TECHNOLOGY TRANSFER AND EDUCATION

TRAINING AND EXTENSION IN GRASSLAND FARMING

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Abstract

Stakeholders in grassland farming, including farmers, rural communities, urban consumers, politicians, educators, and service agencies, widely agree that the goal for grassland farming is the triple bottom line: farming systems that are ecologically sustainable, profitable and socially acceptable. This paper considers how extension and training might contribute to that worthy goal by encouraging practitioners to better manage their management environment. The notion of a management environment refers to a holistic consideration of those factors that impact on farmers, farm advisors or educators, that subset of grassland farming 'practitioners' within the wider range of stakeholders.

The difficulty faced by these practitioners is how to achieve the triple bottom line in a management environment that is changing rapidly, often through influences that are outside their control. To this end the paper progressively develops the following themes. (1) Change is an inherent part of the management environment in grassland farming and is driven by macro influences that arise from outside the farm and by micro influences that impact on farm management options. (2) Successful practitioners must manage change and the role of training and extension is to facilitate management of change. (3) Managing change requires a suite of knowledge and skills that foster innovation in the management environment, thereby demanding successful managers to be self-reliant and to embrace a life-long process of learning. (4) Information to cope with change and to underpin management decisions will, increasingly, be obtained through the World Wide Web and other modern forms of communication. (5) Active learning methods, ranging from apprenticeships to participatory groups are becoming the preferred means for adopting appropriate technologies or actions for managing change. (6) Curricula in training institutions need to move from the traditional emphasis on technologies and the means of production to courses that emphasize a holistic view of agriculture and the skills for handling the management environment at both the macro and micro levels. The overall thrust of the paper is to propose that the most worthy aim in training and extension is to prepare graduates for a world of change by ensuring they have the basic knowledge, skill, confidence and attitude to embark on a lifetime of learning, adaptation and innovation.

Introduction

Speakers at three preceding international congresses have considered this topic. Jiggins (1993) described six models of technological innovation, ranging from the traditional linear transfer of technology model to Participatory Technology Development (PTD), which combines insights from science with indigenous technical knowledge to encourage experimentation and action leaning in communities. Participatory approaches, which build partnerships between farmers and research and extension people, were seen to be more effective and efficient in transferring technology. The effectiveness of the approach in developing countries was shown by Waters-Bayer *et al*. (1999b) when they used PTP to transfer technologies that were practised by indigenous innovators. The benefits of PTP are also recognized in developed countries, (Roling and Wagemakers, 1998) and in disciplines other than agriculture (McTaggart *et al*., 1999). Along with increasing recognition of the role of PTP in extension there has been a dramatic expansion in the range of information available in electronic mediums and the challenge is to effectively integrate these mediums in the workplace and class rooms (Hannaway, 1999). This paper accepts these developments, and reflects on how they might enable stakeholders in grassland farming to cope with the future. The challenge of the future was expressed by Waters-Bayer *et al*. (1999b: '*As land use is in constant flux, not primarily because of changes in ecological conditions but more because of changes in sociopolitical and economic conditions, there is a continuing need for learning, innovation and adaptive management on all levels…. Therefore continuous forms of joint learning are needed*.'

In broad terms the stakeholders in grassland farming include not only the farmers and agencies that serve farmers, but also to an increasing degree the urban community and governments who are interested in good resource management and a secure supply of inexpensive, high quality food (Pinstrup-Andersn and Pandya-Lorch, 1999). Whilst the stakeholders in grasslands are wide and varied they share a common vision. Based on views expressed in numerous reports (e.g. Francis and Madden, 1993) the goal for grassland farming is the triple bottom line: farming systems that are ecologically sustainable, profitable and socially acceptable.

- *Ecological sustainability* refers to the condition of the biophysical resources and processes that underpin grasslands. At a farm scale, interest centres on the impact of technologies on soil, water and vegetation resources of the farm, and on the quality of produce from the farm. At a regional scale the suite of criteria pertaining to ecological sustainability includes biodiversity, type and condition of vegetation, water quality in rivers etc.
- *Profitability* refers to the net profit of farmers relative to other sections of society. A steady decline in profitability of farms producing milk, meat or fibre since WWII in developed countries, (expressed as declining terms of trade), and the associated decline in number of farms and population of rural towns, have become a national concern.
- *Social acceptability* refers to the complex mix of health, social, cultural and spiritual satisfactions of people in grasslands, together with the wider community's perceptions of these issues.

Training and extension must contribute to the triple bottom line by encouraging practitioners, such as farmers, farm advisors, and educators, to better manage their management environment. The notion of a management environment might be new to some readers. It refers to a holistic consideration of those factors that impact on the role of managers. Overall the paper proposes that extension and training must evolve from a traditional emphasis on production technologies and focus on empowering practitioners to better manage their management environment, where production technologies are but one important component. In terms of the historical development of extension, this focus on empowerment and a community approach to management of resources commenced in the 1990's (Chamala, 1999).

What is the management environment?

The management environment is a generic term that refers to all those biophysical, sociopolitical and cultural factors that influence the lives of active adults, be they farmers, academics, merchant bankers, politicians or mothers with children. Understanding and manipulating their management environment is a key characteristic of successful managers since it impacts on all strategic, tactical and operational decisions. It applies to all persons working for an organisation, even the boss of large organisations, and to self-employed farmers. The management environment is constantly changing in response to both external and internal factors. External factors arise from the world outside the workplace while internal factors arise from the workplace.

Development of the wider society in which a manager operates drives the macro or external management environment. It extends from global to local trends in politics, society and economics, factors which impact on the future of farming, often via changes to government policies and regulations. Good managers adapt to change and prepare for the future condition of society rather than for the current or past condition of society. Besides, as Naisbitt, (1982) said, '*trends, like horses are easier to ride if you are facing the direction they are going*'. Some of the major future-shaping forces pertaining to farming in developed countries are listed below.

- Production technologies are changing rapidly on many fronts and may profoundly change farming methods, particularly if biotechnology lives up to expectations.
- Globalisation of economic systems is leading to interdependence of national economies, international mobility of funds and fluctuations in currency exchange rates.
- Population growth in developed countries is relatively static compared to the growth in developing countries.
- Trade is increasingly competitive, and is often tied to regional or global trade agreements, or to special arrangements for credit, such as NAFTA.
- Markets are increasingly fragmented along quality or environmental specifications, as typified by the resistance to genetically modified organisms in the European Union.
- The contribution of agricultural production to gross domestic product is declining as secondary, but particularly tertiary and quaternary industries expand.
- Public participation in land management policy is increasing at all levels, as typified by a move towards managing farms based on landscape or catchment units.
- Climate change will probably be expressed through more variable rainfall and warmer minimum temperatures, eventually leading to changes in the regional boundaries and instability in existing modes of farming.
- The role of the mass media in informing and influencing public opinion is increasing, as is the Internet in allowing interest-groups to coordinate their activities.
- Dietary preferences are changing, such as a decline in consumption of red meat and dairy products in some developed countries and an increase in consumption of these products in some developing countries.
- Education standards of society are improving and this becomes a catalyst for social change as people become more informed and discerning, and less loyal to political and social traditions.
- The use of farms and protected areas for tourism is increasing as developed countries become increasingly urbanized, such as Australia and The Netherlands where, respectively, about 83% and 90% of the population live in cities.

Developments in the workplace drive the micro or internal management environment. Unlike persons working in a public company or government service, the survival and well-being of self-employed farmers depends on their own decisions, initiatives and resourcefulness. Self-employed farmers constantly make decisions of a strategic, tactical or operational nature which impact upon the farm's soil and water resources and profit (Figure 1). To help make good decisions farmers might seek outside advice from friends or professional advisors but ultimately they are responsible for all decisions. Actual decisions depend on factors such as the manager's operational skills, technical knowledge, past experiences, financial resources, and prevailing goals and aspirations. Indeed, a person's internal goals and aspirations tend to underpin their motivation and responses to the management environment, and importantly, goals and attitudes, like the management environment, may change during the lifetime of a farmer (Prevost, 1996). Figure 1 also illustrates the complex, non-linear, management environment for farmers as they respond to prevailing biophysical and socioeconomic forces, which interact with each other. If their decisions are horribly wrong the farming business fails, similar to a juggling act that fails when a ball is fumbled. Or in the words of Schiere *et al.*, (1999) with their eye on ecological sustainability: '*farming systems with production targets beyond threshold values invite collapse, and the setting of sustainability criteria might be seen in this sense as the setting of maximum values for development, a politically difficult but highly relevant issue*'.

The preceding discussion proposes that the management environment for a farm family is constantly changing in a non-linear manner. Further, it is highly likely that the pace and scope of change will continue to increase in response to technological and socioeconomic developments in our global village called planet earth. It therefore follows that the primary role of training and extension in grassland farming is to prepare farmers, and their support agencies to better cope with change - to better manage their management environment while practising farming systems that are ecologically sustainable, profitable and socially acceptable. This is not a simple task because of the variety and complexity of the management environment experienced by farmers. Training and extension in grasslands deal with the interface between hard and soft systems, the mixing of new technologies with indigenous knowledge and experiences, and how to respond to forces of change beyond a manager's control. In keeping with the above discussion, training and extension in grasslands are considered from micro and macro perspectives of a management environment.

Training and extension – micro level

Traditional approach

Traditionally training and extension in grasslands have focused at the micro level of the management environment, particularly on the application of new technologies to improve farm productivity and profitability. This reductionist approach was serviced by courses on pasture and animal science, complemented by courses in rural extension, farm management or agribusiness. Graduates were highly specialized and class sizes were often small, particularly in the advanced specialized courses. In one sense this traditional reductionist approach to teaching, which was underpinned by a similar approach in research, has served grassland farming well. Productivity has increased enormously through the application of new technologies and developments and refinements of existing technologies (Wit, 1992). Notable successes include plant improvement programs and improving and managing soil fertility. Extension often relied on the transfer of the linear technology model. Whilst the traditional approach has notable successes it also has notable shortcomings, particularly through ignoring the 'context' and 'relationships' associated with new technologies (Schiere, *et al.* 1999).

Context refers to how farmers regard new technology, whether it is or is not appropriate to their particular situation. Whilst some technology becomes inappropriate because it is surpassed by improved technology, the situation may also arise where technology is perceived to be inappropriate because the farmer is unwilling to accept it (e.g. Frank, 1997). Relationships refer to both the negative and positive impacts of new technology. Usually new technology is promoted because of positive benefits to production but with the passage of time, negative feedbacks can negate some of these benefits and lead to serious problems that demand another technical solution. Examples include the introduction of legumes leading to a rise in soil acidity, high applications of nitrogen fertilizer leading to more acid soils and nitrate pollution of groundwater, and the removal of trees on the ancient landscapes in Australia leading to dryland salinity. Clearly, understanding the context and relationships associated with new technology is an important responsibility of training and extension agencies. However, the lack of adoption of apparently sound technology is also a concern that has given rise to the models for information transfer mentioned in the introduction, particularly the growing popularity of participatory approaches. Rather than revisiting the various models for extension, attention is given to some emerging trends and their influence on coping with change.

Changes to curricula

Whilst a narrow specialized training is appropriate for some fields of research, it is not appropriate for the grassland manager. Training institutions have changed curricula to give students a more holistic or systemic view of agriculture, and to better prepare them for managing their own management environment (Bor *et al*., 1995; Engel *et al*., 1995; Hodgson *et al*., 1999; Knight *et al*., 1999; Malechek *et al*., 1999). Another approach is to form alliances with industry to provide training programs that enable people in an industry to upgrade their qualifications and gain contemporary skills. To this end the Rural Extension Centre (Fell, 1999) and Rangeland Australia have been formed in the University of Queensland. Such demands have led to an evolution in teaching, which is underpinned by one or more of the following realizations.

- Students need a basic understanding of key discipline areas in agriculture, such as plant production, animal production, management and marketing early in a course. This broad knowledge of fundamentals is essential to those students who choose to specialize in one of these fields and to those who choose to study farming in holistic terms.
- Students need to develop skills in recognizing what information is needed, where to get it, and how to understand and apply the information.
- Students, in preparation for life in a world of change, need to gain the motivation and confidence in their abilities to embark on a lifelong process of learning, to communicate and negotiate effectively, and to think critically in a rapidly changing work environment.
- Teaching institutions need to meet an increasing demand for the lifelong process of learning by preparation of material for study at a remote workplace or home.
- Innovation should be highly valued and encouraged.

Apprenticeships

Apprenticeships, whereby a person learns from experienced operators is an ancient method of teaching that can be applied in various ways to teaching and extension in grasslands. For example, some universities give students as part of a regular award up to six months of work experience or apprenticeship with a well-regarded farmer, advisor or researcher. This 'work experience' not only provides training in real-life experiences and skills, and an appreciation of the seasonality of farming systems, but it also recognises that successful and experienced managers can make a valuable contribution to the training of future managers. Students usually respond positively to such apprentice schemes provided the scheme aims to develop realistic managerial and operational skills, and the experienced supervisor is familiar with the scheme's objectives and the requirements of students. Further, if the experienced manager has a history of successfully managing change, the student will observe at first-hand, the personal and professional attributes that enable a manager to cope with change.

Participatory approaches to extension also use a form of apprenticeship when facilitators learn from persons with local or indigenous knowledge (Scoones and Thompson, 1994). Such knowledge can be the basis of extension programs. For example, Waters Bayer *et al*. (1999a) deliberately selected indigenous innovators in respect to soil conservation, and formed participatory learning groups based on these innovations. Likewise the scientist or facilitator becomes the apprentice when case studies give new insight into a manager's responses to a management environment (e.g. Campbell *et al*., 1997 and Landsberg *et al*., 1998). In all of these situations the professional facilitator seeks to appreciate and understand local knowledge and experiences as an early and essential step towards effective extension. Thus, as Proverbs, 1:5 states *'let the wise listen and add to their learning and let the discerning get guidance'*.

Computer assisted learning

Computer assisted learning (CAL) uses various forms of computer software to either supplement or replace traditional teaching methods, possibly in a self-paced and self-assessed format (Birch and Rickert, 1999; Surber *et al*., 1999; Tow, P. G., *et al*., 1999). CAL puts increasing emphasis on the student's responsibility for learning and shifts the teacher's responsibility from teaching to preparing quality learning materials (Heath and Nicol, 1994). Of the various forms of CAL available, dynamic simulation models of farming systems, coupled to carefully designed exercises with specific objectives, are particularly useful in teaching the impact of components in the management environment on the triple bottom line for a farming system (Figure 1).

Two separate but related definitions of a model illustrate the potential advantages of using dynamic simulation models in teaching. First, a model is a series of mathematical expressions that mimic the behaviour of underlying processes and their interactions, thereby giving quantitative displays of response surfaces and trends of the components in a system. Second, a model is a collection of hypotheses that explain the operation and interaction of the processes in a system, and each hypothesis and their interactions can be tested and modified through research. As such, models can be regarded as a repository for past research and a precursor for new research (Ebersohn, 1976). Good simulation models that mimic a 'virtual' farm are valuable aids to teaching and extension because they provide

- training for novice managers of a farming systems in how to cope with variations in prevailing weather and prices;

- a platform for teaching the principles of systems analysis through the evaluation of management options;
- an introduction to the use of decision support aids in farm management;
- a framework for teaching the underlying principles of plant growth, animal growth and pasture and animal management; and.
- a common framework for discussions and interaction between those directly and indirectly concerned with managing the farm.

BEEFUP is an example of a CAL package (Rickert *et al.*, 1990) that helps novice managers to appreciate a complex non-linear farming systems. It has been widely used in northern Australia in undergraduate courses, and in orientation classes for bank managers who are about to begin a rural appointment. A new version of BEEFUP is due for release. The package teaches the interactions between weather, prices, location, stocking rate and land clearing on the ecological sustainability and profitability of growing beef cattle in Queensland. It operates interactively as a 'virtual farm' where a user buys and sells cattle in response to historical records of rainfall and prices, and the number and condition of cattle on the farm. It also allows different management scenarios to be simulated and compared and demonstrates the benefits of moderate stocking rate in terms of ecological sustainability and profitability (MacLeod and McIntyre, 1997; Rickert, 1996).

The potential benefits of CAL and dynamic simulation models in particular have not always been evident in practice, because of one or more of the following: students with poor computer awareness, computers that are inappropriate for the CAL software, and cumbersome, inappropriate CAL software. Ideally, there needs to be a match between the hardware (specifications of computers), software (purpose-built CAL) and 'liveware'(computer skills of students). Too often CAL is seen as a tool that will help universities cope with a steady decline in funding per student and CAL programs are developed and applied on the cheap. Recent advances in computation speed and graphic displays with personal computers permit CAL programs to have a higher level of sophistication and user-friendliness. However such programs require a team effort and substantial financial outlays to develop, because the teacher of grasslands farming is usually not an expert in software development. Since the market for CAL software for training and extension in grassland science and management is not large, inter-institutional co-operation in its development and support is a logical way forward (Heath and Nicol, 1994).

World Wide Web and e-mail

The rapid development of the World Wide Web (WWW) has dramatically increased the scope and sources of information available to farm managers and advisors, provided they have the skills and time to access and assess the information (Hannaway, 1999). With these two attributes in place, the WWW readily impacts on operational and tactical decisions by providing current information on markets, sources of inputs, recommended technologies, climate forecasts, regulations etc (e.g. Beswick *et al*., 1999, and Hannaway *et al*., 1999). The WWW can also impact on strategic decisions because it sources information worldwide and allows personal networking where experiences and interests can be shared via e-mail. The WWW also stimulates innovation because it is such a rich and varied source of information. For example, as a test for this paper, a worldwide search for 'white clover' using the fast and accurate 'Google' search engine (http://www. google.com/) returned 85,000 hits in 0.1 seconds. Obviously with such a large response ‘information overload’ is a potential problem, which can be reduced by using more specific instruction for a search. However the fact remains that never before has information been so readily available from such diverse sources, and it is expanding rapidly. Further, the number of professional journals available on the WWW is also expanding rapidly, adding to a web-based information explosion. The difficulty for users of the WWW is to synthesize information into useful knowledge for decision-making, a skill that can be developed through training.

From a training perspective, institutions have the responsibility of ensuring that their graduates are familiar with accessing and assessing information from the WWW and other sources. These are emerging as core skills for managing both the micro and macro levels of the management environment. These skills are conveniently taught by addressing complex problems as a class exercise. For example, how should a farmer on a specified beef cattle farm respond to a seasonal weather forecast where there is a given probability that rainfall in the next three months will be less than the median value. Exercises like this encourage students to use the WWW, to examine the emerging technology of seasonal weather forecasts, to consider feeding and/or trading options for the cattle, and to explore predictions of future cattle prices and the role of futures trading. In such an exercise, information from both the WWW and printed materials is combined to address a complex managerial question where there is no clear right or wrong, but a preferred action based on perceived risk.

Decision support systems

Decision support systems (DSS) differ from CAL in that the software is especially designed to assist mangers make tactical or strategic decisions. However DSS is also a valuable aid to learning since users often gain new insight and understanding on the operation of a system. Indeed some CAL packages, such as the BEEFUP package mentioned above, evolve from DSS, being modified to emphasise learning outcomes. The types, structure and development of DSS have been recently reviewed (Rickert *et al*., 2000; Stuth *et al*., 1993), and this paper will briefly consider some recent experiences with DSS as a management tool for policy makers and farmers in grasslands.

There is an important role for DSS in the evaluation of policies pertaining to grasslands as politicians and industry leaders grapple with how to encourage the triple bottom line while spending public money wisely. Such DSS need to be well maintained and based on a sound understanding of the components of the system (Rickert *et al*., 2000). Examples of roles for this type of DSS include identification of exceptional droughts that warrant farmers receiving government assistance (Pisani *et al*., 1998; Stafford-Smith and McKeon, 1998; White *et al*., 1998), and the likely impact of climate change on regional productivity (e.g. Hall *et al*.1998). DSS for policies will continue to be in vogue because no other tool will provide policy makers with quantitative expressions of complex influences and interactions.

The future of DSS at the farm level is not so secure despite the relatively high level of computer ownership because it is often not readily used by individual farmers (Cox, 1996; Greer *et al*., 1994). Reasons for this situation include the time and money that farmers are willing to spend on infrequently used software, a perception that some management factors are not included in the model, and a difficulty in validating the outputs of a conceptual model against their own experiences. This can lead to a view that DSS is an inappropriate technology. Perhaps farm advisors rather than individual farmers should be encouraged to use DSS as a few copies of a package could influence many farms if they were regularly used by a few farm advisors who had many clients (Rickert, 1998). There is also evidence that a successful DSS package needs a product champion to encourage its use by farmers, particularly via a participatory approach in its development and application (Buxton and Smith, 1996; Johnston *et al*., 1996).

Action learning and participatory research

Action learning and participatory research share a common base – learning through participation, usually in the workplace. Increasingly this is seen to be a superior approach to the traditional linear transfer of technology (Roling *et al*., 1998). When properly applied the approach leads to changes in farming practices (e.g. Millar and Curtis, 1997), but when not applied properly, the resulting failure may also lead to an erosion in the self-reliance of the target group (Wetmore and Theron, 1998). Fortunately appropriate techniques in action learning and participatory research can be taught. For example, the Rural Extension Centre at the University of Queensland has shown that an accredited course in action learning can use a blend of theory and practical projects located in the workplace to the benefit of students and their employers (Fell, 1999). Importantly the approach is not confined to the micro-level of the management environment as implied by the discussion so far. Action learning and participatory research have also been applied to community development and social change; in a variety of countries (Selener, 1997; Smith *et al*., 1997), that is the macro-level of the management environment.

Training and extension – macro-level

At the macro-level, extension and training has an outward focus. The aim is to build capacity among the stakeholders to shape their future by working together towards the common goals of ecological sustainability, profitability and social acceptability (Pretty, 1998). Two examples of how this might be achieved follow. Both examples come from Australia, thereby reflecting the author's bias, but the outcomes and training requirements have wider application.

Landcare movement

The landcare movement has been a notable success in Australia (Chamala and Keith, 1995; Roberts and Coutts, 1997). It relies on community participation and aims at bringing together a diverse membership of farmers and other interest groups such as conservationists and government agencies. Members of the community organize their resources and expertise towards ecological sustainability through better land and water management. They hold the philosophy that all land, including farms, is held in trust for future generations of human and other life. They plan for the long-term sustainable use of land at a catchment level, and use public and private funds to implement the plans at a property level. Members of a land care group share information about best practice and management options for sustainable land use, including nature conservation and wildlife management.

The land care movement has existed for more than a decade and has dramatically increased community awareness of the need and options for better land management. Factors that make landcare groups effective and sustainable are described by Ellis-Jones, (1999) as:
a record of past achievements;
horizontal and vertical linkages with other organizations;
two-way participatory linkages with government agencies,

structures for supplying information and participatory decision making;
capacity to respond to changing needs and issues, and
local origin and membership.

The key to its future success is ongoing involvement of local industry and government.

Participatory Action Research at regional scales

The scope and scale of the land care movement is largely confined to better land management within a community. A much wider scale is addressed in the following account of three regional projects in the rangelands of Australia. They provide a structure for a wide range of stakeholders to shape their future by influencing government and industry polices that impact on the triple bottom line in the region. They are located in Western Australia (Atkins *et al*., 1999), western New South Wales (Abel, 1999) and Central Queensland (Bellamy *et al*., 1996) and target regions ranging from 100,000 to 325,000 km^2 in area. The projects differ from the landcare movement in that the spatial scale of application is much greater, each receives more professional and financial resources than a landcare group, and the aim is influencing government and industry polices as well as best practice on farms.

The three projects attempt to deal with the complex issue of improving sustainability of grassland through a common approach and structure. They consist of five components (Figure 2) which is a form of participatory action research and 'high tech' access to information. Basic information on land resources and policies for a region (1) is collected, stored and made accessible through user-friendly software (2) to stakeholders (4). Another suite of software packages (3) enable stakeholders (4) to evaluate land-use options and proposed polices (5), preferable in terms of ecological sustainability, profitability and social acceptability. These five components are considered in more detail below.

The basic information (Box 1) usually comes from a wide range of governmental agencies and other sources, mostly as spatial descriptions of the resource base (soil, vegetation, hydrology etc.), historical records of climate, or regional statistics. The quality of the base information needs to be supervised carefully since erroneous data undermines confidence in the whole planning process. Experience has also shown that collation and storage of the base data is often a major task that is plagued by problems of incompatibility across data sources, missing data, and data collected over different temporal and spatial scales. However once this tedious task is completed the base data can be used over and over again with confidence.

Although not technologically demanding, developing 'user-friendly' displays of resource information usually requires much time and effort, including 'interactive prototyping' where potential users progressively test and evaluate the displays (Stuth *et al*., 1993). The presentation software must be user-friendly since it will be used by stakeholders who are not familiar with databases and how maps and graphs are displayed. Maps of the distribution of soil and vegetation are particularly useful in the planning process, and users should be able to access the software via the World Wide Web. Two of the three projects mentioned above have web sites: http://chrrupp.tag.csiro.au/ and http://www.rangeways.org.au/ .

Evaluating different scenarios within complex systems with many interactions that vary through space and time is a difficult task that benefits from good software packages. The difficulty for the software builder is how to address the interface between the relatively 'hard' quantitative description of ecological sustainability and profitability and the relatively 'soft and abstract' criteria for social acceptability (Barrett and Nearing, 1998). Ideally the approach should have roots to emerging theories on adult learning, and reflect past experiences with participatory action research. The situation is further complicated when participants are inexperienced in using computer software as an aid in evaluating different scenarios (Bischof *et al*., 1999). The software for assessing options may need to be developed to meet the specific needs of stakeholders. For example, in two of the above projects the software allows stakeholders to systematically explore options for spatial resource allocation. These are refined into policies through further evaluation by simulation models, all of which are underpinned by the emerging theories pertaining to complex adaptive systems and by the notion of resilience in rangelands– the capacity to persist by adapting to change (Abel, 1999). Alternatively the central Queensland project has a strong focus on shaping rural policies through planning, and in organizing rural communities to be involved in the planning process. As an aid to this process it has a web-based methodology for multi-criteria analysis and decision making, based on theories pertaining to analytical hierarchy processes (Saaty, 1987). These approaches require strong technical support for software development (Matthews *et al*., 1999).

Together these projects represent a major exercise in using participatory action research. They attempt to influence land-use policies on spatial scales ranging from a farm to a region, on temporal scales that range from the present to 50+ years, and with social groups that include farmers, conservationists, government agencies and indigenous people. They also have a strong theoretical base, use contemporary methods of data storage and presentation, and use rigorous methods for selecting and evaluating options. All three projects provide a framework for stakeholders with widely different views on land use to interact in a constructive manner. They provide a creditable evaluation of land-use scenarios, which can help shape political opinion and policies, and they involve the regional communities in the planning process. They are certainly an attempt at empowering regional communities to better manage their macro-management environment. They also highlight the need for professional training in systemic agriculture within a multidisciplinary and multicultural work environment, in the skills for participatory research and learning, and in the application of contemporary decision support aids. It remains to be seen how these projects will function after the initial developmental phase.

Conclusions

Stakeholders in grassland farming, like many other industries, are responding, or should we say evolving, in response to major forces of change. Society expects them to meet the triple bottom line of ecological sustainability, profitability and social acceptability, but their management environment is also changing rapidly on a micro and macro scale. This need not be a picture of doom and gloom because humans have the ability to adapt to change, and necessity is the mother of invention. The challenge for training and extension activities is to foster adaptation and innovation. In terms of this paper that means managing their management environment by either responding to the forces of change (e.g. farming smarter) or by shaping the forces of change (e.g. influencing government policy).

Procedures for training and extension have also evolved in response to an explosion in information, funding constraints, and to the perceived failure of linear models for transfer of technology. Increasingly the teacher is becoming a facilitator who provides a theoretical base for action or participatory learning. To this end, the time-honoured process of learning while working or studying beside an acknowledged expert practitioner is highly valued. Another effective approach that encourages smarter farming and innovation is group participatory learning, where a diverse membership shares experiences and explores new ideas.

Information technology (IT), be it based on the WWW or other software, is potentially of great benefit to managing a management environment. It encourages innovation by providing ready access to information sources that are rapidly expanding and ranges from indigenous to technical in character. However, information overload is becoming a problem, along with insufficient time to access and distill the information in knowledge and understanding. There is an emerging role for facilitators to collate and present information in packages that address issues in the management environments of different stakeholders in grassland farming.

Training institutions need to construct curricula that meet the emerging needs of stakeholders in grasslands. The traditional emphasis on technologies and the means of production needs to be reduced to make room for courses that emphasize a holistic view of agriculture and skills for handling the management environment at both the macro and micro levels. When making this adjustment, institutions commonly experience pain and internal tension as staff profiles change. Perhaps the most worthy aim in training and extension is to prepare graduates for change by ensuring they have the basic knowledge, skills and confidence to embark on a lifetime of leaning, adaptation and innovation.

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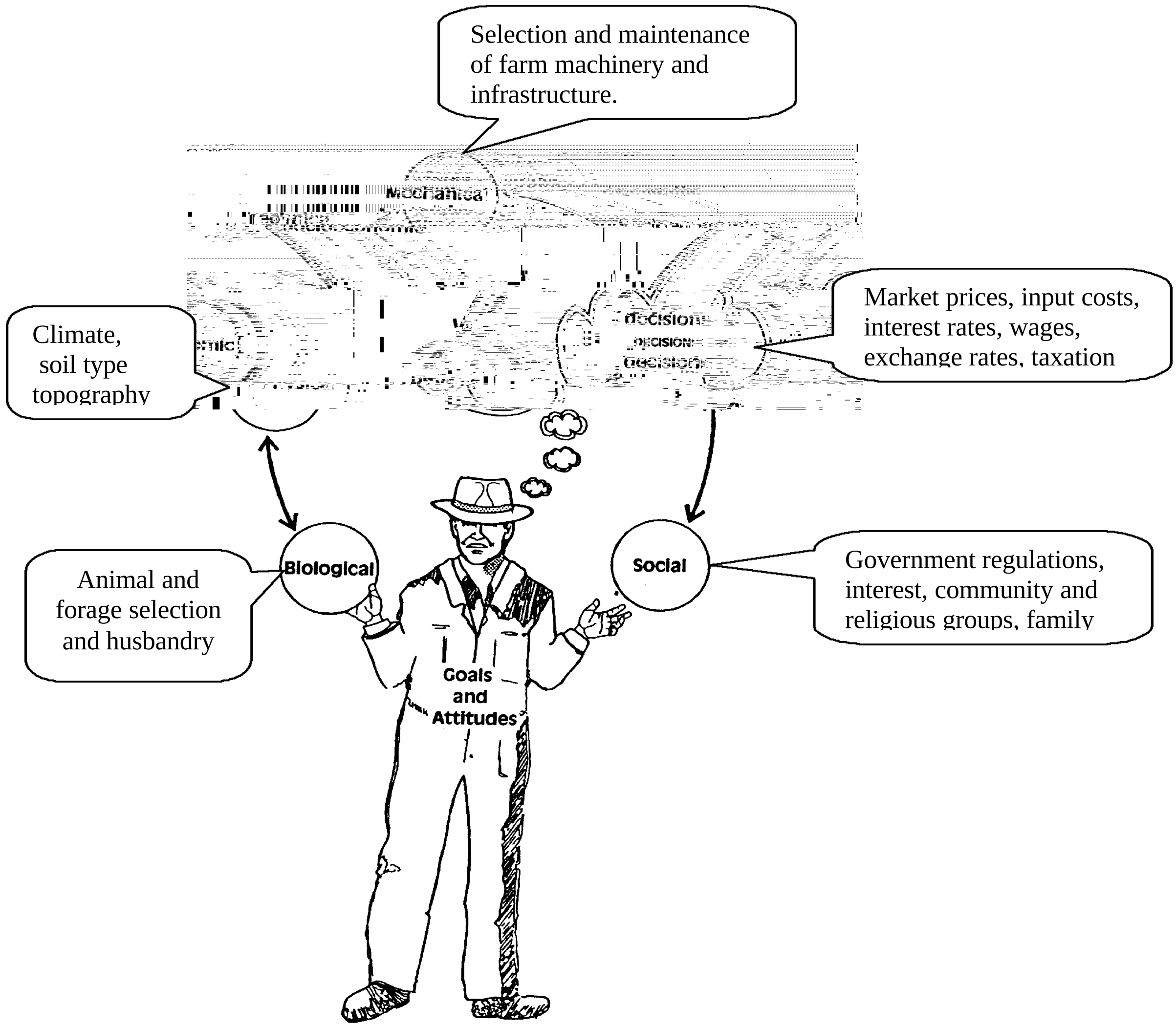

Figure 1 - Management environment of a self employed farmer. Strategic, tactical and operational decisions are constantly made in response to the biophysical and socioeconomic components of the management environment, and are tempered by the farmer's goals and attitudes.

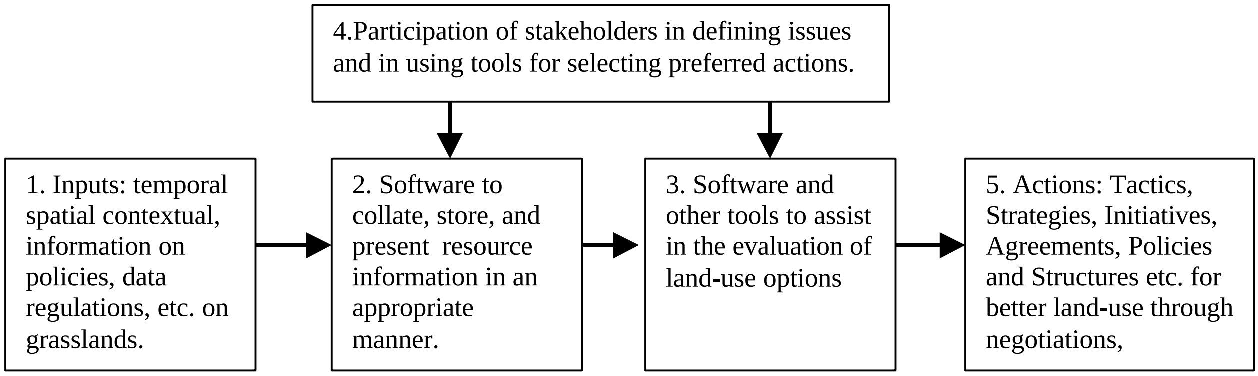

Figure 2 - Structure of three participatory action research projects in Australia that aim to empower stakeholders to access information and evaluate appropriate actions for given issues or scenarios.