From Forest Nursery Notes, Winter 2011

72. How useful is seasonal climate forecasting for tree planting decisions in south-eastern Australia? Perspectives from local knowledge experts. Graham, S., McGinness, H. M., and O'Connell, D. A. IN: Handbook of Agroforestry: Management Practices, chapter 14, p. 407-424. Edited by L.R. Kellimore. Nova Science Publishers, Inc. 2010.

In: Handbook of Agroforestry: Management Practices... ISBN: 978-1-60876-359-7
Editor: Lawrence R. Kellimore, pp. 407-424

Chapter 14

HOW USEFUL IS SEASONAL CLIMATE FORECASTING FOR TREE PLANTING DECISIONS IN SOUTH-EASTERN AUSTRALIA? PERSPECTIVES FROM LOCAL KNOWLEDGE EXPERTS

Sonia Graham**, Heather M. McGinness and Deborah A. O'Connell
CSIRO Sustainable Ecosystems, Canberra, Australia.

ABSTRACT

Climate variability is one of a number of factors that can affect the success of tree plantings. One way to accommodate climate variability in decision making is to use seasonal climate forecasts (SCF). SCF have been used to improve a range of on-farm decisions, however, their usefulness in natural resource management, such as tree planting, has received much less attention. The aim of this project was to use local knowledge to assess the usefulness of SCF for improving the success of tree planting in south-east Australia. Forty-one interviews were conducted with revegetation practitioners, landholders and nursery owners across the southern five catchments of New South Wales: Central-West, Lachlan, Murrumbidgee, Murray and Southern Rivers. The results indicated that the amount of forecast skill and lead times did not correspond well with information needs of landholders, practitioners and nurseries. Furthermore, climate was considered to be of secondary importance relative to site preparation in affecting the success of plantings. Nevertheless, one quarter of the interviewees used SCF in their tree planting decisions, half would only use SCF if they were sufficiently accurate and timely and only one quarter did not and would not consider using SCF. Since the timeframes over which tree planting decisions are made vary from a few weeks to a few years, SCF may prove to be most useful for those people who wish to manage climatic risk and who make the majority of their decisions within three months of planting, when forecasts are the most accurate.

Keywords: Seasonal climate forecast use; local knowledge; tree planting; site preparation.

1. Introduction

Seasonal climate forecasts (SCF) have proved useful for farm decision making (Meinke and Hochman, 2000). The decisions that can be assisted by SCF include crop and variety choice, crop sequence, crop frequency, amount and timing of fertiliser application, time of sowing, sowing densities and grain marketing (Hammer *et al.*, 2000; Meinke and Hochman, 2000; Nelson *et al.*, 2002; Stone and Hochman, 2004). The usefulness of SCF for assisting other farm activities, such as investing resources in revegetation, has received limited attention.

In 2006-2007, 94% of Australian agricultural establishments engaged in natural resource management activities, with one of the top four activities being native vegetation management (ABS, 2008). Since the early 1980s both private and government investment in revegetation activities has increased significantly. Government investment alone has committed more than $5 billion since 1997 to the Natural Heritage Trust and National Action Plan for Salinity and Water Quality, programs which provided significant funding for revegetation activities (Australian Government, 2006; Turnbull and McGauran, 2007). The percentage of this funding dedicated to tree planting is not readily available, however it is known that by 2004 approximately 27 million seedlings had been planted with Natural Heritage Trust funding (Australian Government, 2004).

Despite the significant investment in revegetation activities in Australia, there has been little formal monitoring and evaluation of their success. The monitoring that has been conducted has often been haphazard and infrequent, with little data existing concerning the first twelve months of seedling establishment (Howden *et al.*, 2004; Graham *et al.*, 2009). Nevertheless, both the scientific literature and published guidelines on tree planting suggest that there are a number of management practices and site characteristics that may affect seedling survival, including: weed control (Graham *et al.*, 1989), ground preparation (Shaw and Underdown, 1998), fertiliser (Marcar *et al.*, 2000), mulch (Marcar *et al.*, 2000), tree guards or shelters (Costello *et al.*, 1996), soil moisture (Youngberg, 1957), soil and air temperature (Ball *et al.*, 2002) and provenance (population of a species growing at a particular location) (Measki *et al.*, 1998). Since soil moisture and air temperature are related to climate, it may be possible that SCF could be useful for assisting tree planting decisions.

At present, Australia is served by two operational SCF schemes and two longer term El Niño Southern Oscillation (ENSO) outlook services. The Australian Bureau of Meteorology provides outlooks for rainfall and temperature based on sea surface temperatures (SST) from the Pacific and Indian Oceans (www.bom.gov.au/silo/products/SClimate.shtml). These forecasts are usually issued between the 23rd and 26th of each month and cover the following three months. The Queensland Department of Natural Resources and Water (www.longpaddock.qld.gov.au/SeasonalClimateOutlook/) provides three-month outlooks for rainfall based on the Southern Oscillation Index (SOI). These outlooks are updated once a month with a zero lead time. Beyond three months the Australian Bureau of Meteorology publishes five and eight month outlooks for ENSO based on published global climate models (www.bom.gov.au/climate/ahead/ENSO-summary.shtml). There is also an experimental ENSO forecast system that is provided by the Western Australia Department of Agriculture

* Corresponding author: CSIRO Sustainable Ecosystems, GPO Box 284, CANBERRA ACT 2601, AUSTRALIA, Email: sonia.graham@csiro.au, Phone: +612 6242 1767, Fax: +612 6242 1565

for periods beyond three months, which is updated monthly (www.agric.wa.gov.au/pls/portal30/docs/folder/ikmp/lwe/cli/farmnote_interpretinggess.pdf). Neither of these longer term ENSO forecasts is translated into rainfall or temperature outlooks.

Further information on the seasonal climate can be obtained by using software programs such as Rainman (Clewett *et al.*, 1999) or SSTMan (McIntosh *et al.*, 2005). These programs allow users to examine the influence that the SOI (Rainman only) or SST may have on rainfall over any length of season (1-12 months) up to two years ahead. A number of independent consultants also provide long-range weather forecasts based on their own understanding of the connection between climate and climatic drivers such as the SOI, ocean currents, sunspot activity and the solar system.

A number of approaches could be taken to investigate the usefulness of SCF for tree planting. Traditionally, the usefulness of SCF for agriculture has been assessed through computer simulation modelling (Meinke *et al.*, 2001; Nelson *et al.*, 2002) and field trials. More recently there has been interest in the psychology behind the use of SCF. For example, McCrea *et al.* (2005) explored the relationship between the use of SCF and psychological factors such as perceptions of SCF formats, understanding of SCF and attitudes towards the usefulness of SCF. Both of these approaches tend to assume that SCF will be useful for agriculture and that incorporation of SCF into farm decisions is desirable. Beginning with this premise reasons are then sought as to why SCF is not being adopted, such as the format and dissemination of information, levels of forecast skill and timing of forecast delivery (Ziervogel and Downing, 2004; Klopper et al., 2006). An important alternative approach, which has not been tested, is to assess the importance of SCF relative to other factors that influence farm decisions.

A project was initiated by the Commonwealth Scientific and Industrial Research Organisation to document the relative importance of SCF for tree planting in southern New South Wales (NSW), Australia. The project involved acquiring, comparing and integrating multiple lines of evidence derived from questionnaires (Graham et al., 2008), interviews, scientific field experiments and biophysical modelling (Huth et al., 2008). This chapter reports on evidence acquired from interviews conducted with local knowledge experts.

One of the main aims of the interviews was to examine the relative usefulness of SCF for tree planting, as perceived by the people conducting or providing advice on tree planting. This involved documenting: (1) the factors that influenced whether a particular management technique was used; (2) planning timeframes; and (3) how the importance of climate was perceived relative to other management variables. In contrast to past approaches, this chapter does not assume that SCF will be useful; rather it allows local knowledge to determine SCF usefulness and whether further research is required.

2. METHOD

Three groups were targeted for interviewing: landholders, revegetation practitioners and nurseries. These groups were chosen to provide a comprehensive understanding of the local knowledge that exists about the different aspects of the tree establishment process - from germination to establishment; as well as on a range of scales - from the farm scale to the regional and state scale. These three groups also constitute the market for current use of SCF tools.

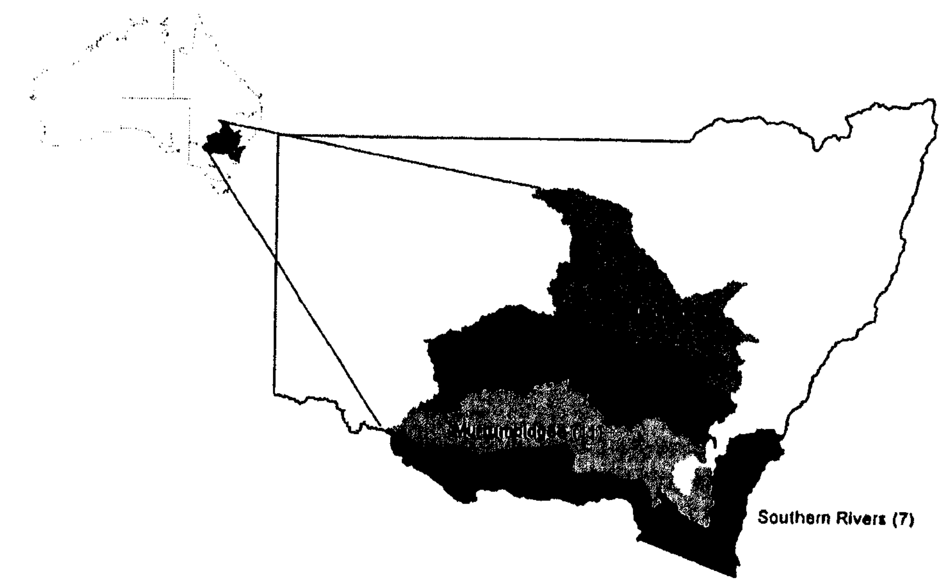

Figure 2. The study area - five south-eastern catchments of New South Wales. Numbers in brackets refer to the number of people interviewed in each catchment.

Semi-structured interviews (Robson, 1998) were used to investigate local knowledge of (1) best practice tree planting practices; (2) the effects of climate on tree establishment success; and (3) the utility of seasonal climate forecasts for tree planting. This technique was chosen due to the exploratory nature of the research and the focus on experiential knowledge. Semi-structured interviews allow researchers the flexibility to alter the research technique in light of information received during the research process (Schwarz & Jacobs, 1979). They are also effective at obtaining in-depth information; allowing the interviewer empathic access to the world and lived meanings of the interviewee (Kvale, 1996). Phone interviews rather than face-to-face interviews were preferred due to the size of the study area.

Between October and December 2005 forty-one interviews (38 phone interviews, two face-to-face interviews and one written response) were conducted with landholders, revegetation practitioners and nursery owners from the five south-eastern catchments of NSW: Central-West, Lachlan, Murrumbidgee, Murray and Southern Rivers (Figure 2; Table 1). The landscapes on which interviewees lived and worked spanned from semi-arid in the west to coastal in the east.

A systematic methodological approach is required when identifying local knowledge experts, to ensure the quality, accuracy and legitimacy of the information collected (Davis and Wagner, 2003). In the present study peer referencing (Davis and Wagner, 2003) was used to determine which landholders and practitioners to interview. Names were provided from at least one other landholder or revegetation practitioner that perceived the participant to be an expert in revegetation, particularly tubestock planting. It was also suggested by a revegetation practitioner from Greening Australia that landholders should be chosen according to their backgrounds, e.g. multigenerational farmers, hobby farmers and amenity migants, as it was perceived that this could also affect their reasons for planting trees and consequently their knowledge base (Aslin *et al.*, 2004).

Table 4. Numbers of landholders, revegetation practitioners, commercial foresters and nurseries interviewed across the five catchments of the Better Knowledge Better Bush project study area.

Catchment	Landholders	Revegetation Practitioners	Commercial Forestry	Nurseries	Total
Central-West	2	2	1	1	6
Lachlan	5	2	0	2	10
Murrumbidgee	5	3	1	2	11
Murray	2	3	1	2	7
Southern Rivers	2	3	0	2	7
Total	16	13	3	9	41

*The figures in this table indicate the main activity that each interviewee was engaged in with regard to tree establishment activities. A number of the landholders also collected seed, from their own properties and/or from the local area, and germinated their own seedlings. Similarly, there were revegetation practitioners and nursery owners who also owned properties and had extensive personal experience with establishing trees.

Nurseries were deliberately selected to represent a range of sizes of business enterprises and a range of proportions to which their businesses were dependent on selling farm trees. These criteria were used as it was conceived that they may influence the extent, if any, to which nurseries are affected by the weather and their perceptions of SCF.

The participation rate was high, with only one person declining due to a family crisis. Nine of the interviewees were women: two landholders, four revegetation practitioners and three nursery owners. With women representing just over one-fifth (22%) of the respondents, their contributions to tree planting are likely to be under represented, as is common in rural research more broadly (Alston, 1998). This highlights the need to achieve greater representation in future research on tree planting.

Partially distinct interview protocols were developed for landholders, practitioners and nurseries. All three interview protocols included questions on: background, seed source, planting time, planting technique, planning timeframes, establishment success and use of SCF. The questions in the sections on background, seed source, planting time, planting technique and planning timeframes differed according the target audience i.e. landholders were asked about their practices while revegetation practitioners and nurseries were asked about the type and form of advice they gave. The questions regarding establishment success and SCF were the same for all groups. Only the responses to the questions about planting window, planning timeframes, drivers of establishment succes and SCF will be reported on in this article. Responses to the remaining questions are reported elsewhere (Graham, 2006).

The draft questions were reviewed by six scientists, including one social scientist and two forestry scientists. Once the reviewers' comments had been incorporated, a joint pilot interview was conducted with a revegetation practitioner and a landholder to assess the necessity, reliability and validity of questions. Feedback from the pilot interview was also incorporated into the protocols prior to starting the phone interviews.

The interviews lasted between 10 and 60 minutes. The qualitative analysis software program NVivo (QSR International Pty Ltd) was used to analyse the transcripts. To ensure anonymity of interviewees, data and quotes were not attributed to particular interviewees, rather they were numbered and dated according to when the interview was conducted and grouped according to whether the comment was made by a landholder (L), revegetation practitioner (P), commercial forestry practitioner (F) or nursery (N).

3. Results

3.1. Interviewee Characteristics

On average interviewees had 18 years experience with tree planting (at least 595 years cumulative tree planting experience) with the amount of experience ranging from 3-47 years. Landholders had 18.9 years experience on average with tree planting with the amount of experience ranging from 5-31 years. During this time approximately 1 013 000 trees were planted by these landholders (assuming a spacing of 1000 trees/ha). On average the practitioners (including commercial forestry practitioners) had 17.2 years experience with tree planting, with the amount of experience ranging from 3-47 years. The nurseries had been operating for 27 years on average, with the number of years of operation ranging from 10-96 years. The percentage of each business dedicated to selling farm trees (trees planted on farms for commercial or environmental reasons) ranged from less than 20% to 100%.

3.2. Planning Timeframes

3.2.1. Planting window

Spring and autumn were consistently mentioned as the preferred times to plant (Figure 3). There were a small number of respondents who did not have a preferred time to plant, but waited for a convenient time according to their other commitments and '*whenever the moisture levels are right, and I've got the trees ready*' (L12, 2005). The one season that was generally avoided was summer unless it was exceptionally wet.

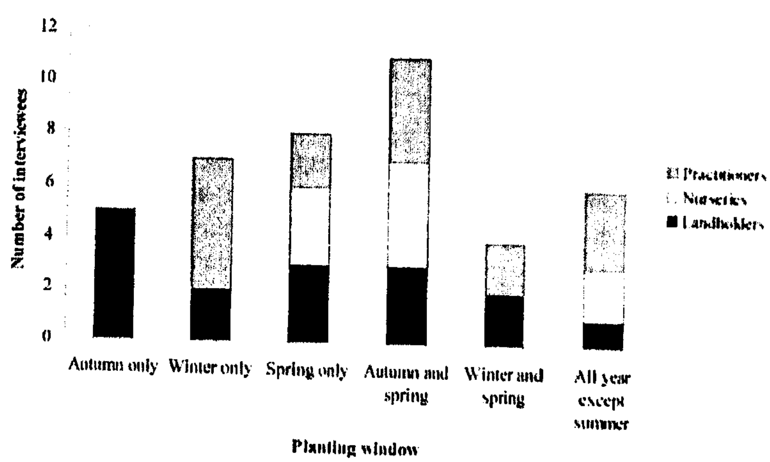

Figure 3. Number of landholders, practitioners and nurseries who planted or recommended planting in certain planting windows.

3.2.2. Placement of orders

Landholders employed three methods for obtaining trees: (1) three landholders called the nursery one to two months in advance of planting (Figure 4) to find out what species were available and to place their orders - these landholders were consequently limited to the trees already being grown by the nursery; (2) for landholders who wanted more control over species choice, orders were placed 4-10 months in advance, depending on the season that the seedlings were to be planted (Figure 4). Practitioners also ordered or recommended that landholders order trees 3-12 months in advance. However, a number of practitioners recognised that this was not always possible due to other constraints such as funding; (3) a number of landholders and practitioners mentioned the need to place orders at least a year in advance, especially if particular provenances were desired: *'it can be up to about a year nearly because if you were going to plant next spring and you wanted a particular provenance, the seed would have to be collected this spring and summer and then propagated very soon after'* (P13, 2005).

The amount of time the nurseries required orders to be placed was between 2.5-6 months in advance for autumn plantings and 7-8 months for spring plantings (Figure 4), as seedlings take longer to grow in the cooler months. The nurseries preferred to receive orders well in advance, *'if not, we mostly just put in a range of species, and we have to guess as to what people are going to want. We get a lot of orders over winter. That's of course too late for us to actually grow them for them'* (N2, 2005).

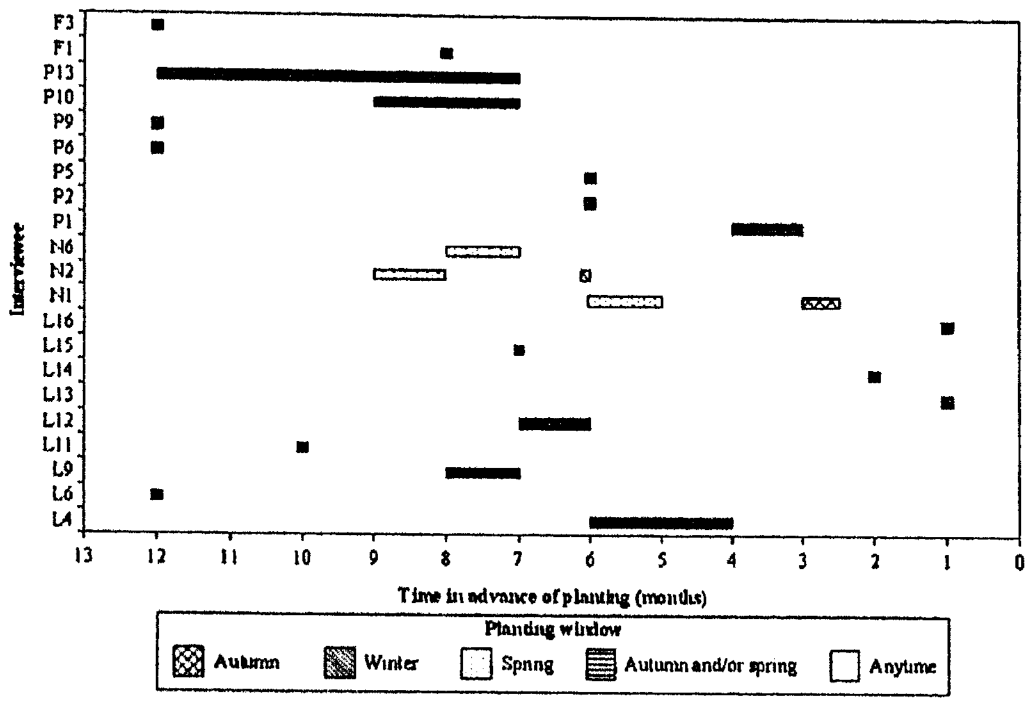

Figure 4. Number of months in advance of planting windows that landholders and practitioners placed orders and nurseries required orders. Black shading indicates landholders, white indicates nurseries and grey represents revegetation practitioners, including commercial forestry practitioners.

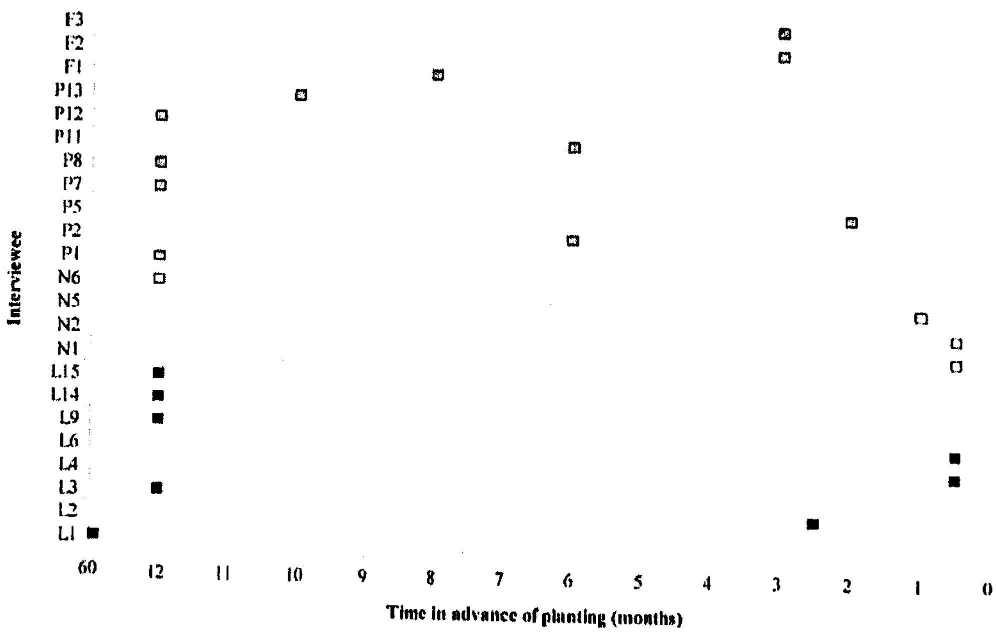

Figure 5. Maximum time in advance of planting that weed control was begun. Black shading indicates landholders, white indicates nurseries and grey represents revegetation practitioners, including commercial forestry practitioners.

3.2.3. Timing of pre-planting weed control

The amount of time in advance that weed control was initiated fell into three main groups. The first group, which included landholders, practitioners and nurseries, began weed control one year in advance of planting (Figure 5). The second group, comprising only practitioners, recommended that weed control be started between six and ten months ahead of planting. The third group, comprising landholders, practitioners and nurseries, began weed control two weeks to three months ahead of planting. There was one outlier who began weed control up to five years in advance of planting.

The majority (25/38) of interviewees who conducted pre-planting weed control used or recommended the use of a knockdown herbicide. Only eight of the thirty-seven interviewees who always or sometimes conducted pre-planting weed control used/recommended a pre-emergent herbicide. There were no apparent trends between the types of herbicides used and the length of time in advance of planting that weed control was initiated.

3.2.4. Timing of ground preparation

There were two main periods during which ground preparation was initiated. The first group of landholders, practitioners and a nursery began, or recommended beginning, ground preparation between one week and six months in advance of planting. The other group began at least 12 months in advance. One landholder started ground preparation up to eight years in advance of planting. This outlier was different to the one for weed control.

The majority (27/35) of interviewees who always or sometimes conducted or recommended ground preparation prepared the ground by deep ripping. Other techniques included mounding (7), hand ripping (1) or use of a jack hammer (1). There were no connections between the type of ground preparation used and the maximum length of time before planting that ground preparation was begun.

3.3. Relative Importance of Climate

The factor most commonly identified as being of foremost importance to seedling establishment was site preparation. Site preparation, or its components of ground preparation and weed control, was identified twenty-three times by interviewees as being the most important or equally most important factor (Table 2). After site preparation, weather and soil moisture were mentioned with the next greatest frequency occurring seven and six times respectively. Other issues identified as important included: aftercare; planting technique; existing vegetation; fertiliser; and fencing for browsing protection and stock management.

3.4. Seasonal Climate Forecasts

3.4.1. Usefulness

Eight interviewees used SCF for their tree growing or nursery activities. Twenty-two interviewees believed SCF would be useful for tree planting if: the forecasts were sufficiently accurate (8); provided on a locally relevant scale (1); provided sufficiently far in advance (2); and/or could forecast extremely dry conditions (2). Eleven interviewees believed that SCF were not be useful because: they were not accurate enough (2); were not specific enough (1); or because the seasonal climate was not relevant to tree planting (4).

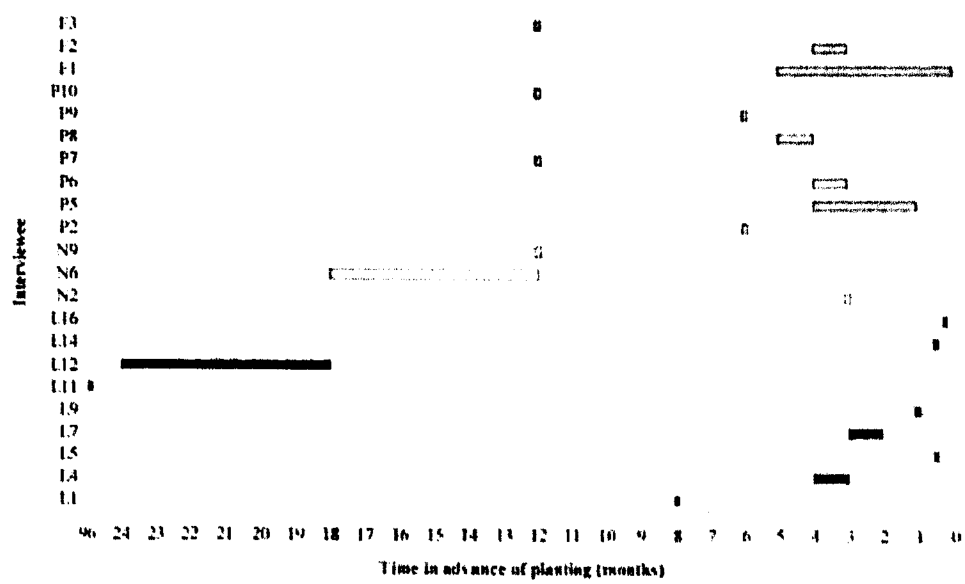

Figure 6. Time in advance of planting that ground preparation is carried out. Black shading indicates landholders, white indicates nurseries and grey represents revegetation practitioners, including commercial forestry practitioners.

Table 5. Frequency with which ten variables were cited as being of foremost importance for seedling establishment. While interviewees were asked to name the most important factor, on six occasions interviewees could only name multiple, equally important factors. To express this in the table, figures in the cells in grey indicate the number of times a factor was identified to be the most important factor on its own. Numbers not in grey cells indicate the number of times the variable was mentioned to be equally important as another factor.
Thirty-seven interviewees provided responses to this question.

Most important factor	Commitment	Ground preparation	Well defined objectives	Landholder understanding	Planting time	Site preparation	Soil moisture	Species choice	Weather	Weed control
Commitment*	1									
Ground preparation		3							1	
Well defined objectives**			1							
Landholder understanding†				0			1			
Planting time					1					
Site preparation						11	1	1	2	
Soil moisture				1		1	4			
Species choice						1		3		
Weather		1				2			3	1
Weed control									1	3
TOTAL	1	4	1	1	1	15	6	4	7	4

* Commitment - level of dedication of the person conducting the tree planting, with regards to the amount of time and resources that they are willing to devote to site preparation and aftercare
** Well defined objectives - having the objectives of the revegetation work well defined
† Landholder understanding - how well landholders understand the dynamics of remnant vegetation and how to mimic it
‡ Site preparation - a combination of weed control and ground preparation e.g. deep ripping

The accuracy of SCF was the main factor that influenced whether SCF was used However, few interviewees clearly defined accuracy. Eight interviewees referred to a particular probability that they would require to make a decision. For these interviewees, one required an 80% chance of above or below average rainfall before changing their practices, four required a 70% chance, one required a 60% chance and one required a 50% chance. Nine interviewees referred to a required percentage of accuracy without specifying a probability, a level of cross-validated forecast skill, or percentage consistency. Ten interviewees could not quantify estimates of the probability or accuracy required. Instead, they stated that SCF needed to be reasonably accurate (5), the more accurate the better (2), tried and proven (1), pretty reliable (1) or able to forecast an extreme drought (1).

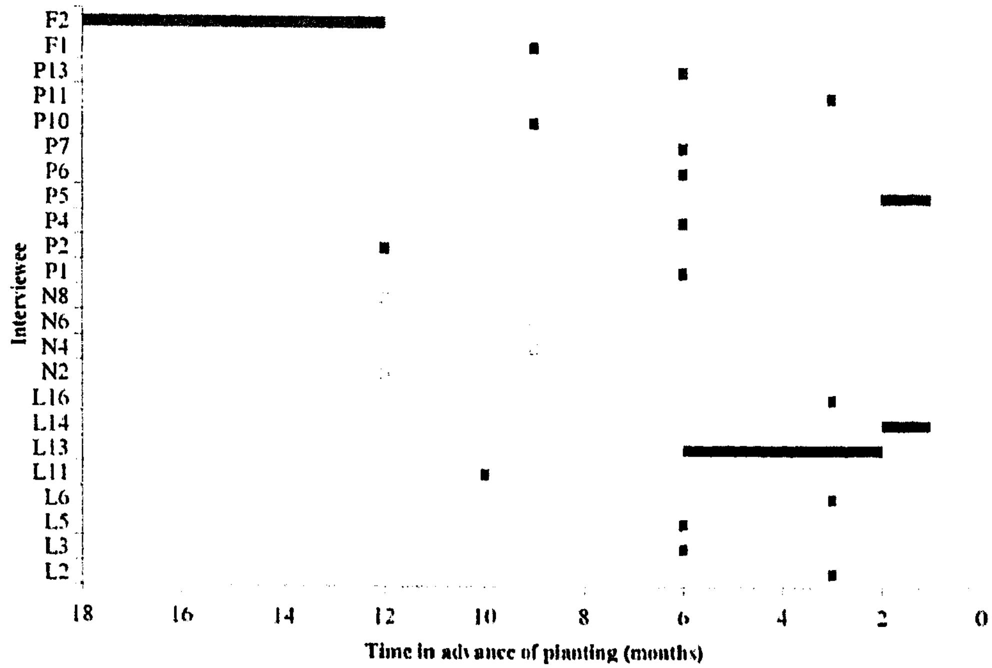

Figure 7. Time in advance that interviewees would ideally like to be able to access SCF. Black shading indicates landholders, white indicates nurseries and grey represents revegetation practitioners, including commercial forestry practitioners. Twenty-three interviewees provided a response to this question.

The amount of time in advance of planting that interviewees desired the climate forecasts ranged from one to eighteen months ahead of planting (Figure 7).

For those landholders and practitioners who used SCF, the forecasts were largely used to determine the resources they should invest in planting (Table 3). SCF influenced the scale of plantings (both on the ground and in the nursery), or whether plantings should be carried out at all. It also influenced the planning process, including the amount of site preparation required, and the aspect and position in the landscape where the seedlings were to be planted.

For those who believed SCF could be useful, the focus was on forecasting during dry seasons. People perceived that such information would affect the scale of their plantings or whether to plant at all (Table 3). It was also seen to be potentially beneficial for planning and coordinating activities. These activities included selecting the level and type of preparation: *'whether to mound or don't mound'* (P10, 2005), choosing species *'if you knew that it was going to be drier than average you would probably still plant but only ... with things that you knew were incredibly hardy and you knew could withstand those conditions. If it was going to be wetter then I think you could make your plantings more diverse and larger plantings'* (P7, 2005) and deciding where to plant.

For nurseries the main benefits of SCF were for decisions regarding the amount and type of species to grow on speculation as well as influencing the advice they gave to clients in terms of planting windows and provisions that should be made in terms of mulching and watering.

Table 6. Decisions affected by consulting SCF by landholders, practitioners and nurseries who currently use SCF as well as decisions which may be altered by consultin SCF by potential users of SCF. Only factors which were mentioned by more than one interviewee are presented in the table.

Decision affected by SCF	Landholder		Practitioner		Nursery		Total
	Current	Potential	Current	Potential	Current	Potential	Overall
Whether to plant	2	1	0	2	0	0	5
Scale of planting	3	3	0	3	1	0	10
Planning timeframe	0	1	1	1	0	0	3
Site preparation	0	0	1	2	0	0	3

4. Discussion

The results provide three options for assessing the usefulness of SCF for tree planting These include: comparing interviewees' planning timeframes and planting windows witl forecast skill of existing SCF; exploring interviewees' conceptions of the factors that drive seedling survival to assess the relative importance of climate information for decisior making; and interviewees' existing attitudes towards SCF. Each will be discussed below.

4.1. Matching Planning Timeframes and Planting Windows with Forecast Skill

The amount of time in advance of planting that interviewees placed orders, began weec control or ground preparation was clustered around three key times. The first was twelve months ahead of planting, at which time four people placed orders (Figure 4); nine begar weed control and four began ground preparation. Only three interviewees conducted twc activities at this time (P7, F3 and N6).

The second period around which activities were clustered was within three months ol planting. In this period three landholders placed their orders, nine interviewees began pre-planting weed control and eight interviewees began ground preparation. Only four interviewees conducted two activities at this time (L14, L16, P5 and N2).

There was less consistent clustering across the three activities for the third timeframe. For placing orders, the majority of orders (12/21) were placed between three and nine months ahead of planting. For weed control four interviewees began between six and ten months of planting and for ground preparation one-third (6/22) of interviewees conducted ground preparation between three and eight months ahead of planting. One interviewee conducted all three activities between three and six months ahead of planting (P2). Three interviewees conducted two activities between three and ten months ahead of planting (L4, P13 and F1).

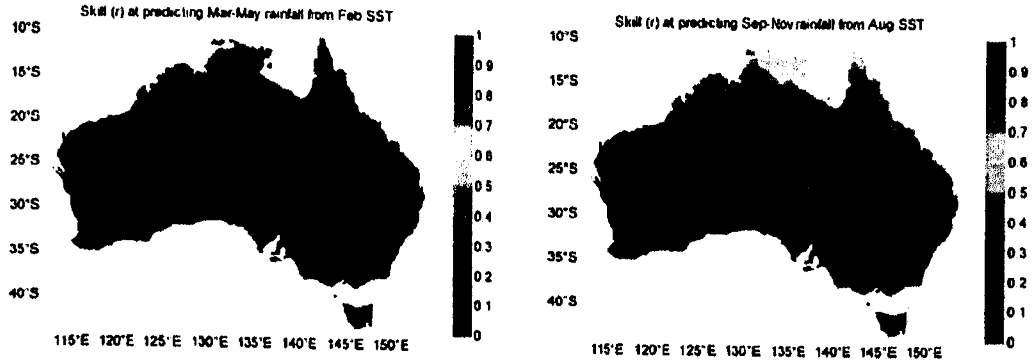

Figure 8. Cross-validated skill that exists for predicting autumn and spring rainfall with a one month lead time across Australia based on sea surface temperatures for the last 100 years. A cross validated r value greater than 0.4 is considered to indicate predictive capacity in the forecast (McIntosh, pers comm.). Graphs provided by McIntosh (unpublished).

Comparing the length of time that information was required with SCF lead times showed that there were only a limited number of interviewees who could benefit from SCF announced via the Bureau of Meteorology or the QDNRW. For both of these schemes three-month outlooks are provided up to one week before the forecast period. This translates into information being available up to three months ahead of planting, which corresponds with the second group mentioned above. This indicates that approximately 40% (16/41) of the interviewees could benefit from SCF.

While SCF may be available year-round, the amount of skill contained in SCF varies throughout the year (Smith *et al.*, 2005). The amount of predictive capacity that exists in SCF derived from SST (such as those provided by the Bureau of Meteorology) shows that while some marginal skill exists for forecasting spring rainfall, there is no skill for forecasting autumn rainfall (Figure 7). Of the sixteen interviewees who made at least one decision within three months of planting four planted in autumn and therefore cannot benefit from SCF based on sea surface temperatures. In principle, this means that SCF from SST has the potential to be useful for 12 interviewees who make decisions in the three months leading up to spring. An additional two interviewees could potentially use SCF for spring planting decisions if an additional month lead time were available.

SSTMan (McIntosh *et al.*, 2005) was used to assess the amount of skill that exists more than one month ahead of spring plantings for a number of towns across the study area. This evaluation shows that there is marginal predictive capacity (cross-validated r: $0.3<r<0.4$; Smith *et al.*, 2005) up to two months ahead of spring for some towns and no skill for others (Table 4). The fourteen late-planning, spring-planting interviewees identified above resided near the nine towns included in Table 4, with two residing near Braidwood, two near Gulgong, two near Orange, three near Canberra and one person in each of the remaining towns. Eliminating those interviewees who resided near towns for which SCF lacks forecast skill means that SCF based on SST are only likely to be partly useful for five interviewees who made one decision within three months of planting and more useful for three interviewees who made two decisions.

Table 7. Cross-validated 'r' values, obtained from SSTMan, which represent the predictive capacity for forecasting spring rainfall in June, July and August. Interviewees who made at least one decision within four and a half months of planting lived near the nine towns presented in the table. Names in brackets refer to the catchment in which the town occurs (Figure 2). A cross-validated r value less than or equal to 0.3 was considered to represent no skill (Smith *et al.*, 2005).

Town	June	July	August
Bega (Southern Rivers)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)
Braidwood (Southern Rivers)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)
Canberra (Murrumbidgee)	No skill ($r \le 0.3$)	$r = 0.39$	$r = 0.39$
Gulgong (Central West)	No skill ($r \le 0.3$)	$r = 0.34$	$r = 0.32$
Holbrook (Murray)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)
Orange (Central West)	No skill ($r \le 0.3$)	$r = 0.33$	$r = 0.34$
Tathra (Southern Rivers)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)
Tumut (Murrumbidgee)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)	No skill ($r \le 0.3$)
Wellington (Central West)	No skill ($r \le 0.3$)	$r = 0.36$	$r = 0.33$

4.2. Conceptions of the Drivers of Seedling Survival

Interviewees' perceptions of seedling survival indicated that climate was not seen to be the primary driving force affecting the success of plantings. Rather, site preparation was seen to be the most important factor. This belief was further reflected in interviewees' management practices as the majority of the interviewees conducted pre-planting weed control (38/39) and ground preparation (35/39) whereas less than half performed watering (18/38), which was perceived to directly mitigate the effects of climate (Graham, 2006).

Although interviewees perceived site preparation as distinct from climate, site preparation is a risk management strategy that precludes the need to consider climate. The main reason interviewees cited for conducting or recommending ground preparation, such as deep ripping, was to increase the amount of water held by the soil: '*we would advise them to start ground preparation, as soon as the rain conditions were right for deep ripping and cultivation, so that they can get the moisture down there*' (N4, 2005). The greater the amount of water available to the seedling at planting, the less important the prevailing weather conditions. Similarly, weeds compete with seedlings for light, nutrients and soil moisture. By reducing the weed load interviewees' increased the amount of soil moisture available to the seedling. Interestingly mulch, which served to control weeds and retain soil moisture (Hermann, 1964), was infrequently used with 24/37 interviewees never using mulch (Graham, 2006).

The small importance given to the influence of climate on seedling survival in interviewees' conceptions, the risk mitigation strategies employed by interviewees through the use of site preparation, combined with the long time frames associated with planning weed control and ground preparation indicated that SCF was unlikely to be easily incorporated into existing decision-making frameworks.

4.3. Attitudes towards the Use of SCF

Despite the mismatch between when seasonal climate information was required to inform tree planting decisions and the amount of predictive capacity that is available, there was considerable optimism regarding the use of SCF. Eight interviewees used SCF to inform their tree planting decisions. The length of time that they used this information ranged from one to ten months ahead of planting. Only one of these interviewees corresponded with those identified at the end of Section 4.1 as having information needs that matched forecast skill. This lack of overlap may be explained by the interviewee who used SCF ten months ahead of planting, who was aware that the forecasts were not reliable at this lead time but believed that it was better to use this information than ignore it.

In addition to the interviewees who used SCF, twenty-two interviewees believed SCF could be useful. However, when asked to identify the amount of time ahead of planting that they would require SCF information the lead times they proposed did not possess significant forecast skill. This contrasts with the findings of McCrea *et al.* (2005) that indicated that use of SCF increased with understanding of SCF. In the present study less understanding may have resulted in greater optimism about SCF. This optimism may decrease if desires regarding the accuracy of forecasts are not met.

Due to the ambiguity of responses regarding the amount of certainty required to alter tree planting decisions, further research is required disentangle how the predictive capacity contained within existing forecasts corresponds with landholder, practitioner and nursery needs.

Despite the considerable optimism surrounding SCF there was relatively little utilisation of the information. This relates to the social science dilemma of understanding the relationship between attitudes and behaviour. While McCrea *et al.* (2005) suggested that favourable attitudes regarding SCF were correlated with SCF use they also suggested that a good understanding of SCF was also required. In this study, confusion regarding the amount of predictive capacity present in forecasts and the lead times with which SCF could provide assistance indicated that there was a poor understanding of SCF among the interviewees. This may be one of the factors contributing to the limited use of SCF.

An alternative explanation can be found by examining why SCFs were perceived to be useful. The main reason offered for using SCF for tree planting was to assist decisions regarding the amount of resources to invest in planting. Although not part of the interview protocol, six interviewees mentioned that they expect to plant every year regardless of the climate, *'We have tree planting planned every year for the next ten years'* (P5, 2005). Given this dedication to revegetation, the decision regarding the investment of resources may be of little significance and consequently the importance of SCF is limited. While SCF was perceived to be useful, the amount of resources and effort required to understand the technology and implement it in decision making may be prohibitive or simply deemed unnecessary.

The finding that SCF may provide limited usefulness for most landholders and practitioners for tree planting decisions due to the short lead times and poor predictive capacity corroborates with other recent research findings for use of SCF in agricultural decisions (Brennan *et al.*, 2006). Nevertheless SCF was being used to inform tree planting decisions by a quarter of the interviewees in the absence of scientific or government support encouraging such behaviour.

5. Conclusion

This study provided a local knowledge approach towards assessing the usefulness of SCF for tree planting decisions. The results indicated that the predictive capacity and lead times of SCF did not correspond well with the information needs of landholders, practitioners and nurseries. Furthermore, climate did not feature prominently in interviewees' conceptions of seedling survival, as most interviewees employed risk management strategies such as long term weed control and ground preparation, which tended to mitigate the effects of climate.

Although SCF was mostly useful for tree planters who left decisions to within a month of planting or who were willing to accept the low level of skill available, SCF may still prove useful for other revegetation activities. One activity which has taken on increased prominence in the last decade is direct seeding. Direct seeding involves much smaller investments of time and resources, is much more susceptible to climatic conditions at planting and is not constrained by the requirement to order seedlings many months in advance of planting. Therefore it may be useful to investigate the decision making processes associated with direct seeding and the amount of predictive capacity required for SCF to be useful.

Acknowledgments

Thanks to our colleagues Toni Darbas, Paul Ryan, Trevor Booth and Nico Marcar for assisting with both the project and development of the interview protocols and Sarah Bruce and Zvi Hochman for reviewing the chapter. Thanks to Sue Streatfield and Simon Katz of Greening Australia and John Ive for helping to road test the interview design. Finally, thanks to all the participants who took the time to participate in this research.

This chapter forms part of the Better Knowledge Better Bush project, using integrated science to improve our understanding of native vegetation management. The project is a partnership between CSIRO, Charles Sturt University, Greening Australia, the NSW Department of Environment and Conservation, RMIT University and the Southern Rivers Catchment Management Authority. Better Knowledge Better Bush has been assisted by the NSW Government through its Environmental Trust.

References

ABS (Australian Bureau of Statistics) (2008). *Natural Resource Management on Australian Farms, Preliminary*, 2006-2007. Canberra: Australian Bureau of Statistics.

Alston, M. (1998). Women: the silent partners of agriculture. *Proceedings of the 9th Australian Agronomy Conference*, Wagga Wagga, Australia, July 1998, 31-36.

Aslin, H., Kelson, S., Smith, J. & Lesslie, R. (2004). *Peri-urban landholders and bio-security issues – a scoping study*. Canberra: Bureau of Rural Sciences.

Australian Government. (2004). *Overview of the Australian Government's Natural Resource Management Initiatives: Protecting, Conserving, Repairing*. HTTP://WWW.NRM.GOV.AU/PUBLICATIONS/NRM-OVERVIEW/PUBS/NRM-OVERVIEW.PDF [Last accessed 2 November 2006].

Australian Government. (2006). *About Natural Resource Management.* http://www.NRM.GOV.AU/ABOUT-NRM.HTML [Last accessed 2 November 2006].

Ball, M. C., Egerton, J. J. G., Lutze, J. L., Gutschick, V. P. & Cunningham, R. B. (2002). Mechanisms of competition: thermal inhibition of tree seedling growth by grass. *Oecologia, 133,* 120-130.

Brennan, L. E., Hochman, Z. H., McCown, R. L., Darbas, T. M., Carberry, P. S., Fisher, J., Hall, C. A. & Dalgliesh, N. P. (2006). *Targeting pragmatist farmers in the transfer of simulation-based decision support. Final Report submitted to the Cooperative Venture for Capacity Building.* Canberra: Rural Industries Research and Development Corporation.

Clewett, J. F., Smith, P. G., Partridge, I. J., George, D. A. & Peacock, A. (1999). *Australian Rainman Version 3: An integrated software package of Rainfall Information for Better Management, QI98071.* Toowoomba: Queensland Department of Primary Industries.

Costello, L. R., Peters, A. & Giusti, G. A. (1996). An evaluation of treeshelter effects on plant survival and growth in a Mediterranean climate. *Journal of Aboriculture, 22,* 1-9.

Davis, A. & Wagner, J. R. (2003). Who knows? On the importance of identifying "Experts" when researching local ecological knowledge. *Human Ecology, 31(3),* 463-489.

Graham, R. T, Harvey, A. E. & Jurgensen, M. F. (1989). Effect of site preparation on survival and growth of Douglas-fir (Pseudotsuga menziessi Mirb. Franco) seedlings. *New Forests, 3,* 89-98.

Graham S. (2006). *Local Knowledge of Seedling Survival in a Variable Climate.* Canberra: Commonwealth Scientific and Industrial Research Organisation. http://www.BETTERBUSH.ORG.AU/PDFS/LOCAL%20KNOWLEDGE%20OF%20SEEDLING%20SURVIVAL%20IN%20A%20VARIABLE%20CLIMATE%20V2.PDF

Graham, S., McGinness, H. M., O'Connell, D. A. & Nicholls, A. O. (2008) Climatic Drivers of Revegetation Management Practices in Australia: Analysis of a Social Survey. *Small-Scale Forestry, 7(2),* 183-203.

Graham, S., McGinness, H. M. & O'Connell, D.A. (2009). Effects of management techniques on the establishment of eucalypt seedlings on farmland: a review. *Agro-forestry systems, 77(1),* 59-81.

Hammer, G., Meinke, H. & Potgieter, A. (2000). The use of seasonal forecasts, climate data, and models to improve the profitability and sustainability of cropping systems.

Hermann, R. K. (1964). Paper mulch for reforestation in southwestern Oregon. *Journal of Forestry, 62,* 98-101.

Howden, M., Crimp, S., Carter, J., O'Connell, D., Carr. D., McIvor, J. & Graham, S. (2004). Enhancing Natural Resource Management by Incorporating Climate Variability into Tree Establishment Decisions. Final report submitted to Land and Water Australia, Climate Variability in Agriculture Program. Canberra: Commonwealth Scientific and Industrial Research Organisation.

Huth, N., Carberry, P., Cocks, B., Graham, S., McGinness, H. & O'Connell, D. (2008). Managing drought risk in seedling establishment: an analysis using experiment and model. *Forest Ecology and Management, 255,* 3307-3317.

Klopper, E., Vogel, C. H. & Landman, W. A. (2006) Seasonal climate forecasts – potential agricultural-risk management tools? *Climate Change, 76,* 73-90.

Kvale, S. (1996). InterViews: An Introduction to Qualitative Research Interviewing. California: Sage Publications, Inc..

Marcar, N. E., Hossain, A. K. M. A., Crawford, D. F. & Nicholson, A. T. (2000). Evaluation of tree establishment on saline seeps near Wellington and Young in New South Wales. *Australian Journal of Experimental Agriculture, 40,* 99-106.

McCrea, R., Dalgleish, L. & Coventry, W. (2005). Encouraging use of seasonal climate forecasts by farmers. *International Journal of Climatology, 25,* 1127-1138.

McIntosh, P. C., Ash, A. J. & Stafford Smith, M. (2005). From Oceans to Farms: The Value of a Novel Statistical Climate Forecast for Agricultural Management. *Journal of Climate, 18,* 4287-4302.

Measki, B., Waters, M. J. & Bird, R. (1998). Results from spotted gum provenance and ripping trials in south west Victoria. *Agroforestry News, 7,* 18-19.

Meinke, H., Baethgen, W. E., Carberry, P. S., Donatelli, M., Hammer, G. L., Selvaraju, R. & Stöckle, C. O. (2001). Increasing profits and reducing risks in crop production using participatory systems simulation approaches. *Agricultural Systems, 70,* 493-513.

Meinke, H. & Hochman, Z. (2000). Using seasonal climate forecasts to manage dryland crops in northern Australia: experiences from the 1997-98 seasons. In C. L. Hammer, N. Nicholls, & C. Mitchell, (Eds.), *Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems: The Australian Experience.* Dordrecht, The Netherlands: Kluwer Academic Publications.

Nelson, R. A., Holzworth, D. P., Hammer, G. L. & Hayman, P. T. (2002). Infusing the use of seasonal climate forecasting into crop management practice in North East Australia using discussion support software. *Agricultural Systems, 74,* 393-414.

Proceedings of a Conference on Emerging Technologies in Agriculture: From Ideas to Adoption, Canberra, Australia, July 2000, 109-118.

Robson, C. (1998). Real World Research: A Resource for Social Scientists and Practitioner-Researchers. Massachusetts: Blackwell Publishers Inc.

Schwartz, H. & Jacobs, J. (1979). *Qualitative Sociology: A Method to the Madness.* New York: The Free Press:.

Shaw, S. & Underdown, M. (1998). Eucalyptus globulus ripping and mounding trial. *Agroforestry News*, *7*, 24.

Smith, I. N., Wilson, S. G. & McIntosh, P. (2005). *An Assessment of the Role and Potential Utility of Dynamical Seasonal Forecasts for Australia.* Hobart: Commonwealth Scientific and Industrial Research Organisation.

Stone, P. & Hochman, Z. (2004). If interactive decision support systems are the answer, have we been asking the right questions? *Proceedings of the 4th International Crop Science Congress: New Directions for a Diverse Planet*, Brisbane, Australia, September 2004.

Turnbull, M. & McGauran, P. (2007) Foreward. Natural Heritage – The Journal of the Natural Heritage Trust, 32, 3.

Youngberg, C. T. (1957) The influence of soil moisture on the survival of planted Douglas-Fir seedlings on clay soils. *Journal of Forestry, 57,* 842-844.

Ziervogel, G. & Downing, T. E. (2004). Stakeholder networks: improving seasonal climate forecasts. *Climatic Change, 65,* 73-101.