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SIMULATION AS AN AID TO RESEARCH INTO EXTENSIVE BEEF PRODUCTION

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Summary

A simulation model of an extensive beef production enterprise in the Clarence region of N.S.W. is outlined in this paper. Some preliminary results are discussed and future uses for the model are suggested. Experience with the model supports the hypothesis that simulation is a research approach from which both the biologist and the economist can gain considerable insight into grazing systems.

I. INTRODUCTION

Simulation experiments are no substitute for experimentation on a real system, simply because the framework of a simulation model necessarily depends on the results from physical experiments. Fundamental production processes such as the conversion of organic and inorganic nutrients into pasture energy, and the conversion of pasture into livestock products, have to be determined with reference to some real system. Nevertheless, simulation models can aid biological research in many ways, as evidence advanced in this paper demonstrates.

The present model was developed to assist research into extensive beef production in the Clarence region of N.S.W. Initially the strategy of spatial diversification was investigated (Trebeck 197 1 a, 197 lb). The model has subsequently been generalised so that it is now capable of being used in a variety of situations (Trebeck 1972).

II. OUTLINE OF THE MODEL

The model represents a self-replacing beef breeding enterprise located on native pasture grown on a sandstone soil-type near Grafton. The major output from the enterprise is eight-month-old weaner cattle.

There were three sources of data. First, experiments at Grafton Research Station yielded native pasture growth curves, animal Iiveweight data and some subjective assumptions. Second, data gathered from related experience in south-eastern Queensland helped the formulation of assumptions regarding the rate of pasture deterioration, the pattern of calf drop, milk production of beef cows, and the effect of liveweight at joining on calving percentages. Third, overseas experience provided the basis for determining both the energy requirements for various body functions and the energy content of pasture.

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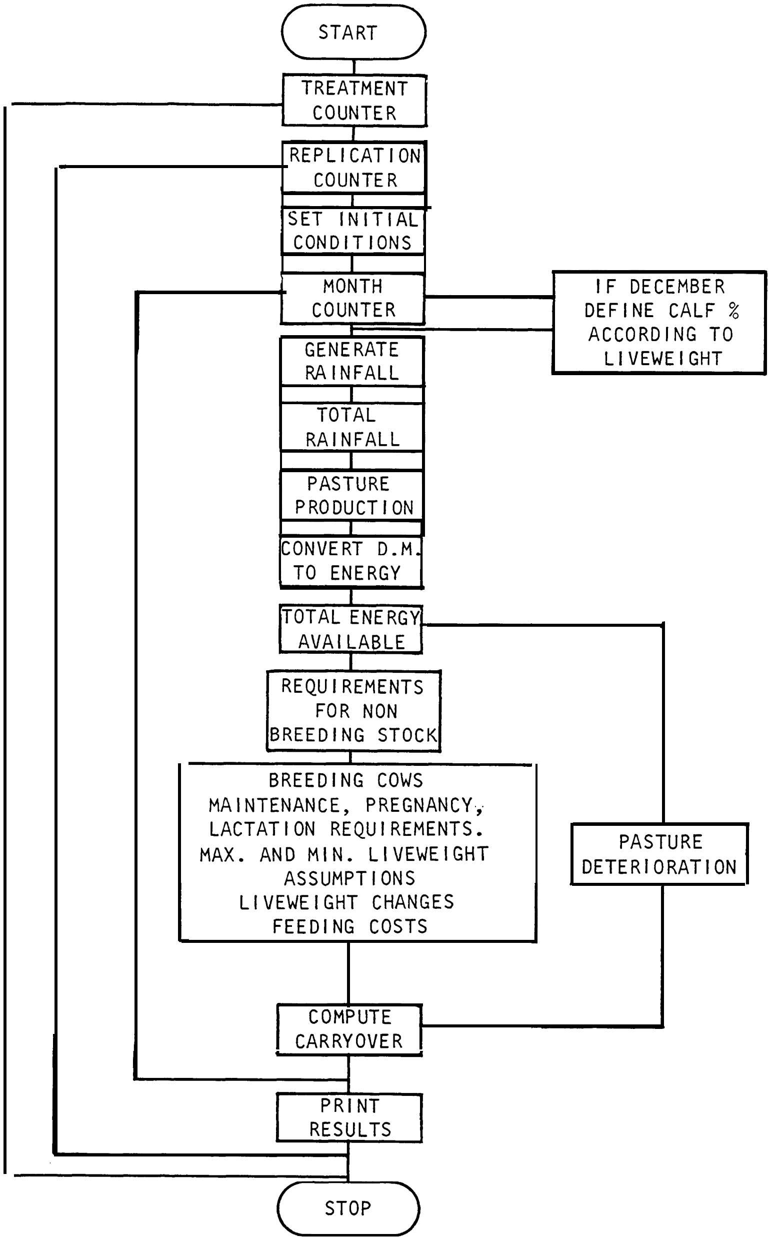

Fig. 1. — Flowchart for simulation model.

The model's structure is indicated by the flow-chart in Figure 1. The sequence of computations closely follows that of the real system. Rainfall is generated and this augments existing soil moisture reserves. The total moisture available determines pasture growth which is added to that carried over from the previous period. Cattle consume pasture according to their energy requirements. Depending on the amount of energy available, cattle may gain or lose weight. At the end of each twelve-month period, the model's performance is assessed in financial terms.

The model is written in FORTRAN IV. A feature is that it is based on a metabolizable energy system. This distinguishes it from some previous models, which employed the more easily measured, but less accurate, digestible organic matter system (e.g. Wright 1970).

III. RESULTS OF PRELIMINARY EXPERIMENTS

Once a simulation model has been constructed, the first task is to ensure that it is running smoothly ("debugging" stage) and that it in fact provides a realistic analogue to the system being simulated (validation). Overall validation is of necessity a subjective process for reasons which are discussed by Anderson (1972). However, certain model components (rainfall, pasture production and liveweight changes) can be validated against information existing for the real system. For these three components, the model produced results which correspond fairly closely to the historical or research data.

To date a simulated stocking rate experiment has been completed and the model has been used to assess the economics of spatial diversification. It is not proposed to discuss the specific results of these experiments, but rather to assess the overall performance of the model and to highlight shortcomings which still remain.

Pasture growth functions were specified from a trial conducted over three years. Production was estimated as dry matter in kg/ha and was related to rainfall in the current month plus half the rainfall in the previous month. With only three observations in each month (and in two months, two observations), it was impossible to derive an accurate monthly series of response curves. Accordingly, months were aggregated. A square root function was fitted to the data for the five main growing, months (November to March) and four linear functions embraced the remaining seven months. These functions produced seemingly satisfactory results. For further studies, however, three years' data are inadequate and it is recommended that further trials be conducted. Fortunately, the type of experimentation required demands few physical or financial resources.

In the sub-tropical Clarence environment, much of the pasture consumed during autumn, winter and spring is grown several months earlier. It is critically important, therefore, that the rate of deterioration in the nutritive value of this pasture is accurately estimated. In the absence of reliable experimental data, it was decided to use a monthly deterioration factor of 10 per cent for October to March and 25 per cent for April to September. As expected, the model proved sensitive to variation in the assumed values. Given that native pasture systems comprise the bulk of the Clarence beef country (Duncan 1966), assessment of pasture deterioration should be given a higher priority in future research programmes, so that these systems can be better understood.

Finally, and most importantly, more research is needed into factors determining calving percentage, with a view to establishing quantitative relationships.

The assumption in the simulation model, certainly naive, was that calving percentage varies linearly with cow liveweight at joining up to a maximum value of 75 per cent.

IV. FUTURE USE OF THE MODEL

Now that a fairly complex, although admittedly imperfect, model of an extensive beef enterprise in the Clarence region has been developed, its future use should be considerd.

First, the model will find direct application in connection with a large grazing trial commencing near Grafton in March 1972. The trial is located on a similar soil-type to that assumed for defining the pasture growth curves. Thus a symbiosis between the grazing trial and the simulation model can be envisaged. The simulation model will provide additional stocking rate results and additional replication in time; as the grazing trial progresses, data will emerge which can be used to refine the simulation model.

Second, the model can be modified to simulate different pasture and animal systems and soil types. Provided the basic data are available, this will be a comparatively straightforward task utilizing the existing framework, and it will facilitate the development of a regional model which embraces beef production patterns from each egronomic component of the region.

Third, additional economic problems can be studied using the existing model or modifications of it. These problems may range from individual farm management problems such as optimal time of calving and the economics of winter supplementary feeding programmes, to a regional beef supply model incorporating firm growth components and predicting supply under a range of situations.

V. EVALUATION OF THE MODEL

Some methodological advantages of simulation have been discussed in this symposium by Anderson (1972). In the study of spatial diversification (Trebeck 197 1 a, 197 1 b), the only conceivable alternative which would have captured the essentials of the stochastic processes would have been a stochastic programming formulation. Unfortunately the size of the problem would have daunted even the most ardent stochastic programmer.

During the construction of the model, the re-emphasis of data shortcomings has been valuable. Not only will qualitative leads be provided for future research, but sensitivity analysis of some of the more crucial assumptions of the model could quantitatively support claims for research funds. In addition,, a significant aspect of the whole modelling process has been an improvement in inter-disciplinary co-operation.

Throughout this paper, the inadequacies of the model have been highlighted. However, an imperfect model, if recognised as such, can still be useful in a practical environment if it constitutes the best stock of available information. The alternative is twenty years or so of research to build up a “respectable” bank of data; producers cannot wait this long before making decisions.

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