SOME CONSIDERATIONS IN RANGE RESEARCH[1/]

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The importance to agriculture of a resource can be measured by its contribution to the final product. One of the measures used to estimate the contribution of western states forage is the number of animal unit months of grazing provided by the private and public range areas. Income from cattle, calves, sheep and lambs grazed upon range and other dry land as a percentage of total income from livestock is another method used. During the 1959 grazing season, an estimated 10-12 percent of the animal unit months of the total forage requirement was obtained from the federal grazing lands. Expressed as number of head of livestock this 10-12 percent of the forage requirement indicates that about 14 million head of the approximately 27.5 million head of domestic livestock in the 11 western states were grazed on federal lands at one time or another during the 1959 season. A comparable figure for the use of private rangelands is not immediately available. However, in the western states, several income measures show a medium to high dependence of livestock production on range.

Continued heavy dependence on range grass seems evident as the trend in livestock numbers moves upward. The magnitude of this dependence will depend upon the rate of development of improved pastures and upon the cost of feed grains and other supplements compared to the cost of increasing the carrying capacity of public and private range land.

Native range has been one of the rancher's cheapest sources of feed. Under the right use conditions and when used at the right time it has been among the most productive of feeds. However, range forage today is less plentiful and more costly than before. Among the factors accounting for less forage are a tightening of the grazing privilege on public lands, wildlife and recreational uses, military setasides, increases in grazing fees, general cost increases, and urban and general farming encroachment.

From the problems thus posed come a series of questions. How can livestock operations be reorganized so as to minimize cost and maximize returns? What is range improvement and how is it accomplished? What will be the results of range improvement? These questions call for several types of treatment and a better understanding of a number of physical and economic relationships. Key considerations in solving these problems at the firm level involve both physical relationships--the plant and its environment, the plant-animal relation--and economic criteria with respect to choice. Part of these considerations relate to matters entirely within the boundaries of the firm while parts depend upon inter-firm considerations. Among the more general developments are policy changes with respect to the direction and distribution of the use of public land, effective demand and employment levels which bear on price and the competitive relationships between the various segments of the

livestock industry.

The principles for maximizing returns to determine the most profitable allocation of the variable resources are well known and need not be described here. The generalized form of a production relationship does not allow specific recommendations; these depend upon the nature of the empirical data and the relationship between inputs. Therefore, knowledge of output can be specified only when the relationship between resource inputs is known. Since specific recommendations are the end product of empirical research, the quantitative value and the association of each variable to all other variables must be specified for each situation. The variable so specified, together with such modifying constraints as may exist, determine the attainable level of profitability with respect to the optimum.

Input-Output Relationships

The western range is diverse in makeup--diverse as to elevation, precipitation, temperature and the soils and topography are many and varied as to composition. The vegetative types are numerous and complex. The present state of productivity is a consequence of plant succession modified from the original state through elements associated with grazing and other use. The means-end or causal relationship with respect to this historical change is not fully understood. Until the pertinent facts are known, one cannot fully interpret the ultimate effect of using native and introduced forages in different ways. Although some of the relationships being uncovered on selected grass species are analogous to other species, each grass or brush type is somewhat independent of other grass species and extensive grazing trials seem necessary.

Since animals are not bushels of wheat or bushels of corn, numerous possible products exist. For a given range type, the animal products may be confined entirely to one type of livestock because of the nature of the plant composition. On the other hand, both cattle and sheep may be grazed on the same area. Further, since present and future output is a function of present and past use, time is a necessary factor in the analysis. Consider the plant and its environment. The same specie of forage plant, whether it is crested wheatgrass, Idaho fescue, or Harding grass, responds differently to different soil and climatic conditions, slope and/or land exposure and altitude. The same specie is not the same plant from place to place. This distinction imposes a necessary condition of input--output interpretation. Some plants are also more drought tolerant than others. And, of course, some plants are more desirable forage plants than others because they are more palatable or more digestible. A sufficient condition for estimate of productivity of rangeland is knowledge of palatability and digestibility. Net productivity depends on how readily the livestock graze the forage available and upon how much of the forage consumed is actually assimilated.

Plant and animal associations, depending upon what form they take, can also change realized output in a number of ways. Due to the selectivity of an animal allowed to graze freely, the composition of the plant community will often be changed in time. Consequently, if the digestibility of the remain-

ing forage plants is lower than that which existed for the more palatable plants a downward adjustment in output will occur. Other determinants of the composition and level of output are the level of stocking, the age and weight makeup of the grazing herd, the grazing system used, and the timing and duration of grazing.

Output can be modified according to special characteristics of animals and grasses. To illustrate: in spite of the evidence of grazing trials, the lamb inherits the grazing pattern of its mother and the beef animal left on its own is reluctant to go up or down steep terrain, or through dense brush, or move far from water. The separation of range into productive capacity components must be accomplished on the basis of the factors already mentioned and also on the basis of what animals will or will not do under certain circumstances.

In addition, output stated in terms of quantity of animal product is usually not sufficient to reflect the true value of output. The quality factor may vary as the grazing system or stocking rate is changed. It is only in the minute details of associations that a sufficient basis for choice is discovered. The implication is that without adequate description of a relationship or process, knowledge is lacking on how the relationship or process works and what will happen if something is changed.

A complete listing of the types of plant-animal relationships is not being attempted. However, it should be pointed out that many aspects of these relationships need to be considered. Too, management and organizational ability can accentuate differences. Single point estimates are usually not sufficient and greater meaning can be given each output estimate if it is located with respect to the sequential output relationship.

The quantity of available forage does not provide an accurate estimate of the amount of usable forage. A portion of the plant must be left to provide food for the repair and extension of the root system and to provide for plant food for regrowth. The grazing level is set by this consideration and the desired rate of income accumulation and reinvestment points. Some plants can be used more heavily than others. The bunch grass area of the Intermountain basin cannot stand as extensive use as the California annual range grasses. Once the grazing level has been determined productivity is a function of the digestibility coefficient times usable forage less waste. If digestibility cannot be estimated an interpretation of the value of the forage can be made indirectly from studies on animal growth. The strict interpretation is based on age and composition of the forage plants, response of the plants to climatic conditions, the time period, and the apparent effect of previous use.

As noted above, with free grazing, animals are selective. Hence, under a light stocking rate the gain will tend to be high since only the top part of the plant, the most nutritious, is grazed. Productivity per acre is low since animal production is subject to diminishing returns. With heavier stocking, the rate of gain per animal will decrease because the animals are forced to eat more of the plant and wider selection of plants. Total gain per acre

will increase at a diminishing rate, reach a maximum, and then decline rapidly. Again a number of choices are possible. If forage is cheap compared to animals, the emphasis moves in the direction of a high rate of gain per animal unit. However, the behavior of an animal in the feed lot is quite different from the behavior of the same animal on open range. Not only does diminishing productivity per animal have to be considered but also feed may go unused unless a heavier rate of stocking is practiced. In addition, other considerations are the grade effect as the total weight per animal is reduced under heavier rates of grazing; the desirability of obtaining the greatest total average weight for some particular period of the grazing season or for the entire period; and stocking and grazing over two or more periods.[1/]

At heavier stocking rates at least two factors are to be taken into account. The grade or quality reduction of the animal product which occurs is one factor. Part of the additional pounds of animal product are needed to make up the price difference due to grade reduction.[2/] Secondly, the impact of each stocking rate on the duration of the life and the subsequent productivity of the plant community must be considered if the particular stocking rate is to be followed for a number of years. In posing the question in this form, the implication is not that a single consideration exists and that it is to maintain the stand of grasses or other plants to the point of termination of some normal life. However, the timing of use and how the plants are used will be reflected in the nature of the long run productivity curve and this in turn has some bearing, as previously noted, upon income distribution and reinvestment rates.

The interpretive framework for output has been mentioned. Other primary restrictions exist. Land quality is restrictive with respect to improvement practices or management. The land quality restriction is listed as the area of each land quality taken together with climate and other physical features, distance from the main base of operations and tenure or use opportunity. Land quality, collectively specified, helps to determine whether it is worthwhile doing anything which would materially change the form of operations and the investment program. Restated, the starting point for input-output estimates is to determine how existing or introduced forage plants respond to the particular environment and to establish how they respond to different types of use by livestock. Experience with various types of range improvement practices is beginning to isolate those areas on which there is a low probability of being

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1/ Caton, D. D., "Selection of Optimum Season and Intensity of Grazing," Economic Research in the Use and Development of Range Resources, Economics of Range and Multiple Land Use, Western Agricultural Economics Research Council Proceedings, Committee on the Economics of Range Use and Development, Report No. 2, Pullman, Washington, August 11 and 12, 1958 and Logan, Utah, July 13 and 14, 1959.

2/ Break even point. $P_1Q_a - P_2Q_a + P_2\Delta Q_b$

$$\Delta Q_b - \frac{[P_1 - P_2]Q_a}{P_2}$$

able to introduce these practices. Future economic studies will probably eliminate still more. Some evidence exists, partly intuitive, that range is, by reason of its physical makeup and climatic setting, the residual claimant on capital investment and intensity of use. And while range responds niggardly to good management it responds sharply and negatively to poor management. Directed management is the keynote of output estimates. Otherwise, output is of the nature of a random distribution.

Given that conditions for interpretation of input-output relationships are established, the next step is to group the forage variable into specific grass communities and to further group them by season of availability. The potential level and distribution of forage is thereby indicated and it can be interpreted if digestibility, palatability and response to management and use can also be specified. Range improvement practices require a further set of conditions to be established. For example, provision should be made for range reseeding. The rate of seeding will determine the density of the stand subject to any limitations imposed by faulty germination or faulty placement of the seed. Correspondingly, inputs which accompany or precede seeding such as fertilizers and the preparation of the seed bed, have an effect upon the final results. One basic deterrent to range improvement through reseeding is the requirement of land setaside, and the time that it takes to get the stand, if it is established, to productive maturity. This means that separate income streams, discounted, must be compared before a decision can be made. So, consequently, it is not only the total expected income that is compared but also the distribution of income over time that enters the decision.

The forage expression has Z_i vegetative possibilities, collected in Q_i seasons, and has V_i productivity coefficients. The V_i coefficients are determined by: (1) timing of use, (2) intensity of use, (3) climatic conditions, and (4) the percentage of growth that must be left to maintain the plant. The $X_i X_j$ plant and animal relation can take an astonishing number of values depending upon the type, size, and age of the animal, upon the stocking rate, and upon many other factors. Among these are the availability and distance to water and the use of supplements.

Estimates of the response of forage growth to moisture conditions is a difficult thing to handle. Several elements are to be considered: the form that the moisture comes in, when it comes, and the percent of the total supply of moisture of each of the possible forms. Over much of the range area critical periods of supply exist for different seasonal ranges. For example, April-May rainfall is the main determinant of forage growth on the spring ranges of the Intermountain region. The accumulated moisture has some bearing on growth but it is not as important as the rainfall in April and May. Thus, we are concerned with a set of factors for each situation, with the form, variance, and periodicity of moisture, with site characteristics, the other features of climate and their variance.

Previously, a time factor was introduced expressed as the effect of a given plant-animal relationship. Another time factor must now be considered. Maintenance practices such as weed eradication, chemical control of brush, fencing, water development, and to some extent the grazing system can modify

the yield of forage slightly, greatly, or not at all depending upon the time period circumstances. The introduction of other types of inputs, fertilization and supplemental feeding have been found to have a marked immediate influence on productivity. The effect of periodic or continued use of these inputs on the plant composition and life of the stand has not been completely traced out. It is known, however, that different fertilizers can have a sharp effect in a relatively short time on one type of plant or another. The nitrogen fertilizers encourage grasses compared to legumes; the sulphates and sulphur fertilizers encourage legumes compared to grasses.

Starting with certain givens--the given climatic conditions, the site characteristics, the vegetative composition, the seasonal aspects--an input--output relationship for each grazing system is established, and within each grazing system an input-output sub-set is identified with each kind of livestock: steers alone, heifers alone, in combination, an all age herd, young animals, older animals, and so on. Supplemental inputs will modify the expected output as noted.

Integration of Resources

The livestock production firm is concerned with the following problems: (1) feed procurement, (2) feed utilization, (3) transformation of feed and forage into livestock productions, and (4) marketing and prices. The specifications and functional relationship that have been explored now must be introduced into the needs and constraints of such a system. Two things must be done simultaneously: consider within and between years net returns from operating in different ways. First, seldom, if ever, is forage found of the kind needed in one place and all of one form. Hence, in the range country spring, summer, fall and winter ranges are aggregated. Further, in the northern part of the range area hay land must be substituted for the winter range. (Under conditions of drought purchased feeds must be substituted for one or more of the four feed source periods.)

The first consideration is a budget or money restraint, that is, unlimited capital is not available. Consequently, working through the marginal rate of substitution of factors the determination of the optimum use of each under the constraint is necessary. By working with a single product, MPP can be equated with respect to X_1 with the MPP with respect to X_2 and so on. If more than one product is to be considered, it becomes a matter of equating the ratio of the marginal value product of each with respect to its cost. The conditions are, then, to use each resource with respect to the proportions specified by the ratio of the marginal physical products and the respective price ratios. The scale of production is determined by a value which is the rate of return desired.

It may not be possible to reach the economic optimum specified by marginal principles due to the restraining influence of forage conditions in the remaining periods. Each period can be considered separately to see what the result would be if all capital, labor, and management were concentrated in the period --any excess could then be shifted to the next highest productivity period. A surplus of labor would unquestionably result and under very intensive con-

centration of capital in one period may become the primary limiting factor instead of capital. Disposal of labor in other periods because of capital used up in the preceding periods is often the reason given for having a year-round operation. However, specialization within a period is entirely logical in many cases. Take the case of fertilization of spring range in California. Capital is used up in fertilizer and its application and the additional livestock needed to utilize the added forage. The period involved is a short one, two months or so, but where capital is available, it has proved to be a profitable investment.

A favorable feed period, or a favorable feed area, always has conditioning its use the least favorable period closest to it. Thus, the rancher has a land problem, i.e., productivity, an allocation problem, and a price or marketing problem. I have not said anything yet about uncertainty with respect to future prices and productivity levels. The range of variability in production can be quite large between years. In combining seasonal forages the rancher can make a number of choices. He may avoid the least productive season of feed supply. Sales off the ranges in the fall to work the herds down to a level where, considering feed quantities and feed prices, the basic herd can be economically maintained through the winter. Numbers of livestock in excess of available feed must be sold unless the cost of feed purchased is less than (or just equal to) the value of the product for each period considered separately. A rising price level would provide an incentive to retain the animals even though the rancher had to buy feed. A representative situation can be stated as follows for three feed periods: (1) in the first period a gain of two pounds per day is considered to be the most economical, (2) in the second period only sufficient forage is available to maintain one-half the number of livestock and feed must be purchased to maintain the remaining head, (3) in the third period renewal of the forage again permits a two pounds per head daily gain. The first period is clearly separate. The next two periods belong together. A choice to sell at the end of the first period depends upon added cost and added value over the next two periods. Price expectations will enter the decision and the rancher will also want to know the probable gain in the last period. If in fact the livestock were gaining during the summer the final price would have to be distributed over that much gain also.

The primary problem of a range-livestock operation is illustrated--that of balancing seasonal forage supplies against the needs of a particular livestock system and the modifications that are needed with respect to each in terms of the other. The problem is composed of several parts: (1) to bring up the least productive period to the level of the others, (2) to raise the general over-all level or, (3) to select one or two periods for concentration. A rearrangement of the use of the several pastures or ranges is often as profitable as added investment. Before considering added investment, an estimate of the productivity level of range land which will be provided by such investment must be compared with present productivity levels. A recent study indicates that it was profitable to reseed native range only if the level of productivity of a range was more than 30 percent below average capacity.3/

3/ Lagrone, W. F., "Reseeding Rangeland: Loss or Profit," Paper American Society of Range Management, June, 1959.

Decisions about how to utilize range forages will consider profitable adjustments in stocking rates made possible by changes in prices, climatic conditions, other inputs, and new range technology. A part of utilization is the question of multiple animal products. It is frequently possible because of differences in the vegetation preferences to have a combination of sheep and cattle. In this respect, sheep and cattle form a complementary relationship over some range of numbers (they eventually become competitive) but they can be competitive with respect to other resources. If a herder for the sheep must be provided a problem is created immediately. First, the number of sheep should be sufficient to warrant the employment of a herder. The next thing to be taken into account is the distance the sheep must be transported, and then the cost of moving the sheep, and the costs of maintaining the herder. Thirdly, except for specialized feeding of lambs, a sheep enterprise is an annual operation and other sources of feed must be determined. Fourth, the management problems--lambing, disease control, shearing--are greater for sheep than they possibly are for cattle. Consequently, it is often much easier to add cattle to a basic sheep ranch than it is to add sheep to a basic cattle ranch.

Public Land Use

It might be argued that the decision process of the public land administration is different than the decisions made by private land holders in that multiple use considerations are to be met. This distinction cannot be supported. As a matter of position in the order of things, the rancher is the recipient of one of the use shares. The private livestock producer who depends upon the use of large amounts of grazing land, should this land be reduced by reason of use rationing or by reason of productivity levels and who is also in the situation that the land he does control will not support intensification, is in difficulty.

Cases do apparently exist where the private base unit would be of limited value without a public grazing permit and reductions in the numbers, timing, and certainity of the permitted use can seriously impair income or sale value. That is, if the return that can be made on the base unit just covers its cost the only source of net return is from cheap grazing land. How many of these units exist is not known. Proof requires an examination of the total annual operating budget not just an evaluation of worth as it is frequently expressed --so much forage from public range equals so many pounds of beef times some price equals what the public range is worth to the rancher.

With respect to more intensive management, public land improvement and private land improvement have moved along in a parallel fashion. Each group has drawn on the other for information and guidance. Every service and many ranchers have played a part in finding out what could and could not be done. The process has not been smooth by any means. Included have been experiments, demonstration plots, grazing trials, the work by the Forest Service on soil and water conservation and developments made by the Bureau of Land Management under the Halogeton control program.

General Considerations

An attempt has been made to describe some of the things governing decisions which are primarily based on firm level considerations and conditions. Economic developments of a more general nature also help determine the basis of choice. The relation of the private and public land units where the public land is a variable but integral part of the firm has already been covered.

Capital is generally considered to be one of the primary restrictions on land development but in recent years specialized types of labor have become quite restrictive. Sheep herders are difficult to find and consequently the sheep-range picture is changing considerably. More of the sheep production units are being brought under fence. Accompanying this shift has been the development of various types of pasture improvement and irrigation programs.

Adjustment to seasonal price variation is limited. However, expectations with respect to the cyclical behavior of prices and the trend in price is of considerable concern to each rancher. These two price characteristics are the primary basis for change in level of operations. Other dynamic features of the economy which will effect production and marketing are: (1) changes in agricultural policies which induce changes in the use of large segments of land, some of which has potential for livestock production, (2) trend toward large-scale retailing, (3) improved quality and increased quantity of beef taken by the market, (4) larger and more specialized feeding units, (5) improved performance of beef animals, (6) expanding science of nutrition, (7) shifting markets--away from central markets toward direct buying and country auctions, and (8) expanding markets for fed beef.

While it is possible to speculate on what the implications of some of the changes which loom on the horizon will be on the competitive position of regions and segments of the livestock industry conclusive evidence is not in yet. Possibilities include a shift of western livestock operations to more strictly cow-calf units, the development of specialized farm production units, a shift in feeding locations, and even possibly a reversal of the traditional relationship of the feeder-finished beef prices.

Much of the data required for the types of solutions set forth are not available and they may not be available for some time to come. Information which is immediately needed are digestibility coefficients and the grade values of realized animal products so that the use of forage productivity estimates can be expanded. Vital to estimates of income distribution are determinations of the effect of different grazing systems and different types of livestock on the life, productivity, and composition of the plant community. The information needed on marketing and prices could best be obtained by developing joint studies with economists now doing research on livestock marketing and livestock price analysis.

The requirement of minute details as stressed herein is the inevitable consequence of trying to apply the broad principles of economics. These broad principles while providing the general framework do not provide a basis for specific recommendations. To realize specific recommendations it is necessary to move beyond the point of abstract conclusions.