SPATIAL DIVERSIFICATION BY BEEF PRODUCERS IN THE CLARENCE REGION

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A simulation model was constructed to ascertain the extent of benefits from spatial diversification when an intensive form of use is assumed for the additional (alluvial) land. Although expected profit increased and coefficient of variation decreased, the return to additional capital was only 2.7 per cent. Spatial diversification successfully overcomes winter-spring feed uncertainties, but appears economically doubtful under present assumptions. Some alternatives and modifications are suggested which, although untested, might improve the economics of diversification.

1 INTRODUCTION

This paper discusses the economics of spatial diversification by beef producers in the Clarence region of New South Wales. Spatial diversification involves the combination (with or without physical integration) of non-adjoining properties within the one agricultural business. It is a well established practice in the Clarence region. Beef producers owning extensive grazing properties have bought areas of alluvial land near the Clarence River. Most of these smaller properties were previously in dairy production and as this is a declining industry in the region,[1] a continuous supply of suitable land has been available.

During unfavourable seasonal conditions in late winter and spring, weaker breeding cows are moved from the larger property to the river and nursed for from two to four months on better quality feed. They are returned to the main property at the onset of the summer growing season, about November.[2] When there are no such winter-spring feed stresses, the better quality pasture is used to fatten steers which would otherwise be sold in store condition.

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[1] The number of registered dairies in the Grafton area has been declining at an annual rate of 7–11 per cent in recent years—New South Wales Department of Agriculture, Grafton, unpublished data.

[2] The subtropical climate of the Clarence region (average annual rainfall approximately 900 mm) means that rainfall is summer dominant, although there is usually an autumn, and slight winter, component. August and September are the driest months. In addition, coefficients of variation for monthly rainfall exceed 80 per cent. Native pasture growth largely ceases about the end of March, and from then on stock have to rely for fodder on pasture carried over from the summer months.

With a few exceptions the alluvial land appears to have been largely wasted to date, considering its high value and productive potential. This is so despite the fact that all graziers interviewed declared strongly in favour of it.[3] There has been little intensive cropping so that similar benefits would probably have accrued from much cheaper non-alluvial land. Capital limitations arising from the purchase of the alluvial land have largely prevented intensification hitherto, and several graziers intend to embark on an irrigated cropping programme in the near future. Thus the absence of pertinent experience with intensive forage cropping provides a further justification for a detailed investigation of the economics of spatial diversification.

In the next section, a brief review of reported research on spatial diversification is given. A model appropriate to the analysis of a spatially diversified firm is outlined and then applied to a hypothetical Clarence grazing situation.

2 RESEARCH ON SPATIAL DIVERSIFICATION

2.1 GENERAL PRINCIPLES

The rationale for diversification under risk is to modify the resource combination so that the effects of risk are lessened.[4] Intuitively, there are two attributes of land which may prompt its diversification. First, there may be climatic differences associated with geographical separation; in extensive agriculture, rainfall is the most obvious and important influence. Second, soil type differences may affect the range of feasible activities and their quantity, quality, and seasonality of production. Negative covariances between new and existing activities may then permit a reduction in the overall level of risk facing the firm. Early researchers expounded the virtue of "not having all one's eggs in the one basket" but mathematical elucidation did not appear until Heady's specification in the early 1950's [15, 16 ch. 17]. Subsequent empirical applications tended to tread the well worn research path of activity mixes for cropping systems. Mostly they endeavoured to determine, with the aid of variety of analytical tools, the optimal combination of feasible risky activities in specific situations. There have been few applications of this type of research to predominantly grazing systems.

Measures for determining the effectiveness of diversification are not clear cut. While it is obvious that the assessment criterion should compare the extent of risk in diversified and undiversified situations, this presupposes a universally accepted measurement of risk. The traditional measure (variance) is currently under attack from theoretical considerations [13, 14]. However, as Anderson notes [3] this measure, while imperfect, is both convenient to estimate and more useful than practical alternatives.

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[3] The past and present situation with spatial diversification in the Clarence region was assessed by surveying twenty-five diversifiers.

[4] Under conditions of certainty, diversification can be undertaken to benefit from complementary relationships or to equate marginal rates of transformation with inverse price ratios. Neither is relevant in the present context.

The simplest comparison is in terms of relative variability—standard deviation as a percentage of expected outcome. This is more appropriate than absolute variance because it permits recognition of changes in expected outcome associated with changes in total variance. Better still would be to trade-off expected outcome and variance by using the decision makers' utility function. Since a utility function is a completely individual concept [11], it is more flexible than the somewhat arbitrary criterion of minimizing relative variability. However, expected utility outcomes themselves are only comparable under *ceteris paribus* assumptions, which include, for example, the level of capital required for two investment projects. Where two projects require substantially different amounts of capital, they are not comparable on even an expected utility basis.

This point is clarified by considering the two Headian categories of diversification: (a) total resources remain constant; (b) total resources increase. Category (a) corresponds to the traditional form of diversification where resources are rearranged between alternative forms of production in order to establish a preferable portfolio of activities in the Markowitz sense. Cropping possibilities have most often illustrated this system and livestock activities have sometimes even been explicitly excluded from consideration because of the capital outlays required to establish them. Assessment of such diversification is relatively straightforward using expected utility procedures. In the context of spatial diversification, this form would necessitate selling portion of the existing property and diverting the capital generated to the new land type. It is not appropriate to spatial diversification as practised by Clarence beef producers.

Heady's second category, where diversification is achieved by increasing total resources of the firm, introduces a greater range of possibilities and complexities because of its association with capital accumulation and firm growth. However, it is more appropriate than the previous category to livestock production in general and to Clarence spatial diversification in particular. Unfortunately though, it is more difficult to assess the worth of these patterns of diversification. It is not appropriate to compare them with the original situation because substantially different amounts of capital are likely to be involved. Rather, relevant comparisons are with feasible alternative ways of allocating the same resources as were used to achieve diversification. In some sense this reduces the problem to category (a) (but at a higher level of capital) in that the projects being compared will all have essentially the same level of capital. The size of the study implied by having to trace through the gamut of investment possibilities facing the firm is large indeed—well beyond the scope of the present study.

From this discussion it is clear that caution must be exercised when assessing the economic implications of spatial diversification. In addition, problems associated with multidimensionality of decision makers' goals are not as easily rationalized when concern is with a hypothetical (albeit representative) situation as when a specific situation is being investigated [10]. Hence, while results might be addressed to the typical situation, recognition needs to be given that prescriptions will be sub-optimal or require modification for an individual.

2.2 SPECIFIC RESEARCH

Spatial diversification as a research endeavour has been virtually neglected to date. This undoubtedly stems from the complexity of the problem, the individuality of spatial diversification practised by different firms and the absence of suitable methodological tools to handle the various stochastic processes involved and decision makers' responses to them.

Some early work was conducted in Montana on the problem of hail damage to wheat crops [14, 17, 18]. The initial hypothesis was that, since hail storms are fairly localized, dispersion of farm units could be an effective way to reduce the variability of income caused by hail. However, the analyses were restricted to statistical manipulation of physical yield data from dispersed and concentrated patterns of farming. No attempt was made to quantify the benefits from dispersion in economic terms or to indicate optimal patterns or degrees of dispersion. Nor was the alternative of moving from a known hail belt discussed.

In Australia, research interest has been revived by Campbell [6] who believed that the economics of spatial diversification by arid zone pastoralists might be investigated. Anderson [1, 2, 3] has reported some work along these broad lines. His results indicated that spatial diversification in the pastoral zone does not appear very favourable to pastoralists. However, he did not rule out the possibility of profitable diversification into and within zones and industries.

In the Clarence region, the aim is not to acquire additional similar holdings to reduce risk from erratic weather conditions which may occur at any time of the year. Graziers require a different *class* of land to offset the effects of possible unfavourable climatic conditions in winter and spring. In that demand for additional feed is more seasonal in nature, though still uncertain in a particular year, this form of spatial diversification should prove more tractible in economic analyses than spatial diversification in the pastoral zone.

From a methodological viewpoint, Anderson concluded that the use of simulation models of spatially diversified sheep holdings "seems the logical means of exploring their economics whenever there is some physical integration within the system" [3, p. 112]. The two considerable advantages which simulation provides over other more formal analytical procedures are the ability to realistically incorporate complex stochastic systems elements and second, to handle decision making within the model. In this respect simulation is more in line with behavioural firm theory [8, 12] than with traditional, profit maximizing, perfect knowledge theory. The present study also uses simulation techniques in the light of Anderson's experience.

3 A SIMULATION MODEL

A FORTRAN simulation model was constructed on a monthly basis for an extensive Clarence beef breeding property. A computer based experiment was performed on the model to determine the optimal stocking rate for an undiversified system. Then the model was modified to incorporate an area of alluvial land and a similar stocking rate experiment conducted. Before discussing the results of these experiments, some specifics of the simulation model are provided.

The framework of the model is shown in the flowchart, figure 1. Computations follow the real system sequence. First, rainfall is generated and this augments existing soil moisture reserves and produces pasture growth in addition to that carried over from the previous period. Cattle consume pasture according to their basic energy requirements—weight gain or loss may occur, depending on energy availability. At the end of each twelve month period, the model's performance is assessed in financial terms.

3.1 PASTURE COMPONENT

Pasture growth relationships—pasture growth as a function of smoothed [21] rainfall—were specified using data from a native pasture trial conducted over a three year period on a sandstone derived soil near Grafton. Some aggregation of months was required to offset having only three observations for each month. In addition an allowance was made for initial soil moisture level by including half the previous month's rainfall, together with the current month's rainfall, in the explanatory variable. The resulting functions performed realistically in the model and were judged satisfactory by local agronomists.

The effects of pasture deterioration with age have not commanded the research attention of many biologists, despite its being an important attribute of most extensive grazing systems, especially those exhibiting strong seasonality of pasture production. It is also important in the screening stages of new plant introductions. In the absence of pertinent biological data, arbitrary monthly deterioration factors of 0·9 for October to March and 0·75 for April to September were selected.

3.2 ANIMAL COMPONENT

The model expressed nutritive value of pasture on a metabolizable energy basis rather than the simpler but less accurate digestible organic matter system, on which Wright [25] and Bravo's [5] models were formulated. Hence pasture production, in kg D.M./ha, must be converted to MCal of energy before becoming available to livestock. The conversion factor is an energy density figure (MCal M.E./kg D.M.) and it therefore depends on feed quality, which in turn reflects the time of the year and seasonal conditions. During October to March (when pasture is growing actively) it is assumed that there are 2·18 MCal M.E./kg D.M., while during April to September the energy density is assumed to be 1·85 MCal M.E./kg D.M.

Calves are born during September, October, and November of each year. The calving percentage is influenced by a number of factors, many of them being ill-defined. Of primary importance is the condition of cows at joining and, in general, lactating cows have a poorer chance of conceiving than dry cows (assuming the latter are disease free). The average cow bodyweight at the beginning of December (when joining commences) determines the calving percentage in the following spring.

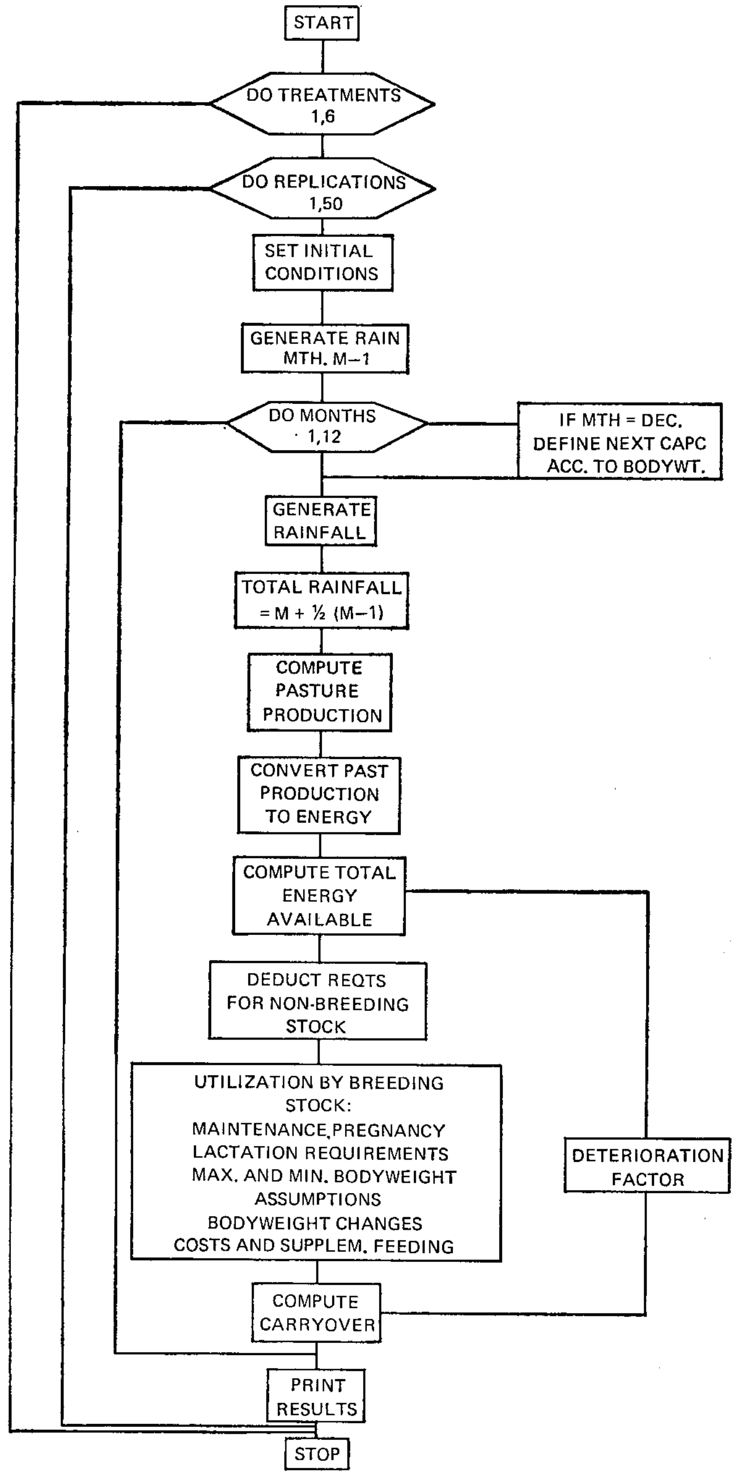

FIGURE 1: *Spatial Diversification Simulation Model Flowchart*

Breeding and non-breeding stock compete for limited supplies of feed. This competition implies an unlimited number of possible feed allocation ratios between the two classes of stock, and to simplify an unnecessarily complex decision problem, the energy requirements of non-breeding stock are assumed to be deterministic. This permits the effects of stochastic seasonal conditions to be fully reflected by the most important and sensitive unit of the herd—the breeding cow.

3.3 MODIFICATIONS FOR A DIVERSIFIED SYSTEM

The above model was modified to study the economics of a spatially diversified system. Between July and October, deterministic supplies of alluvially produced feed[5] augment existing native pasture from the off-river property. The latter will vary between years according to seasonal conditions; however, new native pasture growth during July and August can be assumed constant (due to low temperature effects) and during September and October can be represented by a discrete probabilistic matrix depending on rainfall during the period. Tactics for feeding cattle during this four month period have to be determined. In view of the native pasture growth pattern, the tactical decision phase has been split into two segments, one covering July-August and the other September-October.

The components of this four month tactical decision phase are: variable initial feed supplies; July-August tactical decisions; stochastic variability in September-October feed production; and September-October tactical decisions. These components can be formulated within a stochastic programming framework [7, 22, 23] as shown in schematic form by figure 2.

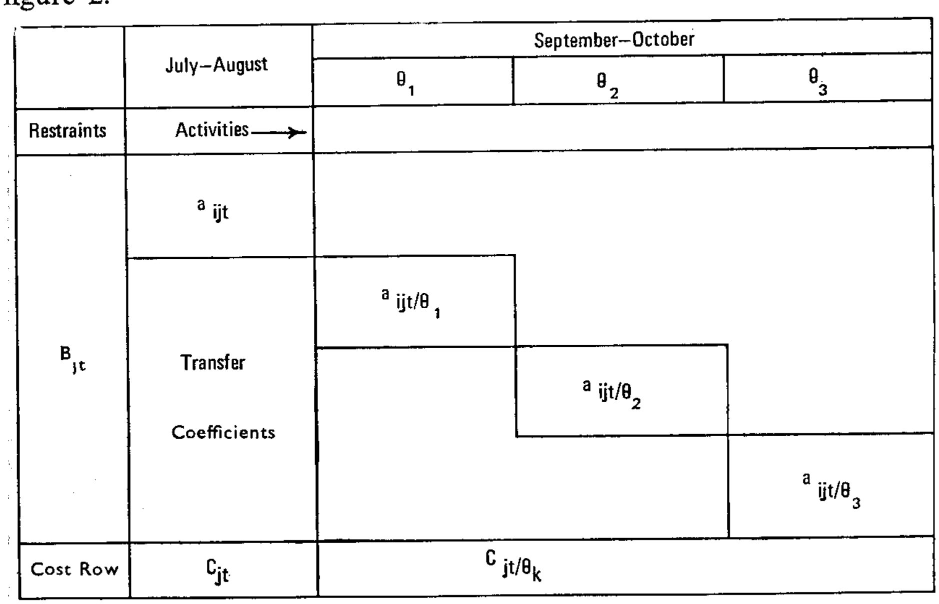

FIGURE 2: *Schematic Matrix for July-October Tactical Decision Phase*

[5] Alluvial feed production is assumed deterministic because of the presence of irrigation.

The July-August period is specified by twenty-two activities which permit the four classes of cattle (calving cows, dry cows, replacement heifers, and weaners) to be fed from available feed sources at various rates of weight gain or loss, or to be sold. The second phase comprises ninety activities which are similar and apply to one of the three possible states of nature (hence native pasture production). Instead of requiring a separate solution to this stochastic programming problem for each replication of each experimental treatment, initial native pasture feed supply (i.e. at the beginning of July, as determined from the simulation model) is parametized over its relevant range. Hence only one stochastic programme for each stocking rate treatment needs to be solved. The methodology is explained in considerably more detail elsewhere [24].

4 RESULTS AND DISCUSSION

The main results from the two stocking rate experiments are summarized in table 1. It is not proposed to comment in detail on the nature of the simulation output. Suffice to say that local agronomists and livestock researchers considered that the model performed in accordance with their experience of Clarence beef and pasture production.

TABLE 1

Results of Optimal Treatments, Diversified and Undiversified Systems

Item	Units	Diversified	Undiversified
Optimal Treatment	Cows	450	300
Expected Feeding Costs	$	541	278
Total Costs, ex Feeding	$	22,956	9,171
Total Expected Sales of Stock ..	$	29,987	15,893
Expected Inventory Change (Stored Lucerne)	$	3,375	..
Expected Profit	$	9,865	6,481
Variance of Profit	^{2}	7,708,397	5,704,481
Co-efficient of Variation		0·282	0·369
Utility	Utils	97·2	85·2
Level of Capital	$	280,050	152,480
Expected Return to Capital	%	3·5	4·25

Diversification has produced a 50 per cent increase in optimal stocking rate, with a similar change in expected profit and less than proportionate increase in variance of profit—hence the coefficient of variation is lower for the diversified system. The changes in "total costs ex feeding" primarily reflect variable irrigation costs for the diversified system. The main additional items are labour, fuel, and repairs to the irrigation plant, transportation costs of cattle to and from the alluvial land, and especially, cropping costs.

Total sales of stock for the diversified system are almost double those for the undiversified. This is due to two factors: a larger herd entailing both more cull cows and more calves, and a higher price obtained for the sale stock because there is sufficient surplus summer feed on the alluvial land to allow them to be fattened before sale. In addition to the sale of stock, the diversified system also receives income from surplus lucerne hay, some of which offsets expected costs of handfeeding up to the end of June each year.

Table 1 also shows the levels of capital assumed for the two systems. The additional capital of $127,000 for the diversified system earns only an extra $3,384—a return of 2·7 per cent.[6] Thus although spatial diversification may be judged a successful strategy in reducing the level of risk facing the firm (in that the coefficient of variation has been reduced) this low return to additional capital is clearly unsatisfactory. Alternative investment possibilities—for example buying more extensive beef country, clearing, superphosphate application, and pasture improvement programmes, and investment outside the agricultural sector—are all likely to produce returns to additional capital in excess of that resulting from spatial diversification.

However, spatial diversification should not be rejected outright before several feasible modifications are first considered. The main reason prompting graziers to diversify was to overcome possible feed shortages in late winter and spring. This has been more than adequately achieved and, in fact, even at high stocking rate treatments, considerable feed surpluses on the alluvial land resulted. One possibility would be to replace some of this forage crop land (perhaps 20 hectares) with a cash crop, such as beans. Although this crop is susceptible to hail and flood damage, gross margins are high ($150–$200 per hectare) and the cash flow generated would be a substantial boost to net farm income. Another alternative would be to graze replacement heifers on the alluvial property year round to increase their growth rates. They could then be joined for the first time at two rather than the present three years old, thus implying fewer replacement heifers and more producing cows in their place.

The efficiency of utilization of the alluvial land will also increase if a superphosphate programme is undertaken on the off-river property.[7] The pasture growth relationships of the present simulation model correspond only to a very low level of pasture production, between 600 and 2,000 kg D.M./ha annually. Superphosphate will increase the quantity of pasture produced, thus allowing higher stocking rates. Its main benefit in the Clarence region, however, is its effect on pasture quality. Higher nutritional value of pasture consumed by stock imply faster growth rates and especially, higher calving rates. These three benefits from superphosphate application will all produce a higher demand for pasture grown on the alluvial land.

Finally it may well be that, even allowing for future increases in off-river productivity, 100 hectares of alluvial land are more than is required to effectively complement 2,000 hectares of extensive Clarence beef country.

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[6] Return to capital of 4.25 per cent for the undiversified system is also below what might be expected. This reflects recent increases in local unimproved land values, due mainly to a high demand for such land by city business interests.

[7] Several of the graziers in the survey are in fact intending to embark on such a programme.

5 CONCLUSIONS

This study does not provide final judgment for or against spatial diversification. However, it does show, under the assumptions of the simulation model and those concerning alluvial land use, that the strategy is of doubtful economic value, even though it provides a relatively more stable income than an undiversified form of beef production. What is needed to more fully assess the strategy is to extend the model assumptions, as suggested in section 4, and to consider available alternative investment opportunities.

The Clarence grazing industry is, in general, more extensive than its counterparts on the Tablelands and Slopes. However, there is considerable variation in district soil types and hence pasture production and carrying capacity. This study is based on one of the most extensive forms, as the pasture production relationships were determined from trials on a poor, sandstone derived soil. On these soil types, the main advantage of spatial diversification is in overcoming the winter-spring feed situation. With this previously critical time of the year no longer a problem, development of the overall productivity of the property can be considered with greater confidence. Such development would typically involve fertilizer application and pasture improvement programmes.

A secondary benefit of this study has been the construction of the simulation model itself. The model should have two areas of usefulness in future Clarence beef research. First, it can form an adjunct to experimentation on real systems, such as grazing trials. Time and cost considerations preclude comprehensive assessments of real systems, but coverage of extreme treatments and complete replication of climatic conditions is possible within a simulation model. Also the construction of the model highlighted present gaps in biological knowledge of Clarence beef production, thus assisting future research on these aspects. Specifically, the two most important areas to emerge warranting future investigation are measurable attributes which determine calving percentages and the deterioration in pasture quality with age. Second, the model can be used in further studies, such as the feasibility of pasture improvement programmes, firm growth, and animal management studies.

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