Sustaining productive pastures in the tropics 12. Decision support software as an aid to managing pasture systems

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Abstract

Decision support software can assist producers to make decisions that can help to achieve economic and biological sustainability of the grazing system. Interactions between management decisions and the physical, biological and financial attributes of a property are often complex, and thus the ability to adequately describe individual properties as pastoral systems is fundamental to effective decision support. Our paper reviews the benefits and success of computer based decision support packages for pasture management in livestock production, and suggests how teams of process and applied researchers can be formed to provide the scientific basis for future development and transfer of this new technology to industry.

Resumen

Los programas computacionales de apoyo a las decisiones pueden ayudar a los productores a lograr un sistema de pastoreo económico y biológicamente sostenido. Debido a la complejidad de las interacciones entre las decisiones de manejo y los atributos físicos, biológicos y financieros de una propiedad, la habilidad para describirla individualmente como un sistema pastoril es fundamental para un apoyo efectivo a las decisiones. Nuestro artículo revisa los beneficios y èxitos de los paquetes computacionales de apoyo a las decisiones sobre el manejo de la pastura en la producción del ganando. y sugiere la manera en la que los equipos de investigadores, de ciencia pura y aplicada, pueden ser formados para proveer las bases científicas de un desarrollo futuro y la forma de transferir esta nueva tecnología a la industria.

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Introduction

Mathematical modelling and computer simulation have been used since the mid-1960s to enhance our understanding of agricultural systems (for example, Slatyer 1964). Initially the software was developed for main-frame computers but since 1985 there has been an increasing emphasis on software for personal computers.

Progress of computer software to assist decision making in the pastoral industry can be traced through the proceedings of the first three Australian Tropical Pastures Conferences. At the first, Winks (1975) concluded that mathematical modelling and computer simulation were logical ways to solve problems of integrating native and sown pastures to increase animal production. At the second, McKeon and Scattini (1980) reported a large number of modelling /simulation studies but concluded that they were being used mostly to interpret the results of research. By the third conference, McKeon *et al.* (1986) demonstrated that climate-soil-plant-animal models could be applied to assist managers to make decisions on commercial properties.

Progress is now in two directions: (a) research involving mathematical modelling and computer simulation experiments to achieve understanding of the interactions within pastoral systems and to derive principles of sound pasture management, and (b) development of 'user friendly' packages that can be run on personal computers, applied to the unique circumstances of an individual property, and used to test a range of 'what if' scenarios. These packages are popularly referred to as decision support software.

Our paper describes potential benefits of decision support software, reviews some successes, and draws on the experience we have gained in developing the GRASSMAN package to propose a general framework for the development of software and its transfer to industry. Attention is focussed on software that is relevant to the beef industry of northern Australia.

Potential Benefits of Decision Support Software

Decision making within the context of pastoral management is complex and involves interactions between land, pasture, trees and livestock against a background of climatic and market variability. While managers often have access to a wide range of relevant information, they frequently find the information to be of limited use because of difficulties in bringing the data together in an objective way. Thus, management decisions are often based on past experience and intuition.

The audience for decision support packages includes primary producers, extension staff, agribusiness people and education institutions. Although the audience is broad, the market is presently small because demand from producers is still in its infancy. A recent survey of beef producers throughout Queensland by the Australian Meat and Live-stock Research and Development Corporation found that 14 percent of the 2100 respondents were using micro-computers in their business and of these 21 percent were using decision support software (A. Kelly, personal communication). It is anticipated that interest in decision support packages will expand exponentially as the number of primary producers with micro-computers increases and as confidence in the use of decision support software grows. In the short-term the main recipients of decision support software will be extension staff and education institutions. Therefore, the main benefits to industry from development of decision support software will continue to occur for some time through conventional extension and education channels.

The main benefits of using decision support software are derived from the capacity of the software to rapidly integrate information to a form that is pertinent to management decision making. Some benefits which flow from this include:

- enhancing the management skills of producers by increasing their capacity to conduct benefit/cost/risk analyses,
- providing a basis for property planning (physical and financial),
- reducing costs of production by allowing the cost effectiveness of options to be compared,
- improving productivity and sustainability by better matching of livestock requirements to forage supplies,
- providing a basis for selecting management options with respect to forecasts of market and climatic conditions,
- improving the quality of advice given by agribusiness and government agencies,
- integrating data from field research experiments so that it is relevant to producers, and
- increasing the effectiveness of educating the next generation of primary producers and consultants at agricultural colleges.

Success of decision support software

There have been some notable successes in decision support software. Packages have been developed to deal with a wide range of issues including woody weed control, stocking rates, drought management, dynamics of beef herds and sheep flocks, cash flow budgeting, and financial analysis of enterprises (Clewett 1990). Examples of such packages are RANGEPAK (Stafford-Smith and Foran 1988, 1990), BEEF-O-NOMICS (Dixon 1989), SHRUBKILL (Ludwig 1988, 1990), the forage cropping component of C.Q.AGWARE (Jamieson 1990) and the BEEFMAN series (Clewett *et al.* 1988, Wilson *et al.* 1987). Within the BEEFMAN series there are two kinds of packages. Firstly, there are the educational packages BEEFUP (Rickert *et al.* 1990a), STOCKUP (Rickert and Espie 1990) and FEEDUP (Rickert *et al.* 1990b) that were developed for teaching students at agricultural colleges, and secondly, there are the decision support packages GRASSMAN (Scanlan and McKeon 1990), STOCKMAN (Taylor *et al.* 1990) and BREEDCOW and DYNAMA (Holmes 1991) that were developed for decision making in 'real life' situations. The authors of this paper are aware of numerous undocumented reports of how the above packages have assisted students, government agencies, agri-business people and pastoral managers by providing a more objective analysis of the biological, physical and financial aspects of many different pastoral enterprises.

Two different approaches have been used in developing the above packages. STOCKUP, STOCKMAN, BREEDCOW, DYNAMA and RANGEPAK use a holistic view of a beef enterprise, concentrate on herd structure and economic analysis, and rely on the user to specify all biological inputs such as carrying capacity and growth rates. These packages have a top-down perspective towards decision making and rely upon user inputs for their accuracy. In contrast, packages such as BEEFUP, FEEDUP and GRASSMAN are based on climate-driven plant/animal growth models and hence they have a bottom-up resource-based perspective to decision making. Their accuracy is dependent upon the reliability of the biological relationships describing climate/soil/plant/animal interactions.

Simulation studies with research models such as GRASP (McKeon *et al.* 1990) that estimate pasture and livestock productivity from base resource information (climate, soils and vegetation) have provided valuable insights into our understanding of grazing systems and have been used to reveal principles of pasture management. Examples are: decision rules for the frequency of burning native pastures in western Queensland (Johnston and Carter 1986), integration of forage resources to optimize beef production (McKeon *et al.* 1986), analysis of sustainable stocking rates on native pastures (Pressland and McKeon 1989; Meppam and Johnston 1990), and impacts of the Southern Oscillation on decision making (Clewett and McKeon 1990).

Research models are powerful analytical tools but their potential to have impacts on industry as decision support software is constrained because their use is confined to a small number of research workers. However, the development of research models is often an essential precursor to the development of 'user friendly' decision support software that can be used by a large number of extension officers, agri-business people and producers. For example, the development of the GRASP model was an essential precursor to development of the GRASSMAN package.

It is useful to examine one package in detail so that some specific issues relating to the success and limitations of decision support software can be considered. The GRASSMAN package has been chosen for this purpose because it has a resource-based perspective to decision making and the authors of this paper have been involved with its development and application.

Case study of the GRASSMAN decision support package

GRASSMAN (Scanlan and McKeon 1990) is a computer program to assist beef producers compare strategies for managing native pastures in eucalypt woodlands of central Queensland. The program integrates information by firstly asking the user to specify resource information (rainfall, soils, and the type and density of eucalypt community), costs of management operations and cattle prices, and then uses the following sets of biological relationships to estimate changes in pasture condition, beef production and financial returns over a 15 year period: (i) potential pasture growth as a function of climate and soils, (ii) changes in tree density due to clearing and regrowth, (iii) actual pasture growth as a function of potential pasture growth, competition from trees, pasture condition and previous forage growth, (iv) beef liveweight gains per head and per hectare as a function of pasture growth, percent utilisation of pasture growth and grazing pressure, and (v) feed-back effects of climate and grazing pressure on pasture condition.

GRASSMAN applies to eucalypt woodlands which do not have an acacia over-storey, have tufted native grasses, are between latitudes 20 and 26 degrees South, and receive an annual rainfall of 575 to 1125 mm. The package can assist decision makng by providing benefit/cost analyses in three important areas.

- Woody weed control. This is often an expensive and difficult aspect of pasture management. GRASSMAN can compare different methods of chemical and physical control (for example, stem injection, Graslan, pulling, fire) on grass production, timber regrowth, beef liveweight gains and profits for 21 different eucalypt communities. The data in Table 1 show simulation results for poplar box communities at four locations.
- Land care issues associated with the effects of changing stocking rate on the condition of native pastures and thus on future cattle liveweight gains and profitability.
- Risk analysis and drought management. By specifying future annual rainfall conditions over the 15 year period, the user can test the consequences of drought on timber and stocking rate management decisions.

Simulation studies using a research prototype of the GRASSMAN package with long-term climatic data show that optimum stocking rates

Table 1. Simulation results from GRASSMAN: effects of Graslan and Tordon, applied in year 1 to four poplar box communities, on timber control, safe stocking rates and financial returns over 15 years

Poplar Box Community	1	2	3	4
Site Description				
Annual Average Rainfall (mm)	900	670	480	460
Soil Type	Clay	Duplex	Duplex	Sand
Soil Fertility	High	Medium	Medium	Low
Potential pasture growth (t/ha/yr)	3.5	2.8	2.2	1.8
Initial Tree Basal Area	12	10	8	6
Presence of understorey	no	no	yes	yes
Tree basal area after 15 years (m^2/ha)				
Do nothing	12	10	8	6
Apply Tordon in first year	6	6	8	6
Apply Graslan in first year	2	2	6	5
Average Stocking Rate over 15 years (beasts/100ha)				
Do nothing	22	16	11	10
Apply Tordon in first year	37	25	14	12
Apply Graslan in first year	45	36	21	18
Net Present Value ($/ha)				
Do nothing	98	53	30	19
Apply Tordon in first year	145	77	25	10
Apply Graslan in first year	93	22	−33	−58

are very dependent upon the period of outlook. This is demonstrated in Figure 1 where optimum stocking rates for maximum economic return/ha (assuming constant costs and prices) are shown for each of the last ten decades at Charters Towers in north Queensland. It is against this very large variation in optimum stocking rates that the pastoral lands of Australia must be managed. While the consequences of drought and rainfall variation can be evaluated in GRASSMAN to determine 'safe' stocking rates, the program does not calculate probabilities of risk and obviously cannot foresee the future to determine optimum stocking rates for future rainfall conditions.

Initial reaction from primary producers upon first seeing GRASSMAN is usually restrained curiosity, however attitudes usually change to positive enthusiasm when they are able to fully consider the program in situations relevant to their own circumstances. This has been particularly the case where the program has been demonstrated to small groups of producers at Land Care meetings. Producers have found the package easy to understand and use because of the menu system, 'on-screen' help and graphical presentation of results. Ease of use and clarity of display have been key factors in producers accepting the package.

The GRASSMAN software is distributed as a compiled Pascal program and it is through use of the Pascal language that the program derives its speed, ease of use and clarity. However, this is also a disadvantage because the program cannot be changed by the user and methods of calculation are unseen. In contrast, BREEDCOW and DYNAMA are spreadsheet models and hence the methods of calculation in the model are fully visible and can be readily adjusted to suit the needs of each user. This may prove to be an important aspect of decision support software in the future as users become proficient in computing.

The most common criticism of GRASSMAN is that the package relates to a paddock and thus a portion of an enterprise rather than the whole grazing enterprise. This constrains the use of GRASSMAN. However, the advantage of GRASSMAN is that it can be used to determine animal growth and stocking rates which are required as inputs to whole enterprise packages such as STOCKMAN, BREEDCOW and DYNAMA. The two sets of biological relationships which have prevented the extension of packages such as GRASSMAN to whole enterprise analyses are: (i) estimating herd dynamics with animal reproduction as a function of previous climate and pasture growth, and (ii) estimating the interactive effects of spatial variability of pastures with animal grazing patterns on pasture condition and subsequent liveweight gains.

A second criticism of GRASSMAN is that the package is too confined in its geographic region of application and too limited in its range of

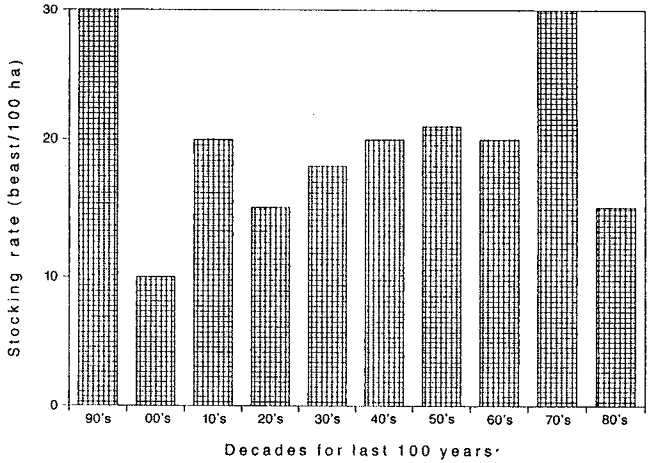

Figure 1. Effect of rainfall variability on optimum stocking rates (for maximum $/ha) for each decade over the past 100 years at Charters Towers in north Queensland.

pastures and management options. For example, producers have sought packages for the brigalow region of central Queensland where there is a diversity of forage options for grazing management. This criticism can only be solved through continued research to define the required biological relationships.

Development of GRASSMAN drew upon more than 150 man-years of research effort in setting up, recording and analysing data from field experiments, and 20 man-years of research effort in developing the methods and knowledge needed for systems analysis. In comparison, the GRASSMAN package required less than 4 man-years for development. This analysis shows that decision support packages such as GRASSMAN are a low cost/high return mechanism for delivering the results of research to industry.

General framework for the development of decision support software

The success of decision support software has resulted in a demand from extension services for development of new programs (Delaney 1990; Clark 1990). However, Hamilton *et al.* (1990) make the point that, to be effective, decision support packages should not be marketed on their own like books, but rather they should be an integral part of wider extension projects.

Our experiences in developing and applying GRASSMAN suggest the following steps are essential to developing an effective decision support package for the management of pastures:

- determine the needs of potential users including producers, extension staff (with projects aimed at important agricultural change) and agri-business people,
- evaluate pasture management options using a systems analysis approach, mathematical modelling and computer simulation to derive understanding and solutions to pasture management problems,
- compare the accuracy and scope of simulation experiments with the requirements of users and be prepared to fill gaps in the knowledge base with 'expert' opinion,
- monitor pasture growth, pasture condition and livestock production on commercial properties to verify biological relationships,
- develop a 'user friendly' decision support package involving a wider audience of producers, agri-business and extension officers in the processes of package design and evaluation, and
- conduct research to develop sound marketing, promotion and extension plans that mesh with the needs defined in the first step so the loop of transferring technology to industry is completed.

Conclusion

To develop effective decision support software, a multi-disciplinary effort involving producers, pasture scientists, animal scientists, biometricians, economists, computer programmers, extension officers and marketing specialists is required. With such a diversity of people in the group, effective management to form a cohesive goalorientated team becomes a key issue for success.

Decision support software is potentially an efficient mechanism for delivering the results of research to industry and has the potential to make significant contributions to effective pasture management. However, there are a number of challenges to the success of decision support software. While primary producers are rapidly adopting computers in their businesses, they also have a natural suspicion of recommendations emanating from computer packages that may challenge their experience and intuition. Thus, adoption of decision support software will not occur until users acquire confidence in the quality of information presented.

In our view the methodologies of mathematical modelling and computer simulation of systems, and the consequent development of decision support software have proven their worth as tools to improve decision making in pasture management. Therefore, we suggest that a review of factors limiting and enhancing the application of decision support software is required so that: (a) priorities for product development can be established, (b) effective methods for promotion to industry can be adopted, and (c) the full potential of this new technology can be realized.

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