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A STUDY OF THE ECONOMIC PERFORMANCE AND POTENTIALS OF THE RANCHERS IN THE WAIMEA PROJECT OF THE DEPARTMENT OF HAWAIIAN HOME LANDS

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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By

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ABSTRACT

This study attempts to evaluate the economic performance of the ranchers in the Waimea project of the Department of Hawaiian Home Lands and to offer some suggestions on the potential means of increasing the monetary returns from ranching. More specifically, the objectives of the study are: (1) to determine the present level of achievement of the ranching project; (2) to determine the physical, economic, and other restrictions under which the ranchers operate; (3) to determine the impact of existing sets of restriction on ranch resource organization and achievement; (4) to show some potentials for increasing returns from ranching; and (5) to provide recommendations and suggestions on how the economic goals or objectives of the ranchers can be achieved.

Results indicated that the economic performances of the ranchers on the average were below optimum. On the average, the ranches appeared to be understocked with cattle. This, coupled with recent low prices for beef has resulted in low net returns from ranching.

If the project is to approach its economic potential for ranching, the ranchers need to stock at a level approaching long run potential capacity. Some of the ranches have inherently good grazing lands. Of the 52 ranches, 21 can be stocked to a maximum of 1.50 acres per animal unit or better according to the inherent productivity of the pasture ranges. Assuming average conditions and present prices prevail, this would mean a potential net ranch income (return to land and management) of approximately $4,000 per ranch for a cow-calf operation or not less than $6,000 per ranch for a cow-yearling operation for the ranchers.

However, the ranching decisions regarding stocking rates have to be made in face of uncertainty in range conditions. This study has used statistical decision theory (Bayesian statistics) to determine long range potential stocking rate under uncertainty. Under this approach, it would appear that the long run returns from ranching would be considerably lower. This analysis indicates that a typical rancher could expect to achieve a net income in the long run of $1,442 for a cow-calf operation and $2,347 for a cow-yearling operation.

Many of the ranches can be made to carry livestock in excess of the computed potential capacity by adopting good pasture improvement practices and other methods of intensifying use of resources.

Changes in the institutional restriction hold considerable promise for improving ranch returns. A change in the policy of the use of the community pasture could produce additional benefits to the ranchers. The limit of 300 acres per ranch could be relaxed in the case of the few ranchers who would be able to fully utilize present resources. Some effect might be achieved by adopting policies encouraging ranchers unable to make full use of grazing potential to sublease their lands to the ranchers who need and could use additional acres. In some cases the ranchers appear to lack interest in intensifying ranch operations; in others, they do not appear to have access to capital as needed to accomplish this.

A major obstacle to increasing the present levels of individual ranch and project incomes appears to be financing. The Department of Hawaiian Home Lands have not had a loan fund adequate to meet the needs of these ranchers. The ranchers tend to have only very limited access

to other sources of financing because of lack of collateral inherent in the land lease arrangements unless the ranchers have off-the-ranch income. Although working off the ranch is one way to accumulate ranch resources, it is necessarily a slow process and diverts interest and energy away from the ranching operation.

In spite of the low economic returns of the project as a whole, it is possible that the objective of rehabilitating the ranchers in terms of their social well-being may have been realized. The ranchers and their families live in well-built comfortable homes in an attractive community. Some have achieved a modest degree of success as ranchers. Others work off the ranch and supplement their incomes with ranch operations. These in turn may use their off-ranch income to finance ranch improvement. These factors should be considered in development of policy to enhance project return.

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INTRODUCTION

The Hawaiian Home Act of 1920 was enacted to rehabilitate the native Hawaiians[1] who were then believed to be headed for certain extinction. The rehabilitation aspect called for a program of homesteading[2] associated with a "return to land" concept whereby land would be made available to those of predominantly Hawaiian blood who showed sincere desire in farming or in ranching. The program is administered at present by the Department of Hawaiian Home Lands (formerly the Hawaiian Homes Commission). As originally conceived, the commission was entrusted with responsibility of locating an area for homestead settlement,[3] clearing the land and providing water supply, and screening the applicants for the settlement.

The controversial part of the rehabilitation program was the assignment of lands to be made available for homesteading.[4] The

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[1]Individuals who have at least 50 percent Hawaiian ancestry as defined by the Act.

[2]The program is different from the original concept of homesteading as practiced in the U. S. Mainland. Here, title to the land is retained by the government and the land is only leased to the homesteaders for a period of 99 years with a fee of $1.00 a year per tract of land leased. The homesteaders pay the tax assessed on the land and improvements thereon. For justification of governmental retention of land titles and its immediate consequences, see A. Spitz, 1964. "Land Aspects of the Hawaiian Homes Program," Legislative Reference Bureau Report No. 1b, University of Hawaii, p. 5.

[3]A settlement may be an agricultural area for farming or an area for ranching. In addition, each homesteader is provided with a one-acre houselot in the village site of the settlement.

[4]All lands within any forest reservation, all cultivated sugar cane lands, and all public lands held under a certificate of occupation, homestead lease, right of purchase lease, or special homestead agreement are excluded from the homesteading use as specified in the law.

exclusion of highly developed lands and the subsequent assignment of less developed lands to the program were argued to be of great advantage to the Hawaiians. Easy living gained by working on already developed cane lands might present a further demoralizing effect to the Hawaiians. It was argued that hard work on less developed lands could provide the homesteaders a "character building experience" necessary though it may not be sufficient for successful rehabilitation. Besides, the financial disadvantage to the then Territorial government of subdividing already developed cane lands could be abated.[5]

On the other hand, the suitability of the lands chosen for homestead use was criticized by many. The objections centered primarily on the high cost of bringing water for irrigation and domestic uses both for farming and ranching purposes.[6]

As a whole, the lands chosen might be unsuitable for the purpose which the law promises to accomplish. However, looking closely into the testimony of those who objected to the selection of homestead lands revealed some interesting points to ponder. A representative of Parker Ranch testified that drought condition would make the land chosen on the Island of Hawaii "worthless for homesteading or for pasture." Yet in a more detailed description of the lands provided for Congressional consideration at that time by A. Horner (one of those who presented his objection), the land chosen in the Island of Hawaii were not that bad for

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[5]Prince Kuhio indicated that the maintenance of the plantation system would provide revenues essential for the support of the Hawaiian homesteading. Spitz, op. cit., p. 7.

[6]Ibid., Spitz, pp. 6 and 7.

ranching uses.[7] It should be mentioned here that Parker Ranch stood to lose 99,000 acres of pasture land when the bill became a law.

The Waimea project is one of the programs of the present Department of Hawaiian Home Lands. At present, there are fifty-three homestead lots in this project with an average ranch of 300 acres per lot. The 300-acre size ranch was conceived as the best size to meet the objective of the project.[8]

The Research Problem and Study Objectives

The Hawaiian Homes Commission Act of 1920 does not set forth explicit objectives. However, hearing and reports of the commission repeatedly refer to degree of success in rehabilitation which imply both social and economic goals. If economic well-being is a clear objective, then the ranch lots should be capable of providing the necessary incomes to meet the economic needs of those families in the project not only for the present but also for the future. Recently, concern has been expressed at many levels that the project is not achieving its economic

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[7]From Table 2 of Spitz, "Land Aspects of the Hawaiian Homes Program," the following were abstracted: Puukapu with 1,200 acres selected was described as "most suitable of available land for homesteading purposes." For the other areas, Kamoku-Kapulena-Nienie (12,350 acres), the description was, "Third class agricultural in part, and balance second class pasture. Water for domestic use would have to be piped in some miles."

[8]In a report (October 20, 1952) attached to the letter of resignation of Commissioner Samuel Wilder King, it was mentioned that through the advice of the then Dean Harold A. Wadsworth and Mr. Edward Y. Hosaka of the Department of Agriculture of the University of Hawaii and former Senator Charles A. Rice, a successful rancher, the 300-acre ranch size was decided to be of economic size. As provided for by the Law, a homesteader can lease a maximum of 500 acres of first class pastoral lands, 1,000 acres of second class and 100 acres of irrigated pastoral lands.

goals: that ranchers are neglecting their ranching for non-farm employment; that the size of ranching unit is inadequate; that much of the ranching operations which are carried on are inefficient; that the ranchers are not using the project resources adequately. However, no comprehensive study has been conducted to show the extent to which these criticisms are justified or to show the causal relationships.

The purpose of this study is to appraise the economic performance and potentials of the ranchers in the Waimea project. The study will attempt to achieve the following objectives:

(1) to determine the present level of achievement of the ranching project,

(2) to determine the physical, economic, and other restrictions under which the ranchers operate,

(3) to determine the impact of existing set of restrictions on ranch resource organization and achievement,

(4) to show some potentials for increasing returns from ranching, and

(5) to provide recommendations and suggestions on how the economic goals or objectives of the ranchers can be achieved.

Institutional and Economic Setting

The Waimea ranching project was started in 1952. The Homesteaders were selected from qualified applicants[9] by lottery since there were more applicants than the number of pasture lots available. Beside the pasture

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[9]Qualification as to experience in ranching was not considered at that time.

lot, each homesteader was provided with a one-acre houselot. To help homesteaders get started in ranching and to assure success of the program, the Department[10] set aside a fund to be loaned to homesteaders for the purpose of building a house, purchasing livestock and ranch equipment or financing cost of ranch improvement and development. The ceiling for residential loan was $10,000 and for ranching loan, $15,000 with an interest rate of two and one-half percent per annum for a maximum of 30 years.[11] Furthermore, in recognition of the lack of "know-how" among the prospective homesteaders, the law provides for the hiring of agricultural experts to teach the homesteaders modern methods of ranching. Other assistance includes maintenance of roads in the settlement and other related services.

While there are numerous administrative policies that affect homesteaders' performance directly, the most obvious ones are the loaning operation and the assistance provided by the Department's hired agricultural experts. In actual practice, the amount of loan and the number of loans approved for the purposes stated above were small due to administrative and policy limitations and to inability of some of the homesteaders to show promise of successful repayment ability.[12] At present there is only one Farm Advisor employed by the Department. The

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[10]"Department" refers to the Department of Hawaiian Home Lands.

[11]Hawaiian Homes Commission of 1920, as amended. Originally, the ceiling for residential loan was $6,000 and most ranchers get this amount when they built their present residential houses.

[12]A. Spitz, 1963. "Organization and Administration of Hawaiian Homes Program," Legislative Reference Bureau, University of Hawaii, pp. 22-26.

demand for technical assistance from the homesteaders may be too great that the Farm Advisor may not be able to cope with. In most cases, the Project Manager by reason of close contact with the homesteaders has performed this task of giving technical advice. The services of the Cooperative Extension Agents are also available to homesteaders.

In selecting qualified applicant for the lots available for homesteads, the Department has formally adopted a criterion which serves as guide in making grants. The applicants are classified into priorities based on percentage of Hawaiian blood. Priority I is reserved for those applicants whose parents are both 100 percent Hawaiian. Two classes of applicants fall into Priority II: in one, a combination of Hawaiian whereby one parent and children qualify as at least 50 percent Hawaiian and in the other, one parent is 100 percent Hawaiian and may be married to a non-Hawaiian. All other applicant whereby only the applicants may qualify, are considered in the last priority, Priority III. In this priority, the children of the applicant cannot qualify under the blood composition requirement of the law.

The leasee may transfer his interest on the homestead to any of his relatives: (1) husband or wife, (2) children, (3) widowers of the children, (4) grandchildren, (5) brothers or sisters, or (6) nieces or nephews; provided such relative qualifies as leasee of Hawaiian Home Lands with respect to Hawaiian blood composition, age notwithstanding. If there is no qualified successor, the Department has the prerogative to make the selection either before or after the death of the leasee. If the leasee desires to surrender his homestead, he will be paid the appraised value of the improvements on his lot, and the improvements and

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lot will be subsequently awarded to the next eligible applicant.

The socio-economic conditions of the Hawaiians who were selected as homesteaders cast doubt on the prospects of becoming successful ranchers. In most cases, there is little indication that those selected had the necessary background, education, or attitudinal characteristics and initiative for successful homesteading. Spitz had these observations:[13]

> "The number of skilled, managerial, and professional workers living on homesteads is low relative to the nation and the State and to other Hawaiians and part-Hawaiian.
>
> "... The occupational rankings and the income total both suggest that the Hawaiian homesteaders are living under below-average conditions.... In any case homesteader family incomes are significantly below both state and national income medians."
>
> "... The data from the homesteads do not reflect high educational achievement."

Those Hawaiian who have the background and experience and are a little better off usually do not apply for homesteads. They believed that the program was set aside for those Hawaiians who are less fortunate. To wit:[14]

> "... While the Hawaiian Homes Commission has not made any sustained effort over the years to select applicants on a basis of need (rather the basis has been degree of Hawaiian blood and date of application), still the nature of the program may be such that it attracts persons who desire a more sheltered, less competitive situation than those normally available in the community-at-large and who are less likely to be 'achiever' in the sense of earning high incomes or holding prestige jobs, and reaching high educational levels. Furthermore, many more highly motivated potential leasees failed to apply very likely because they felt that the land should, out of a sense of justice, be reserved for less fortunate Hawaiians."

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[13]A. Spitz, 1964. "Social Aspects of the Hawaiian Homes Program," Legislative Reference Bureau Report No. 1c. University of Hawaii, pp. 5 and 6.

[14]Ibid., p. 11.

The first ranching project opened up on the Island of Molokai was a dismal failure. Suitability of the land for ranching was the prime reason. Lack of marketing outlet for ranch products contributed much to this failure. In the Waimea project, some of the ranchers have had outside assistance from big ranchers in the area. The assistance was in the form of a chattel mortgage whereby the big ranchers provided the starting herd and some cash to defray the cost of ranch improvements such as fencing and installing watering facilities. This assistance assured the ranchers a market for their cattle because one of the stipulations of the chattel mortgage was the selling of the ranchers' cattle to the big ranchers. Lack of market outlet remains a serious problem for the small ranchers in Hawaii.

The Department also maintains a community pasture to be used by the homesteaders' livestock in time of grass shortage.[15] The Department provides care for the homesteaders' livestock at nominal fee while in the pasture. In some instances the community pasture was also used by those ranchers who have no access to the pipeline for the water needs of their cattle. At present this situation had been remedied by the improvement of watering system for the livestock in the areas affected.

Description of the General Waimea Area

The description of the general Waimea area will give insight as to the physical environment for ranching. Success or failure of the

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[15]When there is a threat of drought or failure of some ranches to provide the necessary feeds for approved numbers of cattle on these ranches, the owners can move some of their cattle to the community pasture until such time that normal conditions prevail.

ranchers (and therefore, the ranching project) depends, to a great degree, on the suitability or oppressiveness of this environment. Good environment is of course conducive to success.[16] Nevertheless, successful living may also be possible in an oppressive environment if the inhabitants subjected to it can adapt themselves adequately.

Waimea[17] is the old name for an area which is a part of South Kohala and Hamakua on the Island of Hawaii. It is seventy miles northeast of Hilo by way of Mamaloa Highway. Within its immediate vicinity is the Kamuela airport which is at present serviced by two airlines.

The climate and topography.[18] The weather in Waimea is fairly cool. Temperature varies from a low monthly mean of 52° F. to a high mean of 75° F. and an annual mean of 64° F. Elevation varies from 1,200 to 3,600 feet above sea level.

Rainfall in the area varies widely from windward to leeward, by elevation and by locality. At an elevation of 2,760 feet, measurements from a rainfall station over a period of 49 years indicate an annual maximum of 58.6 inches to an annual minimum of 14.9 inches. Just a mile away where another rainfall station was located with different elevation (2,670 feet), records indicate a range of annual rainfall from a maximum of 80.1 inches to a minimum of 22.1 inches. At an elevation of 2,850 feet, annual rainfall ranged from 74.3 to 16.8 inches. Figure 1 shows the climatic zone map bordering Waimea.

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[16]As defined in terms of the economic well-being of the individual family.

[17]The present post office name is Kamuela.

[18]Source: Waimea-Kawaihae Community Association, Economic Development Committee. "Summary of Area Facilities and Economic Factors." July 1963.

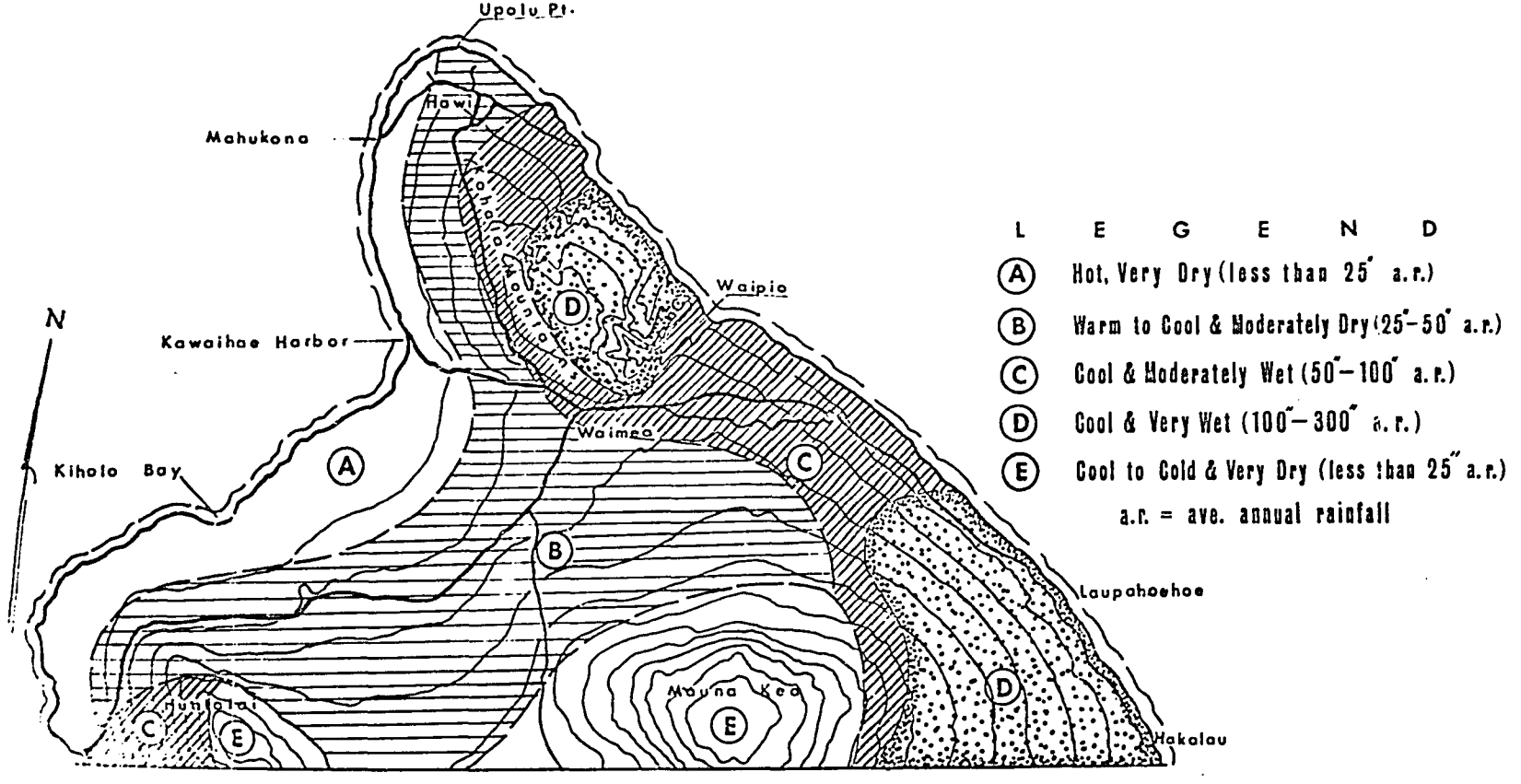

FIGURE 1. CLIMATIC ZONE MAP SHOWING THE RELATIVE POSITION OF WAIMEA

Source: The Kohala-Hamakua Region - General Plan, Island of Hawaii, The Planning and Traffic Commission, County of Hawaii, 1963.

Land use.[19] The land use in the area is very much affected by the physical factors discussed above. At an elevation above 2,500 feet on the slopes of Mauna Kea, the soils are generally less productive for agricultural use. This land is usable for extensive agriculture such as ranching. In fact, the best land for ranching purposes is in the vicinity of Waimea. Diversified farming especially truck farming is also a major agricultural activity in Waimea. This activity is concentrated at areas of lower elevations. Figure 2 shows the present land use pattern in Waimea and its immediate vicinity.[20]

Economic and sociologic conditions.[21] Agricultural activity make up most of the economic activity in Waimea. The town of Waimea is the center for the ranching and farming activities of the area.[22] Two big ranches provide employment to residents in the area in addition to some industrial and commercial establishments in Waimea and in Honokaa. Other sources of employment are the state and federal jobs.

There is one school, the Hawaii Preparatory Academy, in Waimea. The nearest public high school is in Honokaa. The existing public facilities are a school library, a police station, a fire station, a post office, an airport, a park and playground, and a number of government offices.

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[19]Source: The Planning and Traffic Commission, County of Hawaii, "Kohala-Hamakua Region - General Plan," Island of Hawaii, 1963.

[20]There might have been changes in land use since 1963. It is expected that much of the changes will be land use for urban development. It is assumed that this change may not be substantial to change the pattern of land use in the near future.

[21]The Planning and Traffic Commission, County of Hawaii, op. cit.

[22]Parker Ranch, the biggest ranch in the State of Hawaii, has its headquarters in Waimea. This may have a bearing in making Waimea the center of the ranching industry on the Island of Hawaii.

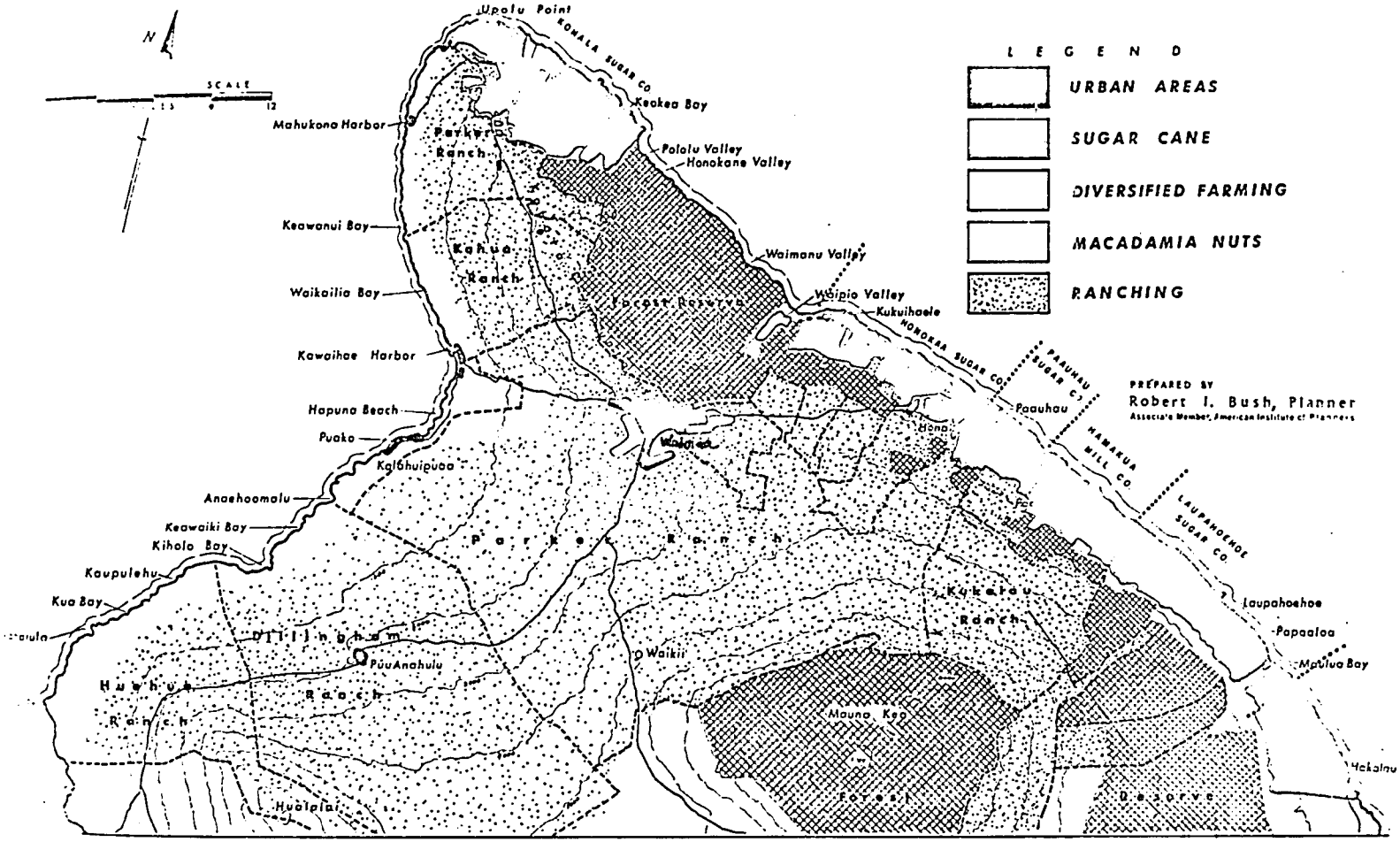

FIGURE 2. PRESENT LAND USE IN WAIMEA AND ITS BORDERING AREAS.

Source: The Kohala-Hamakua Region - General Plan, Island of Hawaii, The Planning and Traffic Commission, County of Hawaii, 1963.

CHAPTER II

THE METHODOLOGY

Success in ranching as defined in this study is measured in terms of income derived from ranching. It is assumed that the objective of each ranching unit is to maximize the net returns from ranching. Therefore, the decision rules which lead to optimum resource utilization and output for the firm may be applied to ranching operation in the Waimea project. In this study, each rancher will be considered as an economic unit or a firm with resources under its control and producing a product, the weaned beef cattle or yearling, for sale.

The procedure followed in the analysis is to describe, first, the characteristics of the ranching area, the individual ranches and the ranch operators and their households. This is presented in Chapter III. The next step is the analysis of the factors affecting ranch incomes as a means of showing the impact of existing sets of restrictions on ranch resource organization and achievement. This is discussed in Chapter IV. Finally, the analysis of some potential alternatives for increasing returns from ranching is discussed in Chapter V.

The physical, economic and other restrictions under which the ranchers have to operate their ranches, and their present level of achievement are presented in Chapters I and III. Chapters IV and V are presented to achieve objectives 3 and 4 of this study. Chapter VI gives the conclusions and implications of the study.

The Methods of Analysis

Three methods of analysis are used; the method of budgeting,

regression analysis and Bayesian statistics.

Budgeting is a tool which can be used effectively in a small scale ranching operation. The method involves the construction and comparison of separate budgets for the several relevant alternatives. Finally, the choice is made of the alternative which best satisfies the objective of the operator.[23] While the process is time-consuming, the rancher's knowledge and insight of production and market alternatives provide guides to those alternatives which are most likely to succeed. It is here that assistance from the Extension Specialist or the hired Farm Advisor of the Department will come in handy. Their technical knowledge and experience of production and market situations can be of great help in the preparation of the various feasible alternatives.

Regression analysis is used, first, to try to ascertain those factors which are associated with success in ranching or those factors affecting present level of achievement of the ranchers. Second, it is used to derive the budget coefficients.

There are two classical methods of deriving the budget coefficients: the use of averages and the use of coefficients synthesized from a typical unit of operation. Implicit in the use of these coefficients is the assumption of a constant or linear relationship between input and output. But technical production relationships seldom seem to exhibit this kind of relationship which gives rise to the criticism of non-representativeness of these coefficients as size of unit or intensity of

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[23]If the objective is one of maximization of net returns, then the choice is on the alternative which gives the highest net returns.

use changes. This is especially true when the cross-section of the sample characteristics with respect to these coefficients vary tremendously. In this case, even a typical case is hard to find.

To take into account other input-output relationships (non-linear) and the non-representativeness of the average coefficients, regression analysis is used to derive the budget coefficients from the sample ranchers. The author feels that when survey results are used to establish the level of ranch costs that budget coefficients are most appropriately derived from functions fitted directly to the survey data. In this type of analysis the function representing the "best" fit can be used as basis for the derivation of budget coefficients regardless of the shape of such function. Furthermore, the accessibility of a computer and the readily available computer programs make regression analysis no longer a tedious and cumbersome work.[24]

The budgeting procedure usually implies certainty. To incorporate some risk and uncertainty conditions[25] in the choice of alternatives, the method of Bayesian statistics will be used.

Bayes strategy is a recent development in the field of decision theory. However, its usefulness seems to be relevant to the problems

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[24]The University of Hawaii Computing Center has an IBM 360/50 unit. It is programmed to perform available computer programs including regression analysis. Of particular interest here is the BMD programs prepared by the University of California.

[25]The difference between decision made under risk and decision made under uncertainty lies on whether the probability distribution of a set of possible specific outcomes is known or not. Under risk, the probabilities are known; under uncertainty, they are completely unknown or are not even meaningful (R. D. Luce and H. Raiffa, "Games and Decisions," John Wiley and Sons, Inc., 1957, p. 13). Only the risk concept is used in this study and whenever uncertainty is used, it is used in the context of risk.

involving decision-making under risk.[26] The criterion is to select that action which maximizes expected gain. The other criteria (the maximin criterion, the minimax risk criterion, the pessimism-optimism index criterion and the principle of insufficient reason criterion) for choosing the optimum action present severe defects as shown by Luce and Raiffa.[27]

Moreover, these criteria are relevant only in cases where the probability of distribution of the state of nature is unknown. It is not inconceivable to assume that in most decision problems, the decision maker has some information, either subjective or objective, regarding the probabilities of the state of nature. The novel departure of Bayes strategy from the rest of the decision rules criteria mentioned previously is the manner in which the relevant probability distribution is employed. Generally, the optimum strategy in the Bayesian concept, is one that maximizes expected utility. If the utility function is linear over the relevant range, maximizing expected profit is equivalent to maximizing expected utility.[28]

Budgeting and Assumptions

The budgets constructed are for two types of cattle systems, the cow-calf system with weaners sold as final products and the cow-yearling

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[26]For some literature on application of Bayes strategy see G. W. Dean, A. J. Finch and J. A. Petit, Jr., "Economic Strategies for Foothill Beef Cattle Ranchers," California Agricultural Experiment Station Bulletin 824, 1966 and V. R. Eidman, G. W. Dean and H. O. Carter, "An Application of Statistical Decision Theory to Commercial Turkey Production," Journal of Farm Economics, Volume 49, No. 4, November 1967.

[27]R. D. Luce and H. Raiffa, Games and Decisions, John Wiley & Sons, Inc., 1958, pp. 278-285.

[28]V. R. Eidman, G. W. Dean and H. O. Carter, op. cit., p. 853.

system. These are the most common type of cattle systems practiced in the project area, with most ranchers practicing a combination of the two.

For each cattle system, six stocking rates are considered ranging from a low of 6.0 acres per animal unit to a high of 2.0 acres per animal unit. The budgets are so constructed that these stocking rates are satisfied subject to other assumptions such as calving percentage at weaning, death rate of matured animals, replacement rate of cow, and cow-bull ratio. Budgets are constructed for a 300-acre ranch.

For the cow-calf system, the weaning age is six to eight months. The assumed weight of the calf sold at this age is 420 pounds. Culled cows weigh 1,030 pounds each. The average price per pound liveweight is 18.50 cents for both culled cows and weaned calves. Two death rates are considered, two and four percent. Replacement rate is 15 percent; calving percentage at weaning is 80 percent; and 25 cows per bull is the cow-bull ratio.

For the cow-yearling system, the assumed weight of the yearling is 660 pounds. Cow weight is the same as in the cow-calf system. The price per liveweight for both culled cows and yearling is 17.50 cents. Calving percentage at weaning, replacement rate, death rate and cow-bull ratio assumed for the cow-yearling system are the same as in the cow-calf system. In addition, it is assumed that no deaths occur from the time the calves are weaned to the time that they are sold.

The technical coefficients are obtained from regression analysis associating expenses per animal unit to the total animal units and to the total pounds of beef sold. This is done to insure that the technical coefficients are representations of what the ranchers are actually

capable of doing. Four equations were tried, as follows:

$$\text{I.} \quad Y = A + BX$$

$$\text{II.} \quad Y = A + B(1/X)$$

$$\text{III.} \quad Y = A + B_1X + B_2X^2$$

and

$$\text{IV.} \quad Y = AX^B$$

where:

X = independent variable measure in total animal units per ranch or total pounds of beef sold per ranch

Y = dependent variable representing the eight items per animal unit.

A, B, B_1, and B_2 = the parameters

The expense items are hired labor, repair and maintenance, veterinary services and supplies, taxes on land and improvements, salt and minerals, depreciation, interest on operating expenses, and interest on capital investment. All are measured in dollars per animal unit. The first five items constitute cash expenses and the last three items, non-cash expenses. Total expense per animal unit is the sum of cash expenses per animal unit and non-cash expenses per animal unit.

High correlation coefficient and relatively low standard error of estimate are the criteria for selecting the equation to use in estimating the technical coefficients for budgeting. Tests of regression coefficients are also conducted. If the particular test is insignificant (at five percent level of significance), the average is used as the technical coefficient.

The Bayesian Strategy[29]

The method of Bayesian statistics involves the construction of a pay-off table and the optimum strategy is one which maximizes (minimizes) expected gains (losses). The critical part of this method lies in the specifications and construction of the pay-off table.

Ranching as practiced by the ranchers in the study area depends on availability of range grass for feed. If supplemental feeding is ever practiced, very few of the ranchers do it. Lack of available funds may be a reason.

The pay-off table is constructed by taking into consideration the uncertainty of weather conditions. It shows what ranchers can do given the conditions whereby funds are limited and in some cases unavailable for them to practice supplemental feeding.

Weather is probably the most important factor affecting growth of range grass. Uncertainty of weather conditions makes it difficult for the ranchers to decide what stocking rate to adopt. Over-stocking has very serious consequences. It affects future availability of grass thereby affecting future income. It may also result in tremendous losses to the ranchers if supplemental feeding is impossible as assumed in this study. On the other hand, under-stocking does not do the ranchers any good either. While it may not involve cost, the potential of getting higher income is lost. If cost is involved net ranch income will be adversely affected.

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[29]A discussion of Bayes strategy with hypothetical data is given in Appendix A.

In constructing the pay-off table, four actions (a_i) and four states of nature (θ_i) are assumed. Actions a_1, a_2, a_3, and a_4 represent stocking rates of five to six, four, three, and two acres per animal unit respectively. The states of nature are θ_1, θ_2, θ_3, and θ_4 representing very poor, poor, normal and excellent range conditions respectively.

The range conditions (states of nature are assumed to be affected by the amount of annual precipitation (inches of rain) received in the area. To get the probability distribution of the states of nature, annual precipitation levels for 41 years are grouped into four classes which correspond to each of the assumed states of nature.[30]

In computing the net ranch income for each combination of various actions and states of nature, information on calving percentage at weaning and its relationship to stocking rates were used. Weights of weaned calves, yearlings, and culled cows and death rates of mature livestock were also assumed to be affected by the stocking rate. Heavier animals were the results of lighter stocking rates and death rates were higher at heavier stocking rates. These assumptions are based on the study conducted by Houston and Woodward.[31]

Range condition is also assumed to affect calving percentage at weaning. For this reason, four functional relationships (each for each assumed range condition) were constructed to estimate calving percentage given the stocking rates and range conditions.

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[30]Precipitation records of the National Weather Records Center, U. S. Weather Bureau, for Kamuela weather station.

[31]W. R. Houston and R. R. Woodward, "Effects of Stocking Rates on Range Vegetation and Beef Cattle Production in the Northern Great Plains," Technical Bulletin No. 1357. U. S. Department of Agriculture, January 1966.

The exponential type of function of the form

$$Y = K(e^{AX} - B)$$

where Y = calving percentage at weaning

X = stocking rate (acres per animal unit)

K, A, & B = the parameters

is considered to be more appropriate for the problem under consideration as viewed against the linear and the quadratic types. As used in this study, each function may be viewed as the expected or long-run function. This is similar to but not the same as the concept of expected value as used in statistical literature. It is akin to the concept of long-run probability distribution.

The method of constructing the four function involves the use of the graphing method and computer simulation. The path that each function will follow given the assumptions above is plotted on graphing paper. Then the estimation of the parameters is done by computer simulation by assuming various values of K, A, and B.

The pay-off table is then constructed by incorporating all the assumptions through the budgeting method. Tables are constructed for the cow-calf and the cow-yearling cattle systems.

The Sources of Data

The data used in the analysis are obtained from both primary and secondary sources. Information about the individual ranches and the ranch operators were obtained by personal interviews of the sample ranchers. Other information such as off-ranch employment and incomes, size of ranch households and cost of pasture improvement and development

were obtained from records of individual ranchers, kept by the Department of Hawaiian Home Lands and the county office of the Agricultural Stabilization and Conservation Service (ASCA). Other related information were obtained from published materials both private and public.

The sampling procedure. Originally, it was conceived that all the 53 ranchers would be interviewed. However, due to limited time available, it became impossible to make a complete enumeration of all the ranchers in the study area. In many cases, it was difficult to meet ranchers because they were either busy with their on-ranch or off-ranch work, on leave from their ranch work (out of the island), or unwilling to present themselves for interviews. Therefore, the interview was conducted on "available" basis. The sample consisted of those ranchers who were willing and could come for interviews. Most interviews were conducted in the evening. This was the only time that most ranchers were available for interviews. The information gathered was for the calendar year 1966.

There were 38 ranchers who were interviewed. This number represents almost 72 percent of the total number of all ranchers in the study area. The ranchers were selected from the alphabetical list of ranchers provided by the project office of the Department of Hawaiian Home Lands in Waimea.

CHAPTER III

THE PRESENT CONSTRAINTS AND LEVELS OF ACHIEVEMENT

Chapter I presented the general background of the over-all restrictions under which the Waimea ranchers have to operate their ranches. These include the acreage limitation of about 300 acres to a ranch and the existing physical and economic environment of Waimea. The present chapter provides a more detailed discussion of the physical, economic, and other restrictions. In addition, the chapter deals with the discussion of the present level of achievement of the ranchers and the ranching project as a whole. Therefore, this chapter attempts to satisfy objectives 1 and 2.

The Physical Characteristics of the Grazing Lands[32]

The grazing lands leased to homesteaders differ considerably in soils, climate, and topography. Of the approximately 15,351 acres of grazing lands, 4,649 acres are in Puukapu, 6,434 acres in Nienie, and 4,268 acres in Kamoku. In terms of variability in the number of land types,[33] Nienie is the most variable, followed by Puukapu. Large areas in Puukapu are of land types 107, 109, and 161, mostly of the soil series Kikoni, Palapalai and Punohu and the Nienie and Maile. Nienie has land types 58, 59, 107, 108, 110, 160, 161, and 162, representing about 99

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[32]Aerial photographic maps from the Land Study Bureau publication, Bulletin No. 6, 1965, were superimposed on a map showing the bounderies of the individual ranches. The land types were delineated and much of the discussion are based on these. See Appendix B for the meaning of the various land type indices.

[33]Land type index numbers are those of the Land Study Bureau publication. See footnote 32.

percent of the Nienie grazing lands. The remaining one percent is in land type 323. About 25 percent of the total Nienie lands is of land type 59, and 32 percent is represented by land type 161. Kamoku has land types 59, 60, 161, and 162, with 40 percent in land type 59 and 35 percent in land type 161. Both Nienie and Kamoku have the Honokaa and the Nienie-Maile soil series occupying large acreages of the respective places. Figures 3, 4, and 5 show the land type distribution of three ranching areas.

Kamoku is a wet area with about 54 percent of its area receiving a mean annual rainfall of 100 to 150 inches of rain. The other 46 percent had 70 to 100 inches mean annual rainfall. The driest of the three areas is Puukapu with about 88 percent of the area receiving a mean annual rainfall of 40 to 60 inches. Only about nine percent of the Puukapu area received a mean annual rainfall of 70 to 100 inches.

The good soils of Puukapu are situated at elevations ranging from 2,600 to 3,600 feet above sea level, accounting for about 88 percent of the Puukapu range. In Nienie, elevations of 1,200 to 2,500 feet accounted for 28 percent of the area and about the same percentage have elevations of 2,600 to 3,600 feet. About 43 percent of the Nienie area is at an elevation of 2,500 to 3,500 feet. In Kamoku, the area is divided half-and-half into elevation of 1,200 to 2,500 feet and 2,500 to 3,500 feet above sea level.

The grazing lands are subject to damage resulting from natural causes. The most serious threat is the damage caused by flood and drought. A 20-month drought which ended in November 1962 curtailed ranch income due to tremendous reduction in carrying capacity of the

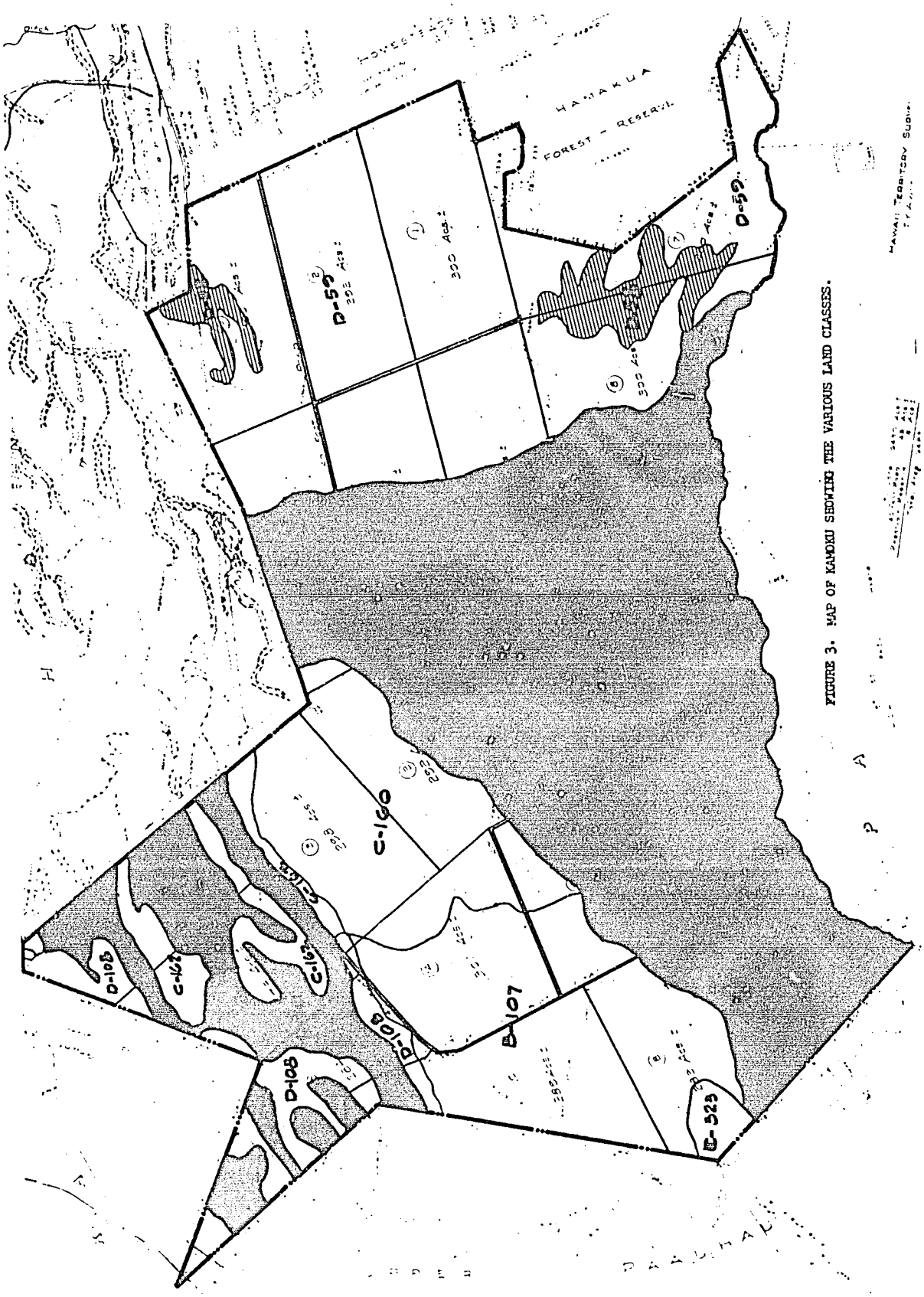

FIGURE 3. MAP OF KAMOKU SHOWING THE VARIOUS LAND CLASSES.

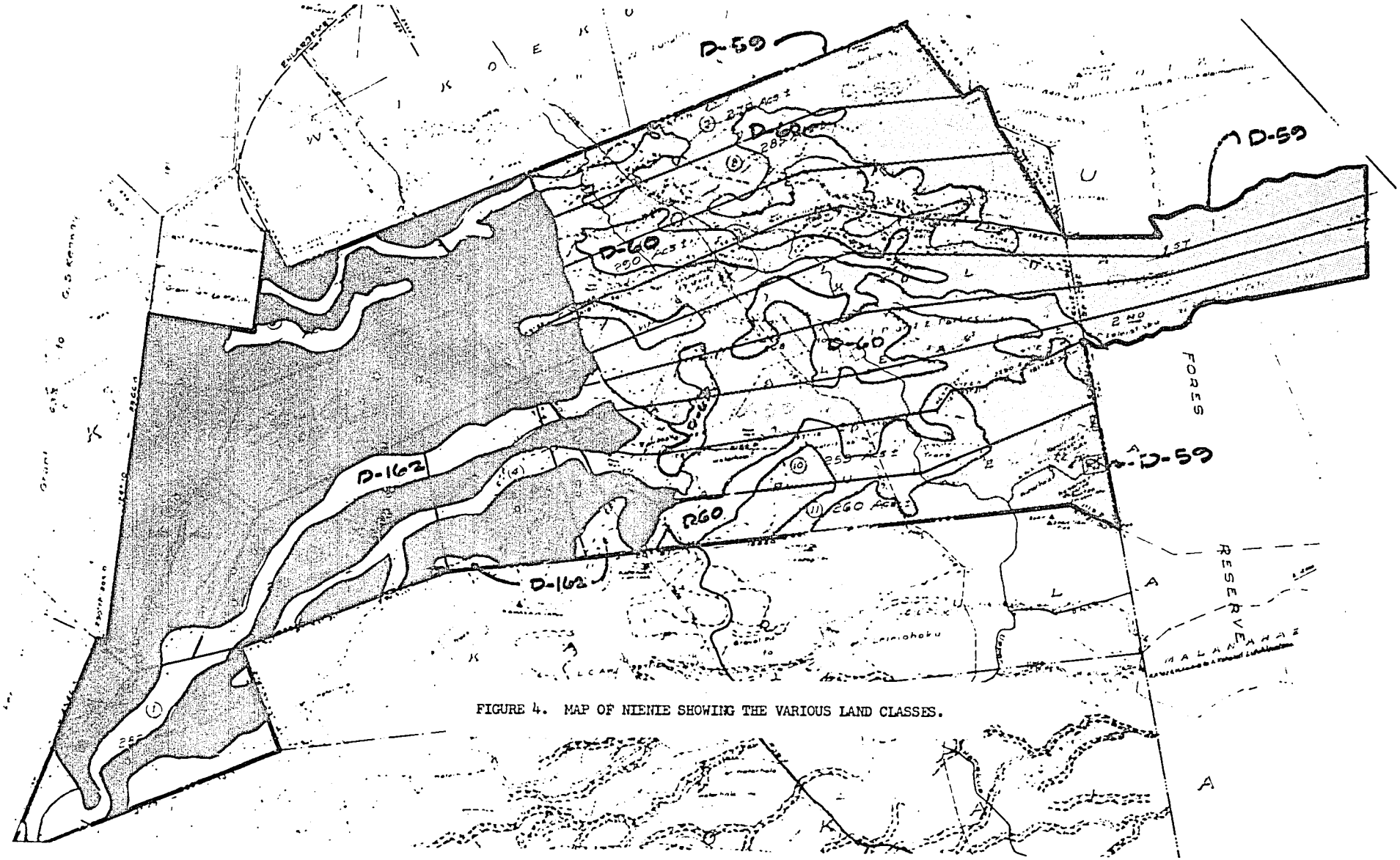

FIGURE 4. MAP OF NIENIE SHOWING THE VARIOUS LAND CLASSES.

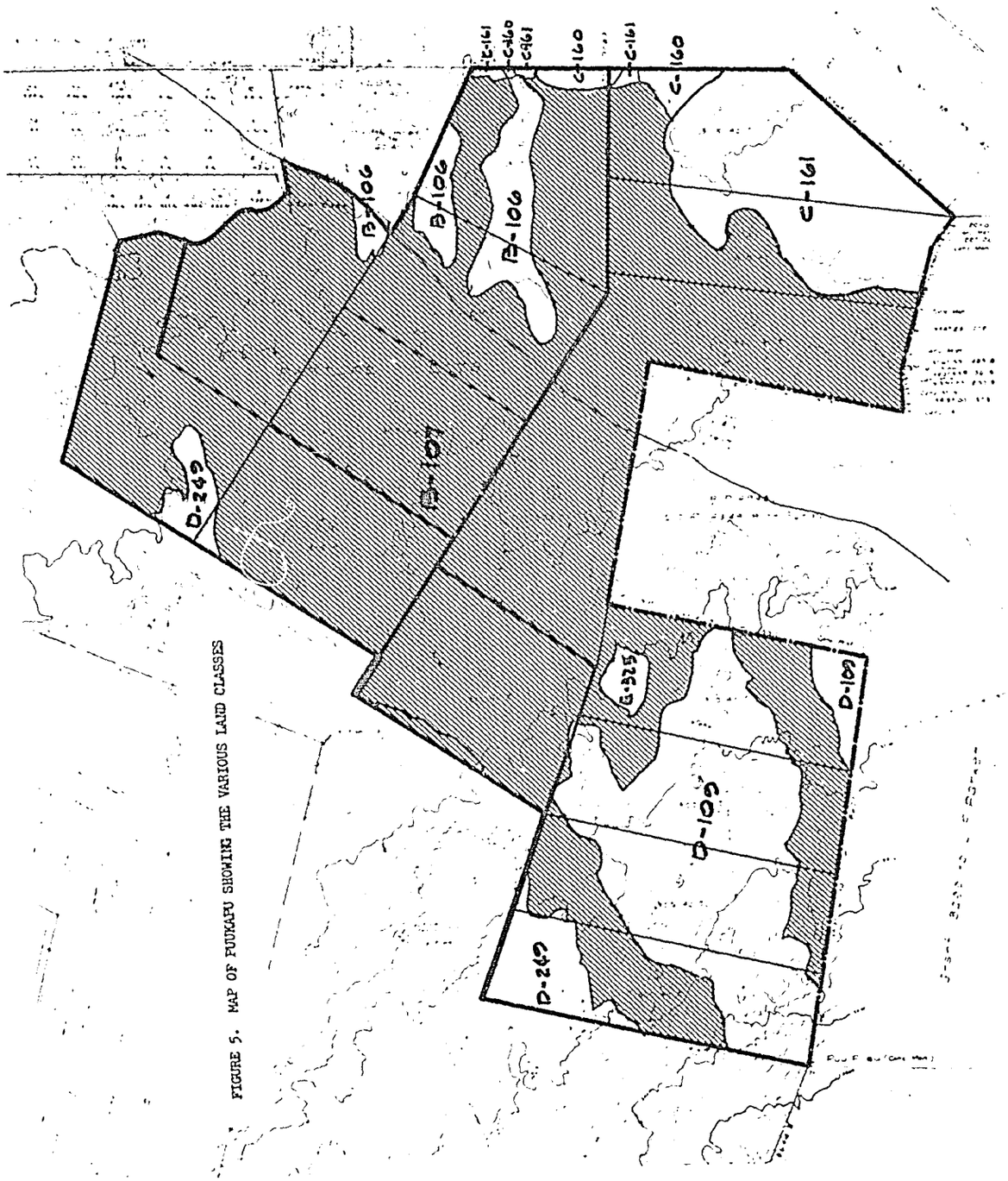

FIGURE 5. MAP OF PUUKAPU SHOWING THE VARIOUS LAND CLASSES

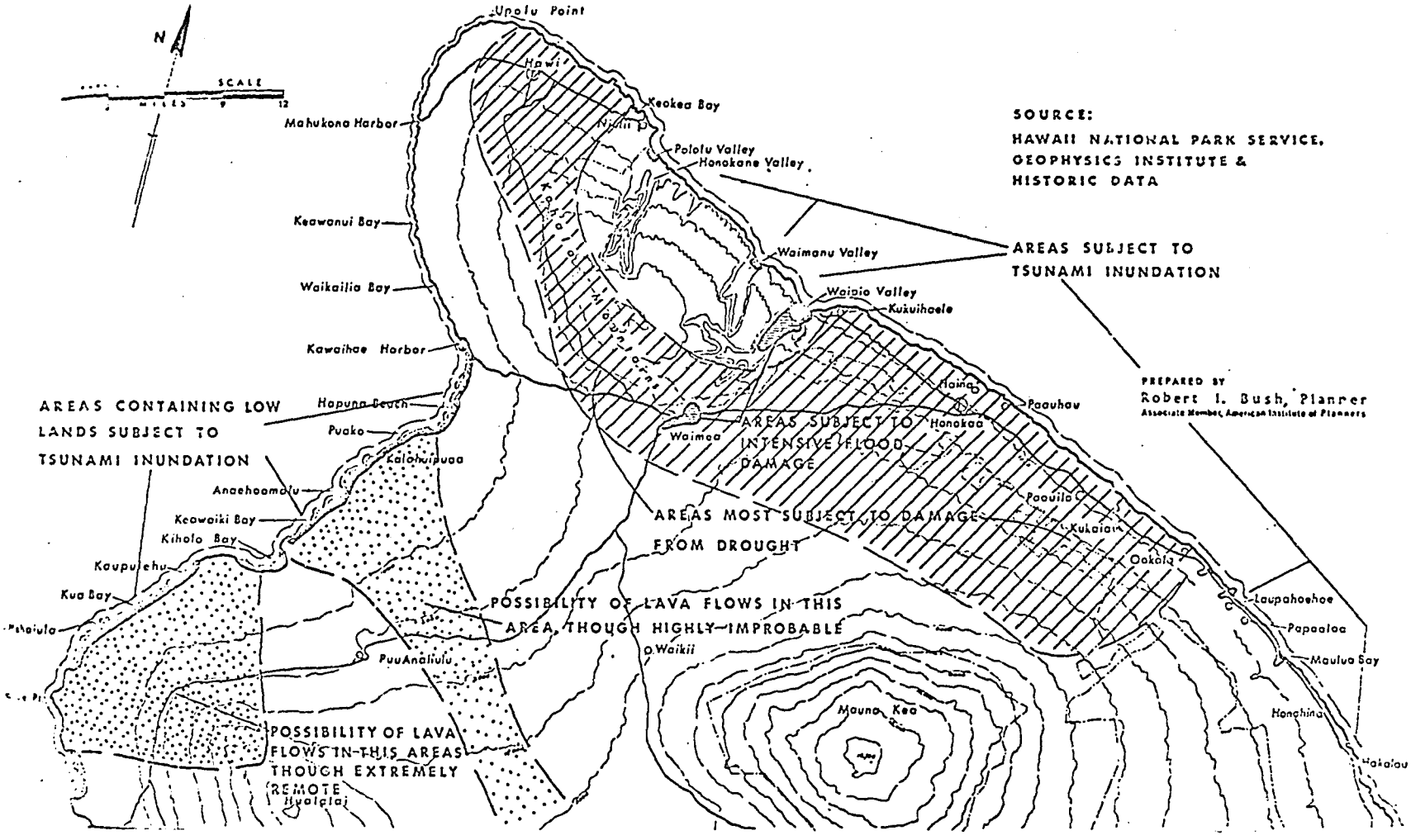

FIGURE 6. AREAS SUBJECT TO DAMAGE FROM NATURAL CAUSES SHOWING THE RELATIVE POSITION OF WAIMEA.

Source: The Kohala-Hamakua Region - General Plan, Island of Hawaii, The Planning and Traffic Commission, County of Hawaii, 1963.

grazing lands throughout the grazing project. Many cattle were sold or slaughtered before maturity because of lack of adequate pasture.

Some lands in the project are subject to damage from both drought and flood damage. Figure 6 shows areas subject to damage from drought and flood.

The vegetative covering. In the personal interview, the ranchers were asked what predominant grasses, legumes and weeds were on their ranches. Their responses are summarized in Table 1. Pangolagrass and kikuyugrass are the predominant grasses in 23 of the 38 ranchers responding. The other predominant grasses are rye, rattail, paspallum, oats, muskite, bermudagrass, carpetgrass and sweet varnal.

Whiteclover is one of the predominant legumes in 31 ranches. The others are trefoil with eleven ranchers reporting, purple clover, and laudenia. Weeds are not very common on most ranches. Sixteen ranchers reported no weed on their ranches. Only nine ranches had thistle as one of the predominant weeds. Other predominant weeds reported were pukala, thinkleberry, pamakani, knoxes and firetrees.

Pangolagrass is the most common grass on the ranches. Of the 14 ranchers who reported only one predominant grass on their ranches, seven had pangolagrass. Next grass of importance is kikuyu.

For the types of soils on the Waimea ranches, the Soil Conservation Service of the U. S. Department of Agriculture has recommended the following grasses: for the Honokaa series, kikuyu and pangola grasses; the Kikoni and Palapalai series, pangola, kikuyu, and orchard grasses; the Punohu and Maile series, Kikuyu and orchard grasses; and for the

TABLE 1. PREDOMINANT GRASSES, LEGUMES, AND WEEDS ON 38 RANCHES, WAIMEA PROJECT

Grass		Legume		Weed	
Common Name	Number of Ranches Reporting	Common Name	Number of Ranches Reporting	Common Name	Number of Ranches Reporting
Pangola	23	White clover	31	Thistle	9
Kikuyu	23	Trefoil	11	Pakala	3
Rye	8	Purple clover	3	Thinkleberry	3
Rattail	8	Laudenia	1	Pamakani	2
Paspallum	5	None	2	None	16
Oats	5			Others[b]	2
Muskite	4				
Bermuda	2				
Others[a]	2				

[a]Carpet grass, sweet varnal reported one for each ranch.
[b]Knoxes and firetree reported one for each ranch.

Waimea series, bufflegrass, kikuyugrass and guineagrass.[34] The average pasture production by season and soils series of the recommended grasses is presented in Table 2.

The Potential Productivity of the Grazing Lands

The productivity of the grazing lands can be measured in terms of the potential average carrying capacity of each ranch aggregated for all the ranches in the area. Carrying capacity as used in this study is the total animal units that a ranch unit can accommodate based on the physical characteristics which affect the ability of the land to produce grasses for feeds.

The potential average carrying capacity of each ranch is computed based on the physical characteristics of the land such as climate, soils, and topography. A combination of these characteristics determines a land type. The Land Study Bureau has computed the maximum and minimum stocking rates (acres per animal unit) for the various land types for the major islands of the State of Hawaii. Based on the same computations, the maximum and minimum carrying capacity (AUY) for each ranch was determined. The computation is as follows: the acreage under each land type for each ranch was divided by the corresponding stocking rate (maximum or minimum). This gave the carrying capacity by land type. Then, the carrying capacity for each ranch is the sum of the carrying capacity by land type. Finally, the potential average carrying capacity for each ranch was determined by adding the maximum and the minimum

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[34]For the acreages under each type of soils for the whole ranching project, see Appendix C.

TABLE 2. AVERAGE PASTURE PRODUCTION OF RECOMMENDED GRASSES FOR CONSERVATION SEEDING OR PLANTING FOR THE TYPE OF SOIL IN WAIMEA RANCHES

Season and soil series	Months	Average Pasture Production (acres per animal unit per period of use)				
		Kikuyu	Pangola	Orchard	Buffle	Guinea
Optimum season						
Honokaa	March to November	1.0	1.0	--[a]	--	--
Kikoni and Palapalai	November to February	1.5	1.5	3.0	--	--
Punohu and Maile	April to September	2.0	--	3.0	--	--
Waimea	November to April	2.0	--	--	2.0	2.0
Off-season						
Honokaa	December to February	2.0	2.0	--	--	--
Kikoni and Palapalai	April to October	4.0	4.0	5.0	--	--
Punohu and Maile	October to March	3.0	--	4.0	--	--
Waimea	May to October	5.0	--	--	5.0	5.0

[a]Blank indicates that the particular grass is not recommended.

Source: Soil Conservation Service, Hawaii Technical Guide, Form HA-40F, June 1967. U. S. Department of Agriculture.

carrying capacities and dividing the sum by two.

The land type, acreage, soil series and carrying capacity of the individual ranches are presented in Tables 3, 4, and 5. The potential average carrying capacity for the whole project is the aggregate of the average carrying capacity of the individual ranches. Based on this aggregation, the whole ranching project in Waimea can carry a potential maximum of 8,848 animal units or a potential average of 5,890 animal units (Table 5).

The Community Pasture

There were formerly 1,200 acres of good pasture range in the community pasture. At present 300 acres are being used by the University of Hawaii for their research on cattle range improvement, breeding and nutrition. The average year-round stocking rate is 4.00 to 5.00 acres per animal unit. However, some areas in the community pasture have excellent animal carrying capacity. If properly managed these areas have the potential to be stocked to the rate of 2.00 to 3.00 acres per animal unit on a year-round basis.

Each rancher-homesteader, when emergency arises, can put a maximum of 25 head of cattle in the community pasture. The length of time that the cattle remain in the pasture depends on the problem on hand of the particular rancher and the needs of the other ranchers. The ranchers are charged a fee of $2.00 per head per month for the cattle place in the community pasture.[35] The policy governing the use of the community

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[35]Information about the community pasture were supplied by Mr. Oscar Asahina, Farm Advisor, Department of Hawaiian Home Lands.

TABLE 3. LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, NIENIE AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
44	D59 (300)	Honokaa	60.00	30.00	40.00
Total	(300)		60.00	30.00	40.00
06	D59 (292)	Honokaa	58.40	29.20	38.93
Total	(292)		58.40	29.20	38.93
30	D58 (30)	Honokaa and Pohakea	6.00	3.00	4.00
	D59 (270)	Honokaa	54.00	27.00	36.00
Total	(300)		60.00	30.00	40.00
53	D59 (100.10)	Honokaa	20.02	10.01	13.35
	C160 (17.16)	Nienie and Maile	6.86	3.43	4.58
	C161 (168.74)	Nienie and Maile	67.50	33.75	45.00
Total	(286)		94.38	47.19	62.93
20	D59 (133.65)	Honokaa	26.73	13.36	17.82
	C161 (163.35)	Nienie and Maile	65.34	32.67	43.56
Total	(297)		92.07	46.03	61.38
42	D59 (153.92)	Honokaa	30.78	13.39	20.52
	C161 (142.08)	Nienie and Maile	56.83	28.42	37.89
Total	(296)		87.61	43.81	58.41
34	D58 (75)	Honokaa and Pohakea	15.00	7.50	10.00
	D59 (225.0)	Honokaa	45.00	22.50	30.00
Total	(300)		60.00	30.00	40.00
16	D58 (78)	Honokaa and Pohakea	15.60	7.80	10.40
	D59 (144)	Honokaa	28.80	14.40	19.20
	C161 (78)	Nienie and Maile	31.20	15.60	20.80
Total	(300)		75.60	37.80	50.40

[1]Figures in parentheses denote acreages of the corresponding land types.

Source: Land Study Bureau, Detailed Land Classification--Island of Hawaii, LSB Bulletin No. 6, University of Hawaii, November, 1965.

TABLE 3. (Continued) LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, NIENIE AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
47	C161 (295.0)	Nienie and Maile	118.00	59.00	78.67
Total	(295)		118.00	59.00	78.67
31	C161 (290)	Nienie and Maile	116.00	58.00	77.33
Total	(290)		116.00	58.00	77.33
41	C161 (293)	Nienie and Maile	117.20	58.60	78.13
Total	(293)		117.20	58.60	78.13
14	C160 (154.76)	Nienie and Maile	61.90	30.95	41.27
	C161 (137.24)	Nienie and Maile	54.90	27.45	36.60
Total	(292)		116.80	58.40	77.87
43	B107 (1.49)	Kikoni, Palapalai and Punohu	1.49	0.62	0.99
	D108 (4.47)	Kikoni, Palapalai and Punohu	4.47	1.86	2.98
	C160 (253.30)	Nienie and Maile	101.32	50.66	63.54
	C161 (8.94)	Nienie and Maile	3.58	1.79	2.38
	D162 (29.80)	Nienie and Maile	11.92	5.96	7.95
Total	(298)		122.78	60.89	77.84
27	B107 (218.225)	Kikoni, Palapalai and Punohu	218.22	90.92	145.48
	D108 (4.515)	Kikoni, Palapalai and Punohu	4.52	1.88	3.01
	C160 (78.26)	Nienie and Maile	31.30	15.65	20.87
Total	(301)		254.04	108.45	169.36
21	B107 (64.34)	Kikoni, Palapalai and Punohu	64.34	26.81	42.89
	C110 (87.60)	Kikoni, Palapalai and Punohu	87.60	36.50	54.40
	C160 (37.92)	Nienie and Maile	15.17	7.58	10.11
	C161 (102.20)	Nienie and Maile	40.88	20.44	27.25
Total	(292)		207.99	91.33	134.65

TABLE 3. (Continued) LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, NIENIE AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
36	C110 (193.92)	Kikoni, Palapalai and Punohu	193.92	80.80	129.28
	C161 (109.08)	Nienie and Maile	43.63	21.82	29.09
Total	(303)		237.55	102.62	158.37
35	C110 (280)	Kikoni, Palapalai and Punohu	280.00	116.67	186.67
Total	(280)		280.00	116.67	186.67
52	B107 (179.18)	Kikoni, Palapalai and Punohu	179.18	74.66	119.45
	C110 (64.736)	Kikoni, Palapalai and Punohu	64.74	26.97	43.16
	E323 (45.084)	Reddish Prairie Cones	9.02	4.51	6.01
Total	(289)		252.94	106.14	162.61
45	B107 (254.32)	Kikoni, Palapalai and Punohu	254.32	105.97	169.55
	D108 (14.45)	Kikoni, Palapalai and Punohu	14.45	6.02	9.63
	C110 (20.23)	Kikoni, Palapalai and Punohu	20.23	8.43	13.49
Total	(289)		289.00	120.42	192.67
26	B107 (4.26)	Kikoni, Palapalai and Punohu	4.26	1.77	2.84
	D108 (130.64)	Kikoni, Palapalai and Punohu	130.64	54.43	87.09
	C110 (149.10)	Kikoni, Palapalai and Punohu	149.10	62.12	99.00
Total	(284)		284.00	118.32	188.33
09	D108 (5.46)	Kikoni, Palapalai and Punohu	5.46	2.27	3.64
	C110 (106.47)	Kikoni, Palapalai and Punohu	106.47	44.36	70.98
	C161 (81.90)	Nienie and Maile	32.76	16.38	21.84
	D162 (79.17)	Nienie and Maile	31.67	16.83	21.11
Total	(273)		176.36	79.84	117.57

TABLE 3. (Continued) LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, NIENIE AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
24	D108 (42.0)	Kikoni, Palapalai and Punohu	42.00	17.50	28.00
	C161 (182.0)	Nienie and Maile	70.80	36.40	48.53
	D162 (56.0)	Nienie and Maile	22.40	11.20	14.93
Total	(280)		135.20	65.10	91.46
Sub Total (Stocking rate)	6,430		3,295.92 (1.95)	1,497.81 (4.29)	2,183.59 (2.94)

TABLE 4. LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY; INDIVIDUAL RANCHERS, PUUKAPU AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
08	B107 (340)	Kikoni, Palapalai and Punohu	340.00	141.67	226.67
Total	(340)		340.00	141.67	226.67
49	B107 (157.50)	Kikoni, Palapalai and Punohu	157.50	66.62	105.00
	C161 (157.50)	Nienie and Maile	63.00	31.50	42.00
Total	(315)		220.50	98.12	147.00
07	B107 (63.0)	Kikoni, Palapalai and Punohu	63.00	26.25	42.00
	C160 (12.60)	Nienie and Maile	5.04	2.52	3.66
	C161 (239.40)	Nienie and Maile	95.76	47.88	64.01
Total	(315)		163.80	76.65	109.67
50	B107 (294.50)	Kikoni, Palapalai and Punohu	294.50	122.71	196.33
	C160 (12.40)	Nienie and Maile	4.96	2.48	3.31
	C161 (3.10)	Nienie and Maile	1.24	0.62	0.83
Total	(310)		300.70	125.81	200.47
19	B106 (62.0)	Kikoni, Palapalai and Punohu	62.00	25.83	41.33
	B107 (248)	Kikoni, Palapalai and Punohu	248.00	103.33	165.33
Total	(310)		310.00	129.16	206.66
28	B107 (305)	Kikoni, Palapalai and Punohu	305.00	127.08	203.33
Total	(305)		305.00	127.08	203.33

[1]Figures in parentheses denote acreages of the corresponding land types.

Source: Land Study Bureau, Detailed Land Classification--Island of Hawaii, LSB Bulletin No. 6, University of Hawaii, November, 1965.

TABLE 4. (Continued) LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY; INDIVIDUAL RANCHERS, PUUKAPU AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
18	B107 (318.50)	Kikoni, Palapalai and Punohu	318.50	132.71	212.33
	D249 (6.50)	Waimea	2.60	1.30	1.73
Total	(325)		321.10	134.01	214.06
02	B107 (274.50)	Kikoni, Palapalai and Punohu	274.50	144.37	183.00
	D249 (30.50)	Waimea	12.20	6.10	8.13
Total	(305)		286.70	150.47	191.13
23	B107 (305)	Kikoni, Palapalai and Punohu	305.00	127.08	203.33
Total	(305)		305.00	127.08	203.33
04	B106 (3.09)	Kikoni, Palapalai and Punohu	3.09	1.29	2.06
	B107 (305.91)	Kikoni, Palapalai and Punohu	305.91	127.46	203.94
Total	(309)		309.00	128.75	206.00
05	B107 (301.95)	Kikoni, Palapalai and Punohu	301.95	125.81	201.30
	C247 (3.05)	Waimea	1.22	0.61	0.81
Total	(305)		303.17	126.42	202.11
13	B107 (144)	Kikoni, Palapalai and Punohu	144.00	60.00	96.00
	C109 (135)	Kikoni, Palapalai and Punohu	135.00	56.25	90.00
	E323 (21)	Reddish Prairie Cones	4.20	2.10	2.80
Total	(300)		283.20	118.35	188.80
32	B107 (75.0)	Kikoni, Palapalai and Punohu	75.00	31.25	50.00
	D109 (225.0)	Kikoni, Palapalai and Punohu	225.00	93.75	150.00
Total	(300)		300.00	125.00	200.00

TABLE 4. (Continued) LAND TYPE, ACREAGE, SOIL SERIES, AND CARRYING CAPACITY; INDIVIDUAL RANCHERS, PUUKAPU AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
10	B107 (100.65)	Kikoni, Palapalai and Punohu	100.65	41.94	67.10
	C109 (201.30)	Kikoni, Palapalai and Punohu	201.30	83.87	134.20
	D249 (3.05)	Waimea	1.22	0.61	0.81
Total	(305)		303.17	126.42	202.11
25	B107 (96.0)	Kikoni, Palapalai and Punohu	96.00	40.00	64.00
	D109 (120.0)	Kikoni, Palapalai and Punohu	120.00	50.00	80.00
	D249 (84.0)	Waimea	33.60	16.80	22.40
Total	(300)		249.60	106.80	166.40
Sub Total (Stocking rate)	4,649		4,300.94 (1.08)	1,842.79 (2.52)	2,867.74 (1.62)

TABLE 5. LAND TYPE, ACREAGE, SOIL SERIES AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, KAMOKU AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
11	B107 (20.868)	Kikoni, Palapalai and Punohu	20.87	8.69	13.91
	D108 (1.692)	Kikoni, Palapalai and Punohu	1.69	0.70	1.13
	C161 (154.818)	Nienie and Maile	61.93	30.96	41.28
	D162 (104.644)	Nienie and Maile	41.86	20.93	27.90
Total	(282)		126.35	61.28	88.22
17	C161 (273.6)	Nienie and Maile	109.44	54.72	72.96
	D162 (11.4)	Nienie and Maile	4.56	2.28	3.04
Total	(285)		114.00	57.00	76.00
39	C161 (176.0)	Nienie and Maile	70.40	35.20	46.93
	D162 (99.0)	Nienie and Maile	39.60	19.80	26.40
Total	(275)		110.00	55.00	73.33
29	D60 (3.85)	Honokaa and Pohakea	0.77	0.38	0.51
	C161 (182.325)	Nienie and Maile	72.93	36.46	48.62
	D162 (88.825)	Nienie and Maile	35.53	17.76	23.68
Total	(275)		109.23	54.60	72.81
37	C161 (282)	Nienie and Maile	112.80	56.40	75.20
Total	(282)		112.80	56.40	75.20
40	C161 (236.80)	Nienie and Maile	94.72	47.36	63.15
	D162 (59.20)	Nienie and Maile	23.68	11.84	15.79
Total	(296)		118.40	59.20	79.94
03	D59 (176.00)	Honokaa	35.20	17.60	23.47
	D60 (46.75)	Honokaa	9.35	4.67	6.23
	C161 (35.75)	Nienie and Maile	14.30	7.15	9.53
	D162 (16.50)	Nienie and Maile	6.60	3.30	4.40
Total	(275)		65.45	32.72	43.63

[1]Figures in parentheses denote acreages of the corresponding land types.

Source: Land Study Bureau, Detailed Land Classification--Island of Hawaii, LSB Bulletin No. 6, University of Hawaii, November, 1965.

TABLE 5. (Continued) LAND TYPE, ACREAGE, SOIL SERIES AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, KAMOKU AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
12	D60 (53.58)	Honokaa	10.72	5.36	7.14
	D59 (182.115)	Honokaa	36.42	18.21	24.28
	C161 (49.305)	Nienie and Maile	9.86	4.93	6.57
Total	(285)		57.00	28.50	37.99
33	D59 (145.58)	Honokaa	29.12	14.56	19.41
	D60 (87.29)	Honokaa	17.46	8.73	11.64
	C161 (49.88)	Nienie and Maile	19.95	9.98	13.30
	D162 (7.25)	Nienie and Maile	2.90	1.45	2.07
Total	(290)		69.43	34.72	46.42
38	D59 (127.50)	Honokaa	25.50	12.75	17.00
	D60 (102.00)	Honokaa	20.40	10.20	13.60
	D162 (25.50)	Nienie and Maile	10.20	5.10	6.80
Total	(255)		56.10	28.05	37.40
46	D59 (187.20)	Honokaa	37.44	18.72	24.96
	D60 (72.80)	Honokaa	14.56	7.28	9.71
Total	(260)		52.00	26.00	34.67
22	D59 (256.70)	Honokaa	51.34	25.67	34.23
	D60 (27.18)	Honokaa	5.44	2.72	3.62
	C161 (9.06)	Kikoni, Palapalai and Punohu	3.62	1.81	2.42
	D162 (9.06)	Kikoni, Palapalai and Punohu	3.62	1.81	2.42
Total	(302)		64.02	32.01	42.69
15	D59 (199132)	Honokaa	39.86	19.93	26.58
	D60 (84.56)	Honokaa	16.91	8.46	11.27
	C161 (3.02)	Kikoni, Palapalai and Punohu	1.21	0.60	0.80
	D162 (15.10)	Kikoni, Palapalai and Punohu	6.04	3.02	4.03
Total	(302)		64.02	32.01	42.68

TABLE 5. (Continued) LAND TYPE, ACREAGE, SOIL SERIES AND CARRYING CAPACITY BY INDIVIDUAL RANCHERS, KAMOKU AREA

Ranch code no.	Land Type[1] (acres)	Soil Series	Carrying Capacity (AUY) Maximum	Minimum	Average
51	D59 (211.40)	Honokaa	42.28	21.14	28.19
	D60 (60.40)	Honokaa	12.08	6.04	8.05
	C161 (30.20)	Kikoni, Palapalai and Punohu	12.08	6.04	8.05
Total	(302)		66.44	33.22	44.29
01	D59 (241.60)	Honokaa	48.32	24.16	32.21
	D60 (33.22)	Honokaa	6.64	3.32	4.43
	C161 (27.18)	Kikoni, Palapalai and Punohu	10.87	5.44	7.25
Total	(302)		65.83	32.92	43.89
Sub Total (Stocking rate)	4,268		1,251.07	623.63	839.16
			(3.41)	(6.84)	(5.07)
Grand Total (Stocking rate)	15,347		8,847.93	3,964.23	5,890.49
			(1.73)	(3.87)	(2.61)

pasture has not been fully enforced. Custom has dictated that ranchers can use the pasture whether or not there is an emergency.

A look at some selected years; 1958 to 1960 and 1962 to 1962, the period of pre-drought years and the period of post-drought condition respectively, revealed that there were some ranchers who continuously used the community pasture.[36] The ranchers who used the pasture continuously for 12 months from 1958 to 1960 were the same ranchers who used the pasture continuously from 1962 to 1964.

Some ranchers even put more than the allowed maximum number of head of cattle in the pasture. This happened in the pre-drought years and also in the post-drought period.

Presented in Figure 7 are the number of head of cattle that were in the community pasture by month from September 1954 to November 1967 and the number of ranchers who owned these cattle. The number of cattle in the pasture reached its peak in April of 1956 with 480 head. It declined very rapidly thereafter. From the end of 1956 to the end of 1962, the number of cattle in the community pasture fluctuated between a low of 181 head of cattle to a high of 353 head. Another decline in the number of cattle was experienced starting in the later part of 1962. From this time until about the middle of 1964, the number of cattle in the pasture each month was at its lowest. Between October 1964 to the end of 1967, the use of the pasture was stabilized except for an upswing that was experienced in June of 1966 when there were 322 head of cattle in the pasture.

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[36]The data were obtained from records of payment of fees for the use of community pasture from the Office of the Project Manager, Waimea Project, Island of Hawaii.

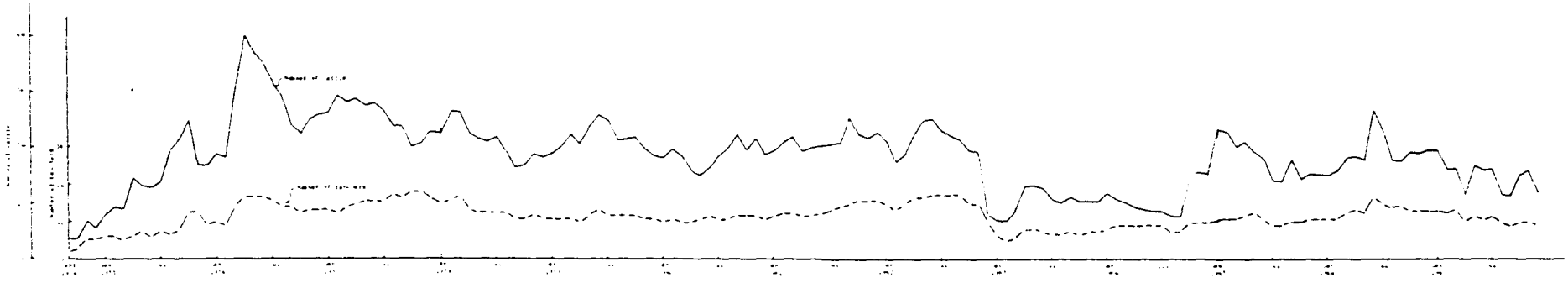

FIGURE 7. NUMBER OF HEAD OF CATTLE IN THE COMMUNITY PASTURE AND THE NUMBER OF RANCHERS USING THE COMMUNITY PASTURE FROM 1954 TO 1967

It should be noted here that from 1954 to about 1963, there were about 1,200 acres in the community pasture. From 1963 up to the present time, only 900 acres were being used as community pasture.

Some explanation is needed regarding the fluctuations in the use of the community pasture. The sudden rise in the number of cattle from September 1954 to April 1956 may be due to the fact that the ranches were just getting stocked. The project was started in 1952. The lots were distributed to qualified homesteader in 1953. Almost all the rancher-homesteaders had chattel mortgages to buy cattle with some big commercial ranchers in Waimea. The arrangements called for some forms of assistance to the ranchers in getting started in ranching. This included herd of cows as starting stocks. While the ranches were being developed, some ranchers place their cattle in the community pasture. Then as the ranches developed (with fences and water facilities), some ranchers took the cattle back and placed them in their own ranches. This might explain the decline in the number of cattle after April of 1956.

The relative stability experienced from 1957 to 1962 was the result of some ranchers maintaining some cattle in the community pasture while they improved their pasture ranges. The sudden drop in the number of cattle in December of 1962 can be attributed to the sale of cattle to meet their chattel mortgage commitments. Most of the original mortgages matured in 1963 and many ranchers had to sell some of their cattle to meet final payments.

The drought of 1962 did not appear to have a great impact in the use of the community pasture. The number of cattle did not increase substantially, though the number of ranchers who made use of the pasture

increased slightly. In most cases, changes in the number of rancher-users had no effect in altering the number of cattle in the pasture except in the early period when the ranchers were just getting started, and in the slump that occurred in the late 1962.

It is apparent from Figure 7 that few ranchers made use of the community pasture either during the period when they were getting started or during the drought of 1962. There were more users during October and November of 1957 than in any other period. During the drought of 1962, twenty-one ranchers or 40 percent of the total number of ranchers used the community pasture.

At its peak of use, the stocking rate for the community pasture was no more than 2.50 acres per animal unit per month, assuming one head of cattle is equivalent to one animal unit. In the early years (1955 to 1963) of community pasture use, the number of cattle each month seldom reached the 320 level. With 1,200 acres of pasture, the stocking rate seldom exceeded 3.75 acres per animal unit per month. The same was true in the latter years (1963 to 1967) when the community pasture was reduced to 900 acres. Very seldom did the cattle exceed 240 in number.

The Financing of the Ranching Operations

The ranchers were required by law to occupy and to start the ranching operations on the lots leased to them within one year after the date of the lease. To help the ranchers get started in ranching, the Department set up a revolving fund, the Hawaiian Home Loan Fund. The ranchers could obtain loans from this fund for the purpose of constructing their dwellings and their repairs and improvement thereof and for the purchase of livestock and livestock equipment and for development

and improvement of the ranches. There were also offers of financing and technical assistances from two big ranches in the area, the Parker Ranch and the Anna-Fiske Ranch. The assistance provided by these two ranches was in the form of chattel mortgages entered into with the Waimea ranchers. The mortgage arrangements may be called for either the purchase of livestock alone or for providing of the other improvement requirements such as fence, water tank and stock water equipment. The Waimea ranchers had to sell their calves to the ranchers until the mortgages were paid in full. Friends and relatives of some of the rancher-leasees offered also some forms of financial and technical assistances.

The initial loans made by the ranchers were for the construction of their dwellings. The maximum amount of loan that they could obtain was $6,000 per leasee. At present this amount was increased to $10,000.

To finance the improvement of the pasture range, some ranchers have availed themselves to the benefits offered by the Agricultural Stabilization and Conservation Service. The benefits range from a full to one-fourth payment of the pasture improvement practices that the ranchers may adopt. Part of the loans obtained for these purposes were repaid from the benefits they obtained.

Some ranchers entered into grazing agreement with some of the non-Waimea project ranchers in the area or with other Waimea project ranchers. The agreement called for the grazing of cattle on the ranch for a specified period of time. The ranchers were paid either in cash or in kind (calves) for the care of the livestock and for the use of their pastures. It was not possible to measure the impact of these

grazing agreements on ranch capital accumulation in this study.

In response to the great demand for funds for ranching and for farming purposes, the Department created the Hawaiian Farm Loan Fund in 1965 with a $100,000 appropriation from the Legislature of the State of Hawaii in that year. Another appropriation was made in 1966 in the amount of $150,000. This is a revolving fund solely created to meet demand for loans by the ranchers and the farmers for their ranching and farming activities.

In addition to the Department funds, the ranchers are free to borrow from the Farmers Home Administration and some private banks. However, access to these financing institutions is very limited for most ranchers because of lack of collateral.

Price Received by the Ranchers

The Waimea ranchers account for only a small portion of the total beef produced on the Island of Hawaii. In Kohala-Hamakua area where seven big ranchers are located, the estimated cattle inventory in 1962 was 73,000.[37] About 8,000 head (or 11 percent) were from the ranchers in the Waimea project. The total animal units will be less than 8,000 because some of the cattle are either heifers, steers or yearling calves, the animal units equivalent of these cattle are usually less than one. Because of the small lots sold, ranchers in the study area obviously have little control over prices that they received for their products. Recent declines in price of beef have been very alarming to the ranchers in Hawaii.

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[37]The Planning and Traffic Commission, "Kohala-Hamakua Region General Plan, Island of Hawaii," County of Hawaii, 1963.

Available statistics show that the average price of beef per pound liveweight in 1952 was 42 cents.[38] It varied and reached a peak of 46 cents in 1958. Thereafter, it declined very slowly until in 1963 it dropped tremendously to 17.5 cents. In 1966, the price ranges from 17 to 19 cents a pound.

Capital Investment

Estimates of the present levels of capital investment per ranch is shown in Table 6. Land is not included in capital investment. Every rancher, on the average, operates a 300-acre ranch unit. The rent is very minimal. A ranch homesteader pays only one dollar a year for the lot he leases. Thus land is not a relevant cost in the decision framework.

The capital investment is divided into livestock, improvements, motor vehicles, and equipment. Improvement investment included fences, watering facilities, and loading facilities. Equipment on the ranch was mostly livestock equipment like corrals, branding chutes constructed with the corrals, and livestock squeezes. The other equipment items were tractor attachments. Ranch buildings were not included in the capital investment because only one or two ranchers have ranch buildings on the ranch. Such buildings existing include sheds, shacks, and ranch hands' quarters built by the ranchers themselves and their costs are very minimal. The dwellings of the ranchers were also not included in the capital investment. It would be difficult to ascertain the portion of the present value of the dwelling that should be considered part of the

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[38]The information on prices was obtained from records kept by the Project Office of the Department of Hawaiian Home Lands in Waimea.

TABLE 6. CAPITAL INVESTMENT PER RANCH EXCLUDING LAND AND RANCH BUILDING, 36 RANCHERS, WAIMEA, 1966

Investment Items	Average (dollars)	Number of ranchers with investment		Investment Range[a] (dollars)
		Below average	Average & Above	
Livestock	17,685	19	17	34,480
Improvement (subtotal)	(1,429)	23	13	3,693
Fences	630	21	15	1,595
Watering facilities	638	23	13	1,957
Loading facilities	161	29	7	397
Motor vehicles (including tractor)	2,228	27	9	11,077
Equipment (excluding water vehicles)	807	27	9	2,588
Total	22,149	--	--	--

[a]Difference between the highest and lowest values.

investment for ranching operation.

On the average, livestock constituted the largest capital investment, about 80 percent of the total. The next item of importance, in percentage, is investment in motor vehicles, ten percent. Investment on improvements and on equipment account for six percent and four percent respectively.

Also presented in Table 6 is the number of ranchers whose investments are below average or average and above average for each of the particular capital investment items. Except for the livestock, the number of ranchers with investment below the average far exceeds the number of ranchers with investment at average or above.

Labor Use

The survey indicated that much of the labor required for ranching operations was hired labor.[39] Hired labor was used for chores like separating the calves from the cows and the accompanying activities like dehorning, castrating, branding, vaccinating against cattle diseases, and related activities. Hired labor was used also in controlling pests and diseases.

It was not possible to separate hired labor by kinds of chores done. The information obtained was for the total man-hours spent on combinations of related activities performed. Therefore, only the total hired labor in man-hours per ranch could be ascertained. The average per ranch was 449 man-hours. It varied tremendously from 72 to 3,540 man-hours per ranch with a standard deviation of 565.72.

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[39]Labor furnished by the ranch household is included.

Ranch Operators and Ranch Households

The ranch operators of this study are not necessarily the leasees of the ranching lots. They are the male heads of the ranch families who are responsible for the operation and management of the ranches. The ranch households include the members of the family who depend on the ranch operators' incomes (including incomes of spouses) for a living.

The size and characteristics of the ranch households may be a factor in the successful operation of the ranching business as it exists in this project, since the members of ranch households are potential sources of labor for some operations on the ranches. Furthermore, outside employment opportunities provide potential sources of cash for funding ranching operations.

In this section some personal characteristics of the ranch operators and some characteristics of the ranch households are discussed. The topics discussed are (1) the age and the off-ranch income of the ranch operators and their spouses, (2) the size of the ranch households, and (3) the relations of off-ranch income to ranch investment and to size of the ranch households.

Age of ranch operators. Table 7 shows the age group of the ranch operators. Most of them were 40 years of age or over. Of the 31 ranch operators, four were 60 years of age and over. The average age was 49 years.

Age of spouses. Some management work is provided by the spouses of the ranch operators. The spouses take cahrge of the ranch when the ranch operators are on their off-ranch work. How the spouses cope with this management responsibility depends to a large degree on their physical

fitness. Shown in Table 8 are the age groups of 32 spouses.

On the average, spouses are younger than their counterparts. However, more than half of the spouses were 40 years of age or over with the age range of 40 to 49 representing more than one-third (34 percent) of all ranches represented.

Operators' off-ranch employment. Almost all the ranch operators have other sources of incomes besides ranching. The jobs were classified as A, B, C, D, and E jobs.[40] The job categories and the corresponding average monthly incomes are shown in Table 9.

The average monthly income for those with off-ranch employment is $350. It should be noted that almost half (48 percent) of those who reported that they received monetary off-ranch renumeration (including those receiving pensions and social security benefits) received off-ranch incomes averaging more than $400 a month.

Spouses' off-ranch employment.[41] Out of 32 ranch households, 13 spouses had off-ranch employment, 15 had none, and four did not report. The average monthly off-ranch income was $251. However, five spouses had average monthly off-ranch incomes above $300 (Table 10).

It is interesting to note that in some cases both operators and their spouses had off-ranch employment. Table 11 shows the combined average monthly income received from off-ranch employment.

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[40]Refer to Appendix D for specific jobs falling in each job category.

[41]Refer to Appendix D for job category descriptions.

TABLE 7. AGE OF RANCH OPERATORS, WAIMEA RANCHING PROJECT, 1966

Age (years)	Ranchers Reporting (number)	Average age (years)	Age range* (years)
Less than 40	1	33	--
40 - 49	14	43	9
50 - 59	9	53	8
60 and above	4	63	6
Non-reporting	3	--	--
All ranchers	31[a]	49	34

*Difference between the highest and lowest value.
[a]One deceased.

TABLE 8. AGE OF SPOUSES, WAIMEA RANCHING PROJECT, 1966

Age (years)	Ranchers Reporting (number)	Average age (years)	Age range[a] (years)
Less than 30	1	24	--
30 - 39	8	35	7
40 - 49	11	44	9
50 - 59	4	52	7
60 and above	2	61	1
Non-reporting	6	--	--
All respondents	32	43	37

[a]Difference between the highest and lowest actual ages falling under each age interval.

TABLE 9. OPERATORS' OFF-RANCH EMPLOYMENT, WAIMEA RANCHING PROJECT, 1966

Kinds of job	Number reporting	Average monthly income
		dollars
A jobs	4	494
B jobs	5	415
C jobs	2	454
D jobs	3	216
E jobs	5	210
Pensions and/or social security benefits	4	170
None	5	--
Non-reporting	4	--
Total (average)	32	($350)[a]

[a]Includes only those who are working.

TABLE 10. SPOUSES' OFF-RANCH EMPLOYMENT, WAIMEA RANCHING PROJECT, 1966

Kinds of job	Number reporting	Average monthly income
		dollars
A jobs	3	378
B jobs	2	350
C jobs	8	178
None	15	--
Non-reporting	4	--
Total (average)	32	($251)

TABLE 11. COMBINED AVERAGE MONTHLY INCOME OF HUSBAND AND WIFE FROM OFF-RANCH EMPLOYMENT, WAIMEA RANCHING PROJECT, 1966[a]

Item	Number reporting	Average family income per month
		dollars
Both husband (lessee) and wife working	7	529
Only husband (lessee) works	7	319
Only husband (non-lessee) works	4	470
Both husband (non-lessee) and wife not working	4	228[b]
Husband (lessee) not working and wife works	3	401[b]
Both husband (non-lessee) and wife working	2	512
Both husband (lessee) and wife not working	1	168[c]
Husband (non-lessee) not working and wife works	1	681[b]
Non-reporting	3	--
Total (average)	32	($426)

[a]Incomes before tax.
[b]Husband receiving pension and retirement or social security benefits.
[c]Both husband and wife receiving retirement and/or social security benefits.

The combined average monthly income for husband and wife from off-ranch employment was $426. Note that this combined monthly income may be the total of the operator's and spouse's off-ranch incomes or just the off-ranch income of one of them. However, in 24 out of 32 ranch families, at least one worked outside the ranch for monetary renumeration. Where both operator and spouse were working, the average monthly off-ranch income was larger than when only husband or wife worked. It should be noted that the average monthly income for both operator and spouse working was more than $500.

Number of dependents in a ranch household. As mentioned earlier, the ranch household is a potential source of labor. Labor required for some ranching operations came from other members of the ranch family, mostly from male members who were 14 years of age or older. As shown in Table 12, a ranch family may have dependents ranging from none to more than six excluding the spouse of the head of the family.

It should be noted that the average ranch household was large. More than two-fifths (41 percent) of those interviewed had dependents numbering two to three and about 28 percent of the ranch families had four dependents or more. Of the 13 ranch families who had at least a son 14 years of age or over, seven had at least two sons in the same age group.

The previous discussion shows some characteristics of the ranch operators and the ranch households. These characteristics are part of the restrictions which affect the levels of achievement. The ability of the ranch operators to cope with the demands of the ranch operations depends to a large degree to their physical conditions. In general, the

TABLE 12. NUMBER OF DEPENDENTS IN A RANCH HOUSEHOLD, WAIMEA RANCHING PROJECT, 1966[a]

Dependents	Ranchers reporting	Number of ranch with at least one son 14 years of age or over
Number	Number	
None to 1	8	1
2 - 3	13	7
4 - 5	7	4
6 and over	2	1
Non-reporting	2	-
All ranchers	32	13[b]

[a]Does not include wife.
[b]Seven had at least two sons 14 years of age or over.

age of the ranch operators affects his physical condition. It was found out that the ranch operators on the average, were quite old. The spouses were not relatively younger either.

The size of the ranch household also affects the levels of achievement. Those who are old enough may be of assistance to the ranch operator in performing some of the necessary chores on the ranch or they may find outside employment which may augment the income derived from ranching or their outside income may be a source of fund to finance some of the needed ranch operations. However, the consequence of a large size of ranch household is obvious. The available income has to be spread over a large number of individuals. In this case, the need for expansion of the ranching operation competes with the needs of the family for any available income.

Relations Between Off-Ranch Incomes and Capital Investment

One possible source of cash for funding some of the required investment on the ranch is the off-ranch incomes of the operators and some members of the ranch households. The question centers on the problem of whether off-ranch incomes help the ranchers in acquiring the necessary ranch resources for the successful operation of the ranch and if this is so, what kind of association exists.

Only the outside incomes of the ranch operators and their spouses were considered in this analysis. They are the only available figures that can be reckoned with. The yearly income is the gross income (salary or wage) per month multiplied by twelve. Not all the 38 sample ranchers were included in the analysis. Some ranchers and/or their spouses have no outside employment or their off-ranch incomes were not

available. Only 25 ranchers were included in the analysis.

The investment items included in the analysis were fencing, watering facilities, loading facilities and a composite items in terms of improvements, livestock investment, motor vehicles, equipment, and total improvement.

Simple correlation analysis was conducted to determine the relations between off-ranch income and capital investment and its components. The correlation coefficients measuring the degrees of association between the various items of capital investment and the off-ranch income are presented in Table 13.

It is very evident from the correlation analysis that the contribution of off-ranch income in explaining the variations in some of the items of investment was very small. Of the three categories of investment on improvement, only the investment in loading facilities was found to be associated with off-ranch income ($r = 0.46$). As a composite item, the investment in total improvement has no appreciable relation with off-ranch income. The other investment item found to be significantly related to off-ranch income was investment in motor vehicles. For all investment items taken as a whole, the correlation coefficient was 0.41.

Relations Between Off-Ranch Income and Number of Dependents 14 Years and Older and Total Number of Dependents

To find out the relations between off-ranch income and the number of dependents 14 years and older and the total number of dependents, simple correlation analysis was conducted.

TABLE 13. SIMPLE CORRELATION COEFFICIENTS OF THE ASSOCIATION BETWEEN THE VARIOUS ITEMS OF INVESTMENT AND OFF-RANCH INCOME

Investment item	Correlation coefficient	t-value	Degrees of freedom[b]
Total improvements	-0.051	$-0.244^{n.s.}$	24
Fences	-0.215	$-1.055^{n.s.}$	24
Watering facilities	0.002	$0.011^{n.s.}$	24
Loading facilities	0.461	2.140^{a}	18
Livestock	0.399	$1.992^{n.s.}$	22
Motor vehicles	0.568	2.763^{*}	17
Equipment	0.253	$1.200^{n.s.}$	22
Total investment	0.409	2.052^{a}	22

$^{n.s.}$Non-significant (ten percent).
*Significant
^{a}Significant at ten percent level of significance.
^{b}The degrees of freedom are not the same in all cases because of the elimination of some extreme values in the particular analysis.

The result of the analysis shows that the number of dependents in the ranch household who are 14 years of age and older is not related whatsoever to off-ranch income. However, the total number of dependents in the ranch household had some resemblance of association with off-ranch income (Table 14). The significance level is not quite high though.

These relationships may explain partly the reason why ranchers seek outside employment. It may be stated that off-ranch income is not only a source of fund to acquire additional ranch resources but also to support the family needs of the ranch household.

Organizational and Operational Characteristics of the Ranches

One of the objectives of the study is to determine the present level of achievement of the ranching project (Objective No. 1). The level of achievement is constrained by the ranch resources under the control of the ranchers and the way these resources are organized and combined. Some resource mixes may result in a higher level of achievement than others. Therefore, this section will deal with the presently existing ranch resources, ranch operations, and ranch organization.

Animal units. The number of animal units is a conventional way of measuring the size of ranch. While there are imperfection in the use of this measurement for describing ranch size, no other measure seems more appropriate. Table 15 shows the ranges of the number of animal units for the sample ranchers.

TABLE 14. RELATIONS BETWEEN OFF-RANCH INCOME AND SOME FAMILY CHARACTERISTICS, 25 RANCHERS, WAIMEA, 1966

Family Characteristics	Simple correlation coefficient	t-value
No. of dependents 14 and over	0.264	1.293[a]
No. of dependents	0.276	1.354[b]

[a]Insignificant at 20 percent level of significance.
[b]Significant at 20 percent level of significance.

TABLE 15. NUMBER OF ANIMAL UNITS[a] PER RANCH

Animal units (number)	Number of ranchers reporting	Percent
Below 66	5	14
66 - 95	8	22
96 - 125	7	19
126 - 155	11	31
156 and above	5	14
Total	36	100

[a]Based on animal unit equivalent of 1.20 for bull, 1.00 for a cow, 0.85 for heifer and steer more than one year but less than two years old, 0.67 for yearling calf, and 0.50 for calf less than one year old.

The lowest number of animal units recorded per ranch was 27.4 and the highest 275.1. A little over one-third of the ranchers interviewed had less than 96 animal units in their ranches.

Stocking rate. As used in this study, stocking rate is the number of acres allotted to an animal unit. It is computed by dividing the total acres in a ranch by its average livestock inventory (in animal units). It is different from the term range carry capacity as used in range management literature.[42] As presented in Table 16, the stocking rates represent the rate adopted by the ranchers with or without regard to good range management practices.

TABLE 16. STOCKING RATE (NUMBER OF ACRES PER ANIMAL UNIT)

Stocking rate (acres per A. U.)	Number of ranchers reporting	Percent of total	Range (animal unit)[a]	Average Stocking rate (acres per animal unit)
2.09 and less	5	14	0.65	1.54
2.10 - 3.09	15	42	0.87	2.51
3.10 - 4.09	7	19	0.70	3.59
Above 4.09	9	25	7.48	6.95
Total (average)	36	100	10.36	(3.70)

[a]Difference between the highest and lowest value.

[42]"Range carrying capacity is the ability of non-cropland to furnish feed for livestock, so that they are maintained in good flesh and make normal growth, and with maintenance of soil fertility and vegetative cover including the palatable species." This definition was taken from the Montana Agricultural Experiment Station, Bulletin No. 557, June 1961.

Number of head of cattle. Presented in Table 17 is the average number of head by animal units and type of livestock. There was a tendency for the number of each cows, bulls, heifers, and steers, calves, and horses to increase respectively as total animal units increase. However, it cannot be ascertained whether the ranchers are keeping too many of a particular type of cattle. Apparently, for smaller ranches (as measured by animal unit category), the number of cows kept per bull is too low and for larger ranches, the ratio is also not ideal.[43]

TABLE 17. AVERAGE NUMBER OF HEAD OF LIVESTOCK PER RANCH IN ANIMAL UNITS, BY TYPE OF LIVESTOCK

Type of livestock	Average	Cattle units				
		Less than 65	66-95	96-125	126-155	156 & above
		Number				
Cows	64	26	45	61	73	110
Heifers	21	9	16	21	26	24
Steers	23	4	13	18	26	38
Yearlings	37	8	18	34	40	56
Calves	42	22	32	42	40	67
Bulls	2	2	2	2	3	3
Saddle horses	4	2	3	5	4	4

[43]Accepted ratio is 25 to 39 cows to a bull.

In Table 18, only 21 percent of the ranchers interviewed kept the ideal ratio of 25 to 30 cows to one bull. The rest are either carrying too many cows to a bull or too few.

TABLE 18. NUMBER OF COWS KEPT PER BULL

Number of cows per bull	Ranchers reporting	Percent
	Number	
Less than 25	16	47
25 - 30	7	21
31 - 36	2	6
Above 36	9	26
Total	34	100

Ranching Costs and Returns

The first step in determining the levels of achievement of the ranchers is the analysis of ranching costs and returns. The prices used in constructing the cost and return structures were for the year 1966. Receipts were primarily from sales of calves. Other sources of receipts were sales of culled cows and bulls. Also included in the receipts was livestocks slaughtered for home use.

The ranch expenses were divided into cash and non-cash. The cash expense items were hired labor which included the family labor, repairs

and maintenance, taxes[44] on ranch land, its improvements, veterinary services and supplies, and salt and minerals. Likewise, the non-cash expense items include interest charged on capital investment and cash operating expenses and depreciation. Two interest rates were used. A five percent interest was charged on capital investment. For cash operating expenses, a six percent interest rate was used. If funds were borrowed from commercial lending institutions to finance the ranching operations, the rates represent explicit costs. If funds were from saving of the ranchers, the rates represent opportunity (implicit) costs. Both concepts were used in this study. To calculate depreciation, the straight line method was employed.

Table 19 shows the average receipts and expenses for the sample ranchers. On the average, the net ranch income was $1,374 per ranch or $10.24 per animal unit. The larger share of the total expenses was in non-cash expenses (63 percent). Cash expenses amounted to only $1,123 per ranch or $10.03 per animal unit. The largest item in the cash expenses was hired labor and interest on capital investment for non-cash expenses. For the 53 ranchers, the estimated net ranch income would be $72,838 which is computed by multiplying the average net ranch income per ranch by 53.

The measure of net income as used in this study would adequately approximate the return to ranch operator's labor and management and return to land. As used in this context, it may become apparent that in

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[44]Assessed values of the individual ranches were obtained from the State of Hawaii Tax Office and the tax rate applied was that of the year 1966.

TABLE 19. AVERAGE RECEIPTS AND EXPENSES, 36 WAIMEA PROJECT RANCHERS, 1966

Item	Average per ranch		Average per animal unit	
	dollars		dollars	
Receipts				
Sales of livestock[a]	4,395.87		36.74	
Total receipts		4,395.87		36.74
Expenses				
Cash (subtotal)		1,123.01		10.03
Hired labor[b]	578.09		5.05	
Repairs and maintenance	271.35		2.21	
Taxes	209.87		2.23	
Veterinary services and supplies	50.28		0.43	
Salt and minerals	12.42		0.11	
Non-cash (subtotal)		1,898.56		16.47
Interest (5%) on capital investment[c]	1,144.65		9.65	
Depreciation	682.63		6.22	
Interest (6%) on operating expenses	67.29		0.60	
Total expenses		3,021.57		26.50
Income above cash expenses		3,272.86		26.71
Net ranch income[d]		1,374.30		10.24

[a]Sales of calves, culled cows and bulls, and livestock slaughtered for home use.
[b]Labor furnished by members of ranch household was included.
[c]Value of land not included.
[d]Returns to land and management.

the presence of other better income-producing alternatives, the return to land and operator's labor and management is quite low. However, most of the land in the ranching project have no other alternative uses except for livestock ranching.[45] It was also observed that most ranchers in the project are operating their ranches on a part-time basis.[46] Most of them have off-ranch employments which are mostly permanent in nature.

Cost Analysis

It was the belief that the ranchers in the Waimea ranching project are not operating their ranches at their optimum levels. To substantiate this belief, cost analysis was conducted. The analysis was for the short run condition and it was assumed that perfect competition prevailed.

In the theory of the firm, the optimum level of production (profit maximization) is at the output at which marginal cost equals marginal revenue. This concept can be shown hypothetically in Figure 8.

The short run average cost curve is SAC and the short run marginal cost curve is SMC. Since, in perfect competition, the price of the product is equal to the marginal revenue, the marginal revenue curve coincides with the demand curve (dd) face by the firm. Both are equal at all possible outputs of the firm to the market price of the product. Therefore, the maximum profit output will be output X_0. At any output less than X_0, say X_1, marginal revenue X_1A exceeds marginal cost X_1C.

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[45]Some areas can be adopted to production of corn and other crops that can be used as feed supplements but these possibilities are very limited.

[46]Only one-third were full-time ranchers as reported in the "Kohala-Hamakua Region - General Plan, Island of Hawaii" by Robert I. Bush and Andrew Gerakas, County of Hawaii Planning Commission, 1963, p. 72.

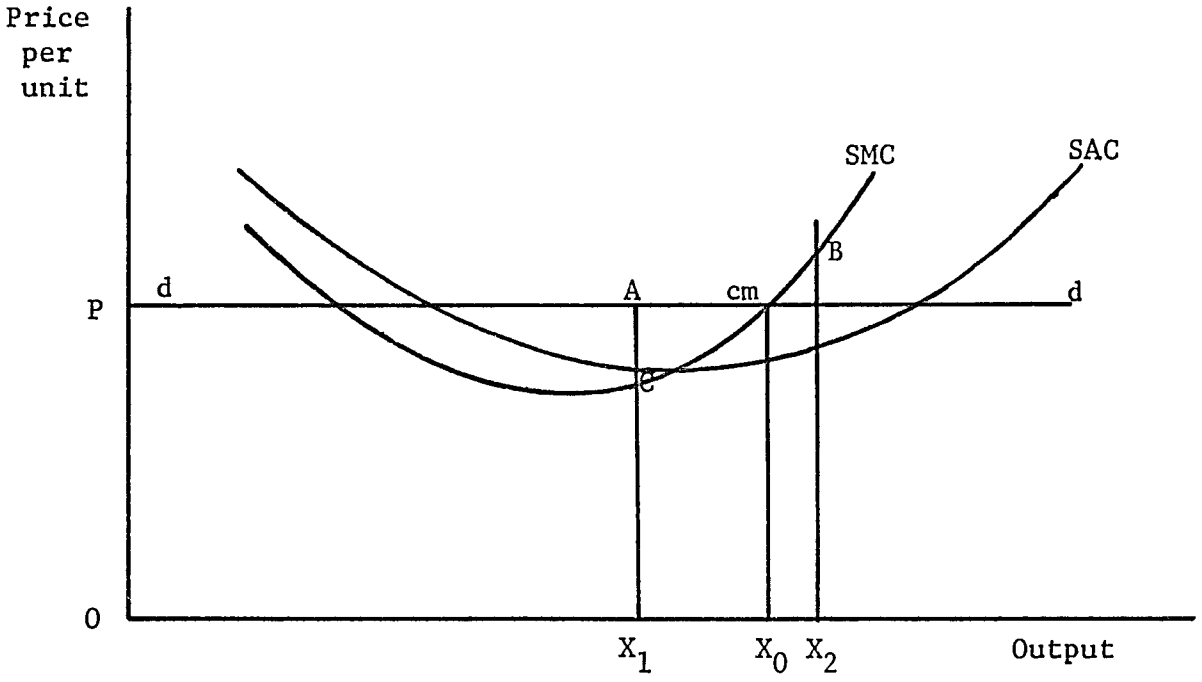

FIGURE 8. HYPOTHETICAL SHORT-RUN AVERAGE UNIT COST CURVES FOR RANCHES OF A GIVEN FIXED RESOURCES

Larger output up to X_0 will increase total receipts more than they increase total costs; hence, profit will increase up to that point. Beyond output X_0, SMC is greater than MR (marginal revenue) and any movement to increase output will cause profit to decline.

Empirical determination of cost curves. The method of least squares was used in fitting of the ranch cost curves. Cost as measured in per hundredweights was the dependent variable. The independent variable was measured in total animal units per ranch and in total pounds of beef sold per ranch. Three forms of functions were considered for each independent variable. The forms of the function were:

I. $Y = A + B \frac{(1)}{X}$

II. $Y = AX^B$

III. $Y = A + BX + CX^2$

where: Y = cost per hundredweight

X = total animal units per ranch or total pounds of beef sold per ranch

A, B, and C = parameters

The standard errors were computed for each function and the function with the smallest standard error was selected as the best fitting function. Table 20 shows the six functions and the corresponding correlation coefficients and standard errors.

While hypothetically the short-run per unit cost curves are "U-shaped" (Figure 8), empirically, the rising portion of the short-run cost curves is difficult to quantify. There is a belief that in

TABLE 20. COST FUNCTIONS AND THE CORRESPONDING CORRELATION COEFFICIENTS AND STANDARD ERRORS

	Functions[a]	Correlation coefficient	Standard error
Ia.	$Y = 11.7698 + 230.1776\left(\frac{1}{X_1}\right)$	0.2691	6.036
Ib.	$Y = 7.00417 + 128.759\left(\frac{1}{X_2}\right)$	0.7650	4.0361
IIa.	$Y = 32.30X_1^{-0.1901}$	0.2703	0.1564
IIb.	$Y = 1421.5X_2^{-0.4693}$	0.7544	0.1066
IIIa.	$Y = 21.0663 - 0\ 1272X_1 + 0.0007X_1^2$	0.2432	6.2784
IIIb.	$Y = 36.89 - 0.0021X_2$	0.7390	4.36058

[a]All functions in a's have the independent variable measured in animal units and the b's in pounds of beef sold.

ranching the rising portion is nearly vertical for all practical purposes.[47] This would imply that there is a definite limit to the capacity of the fixed factors of production rather than a gradual diminishing of their capacity to combine with further variable inputs. This phenomenon may hold true or not for ranchers in the Waimea project. However, results showed that the rising portion of the short-run average cost curve seems to be non-existent in this particular study (Table 20). Function IIIa exhibited a rising portion, but it is very negligible.[48] Besides, its standard error is the largest among the six functions.

In Figure 9, the curve of the function (function IIb) with the least standard error was plotted against the scatter diagram of observed cost per hundredweight per ranch. It is apparent that cost per hundredweight will continue to decline as size (measured in total pounds of beef sold) of ranch increases. However, it is not possible to determine the size of ranch that will result to a minimum cost per hundredweight. This is the nature of the function that has been chosen to be the best fit.[49] However, the decline in cost per hundredweight as size increases becomes exceedingly slow as size approaches 40,000 pounds.

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[47]University of Arizona, Agricultural Experiment Station, Technical Bulletin 155, November 1963, p. 8.

[48]Insignificant according to the t-test of the regression coefficient.

[49]The function is a variant of the Cobb-Douglas function wherein the minimum point of the curve does not exist.

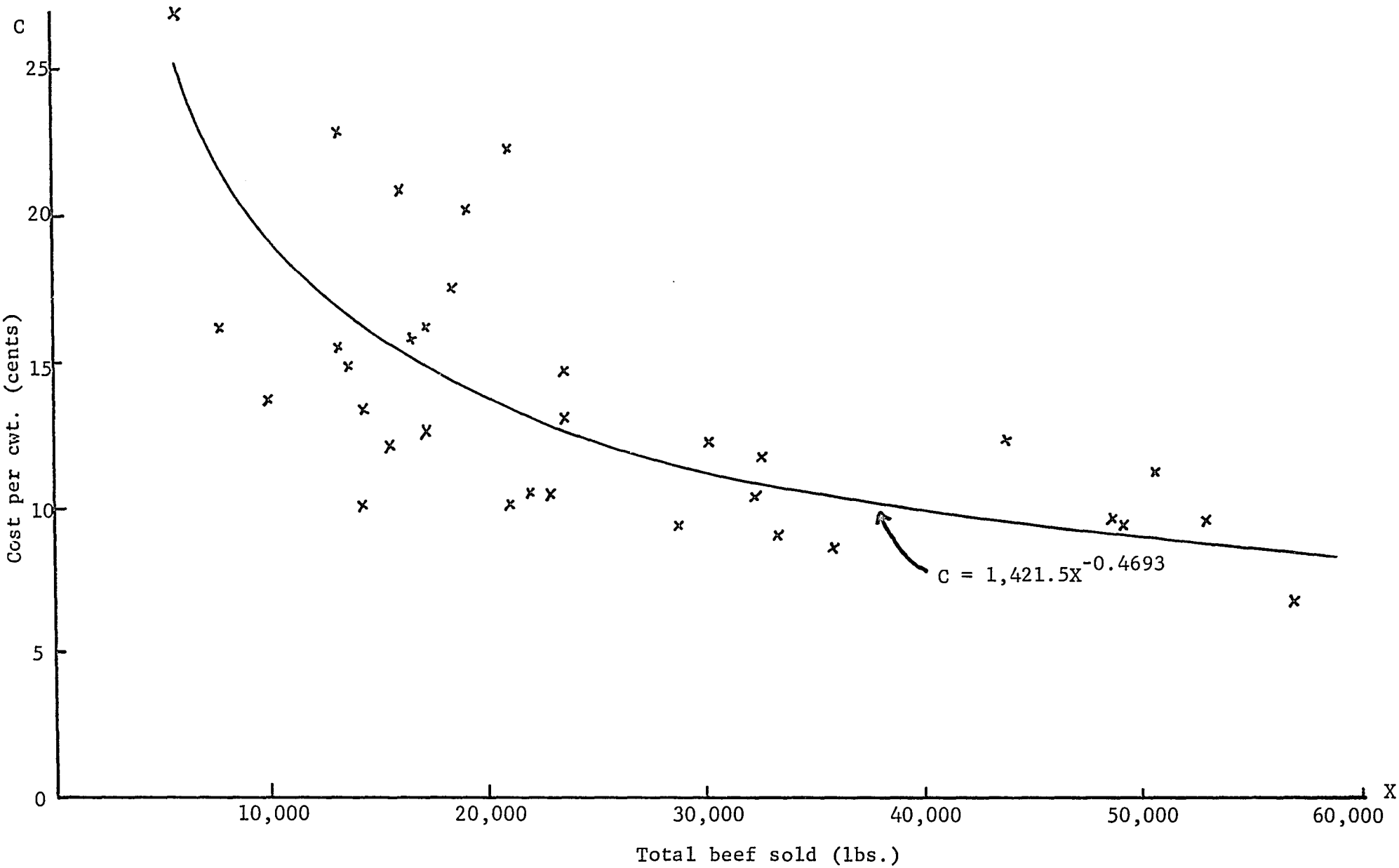

FIGURE 9. SCATTER DIAGRAM OF RELATIONS BETWEEN TOTAL BEEF SOLD AND COST PER HUNDREDWEIGHT

The best fitted function presents some interesting analytical approaches to the problem on hand. As long as the average cost curve is declining, the marginal cost curve is below it. Therefore, profit of the ranchers can still be increased beyond the size of 40,000 pounds. Theory tells us that profit is maximized at the output at which the marginal cost curve intersects the marginal revenue curve at a point where the marginal cost curve is above the average cost curve. It will be noted that optimum output is beyond the size that is presently being pursued by the ranchers.

CHAPTER IV

THE IMPACT OF SETS OF RESTRICTION ON RANCH RESOURCE ORGANIZATION AND ACHIEVEMENT

In the present chapter, the attempt is to show (1) the effect of the project restrictions on the manner in which the ranch resources are acquired and organized and (2) the impact of these restrictions on the level of achievement of the ranchers.

The Effect of the Leasing Provisions[50]

As discussed earlier, the homesteading concept promulgated in the law (the Hawaiian Homes Commission Act of 1920, as amended) calls for leasing of pastoral lands to native Hawaiians of certain blood composition for a period of 99 years. These leases were to serve as a means of rehabilitating this group by abetting the evil consequences of land speculation believed to be working mostly against the native Hawaiians. The 99 years term of the leasing arrangement has appeared to foster a stable community of homesteader-leasees for the Waimea ranching project.

On the other hand, the leasing arrangements embodied in the law tended to place the ranchers at a disadvantage regarding the financing of their ranching operations. The crux of the matter is the lack of collateral on the part of the ranchers. Lending functions of conventional sources of credit to agriculture are tied closely to the notion that the farmers have equity in mortgageable real property to secure the loan.

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[50]Applied only to the Waimea ranchers.

The leasing arrangement while providing security of tenure does not provide a source of building equity and is not a transferable asset. With no recognizable equity in real property, private financing institutions are well out of reach of the ranchers except for those who have adequate outside sources of income. The federal loan assistance available from the Farmers Home Administration has limited applicability to most of the ranchers. Few of the ranchers own any real estate. The only source of security is a lien on their cattle or equipment or assignment made on their salaries or wages from off-ranch employments.

To provide for the capital requirements of the ranch, the law also set up funds from which the leasees may acquire loans to purchase the needed ranch resources. In addition, as previously noted, some big ranchers in the area provided chattel mortgages to the Waimea ranchers for the purpose of developing the ranches and for the purchase of starting stock for the ranches.

The chattel mortgages proved to be very useful to the rancher-leasees. For the duration of the mortgages, marketing of their produce was not a problem. On the other hand, the fund set aside by the law was inadequate to meet the needs of all the leasees of the whole Hawaiian Homes program.[51] While every homesteader is eligible to borrow from the Department fund, not all loan applicants were able to get their loans approved because of various reasons ranging from the lack of security (ability to pay back the loan) on the part of the borrowers to the lack

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[51]Department of Hawaiian Home Lands, Biennial Report to the Legislature of the State of Hawaii, Regular Session 1967, p. 10.

of funds set aside for a particular purpose. In some cases, the loan application had to be reconsidered at a later date because of the unavailability of adequate funds.

Thus the rancher-leasees may not be able to obtain funds at the time or in the amounts needed from the Department and if they already have outstanding loans from the Department, then this ties up their collateral and further limits their ability to obtain additional loans from other sources.

Two analyses were conducted for the purpose of showing: (1) the amount of loans obtained from the Department, the number of ranchers who obtained these loans and the relations of these two factors to the total amount of fund available; (2) the relations of the loans obtained from the Department to the net ranch income and to the capital investment and its composition.

Examination of the number and size of loans obtained by the ranchers for their ranching operations from the Department for the last ten years suggests that the amount borrowed on the average was inadequate to finance normal operations and did not reach a good number of the ranchers (Table 21). The greatest number of ranchers who obtained loans was in the fiscal year 1958-1959. During this period 20 ranchers or 38 percent of the ranchers obtained loans. However, the total amount of loans obtained by the 20 ranchers was only $20,037. In the period 1965-1966 the highest amount of money was loaned to ranchers. During this period the State of Hawaii Legislature appropriated $100,000 to the Hawaiian Farm Loan Fund, a revolving fund created primarily to finance loans for farming and ranching purposes. Only 16 ranchers obtained loans from this

TABLE 21. LOANS FOR RANCHING OPERATIONS OBTAINED FROM THE DEPARTMENT OF HAWAIIAN HOME LANDS FROM THE YEAR 1957 TO 1967; WAIMEA RANCHING PROJECT

Items	Fiscal Year									
	1957-1958	1958-1959	1959-1960	1960-1961	1961-1962	1962-1963	1963-1964	1964-1965	1965-1966	1966-1967
Number of ranchers	1	20	17	7	7	13	4	3	16	2
	DOLLARS									
Total amount of loan	4,600	20,037	20,905	12,050	33,385	22,988	8,134	10,108	69,146	3,165
Average loan obtained per rancher reporting	4,600	1,002	1,230	1,721	4,769	1,768	2,034	2,022	4,322	1,582
Highest loan obtained per rancher reporting	--	6,000	5,000	6,652	19,614	5,259	3,448	4,487	13,500	2,000
Lowest loan obtained per rancher reporting	--	500	175	99	800	125	1,000	1,412	1,000	1,165
Total amount of funds available[a]	156,718	84,527	256,831	369,699	388,047	320,528	105,728	204,677	100,000	7,011
Percent of funds available loaned to ranchers	3	24	8	3	9	7	8	5	69	45

[a]From Hawaiian Home Loan Fund for all Hawaiian Home Projects for fiscal years 1957-1958 to 1964-1965 and from Hawaiian Farm Loan Fund for fiscal years 1965-1966 to 1966-1967. The figures in the row represent the averages of the monthly balances except for fiscal year 1965-1966. The $100,000 in fiscal year 1965-1966 was the amount appropriated initially by the Legislature for the Hawaiian Farm Loan Fund.

Source: Department of Hawaiian Home Lands.

fund during this period.

During the drought of 1962, the total loans to the ranchers amounted to only $22,988. Again, very few ranchers obtained loans for the improvement of their pasture ranges despite the fact that almost all the 53 ranches were affected by drought. In general, the amount of funds available for loan purposes appears to have no effect on the number of ranchers obtaining loans nor on the total amount of loans approved. Loans obtained by the Waimea ranchers as a distinct group comprised a very small percentage of the total amount available to be loaned to homesteaders. Seldom did the amount reach ten percent of the total amount available except for the fiscal years 1958-1959, 1965-1966, and 1966-1967. In fiscal year 1966-1967, only two loans were approved. The fund available during that period was almost depleted. At the end of 1966, the amount available from the Hawaiian Farm Loan Fund, the only source of funds for ranching operations, was only $6,775.

It should be made clear, however, the fact that more money was not made available to the Waimea ranchers is not a criticism of the Department's loan priority policies and procedures. The ranching project in Waimea is only a small portion of the whole Hawaiian Homes program in terms of project money allotment. The intention here is to show how the demand for funds of the ranchers is being met from the limited amounts available from the Department.

An analysis showing the impact of loans obtained by the ranchers from the Department of Hawaiian Home Lands on ranch incomes and on capital investment is presented in Table 22. Total loans obtained by individual ranchers from 1962 to 1966 and for the ten-year period

TABLE 22. RELATIONS BETWEEN LOAN OBTAINED FROM THE DEPARTMENT OF HAWAIIAN HOME LANDS AND NET RANCH INCOMES AND CAPITAL INVESTMENTS

Dependent Variable	Total loan from 1962 to 1966		Ten year loan (1956-1966) total	
	Correlation Coefficient	t-value	Correlation Coefficient	t-value
Net ranch income	0.24	$1.194^{n.s.}$	0.08	$0.400^{n.s.}$
Capital investment				
Fence	0.10	$0.470^{n.s.}$	-0.06	$-0.311^{n.s.}$
Watering facilities	0.44	2.374^{*}	0.50	2.739^{**}
Loading facilities	-0.06	$-0.282^{n.s.}$	-0.04	$-0.181^{n.s.}$
Improvements	0.35	1.796^{a}	0.28	1.405^{b}
Livestock	0.24	$1.184^{n.s.}$	0.24	$1.167^{n.s.}$
Motor vehicle	0.32	1.636^{b}	0.54	3.116^{**}
Equipment	0.08	$0.375^{n.s.}$	0.08	$0.375^{n.s.}$
Total investment	0.28	1.387^{b}	0.30	1.494^{b}

*Significant.
**Highly significant.
^{a}Significant at ten percent level of significance.
^{b}Significant at 20 percent level of significance.
$^{n.s.}$Not significant at 20 percent level of significance.

(1956-1966) were correlated with their net ranch incomes and with capital investment. The net ranch incomes and capital investments were for the year 1966. The reason for separating the effect of the loan total for the period from 1962 to 1966 from the ten-year period is to show whether most recent loans (totals from 1962 to 1966) had more impact than the entire ten-year period loan.

The analysis showed no correlation between net ranch income and total loans obtained from 1962 to 1966 or the total for the ten-year period from 1956 to 1966. Correlation analysis conducted on capital investments showed some interesting results. The analysis was conducted on the individual items that comprised the capital investment such as fence, watering facilities, and loading facilities which comprised the investment on improvement and the other items such as livestock, motor vehicles and equipment.

Investment on watering facilities is associated with the 1962-1966 loan total and with the 1956-1966 total. It is more highly correlated with the latter total though. Investment on improvements; fence, watering facilities and loading facilities lumped together, is significantly related with the 1962-1966 loan total at the ten percent level of significance and with 1956-1966 loan totals at a lower level of significance, 20 percent. The other investment item found associated with 1962-1966 and 1956-1966 loan totals is investment on motor vehicles. Total investment as a composite item is also found to be associated with both the 1962-1966 and 1956-1966 loans. The significance levels are not high though.

This suggests that the loans obtained by the ranchers from the

Department of Hawaiian Home Lands made no great impact on income of the ranchers and on the ranch capital investment in general. The analysis may at fault be due to the small amount of loan that each rancher obtained. Methods of substituting for borrowed capital, livestock raised under contract, financing operations via outside employment, etc. would need to be included to determine the full impact of outside capital on ranch income.

The Effect of Ranch Size

The law limits the size of ranch to be leased to bona-fide Hawaiians to approximately 300 acres per ranch. To determine the impact of this restriction on ranch resource organization and level of achievement, it was necessary to analyze the effect of (1) the other measures of ranch size, (2) the efficiency measures, and (3) the various range improvement practices on net ranch income. A multiple linear regression analysis was also conducted to determine the multiple effect of the other measures of ranch size and the measures of efficiency on net ranch incomes.

The measures of ranch size. There are four other measures of ranch size considered; total animal units, total investment, total pounds of beef sold, and total non-livestock investment. The effect of these measures on net ranch income is presented in Table 23.

To achieve higher levels of income than the potentials projected, it would be necessary for the ranchers to intensify the use of the 300-acre ranch as shown by the analysis of the effect of the four other measures of ranch size on ranch income. Of the four other measures of ranch size, three were found to be positively related to net ranch income.

TABLE 23. RELATIONSHIP BETWEEN NET RANCH INCOME PER RANCH AND VARIOUS MEASURE OF RANCH SIZE, 36 WAIMEA PROJECT RANCHERS, 1966

Measure of ranch size (per ranch)	Simple correlation coefficient	Coefficient of determination
Total pounds of beef sold	0.87**	0.76
Total animal units	0.40*	0.16
Total investment	0.37*	0.14
Total non-livestock investment	0.08n.s.	0.01

*Significant.
**Highly significant.
n.s. Insignificant at 5 percent level.

These more nearly represent increases and improvement in the beef cattle herd than in other basic inputs. These indicate that variations in net ranch incomes can best be explained by the variations in total pound of beef sold, about 76 percent. Only about 16 percent can be explained by the variations in total animal units and 14 percent by total investment per ranch.

The only measure of ranch size found to be uncorrelated with net ranch income is the total non-livestock investment; which logic would suggest may be the most appropriate measure of intensity in the conventional sense. This could be an indication of low level of non-livestock investment in relation to ranch size (that is, absence of any real intensification) or inability to measure significant non-livestock investments by aggregating all non-livestock investment together or the inappropriate mix of non-livestock investments in relation to ranch size. The non-livestock investment consisted of investment on improvements like fences, watering facilities and loading facilities; motor vehicles including tractor; and ranch equipment. The implication of this analysis is that for the project as a whole there is little indication of efforts to intensify to improve the productivity of the grazing resource.

Efficiency measures. Price received by the ranchers for their beef was quite low. It remained to be seen how ranchers could efficiently use the factors under their control to make their ranching operations financially successful. Some efficiency measures were analyzed to determine how their variations affect net ranch income. These measures are: (1) total pounds of beef sold per animal unit, (2) total investment per animal unit, (3) total non-livestock investment per animal unit, (4) percent calving at weaning, (5) total investment per hundredweight

of beef sold, and (6) total non-livestock investment per hundredweight of beef sold.

Presented in Table 24 are the coefficients of simple correlation which measure the degrees of association between ranch income and the efficiency measures associated with it. Negative correlation existed between four measures of efficiency and net ranch income. These measures are total investment per animal unit, total non-livestock investment per animal unit, total investment per hundredweight of beef sold, and total non-livestock investment per hundredweight of beef sold. In the former two measures, the coefficients are quite low though. Only about six percent of the variation in net ranch incomes can be explained by the variation in total investment per animal unit and only 12 percent by the variation in total non-livestock investment per animal unit.

Multiple linear regression analysis. It is the purpose of this section to determine the multiple effect of the factors found to be associated with net ranch income. The analysis previously undertaken was simple correlation. In the multiple regression analysis, the measures of ranch size and the measures of efficiency were considered in groups with one ranch size measure taken at a time. There are four measures of ranch size and six measures of ranching efficiency. Each measure of ranch size was paired with the six measures of efficiency and the multiple effect of these measures on net ranch income was determined.

However, not all the measures of efficiency were used in the analysis. If any two of the measures of efficiency were correlated, then one of them was eliminated in the final regression analysis.[52]

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[52]If found significant at five percent level of significance.

TABLE 24. RELATIONSHIPS OF SOME MEASURES OF RANCHING EFFICIENCY AND NET RANCH INCOME, 36 WAIMEA PROJECT RANCHERS, 1966

Efficiency measures	Simple correlation coefficient	Coefficient of determination
Total pounds of beef sold per animal unit	0.78**	0.61
Total non-livestock investment per animal unit	-0.34*	0.12
Total investment per animal unit	-0.24*	0.06
Total investment per cwt. of beef sold	-0.71**	0.50
Total non-livestock investment per cwt. of beef sold	-0.54**	0.29
Percent calving at weaning	0.13n.s.	0.02

*Significant.
**Highly significant.
n.s. Insignificant at 5 percent level.

This was to insure that the independent variables were not inter-correlated.

Preliminary analysis showed significant correlation among some of the measures of efficiency. The correlation matrix is shown in Table 25. Among the efficiency measures found to be correlated are total pounds of beef sold per animal unit and total investment per hundredweight of beef sold (E_1 and E_3), total investment per animal unit and total non-livestock investment per animal unit (E_2 and E_4), total investment per animal unit and total non-livestock investment per hundredweight of beef sold (E_2 and E_5), total investment per hundredweight of beef sold and total non-livestock investment per hundredweight of beef sold (E_3 and E_5), and total non-livestock investment per animal unit and total non-livestock investment per hundredweight of beef sold (E_4 and E_5).

The final multiple regression analysis was done in a stepwise manner. At each step of the regression, one independent variable is added to the regression equation.[53] The one which contributes to the greatest reduction in the error of sum of squares is added first and the rest of the variables are added (one at a time) according to their error-sum-of-squares-degree of reduction. This is equivalent to saying that this is the variable which has the highest partial correlation with the dependent variable, omitting the variations due to the variables which have already been added.[54]

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[53]W. J. Dixon, ed., BMD Biomedical Computer Programs, Automatic Computation No. 2, University of California, Berkeley and Los Angeles, 1967.

[54]Ibid., p. 233.

TABLE 25. CORRELATION MATRIX AMONG THE SIX MEASURES OF RANCHING EFFICIENCY

Measures of Efficiency	E_1	E_2	E_3	E_4	E_5	E_6
Total pounds sold per animal unit (E_1)	1.00	0.07[b]	-0.81[a]	-0.02[b]	-0.35[b]	0.20[b]
Total investment per animal unit (E_2)		1.00	0.27[b]	0.96[a]	0.87[a]	0.30[b]
Total investment per cwt. of beef sold (E_3)			1.00	0.31[b]	0.67[a]	-0.14[b]
Total non-livestock investment per animal unit (E_4)				1.00	0.89[a]	0.26[b]
Total non-livestock investment per cwt. of beef sold (E_5)					1.00	0.16[b]
Calving percentage at weaning (E_6)						1.00

[a]Highly significant.
[b]Insignificant at 5 percent level.

There are nine regression equations considered after the preliminary elimination was done. The functions are:

I. $Y = F_1(X_1, E_1, E_2, E_6)$

II. $Y = F_2(X_2, E_1, E_2, E_6)$

III. $Y = F_3(X_2, E_1, E_4, E_6)$

IV. $Y = F_4(X_3, E_2, E_6)$

V. $Y = F_5(X_3, E_4, E_6)$

VI. $Y = F_6(X_4, E_1, E_6)$

VII. $Y = F_7(X_1, E_3, E_6)$

VIII. $Y = F_8(X_2, E_3, E_6)$

IX. $Y = F_9(X_4, E_3, E_6)$

where: Y = net ranch income

E = efficiency measures (See Table 25 for individual E)

X_1 = total pounds of beef sold

X_2 = total animal units

X_3 = total investment

X_4 = total non-livestock investment

The multiple coefficients of correlation and the multiple coefficients of determination resulting from the abovementioned regression analysis are shown in Table 26. The first three functions (F_1, F_2, and F_3) exhibited relatively quite high multiple correlation coefficients. Of the total variation in net ranch income, 87 percent can be explained by the variations in the variables jointly considered in each of the three functions. Statistically, this would mean that if the variables are varied in equal proportions, their joint variation would account for 87 percent of the variation in net ranch income.

The order of importance of the variables and their corresponding contributions in increasing the multiple coefficient of determination for the first three functions are shown in Table 27.[55]

[55]Summary of results of stepwise regression analysis for the other six functions is shown in Appendix E.

TABLE 26. THE MULTIPLE COEFFICIENTS OF DETERMINATION OF THE NINE FUNCTIONS

Function number[a]	Multiple coefficients of determination
I	0.87
II	0.87
III	0.87
IV	0.76
V	0.76
VI	0.62
VII	0.64
VIII	0.65
IX	0.55

[a]Refer to Table 25 and page 91 for the variables considered in each of the functions.

TABLE 27. SUMMARY OF RESULTS OF STEPWISE REGRESSION ANALYSIS FOR THE FIRST THREE FUNCTIONS

Variable included[a]	Multiple coefficients of determination (R^2)	Increase in R^2
Function I (F_1)		
E_1	0.6080	0.6080
X_1	0.8556	0.2476
E_2	0.8741	0.0185
E_6	0.8748	0.0006
Function II (F_2)		
E_1	0.6080	0.6080
X_2	0.8067	0.1987
E_2	0.8674	0.0607
E_6	0.8681	0.0007
Function III (F_3)		
E_1	0.6080	0.6080
X_2	0.8067	0.1987
E_4	0.8728	0.0661
E_6	0.8735	0.0007

[a]Refer to Table 25, page 90 for the meaning of the variable symbols.

It was revealed in each of the first three functions that total pounds sold per animal unit (E_1) was the first variable added to the regression equation in a stepwise manner. As a single important factor, its variation contributed about 61 percent of the variation in net ranch income. It is also interesting to note that efficiency in terms of total pounds of beef sold per animal unit in combination with total animal units can explain 86 percent of the variations in net ranch income, an increase of 25 percent in the coefficient of multiple determination.

Simple correlation analysis relating ranch income to some other measures of ranch size or intensity and to some measures of ranching efficiency indicates some interesting relationships. However, a relatively large portion of the variations in ranch income had not been fully explained by the factors associated with it. This observation had been substantiated by the multiple regression analysis between income as the dependent variable and the independent variables in terms of the combination of the measures of ranch size or intensity and measures of ranching efficiency.

The multiple regression analysis indicates that for a 300-acre ranch, some ranchers showed that income could be increased by increasing the size of operation in terms of getting more livestock to the market and increasing the efficiency of operations in terms of total beef sold per animal unit, total investment per animal unit and by higher calving percentage at weaning.

While improvement in the levels of achievement is possible in a 300-acre ranch, the limits by which this improvement can be further

extended could not be explained fully by the abovementioned regression analysis. It is possible that the size of ranch is limiting the ability of some ranchers to achieve higher levels of income. This could be explained by the fact that the factors associated with net ranch income in the multiple regression analysis accounted only about 87 percent of the variations in net ranch income.

Range improvement practices and net ranch income. The data used in this part of the analysis were obtained from the records of individual sample ranchers kept at the county office of the Office of Agricultural Stabilization and Conservation Service, County of Hawaii. The data gathered were costs of improvement practices such as pasture establishment or improvement, fencing, installation of watering facilities like storage tanks, water pipes, dams, and ponds or water troughs, and other related range improvement practices. The size and/or quantity of the improvement practices were also obtained.

In the analysis, the factors thought to be associated with net ranch income are: (1) total improvement cost, (2) average annual improvement cost, (3) total area seeded, and (4) total area improved since 1960. Included in total improvement costs are the costs of all range improvement practices for which the ranchers obtained Agricultural Conservation Practices (ACP) benefits. The average annual improvement cost is the total improvement cost divided by the number of years the improvement had been carried through. The total area seeded is the area seeded since seeding practice was adopted. Total area improved are those areas seeded, fertilized, graded, and/or limed since 1960.

The simple correlation coefficients and the results of the statistical tests of the correlation analysis between net ranch incomes and the factors of range improvement practices are shown in Table 28. Total improvement cost as a factor was found to be highly associated with net ranch income. Total area seeded was also correlated with net ranch income, though correlation was found to be significant at only the 30 percent level of significance.

The analysis on the effect of ranch size implies that ranch income could be improved by (1) adopting higher rate of stocking at least to the maximum that each ranch capacity would permit, (2) by increasing production per unit and (3) by more intensified use of present ranch resources.

TABLE 28. RELATIONSHIPS BETWEEN NET RANCH INCOME AND SOME FACTORS OF RANGE IMPROVEMENT PRACTICES

Factor or range improvement practices	Simple correlation coefficient	t-value
Total improvement costs (dollars)	0.52	3.057[a]
Average annual improvement (dollars)	0.09	0.466[c]
Total area seeded (acres)	0.30	1.224[b]
Total area improved since 1960 (acres)	0.22	0.743[c]

[a]Highly significant.
[b]Significant at 30 percent level.
[c]Insignificant at 30 percent level.

CHAPTER V

ANALYSIS OF SOME POTENTIAL ALTERNATIVES FOR INCREASING RETURNS FROM RANCHING

The objective of this chapter is to formulate various alternatives available to the ranchers to increase income from their ranches. Budgeting and budgeting combined with Bayesian statistics are used in formulating the various alternatives.

The Impact of Increasing Stocking Rate on Ranch Incomes

Cattle ranching as practiced by the ranchers in the Waimea project depends largely on the availability of range grass for feed. However, very few of the ranchers appeared to be stocking their ranches even to the potential average stocking rate (acres per animal unit) that the ranches can maintain at the time of the survey. This section will show how ranch incomes could be increased by increasing the stocking rate that the individual ranches can maintain, thus increasing the animal carrying capacity (total animal units per ranch) of the ranches.

Regression analysis was used to obtain the technical coefficients used in budgeting. The results of the regression analysis are presented in Appendix F.

A regression equation which is linear in logarithms was selected as best. In the derived equations, all of the expense items per animal unit were significantly correlated with the independent variable (total animal units per ranch) except the item on repair and maintenance expense per animal unit. The technical coefficient used in this case was the average repair and maintenance expense per animal unit for the 34 ranchers or $2.22 per animal unit. The resulting regression equations for the other

seven expense items were:

I. Hired labor per animal unit as dependent variable

$$Y = 28.57X^{-0.38685}$$

II. Veterinary services and supplies per animal unit as dependent variable

$$Y = 2.023X^{-0.36398}$$

III. Taxes on land and improvements per animal unit as dependent variable

$$Y = 224.64X^{-1.02669}$$

IV. Salt and mineral per animal unit as dependent variable

$$Y = 0.158X^{-0.39903}$$

V. Depreciation per animal unit as dependent variable

$$Y = 37.22X^{-0.41486}$$

VI. Interest on operating expenses per animal unit as dependent variable

$$Y = 4.03X^{-0.41663}$$

and

VII. Interest on capital investment per animal unit as dependent variable

$$Y = 18.82X^{-0.14606}$$

where:

X = the independent variable measured in total animal units per ranch

The particular technical coefficient was obtained by inserting the total animal units given the stocking rate respectively for each particular expense item per animal unit into the respective equations.

Budgets were then constructed using these coefficients.

The budgets assuming six stocking rates are shown in Tables 29, 30, 31 and 32. Capital investments consisted of livestock and non-livestock investments. Cows were valued at $150 each, bulls at $300, heifers at $125, steers at $130, yearlings at $100, and calves at $75 each. The non-livestock investment consisted of the 1966 dollar value of ranch buildings, equipment, motor vehicles, and ranch improvements based on the average requirement per animal unit.

Note that the number of cows for the different stocking rates for the corresponding cattle systems were not the same. There were more cows at each stocking rate in the cow-calf system than at each corresponding stocking rate in the cow-yearling system. The budgets were so constructed in this manner to satisfy the restriction on stocking rate.[56]

The budgets show that ranchers would be in a better position with respect to income if they keep the calves to yearling age before selling assuming no changes in prices and marketing. At four percent death rate for the cow-calf system, net ranch income amounted to about $4,234 for the best ranch (represented by heavy stocking rate). It was about $4,618 if the death rate was at two percent. For cow-yearling, the corresponding net ranch incomes were $6,303 and $6,664 respectively. These represent increases in incomes of 33 percent at four percent death rate and 31 percent at two percent death rate over a cow-calf operation.

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[56]The total animal units must not exceed the total animal units required for a given stocking rate on a 300-acre ranch.

TABLE 29. BUDGET SHOWING NUMBER OF COWS, CAPITAL INVESTMENT, AND COSTS AND RETURNS PER RANCH UNDER DIFFERENT STOCKING RATES, COW-CALF SYSTEM WITH ASSUMED DEATH RATE OF TWO PERCENT

Item	Stocking rate (acres per animal unit)					
	4.00	3.50	3.00	2.50	2.00	1.50
Number of cows	47	53	62	74	93	125
			Dollars			
Capital investment						
Livestock	11,250.00	12,500.00	14,425.00	17,575.00	22,000.00	29,700.00
Non-livestock	6,079.80	6,607.60	7,387.80	8,279.40	9,485.80	11,096.60
Total investment	17,329.80	19,107.60	21,812.80	25,854.40	31,485.80	40,796.60
Receipts						
Sale of calves	2,408.70	2,641.80	3,108.00	3,729.60	4,662.00	6,293.70
Sale of culled cows	1,143.30	1,333.85	1,524.40	1,905.50	2,286.60	3,048.80
Total receipts	3,552.00	3,975.65	4,632.40	5,635.10	6,948.60	9,342.50
Expenses						
Cash expenses (subtotal)	898.98	956.18	1,041.61	1,166.42	1,336.27	1,610.47
Hired labor	463.71	498.17	548.85	621.22	716.65	863.83
Repair and maintenance	168.25	187.41	217.21	263.07	329.41	444.72
Vet. services & supplies	36.25	39.04	43.16	49.07	56.89	69.05
Taxes	228.34	228.95	229.52	229.82	229.59	228.39
Salt and mineral	2.43	2.61	2.87	3.24	3.73	4.48
Non-cash expenses (subtotal)	1,459.09	1,590.08	1,787.01	2,076.68	2,472.96	3,113.94
Depreciation	535.10	573.13	628.83	707.95	811.57	970.06
Interest on operating expenses (6%)	57.50	61.57	67.54	76.01	87.10	104.05
Interest on capital investment (5%)	866.49	955.38	1,090.64	1,292.72	1,574.29	2,039.83
Total expenses	2,358.07	2,546.26	2,828.62	3,243.10	3,809.23	4,724.41
Net returns[a]	1,193.93	1,429.39	1,803.78	2,392.00	3,139.37	4,618.09

[a]Returns to land and management.

TABLE 30. BUDGET SHOWING NUMBER OF COWS, CAPITAL INVESTMENT, AND COSTS AND RETURNS PER RANCH UNDER DIFFERENT STOCKING RATES, COW-CALF SYSTEM WITH ASSUMED DEATH RATES OF FOUR PERCENT

Item	Stocking rate (acres per animal unit)					
	4.00	3.50	3.00	2.50	2.00	1.50
Number of cows	47	53	62	74	93	125
			Dollars			
Capital investment						
Livestock	11,250.00	12,500.00	14,425.00	17,575.00	22,000.00	29,700.00
Non-livestock	6,079.80	6,607.60	7,387.80	8,279.40	9,485.80	11,096.60
Total investment	17,329.80	19,107.60	21,812.80	25,854.40	31,485.80	40,796.60
Receipts						
Sale of calves	2,408.70	2,641.80	3,108.00	3,729.60	4,662.00	6,293.70
Sale of culled cows	952.75	1,143.30	1,333.85	1,524.40	1,905.50	2,667.70
Total receipts	3,361.45	3,785.10	4,441.85	5,254.00	6,567.50	8,961.40
Expenses						
Cash expenses (subtotal)	898.98	956.18	1,041.61	1,166.42	1,336.27	1,610.47
Hired labor	463.71	498.17	548.85	621.22	716.65	863.83
Repair and maintenance	168.25	187.41	217.21	263.07	329.41	444.72
Vet. services & supplies	36.25	39.04	43.16	49.07	56.89	69.05
Taxes	228.34	228.95	229.52	229.82	229.59	228.39
Salt and mineral	2.43	2.61	2.87	3.24	3.73	4.48
Non-cash expenses (subtotal)	1,459.09	1,590.08	1,787.01	2,076.68	2,472.96	3,113.94
Depreciation	535.10	573.13	628.83	707.95	811.57	970.06
Interest on operating expenses (6%)	57.50	61.57	67.54	76.01	87.10	104.05
Interest on capital investment (5%)	866.49	955.38	1,090.64	1,292.72	1,574.29	2,039.83
Total expenses	2,358.07	2,546.26	2,828.62	3,243.10	3,809.23	4,724.41
Net returns[a]	1,003.38	1,238.84	1,613.23	2,010.90	2,758.27	4,236.99

[a]Returns to land and management.

TABLE 31. BUDGET SHOWING NUMBER OF COWS, CAPITAL INVESTMENT, AND COSTS AND RETURNS PER RANCH UNDER DIFFERENT STOCKING RATES, COW-YEARLING SYSTEM WITH ASSUMED DEATH RATE OF TWO PERCENT

Item	Stocking rate (acres per animal unit)					
	4.00	3.50	3.00	2.50	2.00	1.50
Number of cows	43	50	58	69	87	115
			Dollars			
Capital investment						
Livestock	11,000.00	12,700.00	14,625.00	17,600.00	21,875.00	29,175.00
Non-livestock	6,119.00	6,854.80	7,861.21	8,513.60	9,896.20	11,395.20
Total investment	17,119.00	19,554.80	22,486.20	26,113.60	31,771.20	40,570.20
Receipts						
Sale of calves	3,234.00	3,696.00	4,389.00	5,197.50	6,583.50	8,662.50
Sale of culled cows	1,081.50	1,081.50	1,442.00	1,622.25	1,982.75	2,703.75
Total receipts	4,315.50	4,777.50	5,831.00	6,819.75	8,566.25	11,366.25
Expenses						
Cash expenses (subtotal)	891.87	969.97	1,063.06	1,174.32	1,344.78	1,603.87
Hired labor	459.41	506.68	561.17	625.74	721.34	860.38
Repair and maintenance	165.90	191.84	224.74	266.06	332.85	441.84
Vet. services & supplies	35.90	39.73	44.61	49.44	57.28	68.77
Taxes	228.25	229.07	229.61	229.82	229.56	228.42
Salt and mineral	2.41	2.65	2.93	3.26	3.75	4.46
Non-cash expenses (subtotal)	1,442.93	1,622.83	1,835.63	2,095.09	2,492.84	3,098.53
Depreciation	530.35	582.51	642.34	712.87	816.64	966.36
Interest on operating expenses (6%)	56.99	62.58	68.98	76.54	87.64	103.66
Interest on capital investment (5%)	855.59	977.74	1,124.31	1,305.68	1,588.56	2,028.51
Total expenses	2,334.80	2,592.80	2,898.69	3,269.41	3,837.62	4,702.40
Net returns[a]	1,980.70	2,184.70	2,932.31	3,550.34	4,728.63	6,663.85

[a]Returns to land and management.

TABLE 32. BUDGET SHOWING NUMBER OF COWS, CAPITAL INVESTMENT, AND COSTS AND RETURNS PER RANCH UNDER DIFFERENT STOCKING RATES, COW-YEARLING SYSTEM WITH ASSUMED DEATH RATE OF FOUR PERCENT

Item	Stocking rate (acres per animal unit)					
	4.00	3.50	3.00	2.50	2.00	1.50
Number of cows	43	50	58	69	87	115
			Dollars			
Capital investment						
Livestock	11,000.00	12,700.00	14,625.00	17,600.00	21,875.00	29,175.00
Non-livestock	6,119.00	6,854.80	7,861.21	8,513.60	9,896.20	11,395.20
Total investment	17,119.00	19,554.80	22,486.20	26,113.60	31,771.20	40,570.20
Receipts						
Sale of calves	3,234.00	3,696.00	4,389.00	5,197.50	6,583.50	8,662.50
Sale of culled cows	901.25	901.25	1,081.50	1,442.00	1,802.50	2,343.25
Total receipts	4,135.25	4,597.25	5,470.50	6,639.50	8,386.00	11,005.75
Expenses						
Cash expenses (subtotal)	891.87	969.97	1,063.06	1,174.32	1,344.78	1,603.87
Hired labor	459.41	506.68	561.17	625.74	721.34	860.38
Repair and maintenance	165.90	191.84	224.74	266.06	332.85	441.84
Vet. services & supplies	35.90	39.73	44.61	49.44	57.28	68.77
Taxes	228.25	299.07	229.61	229.82	229.56	228.42
Salt and mineral	2.41	2.65	2.93	3.26	3.75	4.46
Non-cash expenses (subtotal)	1,442.93	1,622.83	1,835.63	2,095.09	2,492.84	3,098.53
Depreciation	530.35	582.51	642.34	712.87	816.64	966.36
Interest on operating expenses (6%)	56.99	62.58	68.98	76.54	87.64	103.66
Interest on capital investment (5%)	855.59	977.74	1,124.31	1,305.68	1,588.56	2,028.51
Total expenses	2,334.80	2,592.80	2,898.69	3,269.41	3,837.62	4,702.40
Net returns[a]	1,800.45	2,004.45	2,571.81	3,370.09	4,548.38	6,303.35

[a]Returns to land and management.

There would virtually be no added costs in keeping the calves to yearling ages except for the cost of rotating the animals to different pastures. The cost of these chores would not be very substantial. Furthermore, the added weights would more than offset the relatively lower price for yearling calves, barring of course, death from calves resulting from injuries and diseases. This would imply that good ranching management is being practiced.

Comparison of actual performance and potential alternatives. Comparisons can be made of actual performance of the ranchers and budgets prepared. Table 19 shows that the average net ranch income per ranch of the 36 sample ranchers was about $1,374. Their average stocking rate was 3.70 acres per animal unit and the average calving percentage was 78.76 percent at weaning time. These figures can be compared with the budget at the stocking rate of 3.50 acres per animal unit.

The average income realized by the sample ranchers was high for a cow-calf system with four percent death rate and almost the same as for a cow-calf system with death rate of two percent. When compared with the cow-yearling system budgets of the same stocking rate, the average income achieved by the ranchers was relatively low.

Presented in Table 33 is the distribution of net ranch incomes of the sample ranchers. The stocking rate interval represent the budgeted stocking rates represented in Tables 29 to 32. The actual average incomes achieved by the ranchers under each stocking rate interval were lower than the corresponding incomes under each assumed stocking rate.

The average income achieved by the ranchers stocking at the rate of 1.50 acres per animal unit or less was 70 percent of the potential income

TABLE 33. DISTRIBUTION OF NET RANCH INCOME BY STOCKING RATES, 36 RANCHERS, WAIMEA PROJECT, 1966

Stocking rates (acres per animal unit)	Number of ranch reporting	Average net ranch income ($)[a]
1.50 & less	4	3,250
More than 1.50 - 2.00	8	1,378
More than 2.00 - 2.50	6	1,525
More than 2.50 - 3.00	7	1,365
More than 3.00 - 3.50	-	--
More than 3.50 and above	11	540
Total (average)	36	(1,374)

[a]Returns to labor and management.

budgeted for the same stocking rate under a cow-calf operation (with two percent death rate). In the other stocking rate interval for the same cattle system, the percentages were 44 percent for stocking rate interval of more than 1.50 to 2.00 acres per animal unit, 65 percent for interval of more than 2.00 to 2.50, 76 percent for interval of more than 2.50 to 3.00, and 45 percent for interval of more than 3.50 and above. For a cow-yearling operation, the respective percentages were supposed to be higher in each corresponding stocking rate. Corresponding incomes in the cow-yearling system were higher with the respective incomes in the cow-calf system.

Potentials for increasing stocking rates. Possibilities exist for improving the stocking rates of the individual ranches. Based on land suitability classification of the ranches in Waimea, it was found that there are 21 ranches (or 40 percent of the total number of ranches) whose stocking rates can be increased to the maximum of 1.50 acres per animal unit or better (Table 34). This can be done just be depending on the inherent productivity of the range land. Only one-fourth (13 ranches) may be considered very poor because of the very low maximum potential stocking rates based on the ranching suitability classification. The stocking rates of the rest of the ranches can be improved substantially by adopting good ranch improvement practices.

It is useful to show actual performance of the ranches regarding the stocking rates for these ranches. The purpose is to compare the actual stocking rates with the potential maximum, minimum, and average stocking rates. This was done in Table 35.

TABLE 34. DISTRIBUTION OF STOCKING RATES BASED ON POTENTIAL MAXIMUM AND AVERAGE STOCKING RATES FOR THE 52 RANCHES AND FOR THE SAMPLE RANCHES, WAIMEA[a]

Stocking rate intervals (Acres/A.U.)	Based on maximum stocking rate		Based on average stocking rate	
	Number of ranches			
Less than 1.51	21	(17)[b]	9	(8)
1.51 - 2.00	2	(3)	10	(7)
2.01 - 2.50	11	(9)	3	(3)
2.51 - 3.50	4	(1)	3	(3)
3.51 - 4.00	1	(2)	10	(8)
4.01 and above	13	(5)	17	(8)
Total	52	(37)	52	(37)

[a]The potential stocking rates were obtained from the Land Study Bureau, "Detailed Land Classification--Island of Hawaii," Land Study Bureau Bulletin No. 6, 1965. The average stocking rates were the weighted averages of the maximum and minimum stocking rates according to the particular land class.

[b]The figures in parentheses represent the number of sample ranches.

TABLE 35. COMPARISON OF ACTUAL STOCKING RATES WITH THE POTENTIAL MAXIMUM, MINIMUM, AND AVERAGE STOCKING RATES, 37 RANCHERS, 1966, WAIMEA

Potential stocking rate	Actual stocking rate higher than	Actual stocking rate lower than	Total
	Number reporting		
Maximum	13	24	37
Minimum	26	11	37
Average	17	20	37
	Percent		
Maximum	35	65	100
Minimum	70	30	100
Average	46	54	100
	Average net ranch income per ranch		
	(Dollars)		
Maximum	1,680.06	1,195.00	--
Minimum	1,602.20	807.56	--
Average	1,423.00	1,330.00	--

It is interesting to note that there were 11 out of 36 ranchers (or 30 percent) who were stocking their ranches even below the minimum that the ranches could hold. However, almost the same number (13 ranches) stocked their ranches above the maximum potential stocking rate. On the average there were more ranchers who understocked their ranches (54 percent) than there were those who overstocked their ranches (46 percent).

The divergence of the actual stocking rates from the potential (maximum, minimum or average) stocking rates had a great impact on net ranch incomes. Ranchers who stocked their ranches above the maximum potential rate appeared to have higher ranch incomes than those who stocked their ranches below the maximum potential. There were some ranchers (30 percent of the sample ranchers) who stocked their ranches below the minimum potential rate that the particular ranches were suited for. These ranchers, on the average, realized exceedingly low net ranch incomes (about $808), while those who stocked above the minimum realized almost twice as much (an average of about $1,602).

It is also of particular interest to note that of the 13 ranchers who stocked their ranches above the maximum rate, 12 have potential stocking rate of 2.50 acres per animal unit or below. Seven of these ranchers can stock their ranches on the maximum of not more than 3.00 acres per animal unit. Nevertheless, these ranchers were able to improve the animal carrying capacities of their ranches through increased stocking rates by adopting good pasture improvement practices. Most of these ranchers were beneficiaries of Agricultural Conservation Practices (ACP) benefits obtained through the Office of the Agricultural Stabilization and Conservation Service (ASCS).

Use of community pasture as an alternative to increasing stocking rate. It seems evident that with the development and improvement of the water system for livestock use,[57] there might be a shift in the role for which the community pasture had been oriented. Instead of using it for emergency purposes only, it can be looked upon as an extension of the land resource of the individual ranchers where they can keep their calves to maturity before selling. The same policy of charging a fee per head per month could be adopted. However, the problem that cases the administrators of the program is how the present policy could be adapted to this change in approach to make it more equitable to all ranchers so that the highest benefit can be obtained. It is not the intent of this section to show how the problem can be resolved. What was attempted here was to construct some partial budgets to show the impact on individual ranch incomes of changing the whole concept of the use of the community pasture.

In preparing the budget to show the impact on ranch incomes of the use of community pasture, various assumptions were made. The stocking rate assumed was 4.00 acres per head of cattle per year. At this rate, it is possible to carry 225 head of cattle. If all the 53 ranchers decided to use the community pasture, each rancher can place 4.33 head. While some areas in the community pasture can be stocked above the assumed rate, the objective here is to show that even at this low rate, some monetary benefits to the ranchers are still possible. Furthermore,

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[57]To minimize the adverse effect of drought and to supply the water needs of other ranchers who have a water problem.

the assumption of 4.00 acres per animal unit stocking rate takes into consideration long run consequences of over-grazing and adverse weather conditions. The partial budget constructed assumed that only weaned calves should be placed in the community pasture. It was further assumed that a head of cattle is equivalent to one animal unit.

Weaning age assumed was eight months. Weaned calves stay in the community pasture from five to six months. During the year a rancher can place a maximum of 8.66 animal units in the pasture if he elects to do so. Yearlings weigh 660 pounds each at marketing time. The price assumed was 17.50 cents per pound liveweight. The ranchers pay a fee of $2.00 per head per month for every head of cattle placed in the community pasture.

With the abovementioned assumptions, a partial budget was constructed and presented below. The budget shows the increase in returns as a result of putting five weaners in the community pasture.[58]

The Impact on Ranch Incomes of Uncertainty in Range Conditions

Uncertainty of range conditions may have a great effect on the incomes of ranchers in the project area. The incomes are affected in two ways. First, if the ranchers stocked their ranches above the rate that the ranches could sustain, the available feeds will be very limited and thus affect the growth of the animals; and the ranchers may have cattle to sell at very low weights. If the feed deficit is too great, the ranchers may be forced to sell cattle before they reached selling

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[58]The number of weaners was determined on the basis of 0.80 animal units per weaner as it reaches the yearling age (or 4.33 divided by 0.80 equals 5.44).

PARTIAL BUDGET A. PUTTING FIVE WEANERS IN THE COMMUNITY PASTURE FOR A PERIOD OF FIVE MONTHS

a.	Added costs				
	Pasture fee[a]	$ 50.00			
	Delivery[b]	20.00			
	Labor[b]	16.65			
	Insurance[b]	0.50			
	Horse use[b]	18.75	c.	Added returns	
	Equipment & fuel[b]	6.25		Sale of six yearlings[c]	$557.50
	Corral use[b]	8.35			
b.	Reduced returns	-----	d.	Reduced costs	------
	Subtotal A	$121.35		Subtotal B	$557.50
		Estimated change	(B - A)		$436.15

[a]For five months at the rate of $2.00 per head per month.
[b]Obtained from record of one of the ranchers.
[c]Based on 660 pounds per head and the price of 17.50 cents per pound liveweight.

selling ages or face possible animal losses resulting from deaths. Second, if the ranchers stock their ranches below the rate the ranches can sustain, large amount of feeds go unutilized, thereby opportunity for higher income is foregone. The optimum stocking rate is that rate which maximizes the weighted average (expected) net income (or minimizes expected losses). The method employed in determining the optimum strategy (one which maximizes expected net income or minimizes expected losses) was the method of Bayesian statistics.[59]

Assumptions in constructing the pay-off matrix. In constructing the pay-off matrix (net ranch incomes for each combination of stocking rates and range conditions) for the two types of cattle system, certain assumptions were made regarding the effects of stocking rate on calving percentage at weaning, weights of weaned calves, yearlings, and culled cows, and the death rate of mature livestock. It was assumed that calving percentage at weaning is affected by the stocking rate. Weights of weaned calves, yearlings, and culled cows and death rates of matured livestocks were also assumed to be affected by the stocking rates. Heavier animals were the results of lighter stocking rates and death rates were higher at heavier stocking rates. These assumptions were based on the study conducted by Houston and Woodward.[60]

The assumed functional relationships relating calving percentage at weaning to stocking rate for the four assumed range conditions are shown below.

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[59]The method of Bayesian statistics is discussed in Appendix A.

[60]W. R. Houston and R. R. Woodward, "Effects of Stocking Rates on Range Vegetation and Beef Cattle Production in the Northern Great Plains," Technical Bulletin No. 1357. U. S. Department of Agriculture, January, 1966.

Function I (Very poor range condition)

$$Y_1 = 10.573\ (e^{0.330X} + 2.216)$$

Function II (Poor range condition)

$$Y_2 = 12.799\ (e^{0.361X} + 1.734)$$

Function III (Normal range condition)

$$Y_3 = 1.409\ (e^{1.253X} + 28.108)$$

Function IV (Excellent range condition)

$$Y_4 = 1.159\ (e^{1.198X} + 49.898)$$

Where:

Y = calving percentage at weaning

X = stocking rate (acres per animal unit)

The assumed weights of weaned calves, yearlings, and culled cows and the assumed death rates for each combination of stocking rates and range conditions are presented in Appendix F, Tables F-1, F-2, F-3, and F-4.

The expenses were budgeted based on the regression analysis presented in Appendix G, Table G-1. The cow herd replacement rate assumed is 15 percent for both cattle systems.

Optimum strategy for the cow-calf cattle systems. Four alternatives were considered regarding the stocking rates (ranging from five to six acres per animal unit to two acres per animal unit) that the ranchers may adopt under four kinds of range conditions. The budgeted net incomes associated with each combination of stocking rates and range conditions were presented in Table 36.

TABLE 36. NET RANCH INCOMES UNDER VARIOUS COMBINATION OF STOCKING RATES (ACRES PER ANIMAL UNIT) AND RANGE CONDITION, COW-CALF SYSTEM

Range condition	Stocking rates and net ranch incomes				Probabilities[a]
	5.00-6.00	4.00	3.00	2.00	
	dollars				
Very poor	897	523	294	-325	0.41
Poor	1,117	1,086	851	848	0.20
Normal	1,227	1,690	2,730	1,928	0.12
Excellent	1,255	1,690	2,730	2,998	0.27
Weighted average net income	1,077	1,091	1,356	1,077.21	1.00

[a]The a priori probabilities.

The weights used in calculating the expected net income for a particular stocking rate were the a priori probabilities shown also in the last column of Table 36. For stocking rate of five to six acres per animal unit, the expected net income is computed as follows:

$897 (0.41) + $1,117 (0.20) + $1,227 (0.12) + $1,255 (0.27) = $1,077

The rest of the weighted average net incomes were calculated in the same manner.

For the cow-calf system, the optimum stocking rate that will maximize long-run expected net income is the rate of three acres per animal unit. The expected net income at this rate is $1,356.

It would seem improbable that any of the ranchers will stock his ranch each year to that optimum rate assumed in Table 36. It is more probable that he will try to adjust his stocking rate to what he thinks will be the range condition of the year. Assuming that he does this, he can construct new probabilities based on certain phenomenon which he thinks (or from expert's opinion or historical data) has a good correspondence with the range conditions. One phenomenon that a rancher may observe is the amount of rainfall in the month of April. Analysis shows a high correlation between the amount of rainfall received for the month of April and the total annual rainfall.[61]

Four rainfall conditions were assumed in April. The classifications were as follows: rainfall of 1.99 inches and below, dry; 2.00 to 3.99 inches, little rain; 4.00 to 5.99 inches, good rain; and 6.00 inches and

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[61]Total annual rainfall was the basis for classifying range condition into very poor, poor, normal, and excellent.

above, plenty of rain. The probability for a particular rainfall condition given the range condition is shown in Table 37. Based on this probability distribution, the rancher with assistance from an Extension Specialist can compute the probability of what the range condition will be given the rainfall condition in April. The latter is the a posteriori probability referred to in Appendix A.

Under the new set-up in which a rancher stocks his ranch by observing the rainfall condition in April, the expected net incomes are as shown in Table 38. They were computed by using the a posteriori probabilities as weights. If the rancher observed that the April rainfall condition was dry and little rain his strategy was to stock his ranch at the rate of five to six acres per animal unit. For good rain and plenty of rain conditions, the optimum stocking rate is three acres per animal unit.

Net income in the long-run is improved by following the bundle of strategies whereby a rancher decides on a certain stocking rate by observing April rainfall condition. In this case, the long-run expected net income is $1,442 as compared to $1,356, the long-run expected net income based on long-run probabilities of range condition (Table 36). The improvement in net income in the long-run is very small, however ($1,442 - $1,356 = $86).

Optimum strategy for the cow-yearling cattle system. The four alternatives in terms of stocking rates that a rancher may adopt were the same as in the cow-calf system. The expected net incomes for the various combinations of stocking rates and range conditions are presented in Table 39. The optimum stocking rate in the long-run is three acres

TABLE 37. THE OBSERVED RAINFALL CONDITIONS IN APRIL AND THE PROBABILITIES OF THEIR OCCURRENCE GIVEN THE RANGE CONDITIONS

Range condition	Observed rainfall conditions in April[a]				
	Dry	Little rain	Good rain	Plenty of rain	Total
Very poor	0.40	0.30	0.20	0.10	1.00
Poor	0.15	0.40	0.30	0.15	1.00
Normal	0.10	0.20	0.40	0.30	1.00
Excellent	0.05	0.15	0.30	0.50	1.00

[a]Adjusted to smooth out the uneven distribution of rainfall. For the original uneven distribution see Appendix H.

TABLE 38. NET RANCH INCOMES FOR VARIOUS STOCKING RATES (ACRES PER ANIMAL UNIT) USING REVISED PROBABILITIES ON THE BASIS OF AMOUNT OF RAIN RECEIVED IN THE MONTH OF APRIL, COW-CALF SYSTEM[a]

Rainfall condition in April	Stocking rates and expected net ranch incomes			
	5.00-6.00	4.00	3.00	2.00
	dollars			
Dry	968	729	614	142
Little rain	1,045	966	1,027	717
Good rain	1,112	1,207	1,586	1,335
Plenty of rain	1,177	1,431	2,115	2,037

[a]Revised probabilities technically are *a posteriori* probabilities. See calculations in Appendix A.

TABLE 39. NET RANCH INCOMES UNDER VARIOUS COMBINATIONS OF STOCKING RATES (ACRES PER ANIMAL UNIT) AND RANGE CONDITIONS, COW-YEARLING SYSTEM

Range condition	Stocking rates and net ranch incomes				Probabilities[a]
	5.00-6.00	4.00	3.00	2.00	
	dollars				
Very poor	1,670	1,450	888	747	0.41
Poor	2,000	2,001	1,800	1,360	0.21
Normal	2,048	2,656	3,747	3,212	0.12
Excellent	2,095	2,716	3,826	4,232	0.27
Weighted average net income	1,896	2,047	2,207	2,106	1.00

[a]The a priori probabilities.

per animal unit and the expected net ranch income is $2,207.

In revising the probabilities by observing April rainfall conditions, the expected net incomes are shown in Table 40. If a rancher observed dry rain condition in April, his action would be to stock five to six acres per animal unit. If little rain condition prevailed, he can stock his ranch at the rate of four acres per animal unit; good rain, three acres per animal unit; and plenty of rain, two acres per animal unit. This bundle of strategies will result to a long-run expected net income of $2,347. The improvement in the long-run expected net income as a result of revising the probabilities is $140.

The decision making process under risk and uncertainty using Bayesian approach could be improved further (making it more realistic) if the data were available regarding a phenomenon which a rancher could observe at the time the decision regarding stocking rate is made. In this analysis the probability distribution of April rainfall (the observable phenomenon) was partially assumed and partially based on empirical results to smooth out the uneven distribution. Another improvement that can be made is to incorporate price variation and be considered together with the variation in range conditions. Maybe a further improvement can be accomplished by incorporating risk brought about by the availability or the unavailability of stock of animals when decision is made to increase or decrease the stocking rate.

The Feasibility of Attaining the Potential Alternatives

Some potential alternatives of increasing returns from ranching have been discussed. They are discussed under conditions where the rancher as decision-maker has complete knowledge about the factors which

TABLE 40. NET RANCH INCOMES FOR VARIOUS STOCKING RATES (ACRES PER ANIMAL UNIT) USING REVISED PROBABILITIES ON THE BASIS OF AMOUNT OF RAIN RECEIVED IN THE MONTH OF APRIL, COW-YEARLING SYSTEM[a]

Rainfall condition in April	Stocking rates and expected net ranch incomes			
	5.00-6.00	4.00	3.00	2.00
		dollars		
Dry	1,766	1,661	1,313	1,130
Little rain	1,866	1,907	1,840	1,656
Good rain	1,938	2,168	2,485	2,371
Plenty of rain	2,008	2,418	3,100	3,167

[a]Revised probabilities technically are the *a posteriori* probabilities. See calculations in Chapter II.

affect his decisions and under conditions where his knowledge about such factors is unknown. While the incomes he is supposed to achieve given these alternatives are larger than what he is presently achieving, neverthelss, the alternative incomes are not high with respect to the economic needs of an average ranch family.

Under conditions of certainty (perfect knowledge about factors affecting decisions), the highest net ranch income of a rancher who could stock at the rate of 1.50 acres per animal unit appears to be a little over $6,600 for a cow-yearling operation with assumed death rate of mature livestock of two percent and about $4,600 for a cow-calf system. It should be noted that only 21 ranches in the area have a potential maximum stocking rate of 1.50 acres per animal unit or better. Based on the land suitability classification of the ranching areas, the average stocking rate of the 52 ranches would be about 2.0 acres per animal unit. Under the cow-yearling budget of two percent death rate, the estimated net ranch income would amount to about $4,729 (Table 31) and $3,139, cow-calf budget (Table 29). Under conditions of uncertainty (risk due to uncertainty in weather conditions), a rancher in the long run expects to achieve $2,347 on a cow-yearling operation and $1,442 on a cow-calf operation.

The potential alternatives for increasing returns from ranching are discussed assuming implicitly that necessary financing is available in acquiring the required ranch resources. To show the feasibility of attaining the potential alternatives, a cow-calf budget at the stocking rate of 2.5 acres per animal unit is adopted as presented in Table 29. With proper range management and considering the inherent characteristics

of the pasture ranges, most ranchers may be able to adopt this potential stocking rate. Some good ranches may even have a stocking rate of 1.5 acres per animal unit.

To stock a 300-acre ranch at the rate of 2.5 acres per animal unit, the total capital investment as budgeted amounts to $25,854. Of this amount, $17,575 is for livestock and $8,279 for non-livestock investments (see Table 29). The repayment schedule is shown in three ways: (1) where loan is obtained in part from the Department of Hawaiian Home Lands and in part from the Farmers Home Administration (called the Department-Farmers Home Administration loan); (2) where the loan is obtained in part from the Farmers Home Administration and in part from a private bank (Farmers Home Administration-bank loan); and (3) from a private bank for the full amount needed (private loan). This is done to show the reality of the existing situation. The department cannot supply the total amount of $25,854. Under this type of loan (intermediate loan), the Farmers Home Administration can loan only up to $20,000. Therefore, only private banks have the ability to lend the total amount needed. To simplify computations, the total amount to be borrowed is rounded to $26,000.

Department-Farmers Home Administration loan. It is assumed that the available funds from the Department permits the loan of $10,000 and the rest of the amount is obtained from the Farmers Home Administration. The Department charges an interest rate of two and one-half percent per annum and the term of the loan is assumed to be ten years.[62] The FHA charge an interest rate of five percent per annum and the term is seven years. The repayment scheme for both loans is the straight method and it is presented

[62]Loan from the Department of Hawaiian Home Lands may be extended for a period of 30 years.

in Table 41.

Farmers Home Administration-bank loan. It is assumed that $15,000 is obtained from the FHA and the rest from a private bank. The interest rate and term and the method of repayment of the loan from the FHA are the same as in the Department-FHA loan. For the bank loan, the interest rate is seven percent per annum and the term is five years. The repayment scheme is the straight method and it is presented in Table 42.

Private loan. The assumed interest rate is seven percent and the term of the loan is twenty years. The repayment scheme is the straight method and it is presented in Table 43.

It is possible for a rancher to repay the loan of $26,000 if he attempts to stock his ranch at the rate of 2.5 acres per animal unit. However, the loan repayment would adsorb much of the total gross receipts for the early life of the loan. From the Department-FHA loan, the rancher would be paying more than $4,000 a year for the first three years and more than $3,000 for the next four years while from the FHA-bank loan he would have to pay more than $5,000 a year for the first four years and almost $5,000 in the fifth year. Since the term of the loan for the private loan is longer, the yearly repayment is not very high. However, before the private loan matures, the rancher may need an additional loan to replace some worn out non-livestock investment items. The total gross receipts of the budgeted ranch is only a little over $5,500.

The budgets constructed, assuming different stocking rates, indicate some possibilities that ranch income could be increased. The partial budget also shows that community pasture could be used effectively to bring additional benefits to the ranchers. These alternatives for increasing ranch income assume perfect knowledge of the factors

TABLE 41. REPAYMENT SCHEDULE OF THE DEPARTMENT-FARMERS HOME ADMINISTRATION LOAN[a]

Year	Balance	Repayment		
		Principal	Interest	Total
1	$26,000.00	3,285.71	1,050.00	4,335.71
2	22,714.29	3,285.71	910.71	4,196.42
3	19,428.58	3,285.71	771.43	4,057.14
4	16,142.87	3,285.71	632.14	3,917.85
5	12,857.16	3,285.71	492.86	3,778.57
6	9,571.45	3,285.71	353.57	3,639.28
7	6,285.74	3,285.71	214.29	3,500.00
8	3,000.00	1,000.00	75.00	1,075.00
9	2,000.00	1,000.00	50.00	1,050.00
10	1,000.00	1,000.00	25.00	1,025.00

[a]For the amount, rate of interest and term of the loan from each source, refer to page

TABLE 42. REPAYMENT SCHEDULE OF THE FARMERS HOME ADMINISTRATION-BANK LOAN[a]

Year	Balance	Repayment		
		Principal	Interest	Total
1	$26,000.00	$4,342.86	$1,520.00	$5,862.86
2	20,857.14	4,342.86	1,202.86	5,545.72
3	17,314.28	4,342.86	997.71	5,340.57
4	12,971.42	4,342.86	736.57	5,079.43
5	8,628.56	4,342.86	475.43	4,818.29
6	4,285.70	2,142.86	214.28	2,357.14
7	2,142.84	2,142.84	107.14	2,249.98

[a]For the amount, rate of interest and terms of the loan from each source, refer to page

TABLE 43. REPAYMENT SCHEDULE OF LOAN TO BE OBTAINED FROM A PRIVATE BANK; $26,000 AT AN INTEREST RATE OF SEVEN PERCENT PER ANNUM ON OUTSTANDING BALANCE, 20 YEARS TERM

Year	Balance	Repayment		
		Principal	Interest	Total
1	$26,000	$1,300	$1,820	$3,120
2	24,700	1,300	1,729	3,029
3	23,400	1,300	1,638	2,938
4	22,100	1,300	1,547	2,847
5	20,800	1,300	1,456	2,756
6	19,500	1,300	1,365	2,665
7	18,200	1,300	1,274	2,574
8	16,900	1,300	1,183	2,483
9	15,600	1,300	1,092	2,392
10	14,300	1,300	1,001	2,301
11	13,000	1,300	910	2,210
12	11,700	1,300	819	2,119
13	10,400	1,300	728	2,028
14	9,100	1,300	637	1,937
15	7,800	1,300	546	1,846
16	6,500	1,300	455	1,755
17	5,200	1,300	364	1,664
18	3,900	1,300	273	1,573
19	2,600	1,300	182	1,482
20	1,300	1,300	91	1,391

affecting the decisions of the ranchers. Given the uncertainty in range conditions, the expected income of the ranchers was very low in comparison with the budgeted income. However, the expected long-run income was still higher than the average income achieved by the sample ranchers.

The possibility of increasing income exist. However, the main problem faced by the ranchers is the financing of the ranch expansion to achieve the potential estimated increase in income. The financing schemes presented indicate the need for large outlay of funds to increase income to the modest goal of about $2,400.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was an attempt to evaluate the present economic achievements of the homesteaders in the Waimea ranching project of the Department of the Hawaiian Home Lands and to offer some suggestions on the potential means of increasing monetary returns from ranching. The project was started in 1952 and only a few of the ranches became partly operational in early 1953. Each rancher operates an average of 300-acre pasture lot on a leasehold basis. The lease contract lasts for 99 years and each rancher-leasee pays a fee of $1.00 per year on the 300-acre lot. The Department provides technical and financial assistance to the ranchers. In some cases this assistance was not substantial due to budgetary and policy limitations.

Summary of Results and Conclusions

Analysis conducted for the 38 ranchers and the whole ranching area showed the principal characteristics of the ranching operations. The grazing lands are generally good for ranching based on the land suitability classification prepared by the Land Study Bureau. Alternative uses of the lands for farming purposes are limited, however,

Most of the ranchers carried very few livestock on their ranches (an average of 81 animal units per ranch). The capital investment excluding land averaged $22,149, 80 percent of which was in livestock, 10 percent in motor vehicles and other equipment including tractor, six percent in improvements and four percent in ranch equipment. The average net ranch income (returns to land and management) is $1,374. The amount

of loans obtained by the ranchers from the Department of Hawaiian Home Lands is very small. This hampered the ability of the ranchers to finance the acquisition of the necessary ranch resources for the efficient operation of the ranches.

Of the 36-ranch operators interviewed, only nine were found to have no off-ranch employment. Of the nine, five were receiving pensions and/or social security benefits. The rest were unaccounted for. The average monthly income from off-ranch employment is $350. In some cases, the off-ranch income of the ranch operator was being augmented by off-ranch income of operator's spouse. On the average, operator's spouse monthly income is $251. However, the combined income of the ranch operator and his spouse averaged only $425 per month and analysis showed that the combined income helped very little in acquiring the needed ranch resources.

The ranch household was relatively large. The average number of dependents per household was 3.4 persons; spouse not included. There was a low correspondence between the number of dependents in a ranch household and the amount that the rancher and his spouse received from off-ranch employment.

Besides having very few head of cattle on the ranch, one of the problems facing the ranchers was the low price they received for their cattle. However, it seemed evident that this problem could be reduced by efficiency in the method of production. It is very apparent in the cost analysis that this can be done. The cost curve fitted showed that efficiency could be increased by expanding the size of operation in terms of output of beef for sale.

It is possible that net income will increase substantially by carrying more cattle on the ranch. Some of the ranches are capable of heavier stocking rates because of the inherent productivity of the range lands. Others can be made to carry more livestock through range improvement practices. Another alternative for increasing net ranch incomes that ranchers may look into is the effective use of the community pasture.

The uncertainty of range condition is very important for the type of ranching adopted by the ranchers in the Waimea project. One alternative as a guide to good decision-making under uncertainty is the application of statistical decision theory. The approach presented by the theory to the problems of decision-making under uncertainty could easily be applied by the ranchers. The theory requires that one attach certain probabilities to the possible alternative outcomes under uncertainty. The determination of these probabilities can be done either objectively from historical data or subjectively based on the ranchers' best personal knowledge or assessment of the situation or with the assistance from the Extension Specialist of the Cooperative Extension Service working in the area. Using these probabilities as weights, the ranchers can compute possible outcomes (net incomes) and the optimum decision is that one which maximizes expected net incomes.

Applying Bayes' strategy, the rancher pursuing a cow-calf operation expects, in the long run, an income of $1,442 and in a cow-yearling operation, $2,347.

The possibility of increasing income from ranching by operating the ranch of 300 acres exists. However, the main bottleneck is the financing

aspects of the ranching operation. The Department cannot cope with the demand of the ranchers for the needed funds. The loaning assistance provided by the Farmers Home Administration may be one possible source of funds. The problem is the general applicability of its services to the Waimea ranchers. Private bank financing is another source of funds.

However, the greatest problem faced by the Hawaiian Homes ranchers is the lack of adequate collateral for long term loans. Usually loans of this type are secured by real estate mortgage. The only collateral available from the ranchers is the lien on their livestock and ranch equipment and income from off-ranch employment. For this reason private banks may usually not consider loaning a substantial amount to the ranchers. This can be explained by the fact that very few ranchers (those with large outside sources of income) were able to borrow from private banks the necessary funds to finance their ranching operations and improvements.

Implication of the Study

In spite of the low economic returns of the project as a whole, it is possible that the objective of rehabilitating the ranchers in terms of their social well-being may have been realized. The ranchers and their families live in a well-built comfortable home in an attractive community. Some have achieved a modest degree of success as ranchers. Others work off the ranch and supplement their incomes with ranch operations. These in turn may use their off-ranch income to finance ranch improvement. These factors should be considered in development of

policy to enhance project return.

In addition to the information this study may provide in terms of guidance for Homestead ranchers and planning by the Department and the State with respect to the Project, the analysis of risk and uncertainty may provide basis for improved decision-making for ranching in Hawaii in general. To further develop this as a useful decision tool further research needed is as follows:

(1) Improvement in the determination of the probability distribution of range conditions based on other physical factors other than rainfall conditions.

(2) Experimentations on the effects on calving percentage, weights of calves and other physical conditions of the livestock of different stocking rates under different range conditions.

(3) Need for adequate information regarding the price fluctuation of beef and the marketing problems faced by the small ranchers in Hawaii.

APPENDIX A

A BRIEF DISCUSSION OF BAYES STRATEGY

The foregoing will be a discussion of the Bayesian statistics which is the formal statistical decision theory used in this study. In choosing the appropriate action for various strategies given risk and uncertainty, the Bayes strategy in general is to maximize the weighted average (or expected value) of the various possible gains or to minimize the weighted average of the possible losses. Gains and losses would be appropriately measured in monetary terms. This would be acceptable since the decision problem is of the reoccurring type.[1] The solution to this problem is to find the expected monetary value of each action and choose that one which has the highest value.[2]

To show the logic and computational procedures underlying Bayes strategies, hypothetical data will be used. The first step is to construct a pay-off table showing gains or losses associated with given actions when a particular "state of nature" occurs. This is shown in Table A-1. The actions (a_i) hypothetically presented here represent various stocking capacities which the rancher could adopt. The "state of nature" (Θ_i) represents the range conditions. The pay-offs are measured in terms of net income. Three actions will be presented, with a_1, a_2, and a_3 respectively representing stocking capacities of 100, 150,

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[1]G. W. Dean, A. J. Finch, and J. A. Petit, Jr., "Economic Strategies for Foothill Beef Cattle Ranchers." Bulletin 824, California Experiment Station, June 1966, pp. 45-46.

[2]If the decision is to the "once-and-for-all" type, utility theory should be applied, and the solution calls for that strategy which has the greatest expected utility.

and 300 animal units, and three "states of nature"; Θ_1, Θ_2, and Θ_3 to represent poor, average, and excellent range conditions respectively.

TABLE A-1. PAY-OFFS (NET INCOMES) OF ALTERNATIVE ACTIONS UNDER VARIOUS STATES OF NATURE AND EXPECTED VALUES OF ACTIONS GIVEN A PRIORI PROBABILITIES

States of nature	Actions			A priori probabilities
	a_1	a_2	a_3	
	dollars			
Θ_1	0	-1,000	-3,000	0.25
Θ_2	500	4,000	1,000	0.45
Θ_3	2,000	8,000	12,000	0.30
Expected value	825	3,950	3,300	--

Each cell in the body of Table A-1 contains the net ranch income resulting from each combination of stocking capacity and range condition.

The choice of what action to undertake would be pretty simple if the "states of nature" are known with certainty. However, this is not true in most cases. Only the probability that a "state of nature" may occur may be known. Long term experience of ranchers or range specialists may be of help in constructing this probability to be referred here as *a priori* probability of each "state of nature" occurring. The *a priori* probabilities are also shown in Table A-1. Given this probability distribution of the "states of nature," the rancher can compute his expected income for each action by using the probabilities as weights. Action a_2 would be the optimum strategy under these circumstances.

In an actual situation, a decision has to be made on a yearly basis. The computed expected value for each action represents long term expectation. Therefore, if the rancher chooses action a_2, it is not expected that the corresponding net income ($3,950) will accrue to the rancher for the particular year that he made the decision of stocking 150 animal units. If the *a priori* probabilities were constructed for a period of 20 years, then the expected value for each action will represent average net income for a 20-year period. Therefore, if income variances were large, then the averages will not be good estimates of the net incomes for a particular year. The Bayesian statistics assume that given the conditional probabilities of the "states of nature" occurring when certain observed phenomenon occurred, would improve decision-making theory. In the choice of action when only the *a priori* probabilities are given the problem is said to be a "no-data" problem. When conditional probabilities are incorporated before a decision is made, then the problem is a "data" problem.

The conditional probabilities can be established by associating a certain phenomenon observed in a given year to the occurrence of particular range conditions. Let us assume that experimental results showed that if the range condition was excellent in January, the probability for this condition to prevail throughout the year is 75 percent. Let us further assume that the probability for a poor range condition to prevail throughout the year if excellent range condition was observed in January is zero and the probability for average range condition to prevail is 25 percent. Probability distributions could similarly be constructed from experiments (or historical data) if

average or poor range condition respectively were observed in January. The conditional probabilities are shown in Table A-2. An observant rancher may also be able to establish similar conditional probabilities based on his own experience.

From Table A-2, joint probabilities of the various combinations of Θ_i and Z_i can be computed by:

$$P(\Theta,Z) = P(Z/\Theta) \times P(\Theta)$$

where: Z = the phenomenon observed when a certain state of nature occurs.

TABLE A-2. CONDITIONAL PROBABILITIES OF Z_i GIVEN Θ_i,P(Z/Θ) AND A PRIORI PROBABILITIES

States of nature	Observations			A priori probabilities
	Z_1	Z_2	Z_3	
Θ_1	0.80	0.20	0	0.25
Θ_2	0.20	0.30	0.50	0.45
Θ_3	0	0.25	0.75	0.30

For example, the joint probability:

$$P(\Theta_1, Z_2) = P(Z_2/\Theta_1) \times P(\Theta_1)$$

Substituting the values from Table A-2, we have:

$$P(\Theta_1,Z_2) = 0.20 \times 0.25 = 0.05$$

The computed joint probabilities are presented in Table A-3.

TABLE A-3. JOINT PROBABILITIES OF $\Theta = \Theta_1$ AND $Z = Z_i$, $P(\Theta = \Theta_i \text{ AND } Z = Z_i)$

States of nature	Observations		
	Z_1	Z_2	Z_3
Θ_1	0.20	0.05	0
Θ_2	0.09	0.135	0.225
Θ_3	0	0.075	0.225
$P(Z)$	0.29	0.26	0.45

The next step is to compute the a posteriori probabilities (w_i) of the "states of nature" given Z_i. The procedure is to divide the joint probability by its corresponding sum or:

$$w = P(\Theta/Z) = \frac{[P(Z/\Theta) \times P(\Theta)]}{P(Z)}$$

where $P(Z)$ = the sum of the probabilities of a particular Z.

For Z_2, $P(Z) = 0.05 + 0.135 + 0.075 = 0.26$

Therefore,

$$w_1 = P(\Theta/Z_1) = \frac{[P(Z_1/\Theta_i) \times P(\Theta_i)]}{P(Z_1)}$$

$$w_2 = P(\Theta/Z_2) = \frac{[P(Z_2/\Theta_i) \times P(\Theta_i)]}{P(Z_2)}$$

and

$$w_3 = P(\Theta/Z_3) = \frac{[P(Z_3/\Theta_i) \times P(\Theta_i)]}{P(Z_3)}$$

where i = 1, 2, and 3.

The a posteriori probabilities are presented in Table A-4.

TABLE A-4. A POSTERIORI PROBABILITIES, $w = P(\Theta/Z) = [P(Z/\Theta) \times P(\Theta)]/P(Z)$

States of nature	Observations		
	Z_1	Z_2	Z_3
Θ_1	0.69	0.19	0
Θ_2	0.31	0.52	0.50
Θ_3	0	0.29	0.50

The rancher can now apply the a posteriori probabilities in selecting the appropriate course of action. Again, the decision is to select that action which maximizes the expected value (net income). The net incomes under each column (action), Table A-1, are weighted by the a posteriori probabilities and their sum is taken. For action a_1 given Z_1, the expected income is computed as follows:

$$155 = 0 \times 0.69 + 500 \times 0.31 + 2{,}000 \times 0$$

The values 0, 500, and 2,000 are from Table A-1 and the probabilities 0.69, 0.31, and 0 are from Table A-4. In the same manner, the expected income for a_1 given Z_2 is:

$$840 = 0 \times 0.19 + 500 \times 0.52 + 2{,}000 \times 0.29$$

For a_2 given Z_1, the income is:

$$550 = -1{,}000 \times 0.69 + 4{,}000 \times 0.31 + 8{,}000 \times 0$$

From these, Table A-5 can be constructed showing expected values (net incomes) for each action when certain Z is observed.

The rancher is making his decision on the basis of what he observes in the beginning of the year. If Z_1 is observed, the strategy is to choose action a_2 (stocking 150 animal units). The same action is chosen if Z_2 is observed. If Z_3 is observed, then the rancher chooses action a_3.

TABLE A-5. SUMMARY OF EXPECTED VALUES OF ALTERNATIVE ACTIONS (a_i) ASSUMING VARIOUS Z_i ARE OBSERVED, AND EXPECTED VALUE OF THE OPTIMUM STRATEGY BUNDLE

Observations	Actions			P(Z)
	a_1	a_2	a_3	
Z_1	155	*550*	-1,760	0.29
Z_2	840	*4,210*	3,430	0.26
Z_3	1,250	6,000	*6,500*	0.45
Expected value of optimum strategy bundle[a]		($4,179.10)		

[a]Summation of italicized actions times P(Z).

The final step is to compute the expected value by following the bundle of strategies mentioned previously. This is done by multiplying the expected values of the optimum action for each observed Z by the probability of observing Z, P(Z). The expected value of the strategy bundle is also given in Table A-5. The expected income from the "data" problem is $4,179.10 (shown in Table A-5) and from the "no-data" problem, $3,950 (shown in Table A-1). The difference between the two is called

the "value of the experiment." It is computed as:

$4,179.10 - $3,950 = $229.10

which is the improvement in expected incomes by observing the Z values (range condition in January) and revising the probability estimates and actions accordingly.

APPENDIX B

TABLE B-1. GENERAL LAND TYPE: DESCRIPTION AND SUITABILITY CLASSIFICATION IN PUUKAPU AREA (4649 ACRES)

Land type	Suitability index[a] General	Selected Grazing	Selected Forage crop	Soil series	Depth	Texture	Stoniness	Drainage	Slope (Percent)	Climate	Mean Annual rainfall (inches)	Elevation (feet)	Machine tillability	Percent of total area
106	B	a	a	Kikoni Palapalai & Punohu	Deep	Medium	Nonstony to slightly stony	Well drained	0 to 10	Cool & sub-humid, frequent fog	40 to 60	2600 to 3600	Well suited	1.4
107	B	a	a	"	"	"	"	"	0 to 10 undulating with slopes to 15	"	"	"	Moderately suited	71.6
109	D	a	e	"	"	"	Rocky	"	0 to 10 undulating with slopes to 22	"	"	"	Unsuited	14.6
160	C	b	d	Nienie & Maile	"	"	Nonstony	Well drained but moist	0 to 10 with inclusions of steeper slopes	Humid, frequent fog	70 to 100	2500 to 3500	Well suited	0.5
161	C	b	e	"	"	"	"	"	0 to 10 undulating with slopes to 23	Cool & humid, frequent fog	"	"	Moderately suited	8.6
247	C	b	e	Waimea	"	"	Stony	Well drained	11 to 20 undulating with slopes to 24	Cool & sub-humid, frequent fog	25 to 45 seasonal	2000 to 4000	Very poorly suited	0.1
249	D	b	e	"	Moderately deep	"	Rocky	"	0 to 30 undulating	Cool & humid	"	"	Unsuited	2.7
323	E	c	e	Reddish Prairie Cones	Generally deep	"	Nonstony to stony	"	36 to 80	Semiarid	20 to 40	1000 to 4000	Unsuited	0.5
												TOTAL		100.0

[a]Upper case letter (A, B, etc.) denotes over-all productivity rating which reflects degree of over-all suitability for agricultural use. Lower case letter (a, b, etc.) denotes selected use ratings which indicates degree of suitability for selected use alternatives. There are five letters used; A for very good, B for good, C for fair, D for poor and E for very poor. For selected suitability index: a denotes carrying capacity of less than 2.5 acres per AUY, b, 2.5 to 5 acres per AUY, c, 5 to 10, d, 10 to 30, and e, more than 30 acres per AUY.

Source: Land Study Bureau, Detailed Land Classification--Island of Hawaii, LSB Bulletin No. 6, University of Hawaii, November, 1965.

TABLE B-2. GENERAL LAND TYPE DESCRIPTION AND SUITABILITY CLASSIFICATION IN NIENIE AREA (6434 ACRES)

Land type	Suitability index[a] General	Selected Grazing	Selected Forage crop	Soil series	Depth	Texture	Stoniness	Drainage	Slope (Percent)	Climate	Mean Annual rainfall (inches)	Elevation (feet)	Machine tillability	Percent of total area
58	D	c	d	Honokaa & Pohakea	Deep	Moderately fine	Nonstony	Well drained but moist	21 to 35	Very humid, frequent cloudiness	100 to 150	1200 to 2500	Poorly suited	2.9
59	D	c	d	Honokaa	Moderately deep to deep	"	"	"	0 to 10 undulating with slopes to 25	"	"	"	Moderately suited	25.2
107	B	a	a	Kikoni, Palapalai & Punohu	Deep	Medium	Nonstony to slightly stony	Well drained	0 to 10 undulating with slopes to 15	Cool & sub-humid, frequent fog	40 to 60	2600 to 3600	"	11.2
108	D	a	e	"	Deep	Medium	Rocky	"	21 to 35 with inclusions of steeper slopes	"	"	"	Unsuited	3.1
110	C	a	d	"	Deep	"	Nonstony to slightly stony	"	11 to 20 undulating with slopes to 25	"	"	"	Poorly suited	14.0
160	C	b	d	Nienie & Maile	"	"	Nonstony	Well drained but moist	0 to 10 with inclusions of steeper slopes	Humid, frequent fog	70 to 100	2500 to 3500	Well suited	6.6
161	C	b	e	"	"	"	"	"	0 to 10 with undulating slopes to 23	Cool & humid, frequent fog	"	"	Moderately suited	31.9
162	D	b	e	"	Moderately deep to deep	"	Rocky	"	21 to 35	Cool & humid	"	"	Unsuited	4.4
323	E	c	e	Reddish Prairie Complex	Generally deep	"	Nonstony to stony	Well drained	36 to 80	Semiarid	20 to 40	1000 to 4000	Unsuited	0.7
												TOTAL		100.00

Note: For footnote and source, please see Table B-1.

TABLE B-3. GENERAL LAND TYPE DESCRIPTION AND SUITABILITY CLASSIFICATION IN KAHOKU AREA (4268 ACRES)

Land type	Suitability index[a] General	Selected Grazing	Selected Forage crop	Soil series	Depth	Texture	Stoniness	Drainage	Slope (Percent)	Climate	Mean Annual rainfall (inches)	Elevation (feet)	Machine tillability	Percent of total area
59	D	c	d	Honokaa	Moderately deep	Moderately fine	Nonstony	Well drained but moist	0 to 10 undulating with slopes to 25	Very humid, frequent cloudiness	100 to 150	1200 to 2500	Moderately suited	40.5
60	D	c	e	"	"	"	Rocky	"	21 to 35	"	"	"	Very poorly suited	13.4
107	B	a	a	Kikoni, Palapalai & Punohu	Deep	Medium	Nonstony to slightly stony	Well drained	0 to 10 undulating with slopes	Cool & sub-humid, frequent fog	40 to 60	2600 to 3600	Moderately suited	0.5
108	D	a	e	"	"	"	Rocky	"	21 to 35 with inclusions of steeper slopes	"	"	"	Unsuited	Less than 0.04
161	C	b	e	Mienie & Maile	"	"	Nonstony	Well drained but moist	0 to 10 undulating with slopes to 23	Cool & humid, frequent fog	70 to 100	2500 to 3500	Moderately suited	35.4
162	D	b	e	"	Moderately deep to deep	Moderately fine	Rocky	"	21 to 35	Cool & humid	"	"	Unsuited	10.2
												TOTAL		100.0

Note: For footnote and source, please see Table B-1.

TABLE B-4. PERCENT OF TOTAL AREA UNDER EACH LAND CLASS TYPE, INDIVIDUAL RANCHERS, PUUKAPU AREA

Ranch code no.	Land Class Type[a]								Total area (acres)
	B 106	B 107	D 109	C 160	C 161	C 247	D 249	E 323	
06	--	100.0	--	--	--	--	--	--	340
29	--	50.0	--	--	50.0	--	--	--	315
07	--	20.0	--	4.0	76.0	--	--	--	315
50	--	95.0	--	4.0	1.0	--	--	--	310
14	20.0	80.0	--	--	--	--	--	--	310
25	--	100.0	--	--	--	--	--	--	305
18	--	98.0	--	--	--	--	2.0	--	325
02	--	90.0	--	--	--	--	10.0	--	305
04	1.0	99.0	--	--	--	--	--	--	309
23	--	100.0	--	--	--	--	--	--	305
05	--	99.0	--	--	--	1.0	--	--	305
13	--	48.0	45.0	--	--	--	--	7.0	300
32	--	25.0	75.0	--	--	--	--	--	309
10	--	33.0	66.0	--	--	--	1.0	--	305
26	--	32.0	40.0	--	--	--	28.0	--	300
TOTAL (Acres)	65.09	3,329.51	681.30	25.0	400.00	3.05	124.05	21.0	4,649.0
Percent	1.4	71.6	14.6	0.5	8.6	0.1	2.7	0.5	100.0

[a]See Table B-1 for land type description and source.

TABLE B-5. PERCENT OF TOTAL AREA UNDER EACH LAND CLASS TYPE, INDIVIDUAL RANCHERS, NIENIE AREA

Ranch code no.	Land Class Type[a]									Total area (acres)
	D 58	D 59	B 107	D 108	C 110	C 160	C 161	D 162	E 323	
44	--	100.0	--	--	--	--	--	--	--	300
06	--	100.0	--	--	--	--	--	--	--	292
30	10.0	90.0	--	--	--	--	--	--	--	300
53	--	35.0	--	--	--	6.0	59.0	--	--	286
20	--	45.0	--	--	--	--	55.0	--	--	297
42	--	52.0	--	--	--	--	48.0	--	--	296
34	25.0	75.0	--	--	--	--	--	--	--	300
16	26.0	48.0	--	--	--	--	26.0	--	--	300
47	--	--	--	--	--	--	100.0	--	--	295
31	--	--	--	--	--	--	100.0	--	--	290
41	--	--	--	--	--	--	100.0	--	--	293
14	--	--	--	--	--	53.0	47.0	--	--	292
43	--	--	0.5	1.5	--	85.0	3.0	10.0	--	298
27	--	--	72.5	1.5	--	--	--	26.0	--	301
21	--	--	22.0	--	30.0	--	35.0	13.0	--	292
36	--	--	--	--	64.0	--	36.0	--	--	303
35	--	--	--	--	100.0	--	--	--	--	280
52	--	--	62.0	--	22.4	--	--	--	15.6	289
45	--	--	88.0	5.0	7.0	--	--	--	--	289
26	--	--	1.5	46.0	52.5	--	--	--	--	284
9	--	--	--	2.0	39.0	30.0	--	29.0	--	273
24	--	--	--	15.0	--	--	65.0	20.0	--	280
TOTAL (acres)	183.00	1,618.67	721.715	205.535	902.056	425.22	2,051.53	281.19	45.084	6,430
Percent	2.9	25.2	11.2	3.1	14.0	6.6	31.9	4.4	0.7	100.0

[a]See Table B-1 for land type description and source.

TABLE B-6. PERCENT OF TOTAL AREA UNDER EACH LAND CLASS TYPE, INDIVIDUAL RANCHERS, KAMOKU AREA

Ranch code no.	Land Class				Type[a]		Total area (acres)
	D 59	D 60	B 107	D 108	C 161	D 162	
11	--	--	7.4	0.6	54.9	37.1	282
17	--	--	--	--	96.0	4.0	285
39	--	--	--	--	64.0	36.0	275
29	--	1.4	--	--	66.3	32.3	275
37	--	--	--	--	100.0	--	282
40	--	--	--	--	80.0	20.0	296
03	64.0	17.0	--	--	13.0	6.0	275
12	63.9	18.8	--	--	17.3	--	285
33	50.2	30.1	--	--	17.2	2.5	290
38	50.0	40.0	--	--	--	10.0	255
46	72.0	28.0	--	--	--	--	260
22	85.0	9.0	--	--	3.0	3.0	302
15	66.0	28.0	--	--	1.0	5.0	302
51	70.0	20.0	--	--	10.0	--	302
01	80.0	11.0	--	--	9.0	--	302
TOTAL (acres)	1,727.415	571.63	20.868	1.692	1,509.938	436.457	4,268
Percent	40.5	13.4	0.5	--	35.4	10.2	100.0

[a]See Table B-1 for land type description and source.

APPENDIX C

TABLE C-1. ACREAGES UNDER EACH TYPE OF SOIL OF PASTURE RANGES BY LOCATION, WAIMEA PROJECT[a]

Location and soil series	Area (acres)	Percent of Total Area	Percent of area under each soil series
Nienie, total	6,430	42	--
Nienie and Maile	2,758	18	54
Kikoni, Palapalai, and Punohu	1,825	12	31
Honokaa	1,802	12	44
Reddish Prairie cones	45	b	68
Puukapu, total	4,649	30	--
Kikoni, Palapalai, and Punohu	4,076	26	69
Nienie and Maile	425	3	8
Waimea	127	1	100
Reddish Prairie cone	21	b	32
Kamoku, total	4,268	28	--
Honokaa	2,299	15	56
Nienie and Maile	1,946	13	38
Kikoni, Palapalai, and Punohu	23	b	b
All areas, grand total	15,347	100	--
Kikoni, Palapalai, and Punohu	5,924	39	100
Nienie and Maile	5,129	33	100
Honokaa	4,101	27	100
Waimea	127	1	100
Reddish Prairie cones	66	b	100

[a]Computed by the author from aerial photos superimposed on the map of the ranches in the Waimea project. The aerial photos are from the Land Study Bureau Bulletin No. 6, 1965, University of Hawaii.

[b]Less than 0.50.

APPENDIX D

TABLE D-1. JOB CATEGORIES OF OPERATORS' OFF-RANCH EMPLOYMENT

A Jobs -- Game management supervisor, grader operator, policeman and mechanic

B Jobs -- Foreman (three working with the State receiving more than $420 per month)

C Jobs -- Custodian and maintenance superintendent

D Jobs -- Truck drivers

E Jobs -- Laborers, cowboys and ranch hands

TABLE D-2. JOB CATEGORIES OF OFF-RANCH EMPLOYMENT OF SPOUSE

A Jobs -- Entertainment directress, restaurant operator and personnel superintendent

B Jobs -- Public relations job, hula instructor

C Jobs -- Kitchen helper, cook, laundry worker, sales clerk and pantry helper

APPENDIX E

TABLE E-1. SUMMARY OF RESULTS OF STEPWISE REGRESSION OF THE LAST SIX FUNCTIONS ASSOCIATING RANCH INCOME WITH A MEASURE OF RANCH SIZE AND SOME MEASURES OF RANCHING EFFICIENCY

Variable included	Multiple correlation coefficient (R)	Multiple coefficients of determination (R^2)	Increase in R^2
Function IV (F_4)			
Total investment	0.8693	0.7557	0.7557
Total investment per A.U.	0.8700	0.7569	0.0013
Calving percentage at weaning	0.8701	0.7570	0.0001
Function V (F_5)			
Total investment	0.8693	0.7557	0.7557
Total non-livestock investment per A.U.	0.8714	0.7594	0.0037
Calving percentage at weaning	0.8714	0.7594	0.0000
Function VI (F_6)			
Total pound sold per A.U.	0.7797	0.6080	0.6080
Total non-livestock investment	0.7873	0.6199	0.0119
Calving percentage at weaning	0.7904	0.6248	0.0049
Function VII (F_7)			
Total investment per cwt. of beef sold	0.7054	0.4976	0.4976
Total pounds of beef sold	0.8007	0.6411	0.1435
Calving percentage at weaning	0.8007	0.6412	0.0001
Function VIII (F_8)			
Total investment per cwt. of beef sold	0.7054	0.4976	0.4976
Total animal units	0.8069	0.6510	0.1535
Calving percentage at weaning	0.8074	0.6519	0.0009
Function IX (F_9)			
Total investment per cwt. of beef sold	0.7054	0.4976	0.4976
Total non-livestock investment	0.7403	0.5481	0.0505
Calving percentage at weaning	0.7423	0.5510	0.0030

APPENDIX F

TABLE F-1. ASSUMED AVERAGE WEIGHT OF WEANED CALVES FOR VARIOUS COMBINATIONS OF STOCKING RATES AND RANGE CONDITIONS

Range condition	Stocking rates and weight of weaned calf			
	5.00-6.00	4.00	3.00	2.00
		pounds		
Very poor	400	390	385	350
Poor	400	390	390	385
Normal	420	420	420	420
Excellent	425	420	420	420

TABLE F-2. ASSUMED AVERAGE WEIGHT OF YEARLINGS FOR VARIOUS COMBINATIONS OF STOCKING RATES AND RANGE CONDITIONS

Range condition	Stocking rates and weights of yearling			
	5.00-6.00	4.00	3.00	2.00
		pounds		
Very poor	650	640	620	600
Poor	660	650	640	610
Normal	670	660	650	640
Excellent	680	670	660	650

TABLE F-3. ASSUMED AVERAGE WEIGHT OF CULLED COWS FOR VARIOUS COMBINATIONS OF STOCKING RATES AND RANGE CONDITIONS FOR COW-CALF AND COW-YEARLING CATTLE SYSTEMS

Range condition	Stocking rates and weight of culled cow			
	5.00-6.00	4.00	3.00	2.00
		pounds		
Very poor	1,050	1,030	990	880
Poor	1,050	1,030	1,000	990
Normal	1,050	1,050	1,030	1,020
Excellent	1,050	1,050	1,030	1,030

TABLE F-4. ASSUMED DEATH RATES OF MATURE LIVESTOCKS FOR VARIOUS COMBINATIONS OF STOCKING RATES AND RANGE CONDITION FOR COW-CALF AND COW-YEARLING CATTLE SYSTEMS

Range condition	Stocking rates and deaths rates			
	5.00-6.00	4.00	3.00	2.00
Very poor	0.20	0.40	0.60	0.80
Poor	0.20	0.20	0.40	0.60
Normal	0.20	0.20	0.20	0.40
Excellent	0.20	0.20	0.20	0.20

APPENDIX G

TABLE G-1. SUMMARY OF REGRESSION ANALYSIS BETWEEN VARIOUS EXPENSE ITEMS PER A.U. AND THE TWO MEASURES OF RANCH SIZE, 34 RANCHES

Function and Dependent Variables (Y)	Ranch size in A.U. (X)				Ranch size in total pounds sold (X)			
	Correlation Coefficient	Standard error of estimate	Regression coefficient (B)	Standard error of B	Correlation Coefficient	Standard error of estimate	Regression coefficient (B)	Standard error of B
I. $Y = A + B\left(\frac{1}{X}\right)$								
1. Total hired labor/A.U.	0.3906*	1.84172	106.65968*	44.43633	-0.0712n.s.	1.99558	-38.25290n.s.	94.73848
2. Total rep. and maint./A.U.	-0.2021n.s.	0.10315	-2.90586n.s.	2.48887	-0.0842n.s.	0.10492	-2.38193n.s.	4.98263
3. Total Vet. serv. and supplies/A.U.	0.3577*	0.16703	8.73193*	4.20995	0.17692n.s.	0.17692	7.04733n.s.	8.39933
4. Total tax/A.U.	0.8982**	0.73886	206.08464**	17.82706	0.7220**	1.16302	325.95776**	55.21346
5. Total salt and mineral/A.U.	0.3107n.s.	0.04865	2.17061n.s.	1.17378	-0.0962n.s.	0.05094	-1.32294n.s.	2.41856
6. Depreciation/A.U.	0.5435**	3.26669	288.68433**	78.81760	0.5392**	3.27735	563.57739**	155.58983
7. Interest on Operating expenses per A.U. (6%)	0.52272	0.12781	19.51465**	3.08371	0.3501*	0.17964	18.03261*	8.52808
8. Interest on capital investment per A.U. (5%)	0.6308**	1.43075	158.73067**	34.52055	0.5149**	1.58059	254.95683**	75.03714
II. $Y = A + B_1X - B_2X^2$								
1. Hired labor/A.U.	0.4585n.s.	1.80641	-0.04475* 0.00011n.s.	0.02001 0.00007	0.1209n.s.	2.01775	0.00213n.s. a/	0.01141 0.00002
2. Repairs and maint./A.U.	0.2783n.s.	0.10279	0.00152n.s. a/	0.00114 a/	0.1526n.s.	0.10576	0.00034n.s. a/	0.00060 a/
3. Vet. service and supplies/A.U.	0.4435n.s.	0.16288	-0.00470* 0.00001*	0.00180 0.00001	0.3268	0.17174	-0.00157n.s. a/	0.00097 a/
4. Tax/A.U.	0.8558**	0.88347	-0.06856** 0.0017**	0.00979 0.00003	0.7107**	1.20147	-0.02764** 0.00003**	0.00679 0.00001
5. Salt and mineral/A.U.	0.3594n.s.	0.04852	-0.00090n.s. a/	0.00054 a/	0.1718n.s.	0.05123	0.00012n.s. a/	0.00029 a/

[a]Less than 0.00000.
*Significant (five percent level).
**Highly significant (one percent level).
n.s.Non-significant.

TABLE G-1. (Continued) SUMMARY OF REGRESSION ANALYSIS BETWEEN VARIOUS EXPENSE ITEMS PER A.U. AND THE TWO MEASURES OF RANCH SIZE, 34 RANCHES

Function and Dependent Variables (Y)	Ranch size in A.U. (X)				Ranch size in total pounds sold (X)			
	Correlation Coefficient	Standard error of estimate	Regression coefficient (B)	Standard error of b	Correlation coefficient	Standard error of estimate	Regression coefficient (b)	Standard error of b
6. Depreciation/A.U.	0.3976$^{n.s.}$	3.62791	-0.06258$^{n.s.}$ 0.00013$^{n.s.}$	0.04016 0.00014	0.4771*	3.47481	-0.05642** 0.00008*	0.01965 0.00003
7. Interest on operating expenses/A.U. (6%)	0.7662**	0.12521	-0.00731** 0.00002**	0.00134 a/	0.3284$^{n.s.}$	0.18403	-0.00177$^{n.s.}$ a/	0.00104 a/
8. Interest on capital investment per A.U. (5%)	0.4923*	1.63060	-0.04991** 0.00014*	0.01898 0.00006	0.4236$^{n.s.}$	1.64688	-0.02312* 0.00003*	0.00960 0.00002
III. $Y = AX^B$								
1. Hired labor/A.U.	-0.3743**	0.22140	0.36685**	0.16944	0.1305$^{n.s.}$	0.23671	0.11931$^{n.s.}$	0.16021
2. Rep. and maint./A.U.	0.2428$^{n.s.}$	0.02296	0.02488$^{n.s.}$	0.01757	0.1286$^{n.s.}$	0.02347	0.01165$^{n.s.}$	0.01588
3. Vet. services and supplies/A.U.	-0.3412*	0.23165	-0.36398*	0.17728	0.0263$^{n.s.}$	0.24635	0.02485$^{n.s.}$	0.16673
4. Tax/A.U.	-0.8658**	0.13706	-1.02669**	0.10486	-0.7400**	0.18425	-0.77601**	0.12470
5. Salt and mineral/A.U.	-0.3492*	0.25476	-0.39903*	0.19497	0.1352$^{n.s.}$	0.26843	0.14025$^{n.s.}$	0.18166
6. Depreciation/A.U.	-0.3757*	0.23638	-0.41486*	0.18088	-0.3426*	0.23961	-0.33456*	0.16217
7. Interest on operating expenses per A.U. (6%)	-0.6552**	0.11096	-0.41063**	0.08492	-0.2026$^{n.s.}$	0.14383	-0.11392$^{n.s.}$	0.09736
8. Interest on capital investment per A.U. (5%)	-0.4884**	0.06028	-0.14606**	0.04613	-0.3531*	0.06483	-0.04339*	0.04374
IV. $Y = A + BX$								
1. Hired labor/A.U.	-0.3767*	1.85339	-0.01330*	0.00578	0.1207$^{n.s.}$	1.98603	0.00167$^{n.s.}$	0.00243
2. Rep. and maint./A.U.	0.2155$^{n.s.}$	0.10285	0.00340$^{n.s.}$	0.00332	0.1343$^{n.s.}$	0.10437	0.00019$^{n.s.}$	0.00013
3. Vet. services and supplies/A.U.	-0.2553$^{n.s.}$	0.17293	-0.00081$^{n.s.}$	0.00054	0.1130$^{n.s.}$	0.17771	0.00014$^{n.s.}$	0.00022
4. Tax/A.U.	-0.7165**	1.17266	-0.02126**	0.00366	-0.5905**	1.35663	-0.00688**	0.00166
5. Salt and mineral/A.U.	-0.2954$^{n.s.}$	0.04890	-0.00027$^{n.s.}$	0.00015	0.1668$^{n.s.}$	0.05047	0.00006$^{n.s.}$	0.00006
6. Depreciation/A.U.	-0.3637*	3.62513	-0.02498*	0.01131	-0.2438$^{n.s.}$	3.77426	-0.00657$^{n.s.}$	0.00462
7. Interest on operating expenses per A.U. (6%)	-0.6182**	0.15074	-0.00209**	0.00047	-0.2162$^{n.s.}$	0.18724	-0.00029$^{n.s.}$	0.00023
8. Interest on capital investment per A.U. (5%)	-0.5694**	1.72849	-0.01133*	0.00539	-0.2400$^{n.s.}$	1.78990	-0.00306$^{n.s.}$	0.00219

APPENDIX H

TABLE H-1. THE ORIGINAL PROBABILITY DISTRIBUTION OF RAINFALL CONDITIONS IN APRIL GIVEN THE RANGE CONDITIONS[a]

Range condition	Observed rainfall conditions in April				
	Dry	Little rain	Good rain	Plenty of rain	Total
Very poor	0.39	0.39	0.17	0.05	1.00
Poor	0.14	0.43	0.29	0.14	1.00
Normal	--[b]	0.25	--[b]	0.75	1.00
Excellent	0.08	0.33	0.42	0.17	1.00

[a]Based on 41 years rainfall observations.

[b]Less than 0.005.

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