved internalizing major feed costs by raising a high protein forage and increasing cow numbers. The second trial consisted of installing a second center pivot irrigation unit to raise corn silage and background ranch-produced calves in addition to the irrigated alfalfa.

Growth via Irrigated Alfalfa

The selected crop to raise under irrigation on the study ranch was high protein forage. It was assumed that 135 acres of an alfalfa-brome grass mixture would be seeded and irrigated. The 135 acres would be utilized for forage production and early and late season grazing.

For a valid comparison with extensive growth the simulation trials again started with the price cycle beginning in 1964. Because intensive growth is not dependent upon acquisition of more land, this growth can occur whenever the manager wishes subject only to credit restrictions. Table 10 summarizes the financial statement for the 15 years of simulated intensive growth.

Net ranch income computed in the intensive growth options was not an exact measure of the amount available for family living and debt repayment. Annual depreciation expense on irrigation equipment was deducted from net cash ranch income each year. This did not mean a cash expenditure for equipment replacement was made or an amount equal to this depreciation was deposited in a depreciation account for future equipment replacement each year. It was assumed that equipment would be replaced at the end of the depreciation period for each particular item of equipment and the cash expenditure for the new equipment would be absorbed by the firm in the year of purchase.

In comparing the first alternative of intensive growth with the normal operation of no growth and the two approaches to extensive growth the following differences became evident. The amount of initial investment capital required for the first stage of intensive growth was much less than for either of the extensive growth strategies. The

Table 10. Annual changes in the firm's financial statement over the 15-year simulation period; intensive growth raising irrigated alfalfa.

Year	Total assets $	Short-term debt $	Long-term debt $	Net worth $	Annual expense $	Net ranch income $	Family living expense $	Return on assets %
1[a]	360,476	15,000	58,990	286,486	37,169	−11,758	5,000	−2.29
2[b]	421,070	36,149	94,560	290,361	39,992	− 2,168	5,000	.84
3	443,554	58,714	89,582	295,258	40,456	4,542	5,000	2.61
4	453,151	59,843	84,605	308,703	40,407	4,031	5,000	2.35
5	449,186	61,482	79,627	308,077	40,290	8,139	5,000	3.35
6	445,085	59,093	74,650	311,342	39,665	6,725	5,000	2.88
7	450,300	58,060	69,673	322,567	39,919	13,880	5,334	4.52
8	457,908	50,947	64,695	342,226	39,227	20,772	6,642	5.87
9	456,168	39,786	59,718	356,664	37,769	19,171	6,305	5.21
10	430,790	29,502	54,741	346,547	36,468	24,064	7,452	6.50
11	450,842	19,498	49,763	381,581	34,929	11,304	5,228	2.80
12	430,282	14,708	44,786	370,788	34,711	8,528	5,000	2.05
13	430,774	12,016	39,808	378,050	34,605	7,185	5,000	1.57
14	430,993	10,569	34,831	385,593	34,103	10,438	5,000	2.28
15	429,410	6,151	29,858	393,405	33,367	7,102	5,000	1.26
End of year 15	420,581	4,810	24,876	390,895				

[a] Irrigation unit installed, 20 additional cows purchased.

[b] Alfalfa established, 75 additional cows purchased.

capital investment for establishing the irrigated system for alfalfa totaled $32,563. One extensive growth purchase option required a $76,800 fixed investment for an additional 70 cow unit. Of course the irrigation equipment purchased under intensive growth will depreciate over time whereas the purchased real estate could appreciate in value. The fixed investment for additional cattle under this intensive growth option was $342 per head and was $1,097 per head under the extensive growth purchase option.

Simulating this first alternative of intensive growth resulted in a better response to the growth criterion. Absolute changes in net worth resulted in an increase of $104,409, from $286,486 to $390,895. This was far superior to attempting no growth at all or attempting growth by the two extensive strategies. Family consumption over the 15-year period was also superior when the first alternative of intensive growth was simulated. Family consumption increased $5,961 above the minimum $5,000 annual amount over the simulation period which exceeded family consumption in the no growth and extensive growth options.

The addition of a stable supply of high protein forage eliminated the purchase of outside forage and protein. It also allowed for firm growth by reducing operating costs per head and increasing the herd size by 95 cows. The interrelationship between herd size, summer grazing and winter feed was expanded until a competitive stage for the resources was reached. A further expansion of herd size would force the firm to purchase winter feed and rent or buy additional acreage for summer grazing. The addition of irrigated alfalfa production also resulted in substitution of capital for labor in providing winter forage.

Growth via Irrigated Corn Silage and Backgrounding Calves

The next alternative of intensive growth in the simulation trials was the addition of another center pivot irrigation unit, raising irrigated corn silage and backgrounding ranch produced calves. The simulation trials again began with the 1964 price cycle. The second stage of intensive growth is not dependent upon the acquisition of more land, so this avenue of growth can take place any year the manager wishes subject only to credit limitations. However, it was assumed that this avenue of growth would be explored only after the establishment of the first stage of intensive alfalfa growth.

The model was simulated over the 15-year period assuming the irrigated alfalfa expansion occurred the first year, and the second stage, raising corn silage, occurred in the third simulation year. If the 135 irrigated acres were planted to corn silage, there would be large quantities of excess corn silage raised, so 90 acres of corn silage were raised and the additional 45 acres were *planted to alfalfa-brome*-grass for hay. Table 11 summarizes the financial statement for the

Table 11. Annual changes in the firm's financial statement over the 15-year simulation period; intensive growth raising irrigated alfalfa, corn silage and backgrounding calves.

Year	Total assets $	Short-term debt $	Long-term debt $	Net worth $	Annual expense $	Net ranch income $	Family living expense $	Return on assets %
1[a]	360,476	15,000	58,990	286,486	37,169	–11,758	5,000	–2.29
2[b]	421,070	36,149	94,560	290,361	39,992	– 2,168	5,000	0.84
3[c]	443,554	58,714	89,582	295,258	55,970	–54,588	5,000	1.33
4	584,155	124,937	125,804	333,414	58,439	18,467	5,000	4.55
5	582,335	124,139	118,659	339,537	60,021	19,886	5,177	4.75
6	580,431	122,352	111,513	346,566	57,122	14,978	6,355	5.75
7	592,651	117,712	104,367	370,572	57,035	27,063	8,569	7.88
8	605,685	105,414	97,221	403,050	55,957	36,792	10,558	9.30
9	609,410	87,360	90,075	431,975	53,400	28,666	8,707	7.25
10	570,035	76,414	82,930	410,691	51,996	31,260	9,499	8.10
11	594,812	67,337	75,784	451,691	49,975	23,430	7,162	5.90
12	551,930	60,537	68,638	422,755	49,876	27,118	8,914	7.03
13	567,197	51,747	61,492	453,958	49,229	15,975	6,599	4.22
14	570,013	46,593	54,347	469,073	48,108	16,961	6,804	4.20
15	562,014	40,860	47,201	473,953	46,805	10,914	5,663	2.77
End of year 15	540,822	38,839	40,055	461,928				

[a] Irrigation unit installed, alfalfa planted, 20 additional cows purchased.

[b] Alfalfa established, 75 additional cows purchased.

[c] Irrigation unit installed, raise corn silage, 20 additional cows purchased. Calves are not sold that year but are carried over and sold the following May.

15 years of simulated intensive growth when both stages of irrigation were considered.

In year 3 when the firm invested to raise corn silage and background calves a sharp increase in short- and long-term debt resulted. The only income received that year was from the sale of cull cows and bulls. This type of operational change must be made with agreement of the firm's creditors even though the firm would still have the unsold calves for collateral. There is an additional interest expense in carrying that amount of operating credit when the sale of calves is postponed 6 months.

This second stage of intensive growth was viewed as a new supplementary enterprise for the ranch firm. It was supplementary because although it added two new dimensions to the ranch firm, raising corn silage and feeding calves, the primary operation of the firm was still calf production. Addition of the second irrigation unit resulted in a slight increase in cow numbers (20 head). Backgrounding calves through the winter required additional labor but there could be a few residual benefits from this activity. The winter backgrounding operation tended to equalize the seasonal labor requirements which enabled the operator to hire fulltime labor rather than seasonal labor.

Intensive growth (two irrigation stages) is a superior growth strategy when compared to extensive growth and when compared to investment in one irrigation system. Intensive growth results in greater absolute changes in net worth and family consumption, the two growth criteria. The growth criteria for all options from the simulation trials are summarized in Table 12. Intensive growth (two irrigation stages) required a smaller amount of investment capital, a total of $74,276 fixed investment compared with $76,800 for one extensive growth purchase option. However, remember that real estate purchased may appreciate over time which would allow extensive growth strategies to grow relative to intensive investment strategies.

Beginning Price Level and Beginning Owner Equity

Simulation trials were conducted to determine the effect of beginning price levels and beginning owner equity on firm growth. In the previous section trials relating to extensive and intensive firm growth were compared assuming a constant beginning point on the price cycle and a constant owner equity. This beginning point on the price cycle (1964) was chosen at random and happened to be the low point on the 14-year price cycle. Beginning owner equity was set at 80% which was high enough to allow the firm to take advantage of the growth opportunities.

It is desirable, however, to determine the minimum owner equity needed for growth to occur and the effect rising or falling livestock prices have on the growth process. The following procedure first

Table 12. Summarization of the growth objectives from the simulation trials.

		No growth	Rent growth	Purchase growth	Irrigated alfalfa growth	Irrigated alfalfa-corn silage growth
Beginning total assets	($)	360,476	360,476	360,476	360,476	360,476
Beginning net worth	($)	286,486	286,486	286,486	286,486	286,486
Ending total assets	($)	360,871	485,514	564,314	429,410	562,014
Ending net worth	($)	315,120	273,323	272,289	390,895	461,928
Change in net worth	($)	28,634	-13,164	-14,197	104,409	175,442
Average rate of return	(%)	1.36	1.84	2.16	2.79	4.77
Family consumption (above minimum)	($)	3,540	2,425	931	5,961	29,007

determined the effect prices had on growth and then used that information in conjunction with the beginning owner equity trials.

Livestock Prices

To determine effect of livestock prices on firm growth success, trials were conducted assuming various beginning points on the historical price cycle. Trials were conducted beginning at the low point in the price cycle (1964), at the start of a price upswing (1968), at the high point on the price cycle (1971) and at the start of a price downswing (1960) (Table 6 and Figure 5). A trial assuming variable production and the 14-year average price was simulated to determine the effect stable prices had on firm growth.

The firm growth option chosen to measure the effect of the price trials was the intensive irrigated alfalfa growth option. Measures for determining the impact of livestock prices on firm growth were change in net worth and increased family consumption. Beginning owner equity was assumed to be 70% with $15,000 short-term debt and $95,384 long-term debt. Table 13 summarizes results.

The opportune time to expand is shown when prices are on the upswing. This resulted in the greatest increase in absolute net worth and increased family consumption over the simulation period. The poorest time to attempt firm expansion is when prices are on the downswing. Both the price upswing and price downswing trials began at about the same initial level of livestock prices but had quite different results over the simulation growth period. Cattle prices played the major role in determining the firm's annual net returns. When low livestock prices in the cycle occurred, the firm was forced to borrow

short-term capital to meet long-term debt commitments and minimum family living expenditures. In both simulated price cycle trials (upswing and downswing) long-term and short-term debt was accumulated during this growth period. In the price upswing the firm attained maximum growth when prices were high. The firm generated sufficient returns to pay the high interest payments on borrowed capital, the fixed long-term debt payments, family living expenses and reduced the principal on short-term credit. As the firm encountered the lower livestock prices in the latter years of the simulation trial, it reduced its total debt load substantially and had lower interest payments. The reverse was true when the firm began expansion when the price cycle was on the downswing. When the firm attained maximum growth for the trial it moved into the lower level on the livestock price cycle. Debt capital increased during the growth stage and net farm income was not large enough to pay the increased interest expense plus the fixed long-term payments and family living expense. Short-term credit was used for family living during the low net income years. This borrowed capital must be repaid during the high income years in addition to annual interest charges that accrue.

Simulating the intensive growth using average livestock prices and variable production produced the second-best growth in net worth but allowed the lowest amount for extra family consumption. The low family consumption under average prices occurred because the consumption function was designed to increase family consumption in high income years. Because average prices reduced the possibility of high income years as well as low income years, family consumption remained nearly stable. Net ranch income followed a stable trend upward.

Historically, price uncertainty has been the greatest barrier to long range planning, and the item of variability least subject to the individual operator's control.

It is evident from the price cycle trials that time of entry into the ranching industry (in relation to the price cycle) plays a major role in determining the success or failure of a ranching operation. *A priori* assumptions concerning the success or failure of ranch firms generally conclude that superior management is the reason for one firm's success and poor management the reason for a neighbor's failure. Good management is important in the success of a firm and certainly must not be downgraded. However, the simulation trials showed that the same management starting from the same economic base with the same livestock production and operating expense may have markedly different success in providing for family consumption and building net worth in a ranch business depending upon a number of factors including prices. As can be observed in Table 13, a difference of only four

Table 13. Summary of cattle price cycle trials on intensive irrigated alfalfa growth; beginning equity equals 70%.

	Average prices	Begin price downswing	Begin high price	Begin low price	Begin price upswing
			(dollars)		
Beginning total assets[a]	367,947	362,472	381,156	360,476	369,780
Beginning net worth	257,563	252,088	270,772	250,092	259,396
Ending total assets	429,613	422,774	446,168	420,277	431,903
Ending net worth	331,492	275,940	334,295	301,854	335,183
Change in net worth	73,929	23,852	63,523	51,762	75,787
Family consumption (above minimum)	840	2,772	1,747	3,827	5,102

[a] Beginning total assets will vary between trials due to valuing livestock at various price levels.

years (price downswing—1960, low price—1964) resulted in increasing net worth at double the rate.

Beginning Equity

The next variable examined in the simulation model was beginning owner equity. This becomes a major variable in any growth study because owner equity serves as the collateral for borrowed capital. Interest expense is the return on invested capital and must be paid at a fixed rate on borrowed capital. As the owner's equity becomes smaller more interest must be paid to outside capital which reduces the amount available for family consumption and reinvestment in the business.

Results from previous price cycle runs were partially incorporated in the equity trials. Minimum beginning equity levels were determined assuming beginning livestock prices were on the upswing and then compared wth the results of a beginning downswing in livestock prices. These results were also compared to growth assuming price coefficients were average over the simulation trial.

Long-term typical and liberal credit policies were also examined. Typical long-term credit limits were assumed not to exceed 60% of current market value of the fixed assets. A more liberal credit limit of 80% of current market value was examined to determine the effect more liberal credit would have on firm growth. The 80% figure was chosen in light of recent legislation passed by Congress authorizing Federal Land Banks to finance up to 85% of the current market value of real estate.[13] Credit limits on current and intermediate assets remained at 50% of the value of machinery and 75% of the current value of livestock.

[13] U.S. Congress, Farm Credit Act of 1971, Public Law 91-181, 92nd Congress, 1971, Title I.

Extensive Growth

Extensive growth trials were examined in a previous section with beginning equity levels of 80%. Beginning and ending net worth figures (Table 8) indicated beginning equity must exceed 80% for the firm to maintain its absolute net worth position.

The high beginning equity needed for either avenue of extensive growth success precluded the need to experiment with liberal credit policies. Typical credit policies allow the firm to borrow capital beyond its repayment capabilities. The low rate of return on the extensive ranching operation necessitates a high equity base, limiting this type of growth to established ranchers who may be in this high equity position.

Intensive Growth

The minimum equity needed for success under the intensive irrigated alfalfa option was examined first. Table 12 indicates the change in net worth and increased family consumption when firm growth was attempted at 80% beginning equity starting at the low point on the livestock price cycle. Several simulation trials were conducted to find the minimum beginning equity level and still have growth. Table 14 summarizes the different financial statements at 65% equity with three livestock pricing runs.

On the basis of several equity trials, 65% beginning equity was needed for any appreciable growth to occur. Comparisons in Table 14 showed a negative growth in net worth if the firm began growth as the price cycle began a downswing. At 60% equity very minor firm growth occurred under typical credit limits assuming a price upswing. When any other beginning price level was assumed negative growth occurred over the simulation period. Given the rigidities built into the simulation model (e.g., fixed annual real estate payment and annual reinvestment in machinery and improvements) 60% beginning

Table 14. Summary of growth trials on intensive irrigated alfalfa growth; beginning equity equals 65%.

	Average prices[a] $	Begin price downswing $	Begin price upswing $
Beginning total assets[b]	360,476	362,472	369,780
Beginning net worth[b]	231,695	233,691	240,999
Ending total assets	420,277	422,744	431,903
Ending net worth	276,181	229,955	291,612
Change in net worth	44,486	−3,736	50,613
Family consumption (above minimum)	0	1,681	3,794

[a] This simulation trial assumes average livestock prices, variable production. The other trials assume variable price and production.

[b] Beginning total assets and net worth vary between trials due to valuing livestock at various beginning price levels.

equity was below the margin considered necessary for intensive irrigated alfalfa growth to occur.

Equity trials below the 60% level will not be detailed, as it is obvious that growth did not occur over the simulated period below that level. Liberal credit arrangements are necessary for growth to be attempted below the 60% level, but advancing liberal credit results in ultimate program termination. This is equivalent to forcing the firm to liquidate its assets to meet creditor demands. In all cases where intensive irrigated alfalfa growth was attempted below the 60% level, the firm's net worth declined over the simulation period.

The next equity trials conducted assumed intensive irrigated alfalfa growth in year 1, coupled with intensive irrigated corn silage and backgrounding calves beginning in year 3. Simulation trials were conducted assuming various beginning equity positions under the different price cycle starting points (Table 15).

Under typical credit limits, the firm could not acquire sufficient capital for growth to occur below 65% beginning equity. Therefore, liberal credit limits were employed when equity fell below 65%.

A beginning equity of 55% allowed growth to occur for all pricing runs except the price downswing. Beginning at that point on the price cycle caused the firm to end operations at the end of year 5. Trials were conducted at 45% and 50% equity under the price upswing and under average prices. At 45% equity, assuming average prices, the program ended in year 3. Assuming a price upswing allowed the firm to operate 13 years before it ended.

Assuming a price downswing at 55% equity allowed the firm an increase in net worth of $3,469 at time of termination. Assuming average prices, 50% beginning equity allowed the firm to complete 15 years' operation with an increase in net worth of $98,717. When a simulation run at 45% equity and average prices was attempted net worth declined steadily and terminated after three years' operation.

Comparisons that can be made from Table 15 give some insight into the growth and termination process. At 55% beginning equity, a price downswing resulted in expenses exceeding gross ranch income by $4,280. Interest expense was 34.5% of cash expenses. The year operation terminated cash expenses exceeded gross ranch income by $4,440 and interest costs were 50% of cash expenses. Assuming average prices and 50% equity, gross ranch income exceeded cash expenses $1,501. Interest costs were 36.1% of cash expenses. In year 15 gross ranch income exceeded cash expenses $20,179 and interest costs as a percentage of total costs remained fairly constant at 37%.

When the price level was on the upswing and beginning equity was 45%, expenses exceeded income $1,065 and interest costs were 37% of total cash expenses. The year of termination, income exceeded cash expense but interest costs as a percentage of expenses rose to 42%.

Table 15. Summary of intensive irrigated alfalfa-corn silage equity-price trials.

		Begin price downswing 55% equity	Average prices 50% equity	Begin price upswing 45% equity
Year 1				
Total assets	(dollars)	362,472	367,947	369,780
Short-term debt	(dollars)	15,000	15,000	15,000
Long-term debt	(dollars)	150,570	168,973	187,370
Net worth	(dollars)	196,902	183,974	167,410
Total cash expenses	(dollars)	42,671	43,908	44,909
Interest paid	(dollars)	14,731	15,861	16,961
Gross income	(dollars)	38,391	45,409	43,844
Number of cows	(No.)	400	400	400
Year Terminated		5	15	13
Total assets	(dollars)	557,442	567,615	552,749
Short-term debt	(dollars)	165,144	217,386	254,874
Long-term debt	(dollars)	191,927	67,538	99,292
Net worth	(dollars)	200,371	282,691	198,583
Total cash expenses	(dollars)	66,194	61,833	65,069
Interest paid	(dollars)	26,548	23,032	26,970
Gross income	(dollars)	61,754	82,012	73,283
Number of cows	(No.	497	500	500
Change in net worth	(dollars)	3,469	98,717	11,213

Only under the average price situation did the firm's income exceed cash operating expense. Short-term credit did not accumulate so rapidly during the early years of operation and built up short-term debt and a heavy annual interest payment as the firm grew over time.

Cow numbers are shown as the measure for generating income. The operation obtained its income from the sale of calves and cow numbers serve as a reminder that the various ranch incomes shown in the table were all generated from this base.

The lowest beginning equity level that allowed an increase in net worth occurred assuming a price upswing and 45% equity. Table 16 details the firm's operation up to the year of termination. The program exceeded its credit limit after operating 13 years with an increase in net worth of $11,213. Quite likely, the firm would have continued to increase net worth over a longer run if credit limits had not forced termination. In the 11th year of operation the firm encountered the low point on the price cycle. A study of the financial statements (Table 16) over time reveals that in the face of future price uncertainties termination in year 13 was a rational decision. The firm slowly improved its net worth from the first year of intensive growth. However, beginning in year 11 its position began to decline due primarily to the falling livestock price level. It would be easy to envision the manager meeting with his creditors after three successive years of poor prices and declining net worth and deciding to end his operation before he lost what little net worth he had gained over the years.

Table 16. Annual changes in the firm's financial statement with beginning equity of 45%, irrigated alfalfa, corn silage and backgrounding calves (firm exceeds credit limit in year 13).

Year	Total assets $	Short-term credit $	Long-term credit $	Net worth $	Annual expense $	Interest expense $	Net ranch income $	Family living expense $
1[a]	369,780	1,500	187,370	167,410	44,909	16,969	-9,533	5,000
2[b]	435,067	40,842	216,522	177,703	46,632	19,199	-3,720	5,000
3[c]	457,587	74,002	205,126	178,459	62,803	25,347	-59,449	5,000
4	611,409	152,104	234,930	224,375	65,729	28,116	21,503	7,477
5	613,222	149,607	221,367	242,248	66,796	27,149	24,308	7,894
6	581,813	145,136	207,803	228,874	63,308	25,875	14,084	6,058
7	593,123	147,146	194,239	251,738	63,333	25,197	6,860	5,000
8	558,712	153,946	180,675	224,091	63,300	24,862	-290	5,000
9	556,614	167,672	167,111	231,831	62,739	25,009	-3,749	5,000
10	567,048	187,540	153,548	225,960	63,261	25,640	13,112	6,080
11	571,242	196,169	139,984	235,089	62,183	25,400	-4,961	5,000
12	544,504	217,249	126,420	200,835	63,790	26,157	-5,708	5,000
13	552,749	239,271	112,856	200,622	65,069	26,970	-2,169	5,000
End	562,589	254,874	99,292	208,423				

[a] Irrigation unit installed, alfalfa planted, and 20 cows purchased.

[b] Alfalfa established, 75 cows purchased.

[c] Irrigation unit installed, raise corn silage, 20 additional cows purchased. Calves are not sold that year but are carried over and sold the following May.

The simulated equity trials have shown growth can occur at much lower beginning equity levels when intensive growth is attempted. The low average rate of return on extensive ranch operations prevents growth except at levels above 80% equity. Intensive growth (two irrigation systems) will occur at 45% beginning equity under a price upswing, at 50% under average prcies, and 55% when the livestock price cycle is on a downswing. Levels of equity higher than this minimum allow growth to occur at a much faster rate.

CONCLUSIONS

In viewing various growth paths under the study assumptions, the simulation trials have shown that intensive growth through addition of irrigation is a superior strategy. Intensive growth is not dependent upon an exogenous real estate market and may occur whenever the operator chooses subject only to credit and managerial limitations. It was assumed that maintaining water availability over time was not a problem for the levels of irrigation in this study. Extensive growth in the study area of the Sandhills is limited to the time when land becomes available on the market. The owner of the firm may be forced to rent or purchase real estate as it becomes available because he may not have another opportunity to lease or purchase additional land for 5 or 10 years.

It should be clear that increasing land values would likely change the conclusions. Depending upon the rate of increase in land values, net worth would increase relatively faster under extensive growth purchases although it is not immediately clear what differences in net income would exist under these circumstances. Goals and values of the operator also bear strongly on investment decisions. Those ranchers having a goal of maximizing owned acres will find extensive growth a preferable alternative. That alternative would be preferred by those operators who wish to avoid new enterprises.

Intensive growth can occur at lower beginning equities which would appeal to younger ranchers in the industry. Older established ranchers will likely continue extensive expansion because they tend to be in superior equity positions and may be more conservative in their outlook towards intensive growth. Intensive growth also provides more potential income for family consumption—a matter of greater importance to a younger operator with a growing family.

The timing of growth in relation to livestock price trends plays an important part in the success of the growth venture. Beginning growth when prices are increasing results in a much better payoff than beginning growth at other points in the cattle price cycle.

Liberalizing credit policies will aid some operators in their growth objectives. However, in the Nebraska Sandhills ranching area, liberal

credit should be used judiciously, depending upon the type of enterprise financed.

This study has shown that despite the traditional narrow profit margins in basic cow-calf ranching operations, firm growth can occur. Extensive growth is limited to firms in high owner equity positions. Intensive growth through irrigation and winter feeding programs offers an attractive alternative for younger beginning operators in lower equity positions. Intensive growth allows the firm greater flexibility in using credit and timing of the growth process.