Farming systems research: purpose, history and impact in New Zealand hill country

D.R. STEVENS[1], M.J. CASEY[2] and K.A. COUSINS[1]
[1]*AgResearch Ltd, Invermay Research Centre, Private Bag 50034, Mosgiel, New Zealand*
[2]*PGG Wrightson, Private Bag 1960, Dunedin, New Zealand*
david.stevens@agresearch.co.nz

Abstract
A review of the literature accessed 234 papers that referenced farm or farming systems research in New Zealand hill country. These were categorised into resource allocation/productivity, modelling, farm studies and sociology. Sociology was further categorised into social, cultural, resilience, policy and regulation, and system behaviour and change. Farming systems research developed over the 5 decades studied from 9 papers in 1960-1975, to a peak of 60 papers during the 1986-1995 decade. The number of papers accessed during the latest decade, 2006-2015, was 57. The focus of research has changed significantly from an initial emphasis on biophysical processes and productivity, peaking in the 1976-1985 decade and then tapering off. This provided data for the development of models that could generate many more comparisons at lower cost. Modelling of the biophysical farm and economic outcomes has been steady through the decades from 1986 to present. The impacts of policy and regulation have featured strongly in the 1986-1995 decade after agricultural deregulation, and again in the 2006-2015 decade as consumer and societal concerns about the environment have emerged. Resilience of the farming system, encompassing production, economic, social and environmental trade-offs, has emerged as a topic being most prevalent in the most recent decade from 2006-2015. The discipline of farm systems research has also matured over this time as a greater range of research techniques, over a wider range of subject matter have been applied. An evolution of the discipline has also seen the integration of the principles of complex adaptive systems into the work.

Keywords: cultural, economic, environmental, farm systems, modelling, policy, production, regulation, resilience, social

Key messages
- Farm systems research has developed from a pragmatic need to provide practical solutions to farming issues
- The increased understanding of biophysical processes and now social drivers of systems behaviour has been used to develop models to investigate farm systems behaviour
- Future farm systems research will be an amalgam of techniques and disciplines (including farmers) to create robust solutions and new farming systems in hill country.

Introduction
Farm systems research is a discipline that examines farming systems to understand the relationships between the elements of the system and the outcome as a whole (Darnhofer *et al*. 2012). It is research to investigate the interactions between the components of the system and the behaviour of the system to external influences. The research is about the system, not the components and so is termed holistic, rather than reductionist.

When examining the conditions of systems research, the definition of the boundary is an essential element. This then determines what is in and out of the research. The second element of systems research is the ability of the approach to examine emergent properties. These two factors provide a definition for systems research in comparison to component or reductionist research, where conditions are controlled to limit the influence of external factors.

So where have we come from in this realm in New Zealand hill country? Understanding the interactions between the components and emergent properties of a system are key to capturing the benefits of changes and improvements. The expansion of research from plot trials and reductionist thinking, to large scale, inclusive trials where interactions could be seen was an early response by scientists as they were confronted by the realities of farming. Sears (1951) stated ‘At the outset I emphasise that all these aspects are interdependent and equally important; also that we must at all times be prepared to modify our outlooks and practices to fit in with changes in plant populations, fertiliser supplies and general production and marketing policies.’ He was referring to understanding the role of plant genetics, soil fertility, grazing practice and animal requirements in a farm systems context, and describes running self-contained farmlets at Palmerston North, Lincoln and Gore. While these trials were intensive farm systems, the lessons were transferable to hill country and experiments were established at Te Awa (Suckling 1954). Grant *et al.* (1972) noted, however, that slope was the complicating factor.

ISSN 0110-8581 (Print) ISSN 2463-4751 (Online)

Sears (1951) introduced the concept of influences beyond the farm gate, when he mentions marketing policies. The framing of influence has developed over time and those trends are investigated in this paper. Realms of influence that we are now familiar with include those relating to 'sustainability': production, economic, environmental, social and cultural. These realms are nominally representative of the outputs of the system, either direct (product) or indirect (economic), and primary (product), or secondary (environmental, social and cultural).

Two facets of system behaviour are most commonly studied. The first is internal interactions. This is when elements within the system respond to one another and new properties may emerge. An example may be the interactions between plant species, soil fertility and grazing management. Sears (1951) provided an early example of this type of systems research where pasture alone is compared with hay supplementation and cropping and the outcome is measured as overall profitability. The second is external interactions where adaptation or evolution may be a result as the system adapts to new conditions. This may be how the farm system as a whole might respond to external influences, or how elements within the farm system evolve and react to those influences. This type of response is documented by Wallace (2014) as the emergence of activities such as deer farming and kiwifruit production from the deregulation of the agricultural economy in the 1980s.

Before examining the history of hill country farm systems research some terms have to be defined. The following descriptions are proposed to ensure clarity when referring to the type of research being undertaken. Farms do not sit in isolation. Farms are grouped into catchments, regions, suppliers, value chains and so on. This moves the research from farm to farming systems, by extending the boundaries and changing the unit of interaction.

Farm system – the workings and configuration of a farm.

Farming system – the conglomeration of farms and associated industries with common linkages (to be determined by the purpose of the study).

Farmlet – a small-scale replica of a biophysical farm. These systems are deemed closed as all activities must be supported within the system.

Put and take open grazing systems – experiments where livestock numbers can be adjusted to reflect changes in pasture growth and demand. These experiments provide a proxy for a closed system by accounting for changes in stocking rate.

The purpose of hill country farm systems research in New Zealand has been of a pragmatic nature, identifying issues or opportunities for farmers and providing solutions through research. A second purpose has been to identify causes of major change in farming systems and document changes in practice and the rural communities that resulted. A third purpose of the research that is currently emerging is the opportunity to design future farm systems in the face of current requirements to change.

This paper reviews the literature reporting farm systems research and demonstrates the evolution of purpose and techniques of that research. The history and focus of farm systems research to date is outlined. Finally the paper provides some analysis of the impacts of hill country systems research and suggests a potential future for farm systems research in hill country.

Methods

A review of farm systems research in New Zealand was conducted through a literature search. Resources searched included CAB Abstracts, Scopus, Google Scholar, WWW and New Zealand Institute of Primary Industry (NZIPIM) (until 2014). The search strategy included the keywords; hill country, hill pastures, hill farms, down lands, farm systems, farmer decision making, production and management. Reference to high country was not explicitly used as a term, but articles which were identified as high country were retained as relevant.

This search returned approximately 120 papers over the period 1951-2014.

The search strategy was expanded to include the terms social, sociology, socio-economic, attitudes, perceptions, adaptation to change, deregulation of agriculture, education, employment, capability, health, resilience, farm governance, succession and management. The inclusion of these terms added another 84 papers, though few papers had hill country as their specific focus.

Other papers known to the authors were added to make a total of 234 papers accessed. While the number of papers accessed is large, it is not exhaustive. Many reports commissioned by government agencies and producer boards, such as the Ministry of Agriculture and Fisheries and the New Zealand Meat and Wool Economic service, are now hard to access electronically. These also provide insight into the situation and thinking that moulded decision making and hence research topics. However, the relative abundance of each type of paper will provide an insight into the distribution of research. To be included in the analysis the research had to exhibit the opportunity for interaction to be expressed between at least two factors, e.g. fertiliser and grazing management, or examine the farm or farming system reactions to external influences, e.g. policy making.

On examination of the papers, the research was characterised into a set of topics based on the authors' insight. From the original review the categories of resource allocation/productivity research, modelling of biophysical processes and economics, and farm studies, which often involved surveys and case studies of practice and practice change, were identified.

The second literature search, identifying social research, was characterised by the following topics; social, cultural, resilience, policy and regulation, and system behaviour and change. The papers were then grouped in decades from 1966 to 2015 to indicate changes of emphasis over time. The papers were also characterised by the types of data collected and the methodology that was chosen for analysis.

Finally the combined literature search was grouped into realms of research and represented in decade time steps, again to indicate the evolution of the research.

Results

An analysis of the results provided the following insights.

Resource allocation/productivity research

This research has been mainly to characterise the interactions between key components of the grazing systems and made up approximately 50% of the initial search and 27% of the total literature pool accessed. These have been grouped in Table 1 under the subject of main interest in each paper, and the main output from each paper. Productivity was the specific focus for approximately 90% of these papers, with grazing, animals and soils being the major focus. The research described the interactions between various components, such as grazing management and fertiliser inputs and often used animal productivity as a primary measure of outputs. The research ranged from simple put and take open grazing systems to farmlet systems.

A financial analysis of farmlets was presented in only 6% of papers. This generally used the productivity results from the farmlets and applied general financial criteria from farm scale statistics of the time. Often financial analysis was unable to be assessed directly because of the limited size of the farmlets and became included in modelling/virtual analysis.

Environmental outputs were the focus of only 5% of these productivity-based studies and they included sustainability indicators, physical soil damage and biology.

Modelling research

The use of virtual investigations into hill country farming systems made rapid progress during the 1980s as computer use and computing power increased. A total

Table 1 Systems type research into production-based technologies in New Zealand hill country (the primary purpose of the paper describing the research has been chosen as the technology).

	Impact area		
Technology	**Productivity**	**Economic**	**Environmental**
Grazing	Suckling 1956; Suckling 1959; Grant *et al.* 1973; Suckling 1975; Dawson & Smith 1976; Smith & Dawson 1977; Grant *et al.* 1978; During *et al.* 1980; Smeaton & Winn 1981; Lambert & Clark 1983; Sheath 1983; Smeaton *et al.* 1984; Allan 1985; Sheath & Rattray 1985; Allan 1992; Smeaton *et al.* 1999; Boom & Sheath 2000; Hodgson *et al.* 2005	Allan & Foran 1994	
Forage	Allan *et al.* 1985; Allan & Keoghan 1994; Stevens & Casey 2014		
Animal	Hight 1968; Joblin *et al.* 1972; Baker & Carter 1976; Dalton 1976; Rattray 1977; Rattray 1978; Smeaton *et al.* 1979; Rattray 1981; Rattray *et al.* 1982; Smeaton *et al.* 1982; Rattray *et al.* 1983; Smeaton *et al.* 1983; Harris & Clark 1985; Smeaton *et al.* 1986; Journeaux *et al.* 1987; McCall & Marshall 1991; Smeaton *et al.* 1995; Boom & Sheath 1998; Smeaton *et al.* 2000; Morris *et al.* 2014		Sheath & Boom 1997
Fertiliser	Clark & Lambert 1982; Lambert & Clark 1983; Lambert & Clark 1985; Clark *et al.* 1986; Lambert & Clark 1986; Lambert *et al.* 1990; O'Connor *et al.* 1990; Ledgard & Jones 1991; Roach *et al.* 1996; Lambert *et al.* 2014	Clark *et al.* 1990; Gillingham *et al.* 2004	Lambert *et al.*1996
Enterprise	Nicoll *et al.* 1978; Rattray 1981; McRae 1988; Sheath *et al.* 1990; Mackay *et al.* 1991; Mackay *et al.* 1998		Mackay *et al.* 2006

of 46 papers were accessed, making up approximately 20% of the total. The rise of modelling coincided with an increasing body of information coming from the biophysical systems experiments that allowed production functions to be developed and tested (Table 2). These papers have been grouped into development or use of models, and into biophysical, financial or environmental predictive outputs.

The development and testing of models primarily for biophysical prediction made up 24%, while finance was the primary driver of 11% of the models. Two models describes an environmental function (Synge *et al*. 2013; Vogeler *et al.* 2014).

The use of models is evenly balanced between biophysical (29%) and financial (27%) outputs with only 7% describing environmental outputs. Again, the progression in this sequence moves from developing and using biophysical models, to adding finances and then moving to environmental impacts. This emphasises the general shift in focus from primary production to profitability impacts and then to secondary impacts.

Farm studies

The use of direct farm studies as a farm systems research tool represented 20% of the total literature search and fell into four categories when broadly characterised by research method. This was then stratified by the focus of the research (Table 3). The first was farmer survey research, 32% of the papers, of which the majority were involved in characterising farming systems. Topics included new enterprise implementation, feed management, variability, animal productivity and financial resilience.

Case studies were the second category, representing 40% of the papers, and characterising equally the farm system, decision making and change. A subsection of this group that documented progress on the Beef + Lamb New Zealand monitor farm programme made up 25% of these papers. This programme was a major source of innovation from 1991 until the late 2000s. These papers identified the role of monitoring programmes in effecting change through the implementation of management, financial and technological change.

Farmer directed research included 24% of the results and generally documented a range of projects that accessed government and industry funding (Beef + Lamb New Zealand, TechNZ and Sustainable Farming Fund) to explore, understand and innovate to include new technologies within the farm system. Topics included forages, fertiliser, animal genetics, feed quality, animal production and constraints to change.

Finally, two papers (4%) used data from many farms over a number of years in a wide range of environments to investigate first principles of animal and pasture production to drive on-farm changes in productivity.

Many of the papers in this category has been driven by the researcher involved and their desire to document the activities or progress of various groups. A key feature of this work is their representation in the New Zealand Grassland Association proceedings. Much of the work has been funded by industry and government bodies. This indicates how important these funding sources are in ensuring that new technologies and practices are tested and reported for wider uptake. The frequency and continuity of paper publication reflects the relative sources of funding. For example, the documentation of Beef + Lamb New Zealand monitor farms covers the period when they were most productive.

The main contributors to this documentation have been Massey University, Lincoln University and AgResearch. A smaller contribution has been from farm consultants.

Sociology research

The inclusion of sociological research acknowledges that people play an extremely important part in the

Table 2 The development and use of modelling research in hill country farming systems (several papers fit more than one category).

	Intent	
Parameter	**Development**	**Application**
Biophysical	Field *et al.* 1981; Bircham & Sheath 1986; McCall *et al.* 1986; Marshall *et al.* 1991; Webby *et al.* 1995; Rollo *et al.* 1996; Woodward *et al.* 2000; Ridler *et al.* 2001; Woodward *et al.* 2001; Rendel *et al.* 2013; Spooner & Li 2013	McCall 1984a; McCall 1984b; McCall *et al.* 1986; Journeaux *et al.* 1987; Parker *et al.* 1992; Barker & Baars 1993; Stevens *et al.* 2000; Webby & Sheath 2000; Murray *et al.* 2007; White *et al.* 2010; Dynes *et al.* 2011; Mackay *et al.* 2012; Stevens *et al.* 2014
Economic	Beck & Dent 1987; Marshall *et al.* 1991; Webby *et al.* 1995; Ridler *et al.* 2001; Rendel *et al.* 2013	Beck & Dent 1987; Journeaux *et al.* 1987; Parker *et al.* 1992; Korte & Rhodes 1993; Dake 1994; Barker *et al.* 1999; Ormond *et al.* 2002; Stevens *et al.* 2000; Webby & Sheath 2000; White *et al.* 2010; Dynes *et al.* 2011; Stevens *et al.* 2014
Environmental	Synge *et al.* 2013; Vogeler *et al.* 2014	White *et al.* 2010; Dynes *et al.* 2011; Mackay *et al.* 2012

development, implementation and evolution of farming systems. The papers describing sociology research provided an insight into the history of the evolution of farm systems focus and the development of tools for the discipline (Table 4).

The social category (Table 4) includes governance, labour, communities and the role of women. This category is about the people in the farming businesses and rural communities. Often the commentary examined the impact of external influences (such as policy and finance) on change. While much of this characterised social impacts and responses, there were few metrics or underlying principles presented as desirable outcomes or as methods to achieve desirable outcomes in the future. The emergence of an increasing role for women in the physical and managerial roles in farming, as well as the diversification of income are key elements of this work.

Only two papers represented cultural elements. This may be reflective of the more recent development of Maori agribusiness as a force in hill country. Again, as with farm studies, a driving impetus to publication may be the researcher themselves and this lack of publication may represent the slow development of important relationships as Māori agribusiness emerges from Waitangi Treaty settlements. Underlying philosophies are identified that drive the needs of the community that must be met by the farm system.

Resilience (Table 4) provided an overall reference to sustainability, stress and shock as well as encompassing papers that combined production, social, environmental and economic drivers. The inclusion of this topic demonstrated a major shift in thinking away from the sustainability paradigm of the 1990s and early 2000s. This paradigm presented sustainability as minimising environmental impacts, often with little acknowledgement of economic performance. The philosophy of resilience encompasses an expansion away from a reductionist approach of environmental damage to an optimisation approach measuring net benefit of combined economic, social and environmental indicators (e.g. Dodd *et al.* 2008a; Darnhofer & Rosin 2012). Dodd *et al.* (2008) preceded the terminology but enacted a community-based approach to researching the trade-offs between landscape, production, economic returns and environmental impacts. The environment sits across many of the categories, often as a potential outcome measure. It is finally encompassed in the resilience category as one of the trade-offs to be

Table 3 A collation of papers regarding farm studies with hill country farming systems research grouped by research method and research focus.

	Farming system research focus			
Research method	**Characterisation**	**Decision making**	**Change**	**Influence of policy**
Farmer survey	Attwood 1984; Beck & Dent 1984; Parker 1984; Parker & Townsley 1986; Frengley & Johnston 1992; Fairweather & Keating 1994; Tarbotton & Webby 1999; Rhodes & Willis 2000; Mulet-Marquis & Fairweather 2008; Hawkins & Wu 2011	Gray *et al.* 2011	Gray *et al.* 1989; Wright *et al.* 1989	Johnston & Frengley 1994; Martin & McLeay 1998
Case studies	Holden 1967; McLaren 1976; Linton & Snodgrass 1978; Gray 1987; Journeaux *et al.* 1987; Page *et al.* 1996; Rosin *et al.* 2007b; Meikle & Green 2012	Nicholls *et al.* 1990; Sheath *et al.* 1999; Hanna *et al.* 2001; Gray *et al.* 2004; Gray *et al.* 2005; Gray *et al.* 2006	Smith *et al.* 1979; Pedosfsky & Douglas 1987; Daniell 1993; Neely & Parminter 1993; Small *et al.* 2005; Grigg *et al.* 2008	
Farmer directed research	Litherland & Lambert 2000	Webby *et al.* 2001; Mackay *et al.* 2008	Webby & Sheath 1991; Reid *et al.* 1993; Cocks *et al.* 2002; Collins 2013; Macfarlane *et al.* 2014	Crofoot *et al.* 2010; Rhodes *et al.* 2011; Reid & Brazendale 2014
Meta analysis	Townsley & Parker 1987		Stevens & Young 2013	

considered. This development into resilience heralded a true step forward into full farm systems research as the trade-offs and potential systems change that may emerge, were recognised.

Policy and regulation drew together the expressions of external forces on farm systems, including consumer demands. These reflected the changes of the time, with a strong emphasis on the deregulation of the

Table 4 Sociological research with some reference to hill country farm systems in New Zealand. A summary of the central focus of the research from 1966 until 2015.

	Timeline (by decade)				
Research focus	**1966-1975**	**1976-1985**	**1986-1995**	**1996-2005**	**2006-2015**
Social	Baldock 1971; Campbell 1968	Harris 1980; Willis 1982	Fairweather 1989; Fairweather 1992b; Heron *et al.* 1994; Keating & Little 1994; Wilson 1994	MAF 1997; Campbell *et al.* 2004; Clifford-Walton *et al.* 1997; Hobson 1998; Jay 1999; Johnsen 2004; Scott *et al.* 2000; Spedding 1996; Taylor & McClintock 2004; Teather 1996	Fairweather *et al.* 2007a; Fairweather & Mulet-Marquis 2009; Lovelock 2012; Nuthall & Old 2014; Robertson *et al.* 2008; Stock *et al.* 2014
Cultural					Kerckhoffs & Smith 2010; White & Sheath 2011
Resilience				Cotman 1996; Rhodes & Willis 2000; Rhodes *et al.* 2003; Shadbolt & Morriss 1999	Cradock-Henry 2011; Darnhofer *et al.* 2010; Dodd *et al.* 2008a; Dodd *et al.* 2008b; Dodd *et al.* 2008c; Dodd *et al.* 2008d; Nettle *et al.* 2015; Parsonson-Ensor & Saunders 2011; Rosin *et al.* 2012; Smith *et al.* 2011; Smith *et al.* 2007
Policy and regulation		Tavendale 1984	Fairweather 1986; Fairweather 1989; Fairweather 1992a; Sandrey & Reynolds 1990; Smith & Saunders 1995; Wilson 1994; Wilson 1995	Johnsen 2003; Smith & Montgomery 2004	Bewsell & Dake 2008; Burton & Peoples 2014; Dungen *et al.* 2011; Haggerty *et al.* 2009; Hunt *et al.* 2011; Loveridge 2013; Morgan & Daigneault 2015; Rosin *et al.* 2007a; Saunders *et al.* 2009; Tipples 2007; Wallace & Fraser 2015
System behaviour and change			Foran & Wardle 1995; Heron *et al.* 1994; Moran *et al.* 1993	Allan 2005	Campbell *et al.* 2012; Fairweather *et al.* 2008; Fairweather *et al.* 2007b; Fairweather & Hunt 2011; Fairweather *et al.* 2009; Hunt *et al.* 2010; Stock & Forney 2014; Wedderburn *et al.* 2011
Methodology	Survey Sector/ trend analysis	Survey Sector/ trend analysis Interviews	Survey Sector/trend analysis Interviews Case studies Multi-agent simulation	Survey Sector/trend analysis Interviews Case studies Focus groups Workshops Participant observation Multivariate analysis	Survey Sector/trend analysis Interviews Case studies Multi-agent simulation Focus groups Workshops Participant observation Multivariate analysis Temporal repeat interviews Segmentation Longitudinal matched panels Causal mapping Narratives of change Network analysis Principle components analysis

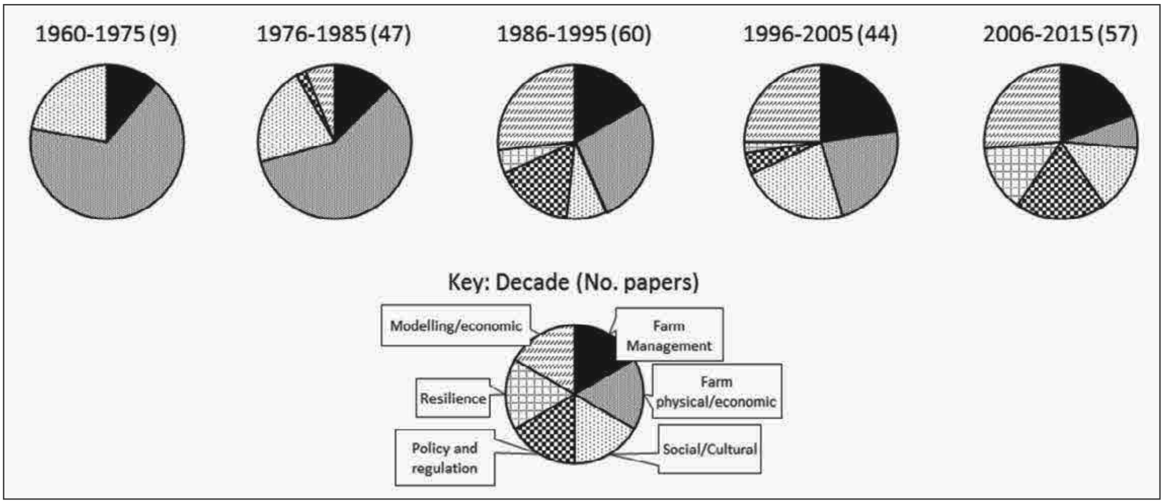

Figure 1 The development of New Zealand hill country farm systems research as represented by the literature, from the 1960s until 2015. Each decade is represented and numbers within each research type represents the percentage of papers accessed within that decade.

agricultural economy during the 1980s and then the rise of consumer/supermarket audit and quality assurance programmes during the 2000s.

Behaviour change is characterised in papers that analysed or categorised the expression of behaviours, the potential to influence behaviour and the mapping of factors affecting behaviour and decision making.

The development of the discipline as a tool (Table 4) began as sector statistics, case studies and surveys and moved to focus groups, workshops, in-depth interviews and longitudinal studies. Data analysis moved from trend analysis to principle components, cluster and multivariate analysis, and causal loop mapping and multi-agent-based rural simulation modelling.

Reviews of farm systems research

A total of 28 papers were characterised as review or discussion papers analysing aspects of hill country farm systems (Table 5). These were grouped according to topic. Those discussing the role, or impact, of research made up 20% of the total. Benchmarking of the industry was the topic of 7%. Opportunities for improved productivity were a feature in 31% of the papers. The influence of policy was a subject in 14% of papers while the role of external forces such as markets added another 14%. Finally, reviews of enterprises and their implementation also made up 14%.

Development of farming systems research through the literature

The progression of hill country farm systems research has gone from biophysical to economic, social, and on to policy and regulation. Over time it has moved from internal to external drivers of farming systems (Figure 1). The environment has had little specific research at the farming system scale for hill country. More recently, resilience, and the trade-offs required to achieve it, has become the focus which has included environmental impacts (e.g. Dodd *et al.* 2008a; Darnhofer *et al.* 2010).

The development of the research approaches and topics has been closely aligned with both Government

Table 5 Reviews and discussion documents analysing hill country farming.

Type	References
Role of, or impact of research	Molloy 1980; Floate *et al.* 1987; McCall *et al.* 1994; Parke *et al.* 1994; Hodgson *et al.* 2005; Clark 2013
Benchmarking at the industry level	Ward 1962; Davison 2002
Opportunities for improved productivity	Tripe 1965; Wright 1965; Hight 1976; Hight 1979; Tripe 1979; Taylor 1983; Sheath 1988; Garden 2009; Sheath 2011; Stevens & Garden 2014
Influence of policy	Tavendale 1984; Le Heron 1989; Rhodes & Willis 2000; Stevens & Garden 2014
Role of external forces (e.g. marketing)	Mauger 1979; MacLeod & Moller 2006; Copland & Stevens 2012; Morris & Kenyon 2014
Enterprise review	Wright *et al.* 1990; Webby & Thomson 1994; Morris 2013a; Morris 2013b

policy and farmer need. Increased productivity was a clear focus of Government throughout the 1960s to early 1980s. This was characterised by farming subsidies and tariff protections, many introduced in the 1960s, which saw up to 40% of farmer income being subsidised by Government (Wallace 2014) by the early 1980s. Programmes such as the Livestock Incentive and Land Development Encouragement Loan schemes saw an increase in sheep numbers from 55 to 70 million from 1976 to 1984. This drive for production at any cost was also reflected in government research programmes such as the dry hill country improvement programme, as market signals were ignored.

The changing policy and deregulation of the 1980s opened the farm system to severe pressure from beyond the farm gate (Wallace 2014). This gave rise to change in the farm system and farming systems in general, as farming was subjected to market forces and changed from quantity to quality as a production model. These changes were documented, new programmes to facilitate change were implemented (Rhodes & Aspin 1993) and farm systems evolution was observed (Neely & Parminter 1993).

Over this time the value of the product mix from hill country farms has shifted from a relatively equal balance between wool and meat as income streams, to the reduced importance of wool as an income source, as synthetic fibres have become dominant, especially for carpet manufacturing. This has also shifted the focus of research from stocking rate to individual animal performance metrics.

As the cost structure of farming shifted with subsidy removal and exposure to market forces, research also shifted from maximising production to reducing costs, e.g. fertiliser use, and to optimising resource use, including more production from individual animals to reduce the feed required for capital stock. This was also manifest with the rise of bull beef both as research (McRae 1988) and on farm implementation (Journeaux *et al*. 1987), as calves were generated from the dairy herd, removing the direct capital cost structure for beef production in hill country.

The progression of research also documents the growing maturity of both knowledge and thinking. This progression is required as it is not until first principles, or simple rules, are discovered, that we can develop tools to investigate system behaviour. For the biophysical elements of the farming system, this was during the 1960s to 1990s and was acknowledged in a review by Parker *et al.* (1994). This then provided the knowledge to develop tools, such as models, that could aid us in examining potential futures, or alternative options.

Growing concern and increasing consumer pressure over declining water quality has led to further expansion of the research into the impacts of external drivers on farming systems. While the initial creation of the Te Awa research site in 1944 was prompted by a soil conservation effort, the reporting from that site was about maximising productivity, albeit using best grazing management practice to maintain pasture cover. Sustainability as a concept was not readily introduced until the 1980s. This has been replaced by resilience which has provided insight into understanding the trade-offs at the systems level, including off-farm impacts and profitability implications.

Impacts of hill country farm systems research

Impacts of research are hard to directly quantify, and the impact of then combining the research into a systems context even more so. One of the most direct measures was undertaken by McIvor & Aspin (2001) when they quantified the impacts of research and development funding from Meat New Zealand (now Beef + Lamb New Zealand). The net present value of the investment in the Monitor Farm Programme was estimated to be 21.4:1. Farmers associated with the programme estimated that they had increased their net annual benefit by $6 700, or approximately 9% of the benchmark farm cash surplus of $74 000 (MAF 2000). This was attributed to increased knowledge of feed allocation and matching of feed supply and demand to improve both ewe and lamb performance. This direct application of the research results, proven through farm systems research, by hill country sheep and beef farmers provides some quantification of the potential benefits of the research being done in advance of the requirement to shift from a stocking rate to a per head performance system as the New Zealand hill country farmer was exposed to market forces.

Farm systems research can cover a wide range of topics. This is why it may not exhibit a clearly defined body of research. Of importance in the literature search was the body of work presented at the New Zealand Grassland Association conference. This made up nearly 25% of all papers recovered, indicating that the conference forum has been an important focal point for presenting farm systems research. Barbier *et al.* (2012) provided a unique insight into the International Farming Systems Association community of authors and found that, though they were well connected within the IFSA conference publication network, they were indistinguishable in international literature as a cohort. This suggests that authors were combining to present farm systems approaches to problems at conference time, but were publishing in their disciplines in formal journals. This may suggest that the Farming Systems approach has not gained the respect of the International science community as a discipline.

The progression shown in Figure 1 indicates the logical development of the requirements for farm systems research. In the first instance biophysical research provided the basis for the evolution of hill country farming in the post-regulation/government support era. Farmers adapted and farming systems evolved as the principles, developed through the strong body of research in the 1960-1980s, were applied. This is well documented through the Monitor Farm Programme and others (e.g. McIvor & Aspin 2001; Cocks *et al.* 2002).

The documentation and analysis of the external drivers of farming systems has provided insights into the evolution of farming systems, especially since the removal of agricultural protections in the 1980s (e.g. Le Heron 1989; Burton & Peoples 2014). Recent investigations are beginning to investigate how the decision making process, in response to external drivers, is shaped (e.g. Morgan & Daigneault 2015). This then moves this type of research from description towards the design of potential options that may guide future farm system design and development (e.g. Foran & Wardle 1995; Wedderburn *et al.* 2011).

Development of modelling, and the increase in computing power, has enabled the investigation of the dynamics of the farm system and its re-configuration (e.g. Rendel *et al.* 2013). These models have been of two types; simulation (e.g. Farmax) and optimisation (e.g. INFORM). Simulation models provide the opportunity to examine potential interactions of biophysical processes and an investigation of current known situations. Optimisation models provide an opportunity to explore unknown situations, resource optimisation, and to optimise specific criteria, such as profit, in the face of other constraints. Understanding the dynamics has given rise to insights about how the farm system may change or evolve, in response to changing conditions. This initially took place within the farm system, but more recently tools such as causal mapping have been used to examine farm systems in general (e.g. Fairweather & Hunt 2011). These tools give rise to the opportunity to test the potential for new configurations and enable the linking of production, economic, social and environmental outcomes and the trade-offs that may occur.

The shift towards resilience in New Zealand has mirrored research throughout Europe (Darnhofer *et al.* 2012). The growing maturity of thought and understanding of a growing range of methodologies to interpret properties observed at a systems level has also reflected a growing understanding of systems research internationally.

Challenges for the future

The challenges for future hill country farm systems will be present at several different levels. These include internal (within the farm gate) and external (from society and the market) influences. They may be formal (regulation) or informal (societal pressure). Future farm systems may not be directly linked to biophysical processes optimised for production as they have in the past. Secondary outputs from the farm system have already come under the spotlight as regional councils develop water plans that restrict sediment and nutrient loss to water. The type of inputs and practices within the farm system, such as chemical inputs, animal welfare and work safety practices, are also undergoing scrutiny. All of these potential changes influence the configuration of the farm and the farming system, and so produce an evolution of those systems.

Recent opinion pieces in the Proceedings of the New Zealand Grassland Association (now the Journal of New Zealand Grasslands) have highlighted a long list of challenges. These include freedom to operate (Hay 2012), resource use optimisation (Garden 2009), farm business structure and financing (Sheath 2011); climate change (Garden 2009; Sheath 2011), ecosystems services (Garden 2009; Sheath 2011; Stevens & Garden 2014), biophysical challenges (Garden 2009; Sheath 2011; Stevens & Garden 2014), land use competition (Garden 2009; Sheath 2011; Copland & Stevens 2012; Stevens & Garden 2014), and the sustainability of communities (Sheath 2011; Stevens & Garden 2014). This list is not complete, and these challenges continue to provide topics for research. Interestingly, most of these topics have always been on the list. Lionel Corkill, in his presidential address to the NZGA (Corkill 1958) described productivity increases in both meat and wool production of approximately 90% in the previous 25 years. He also described future challenges of market prices, land use competition, potential phosphate supply limitations and labour and social issues in rural communities. What may be different will be the fullness of the answers that are developed to address those challenges as complexity increases.

This means that farming systems research will also face challenges to ensure it can provide answers. As was stated in the introduction, the development of farm systems research has been driven by need. The purpose was to provide practical answers to the questions farmers were facing. Research beyond the biophysical documented how change was made and the outcomes of those changes. Over the past 60 years the research has shifted from farm systems and farm management research which has worked within the farm boundary tto optimise biophysical parameters, to farming systems research which encompasses the broader domain of influences beyond the farm gate, such as markets and social needs.

Much of the basic principles of biophysical processes are now known and incorporated into computer models that will provide the opportunity to examine farm systems responses to changing biophysical conditions such as climate change. These models will also provide insight into the impacts of farm practise on secondary outputs such as greenhouse gases and nitrate in water, as well as helping to predict future farm systems configurations when farming under limits.

The influence of factors beyond the farm gate are becoming more and more a focus as societal and consumer pressure is exerted through regulation and market requirements. Research has begun to investigate how systems might change in the face of these pressures (e.g. Wedderburn *et al.* 2011). The range of techniques for social investigations has greatly expanded and all of those techniques will continue to have a role in generating understanding. The more traditional outside assessments using the techniques found in rapid rural appraisal will be augmented with approaches such as co-development and co-innovation, as they provide different insights and can be used in different situations. The current developing body of research into the social sciences is beginning to provide insights into how farm systems may change as a result of market and societal pressures through multi-agent simulation models (e.g. Morgan & Daigneault 2015), and the continued development of this approach will provide power when examining potential farm systems of the future.

The role of traditional approaches, such as farmlet experiments, is often limited to providing biophysical outcomes which may not address greater societal influences. A new approach, created from an amalgam of physical on-farm and farmlet measurement linked with modelling tools, will provide further opportunities and insights that can be developed in partnerships between farmers, agribusiness and science. This will enable a much greater range of environments to be included and broader farming systems questions, not just farm systems questions, will be answered. This approach may lose some science precision but adds practical application and innovation. Uptake of results may also be aided with this co-development approach.

This approach can be used as a basis for exploratory programmes that investigate what the future might bring. These programmes will interpret the current and potential future drivers of farming systems evolution and explore the futures that may develop. This approach will provide regulators with an understanding of policy impacts and give retailers and marketers insights into changes that may be created by pricing and audit processes. Most importantly, it will provide farmers with new opportunities and scenarios that will enable resilience for future hill country farming systems.

A final requirement is an active move from single or even multi-disciplinary approaches towards trans-disciplinary approaches. This requires team members who have knowledge of the wider issues and understand a range of disciplines, and recognition that the most important trans-disciplinary team member is often the farmer. Future work then becomes built on a deeper understanding of farming systems. Training such 'generalist specialists' will need to include a sound knowledge of systems properties as well as underlying familiarity with both biophysical processes and market, social and cultural influences to aid development of future farming systems solutions through research.

Farm systems research is not without significant cost, both financially and culturally. The combining of disciplines and the inclusion of the wider community to create new farming systems for the future will only be productive when important issues are identified and teams can develop an appropriate cultural ethos for true cooperation.

ACKNOWLEDGEMENTS

Thanks to AgResearch for CORE funding of the work, and referees for their constructive critique of the document.

REFERENCES

Allan, B.E. 1985. Grazing effects on pasture and animal production from oversown tussock grassland. *Proceedings of the New Zealand Grassland Association 46*: 119-125.

Allan, B.E. 1992. Grazing management of oversown tussock country. 1. A review of traditional practice, experience and research. *New Zealand Journal of Agricultural Research 35*: 1-6.

Allan, B.E.; Foran, D.B. 1994. Developing the Tara Hills farm in today's world: the risks and returns. *Proceedings of the New Zealand Grassland Association 56*: 229-232.

Allan, B.E.; Keoghan, J.M. 1994. More persistent legumes and grasses for oversown tussock country. *Proceedings of the New Zealand Grassland Association 56*: 143-147.

Allan, B.E.; Lowther, W.L.; Walton, P.J. 1985. Planning, establishment and management of pastures in high country. *Using Herbage Cultivars. Grassland Research and Practice Series 3*: 17-21.

Allan, J. 2005. Farmers as learners: evolving identity, disposition and mastery through diverse social practices. *Rural Society 15*: 4-21.

Attwood, E.A. 1984. The New Zealand farm business and the current changes in its structure. Discussion Paper, (87): Agricultural Economics Research Unit, Lincoln College, University of Canterbury, New Zealand. 87 pp.

Baker, R.L.; Carter, A.H. 1976. Influence of breed and crossbreeding on beef cow performance. *Proceedings of the Ruakura Farmers' Conference 28*: 39-44.

Baldock, G.V. 1971. Vocational aspirations of farm boys and nonfarm boys in New Zealand. *Rural Sociology 36*: 157-172.

Barker, D.J.; Baars, J.A. 1993. Comparing the seasonal productivity of cocksfoot and resident pastures on hill country farms using a system model. *Proceedings of the New Zealand Grassland Association 55*: 81-85.

Barker, D.J.; Sheppard, D.G.; Mackay, A.D.; Dymock, N. 1999. Hill country farm investment options - cocksfoot pasture versus superphosphate fertiliser. *Proceedings of the New Zealand Grassland Association 61*: 17-21.

Beck, A.C.; Dent, J.B. 1987. A farm growth model for policy analysis in an extensive pastoral production system. *Australian Journal of Agricultural Economics 31*: 29-44.

Beck, A.J.; Dent, J.B. 1984. An analysis of production, consumption and borrowing behaviour in the North Island hill country pastoral sector. Research Report (163): Agricultural Economics Research Unit, Lincoln College, University of Canterbury, New Zealand. 86 pp.

Bewsell, D.; Dake, C. 2008. Socio-economic issues in pasture-based farming. pp. 98-121. *In*: Environmental impacts of pasture-based farming. Ed. McDowell, R. W. CAB International, Wallingford.

Bircham, J.S.; Sheath, G.W. 1986. Pasture utilization in hill country. 2. A general model describing pasture mass and intake under sheep and cattle grazing. *New Zealand Journal of Agricultural Research 29*: 639-648.

Boom, C.J.; Sheath, G.W. 1998. Grain supplementation of finishing beef cattle. *Proceedings of the New Zealand Society of Animal Production 58*: 239-242.

Boom, C.J.; Sheath, G.W. 2000. The effects of winter grazing rotation speed on the performance of beef finishing systems. *Proceedings of the New Zealand Society of Animal Production 60*: 139-142.

Burton, R.J.F.; Peoples, S. 2014. Market liberalisation and drought in New Zealand: A case of 'double exposure' for dryland sheep farmers? *Journal of Rural Studies 33*: 82-94.

Campbell, A.G. 1968. Presidential address: Agricultural science in the human environment. *Proceedings of the New Zealand Society of Animal Production 28*: 1-10.

Campbell, H.; Fairweather, J.; Hunt, L.; McLeod, C.; Rosin, C. 2004. Social dimensions of sustainable agriculture: a rationale for social research in ARGOS. Argos Working Paper (1): Agribusiness & Economics Research Unit, Lincoln University, Canterbury. 113 pp.

Campbell, H.; Rosin, C.; Hunt, L.; Fairweather, J. 2012. The social practice of sustainable agriculture under audit discipline: initial insights from the ARGOS project in New Zealand. *Journal of Rural Studies 28*: 129-141.

Clark, D.A. 2013. The changing nature of farm systems research. *Proceedings of the New Zealand Society of Animal Production 73*: 54-64.

Clark, D.A.; Lambert, M.G. 1982. Animal production from hill country: effect of fertiliser and grazing management. *Proceedings of the New Zealand Society of Animal Production 42*: 173-175.

Clark, D.A.; Lambert, M.G.; Grant, D.A. 1986. Influence of fertiliser and grazing management on North Island moist hill country. 5. Animal production. *New Zealand Journal of Agricultural Research 29*: 407-420.

Clark, D.A.; Ledgard, S.F.; Lambert, M.G.; O'Connor, M.B.; Gillingham, A.G. 1990. Long term effects of witholding phosphate application on North Island hill country: Economics. *Proceedings of the New Zealand Grassland Association 51*: 29-33.

Clifford-Walton, V.A.; Liepins, R.; Romans, S.E.; Herbison, G.P. 1997. Adapting to change: women, work and farm. *New Zealand Sociology 12*: 129-158.

Cocks, A.; Williams, M.; Casey, M.; Brown, C.; Ware, J.; Morrison, N.; Morrison, G.; Pearce, G.; Taylor, W.; Cochrane, G.; Cochrane, J.; Harris, T. 2002. Farmers adopting technology to improve sheep production - a nine year study. *Proceedings of the New Zealand Grassland Association 64*: 49-53.

Collins, H. 2013. Resilience through change:'Beyond reasonable drought'. *Extension Farming Systems Journal 9*: 20-26.

Copland, R.J.; Stevens, D.R. 2012. The changing face of southern New Zealand farming: opportunities of land use change. *Proceedings of the New Zealand Grassland Association 74*: 1-6.

Corkill, L. 1958. Presidential Address. *Proceedings of the New Zealand Grassland Association 30*: 1-10.

Cotman, J.H. 1996. Farmer perspectives on sustainable farming. *Proceedings of the New Zealand Grassland Association 57*: 27-30.

Cradock-Henry, N.A. 2011. Farm-level vulnerability to climate change in the Eastern Bay of Plenty, New Zealand, in the context of multiple stressors. PhD thesis. University of Canterbury.

Crofoot, A.N.; Crofoot, E.W.; Hoogendoorn, C.J.; Litherland, A.J.; Garland, C.B. 2010. N-leaching in hill country; farmer led research. *Proceedings of the New Zealand Grassland Association 72*: 55-60.

Dake, C.K.G. 1994. Variable animal performance and farm diversification. *Proceedings of the New Zealand Society of Animal Production 54*: 399-402.

Dalton, D.C. 1976. Performance of Romney and crossbred sheep on east coast hill country. *New Zealand Journal of Experimental Agriculture 4*: 35-40.

Daniell, D. 1993. The long-term use of nitrogen fertiliser in intensive hill country farming. *Proceedings of the New Zealand Grassland Association 55*: 59-61.

Darnhofer, I.; Fairweather, J.; Moller, H. 2010. Assessing a farm's sustainability: insights from resilience thinking. *International Journal of Agricultural Sustainability 8*: 186-198.

Davison, R. 2002. Benchmarks measure progress. *New Zealand Meat Producer 30*: 8.

Dawson, A.; Smith, M. 1976. Hill-country grazing management. 1. Principles. *New Zealand Journal of Agriculture 132*: 8-11.

Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. 2008a. Improving the economic and environmental performance of a New Zealand hill country farm catchment. 3. Short-term outcomes of land-use change. *New Zealand Journal of Agricultural Research 51*: 155-169.

Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G.; Wedderburn, M.E. 2008b. Improving the economic and environmental performance of a New Zealand hill country farm catchment: 1. Goal development and assessment of current performance. *New Zealand Journal of Agricultural Research 51*: 127-141.

Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G.; Wedderburn, M.E. 2008c. Improving the economic and environmental performance of a New Zealand hill country farm catchment: 2. Forecasting and planning land-use change. *New Zealand Journal of Agricultural Research 51*: 143-153.

Dodd, M.B.; Wedderburn, M.E.; Parminter, T.G.; Thorrold, B.S.; Quinn, J.M. 2008d. Transformation toward agricultural sustainability in New Zealand hill country pastoral landscapes. *Agricultural Systems 98*: 95-107.

Dungen, S.V.D.; Rosin, C.; Hunt, L. 2011. Recalling management changes in the New Zealand sheep/beef and wool sectors in response to external and internal drivers: Preliminary analysis of ARGOS retrospective interviews. ARGOS Research Report 2011-06. (11/01). Agribusiness Group, Christchurch. 40 pp.

During, C.; Dyson, C.B.; Webby, R.W. 1980. The relationship of pasture parameters to liveweight gain of hoggets on North Island hill country. *Proceedings of the New Zealand Society of Animal Production 40*: 98-105.

Dynes, R.A.; Smeaton, D.C.; Rhodes, A.P.; Fraser, T.J.; Brown, M.A. 2011. Modelling farm management scenarios that illustrate opportunities farmers have to reduce greenhouse gas emissions while maintaining profitability. *Proceedings of the New Zealand Society of Animal Production 71*: 167-171.

Fairweather, J.; Hunt, L.; Cook, A.; Rosin, C.; Campbell, H. 2007a. New Zealand farmer and grower attitude and opinion survey: analysis by sector and management system. ARGOS Research Report. (07/07): Agribusiness Group, Christchurch. 70 pp.

Fairweather, J.; Hunt, L.; Rosin, C.; Campbell, H. 2008. Causal mapping of ARGOS dairy farms and comparisons to sheep/beef farms. ARGOS Research Report. (08/01): Agribusiness Group, Christchurch. 42 pp.

Fairweather, J.; Hunt, L.; Rosin, C.; Campbell, H.; Lucock, D. 2007b. Understanding sheep/beef farm management using causal mapping: development and application of a two-stage approach. ARGOS Research Report. (07/02): Agribusiness Group, Christchurch. 82 pp.

Fairweather, J.; Mulet-Marquis, S. 2009. Changes in the age of New Zealand farmers: problems for the future? *New Zealand Geographer 65*: 118-125.

Fairweather, J.R. 1986. Farm structure change in New Zealand and implications for policy. Discussion Paper, (99): Agricultural Economics Research Unit, Lincoln College, University of Canterbury, New Zealand. 43 pp.

Fairweather, J.R. 1989. Some recent changes in rural society in New Zealand. Discussion Paper (124). Agribusiness & Economics Research Unit, Lincoln College. Canterbury. 39 pp.

Fairweather, J.R. 1992a. Agrarian restructuring in New Zealand. Research Report (213). Agribusiness & Economics Research Unit, Lincoln College. Canterbury. 62 pp.

Fairweather, J.R. 1992b. Topics for rural social research. Discussion Paper (132): Agribusiness & Economics Research Unit, Lincoln College. Canterbury. 26 pp.

Fairweather, J.R.; Hunt, L.M. 2011. Can farmers map their farm system? Causal mapping and the sustainability of sheep/beef farms in New Zealand. *Agriculture and Human Values 28*: 55-66.

Fairweather, J.R.; Keating, N.C. 1994. Goals and management styles of New Zealand farmers. *Agricultural Systems 44*: 181-200.

Fairweather, J.R.; Rosin, C.J.; Hunt, L.M.; Campbell, H.R. 2009. Are conventional farmers conventional? Analysis of the environmental orientations of conventional New Zealand Farmers. *Rural Sociology 74*: 430-454.

Field, T.R.O.; Clark, D.A.; Lambert, M.G. 1981. Modelling a hill-country sheep production system. *Proceedings of the New Zealand Society of Animal Production 41*: 90-94.

Floate, M.J.S.; Boswell, C.C.; Allan, B.E.; Scott, D. 1987. Towards 2000: strategies to achieve more efficient fertiliser use in inland South Island hill and high country. *Proceedings of the New Zealand Grassland Association 48*: 53-58.

Foran, B.; Wardle, K. 1995. Transitions in land use and the problems of planning: a case study from the mountainlands of New Zealand. *Journal of Environmental Management 43*: 97-127.

Frengley, G.A.G.; Johnston, W.E. 1992. Financial stress and consumption expectations among farm households - New Zealand's experience with economic liberalisation. *Journal of Agricultural Economics 43*: 14-27.

Garden, P. 2009. Opportunities and challenges ahead for hill country farming. *Proceedings of the New Zealand Grassland Association 71*: 1-3.

Gillingham, A.G.; Gray, M.H.; Morton, J.D. 2004. Animal production, economic results and lessons from nitrogen fertiliser use on dry hill country. *Proceedings of the New Zealand Grassland Association 66*: 35-40.

Grant, D.A.; Lambert, M.G.; Guy, M.C. 1978. Management effects on productivity of southern North Island hill country. *Proceedings of the New Zealand Society of Animal Production 38*: 110-115.

Grant, D.A.; Rumball, P.J.; Suckling, F.E.T. 1973. Pasture improvement and potential productivity in southern North Island hill country. *Proceedings of the New Zealand Grassland Association 34*: 185-194.

Gray, D.I. 1987. A case farm study of high and low sheep performance on southern North Island hill country. Masterate thesis. Massey University.

Gray, D.I.; Nicholls, J.R.; Fraser, P.A.G.; Wright, A. 1989. Farming in the Pongaroa region. A report on a 1989 survey of farm adjustment strategies. Department of Agricultural and Horticultural Systems Management. Massey University. 45 pp.

Gray, D.I.; Reid, J.I.; Horne, D.J. 2011. The management of risk in a dryland environment. *Proceedings of the New Zealand Grassland Association 73*: 13-22.

Gray, D.I.; Reid, J.I.; Kemp, P.D.; Brookes, I.M.; Horne, D.; Kenyon, P.R.; Matthew, C.; Morris, S.T.; Valentine, I. 2004. Controlling pasture quality on hill country - key decisions and techniques. *Agronomy New Zealand 34*: 73-82.

Gray, D.I.; Reid, J.I.; Kemp, P.D.; Brookes, I.M.; Horne, D.; Kenyon, P.R.; Matthew, C.; Morris, S.T.; Valentine, I. 2005. Summer management of sheep on summer-wet hill country: insights into decisions made by an "expert" farmer. *Proceedings of the New Zealand Grassland Association 67*: 87-95.

Gray, D.I.; Reid, J.I.; Kemp, P.D.; Kenyon, P.R.; Morris, S.T.; Brookes, I.M.; Matthews, C.; Horne, D. 2006. High sheep performance on hill country: critical winter management decisions. *Agronomy New Zealand 36*: 12-23.

Grigg, D.W.; Grigg, J.M.; Lucas, R.J. 2008. Maximising subterranean clover in Marlborough's hill country is key to weaning 80% of sale lambs prime. *Proceedings of the New Zealand Grassland Association 70*: 25-29.

Haggerty, J.; Campbell, H.; Morris, C. 2009. Keeping the stress off the sheep? Agricultural intensification, neoliberalism, and 'good' farming in New Zealand. (Special Issue: Land, labor, livestock and (neo) liberalism: understanding the geographies of pastoralism and ranching.). *Geoforum 40*: 767-777.

Hanna, A.B.; Hanna, A.M.; Webby, R.W. 2001. Farm monitoring to futures contracts: the Hannas' experience. *Proceedings of the New Zealand Grassland Association 63*: 29-32.

Harris, A.J.; Clark, D.A. 1985. Meeting animal needs from mixed grass-legume pastures. p 1143. *In*: Proceedings of the XV International Grassland Congress, August 24-31, 1985, Science Council of Japan and Japanese Society of Grassland Science. Kyoto, Japan.

Harris, G.T. 1980. A socio-economic study of farm workers and managers. Research Report (115): Agricultural Economics Research Unit, Lincoln College, New Zealand; 1980. 72 pp.

Hawkins, B.W.; Wu, S. 2011. Understanding the variability in sheep and beef farm profitability. *Proceedings of the New Zealand Grassland Association 73*: 23-26.

Heron, R.l.; Roche, M.; Johnston, T. 1994. Pluriactivity: an exploration of issues with reference to New Zealand's livestock and fruit agro-commodity systems. *Geoforum 25*: 155-171.

Hight, G.K. 1968. Hill country beef cattle research at Whatawhata. *Proceedings of the New Zealand Society of Animal Production 28*: 131-144.

Hight, G.K. 1976. Problems and potential of farming on North Island hill country. *New Zealand Agricultural Science 10*: 141-147.

Hight, G.K. 1979. Hill country: a major agricultural resource and its capacity for increased production. *Proceedings of the New Zealand Society of Animal Production 39*: 1-12.

Hobson, S. 1998. Sustainable agriculture - past, present and future: a New Zealand perspective. pp. 24-27. *In*: Agriculture in the Commonwealth: sustainable use of land and water. Eighteenth biennial conference, Darwin, Australia, 1998. Kensington Publications Ltd, London.

Hodgson, J.; Cameron, K.; Clark, D.; Condron, L.; Fraser, T.; Hedley, M.; Holmes, C.; Kemp, P.; Lucas, R.; Moot, D.; Morris, S.; Nicholas, P.; Shadbolt, N.; Sheath, G.; Valentine, I.; Waghorn, G.; Woodfield, D. 2005. New Zealand's pastoral industries: efficient use of grassland resources. pp. 181-205 *In*: Grasslands: developments, opportunities, perspectives. 2005. Eds. Reynolds, S. G.; Frame, J. Grasslands Science Publishers, Inc, Enfield, UK.

Holden, J.S. 1967. The profitability of hill country development: Part 2: case history results. *Publication of the Agricultural Econonomics Research Unit, Lincoln College 24*: 24 pp.

Hunt, L.; Benge, J.; Campbell, H.; Fairweather, J.; Greer, G.; Lucock, D.; Manhire, J.; Moller, H.; Reid, J.; Rosin, C.; Saunders, C. 2010. Building sustainable rural futures. Experiences of transdisciplinarity in research on agricultural sustainability. pp. 981-991. *In*: 9th European IFSA Symposium Proceedings, Vienna, Austria, 4-7 July 2010. Eds. Darnhofer, I.; Grotzer, M. BOKU - University of Natural Resources and Applied Life Sciences, Vienna.

Hunt, L.; Dungen, S.V.D.; Rosin, C. 2011. High country farming in New Zealand: exploration of the pathways to sustainability revealed through responses to external and internal drivers derived from the ARGOS retrospective interviews. ARGOS Research Report. 2012. (12/09). Agribusiness Group, Christchurch. 93 pp.

Jay, M. 1999. Rugged individualism versus cooperative enterprise: different responses by New Zealand pastoral farmers to agricultural change. *Development Bulletin 49*: 88-91.

Joblin, A.D.H.; Blackmore, L.W.; Bircham, J.S.; Cossens, G.G.; Cumberland, G.L.B.; O'Connor, M.B.; Thomson, N.A.; Smith, R.G.; Wright, D.F. 1972. Review of Field Research Section fertilizer. X stocking rate grazing trials in New Zealand. *Proceedings of the New Zealand Society of Animal Production 32*: 64-76.

Johnsen, S. 2003. Contingency revealed: New Zealand farmers' experiences of agricultural restructuring. *Sociologia Ruralis 43*: 128-153.

Johnsen, S. 2004. The redefinition of family farming: agricultural restructuring and farm adjustment in Waihemo, New Zealand. *Journal of Rural Studies 20*: 419-432.

Johnston, W.E.; Frengley, G.A.G. 1994. Economics adjustments and changes in financial viability of the farming sector: the New Zealand experience. *American Journal of Agricultural Economics 76*: 1034-1040.

Journeaux, P.R.; McRae, A.F.; Parker, W.J. 1987. Bull beef production on hill country. *Proceedings of the New Zealand Society of Animal Production 47*: 119-122.

Keating, N.C.; Little, H.M. 1994. Getting into it: farm roles and careers of New Zealand women. *Rural Sociology 59*: 720-736.

Kerckhoffs, H.; Smith, W. 2010. Reaching distant rural Maori communities in New Zealand through successful research partnerships. pp. 321-329. *In*: Building sustainable rural futures. 9th European IFSA Symposium Proceedings, Vienna, Austria, 4-7 July 2010. Eds. Darnhofer, I.; Grotzer, M. BOKU - University of Natural Resources and Applied Life Sciences, Vienna.

Korte, C.J.; Rhodes, A.P. 1993. Economics of drought-tolerant pastures for cattle finishing on Hawkes Bay and Wairarapa hill country farms. *Proceedings of the New Zealand Grassland Association 55*: 45-49.

Lambert, M.G.; Barker, D.J.; Mackay, A.D.; Springett, J. 1996. Biophysical indicators of sustainability of North Island hill pasture systems. *Proceedings of the New Zealand Grassland Association 57*: 31-36.

Lambert, M.G.; Clark, D.A. 1983. Effect of fertilizer application and grazing management on grazed New Zealand hill country. pp. 108-114. *In*: Proceedings of the 39th southern pasture and forage crop improvement conference.1983. USDA-ARS, New Orleans, Louisiana.

Lambert, M.G.; Clark, D.A. 1985. Increasing productivity of hill country with nitrogen. pp. 274-283. *In*: Proceedings 20th Technical Conference of New Zealand Fertiliser Manufacturers' Research Association. Volume I. New Zealand Fertiliser Manufacturers' Research Association, Auckland.

Lambert, M.G.; Clark, D.A. 1986. Effects of late-autumn nitrogen application on hill country pastures and sheep production. *Proceedings of the New Zealand Grassland Association 47*: 211-215.

Lambert, M.G.; Clark, D.A.; Mackay, A.D. 1990. Long term effects of withholding phosphate application on North Island hill country: Ballantrae. *Proceedings of the New Zealand Grassland Association 51*: 25-28.

Lambert, M.G.; Mackay, A.D.; Ganesh, S.; Upsdell, M.P. 2014. Responses of grazed New Zealand hill pastures to rates of superphosphate application. *New Zealand Journal of Agricultural Research 57*: 149-164.

Le Heron, R. 1989. A political economy perspective on the expansion of New Zealand livestock farming, 1960-1984 - Part II. Aggregate farmer responses - Evidence and policy implications. *Journal of Rural Studies 5*: 33-43.

Ledgard, S.F.; Jones, K.R. 1991. Effects of reactive phosphate rock and superphosphate on sheep and pasture production in hill country. *Proceedings of the New Zealand Grassland Association 53*: 197-202.

Linton, J.W.; Snodgrass, A.G. 1978. Hill country farming - the farmers' view. pp. 183-189. *In*: Proceedings of the 28th Lincoln College Farmers' Conference, 8-10 May 1978. Lincoln.

Litherland, A.J.; Lambert, M.G. 2000. Herbage quality and growth rate of single and twin lambs at foot. *Proceedings of the New Zealand Society of Animal Production 60*: 55-57.

Lovelock, K. 2012. The injured and diseased farmer: Occupational health, embodiment and technologies of harm and care. *Sociology of Health and Illness 34*: 576-590.

Loveridge, A. 2013. Changes in animal welfare views in New Zealand: Responding to global change. *Society and Animals 21*: 325-340.

MAF. 1997. Managing Social Transformation in Rural New Zealand. Proceedings of the UNESCO/Ministry of Agriculture and Fisheries Seminar, 21 October 1997. Technical Paper 97/20. Ministry of Agriculture and Fisheries. Wellington. 46 pp.

MAF. 2000. Sheep and Beef Farm Monitoring report July 2000. Wellington, New Zealand. 109 pp.

Macfarlane, M.J.; Thomson, B.C.; Crofoot, E.; Hamilton, G.; Ashby, H.; Muir, P.D. 2014. Evaluating new forage systems for East Coast dryland. *Proceedings of the New Zealand Society of Animal Production 74*: 108-114.

Mackay, A.D.; Betteridge, K.; Devantier, B.P.; Budding, P.J.; Niezen, J. 1998. Chemical-free hill country sheep and beef livestock production systems. *Proceedings of the New Zealand Grassland Association 60*: 15-18.

Mackay, A.D.; Devantier, B.P.; Pomroy, W.E. 2006. Long-term changes in the biology of a livestock farm system associated with the shift to organic supply. *Proceedings of the New Zealand Grassland Association 68*: 133-137.

Mackay, A.D.; Gray, D.I.; Brookes, I.M.; Barker, R.A.; Blakeley, J.E. 1991. Towards more sustainable biological hill country sheep and beef farming. *Proceedings of the New Zealand Grassland Association 53*: 231-234.

Mackay, A.D.; Knight, T.W.; Koolaard, J.P.; Sheppard, G.; Coleman, G. 2008. Lambs and landscapes. *Proceedings of the New Zealand Grassland Association 70*: 165-170.

Mackay, A.D.; Rhodes, A.P.; Power, I.; Wedderburn, M.E. 2012. Has the eco-efficiency of sheep and beef farms changed in the last 20 years? *Proceedings of the New Zealand Grassland Association 74*: 11-16.

MacLeod, C.J.; Moller, H. 2006. Intensification and diversification of New Zealand agriculture since 1960: an evaluation of current indicators of land use change. *Agriculture, Ecosystems & Environment 115*: 201-218.

Marshall, P.R.; McCall, D.G.; Johns, K.L. 1991. Stockpol: a decision support model for livestock farms. *Proceedings of the New Zealand Grassland Association 53*: 137-140.

Martin, S.; McLeay, F. 1998. The diversity of farmers' risk management strategies in a deregulated New Zealand environment. *Journal of Agricultural Economics 49*: 218-233.

Mauger, J.H. 1979. Hill country - our life blood. *New Zealand Agricultural Science 13*: 1-9.

McCall, D.G. 1984a. Relative priorities for feed between ewes and ewe hoggets in winter and spring: a modelling analysis. *Proceedings of the New Zealand Society of Animal Production 44*: 121-124.

McCall, D.G. 1984b. A systems approach to research planning for North Island hill country. PhD thesis. Massey University, Palmerston North.

McCall, D.G.; Marshall, P.R. 1991. Factors affecting beef finishing efficiency on pasture. *Proceedings of the New Zealand Society of Animal Production 51*: 453-457.

McCall, D.G.; Sheath, G.W.; Pleasants, A.B. 1994. The role of systems research in animal science. *Proceedings of the New Zealand Society of Animal Production 54*: 417-422.

McCall, D.G.; Townsley, R.J.; Bircham, J.S.; Sheath, G.W. 1986. The interdependence of animal intake, pre- and post-grazing pasture mass and stocking density. *Proceedings of the New Zealand Grassland Association 47*: 255-261.

McIvor, S.D.; Aspin, M.D. 2001. R&D success stories and principles to practice. *Proceedings of the New Zealand Grassland Association 63*: 23-27.

McLaren, N. 1976. Hill-country grazing management. 2. Practice. *New Zealand Journal of Agriculture 132*: 11-12.

McRae, A.F. 1988. Bull beef production: the Tuapaka experience. *Proceedings of the New Zealand Grassland Association 49*: 41-45.

Meikle, T.J.; Green, R.B. 2012. A case study: North Otago downlands – farming for profit. *Proceedings of the New Zealand Grassland Association 58*: 13-16.

Molloy, L.F. 1980. Land alone endures. Land use and the role of research. Report No. 0-477-06662-3. Department of Scientific and Industrial Research, New Zealand. 286 pp.

Moran, W.; Blunden, G.; Greenwood, J. 1993. The role of family farming in agrarian change. *Progress in Human Geography 17*: 22-42.

Morgan, F.J.; Daigneault, A.J. 2015. Estimating impacts of climate change policy on land use: An agent-based modelling approach. *PLoS ONE 10*: e0127317. doi:10.1371/journal.pone.0127317

Morris, S.T. 2013a. The New Zealand beef cattle industry. *Proceedings of the New Zealand Society of Animal Production 73*: 1-4.

Morris, S.T. 2013b. Sheep and beef cattle production systems. pp. 79-84 *In*: Ecosystem services in New Zealand. Ed. Dymond, J. R. Manaaki Whenua Press, Landcare Research, Lincoln.

Morris, S.T.; Chan, F.Y.; Lopez-Villalobos, N.; Kenyon, P.R.; Garrick, D.J.; Blair, H.T. 2014. Growth, feed intake and maternal performance of Angus heifers from high and low feed efficiency selection lines. *Animal Production Science 54*: 1428-1431.

Morris, S.T.; Kenyon, P.R. 2014. Intensive sheep and beef production from pasture - a New Zealand perspective of concerns, opportunities and challenges. *Meat Science 98*: 330-335.

Mulet-Marquis, S.; Fairweather, J. 2008. New Zealand farm structure change and intensification. AERU Research Report No. 301. Agribusiness and Economics Research Unit. Lincoln University.

Murray, R.I.; Yule, I.J.; Gillingham, A.G. 2007. Developing variable rate application technology: Modelling annual pasture production on hill country. *New Zealand Journal of Agricultural Research 50*: 41-52.

Neely, R.A.; Parminter, T.G. 1993. Sheep and beef farming on the West Coast of the North Island of New Zealand. pp. 999-1002. *In*: Proceedings of the XVII International Grassland Congress, New Zealand Grassland Association, Palmerston North, New Zealand.

Nettle, R.; Ayre, M.; Beilin, R.; Waller, S.; Turner, L.; Hall, A.; Irvine, L.; Taylor, G. 2015. Empowering farmers for increased resilience in uncertain times. *Animal Production Science 55*: 843-855.

Nicholls, J.R.; Gray, D.I.; Wright, A.; Fraser, P.A.G. 1990. Adjustment strategies used by hill country farmers. *Proceedings of the New Zealand Grassland Association 51*: 93-96.

Nicoll, G.B.; Hight, G.K.; Everitt, G.C. 1978. Some components of improved beef cow productivity on hill country. *Proceedings of the New Zealand Society of Animal Production 38*: 151-160.

Nuthall, P.L.; Old, K.M. 2014. Report on a succession and governance survey of a random stratified sample of NZ farmers. Agricultural Economics Research Unit. Lincoln University.

O'Connor, M.B.; Smart, C.E.; Ledgard, S.F. 1990. Long term effects of withholding phosphate application on North Island hill country: Te Kuiti. *Proceedings of the New Zealand Grassland Association 51*: 21-24.

Ormond, A.W.A.; Muir, P.D.; Fugle, C.J. 2002. The relative profitability of calf rearing and bull beef finishing. *Proceedings of the New Zealand Grassland Association 64*: 25-29.

Page, C.R.; Thomson, R.D.; Webby, R.W. 1996. Matching sheep and beef policies to pasture supply on Northland hill country. *Proceedings of the New Zealand Grassland Association 57*: 207-212.

Parker, W.J. 1984. A study of management practices and productive performance on a sample of hill country sheep farms in north-east Wairarapa. Masterate thesis. Massey University, Palmerston North.

Parker, W.J.; Gray, D.I.; Lockhart, J.C.; Townsley, R.J. 1994. Farm management research in New Zealand and its contribution to animal production. *Proceedings of the New Zealand Society of Animal Production 54*: 357-362.

Parker, W.J.; Gray, D.I.; Morris, S.T.; McCutcheon, S.N. 1992. A modelling study of the productivity and profitability of unmated and mated ewes on North Island hill country. *Proceedings of the New Zealand Society of Animal Production 52*: 221-223.

Parker, W.J.; Townsley, R.J. 1986. Management practices and productive performance on hill country sheep farms. *Proceedings of the New Zealand Society of Animal Production 46*: 133-137.

Parsonson-Ensor, C.; Saunders, C. 2011. Resilience of farming systems during periods of hardship. ARGOS Research Report 2011. (11/03): Agribusiness Group, Christchurch. 32 pp.

Pedosfsky, J.F.; Douglas, M.H. 1987. The development and production of Tara Hills high country research station. *Proceedings of the New Zealand Grassland Association 48*: 59-64.

Rattray, P.V. 1977. Effect of lambing date on production from breeding ewes and on pasture allowance and intake. *Proceedings of the New Zealand Grassland Association 39*: 98-107.

Rattray, P.V. 1978. Pasture constraints to sheep production. *Proceeding of the Agronomy Society of New Zealand 8*: 103-108.

Rattray, P.V. 1981. Maximizing sheep production from grassland. *Proceedings of the New Zealand Grassland Association 42*: 70-81.

Rattray, P.V.; Jagusch, K.T.; Duganzich, D.M.; MacLean, K.S.; Lynch, R.J. 1982. Influence of feeding post-lambing on ewe and lamb performance at grazing. *Proceedings of the New Zealand Society of Animal Production 42*: 179-182.

Rattray, P.V.; Jagusch, K.T.; Smeaton, D.C. 1983. Interactions between feed quality, feed quantity, body weight and flushing. pp. 21-34. *In*: Sheep and Beef Cattle Society of the New Zealand Veterinary Association. Proceedings of the Society's 13th Seminar, Waikato University, May 27-28th, 1983. Hamilton.

Reid, J.; Brazendale, R. 2014. Insights from the New Zealand experience of Farmer First Research. *Outlook on Agriculture 43*: 213-218.

Reid, J.I.; McRae, A.F.; Brazendale, R. 1993. Farmer First Research: a review of phase one results in relation to farmers' willingness and ability to change. *Proceedings of the New Zealand Grassland Association 55*: 17-21.

Rendel, J.M.; MacKay, A.D.; Manderson, A.; O'Neill, K. 2013. Optimising farm resource allocation to maximise profit using a new generation integrated whole farm planning model. *Proceedings of the New Zealand Grassland Association 75*: 85-90.

Rhodes, A.P.; Aspin, M.D. 1993. MRDC Monitor Farms - using information. *Proceedings of the New Zealand Grassland Association 55*: 23-26.

Rhodes, A.P.; Dynes, R.A.; Brown, M. 2011. McRae Trust - a study of issues around livestock greenhouse gas emissions and the implications for farmers. *Proceedings of the New Zealand Grassland Association 73*: 31-36.

Rhodes, T.; Willis, B. 2000. Impediments to optimising the economic and environmental performance of agriculture. Volume one: A study of issues affecting North Island hill country farmers. Technical Paper 2000/17. Ministry of Agriculture and Forestry. Wellington. 191 pp.

Rhodes, T.; Willis, B.; Smith, W.; McCann, J. 2003. Farm Adjustment and Restructuring in the North Island Hill Country. Technical Paper 2003/2. Ministry of Agriculture and Forestry. Wellington. 118 pp.

Ridler, B.J.; Rendel, J.M.; Baker, A. 2001. Driving innovation: application of linear programming to improving farm systems. *Proceedings of the New Zealand Grassland Association 63*: 295-298.

Roach, C.G.; Nemaia, E.K.K.; Ledgard, S.F.; Brier, G.J.; McLay, C.D.A. 1996. Effects of long-term differences in fertiliser history on hill country: seasonal pasture production, legume growth and soil phosphorus status. *Proceedings of the New Zealand Grassland Association 57*: 105-109.

Robertson, N.; Perkins, H.C.; Taylor, N. 2008. Multiple job holding: Interpreting economic, labour market and social change in rural communities. *Sociologia Ruralis 48*: 331-350.

Rollo, M.D.; McCall, D.G.; Boom, C.J.; Sheath, G.W. 1996. Evaluation of a beef growth model for use in beef finishing decisions. *Proceedings of the New Zealand Grassland Association 57*: 95-99.

Rosin, C.; Dwiartama, A.; Hunt, L.; van den Dungen, S. 2012. Resilience in retrospective: analysis of response to shocks and stress in the New Zealand kiwifruit and sheep and beef sectors. ARGOS Research Report 2007. (12/08). Agribusiness Group, Christchurch. 50 pp.

Rosin, C.; Hunt, L.; Campbell, H.; Fairweather, J. 2007a. Becoming the audited: response of New Zealand sheep/beef farmers to the introduction of supermarket initiated audit schemes. Report on ARGOS' second qualitative interview. ARGOS Research Report. 2007. (07/05): Agribusiness Group, Christchurch. 31 pp.

Rosin, C.; Hunt, L.; Fairweather, J.; Campbell, H. 2007b. Social objective synthesis report: differentiation among participant farmers/orchardists in the ARGOS research programme. ARGOS Research Report. 2007. (07/13). Agribusiness Group, Christchurch. 51 pp.

Sandrey, R.A.; Reynolds, R.G. 1990. Farming Without Subsidies: New Zealand's Experience in the 1980s. *In*: ECON 34th Conference Proceedings, February 13-15, Brisbane Australia,1990. Australian Agricultural and Resource Economics Society, Brisbane, Australia.

Saunders, C.; Kolandai, K.; Greer, G.; Kaye-Blake, W.; Sorensen, L.C. 2009. An application of agri-environmental indicators to panels of New Zealand farms. *Aspects of Applied Biology 93*: 139-142.

Scott, K.; Park, J.; Cocklin, C. 2000. From 'sustainable rural communities' to 'social sustainability': giving voice to diversity in Mangakahia Valley, New Zealand. *Journal of Rural Studies 16*: 433-446.

Sears, P.D. 1951. Potentialities of intensive grassland farming. *Proceedings of the New Zealand Grassland Association 13*: 66-76.

Shadbolt, N.M.; Morriss, S.D. 1999. Financial indicators of sustainability for farming businesses and families: a conceptual model to relate these indicators to those used for environmental and social sustainability. *Journal of International Farm Management 2*: 53-66.

Sheath, G.W. 1983. Pasture utilization in hill country. 1. Influence of grazing duration and land contour. *New Zealand Journal of Experimental Agriculture 11*: 309-319.

Sheath, G.W. 1988. Pasture - the future? *New Zealand Agricultural Science 22*: 49-53.

Sheath, G.W. 2011. Hill farming - An opinion on the future. *Proceedings of the New Zealand Grassland Association 73*: 1-4.

Sheath, G.W.; Boom, C.J. 1997. Impact of beef cattle grazing systems on treading damage and forage supply. *Proceedings of the New Zealand Grassland Association 59*: 87-92.

Sheath, G.W.; Rattray, P.V. 1985. Influence of pasture quantity and quality on intake and production of sheep. p. 1131. *In*: Proceedings of the XV International Grassland Congress, August 24-31, 1985, Kyoto, Japan. Science Council of Japan and Japanese Society of Grassland Science, Kyoto, Japan.

Sheath, G.W.; Webby, R.W.; Keeling, P.; Thomson, R.D.; Page, C.R.; Burton, G.T. 1999. The results and success factors of nine group farm monitoring programmes. *Proceedings of the New Zealand Society of Animal Production 59*: 87-90.

Sheath, G.W.; Webby, R.W.; Pengelly, W.J.; Boom, C.J. 1990. Finishing lambs in hill country. *Proceedings of the New Zealand Grassland Association 51*: 181-186.

Small, B.; Murphy-McIntosh, A.; Waters, W.; Tarbotton, I.; Botha, N. 2005. Pastoral farmer goals and intensification strategies. *AERU Discussion Paper 152*: 223-227.

Smeaton, D.C.; Bown, M.D.; Clayton, J.B. 2000. Optimum liveweight, feed intake, reproduction, and calf output in beef cows on North Island hill country, New Zealand. *New Zealand Journal of Agricultural Research 43*: 71-82.

Smeaton, D.C.; Bown, M.D.; Clayton, J.B.; McMillan, W.H. 1995. Estimated pasture intake and cow output of single and twin calving beef breeding cows. *Proceedings of the New Zealand Society of Animal Production 55*: 161-164.

Smeaton, D.C.; McCall, D.G.; Clayton, J.B.; Dow, B.W. 1986. Calving date effects on beef cow productivity. *Proceedings of the New Zealand Society of Animal Production 46*: 149-152.

Smeaton, D.C.; McCall, D.G.; Wadams, T.K. 1983. Effects of pasture allowance level after calving on performance of beef cows on hill country. *New Zealand Journal of Experimental Agriculture 11*: 303-308.

Smeaton, D.C.; Reardon, T.F.; Nicoll, G.B.; McCall, D.G.; Welch, R.A.S. 1979. Minimum feeding requirements of beef cows. *Proceedings of the Ruakura Farmers' Conference 31*: 27-35.

Smeaton, D.C.; Wadams, T.K.; Hockey, H.U.P. 1982. The influence of an extra flush of pasture before and during mating on the performance of beef cows on hill country. *Proceedings of the New Zealand Society of Animal Production 42*: 79-81.

Smeaton, D.C.; Wadams, T.K.; Mackisack, B.D.; Winter, R.D.; Miller, C.M.; Hockey, H.U.P. 1984. Spring-summer grazing management on hill country: effects on ewe performance. *Proceedings of the New Zealand Society of Animal Production 44*: 117-120.

Smeaton, D.C.; Webby, R.W.; Tarbotton, I.S. 1999. Nutritional effects, in early pregnancy, on lamb production of Finnish Landrace x Romney ewes. *Proceedings of the New Zealand Society of Animal Production 59*: 108-110.

Smeaton, D.C.; Winn, G.W. 1981. Nutrition of weaner beef heifers; growth, puberty and yearling mating on hill country. *Proceedings of the New Zealand Society of Animal Production 41*: 267-272.

Smith, M.E.; Dawson, A.D. 1977. Hill country grazing management. *Proceedings of the New Zealand Grassland Association 38*: 47-55.

Smith, M.E.; McLaren, P.N.; Hopkins, D.R. 1979. Farm production gains following adoption of a hill country grazing management system. *Proceedings of the New Zealand Society of Animal Production 39*: 251-253.

Smith, W.; Davies-Colley, C.; Mackay, A.; Bankoff, G. 2011. Social impact of the 2004 Manawatu floods and the 'hollowing out' of rural New Zealand. *Disasters 35*: 540-553.

Smith, W.; Montgomery, H. 2004. Revolution or evolution? New Zealand agriculture since 1984. *Geojournal 59*: 107-118.

Smith, W.; Montgomery, H.; Rhodes, T. 2007. North Island hill country farmers' management response to issues of sustainability. *New Zealand Geographer 63*: 30-42.

Smith, W.; Saunders, L. 1995. Agricultural policy reforms and sustainable land management: New Zealand case study. *Australian Geographer 26*: 112-118.

Spedding, S.C. 1996. Sustainability in agricultural systems. New Zealand Institute of Agricultural Science, Christchurch. 7 pp.

Spooner, C.; Li, R. 2013. Web based lambing percentage benchmark tool. *Primary Industry Management 17*: 31-32.

Stevens, D.R.; Casey, M.J. 2014. Changing farm management practices using lucerne for sheep grazing. *Options Mediterraneennes. Series A, Seminaires Mediterraneens 109*: 801-804.

Stevens, D.R.; Garden, J.P. 2014. Challenges facing the farmers of Central Otago. *Proceedings of the New Zealand Grassland Association 76*: 25-28.

Stevens, D.R.; Gibson, A.K.; Casey, M.J. 2000. Improving on-farm profitability of sheep and deer systems using pasture renewal in the southern South Island. *Proceedings of the New Zealand Grassland Association 62*: 201-205.

Stevens, D.R.; Thompson, B.R.; Catto, W.D.; Trainor, K.D. 2014. Is nitrogen fertiliser an economic option in tussock hill country? *Proceedings of the New Zealand Grassland Association 76*: 149-154.

Stevens, D.R.; Young, G. 2013. Using data from large scale farming operations to understand the importance of feeding the ewe to improve whole farm performance. *Proceedings of the New Zealand Grassland Association 75*: 97-102.

Stock, P.V.; Forney, J. 2014. Farmer autonomy and the farming self. *Journal of Rural Studies 36*: 160-171.

Stock, P.V.; Forney, J.; Emery, S.B.; Wittman, H. 2014. Neoliberal natures on the farm: farmer autonomy and cooperation in comparative perspective. (Special section on neoliberalising rural environments.). *Journal of Rural Studies 36*: 411-422.

Suckling, F.E.T. 1956. Sheep Management on Improved Hill Pastures. *Proceedings of the New Zealand Society of Animal Production 16*: 39-47.

Suckling, F.E.T. 1959. Pasture management trials on unploughable hill country at Te Awa. II. Results for 1951-57. *New Zealand Journal of Agricultural Research 2*: 488-543.

Suckling, F.E.T. 1975. Pasture management trials on unploughable hill country at Te Awa. 3. Results for 1959-69. *New Zealand Journal of Experimental Agriculture 3*: 351-436.

Synge, K.A.; MacKay, A.D.; Palmer, A.S. 2013. An evaluation of the Land and Environment Planning Toolkit for advancing soil and nutrient management on sheep and beef farms. *Proceedings of the New Zealand Grassland Association 75*: 91-96.

Tarbotton, I.S.; Webby, R.W. 1999. Variation in lamb survival within farm and between farms: results from farmer studies. *Proceedings of the New Zealand Society of Animal Production 59*: 73-75.

Tavendale, J. 1984. The impact of agricultural policy: South Island hill and high- country farms (New Zealand). *New Zealand Agricultural Science 18*: 191-193.

Taylor, N.W. 1983. A policy to utilise hill country potential. Report 1882. New Zealand Meat and Wool Boards' Economic Service. Wellington.

Taylor, N.; McClintock, W. 2004. Some characteristics of multiple job holding by New Zealand farm men and women. *AERU Discussion Paper 151*: 214-222.

Teather, E.K. 1996. Farm women in Canada, New Zealand and Australia redefine their rurality. *Journal of Rural Studies 12*: 1-14.

Tipples, R. 2007. The further re-regulation of farming employment relations in New Zealand. *Sociologia Ruralis 47*: 63-79.

Townsley, R.J.; Parker, W.J. 1987. Regression analysis of farm management survey data (New Zealand). *New Zealand Journal of Experimental Agriculture 15*: 155-162.

Tripe, J.N. 1965. Rapid increases possible on Wanganui hills. *Proceedings of the New Zealand Grassland Association 27*: 38-45.

Tripe, J.N. 1979. Improvement of hill country output. *New Zealand Agricultural Science 13*: 104-106.

Vogeler, I.; Vibart, R.; Mackay, A.; Dennis, S.; Burggraaf, V.; Beautrais, J. 2014. Modelling pastoral farm systems - scaling from farm to region. *Science of the Total Environment 482/483*: 305-317.

Wallace, N. 2015. When the farm gates opened: the impact of Rogernomics on rural New Zealand. Otago University Press, Dunedin, N.Z. 160 pp.

Ward, F.L. 1962. Beef cattle and sheep on hill country farms. *Proceedings of the New Zealand Grassland Association 24*: 95-103.

Webby, R.W.; Johnstone, L.C.J.; Sherlock, R. 2001. Reducing the impact of adverse summer-autumn pasture conditions on livestock performance: results from farmer experience. *Proceedings of the New Zealand Grassland Association 63*: 229-233.

Webby, R.W.; McCall, D.G.; Blanchard, V.J. 1995. An evaluation of the StockpolTM model. *Proceedings of the New Zealand Society of Animal Production 55*: 145-149.

Webby, R.W.; Sheath, G.W. 1991. Group monitoring, a basis for decision making and technology transfer on sheep and beef farms. *Proceedings of the New Zealand Grassland Association 53*: 13-16.

Webby, R.W.; Sheath, G.W. 2000. The impacts of change in forage quality and seasonality on sheep farm profitability. *Proceedings of the New Zealand Grassland Association 62*: 189-194.

Webby, R.W.; Thomson, R.D. 1994. The current status of the beef breeding cow in New Zealand mixed livestock production systems. *Proceedings of the New Zealand Society of Animal Production 54*: 311-314.

Wedderburn, M.E.; Kingi, T.T.; MacKay, A.D.; Brown, M.; Oca, O.M.D.; Maani, K.; Burton, R.; Campbell, H.; Peoples, S.; Manhire, J.; Dynes, R.; Kaye-Blake, B. 2011. Exploring rural futures together. *Proceedings of the New Zealand Grassland Association 73*: 69-74.

White, T.A.; Snow, V.O.; King, W.M. 2010. Intensification of New Zealand beef farming systems. *Agricultural Systems 103*: 21-35.

White, T.D.; Sheath, G.W. 2011. Building rural capability through collaboration of Maori farm businesses. *Proceedings of the New Zealand Grassland Association 73*: 9-12.

Willis, R. 1982. The influence of some social factors on farm production. *New Zealand Agricultural Science 16*: 161-164.

Wilson, O. 1994. 'They changed the rules': farm family responses to agricultural deregulation in Southland, New Zealand. *New Zealand Geographer 50*: 3-13.

Wilson, O.J. 1995. Rural restructuring and agriculture-rural economy linkages: A New Zealand study. *Journal of Rural Studies 11*: 417-431.

Woodward, S.J.R.; Lambert, M.G.; Litherland, A.J.; Boom, C.J. 2001. Can a mathematical model accurately predict intake of grazing animals? Testing the Q-Graze model. *Proceedings of the New Zealand Society of Animal Production 61*: 4-7.

Woodward, S.J.R.; Webby, R.W.; Johnstone, L.J.C. 2000. A decision tool for calculating herbage mass and metabolisable energy requirements of growing cattle and sheep. *Proceedings of the New Zealand Grassland Association 62*: 13-18.

Wright, A. 1965. The potential of Taranaki Hill Country. Report 31, Department of Agricultural Economics and Farm Mamagement, Massey University, Palmerston North. 7 pp.

Wright, A.; Nicholls, J.R.; Gray, D.I.; Fraser, P.A.G. 1989. Aspects of farm firm growth in the Pongaroa region. *Discussion Paper Agribusiness & Economics Research Unit, Lincoln College 125*: 59-64.

Wright, D.F.; Rhodes, A.P.; Hamilton, G.J. 1990. Merinos - a profitable diversification option for most North Island hill country. *Proceedings of the New Zealand Grassland Association 51*: 177-180.