THE ASSESSMENT OF FORAGE PRODUCTION FROM IRRIGATED PASTURES BY MEANS OF BEEF CATTLE

-by-

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A B S T R A C T

The use of Irrigated Pastures for the production of beef cattle in British Columbia is a relatively new venture. That they have a place in the ranch ecomony of the province is appreciated when it is realized that the natural range resources are being used to their fullest extent at the present time. Irrigated pastures provide a means of intensification of production and permit increased beef output from the limited land areas available in the province.

The various methods of estimating pasture production through the use of grazing animals have been investigated. These investigations indicate the need for accuracy of experimental procedure since the variables encountered are numerous. The production of forage from irrigated pastures in 148 days was 4290.0 to 5011.8 pounds of total digestible nutrients per acre depending upon method used in calculation.

The young succulent grasses and legumes encountered in irrigated pastures are high in protein with a corresponding deficiency in carbohydrate. The use of high energy supplementation may be worthy of further investigation.

The incident of bloat and foot rot in animals on orrigated pasture can be a problem. Correct management procedures and prompt treatment will assist in alleviating these problems.

A C K N O W L E D G M E N T S

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To the numerous other people who assisted in gathering data on the pastures and the expressing of that data in written form, I tender my sincere thanks.

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I. INTRODUCTION

Irrigated lands have provided forage for beef cattle in British Columbia since the time of the earliest ranch settlements. The forage has normally been recovered as hay and has been used for winter feeding. Some aftermath grazing is practiced on these irrigated lands during the fall months. A recent innovation has been the use of intensively managed irrigated lands for summer grazing and fattening of beef animals. Interest in such irrigated pastures has been furthered by the findings of investigators in the Pacific Northwest States which suggest that the yield of animal products per acre can be greatly expanded by such pastures.

Approximately fifteen million acres of forest grazing land and two million acres of open grassland comprise the grazing land potential of British Columbia. Anderson (1952) estimates that thirteen million acres of open and forested grazing lands are being used and it represents almost the entire actual grazing potential. MacGillivray (1949) makes the following statement: "Though the province is supposed to be capable of further expansion of its cattle ranching and its sheep ranching, information supplied by the Grazing Branch of the Department of Lands and Forests would indicate that the unused areas of ranch land in British Columbia are very limited in extent. Muѡh of the range land is now over grazed and would probably be a more profitable resource if carrying fewer cattle and sheep." From these statements it appears safe to conclude that the open grasslands are at present being fully utilized and in fact in many cases are being over utilized. The available open grasslands are used in the main for early spring and late fall grazing. The forest lands are used for summer grazing during July, August and September.

If it can be shown that irrigated pastures possess the productive capacity suggested by other workers then such pastures may fulfill in a measure the apparent need for greater per acre productivity.

The irrigated pastures initiated at the Canada Range Experiment Station, Kamloops, British Columbia, were designed to study the fundamentals of plant and animal growth and their inter-relationships. While the research project is still in its initial stages, it is already possible to delineate certain basic conclusions from this early data. This study had as its primary objective the determination of suitable ways and means to assess pasture production through the use of beef animals. Such a method of assessment is necessary to form a base upon which to build pasture research and pasture recommendations.

II. REVIEW OF LITERATURE

The assessment of pasture production by means of grazing animals has been the subject of many technical communications. These have ranged from detailed observations of grazing behaviour (Tribe and Gordon (1953), Wordrop (1953), Taylor (1953)) to extensive laboratory studies designed to determine its digestibility and nutritive quality, (Crampton (1939), Algren (1947), Report (1952)). Before reviewing the literature relative to the various methods proposed for assessing pasture production, it is perhaps well to examine the nutritive requirements of beef cattle relative to their stage of growth. On the basis of these requirements, it should be possible to estimate the necessary production of pastures to sustain any given rate of gain.

The National Research Council (U.S.A.) in their Recommended Nutrient Allowances for Beef Cattle (1950) list the requirements for fattening yearling cattle. This information is presented in Table I.

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TABLE I : "NATIONAL RESEARCH COUNCIL RECOMMENDED NUTRIENT ALLOWANCES FOR FATTENING YEARLING CATTLE"

Body Weight Pounds	Expected Daily Gain Pounds	Percent of Live Weight	Per Animal Pounds	Digestible Protein Pounds	Total Digestible Nutrients Pounds	Calcium Grams	Phosphorus Grams	Carotene Mg.	T.D.N. per Pound Gain	Dry Matter per Pound Gain
600	Average	3.0	18	1.3	11.5	20	17	36	5.22	8.18
700	for	3.0	21	1.4	13.5	20	18	42	6.14	9.54
800	period	2.8	22	1.5	14.0	20	19	48	6.64	10.00
900	22	2.7	24	1.6	15.5	20	20	54	7.04	10.91
1000	pounds	2.6	26	1.7	17.0	20	20	60	7.73	11.82
1100	daily	2.4	27	1.7	17.5	20	20	66	7.95	12.27

Morrison's (1949) recommendations (Table II.) for cattle in the same weight range appear to be appreciably below those of the National Research Council as recorded in Table I.

TABLE II.

MORRISON'S FEEDING STANDARD FOR FATTENING YEARLING CATTLE

Weight	Dry matter	Digestible Protein	T.D.N. lbs.	Nutritive Ratio	Net Energy-Therms
600	13.2-16.3	1.20-1.41	10.3-12.7	7.0-8.0	9.3 -11.5
700	15.2-18.3	1.41-1.60	12.0-14.4	7.0-8.0	11.0 -13.2
800	17.0-20.3	1.59-1.79	13.5-16.1	7.0-8.0	12.6 -15.0
900	18.5-21.8	1.79-1.94	14.8-17.4	7.0-8.0	13.9 -16.4
1000	19.7-22.9	1.87-2.06	15.9-18.5	7.0-8.0	14.9 -17.4
1100	20.8-24.0	1.99-2.17	16.9-19.5	7.0-8.0	15.9 -18.3

Unfortunately Morrison does not suggest the rate of gain to be expected from the feeding level that he has recommended, hence it may be reasonable to conclude that his lower recommendations are designed to produce a gain of less than the 2.2 pounds per day suggested by the National Research Council. Morrison's presentation also precludes the calculation of the dry matter or total digestible nutrients required per unit of gain. Reference to Table I suggests that the efficiency of gain to be expected in cattle of the weight 800 pounds will be 6.64 pounds of total digestible nutrients and 10.91 pounds of dry matter per pound of body weight gain.

From Morrison (1949) (Table 111) the average composition of pasture grasses and legumes can be estimated. It may be interesting to determine if the 800 pound animal mentioned above can consume the amounts of forage necessary to obtain 6.64 pounds of total digestible nutrients and 10.91 pounds of dry matter per pound of body weight gain.

TABLE III.

DRY MATTER, DIGESTIBLE NUTRIENTS AND NET ENERGY IN PASTURE FORAGE (AFTER MORRISON)

GRASSES	Total Dry Matter in Percent	Total Digestible Nutrients in Percent	Est. Net Energy 100 lbs. Therms
Pasture Grasses and Legumes from well grazed, Fertile Pasture, Northern States	22.0	14.9	13.0
Past.grasses and Legumes from well grazed, fertile pasture, Southern States	25.1	16.6	14.4
Pasture grasses with small amt. legume from well grazed, fertile pasture, Southern States	22.0	14.6	12.2
Average of Pasture Forage	23.0	15.3	13.5

This animal must consume 43.4 pounds of green forage to provide the necessary total digestible nutrients to produce one pound of body weight gain. For 2.2 pounds of gain 95.48 pounds of green forage must be consumed. This amount of forage at 23 percent dry matter represents a dry matter intake of 21.9 pounds per day. Experimental work by Garrigus as reported by Crampton (1939)(Table IV) would tend to indicate that such a dry matter intake or what is more important such a green forage intake is well within the realms of possibility for an animal weighing 800 pounds. The above calculation is dependent for its validity upon numerous ad hoc feeding trials as summarized by Morrison.

An alternative approach to the same problem can be obtained from the field of energetics. For example, a reasonable approximation of the Caloric intake required by an animal to make a specific daily gain can be determined by using Brody's (1945) Resting Metabolism data and Haeker's (1920) data on the composition of gains in beef animals. The composition of the weight gain is an important consideration. Brody has stated: "Two animals may gain weight at different rates, yet gain energy at the same rate. This is because some types of weight gain involve greater energy storage per unit live weight than others. For instance, one gram of protein gain is necessarily associated with three grams of water gain. Moreover, the energy equivalent of one gram of fat is two and one quarter times one gram of protein. Hence one gram of fat gain is Calorically equivalent to about eight grams protein gain."

TABLE IV.

WEIGHT OF ANIMAL AND DAILY DRY MATTER CONSUMPTION OF PASTURE HERBAGE BY FREELY GRAZING STEERS

Steer No.	Forage Grazed	Weight of Steers Individually	Weight of Steers Average	Dry Matter Consumed Individually	Dry Matter Consumed Average
A	Blue Grass ½ headed	938	963	25.8	19.5
	Alfalfa ¾ bloom	988		13.1	
B	Clover mixture ¼ bloom	535	535	12.3	12.3
C	Alfalfa ¾ bloom	602	610	10.5	10.3
	Alfalfa, full bloom	618		10.2	
D	Alfalfa, ¾ bloom	758	766	12.0	12.0
	Alfalfa, full bloom	775		12.0	
E	Blue grass, 5 weeks	364	373	10.4	12.2
	Red Clover, mature	362		12.3	
	Red Clover, ¼ bloom	394		13.9	
F	Blue grass, 5 weeks	584	596	12.6	16.3
	Red Clover, mature	582		19.7	
	Red Clover, ¼ bloom	622		16.7	
G	Blue grass, 5 weeks	844	847	14.4	17.1
	Red Clover, mature	834		19.5	
	Red Clover, ¼ bloom	862		17.5	

(continued next page)

TABLE IV CONTINUED.

Steer No.	Forage Grazed	Weight of Steers Individually	Average	Dry Matter Consumed Individually	Average
H	Blue Grass, 5 weeks	940		21.7	
	Red Clover, mature	942	948	25.0	22.9
	Red Clover, ¼ bloom	963		22.0	
I	Reed Canary mixture	410		7.4	
	Brome Grass	470	440	8.5	7.9
J	Reed canary mixture	505		14.8	
	Brome grass	600	552	14.3	14.5
K	Reed canary	800		15.6	
	Brome grass	850	825	14.9	15.2
L	Reed canary	745		15.0	
	Brome grass	815	780	12.5	13.7

Recalculation of Haeker's data (Table V) lends support to Brody's statement. It should be noted that Brody has erred in assuming that one gram of fat is Calorically equivalent to 2.25 grams of protein. This is true in the metabolizable energy sense but his context infers that he is describing the gross energy gain of the animal. In such an event fat contains approximately 9/5.65 Calories more than protein.

TABLE V: "CHANGES IN BODY COMPOSITION WITH CHANGES IN BODY WEIGHT."

Body weight lbs.	Percent Protein	Calories/ 100 Grams	Percent Fat	Calories/ 100 Grams	Total Caloric Gain
100	16.88	95.4	3.41	32.4	127.8
200	15.12	85.4	4.73	45.9	131.3
300	15.32	86.6	9.17	87.1	173.7
400	15.77	89.1	8.63	81.9	171.0
500	15.89	89.7	11.41	108.4	198.1
600	15.75	89.0	12.22	116.1	205.1
700	15.43	87.2	13.76	130.7	217.9
800	15.96	90.2	15.73	149.4	239.6
900	15.10	85.3	20.59	195.5	280.8
1000	14.93	84.0	23.54	223.6	307.6
1100	14.43	81.5	28.21	268.0	349.5
1200	14.49	81.9	29.27	278.1	360.0
1500	14.10	79.8	33.71	320.2	400.0

By uniting the data of these two workers Mills (1953) has evolved and established a feeding standard for fattening yearling cattle. Mills allowed no increment for movement of his animals. Since the animals used were confined to a small area and movement was kept to a minimum, the error in Calories for Resting Metabolism would be at a minimum. Animals on pasture usually have full freedom of movement, therefore a 12 percent increment has been added to the Resting Metabolism to allow for this movement. The work of Ritzman and Benedict (1938) would indicate that this figure is approximately correct. This information is presented in Table VI. below.

T A B L E VI: "DISTRIBUTION OF ENERGY INTAKE OF YEARLING CATTLE"

Body Weight	Resting Metabolism Calories	Gain (1) Expected Pounds/Day	Net Caloric Content of Gain/Lb.	Gain/ Day in Calories	Net Caloric Intake required per Day
500	6989	1.50	1100	1650	8639
525	7163	1.58	1150	1817	8980
550	7336	1.65	1170	1921	9257
575	7514	1.73	1250	2163	9677
600	7692	1.80	1320	2376	10068
625	7862	1.88	1400	2632	10494
650	8030	1.95	1450	2828	10858
675	8182	2.03	1510	3065	11247
700	8323	2.10	1620	3402	11725
725	8469	2.18	1710	3728	12197
750	8620	2.25	1800	4050	12670
775	8771	2.33	1870	4357	13128
800	8916	2.40	1950	4680	13596
825	9072	2.48	2020	5010	14082
850	9224	2.55	2120	5406	14630
875	9377	2.63	2230	5865	15242
900	9462	2.70	2320	6264	15726

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TABLE VI continued: "Distribution of Energy Intake of Yearling Cattle"

Body Weight	Resting Metabolism Calories	Gain (1)Expected Pounds/ Day	Net Caloric Content of Gain/Pd.	Gain/ Day in Calories	Net Caloric Intake required per Day
925	9600	2.78	2410	6700	16300
950	9798	2.85	2510	7154	16952
975	9946	2.93	2620	7677	17623
1000	10092	3.00	2700	8100	18192

(1) Assuming an instantaneous relative growth rate constant of 0.0030 (or 0.3 percent) throughout the body weight range 500 to 1000 pounds.

Reference to Table VI suggests that an 800 pound animal gaining 2.4 pounds per day requires 13,596 Calories of Net Energy per 24 hours. Accepting Morrison's figures given in Table III for the Net Energy content of forages as 135 Calories per pound of green forage, it would appear that the 800 pound animal cited above will be required to consume 100.1 pounds of green forage per diem to support this rate of gain. In other terms 41.7 pounds of green forage should be required to produce 1 pound of body weight gain. This value is not in too great disagreement with the value of 43.4 pounds as calculated using the National Research Council's nutrient allowances. In fact the two values can probably be brought into closer agreement when one realizes that the daily rate of gain of 2.2 pounds as estimated by the National Research Council is a mean rate of gain over the weight range 600 to 1000 pounds.

The actual rate of gain at 800 pounds probably is in the neighborhood of 2.4 pounds per day. Support for this contention can be found in Mill's work in which the Mean Instantaneous percentage growth rate for yearling steers was found to be 0.3 percent.

The previous calculations can best be summarized in tabular form. Table VII presents such a summary.

TABLE VII: "SUMMARY OF NATIONAL RESEARCH COUNCIL AND ENERGETIC METHODS OF CALCULATING FORAGE REQUIREMENTS."

Body Weight	N. R. C. CALCULATIONS REQUIRED PER POUND OF GAIN T.D.N.	 GREEN FORAGE	 DRY MATTER	ENERGETIC CALCULATIONS REQUIRED PER POUND OF GAIN NET ENERGY CALORIES	 GREEN FORAGE	 DRY MATTER
600	5.22	34.1	7.84	5593	41.4	9.51
700	6.14	40.1	9.22	5583	41.3	9.49
800	6.64	43.4	9.98	5665	41.9	9.62
900	7.04	46.1	10.60	5824	43.1	9.91
1000	7.73	50.5	11.61	6064	44.9	10.32

Sylvestre and Williams (1952) have proposed a method by means of which the digestible nutrient production of forage can be computed from the gain made by animals consuming such forage. In essence they have selected Morrison's feeding standard for growth and fattening and deducted from it the estimated maintenance requirement as proposed by Armsby. The difference between these two estimates they take to be that portion of the digestible nutrient intake which was utilized for weight gain by the animal. Their calculations may be summarized in part as shown by Table VIII.

TABLE VIII: "ESTIMATED T.D.N. REQUIREMENTS FOR MAINTENANCE AND PRODUCTION IN BEEF CATTLE"

Live Weight Range Pounds	Maintenance Total Digestible Nutrients /100 lbs. Live Weight	Gain Total Digestible Nutrients per 1 Pound Gain
600	.775	2.11
650	.754	2.32
700	.732	2.52
750	.710	2.72
800	.697	2.92
850	.684	3.12
900	.671	3.32
950	.658	3.53
1000	.646	3.73

To illustrate the use of Sylvestre and William's method of calculation, assume that a given animal weighing 800 pounds gains 50 pounds in a period of 20 days. Then from Table VIII the animal will require for maintenance 113.8 pounds of total digestible nutrients. For body weight gain the same animal will require 151.0 pounds of total digestible nutrients, yielding a total digestible nutrient intake of 264 pounds over a period of 20 days or 13.2 pounds of total digestible nutrients per day. Using grazing animals weighing 800 pounds and gaining at the rate of 2.5 pounds per day, each pound of weight gain must represent the consumption of 5.24 pounds of digestible nutrients. It is evident that the product of weight gained and 5.24 represents the total forage digestible nutrients produced by the area of land on which the animals are grazing.

To summarize, using National Research recommendations, the production of one pound of gain by an 800 pounds animal represents the consumption of 6.64 pounds of total digestible nutrients, and if the animal made this gain on pasture forage then the pasture must have yielded the 6.64 pounds of total digestible nutrients if no supplementary feeding had been carried out. In the case of the energetic calculations, one pound of weight gain represents the consumption of 5665 Calories in the net sense. If it is assumed that the ratio of digestible energy to net energy is as 3.2 is to 2.2, then the digestible energy consumption must be 8240 Calories of digestible energy. This would then represent 5.09 pounds of total digestible nutrients if it be assumed that 1616 Calories of digestible energy is obtained from one pound of total digestible nutrients.

These values, 6.64 (National Research Council), 5.24 (Sylvestre and Williams), 5.09 (Energetic) indicate that there will be some variation in digestible nutrient yield dependent upon the method of calculation used. It does seem safe to conclude however that a not unreasonable estimate of productive capacity of pastures can be obtained using any one of the three methods.

Various other methods of reporting productivity of pastures have been developed. Clipping methods, whereby the yields are expressed as pounds of dry matter per acre have been reviewed by Algren (1947). He emphasizes the advantages of using grazing animals. The four generally accepted methods involve the reporting of production in the form of Animal Unit Months, Standard Cow Days, Standard Steer Days or pounds of production per acre. Burlingame (1949) reports live weight gains of lambs and steers in the form of Animal Unit Months. An Animal Unit Month being the total digestible nutrients required for a mature cow to produce 200 pounds of butterfat per year. This is taken to be equal to 400 pounds of total digestible nutrients. Bateman and Packer (1945), Rich,et al.,(1950) report pasture production in terms of Standard Cow Days which is taken to be represented by 16 pounds of total digestible nutrients per day. Other workers too numerous to mention use as a reference point the Standard Steer Day which is taken to be represented by 12 pounds of total digestible nutrients per day. Bartels (1944A) reports young sheep production in terms of pounds of lamb per acre which is arrived at by dividing the total gain by the number of acres grazed.

The use of the terms, Animal Unit Month (A.U.M.), Standard Cow Day (S.C.D.) or gain per acre in reporting gains in animals have a number of inherent errors. The reference points for the terms, Animal Unit Month is estimated to be 400 pounds of total digestible nutrients for a mature cow giving 200 pounds of butterfat per year. Standard Cow Day is taken to be equal to 16 pounds of total digestible nutrients per day, and a Standard Steer Day (S.S.D.) is taken to be equal to 12 pounds of total digestible nutrients per day. These reference points are the product of the number of pasture days and the average number of stock carried on the pasture.

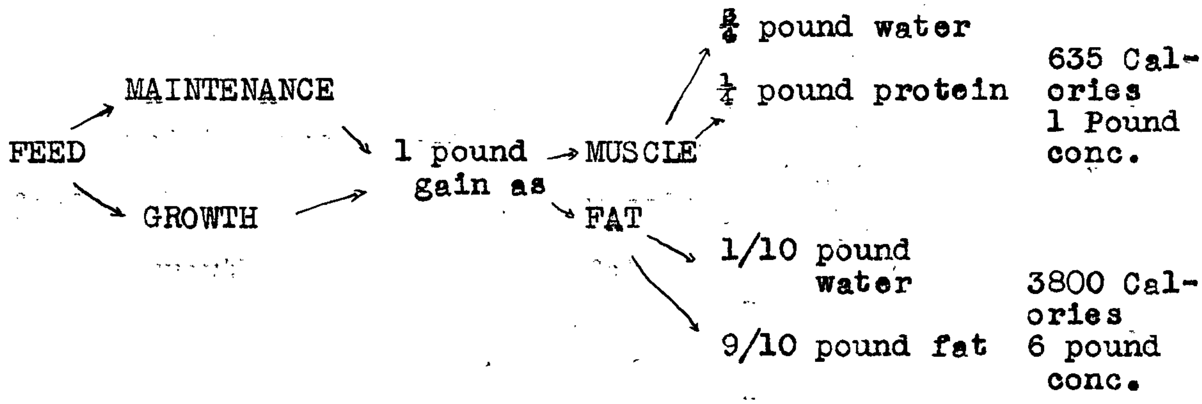
The main disadvantages of the "Animal Day" method of reporting pasture productions are listed by Mowstad (1953):

"(a) No allowance can be made for gain or loss in weight.

(b) High producing animals are not distinguished from those having lower nutrient requirements because of lower production.

(c) No allowance is made for supplementary feeding."

A further disadvantage is that the nutrient requirements of animals vary according to the nature of the gain they are making. Steers weighing 500 pounds require less total digestible nutrients per pound of gain than 950 pound steers because they are making their gain in the form of muscle or protein rather than fat. The extreme case of this is illustrated by Williams and Wood (1952) in the following Chart.



They point out that such absolute distribution of gain to muscle and fat never occurs. The actual case will fall between the two extremes. Table V illustrates the change in composition of gain in actual cases.

The relative amount of total digestible nutrients required to produce one pound of gain as compared to one pound of four percent milk will also affect the accuracy of results reported as Animal Unit Months or Standard Cow Days. Forbes et al (1928, 1930, 1932, 1938) found the relative value of feed energy for maintenance, milk production and body increase to be 1.000, 0.985, and 0.761 respectively. This calculation would indicate that 0.341 pounds of total digestible nutrients which will produce one pound of four percent milk with an energy value of 336 Calories would produce only 200 Calories when used to increase body weight. It would require 10.36 times as much total digestible nutrients to produce a pound of gain in body weight as would be required to produce one pound of four percent milk.

Therefore, the weight gain of animals as well as the production must be accurately measured to obtain a true production figure for the pasture. The reader is referred to Report (1952) and Nowstad (1953) for a more detailed study of these methods of reporting pasture production.

The foregoing discussion would indicate that there are several methods at present in use to assess pasture production. For purposes of comparison these methods are summarized briefly in Table IX.

TABLE IX: "SUMMARY OF METHODS USED TO MEASURE PASTURE PRODUCTION"

METHOD	WORKERS	Units Per Pound of Gain
National Research Council	Committee on Animal Nutrition	Total Digestible Nutrients Necessary per Pound of Gain
Energetics	Brody Haeker Armsby and others	Energy Expressed as Calories Required to Produce a Pound of Gain
Maintenance plus Gain	Sylvestre Williams	Total Digestible Nutrients Required to maintain a given weight and produce a given gain
Standard Cow Days	Bateman, Packer, Rich and others	16 Pounds of Total Digestible Nutrients taken as requirements of one Standard Cow
Standard Steer Day	Numerous Workers	12 pounds of total digestible nutrients taken as requirements of one stahdard Steer.
Animal Unit Month	Burlingame and Others	400 pounds of total digestible nutrients taken as requirements for one mature cow to produce 200 pounds of butterfat per year

III. E X P E R I M E N T A L

A. EXPERIMENTAL ANIMALS.

The animals used to graze the Irrigated pastures were loaned for the purpose. The pasture production was such that eighteen yearling Holstein steers had to be used during the last thirty days of grazing. All other animals used were of predominantly Hereford breeding. Since the steers had to be returned to the owner at a body weight of 1000 pounds, a continuous removal and replacement of animals took place throughout the grazing season. In general, the type of animals available for this test left much to be desired. The animals were extremely variable with respect to weight and age. The first thirty-eight animals obtained ranged in age from eighteen months to thirty months. The range in weight was from 600 to 900 pounds with an average weight of 843 pounds. From previous calculations such animals would require 5.09 to 6.64 pounds of total digestible nutrients per day to produce one pound of body weight gain.

A number of the first steers obtained were extremely nervous in temperament and required a longer period of acclimatization before they settled down in the confined space of the irrigated pastures.

B. ANIMAL PROCEDURE.

The animals were weighed on a Fairbanks Morse platform scale equipped with a fully enclosed box. See Photograph, Appendix VI. The increment of weight on such a scale is two pounds. The repeatability of weight on a scale of this type is shown in Table X. To obtain this repeatability, ten steers were weighed ten individual times in succession. The scale was balanced following each weighing.

TABLE X

"Repeatability of Scale Used in Weighing Experimental Animals"

Weights Obtained	Average of Ten Weights Obtained	Variation from Average	Range in Weights
1) 8266		+ 6.2	
2) 82 68		+ 8.2	
3) 8266		+ 6.2	
4) 8262		+ 2.2	
5) 8260	8259.8	+ 0.2	16
6) 8256		- 3.8	
7) 8256		- 3.8	
8) 8258		- 1.8	
9) 8254		- 5.8	
10) 8252		- 7.8	

The error in weighing based on a group weighing and average weight of the ten weighings would be 0.19 percent. Such an error is negligible on a group basis but if such an error was committed for the individual weighing it would amount to 1.9 percent of the animal's weight and this would be an appreciable error. A similar repeatability test using one animal was performed and the range in weights was found to be six pounds on an animal averaging 852.8 pounds over ten weighings. This represents an error of 0.70 percent of the animal's body weight. Such an error would appear to be negligible and may well be accounted for by the defecation of the animal while being moved on and off the scale.

The experimental animals were weighed in groups of ten animals to obtain a group weight. The scale was balanced after weighing each group to correct for manure accumulation on the platform during weighing. One weight was taken as the initial weight after the animals had been in dry lot feeding for twenty-four hours on full feed. Subsequent weighings were obtained when the animals went into and came out of each pasture. In actual practice this allowed the collection of a group weight every four to five days, as grazing time on each pasture amounted to four or five days. (See Appendix III). Care was taken to weigh the animals at the same time of day so that the degree of fill would be approximately the same. In addition, an attempt was made to leave the same amount of aftermath in each pasture as this factor has an effect on degree of fill. The importance of allowing for degree of fill has been fully discussed by Ritzman and Benedict (1938) and Taylor (1953).

C. PASTURE FORAGE ASSESSMENT PROCEDURE.

Dry matter content of the pasture forage as well as total dry matter production was determined from clip plots.

Eight mower strips, 32 inches by 40 feet were cut immediately before the animals went on pasture. These strips were located at random over the whole pasture area. The forage cut from each mower strip was weighed individually. A two pound sample from each strip was oven dried at 200 degrees Fahrenheit for forty-eight hours. The average dry matter content of the eight samples was then taken to represent the dry matter content of the forage for that pasture.

Protein content of the pasture was determined on a representative sample from every eight pasture clips. The procedure used was that of the Association of Official Agricultural Chemists (1950).

The establishment and management of the pastures is discussed fully elsewhere in the text, see Appendix II and III.

Animal disease factors and abnormal physiological conditions encountered are discussed in Appendix V.

IV. RESULTS:

A. ANIMALS:

Table XI presents a summary of all weight data obtained on the experimental steers.

see over.

T A B L E XI: "SUMMARY OF ANIMAL WEIGHT DATA"

Experimental Period	1	2	3	4	5	6	7	8	9	10	11	MEAN
Number of Pasture Days	8	6	28	3	5	33	6	7	2	20	30	148
Number of Animal Days	304	240	1512	165	190	1320	276	315	92	520	1200	6134
Actual Number Animals Starting	38	40	54	53	38	40	46	45	46	51	40	44.6
Actual Number Animals Finishing	38	40	54	53	38	40	46	45	46	51	40	44.6
Total Initial Weight	32040	34784	46452	49286	33784	36310	43408	42866	44096	47422	36536	40,634.9
Total Final Weight	33524	35192	50240	49408	34435	38248	43776	43192	44548	48772	38560	41,808.6
Average Initial Weight	843.1	869.6	860.2	929.9	889.0	907.7	943.6	952.5	958.6	929.8	913.4	908.8
Average Final Weight	882.4	894.8	922.9	932.2	906.1	956.2	951.6	959.8	968.4	956.3	964.0	935.8
Average Weight During Period	862.7	882.2	891.5	931.0	897.5	931.6	947.6	956.1	963.5	943.0	938.7	
Total Gain per Lot	1484	408	3788	122	651	1938	368	326	452	1350	2024	12911
Average Daily Gain per Head	5.2	4.2	2.5	.73	3.4	1.4	1.3	1.1	4.9	2.6	1.6	2.6

B. PLANT DATA

Table XII presents a summary of the data collected and calculated on the pasture forage.

Using the information embodied in Tables VII, VIII, IX and XII, it is possible to arrive at an estimated production figure for the pastures. This information is presented in summary form in Table XIII. The pasture period was 148 days.

Calculated as per the method of Sylvestre and Williams, (Table VIII), the total production of total digestible nutrients on the pasture was 77,221.7 pounds. Represented on a per acre basis, this amounts to 4290.0 pounds of total digestible nutrients per acre. Calculated as per the standard of the National Research Council (Table VII), the total production was 89,612.6 ppunds of total digestible nutrients or 4978.4 pounds of total digestible nutrients per acre. Similar calculations by energetic methods (Table IX) give a net Caloric figure of 145,784,874 Calories. Assuming 1616 Calories per pound of total digestible nutrients, this represents a total production of 90,213.4 pounds of total digestible nutrients or 5011.8 pounds of total digestible nutrients per acre.

The protein percentages expressed in Table XII would indicate the high crude protein content of pasture forage.
The percent crude protein is based on nitrogen x 6.25 since this is the generally accepted figure for calculating the protein content of feedstuffs.
The average crude protein percentage for the season was 25.71 percent

with one pasture going as high as 34 percent during the season. There did not appear to be a relationship between the application of nitrogen fertilizer and the protein content of the forage. One hundred pounds of ammonium nitrate per acre was applied to the following pastures on the dates listed.

Pasture Number 5:	July 3	1952
Pasture Number 4:	July 3	1952
Pasture Number 3:	July 10	1952
Pasture Number 2:	July 16	1952

If high crude protein content of the forage had been encountered on clips immediately following the application of ammonium nitrate, it would have indicated a large proportion of nitrate nitrogen to be present. The clipping dates as recorded in Table XII show that this did not occur.

TABLE XII: "SUMMARY OF PLANT DATA ON PASTURE FORAGE"

PASTURE #1					PASTURE # 2					PASTURE #3				
Clipping Date	Average Pds. Green Forage Per acre	Average Dry Matter Per Acre	Percent Dry Matter	Per-c cent Protein 6.25XN	Clipping Date	Average Pds. Green Forage per acre	Average Dry Matter per acre	Percent Dry Matter	Percent Protein 6.25XN	Clipping Date	Average Pds. Green Forage Per acre	Average Dry Matter Per acre	Percent Dry Matter	Percent Protein 6.25XN
May 31	7921.8	1915.7	24.1	19.61	May 26	7942.3	1674.3	21.9	28.64	May 20	5035.6	1162.2	24.0	14.37
June 24	3111.4	954.4	26.4	27.11	June19	3746.0	980.8	26.2	18.74	Jun 16	1965.1	556.9	28.6	24.96
July 14	3745.9	768.8	20.3	31.53	Jul 9	5567.8	982.5	17.6	34.05	Jul 5	1924.2	373.3	19.4	32.90
Aug.18	11667.9	2558.8	22.3	20.05	Aug11	12015.9	2366.2	19.8	29.94	Aug 1	5997.7	1336.8	22.2	30.01
Sep.10	1330.5	364.1	27.6	24.30	Sep 6	3213.7	795.8	24.7	24.20	Sep 3	2702.0	567.6	31.0	31.84
Sep.29	1658.0	350.1	21.1	28.45	Sep 24	2845.3	569.1	20.0	24.20	Sep20	1248.6	334.0	27.2	19.50
Total	29,434.3	6911.6			Total	35,331.0	7368.7			Total	18,873.2	4331.0		
Average				25.17	Average				26.62	Average				25.59
Range				11.92	Range				15.31	Range				18.53 T

--continued next page---

TABLE XII. continued. "SUMMARY OF PLANT DATA ON PASTURE FORAGE"

PASTURE #4					PASTURE # 5				
Clipping Date	Average Pounds Green Forage per acre	Average Dry Matter per acre	Percent Dry Matter	Percent Protein 6.25XN	Clipping Date	Average Pounds Green Forage per acre	Average Dry Matter per acre	Percent Dry Matter	Percent Protein 6.25XN
May 14	5997.7	1346.0	22.5	32.05					
June 11	6468.5	1499.9	23.4	20.70	June 5	10,890.0	2436.2	22.5	23.85
July 2	3316.1	716.3	21.6	34.47	June 28	1801. 3	344.1	19.2	20.49
July 26	7778.6	1775.0	22.8	20.59	July 19	5997.7	1191.4	19.7	22.23
Aug 29	3131.9	752.3	23.9	26.08	Aug. 25	8167.5	1983.6	24.7	30.37
Sept.18	3152.4	354.3	22.3	33.73	Sept.15	1637.6	503.7	32.5	19.50
Total	29,845.2	6443.8			Total	28,494.1	6486.0		
Average				27.93	Average				23.28
Range				13.88	Range				10.87

AVERAGE YIELD OF DRY MATTER FOR THE FIVE PASTURES: 6308.3 POUNDS DRY MATTER PER ACRE

TOTAL YIELD FOR 18 ACRES: 113,549.4 POUNDS OF DRY MATTER

OVER ALL PERCENT PROTEIN: 25.71 PERCENT.

TABLE XIII: "SUMMARY OF PASTURE PRODUCTION CALCULATED BY VARIOUS METHODS"

Experimental Period	Sylvestre and Williams	National Research Council	Energetics
	Pounds	Pounds	Calories
1	6393.2	10,239.6	16,887,920
2	2770.5	2,835.6	4,708,320
3	21,496.9	26,516.0	43, 940,800
4	1437.1	884.5	1,467,660
5	3282.3	4589.5	7,593,915
6	14,893.1	14,050.5	22,227,240
7	2,982.6	2,712.1	4,393,280
8	3,103.7	2,428.7	4,009,800
9	2,175.1	3,376.4	5,591,240
10	7,937.5	9,922.5	16,457,500
11	14,464.7	14,775.2	24,510,640
Total	80,936.7	93,327.6	151,788,315
Less T.D.N. Fed (1)	3,715.0	3,715.0	6,003,440
	77, 221.7	89,612.6	145,784,875 (2)

(1) 7430 pounds of good quality oat hay was fed during the last period. As per Morrison's recommendations, this was taken to have a digestibility of 50 percent.

(2) The 3715 pounds of total digestible nutrients derived from hay was taken to have a Caloric content of 1616 Calories per pound.

V. DISCUSSION

The production data presented in Table XIII tends to bear out conclusions expressed in Section III. The National Research Council method and the energetic method of estimating pasture production would appear to be comparable, there being only a 600.8 pound difference in the two calculated amounts of total digestible nutrients. This represents a difference of .66 percent between the two methods. The method of Sylvestre and Williams appears to be appreciably below that of the other two and here the difference is approximately thirteen percent between their method and the other two.

The only figure against which these calculations can be checked is that of the forage production data presented in Table XII. From these data the calculated total production of dry matter was 113, 549.4 pounds. Using the recommendations embodied in Report (1952) in which an average digestibility of 72 percent for pasture forage is suggested, the dry matter production would represent 81,755 pounds of total digestible nutrients . In this case the method of Sylvestre and Williams is approximately 5 percent below that of the dry matter calculation while the National Research Council and energetic methods are approximately 10 pereent above that of the dry matter calculations. This is not an uncommon occurrence when comparing clip plot data with grazing animal data. The reasons for this have been investigated by numerous workers and have been summarized in Report (1952) as follows: "When the herbage is upstanding more herbage is cut by clipping techniques than is procured by animals when grazing.

(2) When the herbage is procumbent, such as with White Dutch clover, the animals can graze more forage than can be obtained by clip methods.

(3) Animals soil and trample a certain amount of forage which is not eaten.

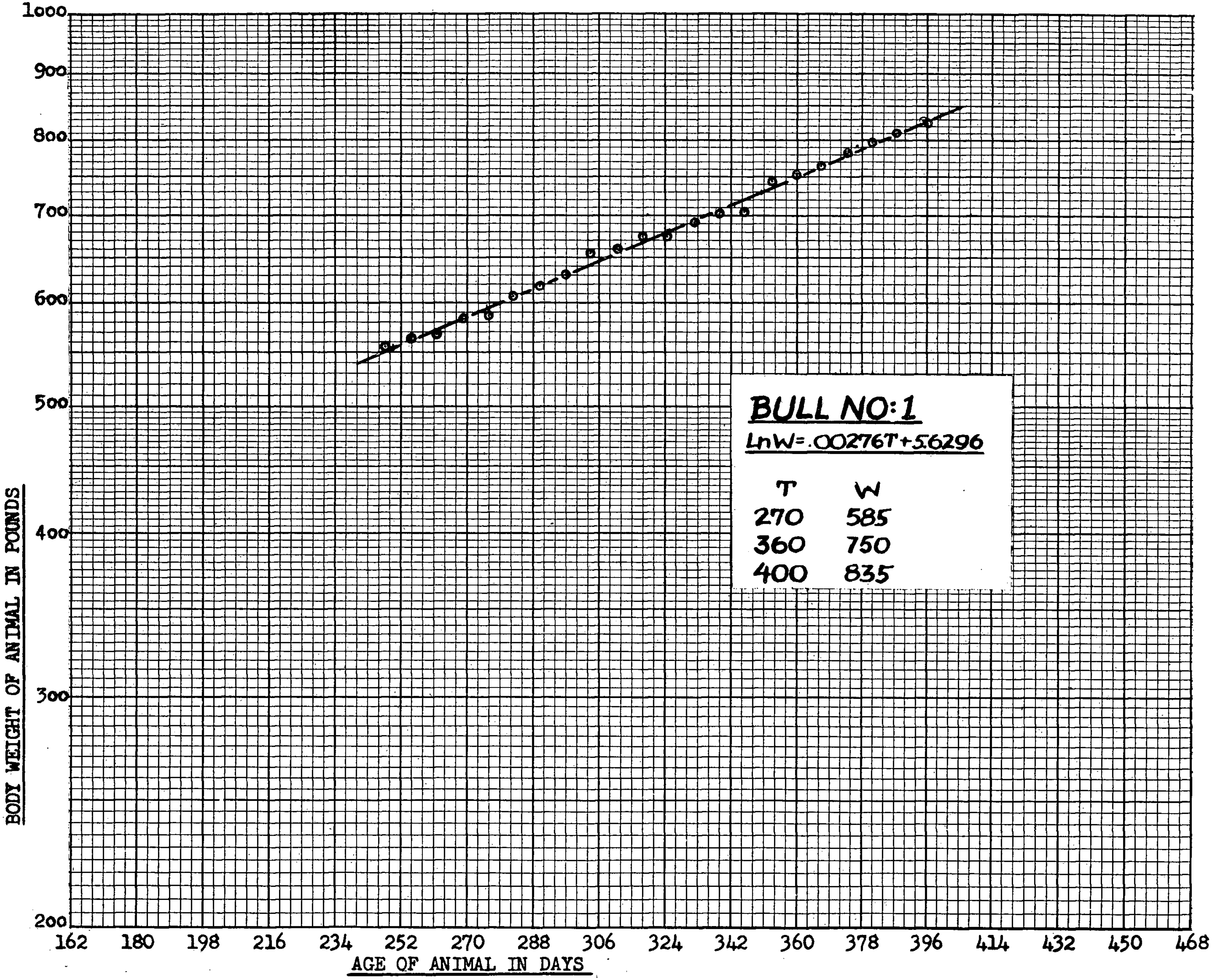
(4) When mower strip methods are used no account can be made for forage growth during the days the animals are on the pasture."

The foregoing differences in the methods of estimating pasture production point up the need for accurate data. For example during period One, the animals produced an average daily gain of 5.2 pounds per day. Such a gain would indicate that an error due to weighing increase in degree of fill has been committed. When we consider that fill in an animal can account for up to 31 percent of its live body weight, (Ritzman and Benedict 1938)) the importance of such a factor is apparent. That such a daily gain is improbable can be seen by the fact that an animal weighing 862 pounds would have to consume 35.88 pounds of total digestible nutrients per day to produce 5.2 pounds of body weight gain. This represents an intake of 235 pounds of green forage or an intake of 54.05 pounds of dry matter per day. The capacity of an 862 pound animal would not allow such forage consumption.

On the animal side of estimating forage production it would appear that accuracy could be increased by more frequent individual weighings. An individual weight taken at weekly intervals would allow the regression of weight against time and hence permit a much more accurate estimate of the total digestible nutrients or Caloric intake necessary to produce a given gain. In conjunction with the frequent individual weighings of the animals, digestibility trials and complete chemical analysis of the forage would aid in increasing the accuracy of estimating pasture production.

The use of individual weights would also allow for accurate graphic presentation of weight gain data. Such graphic presentation would allow for an assessment of the type of gain being laid on by each animal. An example of this type of graphic presentation is shown in Graph I (which is taken from Williams and Wood (1952)).

see over.


BULL NO:1
LnW=.00276T+5.6296
T W
270 585
360 750
400 835
BODY WEIGHT OF ANIMAL IN POUNDS
AGE OF ANIMAL IN DAYS
1000
900
800
700
600
500
400
300
200
162
180
198
216
234
252
270
288
306
324
342
360
378
396
414
432
450
468

An interesting aspect arising out of the chemical analysis of the forage samples for protein is that there is an excess of available nitrogen to the animals. Therefore there must be a high excretion of nitrogen in the feces and urine. This is one of the reasons why extreme clumping occurs on irrigated pastures around droppings. This high excretion points up the need for good management of pastures so that the droppings will be adequately spread to reduce this clumping. Very little trouble is experienced from urine spots since the irrigation water acts as a diluent.

To illustrate the above case of nitrogen excretion, the following theoretical case is set up: an 800 pound steer consuming 100 pounds of pasture forage per day which contains 20 percent dry matter and 25 percent protein will consume five pounds of crude protein.

Crampton (1939) lists the digestibility of the crude protein of mixed dried pasture grass as 75 percent, therefore this steer would consume 3.7 pounds of digestible crude protein (D.C.P.) per day. Brody (1945) indicates that an 800 pound steer requires .4 pounds of digestible crude protein (D.C.P.) for maintenance. If this steer made a gain of 3 pounds per day and the assumption is made that this gain is totally protein the steer would need .8 pounds of protein, assuming protein gain as being 75 percent water.

The following relationship exists:

Digestible crude protein consumed: 3.7 pounds

Digestible Crude Protein required for Maintenance	.4 pounds
Digestible Crude protein required for gain	.8 pounds
Excess digestible crude protein	2.5 pounds

Therefore 2.5 pounds of Digestible crude protein are returned to the pasture per day in the degraded form with the feces and urine. Converted back to nitrogen, assuming protein is nitrogen x 6.25, this would equal .4 pounds of nitrogen excreted per day by the steer.

Table XII lists the average dry matter yield per acre as 6308.3 pounds. The average protein percent for the season was 25.71 as shown in Table XII. Therefore 1621.8 pounds of crude protein was produced per acre. Converted to nitrogen this would equal 259.4 pounds of nitrogen. The above facts point up the need for heavy fertilization of irrigated pastures because a depletion of nitrogen reserves would soon occur under such heavy production. In fact the growth response obtained by mid-summer and fall applications of ammonium nitrate bear this out. Since there is an excess of protein produced in pasture forage, it would be logical to assume that there may be a deficiency of energy. Foley (1933), Harwood (1933), and Perkens (1935) have shown that in supplementary feeding it is energy that is required. They came to the conclusion that low protein feeds were best suited for supplementary feeding.

VI. SUMMARY AND CONCLUSIONS

The various methods of estimating pasture production by use of animals have been investigated and discussed. The following conclusions can be drawn:

1) To obtain an accurate estimate of pasture production, using animls as the necessary device, the type of gain being made by the animal must be considered. Evidence from other work indicates that frequent weighing on an individual animal basis will assist materially in increasing the accuracy of the production estimates. In conjunction with these frequent individual weighings, digestibility trials and complete chemical analysis of the pasture forage should be undertaken.

2) The degree of "fill" in an animal can materially affect the weight recorded, therefore care should be taken to eliminate inaccuracies due to this cause as much as possible. This may be done by weighing the animals at the same time of day at each weighing.

3) The Standard Steer Day, Standard Cow Day, Animal Unit month, and pounds of beef per acre are methods of assessing pasture forage but have a number of inherent errors and should be used with reservations.

4) The crude protein content of pasture forage is high and would indicate that there may be a deficiency of energy in pasture forage.

5) The production of beef through the use of irrigated pastures is one means of intensifying beef production.

6) The production of total digestible nutrients from the experimental pastures under study was found to be from 4290.0 to 5011.8 pounds per acre in 148 pasture days depending upon the method used in calculating the production.

A P P E N D I C E S

The Appendices which follow are included with this Thesis because they form an essential background for the evolution of these first irrigated pastures. Since the present work must represent an exploration into, what for this area is a new field of investigation, much of what is included in the following pages is necessary to obtain a perspective of the entire field of Irrigated Pasture investigations. It is regrettable that more detailed and recorded information is not available in the Agronomic and economic aspects of Irrigated pasture production.

APPENDIX I.

IRRIGATED PASTURE BACKGROUND

I. HISTORY:

Irrigated pastures have been in existence for years but the intense interest shown in these pastures has been brought about in latter years through a need to intensify forage production. Morgan (1949) points out that a five acre planting in 1915 in the Wuribee District of Victoria, Australia was the beginning of a development which reached approximately one third million acres by 1947. The 1940 Census of Irrigation in the United States estimated that 2.7 million acres of irrigated lands in the seventeen western States are used for forage production for livestock. Anderson (1952) estimates that 150,000 acres of land are under irrigation in B.C. Further estimates are made that an additional 500,000 acres could be brought under irrigation. (Farrow, 1949).

It is not to be presumed that all this acreage is or will be used for irrigated pastures but the acreage is on the increase and it is likely that some land that is at present in tree fruits, vegetable production or hay production will be converted to intensified irrigated pastures. Factors which contribute to this change over are the development of new irrigated lands, the need for more forage, the low labor cost of irrigation in this manner and the necessity of changing the type of agriculture practiced in areas that are marginal for certain other crops.

Miller (1951), reporting on the first improved irrigated pasture in Oregon, mentioned that 5000 acres of new seedings had taken place within three years of the establishment of the first improved pasture. This pasture produced 600 pounds gain per acre at a cost of a little over seven cents per pound of gain.

2. SOILS:

Soils used for irrigated pastures vary greatly as to physical and chemical characteristics. Some of the soils used are high in fertility but there is a tendency to use poorer classes of soils. These soils may be relatively non-arable because of the presence of salts, shallowness, presence of rocks or steepness of slopes, or other conditions.

Most of the soils used for irrigated pastures are typical of arid conditions. Thorne (1948) characterizes these soils as being low in organic matter and containing adequate or excessive quantities of calcium, sodium, magnesium, potassium, carbonates and sulphates. He also indicates that these soils when put under irrigation often contain inadequate amounts of phosphorus and nitrogen for maximum production. Under irrigated pastures these soils rapidly increase in content of organic matter and nitrogen.

Magistad and Christiansen (1944) claim that a large part of the 20 million acres under irrigation in the nineteen western states contain enough soluble salts to depress crop yields. A smaller area contains enough alkali that crop production is greatly curtailed and unprofitable.

Richards (1947) has classified soils into saline, saline-alkali, and non-saline-alkali soils. The saline soils are defined as soil "for which the conductivity of the saturation extract is greater than four millimhos per cm. (at 25oC) and the exchangeable (SP) sodium percentage is less than 15. The pH of the saturated soil paste may exceed 8.5". These soils are characterized by white crusts on the surface or by streaks of salt in the soil. They can be reclaimed by leaching and drainage. The saline-alkaline soils are defined as "soils for which the conductivity of the saturation extract is greater than 4 millimhos per cm. (at 25^{o}C) and the exchangeable sodium percentage is greater than 15. The pH of the saturated soil paste may exceed 8.5".

The non-saline-alkali soils are those "for which the exchangeable sodium percentage is greater than fifteen and the conductivity of the saturation extract is less than 4 millimhos per cm. (at 25^{o}C). The pH values for these soils generally range between 8.5 and 10. The latter two types of soil are more difficult to reclaim because of the low rate of water penetration.

Richards (1947) and Hamilton et al.(1945) indicate that the roots of salt tolerant forage plants increase permeability of salty soils and speed up rate at which salts may be leached from them.

Morgan (1947) considers land levelling essential to reclamation of salty land. Levelling makes possible the uniform application of water to leach salts downward. Richards (1947) has reported on the salt tolerance of a number of species. Table XIV (in Appendix I) summarizes his findings.

T A B L E XIV

"SALT TOLERANCE OF FORAGE CROPS ACCORDING TO RICHARDS (1947)." Tolerance decreases from top to bottom. Scientific names added by Keller and Peterson (1950)

GOOD SALT TOLERANCE	
Alkali sacaton	(Sporobolus airoides)
Salt grass	(Distichlis spp.)
Nuttal alkali grass	(Puccinellia nuttalliana)
Bermuda grass	(Cynodon dactylon)
Rhodes grass	(Chloris gayana)
Rescue grass	(Bromus catharticus)
Canada wild rye	(Elymus canadensis)
Beardless wild rye	(Elymus triticoides)
Western wheatgrass	(Agropyron smithii)
MODERATE SALT TOLERANCE	
White sweet clover	(Melilotus alba)
Yellow sweet clover	(Melilotus officinalis)
Perennial ryegrass	(Lolium perenne)
Mountain brome	(Bromus carinatus)
Barley (hay)	(Hordeum vulgare)
Birdsfoot trefoil	(Lotus corniculatus)

TABLE XIV (continued)

Moderate Salt Tolerance	(continued)
Strawberry clover	(Trifolium fraguferum)
Dallas grass	(Paspalum dilatatum)
Sudan grass	(Sorghum vulgare sudanense)
Hubam clover	(Melilotus alba annua)
Alfalfa	(Medicago sativa)
Tall fescue	(Festuca elatior arundinacea)
Rye (hay)	(Secale cereale)
Wheat (hay)	(Triticum sativum aestivum)
Oats (hay)	(Avena sativa)
Orchard grass	(Dactylis glomerata)
Blue grama	(Bouteloua gracilis)
Meadow fescue	(Festuca elatior)
Reed's canary	(Phalaris arundinacea)
Big trefoil	(Lotus uliginosus)
Smooth brome	(Bromus inermis)
Tall (meadow) oat	(Arrhenatherum elateus)
Cicer milk vetch	(Astragalus cicer)
Sour clover	(Melilotus indica)
Sickle milk vetch	(Astragalus falcatus)
POOR SALT TOLERANCE	
White (dutch) clover	(Trifolium ripens)
Meadow foxtail	(Alopecurus pratensis)
Alsike clover	(Trifolium hybridum)
Red clover	(Trifolium pratense
Ladino clover	(Trifolium ripens latum)
Burnet	(Sanguisorba minor)

3. PASTURE MIXTURES:

Keller and Peterson (1950) point out how difficult it is to conduct studies on pasture mixes because of the number of combinations. Only three grasses and three legumes give rise to forty-nine different mixtures containing one or more grasses with one or more legumes. Eight grasses and eight legumes provide sixty-four mixtures of a single grass with a single legume, 784 mixtures of two grasses with three legumes and 4,900 mixtures of four grasses with four legumes. There are a possible 65,025 different mixtures, using one to eight grasses with one to eight legumes, not including differences in seeding rates. They also point out that most pasture mixture studies have included selected species put in combinations considered of most value by the experimenter.

Keller and Peterson (1950) mention that Sanborn (1894) and French (1902) recommended that Kentucky blue grass be not included in pasture mixtures as it is relatively unproductive as a pasture grass. Welch (1914) recommended a mixture of Kentucky blue grass 8, Orchard grass 5, Smooth brome 5, Meadow fescue 4, Timothy 4, and White clover 2 pounds per acre. Later Welch (1917) pointed out that Orchard grass and Brome grass were the more important grasses, while Kentucky bluegrass, Meadow fescue and Timothy were of lesser importance.

Current recommendations appear to exclude Kentucky bluegrass from pasture mixtures. Common white clover has been replaced largely by Ladino clover and Tall fescue is included in nearly all mixtures.

Hegnauer (1942) recommends the following mixtures for the various soil conditions encountered in western Washington. For bottom lands, moist and fertile:

Italian rye grass	4 pounds
English rye grass	4 pounds
Orchard grass	4 pounds
Kentucky bluegrass	3 pounds
Common white clover	2 pounds
Red clover	2 pounds
Alsike clover	4 pounds
	23 pounds

For upland soils of clay loam or sand or sandy loam types:

English rye grass	3 pounds
Italian rye grass	3 pounds
Tall meadow oat grass	4 pounds
Orchard grass	6 pounds
Kentucky bluegrass	2 pounds
Common white clover	1 pound
Red clover	2 pounds
Alsike clover	3 pounds
	24 pounds

He suggests that Chewing fescue could replace Kentucky bluegrass on bottom land.

Law et al.(1945) recommends the following mixtures for irrigated pastures in Central Washington:

(1) well drained, deep soils, that can be irrigated

uniformly.

(a) mixtures containing Alfalfa

Alfalfa	5 pounds per acre
Smooth brome	6 pounds per acre
Orchard grass	4 pounds per acre
Tall oat grass	4 pounds per acre

(b) Mixtures containing clover:

Ladino clover	2 pounds per acre
Smooth brome	6 pounds per acre
Orchard grass	4 pounds per acre
Tall oat grass	4 pounds per acre

(2) sub-irrigated or poorly drained soils:

Ladino clover	2 pounds per acre
Meadow foxtail	7 pounds per acre
Alta fescue	4 pounds per acre

(3) Dry areas where water is likely to be limited in amount:

Alfalfa	6 pounds per acre
Crested wheat grass	4 pounds per acre
Smooth brome	6 pounds per acre

Rogers (1949) indicates the best mixture for irrigated pastures in Central Oregon is Ladino clover 2, Smooth brome 5, Orchard grass 3, and Alta fescue 2 pounds. Later information from Rogers indicates that Smooth brome grass has been dropped from the mix as it did not do well under irrigation.

Miller (1951) indicates that after planting complex mixtures and testing them, the recommended mix for Central Oregon now is:

Alta fescue	6 pounds per acre
Orchard grass	4 pounds per acre
Intermediate wheat or Smooth brome	6 pounds per acre
Ladino clover	1 - 2 pounds per acre

Many problems surround the selection of the best pasture mixture. Further investigation is needed to determine the pasture mix best suited for different soil types and climatic conditions. As an example, Tall or Alta fescue is considered unpalatable in some areas of the U.S. and Cunningham (1948) reports it is poisonous to cattle in New Zealand.

4. PREPARATION OF LAND FOR IRRIGATION

The literature will not be reviewed on this complex problem. The subject has been adequately covered by Hamilton et al (1945); Jones and Brown (1949); Bartels and Morgan (1944) and Raynor (1941). Although numerous types of irrigation systems are used they can be classified as Sprinkle or Flood. In Flood irrigation, levelling of some type is usually necessary.

5. SEED BED PREPARATION

Hamilton et al (1945) list the requirements of a good seed bed as fine textured, firm, moist, fertile and free of weeds. These conditions can be obtained through various methods of tillage and management.

Jones and Brown (1949) in California, recommend an irrigation just prior to seeding to settle fills, firm the soil and provide sub-soil moisture. When sprinkler irrigation is used, post seeding irrigation in small applications appears desirable.

Time of seeding depends largely upon climatic conditions of the area in which the pasture is situated. In areas where mild winters prevail, Jones and Brown (1949) recommend fall and early winter seedings. Post and Tretsvin (1939) and Hamilton et al (1945) recommend fall seeding if the land is not weedy, the grain has not shattered, and adequate irrigation water can be applied.

APPENDIX II.

MANAGEMENT OF PASTURES:

1. Grazing Management:

New stands should be managed to promote rapid development of the young seedlings. Prolonged close grazing when the pastures are wet should be avoided. Bartels (1947) points out that heavy grazing of young pastures is sometimes necessary to prevent perennial rye grass from smothering out slower growing white clover.

Keller and Peterson (1950) list three objectives of grazing management:

(a) to maintain the desired balance between species

(b) to obtain continuous high production

(c) to obtain utilization of the forage when it is most nutritious.

They point out that most pasture species now recommended provide high production but must have periods of regrowth. This is provided by rotation grazing.

Rotation grazing consists of the use of two or preferably three or more pastures in a rotation. After grazing, each pasture is irrigated and allowed to recover. The animals return to the first pasture three to six or eight times in one season.

Important considerations in a grazing rotation are: (1) Length between grazing periods. This must be adjusted so that the animals graze the pastures when the forage is at its most nutritious stage. If it is too young the stand will be weakened. If it is over mature it will be relatively unpalatable.

(2) Number of days grazing in each pasture. This should be kept to a minimum so that the animals do not have the chance to graze selectively.

(3) Number of sub-divisions in the field. These must by necessity be kept to a minimum to allow for ease of irrigation and to lower the cost of fencing.

Hodgson et al (1934) report 8.82 percent gain from rotation grazing over continuous grazing. Semple et al (1934) indicates that in studies at Beltsville, Maryland, rotational grazing increased production 10 percent over continuous grazing. Keller and Peterson (1950) mention that Starke (1947) of South Africa lists five reasons for rotation grazing of sheep:

1. less selective grazing
2. less fouling of forage
3. more regular irrigation
4. less internal parasite infection
5. better quality and more palatable forage.

A P P E N D I X III.

ESTABLISHMENT OF EXPERIMENTAL PASTURES

1. Preparation of Land:

The eighteen acres used in this pasture were native sod that was extremely rough with "Nigger Heads." The land was ploughed and allowed to rot down over the winter. In the early Spring the land was disced twice with a heavy offset disc and then harrowed with a chain harrow. To produce a firm seed bed the land was packed with a Cultipacker.

Seed bed preparation is one of the most important aspects in establishing an irrigated pasture. Burlison et al (1936) say, "More stands of pasture plants are lost because of poor seedbeds than from any other single cause. These plants need a moist, fine, compact and fertile seedbed. In fact a well prepared seedbed is probably more essential for them than for any other crop." Most other investigators have arrived at the conclusion that a well worked firm seedbed pays off in dividends of greater germination, stronger stands and greater production.

2. Seeding Pastures

The eighteen acres of pasture was divided into five equal sized fields and seeded to five different mixtures as follows:

Pasture Number One	Pounds per acre
Brome grass	6
Orchard grass	4
Alta fescue	2

(continued)

Alfalfa	4 pounds per acre
Ladino clover	1 pound per acre

Pasture Number Two	Pounds per acre
Brome grass	6
Orchard grass	4
Alta fescue	6
Ladino clover	2

Pasture Number Three	Pounds per acre
Brome grass	6
Orchard grass	4
Meadow fescue	2
Alfalfa	4
White clover	1

Pasture Number Four	Pounds per Acre
Brome grass	6
Orchard grass	4
Meadow fescue	6
White clover	2

Pasture Number Five	Pounds per Acre
Brome grass	5
Orchard grass	4
Timothy grass	3
Alfalfa	4
Red clover	2

Seeding was accomplished using a grain drill with grass seed attachment. The grass seeds were seeded through the grain box and the Legume seeds through the grass seed box. The drill discs or shoes were set into the ground quite deeply but the tubes were removed from the shoes and allowed to dangle. In this way the seed is broadcast on top of the ground and then covered slightly by the drag chains. To further cover the seed to the desirable depth, the seeded land was packed after seeding with a Cultipacker. This method of seeding covered the seed to a depth of 1/4 to 1/2 inches.

3. Fertilization of Pastures

Immediately before seeding,300 pounds of ammonium phosphate 11.48.0 per acre was spread on the land. This was put on prior to the last harrowing and then harrowed into the surface of the land.

An alternate fertilizer and one recommended strongly is super phosphate 0-20-0 at 600 pounds per acre. The reason 11.48.0 was used in this case was that the soils showed a depletion of nitrogen and the nitrogen in the 11.48.0 was thought to be advantageous for germination and growth of the young seedlings.

Fertilization after seeding has taken the form of applications of ammonium nitrate 33-0-0 at the rate of 100 pounds per acre when thought necessary. In practice this is usually found to be in the last week of June or the first week of July when growth tends to slow down, and again during the first week of September.

The initial application of 600 pounds of Super Phosphate, or 250 pounds of ammonium phosphate is recommended so that sufficient phosphate is added to supply a readily available source of that material. Most of the soils found in the dry belt of the Interior of B.C. are deficient in available phosphorus. This is brought about by the fact that these soils are alkaline in reaction. The pH of the soils on the Range Station is between 7.8 - 8.0. These soils can be termed "white alkali" soils and contain relatively large quantities of soluble salts. These soluble salts form a complex with phosphates through fixation of the phosphate as insoluble salts, thus a large quantity of phosphate must be applied to satisfy this complex before the plants can have a readily available source of phosphate. It is considered that 600 pounds of super phosphate per acre every three years will supply sufficient phosphate to satisfy the complex and to supply a source of phosphate that is readily available to the plants.

4. Grazing Rotation

The eighteen acres of pasture was divided into five equal sized areas of 3.6 acres each. Through this division it was possible to practice a rotational system of grazing. The pastures were stocked at such a rate that the animals grazed the forage on each pasture in four to five days, thus giving a 20-25 day period between grazing on each individual pasture. This period allowed sufficient regrowth of the forage so that it could be grazed when at a height of 6-8 inches. The forage was grazed to a level of 2-3 inches. An aftermath of 2-3 inches is thought advisable so that the forage will make a quick recovery. This much aftermath gives enough leafage to allow photosynthesis to go on at a more or less constant rate. In other words, plant recovery is not slowed by a lack of top growth. This rate of grazing promotes a strong vigorous stand.

5. Management of Pastures:

Proper management of the pasture sward is of extreme importance. In many cases pastures are not considered a crop and therefore are not managed properly.

Burlison (1936) indicates that unproductive pastures usually result from poor soil conditions and poor management with management being the cause of most failures. He lists over-grazing as a prime reason for low production and suggests that alternate grazing be used as it produces more feed than continuous grazing.

In managing the experimental pastures on the Range Station, the following practices are followed:

(a) Animals are turned into graze when the forage is 6-8 inches high and they are removed when the forage has been grazed to a height of 2 to 3 inches.

(b) Clumping of the grasses is prevented by frequent mowings and harrowings to spread the droppings. It would appear that this operation should take place four to five times during the grazing season to maintain an even sward.

The maintenance of an even sward reduces selective grazing and thus assists in a greater utilization of the forage.

c) The pastures were seeded on June 5th, 1951. Pasturing was started on August 6th, 1951. A very light grazing was permitted at this time to assist in control of weeds and to firm the top soil. To further control weeds, the pastures were clipped twice before grazing commenced. That weeds were effectively controlled by these measures is established by the complete lack of weeds on the pasture during the grazing season of 1952.

6. Irrigation of Pastures:

The amount of water necessary and the frequency of irrigation depends on the characteristics of the soil. The most important aspect of irrigation is to keep the roots of the pasture plants supplied with readily available water at all times. Without this, rapid growth and high production cannot be maintained.

Sprinkler irrigation is the most versatile method of irrigation and eliminates the problem of irrigating each pasture immediately after being grazed. With flood irrigation the problem arises of keeping the water off pastures that are being grazed. It should be pointed out that sprinkler irrigation is generally more expensive than flood irrigation and should not be used where flood irrigation is available and efficient.

Water requirements of the pasture under study have been 2.5 acre feet per season so far but this will vary depending upon climatic and soil conditions. The irrigation aspects require further study.

A P P E N D I X IV

"ANIMAL DISEASES AND ABNORMAL PHYSIOLOGICAL CONDITIONS"

1. Bloat:

Bloat can be a severe problem on irrigated pasture. Animals should be closely watched for the first day after being turned into an irrigated pasture. Prompt treatment is necessary once an animal shows signs of bloat. There are several recommended treatments to alleviate bloat, none of them are completely satisfactory but all of them will reduce the bloat in animals if used early enough. Drenching of the animals with a pint of mineral oil, or a cup of coal oil in a cup of milk appears to relieve bloat in many cases. Injection of "Rumene", a commercial preparation, into the rumen of a bloated animal using a 3 inch, 16 gauge needle and 100 c.c. of the material has relieved several cases of bloat that the writer has encountered. The use of a Trocar and Canula is a positive means of relieving bloat, but care must be taken that the instrument is inserted in the right area and that the instrument is clean.

The following practises will assist in preventing bloat. (a) Pasture forage should not contain more than 50 percent by weight of legumes.

(b) Animals should be fed dry hay before being turned out on pasture.

(c) Animals should be left on the pasture at all times. The removal of the animals at night has a tendency to increase bloat because they are too hungry when turned out the following morning.

2. Foot Rot:

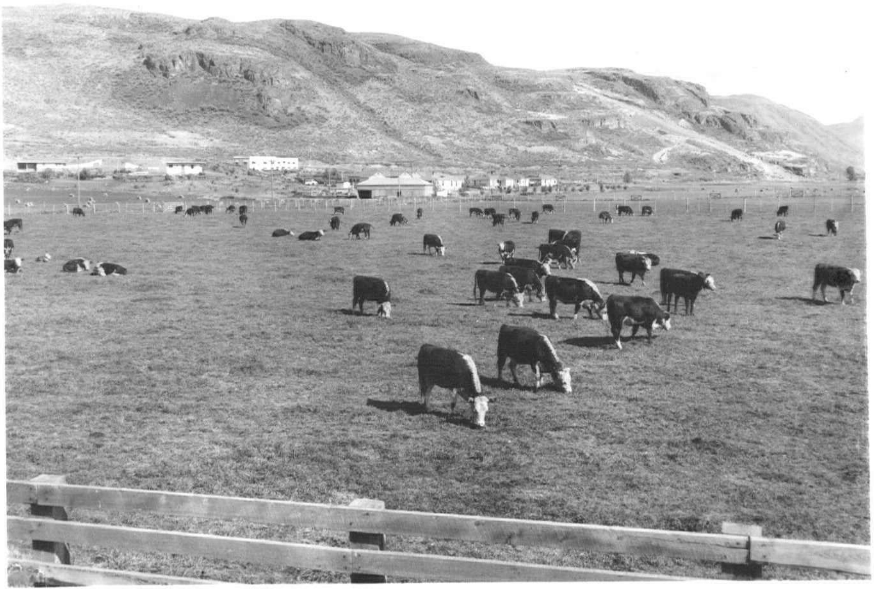
Foot Rot can become a problem on irrigated pastures since under the conditions prevailing it can spread quickly from infected animals to non-infected animals. During the pasture season of 1952, twelve animals showed typical signs of Foot Rot. All these animals were successfully treated using a 100 c.c. subcutaneous injection of a Sulfa drug preparation supplied by a local veterinarian. Although all these animals recovered within three days of commencement of treatment, there was an appreciable loss of fleshing in all the animals.

3. Parasites:

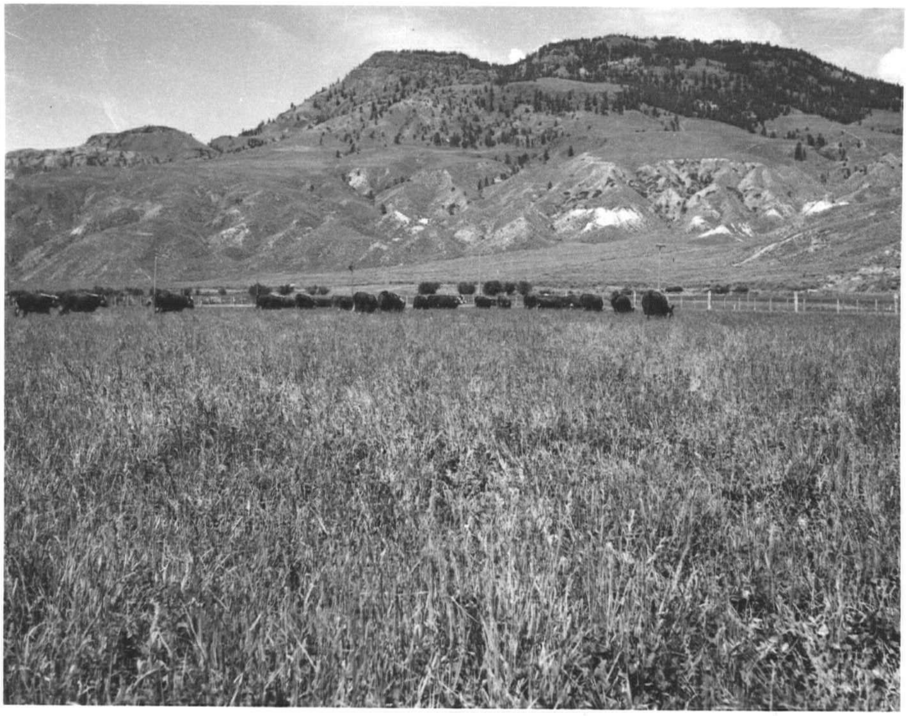
No trouble has as yet been experienced with Parasites on irrigated pastures but it is understandable that the conditions that prevail,- close confinement and continuous use, lend themselves to creating this problem and pasture managers should watch for signs of parasitic infection.

A P P E N D I X V.

"PHOTOGRAPHS"

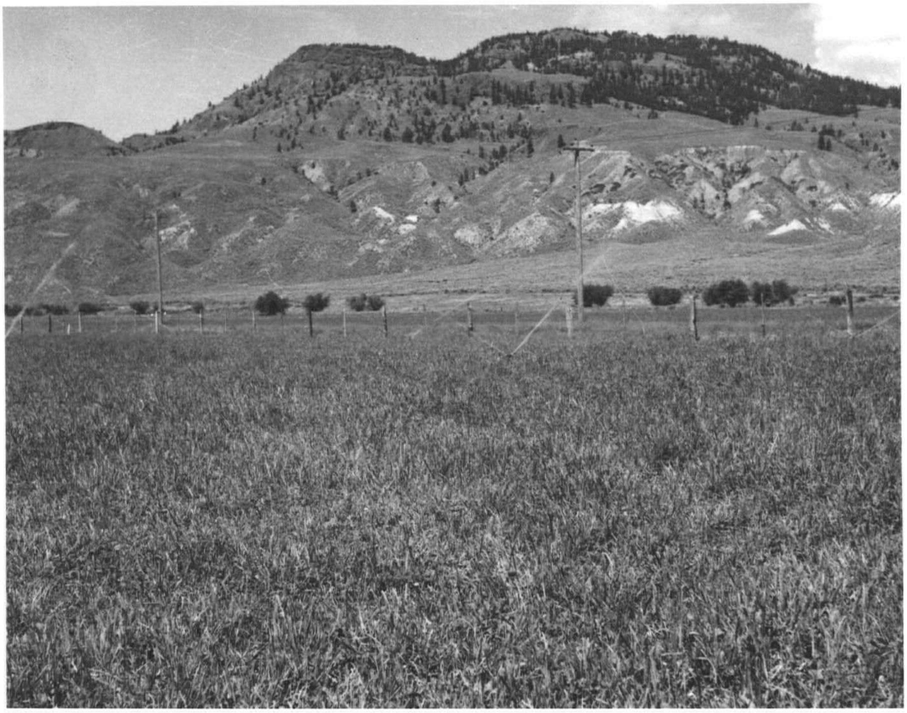


ANIMALS ON IRRIGATED PASTURE

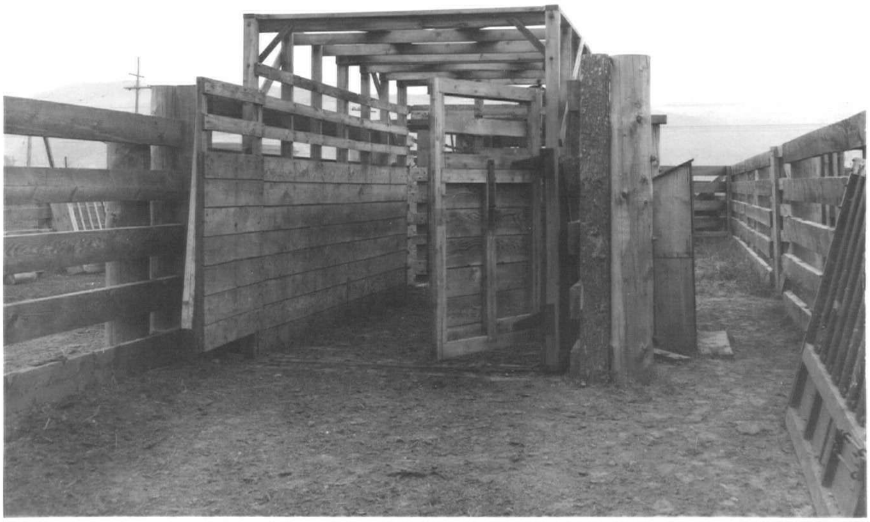


ANIMALS ON IRRIGATED PASTURE.

Notice height of forage in foreground



A pasture immediately after
removal of animals



Scale used to weigh the animals

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