Understanding and promoting adoption of conservation technologies by rural landholders

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Abstract. Research on adoption of rural innovations is reviewed and interpreted through a cross-disciplinary lens to provide practical guidance for research, extension and policy relating to conservation technologies. Adoption of innovations by landholders is presented as a dynamic learning process. Adoption depends on a range of personal, social, cultural and economic factors, as well as on characteristics of the innovation itself. Adoption occurs when the landholder perceives that the innovation in question will enhance the achievement of their personal goals. A range of goals is identifiable among landholders, including economic, social and environmental goals. Innovations are more likely to be adopted when they have a high "relative advantage" (perceived superiority to the idea or technology that it supersedes), and when they are readily trialable (easy to test and learn about prior to adoption). Non-adoption or low adoption of a number of conservation technologies is readily explicable in terms of their failure to provide a relative advantage (particularly in economic terms), and/or a range of difficulties that farmers may have in trialling them. Implications for research, extension, and policy are discussed.

Introduction

Scientists have been striving to discover and develop new ‘conservation technologies’ that reduce the extent or the consequences of land and water degradation resulting from extensive agriculture and other rural land uses. Environmental programs like the National Landcare Program, the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality have sought to encourage landholders to adopt these conservation technologies, mainly through information provision and social processes but to some extent through the payment of incentives.

Some conservation technologies have been readily and widely adopted by farmers. Most of these are technologies that primarily address on-farm issues, including lime application to treat acid soils, reduced tillage for reducing erosion and improving soil structure, and, in relevant regions, claying to overcome water-repellency. In other cases, adoption has been modest, at best. For issues like dryland salinity and biodiversity loss, the response by farmers as a whole is clearly insufficient to overcome degradation processes.

Some scientists and policy makers have expressed frustration at the observed levels of adoption, and expressed a desire to understand it. We propose that it is quite understandable based on the large body of literature which considers the adoption of innovations by farmers and other landholders.

This paper provides a selective review and interpretation of what is known about the determinants of technology adoption by landholders, both conservation technologies and other types. The enormous literature on adoption of innovations has previously been reviewed in general, (e.g., Rogers 2003), and for agriculture (e.g., Feder and Umali 1993; Ruttan 1996), including by Australians (e.g., Lindner 1987; Guerin and Guerin 1994) and in the context of extension (Black 2000). There have been reflective papers outlining lessons from adoption research for the adoption of conservation technologies (e.g., Vanclay 1992; Vanclay 1997; Pannell 1999; Barr and Cary 2000; Cary \textit{et al.} 2002; Vanclay 2004) and various studies of the adoption of specific conservation technologies in Australian agriculture (e.g., Sinden and King 1990; Vanclay and Lockie 1993; Ransom and Barr 1994; Cary and Wilkinson 1997; Lockie \textit{et al.} 1995; Curtis \textit{et al.} 2000; Kington and Pannell 2003).
A feature of the adoption literature is its disciplinary fragmentation. Relevant research is conducted under the banner of economics, sociology, psychology, medical science, marketing, agricultural extension and anthropology. Despite differences in language and perspective, we believe that the general lessons of these different branches of work are broadly consistent and can be readily translated between disciplines.

This paper is distinguished from past reviews by its aim to present a cross-disciplinary consensus involving authors who come from several disciplinary backgrounds – economics (Marshall, Pannell), rural sociology (Curtis, Vanclay, Wilkinson), and psychology (Barr) – and who have knowledge of agricultural and environmental issues. This diversity of backgrounds allows us to present and integrate a broader range of perspectives than in previous reviews and overviews. The paper has been written with conscious avoidance of discipline-specific jargon, theories and ideologies in order to allow wide communication and wide applicability.

The intended audience for the paper is broad. We believe the results and implications presented here are highly relevant to scientists and their funders, extension agents and funders, policy makers, managers in government agencies, natural resource management bodies (such as Catchment Management Authorities), non-government conservation organizations, farmer organizations, and others. Extension has been given a particular emphasis in natural resource management programs to date. We define extension broadly to include public and private sector activities relating to technology transfer, education, attitude change, human resource development, and dissemination and collection of information. We will be emphasizing that extension is just one information source among many that landholders use.

We have attempted to relate the review to the perspective of our intended audience, focusing on their concerns about adoption of conservation technologies. We imagine that the non-landholder audience described above has an objective to enhance some conservation outcome(s), and that this would require changes in behaviour by land managers. The question is, what might influence or limit the achievement of such changes? This leads us directly to consider the way that landholders might identify and deal with problems or opportunities, so we are fundamentally concerned with landholders’ perspectives as well, but the primary aim is to translate those perspectives to the other side of the fence.

We have tended to use the term ‘landholders’ rather than ‘farmers’ (by which we mean people who use their land to produce food and fibre as a significant share of their family income) as many rural landholders are not farmers. Some of the evidence we present relates specifically to farmers, and where this is so we use the more specific term. As discussed later, non-farm rural landholders differ from farmers in some systematic ways, and some important differences in their adoption of conservation behaviours have been observed (e.g., Curtis and Robertson 2003).

The core common theme from several decades of research on technology adoption in agriculture is that landholder adoption of a conservation technology depends on them believing or expecting that it will allow them to better achieve their goals. Goals vary widely between individual land managers depending on their circumstances and personal preferences, but may include economic, social and environmental goals. Adoption is based on subjective perceptions or expectations rather than on objective truth. These perceptions depend on three broad sets of issues: the process of learning and experience, the characteristics and circumstances of the land manager within their social environment, and the characteristics of the technology. These three elements are considered in detail in the following three sections. The last section discusses the implications of the review for various stakeholders: researchers, extension agents, and policy makers.

The process of learning and experience to inform adoption decisions

Adoption is a learning process with two distinct aspects (Abadi Ghadim and Pannell 1999). One is the collection, integration and evaluation of new information to allow better decisions about the innovation. Early in the process, the land manager’s uncertainty about the innovation is high, and the quality of decision-making may be low. As the process continues, if it proceeds at all, uncertainty falls and better decisions can be made (Marra et al. 2003). At least for relatively simple innovations, a landholder’s probability of making a good decision – one that best advances their goals – increases over time with increasing knowledge of, and perhaps experience with, the technology. Viewed in this light, the adoption process is never completed, in the sense of eliminating all uncertainty. All options are continuously open to question and review as new information is obtained and/or circumstances change.

The other aspect of learning is improvement in the land manager’s skills in applying the innovation to their own situation (Tsur et al. 1990; Abadi Ghadim and Pannell 1999). Most farming innovations require a certain level of knowledge and skill to apply them in practice (i.e., how it is done) and there can be a wealth of choices in the
method of implementation (e.g., timing, sequencing, intensity, scale). Through learning-by-doing, as well as by reading, listening and watching, the necessary skills can be established and enhanced.

This dynamic process has been broken down into stages or phases in a number of different (though similar) ways (e.g., Lindner et al. 1982; Pannell 1999; Barr and Cary 2000; Rogers 2003). One typical description of the sequence follows.

- **Awareness of the problem or opportunity**: In this context, ‘awareness’ means not just awareness that an innovation exists, but that it is potentially of practical relevance to the landholder.

- **Non-trial evaluation**: Reaching the point of awareness is a trigger that prompts the landholder to begin noting and collecting information about the innovation in order to inform the decision about whether or not to go to the next step of trialling the innovation. Conducting a trial incurs costs of time, energy, finance and land that could be used productively for other purposes. To be willing to trial an innovation, the landholder’s perceptions of it must be sufficiently positive to believe that there is a reasonable chance of adopting it in the long run.

- **Trial evaluation**: Trials contribute substantially to both the decision making and skill development aspects of the learning process. If small-scale trials are not possible or not enlightening for some reason, the chances of widespread adoption are greatly diminished. Landholders will be cautious about leaping to full-scale adoption due to the risk that the innovation will prove a full-scale failure. Untrialable technologies may still be adopted (rotary milking platforms are one example), but generally only after substantial information-seeking, discussion, analysis and reflection.

- **Adoption**: Depending on the trial results, use of the innovation may be scaled up. Typically, adoption is not an all-or-nothing decision – there is a grey area between small-scale trialling and the eventual scale of adoption (Duncan 1969). Adoption is often a continuous process, and may occur in a gradual or stepwise manner, sometimes ending in only partial adoption (Wilkinson 1989). As noted earlier, in one sense, trialling is never completed, as farmers continue to evaluate the performances of all their practices. However, as the scale of use of an innovation increases on the farm, the balance of reasons for using the technology shifts from mainly evaluation to mainly beneficial use.

- **Non-adoption or dis-adoption**: If off-farm information or on-farm trial results are not sufficiently encouraging (i.e., it appears that the landholder’s goals will not be advanced by the innovation), the landholder will reject the innovation. If it is initially adopted but then, say, economic circumstances change or a replacement technology becomes available, use of the original innovation may be scaled down and eventually discontinued.

The knowledge that is developed through this process is held by the landholder and is likely to be unique to them, to some extent. It will probably be based on a mixture of scientific information, personal experience, and cultural influences. Culture includes laws, social norms, ideologies and other human-devised factors that influence behaviour. The culture of landholders is the result of a rich history and it is dynamic, being continually modified by a wealth of factors.

The learning process is influenced by the characteristics of individual landholders, their families and broader social environments (as discussed in the next section) and by the characteristics of the innovation (in the section after next). Prior to trialling, information from off the farm is the sole basis for judging a technology, so that social and information networks would be important influences on the decision to proceed to trial (see next section), but after trialling has commenced, personal experience gained in that way is likely to be the main influence on further decisions about the technology (Dong and Saha 1998; Marsh et al. 2005). This has implications for the role of extension to promote adoption, as discussed later.

There is no guarantee that a landholder’s subjective beliefs will ultimately converge on the objective truth, and hence no guarantee that the final decision will actually be the one most likely to best achieve the landholder’s goals. Lindner (1987) argued that final adoption decisions are usually correct in the sense that they do actually advance the landholder’s goals, but we suggest that some conservation technologies are less likely to conform to this generalisation than productivity-related innovations. Reasons include that some conservation technologies are relatively complex and that the benefits and costs of some conservation technologies are poorly observable (see the section below on characteristics of conservation technologies).
An example of a prominent conservation-related learning failure is provided by Pannell et al. (2001). They noted that many landholders (as well as scientists and policy makers) came to believe that successful prevention of dryland salinity on a farm would generally depend on co-operation from neighbours. While this is true in some cases, in many it is not. This learning failure would seem to be due to the difficulty of observing the salinisation process, most of which occurs underground with long lags between cause and effect. The point is that even after more than a decade of these farmers using the tools recommended for salinity prevention, their personal experience had not allowed them to converge on an accurate understanding of the impacts of the salinity-management tools. In the absence of readily visible connections between action and response, they had continued to believe what they had been told.

Factors that enhance the learning process can accelerate the adoption process. These factors may relate to the flows of information between people (e.g., the strength of social networks – see next section) and to characteristics of the innovation itself (e.g., easy observability of trial results – see section after next).

Social, cultural and personal influences on adoption decisions

The previous section was couched in terms of solitary decision-making by an individual. Decision-making is often also a social process as the decision-maker enlists the involvement of others in the decision-making process, or operates as part of a family team. Where a farm is managed by a family (less than 10 percent of farms were run by single operators in 2001: Australian Bureau of Agricultural and Resource Economics 2003) the process of decision making is made more complex by the interplay of family members. Although, for convenience, we will often refer to the (singular) landholder or farmer, the reader should bear in mind that for many decisions, particularly larger ones, the decision making unit can be a team, so that individual perceptions and goals influence a consensus rather than leading directly to a decision.

Phillips (1985) found that a typical dairy farmer may embark on anything up to 30 learning projects in one year. A landholder (or landholding family) has limited learning time, and each project must compete with the others for that limited time. A minor decision will receive minimal information time, sufficient to achieve an acceptable solution, which is not necessarily the best possible solution. When contemplating a major change to their farming system, the landholder will often have a hunger for information on the particular issue. The more serious the consequences, the stronger the need for information and for some confidence about the outcomes. For more important decisions, the dairy farmers in Phillips’ (1985) study sought information from up to 40 people. Weaknesses in the farmer’s knowledge were remedied by seeking technical information from what were seen by the farmer as experts. These could be other farmers, company representatives, stock agents, consultants or researchers. In this initial stage, judgement on the source of information and its credibility is often only cursory. Non-feasible alternatives are rejected, but any option or advice that may be useful is retained (Janis and Mann 1977).

Depending on their personal and family circumstances, the issues about which landholders are most concerned at a particular time may not relate to conservation, or any aspect of land management. A particular landholder family that would at other times welcome information about land conservation practices may have no time or energy for it in the midst of more pressing family issues. Extension activities will at best only reach those landholders who are in a position to be receptive at the time they are delivered.

Relative to the information-seeking stage, the next stage, evaluation of the worth of information, is often more socially shared. Information must be assessed against the objectives of the landholder and their family. The goals of landholder families or individuals are heterogenous, and can include the following:

- material wealth and financial security;
- environmental protection and enhancement (beyond that related to personal financial gain);
- social approval and acceptance; and
personal integrity and high ethical standards.

Many more specific objectives can be identified, although they generally relate to one or more of the four broad goals outlined above. Makeham and Malcolm (1993) listed the following goals common within the farming community: to survive and grow, to set and overcome challenges, to farm well and be recognised for this, to improve the physical state and appearance of the farm, to acquire extra land or to control a larger business for the future and for heirs, to have a reasonable but not profligate standard of living which compares reasonably with others in farming and society at large, to earn enough profit to be able to improve and develop the farm so as not to have to work so hard in old age; to achieve capital gain and increase wealth; to have good quality animals and crops in good condition; to reduce income tax; to have a satisfying rural way of life; to have children well educated; to have enough leisure, increasing over time; to be a respected member of the community; and to have enough money to pursue non-farm interests. Some of these goals are complementary, others are in conflict, so trade-offs are often necessary.

One issue of long-standing discussion and debate has been the relative importance of economic factors as drivers of adoption. The debate started early, with contributions by some of the first researchers in the area (Griliches 1957, 1960; Havens and Rogers 1961). To this day, not surprisingly, economists tend to put greater emphasis on the influence of economic factors than do sociologists.

We note that the different views of economists and sociologists sometimes have more to do with language than with substance. For example, from within our own ranks have come papers that describe exactly the same factors as being "social" (e.g., Vanclay 1992) and "economic" (e.g., Pannell 1999). Economists tend to have a broad concept of what constitutes an economic benefit (e.g., including consideration of costs and benefits over the long-term, risk, the cost of foregoing other opportunities, the value of keeping options open, resource degradation, farming-system issues, and non-financial benefits and costs). Economists may actually be considering factors that others consider to be non-economic, but interpreting them through an economic prism. In the same way, sociologists have a broad concept of what constitutes a social benefit (Vanclay 2002).

In our judgment, there are several influences on adoption, and economic benefit (broadly defined) is one of them. Reflecting our combination of economic and social perspectives, when we say ‘economic benefit’, we mean the net economic benefit as perceived by the landholder, not as calculated by an economist. Often the (perceived) potential financial gain plays an important role (e.g., Cary and Wilkinson 1997), although sometimes it is counterbalanced by concerns over issues such as time, lifestyle or risk. Some landholders place the desire to make more money low on their list of priorities (Hawkins and Watson 1972; Presser and Cornish 1968; Vanclay 2004). For most, making money will not be their core goal, but it will be an important tool for achieving higher value goals such as a secure family lifestyle or keeping the farm property in the family (which means that economic return is still an important influence on their behaviour). Further, even landholders with a low emphasis on generating additional cash income are unlikely to be attracted to adoption of practices that would involve large economic losses (e.g., removal of woody weeds in some situations).

When an adoption decision has a potential to threaten the higher order goals, the process of decision making is much more likely to be socially shared. Dealing with risky decisions with important consequences is a stressful experience for most people. Most decision-makers cope with the stress of uncertainty by seeking both further information and social or family support for decision making, particularly in the non-trial evaluation phase. The issues will not only be ‘will this work?’ but also ‘will these people share the responsibility of the decision’, and ‘will they support me if it fails?’.

The more difficult the decision, the more the decision-maker will engage and re-engage both their personal support network and other sources of information. The major decision will be often be preceded by a series of smaller decisions to continue investing time, effort, and sometimes money, in continuing the decision evaluation. At each of these subsidiary decision-points the decision maker (or members of the decision making team) will seek the advice and support of close contacts (Phillips 1985). Later in the process, social commitment and support will help maintain confidence in the uncertain stages of trialling and early adoption. Peer expectations of continued commitment or personal support and encouragement will reinforce commitment and inoculate against setbacks (Janis and Mann 1977).

When adoption is viewed as a social process, it becomes clear that one should expect adoption behaviour to be influenced by the personality of the decision-maker, their social networks, personal circumstances and family situation. It seems that in the empirical literature every measurable characteristic of farms and farmers has been found to be statistically related to some measure of adoption of some innovation. This reflects the heterogeneity of adoption study settings, the very large size of the literature, the relative ease or difficulty of measuring some personal characteristics, but also the variable quality of empirical studies (as noted, for example, by Lindner 1987).
Personality may potentially play a major part in the style of decision making used by farmers, though because of measurement complexity, it has rarely been studied. One important personality trait is ‘locus of control’. Individuals with a strong belief in their own ability to influence the circumstances of their lives are described as having an ‘internal locus of control’. Persons with this personality trait are likely to experience less stress in decision making. The individual portrayed in John O’Brien’s famous Australian poem “Said Hanrahan” no doubt had an external locus of control. (“If we don’t get three inches, man, or four to break this drought, We’ll all be rooned,” said Hanrahan, “Before the year is out.”) and may have been more troubled by stress during decision making. The limited research into farmer stress in Australia has shown that financial difficulty alone does not predict stress. Stress is instead a combination of circumstances and the interpretation placed upon those circumstances by the individual. There is great variation in psychological propensity towards the experience of stress (Weston and Cary 1979; Cary and Weston 1978).

Economists study ‘risk aversion’ which is perhaps a personality trait. Risk aversion describes an individual’s tendency to take or avoid risks in their decision making. Empirical evidence is that landholders vary widely in their personal degree of risk aversion (Bond and Wonder 1980; Bardsley and Harris 1987; Abadi Ghadim and Pannell 2003). More risk-averse farmers may tend to rapidly adopt an innovation that is perceived to reduce risk (e.g., Shapiro et al. 1992) or to not adopt an innovation that is perceived to increase risk (e.g., Abadi Ghadim et al. 2005).

Another important personality trait is introversion-extroversion. Shrapnel and Davie (2001) and Shrapnel (2002) examined the personality profile of a sample of Queensland graziers. Of 14 general personality styles expected in the wider community, graziers were found to generally fall into a limited suite of five styles. ‘Our findings indicate that they are indeed a special breed, with characteristic[s] that set them apart from members of an urban community’ (Shrapnel and Davie 2001, p. 177). These characteristics include a tendency to introversion and discomfort within group situations. Whilst this work is formative, it provides an indication of why one-on-one relationships are likely to be preferred by many farmers over group settings in the evaluation of options for important decisions. This personality trait will influence the extent and nature of a farmer’s personal networks. Personal networks are an important influence on adoption behaviour and are increasingly important as a medium for the implementation of government and industry programs.

A widely discussed and long-standing concept is categorisation of landholders across a spectrum from innovators to laggards, presented with little change from Rogers (1962, pp. 168-171) to Rogers (2003, pp. 282-285). Landholders do indeed have personal characteristics that influence their adoption decisions fairly consistently. However, the concept of adopter categories implies that innovativeness is a personal characteristic that people apply equally to every adoption decision that they make. This is not so. People who adopt one innovation early are not necessarily early adopters of all innovations. It may be that the innovation in question is particularly attractive in their individual circumstances, whereas the same decision-maker when considering a different innovation that is less attractive to them than to others may behave as a slow adopter or non-adopter.

Several aspects of the linkages between landholders and others may affect the adoption decision:

- The existence and strength of landholders’ social networks and local organisations (e.g., Sobels et al. 2001) and farmer membership of organisations such as catchment groups have been shown to be positively related to adoption (e.g., Kington and Pannell 2003). A number of studies have found a positive relationship between membership of Landcare groups and adoption of some conservation technologies (Cary et al. 2002; Curtis 1997; Curtis and De Lacy 1996; Mues et al. 1998), although the direction of causality is not clearly established;

- The physical proximity of other adopters is positively related to adoption (e.g., Hagerstrand 1967; Ruttan 1996);

- The physical distance of the property from sources of information about the innovation is important—more distant farmers are less likely to adopt, perhaps because the information appears less relevant to them than to those who are close to the information source, or perhaps because they receive less exposure to the information (e.g., Lindner et al. 1982);

- A history of respectful relationships between landholders and advocates for the innovation, including scientists, extension agents, other landholders, and private companies is positively related to adoption, through enhanced trust in the advice of the advocates (e.g., Marshall 2004a, 2004b; Anderson 1981);
• Ethnic and cultural divisions within a landholder population can act as significant barriers to the flow of information about environmental innovations (Stoyles 1992);

• Extension, promotion and marketing programs by government workers and/or the private sector is often positively related to adoption (e.g., Marsh et al. 2000; Llewllyn et al. 2004). Characteristics of extension agents that enhance effectiveness of extension are discussed in the Implications section below.

Demographic and situational variables are judged to be important because they will influence the goals of the farm manager and potentially influence the capacity to adopt an innovation. Some examples of these variables are listed below.

• Lack of financial viability would be expected to inhibit adoption of innovations by reducing the capacity to adopt, rather than the benefits of adopting. Interestingly, work by Cary et al. (2001) shows that profit outlook expectations can be a better indicator of past adoption than current farm performance, underlining the link between farm and personality characteristics.

• Landholders’ access to and reliance on off-property income can influence the adoption of practices by increasing financial security but also by decreasing the tendency to adopt some practices that would increase profitability but involve greater management demands (Kebede 1992).

• Property size is often related to innovation adoption (e.g., Abadi Ghadim et al. 2005) – larger areas tend to increase the overall benefits of adoption and so increase the likelihood of adoption of highly beneficial innovations. In north-east Victoria conservation cropping technology was more likely to be owned by operators of larger and specialist cropping enterprises rather than owners of smaller or opportunistic cropping enterprises (Wilkinson and Cary 1993). In north central Victoria the adoption of perennial pastures was strongly related to property size, but the adoption of tree planting was not (Wilkinson and Cary 1992).

• Age would appear to be of particular relevance to adoption of conservation technologies that have long lags between investment and payoff. If the farm is not to be passed on to the farmer’s children, and if the benefits of conservation technologies are not expected to be fully reflected in the farm’s sale price, then older farmers may have less incentive to invest in something that will be of benefit to the subsequent owner (Gasson and Errington 1993). We speculate that age may also influence adoption via a correlation with physical health. However, the evidence of a relationship between adoption and age, stage of life or farmer experience is mixed. The most extensive meta-review of socio-economic factors influencing adoption found both positive and negative relationships between age and adoption (Rogers 2003). The limited research addressing the influence of age on adoption of conservation technologies (e.g., Cary et al. 2002; Curtis and Byron 2002; Latta 2002) is just as mixed.

• There can sometimes be relationships between education and the adoption of conservation farming practices. It has often been concluded that beneficial innovations tend to be adopted more quickly by farmers with higher levels of education (e.g., Rahm and Huffman 1984; Feder et al. 1985; Goodwin and Schroeder 1994; Kilpatrick 2000). However, in the case of a complex technology or practice that is actually disadvantageous when all of its effects are considered, education may tend to reduce or delay adoption by allowing the limitations of the practice to be recognised (e.g., Marsh et al. 2000). Kilpatrick’s (2000) work has shown the catalysing impact of education in general (not just agricultural education and training) on farmers’ abilities and levels of interest in modifying farming practices. Given the decline in the traditional family farm apprenticeship as a means of entering farming in preference for a longer period of education (Barr, 2004), the future farm management force will be increasingly educated and, presumably, increasingly interested in ongoing self-education about farming systems. Nevertheless, we suggest that a farmer’s general level of education is likely to be less important as a predictor of adoption than their participation in specific relevant training courses.

• The reason for holding land (e.g., agricultural production vis a vis lifestyle) can influence adoption decisions. As Vanclay observed, “Different farmers have different priorities, different understandings, different values, different ways of working, and different problems,” (Vanclay 2004, p. 214). Regions within comfortable driving distance of major cities and regional centres in some Australian states (particularly New South Wales and Victoria) have seen social and demographic changes resulting from city dwellers purchasing what was formerly extensive farming land and pursuing their rural dreams. In these regions, traditional commercial
Agriculture has become a less important land use than it once was, occupying a declining proportion of the land, and the trend in this direction will continue (Barr and Wilkinson 2005). The new landholders may not have the time or financial resources for investment in large-scale adoption of expensive conservation technologies (e.g., woody perennials), even if such technologies would be financially beneficial in the long run (Nicoll 1994). Vanclay et al. (1998) promoted the idea of “farming styles” as a useful mental model for making some sense of this diversity of farming objectives. The farming styles model has been used in an exploratory fashion to try to explain conservation innovation adoption with mixed success (Howden et al. 1998; Howden and Vanclay 2000).

Attributes of technologies that affect their adoption

We consider that there are two broad categories of characteristics of a technology that drive its adoption or non-adoption: the innovation’s relative advantage and its trialability. Relative advantage refers to the perceived net benefits if you do adopt, while trialability refers to how easy it is to move from non-adoption to adoption via a learning phase. Other characteristics that are mentioned in the literature will be discussed under these broad headings.

Relative advantage

Relative advantage means “the degree to which an innovation is perceived as being better than the idea [or technology] it supersedes” (Rogers 2003, p. 229). Relative advantage depends on the landholder’s unique set of goals and the biophysical, economic and social context where the innovation will be used. Relative advantage is the decisive factor determining the ultimate level of adoption of most innovations in the long run.

Relative advantage depends on a range of economic, social and environmental factors, such as:

- the short-term input costs, yields and output prices of the innovation or of all farming activities that it effects. For example, Marsh et al. (2000) and Abadi Ghadim et al. (2005) found that the short-term profitability of new legume crops lupins and chick peas significantly influenced their adoption. Sinden and King (1990) and Cary and Wilkinson (1997) found that short-term expectations about variables related to profitability influenced the adoption of conservation technologies.

- the innovation’s impact on profits in the medium-to-long term. The relative importance of short-term and long-term profits depends on the individual’s personal goals and circumstances, but most landholders profess concern with outcomes beyond the short-term (Makeham and Malcolm 1993; Wilkinson and Cary 1992).

- the innovation’s impacts on other parts of the whole-farm system within which it will be imbedded. For example, a legume crop or pasture can increase the yield of subsequent cereal crops by nitrogen fixation and impacts on crop disease (e.g., Pannell 1996). Long-lived trees may reduce the flexibility of crop producers who wish to switch in and out of crop production from year to year in response to weather conditions – an important strategy in some low-rainfall environments (Kingwell et al. 1993; Cary 1986).

- adjustment costs involved in adoption of the innovation. One reason that the adoption of integrated pest management has been relatively slow is the relatively high adjustment cost it entails (Wiebers 1992)

- the innovation’s impacts on the riskiness of production (Marra et al. 2003; Abadi Ghadim et al. 2005). The relative advantage of an innovative land use would be reduced if it is perceived to be more subject to price variability, to establishment failure, or to yield losses due to drought, weeds or pests than the current land use.

- the innovation’s compatibility with a landholder’s existing set of technologies and resources (Kaine and Lees 1994). For example, a new higher yielding wheat variety is readily adoptable by an existing wheat farmer because it is compatible with the farmer’s current machinery, rotations, agronomic practices, herbicide usage, and so on. To such a farmer, a new type of tree crop is unlikely to be so compatible with existing practices, and so the cost of making the transition to a new farming system that includes the tree crop would tend to reduce its relative advantage and moderate its adoption. Some technologies are sensitive to the soil types on which they are used, and so may be have higher relative advantage on some farms with particular soils. For
example, different crops prefer sandy soils or loamy soils. Some plants are sensitive to soil acidity or soil salinity and some are tolerant, influencing their attractiveness to a farmer depending on which soils are present on their farm. One resource that is a critical determinant of a landholder’s ability to make an innovation work is their own management skill.

- **The innovation’s complexity** (Wilkinson 1989; Rogers 2003). Complexity may increase the intensity of effort required for ongoing management, and the risk of the innovation failing in any given year, each of which reduces the innovation’s relative advantage. Alternatively an innovation may be no more complex in itself, but adoption of it may add to the overall complexity of the whole-farm system. For example, a farmer considering a suite of crop types may find that the managerial complexity of managing five different crops on the farm, each with its own requirements for machinery, agronomy, marketing, and storage, is unacceptably greater than the complexity of managing four. Even if the fifth crop type would actually be profitable to adopt, this could be outweighed by considerations of convenience, stress and risk. Likewise, the conversion from an annual pasture production system to one including perennial pastures such as lucerne can entail significant flow-on impacts upon the farm system.

- **Government policies.** For example, in the US, support programs that are based on yield tended to increase the relative advantage of the intensification of farming and thus increase adoption and use of herbicides (Helms et al. 1987; Miranowski et al. 1991).

- **The cost or profitability of the traditional practice which the innovation would replace.** For example, increases in the price of fuel and labour tended to increase the adoption of herbicides in the US, as herbicides substituted for cultivation which was becoming more costly (Miranowski and Carlson 1993; Carlson and Wetzstein 1993). A history of specialisation in a particular practice is likely to increase the farmer’s skill level and managerial abilities specific to that practice, and so reduce the financial relative advantage of an alternative innovation.

- **The compatibility of a technology with existing beliefs and values.** At least in the short-to-medium term, farmers may consider themselves to be wedded to production of a particular output (e.g., grain cropping, not livestock or trees) or to a particular method of production (e.g., traditional farming methods, not organic) because they identify with it personally (e.g., all my friends are wheat farmers, I am a wheat farmer too, it is what I like doing, it is what I’m good at, it is what my family does, it is an important and respectable occupation for me).

- **The impact of the innovation upon the family lifestyle.** Relationship failure is one of the major causes of farm business failure (Barr 1999). To most farm families, the farm is the means towards the goal of a secure family life. Some innovations can promise a change in the quality of the family lifestyle or potentially even marriage relationships. In the eastern wheatbelt of Western Australia, the large-scale introduction of perennial pastures into a cropping system may threaten the traditional summer holiday that allows the family to temporarily escape the harsh summer wheatbelt environment. The adoption of irrigation re-layout in northern Victoria was in part assisted by the advantages of less broken sleep and more time for couples to share in the evening.

- **Self-image and brand loyalty.** An innovation may change the social standing of some people within local farming culture. In some situations this can accelerate the rate of adoption while in others it can retard adoption. The adoption of cross-breeding of beef cattle was slowed in the high-rainfall beef zone by the traditional status gained by the production of pure-bred Hereford cattle. While minimum-tillage techniques are now widely adopted, early adopters tell stories of the social challenges of not cultivating while neighbours were busy cultivating and maintaining a social network through tractor-cabin CB radios.

- **The perceived environmental credibility of the practice.** Environmental advantage is not always clearly observable, as recent changes in the understanding of dryland salinity attest (Ridley and Pannell 2005). In north central Victoria, trees and perennial pasture have differed in their environmental credibility for dryland salinity management. Tree planting by farmers was based on ‘symbolic’ beliefs (symbolising a personal expression of concern for the public good), while pasture sowing was based on ‘instrumental’ beliefs (providing tangible personal benefits such as increased production) (Cary 1993). Consequently, farmers planted a similar number of trees no matter what size their farm, while those with large farms tended to sow a larger areas of perennial pasture than those with small farms (Wilkinson and Cary 1992).
The crucial role of “relative advantage” as a driver of adoption, and the importance of profit as one the drivers for most farmers has strong implications for conservation technologies. Among those farmers with a focus on profit, the farm-level economics of the conservation technologies will be most important. Those conservation technologies that are not profitable at the farm level will tend to be adopted only by farmers with stronger conservation goals. The lower the perceived profitability, the stronger the conservation goals need to be for adoption to occur. Unprofitable conservation technologies are likely to be more widely adopted if they are able to generate conservation benefits when adopted at a small scale. Conservation land uses that require adoption at large scale to generate conservation benefits will probably not be adopted sufficiently if they are perceived to be less profitable than the land uses they replace.

There are numerous examples that illustrate and reinforce these implications. There has been a very widespread but small-scale adoption of unprofitable conservation practices among many farmers, triggered in part by government programs such as the National Landcare Program and the Natural Heritage Trust (Mues et al. 1998). For example, the resources committed to fencing off streams and remnant vegetation attest to the conservation concerns of many farmers. However, for all but a minority, the costs and areas involved are small relative to the scale of the farm businesses (Curtis and De Lacy 1996).

Some conservation-related technologies have been adopted very widely and over very large areas in Australia, most notably reduced tillage and liming of acid soils (e.g., Mues et al. 1998). These are both technologies that contribute positively to farmers’ economic goals in the medium term in many locations. This highlights that the relative advantage that drives adoption may not necessarily relate to the environment. Indeed, environmental benefits can often be most readily achieved by creating conservation technologies that provide a commercial advantage to farmers.

Conversely, the scale of adoption of perennials for salinity abatement in low- to medium-rainfall areas has been much less than needed to significantly reduce the salinity threat (e.g., ABS 2002; Kington and Pannell 2003). A recent comprehensive review of the economics of salinity abatement measures available to grain growers provides a convincing explanation for this, as there were few example of locations and technologies where the economics favoured high levels of adoption (Kingwell et al. 2003).

Other factors that tend to reduce the relative advantage of at least some conservation technologies are as follows.

- **High establishment costs.** Land conservation practices are often characterised by high up-front costs, and benefits that occur some time in the future (e.g., the establishment of woody perennials for salinity mitigation). The cost of accumulated interest on up-front costs therefore reduces the attractiveness of these practices.

- **Long time scales.** A number of the land degradation issues of concern are long-term by nature. In some cases, degradation processes of concern occur over decades (e.g., dryland salinity, soil acidification, decline of remnant native vegetation) and the practices designed to ameliorate the degradation can be slow to take effect. For this reason, land conservation innovations are often particularly susceptible to the problems of up-front costs and delayed benefits, as outlined above. It also means that farmers who are forced by circumstances to give priority to short-term profits are unable to adopt even if the innovation would eventually generate benefits sufficient to offset the up-front costs plus interest.

- **Riskiness.** Long time lags between planting and harvest (e.g., decades for many woody perennials) contribute to the riskiness of production, because it gives scope for unanticipated developments in product markets, development of competing technologies, accidents or natural events (e.g., fire or pests) to damage the harvestable product.

- **Complexity.** Some conservation technologies are relatively complex, further reducing their relative advantage. For example, many farmers perceive that lucerne pasture (a perennial pasture plant that helps in salinity management) requires a greater intensity of management than do traditional annual pastures (e.g., Lodge 1991). The prospect of expanding the portfolio of farming activities by adopting additional landuses for conservation purposes is likely to be perceived as increasing the overall complexity of the farming system. Greater complexity may contribute to an increased risk of failure.

- **Spillovers.** Some of the benefits from conservation technologies can extend to individuals other than the adopting landholders. A result can be that adoption is less than it would be if the landholder considered all the benefits to the broader community. However, there is scope in some cases for landholders to reciprocate part
or all of the off-site benefits they obtain from one another’s adoption, and thus narrow the gap between the interests of potential adopters and the wider community. An example is shallow groundwater pumping to lower the watertable beneath adjoining irrigation properties. In such a situation, adoption of pumping on any of the properties would lower the watertable not only on that property but, to a lesser extent, on the neighbouring properties as well. If a landholder expects the neighbouring landholders to reciprocate in the investment in pumps, the incentive for the first landholder to invest is increased. On the other hand, the expected relative advantage to any landholder from adopting will be lower if the reciprocation cannot be trusted (i.e., if the other landholders are expected to ‘free ride’ on the actions of the first landholder) (Marshall 2004b). Given that it can be difficult for landholders to develop mutual trust, a perception that adoption of a conservation technology generates reciprocal spillover benefits can itself be a disincentive to adoption, even if the perception is incorrect. As an example where this occurred, in the 1980s and 1990s, there developed a widespread misperception among Australian landholders that adoption of measures to ameliorate dryland salinity on farms generates reciprocal spillover benefits, although this is rarely true in reality. For many farms (particularly in Western Australia), the control of salinity is solely dependent on actions within the farm boundary (Pannell et al. 2001). In all states where spillovers from dryland salinity are significant, they are almost always unidirectional (uplands affecting lowlands) rather than reciprocal.

**Trialability**

In the previous section we discussed a number of social, cultural and personal factors that influence learning about an innovation. Here we consider characteristics of the innovation itself that affect how easily the farmer can learn about its performance and optimal management – in other words, the trialability of the innovation. Trialability has been found to enhance adoption (e.g., Ohlmer et al. 1998). As noted earlier, trialling an innovation provides information that reduces uncertainty about the relative advantage of the technology (Tonks 1983). Thus, trialling is important because it can increase the probability of the farmer making a correct decision about the technology. Trialling also provides an opportunity for the farmer to learn the skills needed to apply the innovation. The small-scale nature of a trial allows the farmer to avoid the risk of large financial costs if the technology turns out to be uneconomic or fails due to inexperience. The reductions in uncertainty and risk from these two aspects are themselves of benefit to the majority of farmers who are psychologically averse to risk and uncertainty.

The trialability of a technology is affected by a number of factors, including the following.

- **The divisibility of an innovation** refers to its use on a small scale, or the use of a sub-component of an innovation package. A degree of divisibility is essential to allow small-scale trialling for learning purposes (Leathers and Smale 1992). For example, a new herbicide would be triable on a very small scale. On the other hand, a new landuse intended to contain a rising groundwater table requires a minimum scale for their effects to be apparent and hydrological evidence indicates that the necessary scale for impacts to be apparent at any distance from the trial is very large (e.g., George et al. 1999). Indeed, it appears that little short of full adoption is often necessary. High fixed costs for an innovation (e.g., the need to purchase new machinery) reduce its divisibility. Even when an innovation package is promoted to farmers as a tightly-bundled, complex technology, farmers have a strong propensity to pull it apart and adopt only some of its components, or adopt selected components in a stepwise manner (Wilkinson 1989).

- **The observability of results from an innovation** is positively related to adoption (Pannell 2001b). Trialling a technology becomes less costly, and thus more likely to be seen as worthwhile, the greater the observability of trial outcomes. Higher observability means that fewer trials may be necessary to sufficiently reduce uncertainty to make the choice between adoption and non-adoption. Observability also enhances the prospects of ‘over the fence’ learning by landholders from one another, and thus promotes diffusion of a technology (Shampine 1998; Geroski 2000). The impacts of new production technologies (e.g., a new herbicide) are often readily and rapidly observable by a farmer. By contrast, a new landuse intended to contain a rising groundwater table in a neighbouring paddock may have effects that are long delayed and physically difficult to observe, requiring the costly installation of piezometers. Even when a piezometer reading is obtained, given the considerable complexity and heterogeneity of underground geological structures in agricultural regions of Australia, it can be difficult to know how representative the observation is. The introduction of Watertable Watch bore flags in Victorian irrigation settlements in the 1980s was an attempt to increase the observability of the underground phenomenon of watertable rise.

There is also considerable difficulty in attributing any change in a watertable to the practice that is being trialled. One difficulty is the absence of a suitable control against which the result can be compared. When
trialling an innovation, such as a new grain crop variety, it is relatively easy to compare the crop’s performance with traditional varieties in the same growing conditions. When trialling an agronomic practice, results can easily be compared with and without the practice. However, for a perennial plant enterprise established in order to prevent rises in the groundwater table, such comparisons are much more difficult and less informative.

It may be that the only available method for assessing the impact of an area of perennials on the watertable would be to observe the deviation from a prior trend. The need to look for a deviation in a historic trend, rather than comparing two current treatments, would add to the delay before any conclusion could be reached confidently. This is because, in the absence of a control treatment, it is more difficult to determine whether any observed deviation is attributable to the new practice or to other factors, such as atypical rainfall. Uncertainty about the response lag time adds to the difficulty of interpreting any observed trend deviation.

- **Long time scales.** Even if observability was high, and a control treatment was available for comparison, groundwater movements are slow, so it may be a very long time indeed before a landholder’s uncertainty about the soundness of a technology for groundwater management is sufficiently reduced to prompt widespread adoption. Slowness reduces the overall value of trialling and may contribute to a judgment that the benefits of the trial do not outweigh the costs.

- **The complexity of an innovation** is negatively related to its adoption. The greater the complexity, the greater the information that landholders require to be certain about the consequences of adopting it. In a sense, this aspect of complexity is related to the innovation’s observability. If there are multiple consequences from adoption, it is more difficult or expensive to observe them all, and it may take a longer duration of trialling to develop confidence in one’s judgment. A separate issue is that greater complexity of an innovation will likely increase the risk of technical failure when conducting the trial. In general, greater complexity increases the difficulty, required effort and time to learn about the innovation’s performance and how best to implement it. This reduces the anticipated value of trialling and so may discourage it from occurring, to some extent.

- **The cost of undertaking a trial** will be negatively related to adoption. For example, if seed of a new crop is in short supply, and so temporarily expensive, landholders may decide to delay their trialling of the crop. Where a large-scale trial is necessary (e.g., for water management technologies), the cost of trialling is correspondingly larger, and trialling is therefore less attractive. A large trial consumes land, labour and finance which could otherwise be used productively on the farm.

- **Risks of trial failure.** Threats to a biological trial may include drought, diseases, pests, and establishment failure. Trials of any innovation always face a risk of failure, but given the large area for which a trial of a tree enterprise appears necessary to discern watertable impacts, the potential losses from a trial failure are relatively large. This provides further discouragement to a risk-averse farmer considering such a trial.

- **Quality of implementation.** For the information from a trial to have value for decision making, the trial needs to be indicative of the innovation’s performance in the long run. If the technology used in the trial is implemented poorly, then the trial will clearly be less likely to meet this requirement. Poor implementation is more likely when the innovation is radically different from technologies with which the farmer is familiar, and this does appear to describe the situation for some conservation technologies.

- **Similarity in behaviour of the innovation to a familiar practice** can be helpful in the learning process. For example, if the pattern of yield responses to weather for a new crop is similar to that for familiar crops, the farmer can extrapolate more readily from a small number of observations of the new crop. Abadi Ghadim et al. (2005) found that differences among farmers in their perceptions about the similarity of responses between yields of a new crop (chick peas) and a traditional crop (wheat) was a significant variable explaining their adoption intentions. New conservation-related landuses are likely to be less similar to traditional landuses in their behaviour than are new production-oriented technologies.

- **Perceived spillovers.** The presence of spillover effects can reduce the motivation for trialling. In a survey of farmers in the upper Kent River catchment of Western Australia, Kington and Pannell (2003) found that 62 percent of farmers believed that their neighbours were causing spillover salinity impacts. While the survey did not explore the proportion of the problem that was attributed to inter-farm flows, it appeared that many of these farmers were significantly over-rating the extent of the spillover problem (Pannell et al. 2001). If
farmers believe (correctly or incorrectly) that the rise in their watertable is due to the management practices of their neighbours, their motivation to trial a technology for groundwater control on their own farm is reduced.

**Implications**

**Implications for research**

Following Marsh (1998), we provide the following suggestions for biophysical scientists to help them achieve greater adoption by landholders of conservation technologies being researched.

- Be conscious of the type of technologies that landholders adopt more readily – those with high relative advantage and high trialability. Appreciate that landholders have legitimate reasons for non-adoption (Vanclay 2004). If the community has a wish to reduce a particular form of environmental degradation originating from farms, but the available technologies for reducing the degradation conflict with core goals of landholders (e.g., salinity treatments highly unprofitable to farmers), one sound response for scientists is to consider the viability of developing new technologies that achieve both community and landholder goals.

- Encourage a participatory process. Working with landholders forces researchers (and extension workers) to recognise that their own goals may be different to landholders’ goals. In a participatory project, this can be recognised as a constraint, and the research/extension adapted accordingly. Such interaction increases landholders’ knowledge of the research and their ownership of, and faith in, the results. Participation also helps to develop better programs and recommendations by making better use of local knowledge so that recommendations are more often corroborated by subsequent experience, and in this way promotes landholders’ trust in R&D and extension over the longer term.

- Look constructively at what landholders are doing already. Work with them where possible rather than against them (or at least acknowledge the difficulty of getting them to stop believing that what they are already doing is appropriate). This suggestion acknowledges the importance of local knowledge in landholders’ decision making, and the importance of respecting their personal goals and perceptions. We suggest that scientific and local knowledge can be strongly complementary.

- As we have tried to argue, adoption of conservation technologies by landholders is not solely a biophysical issue, it is also an economic, social and psychological issue, so biophysical researchers can benefit from working closely with economists, sociologists and psychologists. Social scientists should be involved in projects from an early stage so that their advice can influence the direction of the research, rather than being limited to analyzing the results (e.g. attempting to explain landholders’ responses or lack of response).

Attending to these suggestions would help to enhance trust and credibility in the relationship between researchers and landholders. This is crucial if the researchers are to influence the adoption process (see also below).

Kaine and Lees (1994) suggested the idea of R&D market segmentation on the basis of farming contexts. The contexts would include existing social and cultural factors as well as biophysical and technological conditions. In practice, agricultural and environmental R&D does focus on locally relevant issues to a considerable extent. The concept of market segmentation suggests further targeting of R&D to identified subsets of the local landholder community, based on their goals and circumstances.

Given the importance of trialability for adoption of an innovation, it may be useful for researchers and extension agents to consider ways in which farmer learning from trials can be enhanced. One possibility suggested by the findings of Abadi Ghadim et al. (2005) is to provide information about the trial performance of familiar reference landuses or practices that are as similar to the innovation as possible, in conjunction with information about the performance of the innovation. It may be feasible to facilitate physical observation, or at least present results of physical measurements, of important process that are not readily visible (e.g., groundwater processes). Perhaps it is possible to provide rules of thumb about final yields based on early growth of plants that have long lags before harvest (e.g., woody perennials). Similarly, where a novel land-use requires large-scale adoption to achieve environmental benefits, ways to predict those benefits based on performance in small-scale trials may be helpful.
Implications for extension

A criticism of traditional extension is that it viewed the extension process primarily as a matter of communication. Lack of adoption was blamed on a failure of the extension communication process. The solution was to better target extension and to improve the methods of information delivery. The assumption was that farmers were information deprived and relatively passive recipients of knowledge. In reality, farmers have excessive information (e.g. from consultants, banks, accountants, agronomists, agribusiness firms, other farmers and farm workers), some of which is conflicting, and they are almost never passive recipients. Recognising its place within this complex web of information sources, extension needs to be more focused on credibility, reliability, legitimacy, and the decision making process. Features of current conservation-related extension that mitigate against the development of credibility include: short-term funding, rapid turnover of staff, the youthfulness and inexperience of many staff, and the lack of technical farming expertise of many staff (Vanclay and Lawrence, 1995).

Expectations for extension: Even with the most expert and persuasive extension, landholders are not likely to change their management unless they can be convinced that the proposed changes are consistent with their goals. Therefore, expectations about the extent of change that is likely to result from extension need to be realistic (Vanclay 2004). Large changes made by large numbers of farmers are not likely to be attributable to extension in most cases. For one thing, landholders and their lands are highly heterogeneous. Any given technology only advances the goals of some landholders, and often only on some of their land.

It is likely that the main contributions of extension will be through raising awareness and, to some extent, changing perceptions of the relevance and performance of an innovation. It is much more difficult (and sometimes ethically problematic) to change the goals of people. It seems that the Landcare movement in Australia has increased the emphasis given to conservation goals by landholders, but the extent of increase has been modest for most landholders (Reeve 2001) and the movement has perhaps reached the limits of its influence (Reeve et al. 2002).

This suggests that for many innovations, extension’s main role will be to accelerate the adoption process, rather than to lift the final level of adoption (Marsh et al. 2000). Exceptions to this may include technologies which would have entirely failed to diffuse in the absence of extension, perhaps due to problems with trialability (e.g., low observability, high complexity). Related to this, extension is unlikely to persuade landholders to make greater use of a technology with which they already have personal experience, unless the extension provides new information about a change that increases the attractiveness of the innovation (e.g., new information about how to better implement the innovation, or about new incentive payments to encourage adoption).

Another important expectation for extension (as for science) is that it does not have automatic legitimacy and credibility (Vanclay 2004) – these have to be earned. A landmark study of the social process of agricultural extension in the 1970s showed that the key determinant of an adviser’s credibility to a farmer was trust. Trust was, in turn, strongly related to the extent a farmer believed an adviser understood and respected the goals of the farmer (Anderson 1979; Anderson 1981). Trust determines the nature of the role that an adviser may play in the social aspects of the decision making process of the landholder. Without trust, an adviser may only expect to participate as a provider of information that will be later evaluated within a closer circle of trusted contacts (Phillips 1985). The adviser who is trusted may be invited to participate at a deeper level of decision making where information is more deeply assessed against the goals of the landholder. Participation at this level of decision making is important in gaining understanding of the process of adoption and adaptation that determines the fate of conservation farming technologies. The next section includes suggestions of how credibility and trust may be achieved.

The conduct of extension: Here we briefly present some suggestions about the conduct of extension that can be related to the findings we have reported earlier. It is not an exhaustive manual of extension methods, but focuses on core issues related to enhancing adoption.

Any sound extension campaign needs to use multiple methods (Vanclay 2004). Multiple extension channels, repetition, multiple deliverers of the message, and harnessing of peer pressure are among the standard tools of effective extension agents. Reliance on any particular method (e.g., print articles, verbal presentations, group extension, advertisements) will fall short of the potential impact on adoption from a diverse portfolio of extension approaches and channels. One advantage of using multiple approaches is that it increases the chances of reaching more of the relevant groups of farmers. Secondly, different farmers have different learning styles and prefer to receive information in different ways, or through different channels (Bardsley 1982). Thirdly, repetition can help to reinforce a message and build confidence, especially if it comes through different channels and from different sources.
In situations where adoption of innovations by a group of landholders confers reciprocal spillover benefits, developments in the theory of collective action (Ostrom 1998) suggest that adoption of these innovations may be enhanced by promoting the learning of social norms that emphasise mutual benefit and reciprocal benefits and by facilitating the building of the mutual trust within that group (Marshall 2004b).

A notable trend in extension practice in Australia over the last 15 years has been the substantial decline in public funding for traditional one-on-one extension and a rise in group-based extension (Marsh and Pannell 2000). It could be argued that group-based extension has never been funded at a level that would allow its efficacy to be comprehensively tested (Curtis 2000). Nevertheless the data of Mullen et al. (2000) show that increased funding for what could broadly be called group-based environmental extension (including group facilitators) has approximately offset the decline in traditional production-oriented extension. Group-based extension is, of course, an important part of the extension system, but like any extension approach it has its limitations (Vanclay 2004). In the 1990s, group-based extension processes came to be relied on in the National Landcare Program, partly in response to perceptions about their ability to harness peer pressure to address what were often perceived (incorrectly in some cases) to be environmental problems requiring collective action by landholders for their effective resolution. Group-extension processes grew in favour among extension theorists in response to an increased emphasis on adult learning principles and participation by stakeholders (Knowles 1984; Röling 1988; Chamala and Keith 1995). They were embraced by state agriculture agencies, in significant part, for budgetary reasons (Marsh and Pannell 2000; Barr 1994).

While group-extension approaches are undoubtedly useful, the swing from individuals to groups may have gone too far. For example, the introverted personality profiles of graziers described in Shrapnel and Davie’s (2001) work indicate the continued importance of one-on-one extension. Noting the importance of credibility in effective extension, Vanclay (2004, p. 221) observed that, “Credibility is developed over time through the provision of credible, practical, useful answers that assist farmers in their day-to-day operations. Group facilitators who never provide on-farm advice rarely develop credibility and their ideas are easily dismissed.”

We have earlier discussed the importance of credibility, trust and confidence in extension agents on the part of farmers. We agree that a history of valuable advice relevant to a farmer’s goals is the single most important source of credibility, but it can be enhanced to some extent by a wide range of factors, including:

- authority and technical expertise of the extension agent;
- perceived similarity of the extension agent to their audience;
- local profile of the extension agent (e.g., local residence);
- communication skills of the extension agent;
- personal relationships between the extension agent and farmers; and
- extension-agent acknowledgement of/empathy with the circumstances and problems of farmers.

Adviser credibility and trust is a valuable commodity, but it is only earned slowly. Adviser credibility and trust can be easily lost by the support of an innovation or practice clearly unsuited to local circumstances, or through the evangelical promotion of a practice that is clearly in conflict with the goals of the majority of landowners. In the past two decades, the role of government extension agents in many states has changed away from that of supporting farmers in making good decisions to achieve their own goals, towards encouraging landholders to make decisions that achieve outcomes for the greater public good. In many situations, this has the potential to reshape the social contract between adviser and farmer, creating a far more complex social interaction that may be less comfortable for both the adviser and landholder. The importance of this changed social relationship is not recognised by the relevant public agencies, which publicise their programs using the rhetoric of community development, yet place clear requirements for technology transfer outcomes upon their agents.
Implications for policy and for regional bodies

As noted in the introduction, some government officers express frustration at the lack of adoption by landholders of conservation technologies and call for additional social research to better understand adoption. Sometimes it can be helpful to better understand the adoption of specific practices, but the influences on adoption in general have been studied intensely and we believe that they are sufficiently well understood. Rather than more research into adoption, the more pressing need is to apply what is already well established in the adoption literature.

As we have seen, one implication is that if a practice is not adopted in the long term, it is because the farmers are not convinced that it advances their goals sufficiently to outweigh its costs. A consequence of this is that we should avoid putting the main burden for promoting adoption onto communication, education and persuasion activities. This strategy is unfortunately common, but is destined to fail if the innovations being promoted are not sufficiently attractive to the target audience. The innovations need to be “adoptable”. If they are not, then communication and education activities will simply confirm a farmer’s decision not to adopt as well as degrade the social standing of the field agents of the organisation. Extension providers should invest time and resources in attempting to ascertain whether an innovation is adoptable before proceeding with extension to promote its uptake.

For some environmental issues, the real challenge is to find or develop innovations that are not only good for the environment, but also economically superior to the practices they are supposed to replace. If such innovations cannot be identified or developed, there is no point in falling back onto communication. Promoting inferior technologies will only lead to frustration for all parties.

Sometimes unattractive technologies can be made sufficiently attractive by the provision of financial incentive payments (e.g., through economic policy instruments). However, it is important to be realistic about the potential of this approach. In some cases, the level of payment required to achieve sufficient adoption would be more than can be justified by the resulting environmental benefits (e.g., Pannell 2001a). In some situations, the most sensible strategy is not to attempt to encourage uptake of existing technologies or systems. Rather, it may be more sensible to attempt to develop better technologies (more effective and/or more adoptable), or it may be that research and policy needs to address the task of living with the problem.

Acknowledgements

The authors are grateful to Amabel Fulton for her detailed and insightful comments on an earlier draft. Funders who have contributed directly or indirectly to the preparation of this review include Land and Water Australia, the Australian Research Council, Rural Industries Research and Development Corporation, Grains Research and Development Corporation, and the CRC for Plant-Based Management of Dryland Salinity.

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