CSIRO PUBLISHING

Animal Production Science, 2013, **53**, 628–642
http://dx.doi.org/10.1071/AN12265

Selection of experimental treatments, methods used and evolution of management guidelines for comparing and measuring three grazed farmlet systems

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Abstract. The Cicerone Project was a collaborative effort by livestock producers, researchers and extension specialists, which aimed to explore the profitability and sustainability of grazing enterprises on the Northern Tablelands of New South Wales, Australia. A major part of the Project was the creation of a moderate scale, unreplicated farmlet experiment. The process of selecting the farmlet treatments and the design of the experiment involved considerable negotiation over an extended period in order to achieve 'ownership' by all those involved.

The farmlets were designed to compare a typical farmlet (B) as the control with a second farmlet (A), which received higher levels of pasture renovation and soil fertility, and a third (C), which employed intensive rotational grazing management with short graze and long rest periods. Management guidelines were developed for all soil, pasture, livestock and grazing management decisions on the three farmlets.

Whole-farmlet data are presented for the pastures sown, fertiliser applied, supplement fed, the stocking rates attained and the pattern of graze and rest periods over the experimental period from July 2000 to December 2006. Over the first 4 years of the trial, pastures were renovated on 71% of farmlet A while 8% of each of farmlets B and C were renovated. The rates of fertiliser applied to the three farmlets varied according to soil test values and the different target values for soil phosphorus and sulfur. In the first year of the trial (2000–01), the annual average stocking rates on farmlets A, B and C were 9.5, 7.9 and 9.1 dry sheep eqivalents/ha, respectively, whereas by the fifth year (2005), the stocking rates were 11.2, 7.8 and 7.4 dry sheep equivalents/ha, respectively.

This paper provides details of the general methods used in the farmlet trial, of relevance to a series of related papers which explore all aspects of the farmlet experiment and its findings. It also reports on the selection and definition of the farmlet treatments and describes how the guidelines evolved over the duration of the trial in response to the practical realities of conducting this complex, agroecosystem experiment.

Additional keywords: action learning, farming systems research, farmlet studies.

Received 1 August 2012, accepted 30 October 2012, published online 10 July 2013

Introduction

The Cicerone Project was formed by livestock producers and collaborators with the aim of improving the profitability and sustainability of grazing enterprises on the Northern Tablelands of New South Wales (NSW), Australia (Sutherland *et al*. 2013). During the Project's planning phase, a survey was commissioned to determine the most important problems faced by graziers of the region (Kaine *et al*. 2013). A major issue for these livestock producers was maintaining an adequate pasture feed supply and quality, especially during dry seasons and also during winter when ewes are typically pregnant, without the need for high rates of supplementary feeding. The survey respondents were interested in pasture productivity and persistence, including that of native pastures, the affordability and effectiveness of fertilisers, and the effects of grazing management on pastures, livestock production and the control of internal parasites of sheep. All of these factors are known to interact in complex ways within commercial extensive grazing enterprises.

Bywater (1990) noted the lack of scientific understanding of farming systems through experimentation due to insufficient rigour being applied to measuring the dynamics between the complex system components which make up whole farms with 'hard, objective and quantitative explanations of why the system worked or did not work'. Morley and Spedding (1968) acknowledged that, while it may not be feasible to accurately measure all detailed components, grazing system experiments need to be large in order to be realistic. They acknowledged that, although such experiments can be 'complex and difficult to execute', good experimental design and analysis is nevertheless essential.

The overall goal of enhancing the profitability and sustainability of grazing enterprises is both challenging and multi-dimensional. The findings from the Temperate Pasture Sustainability Key Program (Kemp *et al*. 2000) suggested that grazing management, particularly through tactical rest periods, may be one way of enhancing the persistence of desirable perennial grass species, which contribute to sustainability. Following on from that research, the Sustainable Grazing Systems national research program found important factors included the management of soil fertility, pasture botanical composition and grazing in order to optimise the level of profit from different systems (Andrew *et al*. 2003).

Because livestock producer members of the Cicerone Project wished to better understand the influence of soil fertility, pasture renovation and intensive rotational grazing on the profitability and sustainability of grazed systems, this work was conducted on whole farmlets located on contiguous areas of land subject to exactly the same climatic conditions. The three farmlet areas were designed to be as similar in land capability as was feasible (Scott *et al*. 2013*b*).

Jones *et al*. (1995) pointed out the need for studies of system changes in grazing experiments to be carried out over the long term, as the cumulative effects of stocking rates and changes in soil fertility over extended periods of time impact on botanical composition and animal production, and are affected by rainfall variability. This is in conflict with the increasing focus of research funding on shorter term projects (Jones *et al*. 1995).

The literature on grazing management is extensive; in spite of this, there is considerable controversy about the benefits of different systems (Saul and Chapman 2002). Kemp (2000) stated that, in order to manage botanical composition of pastures, the grazing process has to be better managed. However, the findings of the majority of reviews of grazing systems have concluded that, from the point of view of animal production, continuous grazing is at least as good, or better than rotational grazing (Norton 1998).

A proponent of time-control grazing, a form of cell grazing, has suggested that such systems can increase business profitability up to 2–3 times, improve soils with a doubling of soil phosphorus (P) on some properties, a 50–100% increase in rainfall-use efficiency, increased biodiversity and, at times, animal performance (McCosker 2000). However, in south-east Queensland, Sanjari *et al*. (2008) found that, compared with continuous grazing, time-control grazing decreased extractable soil P. While it has been claimed that short duration grazing systems can increase stocking capacity of rangelands, a study over 5 years in Wyoming found no effect on daily weight gains whereas increases in stocking rate could only be achieved with unacceptably high risks of deterioration of the rangelands (Hart *et al*. 1988).

In view of the conflicting views about grazing management, the producer members of the Cicerone Project sought a thorough investigation of intensive rotational grazing compared with other, more traditional forms of grazing management. Importantly, Cicerone members chose two important differences to previous grazing experiments in the studies to be undertaken. First, the producer members recognised that, as pointed out by Briske *et al*. (2011) in the USA, there are whole-farm ramifications of grazing systems such as stocking rate, different classes of animals, investments in fencing and watering points, labour and economics. They therefore chose to explore various technologies, including grazing management, within whole-farm scenarios. Second, they decided that the control grazing system would not be the 'continuous grazing' used by many other investigators (Earl and Jones 1996; Garden *et al*. 2000; Waller *et al*. 2001; Dowling *et al*. 2005; Sanjari *et al*. 2008) as it is rarely practised by commercial livestock producers on the Northern Tablelands. Thus, the treatment chosen to represent typical grazing management practice in the region, was flexible rotational grazing over a moderate number of paddocks with relatively long graze periods and short rest periods. Therefore, the grazing management question asked by Cicerone members was whether *intensive* rotational grazing was superior to *flexible* rotational grazing for achieving greater profitability or sustainability.

The Cicerone members accepted that it was appropriate to allow stocking rate to change in order to meet changes in the feed supply. The need to consider stocking rate as an emergent property of the farming system has also been acknowledged by Morley and Spedding (1968), Chapman *et al*. (2003) and Clark (2010).

The fact that most graziers on the Northern Tablelands run both sheep and cattle enterprises (Alford *et al*. 2003) meant that Cicerone members were interested in including some cattle as part of a predominantly wool production enterprise. Cattle were therefore incorporated with sheep, especially during summer when surplus feed was available, at a similar ratio of stocking rate for sheep and cattle on each farmlet.

This paper describes the process of designing the farmlet experiment and developing the guidelines for management of the farmlets to ensure a balance between scientific rigour and practical realism to satisfy not only the research and extension partners but, most importantly, the livestock producer stakeholders of the Cicerone Project.

Methods and their evolution

Scale, complexity and validity

While acknowledging the need for scientific validity and publication of results, the producer-led management Board had a strong desire to see that the research would also have practical and credible outcomes. Thus, it was decided to explore the farmlet management strategies at a scale and complexity that was credible to them, even if that meant that the farmlets would not be replicated. This approach, involving comprehensive measurements of moderate-sized farmlets, was judged to be a superior approach to replicated farmlets, which would have necessitated smaller, less complex, and therefore, less credible farmlets.

The Cicerone farmlet experiment was an attempt to evaluate scientific principles and strategies determined from smaller scale, replicated experiments, such as those conducted under the Temperate Pasture Sustainability Key Program, at a commercial scale, as suggested by Kemp *et al*. (2000).

Measurement protocols

The methods used in the farmlet experiment were based on the experimental protocols of the Temperate Pasture Sustainability Key Program (Lodge and Garden 2000) and the Sustainable Grazing Systems national experiment (Andrew and Lodge 2003). These included those for measuring herbage mass, botanical composition, pasture growth rate, animal liveweight and condition score.

Data management

A relational database, using the software Microsoft Access, based on an earlier database created for the Sustainable Grazing Systems Project (Scott and Lord 2003), was adapted to manage the data for the Cicerone Project. The database structure consisted of two linked databases: one containing queries and derived tables (660 Mb) and a second containing tables of data (350 Mb). The database contained some hundreds of tables and queries enabling the storage and retrieval of most experimental data both during and after completion of the trial. Datasets included those for: soil electromagnetic data, soil fertility, pasture establishment, botanical composition, pasture growth, herbage mass and quality, remote sensing, livestock weights, fat scores, reproduction variables, mob details, stock moves, wool quantity and quality, animal health, modelling results, tree establishment and growth, paddock sowing and fertiliser applications, and livestock treatments such as drenches and supplement fed. Data for other Cicerone experiments, such as the footrot trial (Gaden *et al*. 2013), were also included in the database.

Statistical methods

The issues relating to exploring causal inference from the unreplicated farmlet study have been discussed by Murison and Scott (2013) who described several analytical approaches to examining the significance of farmlet treatment effects. More details of the specific statistical analyses carried out for different datasets are provided within the relevant companion papers of this Special Issue.

Choice of farmlet size

Early discussions explored the number of management options that could feasibly be compared in an experiment. Ideally, three or four monitored farmlets were thought to be desirable. It was estimated that a farmlet size of ~50 ha would, depending on the productivity of the systems, allow the carrying capacity of each farmlet to range from ~400 to 750 dse (dry sheep equivalents). This meant that mobs of animals could be of a sufficient size (greater than 100) and paddocks sufficiently large (of several hectares), to be considered by livestock producers to mimic grazing enterprises in a realistic fashion. Resource limitations for setting up the farmlets and the limited area of land available, resulted in a decision to restrict the number of farmlets to be compared to three.

Each farmlet needed to have the same initial productive potential and hence required similar areas of comparable soil type, similar drainage and topographic features (Scott *et al*. 2013*b*); however, the livestock carrying capacity was recognised as an emergent property of each farmlet, dependent on any changes in pasture production. In addition, each farmlet was to be managed independently while decisions made for each farmlet needed to reflect commercial practice. Hence the different farmlets were permitted to evolve along their own trajectories, expressing the differences between management systems, provided that the overall treatment regimes applied to each farmlet remained consistent.

Defining and selecting the farmlet treatments

The different management strategies were evaluated within self-contained, whole-farming systems. Each farmlet needed to be contained physically within boundary fences with internal fencing allowing stock to be rotated at desired intervals according to the chosen management system. Movement of stock between paddocks within each farmlet needed to be based on decision criteria which were refined as the experiment progressed. All stock 'belonging' to a farmlet had to be either kept on the farmlet or else 'sold' off the farmlet, suffering price penalties if drought conditions existed.

Potential management treatments considered for the different farmlets included:

(1) A 'typical' or 'control' system to reflect the most common management practices on the Northern Tablelands such as flexible rotational grazing with relatively short rest periods, moderate levels of soil fertility with some sown pasture and a moderate stocking rate,
(2) A higher input system with ~70% of sown pasture (in good condition) fertilised to reach a high soil P target (60 ppm available P), with monitoring of sulfur, strategic nitrogen applications, possible fodder conservation if opportunities arose, and flexible rotational grazing,
(3) A system similar to the 'cell' grazing described by Earl and Jones (1996) and McCosker (2000). However, Cicerone members felt that the term 'cell grazing' was somewhat controversial and thus chose the more neutral term 'intensive rotational grazing'; and
(4) A farmlet which would be run according to 'holistic resource management' (HRM) principles (Savory 1983).

Following a meeting of Cicerone members with commercial trainers in the HRM method, who expressed the view that this method of management was not amenable to measurement, a decision was taken that such a farmlet would not be included in the trial. Thus, the three treatments remaining became the focus of the farmlet studies.

After further extensive discussions, the desired characteristics of a farmlet trial were decided upon (Box 1). The naming the farmlets adopted the non-prejudicial names of farmlets A, B and C, as used in a dairy farmlet trial in Victoria (Grainger 1998). In order to limit the scope of the trial, a deliberate decision was taken to exclude issues such as product marketing, changes of farm size and of livestock enterprises other than sheep and cattle.

A brief description of each of the farmlet treatments is provided in Table 1 while the relationships between the three systems are shown in Fig. 1. Given that farmlet B represented a typical, control farmlet with moderate inputs and flexible grazing, the overall experimental hypotheses posed were that, compared with the typical farmlet (B):

(1) higher inputs of sown temperate species combined with higher soil fertility and/or
(2) intensive rotational grazing with short graze and long rest periods, will result in a more profitable and sustainable grazing enterprise.

Scope of farmlet trial measurements

A wide array of measurements was considered to be necessary if farmlet productivity, profitability and sustainability were to be assessed adequately. The list of measurements considered feasible, unconstrained by Project resources, included: soil (type, fertility, hydrology, runoff, compaction, erosion), pastures (botanical composition, proportions of sown species, herbage mass and quality), trees (survival, growth and effect on livestock), livestock (stocking rates, weight changes, wool production and quality, animal health), climate (rainfall, temperature, and evaporation) and profitability (costs of inputs and capital expenses and values of products sold).

Box 1. Desirable characteristics of a farming systems experiment determined following initial discussions and negotiations between all participants

- Secure land tenure for the life of the Project
- Ability to compare different relevant systems
- Compare at least two different levels of inputs
- Soil types to be representative of the region
- Good visibility to community and producers
- Site which producers can identify with
- Ease of access for field days, skill enhancement days, etc.
- Ideally, should have good baseline data on previous soil and pasture history
- Desirable to have some areas with existing trees to reduce lead time needed
- Good animal handling facilities
- Reasonable proximity to research facilities
- Allow recycling of farmlet income earned from livestock products to assist in achieving sufficient scale
- Large enough to have sufficient credibility with graziers (say 300–500 dse per farm),
- Permit sufficient animals to be run so that issues of grazing animal behaviour and selective grazing would occur realistically across and between paddocks,
- Allow both sheep and cattle to be run,
- Small enough so that the soil types could be mapped and monitored over the entire farmlet with similar soil types to be allocated across each farmlet,
- Allow for any off-site flows of soil, water and nutrients to be sampled and measured,
- Monitor pasture composition and growth over time, and
- Facilitate the monitoring of all animals for production and health.
- Adequate record keeping and ready access to all measurement records

Life of the Project

Support was sought, and granted, for an initial period of 5 years. However, it was recognised that, if the Project were successful, it may continue over a longer term if funding was adequate. It was acknowledged during the planning phase that, if the farmlets were set up and run well, that they could continue to be a useful focal point for evaluation of new ideas many years into the future.

Budget needs

It was clear that the costs in the initial year would be much greater than those in subsequent years. Funds were committed for the set-up cost of the farmlets and then ongoing costs were needed for the support of administrative and farm staff, as well as for ongoing expenses of soil testing, fertilisers, supplementary feeding and other general running expenses. Details of the overall funding of the Cicerone Project have been described and discussed in a related paper by Coventry *et al*. (2013). Throughout the Project, there was considerable reliance on in-kind contributions from collaborators not only during the planning phase but also during the operational phase and especially during the publication phase.

Creating the Cicerone farmlets

After reviewing the scope and characteristics of the farmlets with those who attended a broad consultation meeting, the Cicerone Board was given the task of deciding the final parameters of the farmlet systems and negotiating a lease of sufficient land.

The Cicerone Project leased 200 ha of land from the CSIRO McMaster Research Laboratory (lat.: 30°37′S; long.: 151°33′E), Chiswick, near Uralla, NSW, initially for a period of 5 years from 1 January 1999. The land was subdivided into three equal 53-ha farmlets after taking into account soil type, slope and soil conductivity (Scott *et al*. 2013*b*). Non-contiguous paddocks were found to be necessary and therefore laneways were incorporated to facilitate stock movements. There was also an outer area, the periphery, where stock could be 'sold' or 'purchased' without animal disease quarantine issues.

The three farmlets were operated as self-contained, separate whole farmlets, which demanded considerable flexibility in their management in response to the variable climatic conditions experienced. Consequently, the Board deliberately adopted a pragmatic focus, which allowed some flexibility over time as conditions changed.

The producer majority of the Cicerone Board readily accepted the need to allow variations in the graze and rest periods as seasons and stocking rates fluctuated over time, especially when liveweights indicated problems. Also, it was acknowledged that it may be necessary to slow down the speed of grazing rotation during lambing to avoid mis-mothering.

It was agreed that strategies could be 'fine-tuned' and that, wherever possible, the Board needed to respond proactively to

Table 1. Summary of treatment parameters that defined farmlets A, B and C (each 53 ha)

Parameter	A (higher pasture inputs)	B (typical district practice)	C (intensive rotational grazing)
Number of paddocks	8	8	37 17 major paddocks subdivided with electric fencing to 37 subpaddocks
Legume content objective	High (up to 30%) – through sowing and broadcasting	Moderate – through broadcasting	Moderate – through broadcasting
Renovation of pastures	Aim for all pastures to be dominated by sown species through renovation using direct drilling	Minimal renovation of pastures	Minimal renovation of pastures
Initial fertiliser strategy – using superphosphate as the most common fertiliser to be applied – depending on soil test results	250 kg/ha.year to entire farmlet	125 kg/ha.year to 1/3 of farmlet	125 kg/ha.year to 1/3 of farmlet
Soil phosphorus – target level (ppm)	60	20	20
Soil sulfur – target level (ppm)	10	6.5	6.5
Nitrogen fertiliser	At sowing + strategic applications allowed	At sowing	At sowing
Target stocking rate (dse/ha) – within 5 years	15	7.5	15
Minimum number of mobs	5	5	3
Grazing method	Flexible rotational grazing employing Prograze principles	Flexible rotational grazing employing Prograze principles	Intensive rotational grazing with short grazing and long rest periods of 60–200 days depending on the season (excluding lambing time when set stocking may need to occur)[A]
Supplementary feeding strategy	May feed supplements (e.g. lupins) to reach desired target condition score at certain times of the year	May feed supplements (e.g. lupins) to reach desired target condition score at certain times of the year	May feed supplements (e.g. lupins) to reach desired target condition score at certain times of the year

[A]Controlled or planned grazing principles to apply. Mobs may be combined to maintain appropriate rest periods and grazing pressure for all paddocks. Agisted stock allowed if necessary to get the pasture 'under control' if the grazing pressure is considered by the manager to be inadequate. Aim to eat 1/3, trample 1/3 and leave 1/3 of pasture. Rest periods determined by pasture recovery, do not graze plants growing on root reserve. Mobs may be combined to maintain appropriate rest periods and grazing pressure for all paddocks.

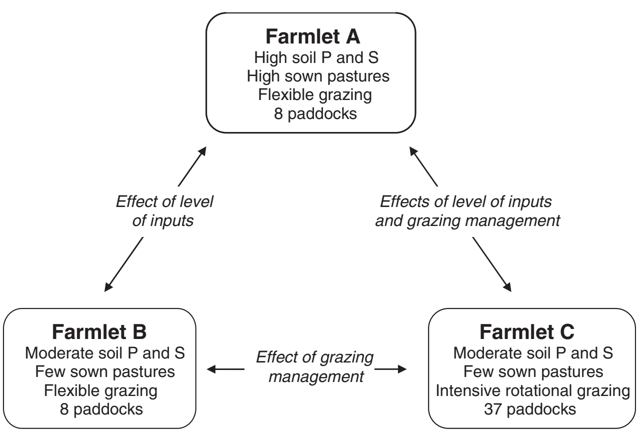

Fig. 1. Relationship between treatment comparisons to levels of inputs and grazing management among farmlets A, B and C.

avoid problems. The Board attempted to resolve issues through consensus rather than with voting and made regular visits to the farmlets before monthly Board meetings.

Measurements

The substantial task of taking all the measurements was assisted greatly through the active participation of four postgraduate students who helped gather, analyse and interpret the information. Initially, four or five pasture assessments per year were planned but soon it was realised that much more intensive measurements were needed such as annual detailed measurements of botanical composition (Shakhane *et al*. 2013*b*) and monthly assessments of herbage mass, legume content, herbage quality and ground cover (Shakhane *et al*. 2013*a*). During the 2001–05 shearings, individual fleeces were weighed and samples tested for quality characteristics using OFDA and AWTA measurements (Cottle *et al*. 2013). Regular monitoring of faecal egg counts allowed drench strategies to be applied and adapted as results and conditions varied (Walkden-Brown *et al*. 2013).

Stocking rate decisions

Discussion took place each autumn before joining to determine the most appropriate winter stocking rate based on estimates of pasture productivity and the needs of the various classes of livestock. In the most challenging drought year (2002), even though there was little pasture available in that particularly dry autumn, the Board decided that a certain minimum number of breeding ewes would be run on each farmlet through winter and fed as necessary with purchased feed as, fundamentally, the enterprises of each farmlet were self-replacing Merino flocks where the retention of core breeding stock was essential. The sale of sheep and cattle was also guided by animal growth rates and condition score assessments in addition to herbage mass and quality in relation to the climate at the time. These factors were taken into account by the farm manager, in conjunction with the Cicerone Board.

Livestock

For simplicity, the number of classes of livestock were limited to Merino ewes plus followers, rams, and non-breeding cattle (heifers and steers). It was agreed that some cattle should be included together with sheep so long as the ratio of the stock units from both were consistent between farmlets.

Initially, Merino ewes were purchased from the CSIRO Pastoral Research Laboratory and from a commercial woolgrower (Wilson's Creek) with Merino rams purchased from Birrahlee, Deeargee and Wilson's Creek (Cottle *et al*. 2013). All purchased sheep were randomly divided into three equal mobs and colour ear-tagged according to farmlet. Accreditation for Ovine Johne's Disease was obtained for all sheep before purchase and accreditation was updated as required under the Ovine Johne's Disease MAP scheme (http://www.dpi.nsw.gov.au/agriculture/livestock/health/specific/veterinarians, verified 6 December 2012).

Considerable effort was put into the physical planning and partitioning of the land into three farmlets each with equivalent starting conditions (Scott *et al*. 2013*b*). Fencing and water lines were installed between December 1999 and June 2000. The first three paddocks were renovated during June 2000. The farmlet treatments were deemed to have commenced on 1 July 2000.

Stock moves

It was decided that the flexible rotational grazing would, where feasible, employ guidelines from Prograze (Bell and Allan 2000) including grazing above critical minimum levels of green herbage mass and attaining a minimum fat score of sheep. The movement dates of all mobs of sheep and cattle between paddocks were kept using manual recording sheets that were completed weekly. At each move, an estimate of the average dse rating of the stock and an approximate visual estimate of the pasture herbage mass (green and dead) was made and recorded by the farm manager. Over the duration of the trial, records were kept of the movements of a total of 103 mobs of sheep and cattle across 57 paddocks and subpaddocks across all three farmlets. Colour charts showing all livestock moves were prepared regularly to inform the Board and for communication to Cicerone members at field days.

Weights and fat scores

Ewes were fat scored at lamb marking, weaning, at joining and near shearing. In addition, they were weighed pre-joining and pre-lambing. Any ewes not meeting the fat score targets at joining, mid and late pregnancy were given priority for extra access to pasture and/or supplements. Lambs were weighed at marking, at weaning and every 4–6 weeks thereafter.

Wool measurements

At shearing, each sheep, including rams, had greasy fleece weights recorded and mid-side samples taken from fleeces for fibre diameter, length and strength measurements.

Cattle weights

Cattle weights were recorded regularly and especially when they moved onto and off the three farmlets.

Animal welfare

All animal experiments within the Cicerone Project were assessed and approved by the CSIRO Animal Ethics Committee with close oversight by the CSIRO veterinarian.

Soil and pasture measurements

Soil measurements

Initially, it was planned to carry out at least two soil tests per farmlet per year. From 2002 onwards, in most years, all paddocks were soil sampled so that fertiliser recommendations could be made for individual paddocks (Guppy *et al*. 2013).

Herbage mass

Initially, assessments of herbage mass and botanical composition were conducted on each farmlet in late summer of each year. However, this frequency was found to be inadequate, especially when attempting to apply Prograze benchmarks, so monthly herbage mass and quality assessments were conducted by a technician experienced in pasture assessment from April 2003 to December 2006 (Shakhane *et al*. 2013*a*).

Feed supplements

Over the life of the Project a wide range of supplements were fed ranging from dry feed blocks to 'Dry Lic' loose mix (Meredith Seed Co, Armidale, NSW, Australia), which has been promoted for use in intensive rotational grazing systems to more conventional, protein-rich grain supplements. The aim was to maintain breeding ewes with a fat score of 2.5 or above, especially during pregnancy. Whenever feasible, supplements were given early to avoid weight loss. In the case of hoggets, the minimum target weight gain was 50 g/head.day. In the week before weaning, lambs were exposed to supplementary feeds which were trailed out each day so that they became accustomed to eating supplements when offered.

Economics

It was proposed that the economic analyses for the farmlet study should include, where possible, gross margins, costs of production and common production statistics including production of wool and meat per ha as well as lambing and weaning percentages and mortality losses. The capital costs of subdivision and of pasture development also needed to be taken into account. These capital expenses of fencing and installing watering pipes and troughs were recorded and incorporated into the farmlet profitability analyses by Scott *et al*. (2013*a*).

The Farm Manager recorded all management time spent on each farmlet using time sheets, including research and administrative tasks in relation to individual farmlets, so that a realistic assessment could be made of the labour required for each farmlet management system.

The rates and costs of inputs such as drenches and supplementary feed were allocated to each farmlet whenever used. For comparisons of the relative profitability of the farmlets attributable to the different management strategies, the actual costs incurred were used for all economic calculations.

Evolution of the farmlet management guidelines

The need for a set of clear guidelines was made clear by the farm manager who found he was receiving variable advice from different Project participants; it was agreed that there was a need for explicit management guidelines to be negotiated and put in writing. The guidelines evolved from early planning in 1999, through refinements made during review meetings in 2000 and 2003, up to March 2004 when further minor amendments created the 'final' set of farmlet guidelines. This evolution confirmed the willingness of management to adapt as conditions changed, such as the need to shorten grazing rest periods on farmlet C, which had become more apparent as animal measurements confirmed differences between farmlets in liveweight (Hinch *et al*. 2013).

Animal management

Joining and shearing dates

Joining usually commenced in late April and continued for a period of 5–6 weeks, with lambing in September. Shearing was carried out 1 month before lambing. In 2000, the ewes purchased had already been joined. In 2001 and 2002, joining took place within each farmlet with rams from the same stud source randomly allocated between farmlets (at 2% of ewe numbers). In order to help ensure that the genetic potential of animals on each farmlet were equivalent, from the 2003 joining onwards, all ewes and rams were run together on 'periphery' paddocks outside the farmlets for the joining period to ensure that the genotype of sheep was uniform across the three farmlets. As the experiment was to be terminated by the end of 2006, no ewes were joined in that year on any farmlet.

Worm control

Monitoring of faecal egg counts was carried out on all farmlets at regular intervals. These data provided the evidence to allow the veterinary consultant (Betty Hall Pty Ltd) to make drench recommendations specific to each mob on each farmlet so that drenches were used only when needed. The exception was when sheep from all farmlets were required to have a quarantine drench before using the CSIRO shearing shed.

Vaccination and trace element (selenium) nutrition

Lambs were given their first '6-in-1' vaccination, together with selenium, at marking and a booster vaccine at weaning. All sheep were given annual boosters at shearing which, for ewes, was 1 month before lambing. All adult sheep were treated with a long-acting selenium supplement (Deposel, Novartis Animal Health Australasia Pty Ltd, North Ryde, NSW, Australia).

Classing of ewes and rams

Ewes were classed by the farm manager, with the aid of an experienced producer Board member (P. Dutton) in March of each year, before joining. The aim was, within 5 years, to reach a fibre diameter in each flock of 18 microns and an average wool cut of 4 kg greasy for adult ewes, 4.5 kg for wethers and 3 kg for hoggets.

Communications

The results from the farmlets were made available both through the regular newsletters as well as two annual symposia held in 2005 and 2006. A website (http://www.cicerone.org.au/, verified 6 December 2012) was established to assist in getting information out to a wider range of stakeholders. Reports and newsletters were also sent to a wide array of funding agencies which occasionally reproduced some of the results in their publications. More details of the communication and extension outcomes of the Project have been described in a related paper by Edwards *et al*. (2013).

Climate

Climatic records were accessed for the nearest Bureau of Meteorology site (17 km north, in Armidale, NSW) as resource constraints meant that an automated weather station was unable to be purchased for the experimental site. A detailed analysis of the climate experienced during the trial has been provided in a related paper by Behrendt *et al*. (2013).

Results

Pasture establishment

The activities undertaken during the establishment of all pastures during the farmlet experiment are detailed in Table 2. At times, both spray topping in late spring and winter cleaning were carried out to control annual grass weeds such as *Vulpia* spp. Before sowing, one or more 'knockdown' sprays were used in order to kill resident vegetation and allow subsoil moisture to be stored before sowing which occurred in autumn or early winter. All sowings were carried out with minimal disturbance using contracted direct drilling machinery. As shown in Table 2, the cumulative area of farmlet A on which pastures were sown was 71% whereas for farmlets B and C, 8% of each farmlet was sown. As the management Board decided to differentiate the farmlets quickly, based on the chosen management treatments, the rate of pasture renovation on farmlet A in any one year was deliberately high, ranging from 29% in 2000 through to 9% in 2004. This was a much higher rate than would occur on a commercial farm and had consequences for the availability of paddocks for grazing and periodically resulted in higher-than-normal stock densities being imposed on those unsown paddocks. The changes in the botanical composition of all pasture paddocks in response to the pasture renovation, soil fertility and grazing management treatments have been described in a related paper by Shakhane *et al*. (2013*b*).

Table 2. Summary of pasture establishment details for each paddock sown on farmlets A, B and C over duration of trial

			Herbicide application date, type and rate				Pasture species, cultivar and sowing rate				Farmlet area sown (ha)		Area sown	Cumulative area
Year	Farmlet	Paddock	Herbicide date	Spray type	Herbicide	Rate (L/ha)	Sowing date	Species	Cultivar	Rate (kg/ha)	Initial	Resown	(% of farmlet)	sown (% of farmlet)
2000	A	A3, A4, A5	June 2000	Fallow 1	Glyphosate	3	June 2000	Phalaris	Australian	1.1	15.5	–	29%	29%
	–	–	–	–	–	–	–	Tall fescue	Quantum	9.0	–	–	–	–
	–	–	–	–	–	–	–	Cocksfoot	Porto	0.6	–	–	–	–
	–	–	–	–	–	–	–	Perennial ryegrass	Lincoln	1.1	–	–	–	–
	–	–	–	–	–	–	–	White clover	Huia	0.6	–	–	–	–
	–	–	–	–	–	–	–	Red clover	USA	1.1	–	–	–	–
2001	A	A6	Jan. 2001	Fallow 1	Glyphosate	2.2	April 2001	Italian ryegrass	Conquest	10.0	8.4	–	16%	45%
	–	–	Apr. 2001	Fallow 2	Glyphosate	1.2	–	White clover	Haifa	1.0	–	–	–	–
	–	–	Apr. 2001	Fallow 2	2,4-D amine	1.2	–	Red clover	USA	1.5	–	–	–	–
2002	A	A1	Nov. 2001	Fallow 1	Glyphosate	1.8	Feb. 2002	Italian ryegrass	Dargle	10.0	4.6	–	9%	54%
	–	–	Feb. 2002	Fallow 2	Glyphosate	2	–	White clover	Haifa	1.5	–	–	–	–
	–	–	Feb. 2002	Fallow 2	2,4-D amine	2	–	Red clover	USA	1.5	–	–	–	–
	A	A2	Nov. 2001	Topping	Glyphosate	0.35	April 2002	Phalaris	Australian	2.4	9.1	–	17%	71%
	–	–	Feb. 2002	Fallow 1	Glyphosate	2	–	Tall fescue	Quantum	12.0	–	–	–	–
	–	–	Feb. 2002	Fallow 1	Dicamba	0.28	–	White clover	NuSiral	1.5	–	–	–	–
	–	–	April 2002	Fallow 2	Glyphosate	3	–	–	–	–	–	–	–	–
2003	A	A5	Jan. 2003	Fallow 1	Glyphosate	2.2	May 2003	Phalaris	Holdfast	2.5	–	3.0	6%	71%
	–	–	Jan. 2003	Fallow 1	Dicamba	0.35	–	Tall fescue	Jessup	12.0	–	–	–	–
	–	–	May 2003	Fallow 2	Glyphosate	3	–	White clover	NuSiral	1.3	–	–	–	–
	–	–	May–2003	Fallow 2	Dicamba	0.28	–	–	–	–	–	–	–	–
	A	A6	Jan. 2003	Fallow 1	Glyphosate	2.2	May 2003	Phalaris	Holdfast	2.5		8.4	16%	71%
	–	–	Jan. 2003	Fallow 1	Dicamba	0.35	–	Tall fescue	Jessup	12.0	–	–	–	–
	–	–	May 2003	Fallow 2	Glyphosate	2	–	White clover	NuSiral	1.3	–	–	–	–
	–	–	May 2003	Fallow 2	Dicamba	0.28	–	–	–	–	–	–	–	–
2004	A	A1	Nov. 2003	Topping	Glyphosate	0.35	June 2004	Phalaris	Atlas PG	2.5		4.6	9%	71%
	–	–	Feb. 2004	Fallow 1	Glyphosate	2	–	Lucerne	Aurora	6.0	–	–	–	–
	–	–	Feb. 2004	Fallow 1	2,4-D amine	1.2	–	Chicory	Puna	1.0	–	–	–	–
	–	–	May 2004	Fallow 2	Glyphosate	2	–	–	–	–	–	–	–	–
	–	–	May 2004	Fallow 2	2,4-D amine	1.2	–	–	–	–	–	–	–	–
	B	B6	Nov. 2003	Topping	Glyphosate	0.35	June 2004	Phalaris	Australian	2.5	4.2		8%	8%
	–	–	Feb. 2004	Fallow 1	Glyphosate	2	–	White clover	Huia	1.3	–	–	–	–
	–	–	Feb. 2004	Fallow 1	2,4-D amine	1.2	–	Tall fescue	Quantum	12.0	–	–	–	–
	–	–	May 2004	Fallow 2	Glyphosate	2	–	–	–	–	–	–	–	–
	–	–	May 2004	Fallow 2	2,4-D amine	1.2	–	–	–	–	–	–	–	–
	C	C17	Nov. 2003	Topping	Glyphosate	0.35	June 2004	Phalaris	Australian	2.5	4.2	–	8%	8%
	–	–	Feb. 2004	Fallow 1	Glyphosate	2	–	White clover	Huia	1.3	–	–	–	–
	–	–	Feb. 2004	Fallow 1	2,4-D amine	1.2	–	Tall fescue	Quantum	12.0	–	–	–	–
	–	–	May 2004	Fallow 2	Glyphosate	2	–	–	–	–	–	–	–	–
	–	–	May 2004	Fallow 2	2,4-D amine	1.2	–	–	–	–	–	–	–	–

Commencing in 2000 and continuing through to 2004, a total of six paddocks on farmlet A were renovated, due to inadequate content of sown perennial grasses, while the other two paddocks on this farmlet (A7 and A8) were not renovated at all over the experimental period (2000–06) as the latter were judged to have a desirable botanical composition throughout the experimental period. All pastures, except one, were established successfully; paddock A5 required resowing in 2003 as there had been inadequate survival of sown species following renovation in June 2000 due to inadequate weed control, which resulted from only one pre-sowing herbicide application. Two other paddocks, A6 and A1, required resowing to perennial species due to the lack of persistence of the biennial *Lolium multiflorum* pastures, which had been successfully established in 2001 and 2002, respectively. On farmlets B and C, only one paddock of each (B6 and C17) was renovated, in June 2004, with the same perennial species mix as that used on farmlet A.

In order to increase the composition of legumes in the pastures over the duration of the experiment, whenever fertiliser was applied to any paddock, seed of white clover (*Trifolium repens* cvv. Huia, Haifa or Nusiral), which had been inoculated, lime-pelleted and treated with molybdenum, was broadcast over those paddocks of all three farmlets. These surface-sown additions of white clover were applied at a rate of 1 kg seed/ha on average 5 times to each of the eight paddocks of farmlet A, and 1.5 times to each of the eight paddocks and 17 main paddocks of farmlets B and C, respectively.

Fertiliser applications

Details of the soil test results and their relationship to pasture growth and herbage mass are provided in a related paper by Guppy *et al*. (2013). The different fertilisers which were used in response to the nutrient deficiencies detected by the soil tests, together with the approximate nutrient concentration of each, are shown in Table 3. The cumulative quantity of the major nutrients applied in fertilisers to each paddock and the average amount per farmlet are shown in Fig. 2.

Supplements fed

The amount and type of supplement fed on each of the farmlets over the duration of the trial is shown in Fig. 3. The approximate energy and protein content of the various feeds fed is shown in Table 4. In the early part of the trial, some hay and blocks were used on all farmlets. Again, early in the trial, a supplement recommended for stock being grazed intensively, namely a 'loose mix' of grain and minerals was offered only to stock on

Table 3. Analysis of the fertilisers used on farmlets A, B and C over all years from 2000 to 2006 inclusive

Fertiliser	Sulfur (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Single superphosphate	11.0	0	8.8	0
Granulock 15[A]	10.5	14.3	14.3	0
Pasture plus[A]	15.4	0	15.4	0
Pasture P[A]	9.2	0	17.7	0
Pasture special[A]	12.6	0	12.7	0
Pasture 25[A]	5.5	0	4.4	25.0
Sulfur fortified SF 25[A]	26.5	0	7.2	0
GreenGraze[A]	3.2	23.0	5.4	5

[A]Trade name of Incitec Pivot Pty Ltd.

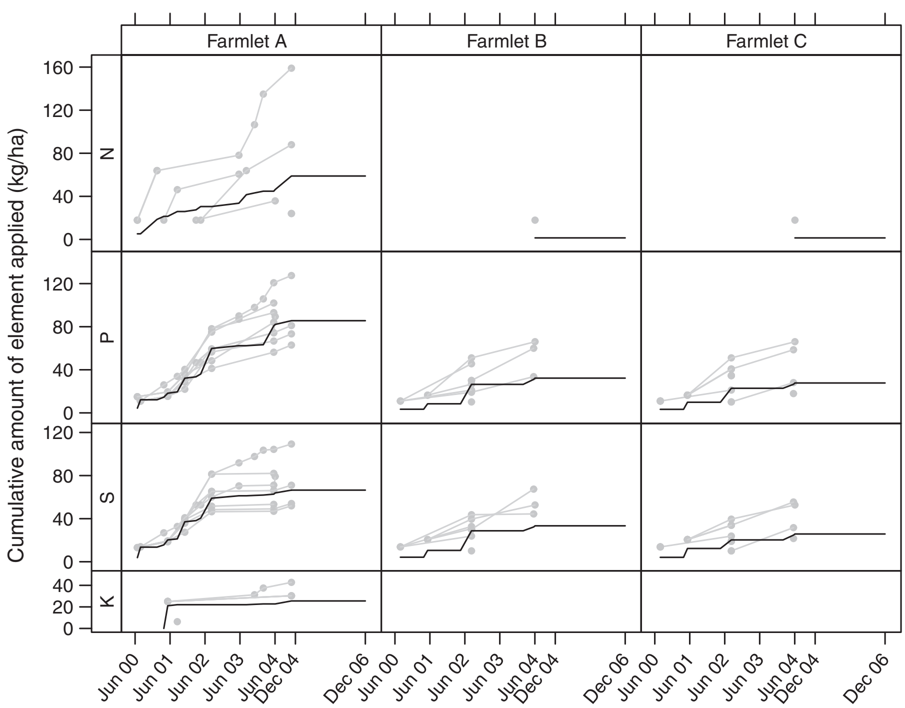

Fig. 2. Cumulative amount of N, P, K and S applied from 2000 to 2006. Grey lines and points indicate individual application times and paddocks whereas black lines show the average over all paddocks of each farmlet for each nutrient over time.

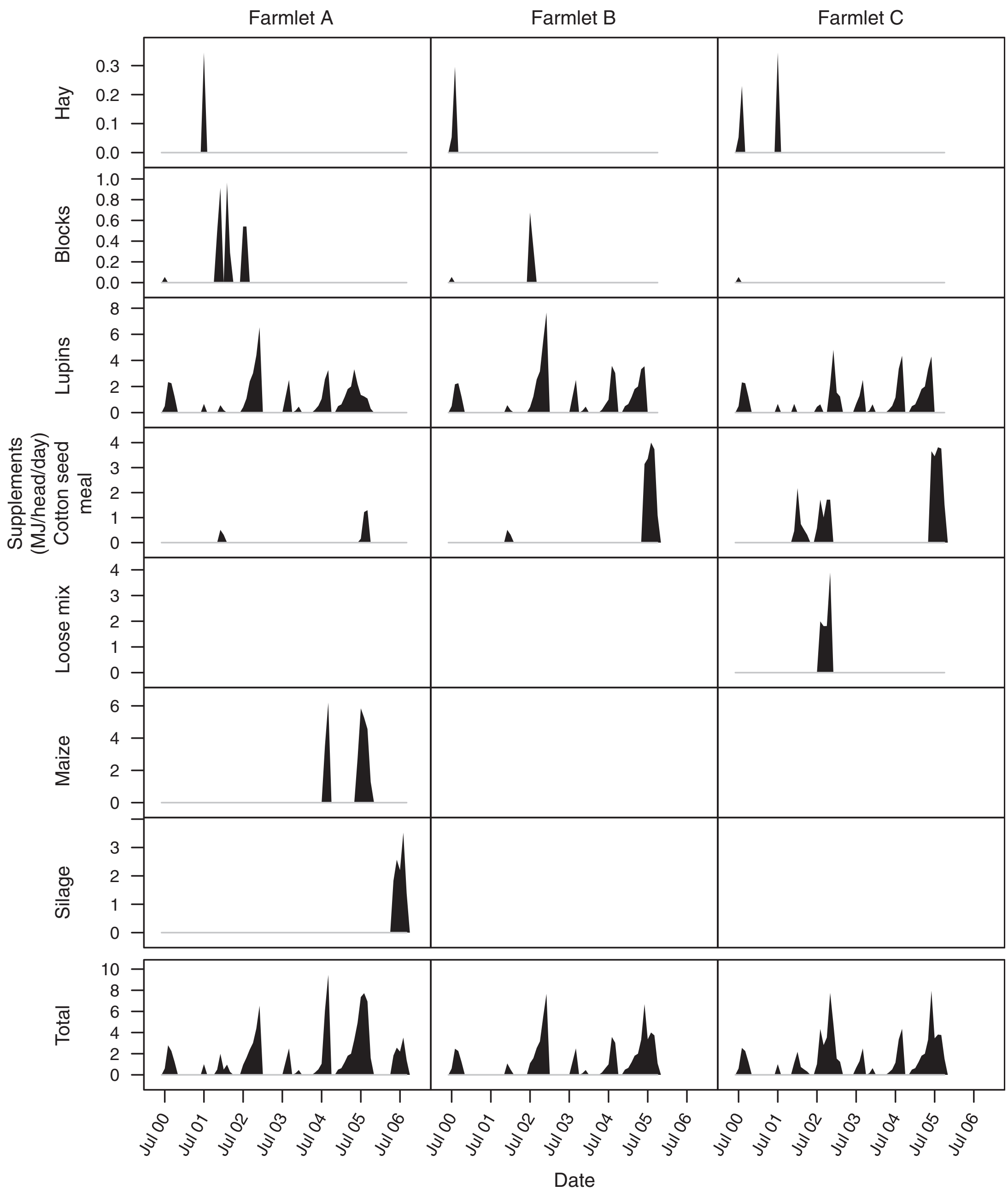

Fig. 3. Type and average daily amount of supplement fed, to those sheep which received supplement, on each of farmlets A, B and C over the duration of the farmlet experiment.

the farmlet practising intensive rotational grazing (C) by allowing animals to self-feed from trailers that moved between paddocks with the stock. Later in the trial, because of the potential for the different feed types to cause confounding of the farmlet treatments, a decision was made to restrict supplements to a common protein supplement such as lupins or, when the price became too high, cotton seed meal. However, when both total and green herbage mass became limiting on farmlet A during the latter part of 2005, maize was added to the lupins and cotton seed meal on that farmlet to provide both an energy and protein supplement for those livestock.

In the spring–summer of 2005, due to a favourable season, one paddock of farmlet A (A1), which had been sown to phalaris (*Phalaris aquatica* cv. Atlas PG), lucerne (*Medicago sativa* cv. Aurora) and chicory (*Cichorium intybus* cv. Puna) was saved for conservation as silage, in part to help reduce the high supplementary feeding costs, but also to help decrease the grass dominance and increase the proportion of lucerne in the pasture. Wet conditions delayed the harvest until late December, by which time the phalaris had gone to head and was over 1.5 m tall, and all plants, including the lucerne and chicory, had large stems and were at an advanced stage of flowering. Nevertheless,

Table 4. Approximate energy and protein composition of the main supplements fed on farmlets A, B and C over the duration of the trial

Feed	Energy content (MJ/kg DM)	Protein content (%)
Cottonseed meal	10.5[A]	41[A]
Lupins	13.0[A]	32[A]
Feed blocks[C]	7.1[B]	30
Loose mix supplement[D]	10.9	15
Hay	9.2	16
Maize	13.3	12
Maize (80%) : lupins (20%)	13.2	16

[A]Source: NSW DPI publication 'Managing drought'.
[B]McLennan *et al*. (2011).
[C]'Rumevite' blocks (Ridley Corporation).
[D]'Dri Lic' mix, Meredith Seeds Pty Ltd, Armidale, NSW.

160 bales of silage were produced from the 4.6 ha resulting in ~8 t DM/ha harvested, albeit of low quality.

The quality of the pasture conserved, both before harvest and of the silage after maturation, was low (Table 5). The results of quality tests and inspection by experts in fodder conservation confirmed that the pasture was too mature at harvest, and insufficiently crimped during harvest, thus preventing the development of anaerobic conditions within some of the bales, leading to substantial spoilage. Nevertheless, by March of 2006, the botanical composition had shifted from the original phalaris-dominated pasture (over 90%) to one composed of ~30% legume, 30% chicory and 30% phalaris and had the highest amount of green herbage available of any of the farmlet paddocks.

During the winter of 2006, in spite of the low quality of the silage, it was fed out to the 477 sheep to support this higher number of stock on farmlet A, while the 247 and 233 sheep on farmlets B and C, respectively, received no supplement in that final year.

Stock movement and stocking rate

In October 2001, a decision was taken to subdivide the initial 17 'major' paddocks on farmlet C into 37 subpaddocks to facilitate achieving short graze and long rest periods. A detailed map of the farmlets and all subpaddocks has been provided in a related paper on the planning of the farmlets (Scott *et al*. 2013*b*). When severe drought conditions occurred in 2002, the farm manager, with advice from those experienced with 'cell' grazing, sought to extend rest periods up to 200 days. Hence, the management Board approved the use of temporary electric fences within some of the farmlet C subpaddocks. Of the 37 subpaddocks on farmlet C, 11 were temporarily subdivided into two parts, five were temporarily subdivided into three parts with the balance of 21 subpaddocks not temporarily partitioned. Thus, the maximum number of areas grazed (i.e. subpaddocks and temporary further subdivisions) on farmlet C comprised $(11 \times 2) + (5 \times 3) + 21 = 58$. The temporary subdivisions of subpaddocks in farmlet C were utilised for only parts of some years as follows: 2002 (August–November), 2003 (April, May, July, September, October), 2004 (March, May, August, September, October, November, December), 2005 (January, February) and 2006 (February, March, November). Monthly details of stocking rates, stocking density, the proportion of each farmlet grazed and the graze and rest periods are shown in a related paper on the liveweight changes of all classes of livestock (Hinch *et al*. 2013).

Figure 4 shows the changes in average annual stocking rate on each farmlet over time. Over the first 2 years, the average stocking rates were 9.5, 7.9 and 9.1 dse/ha on farmlets A, B and C, respectively. By 2005, the stocking rates had changed to 11.2, 7.8 and 7.4 dse/ha for farmlets A, B and C, respectively.

Although the proportion of sheep and cattle, or the percentage of total stocking rate expressed as dse, changed somewhat between years, it was nevertheless approximately equivalent between farmlets within years over the duration of the experiment with 70–90% of dse being run as sheep and 10–30% as cattle (Fig. 5).

The pattern of grazing across the three farmlets, shown in Fig. 6, demonstrates the similar, relatively long graze periods on farmlets A and B and the short graze and long rest periods on farmlet C. The pattern shown for the intensive rotational grazing treatment is similar to that shown for short duration grazing by Heitschmidt and Taylor (1991).

Trees

In an attempt to increase the amount of shelter on each of the farmlets for lambing ewes, a range of exotic and native trees were established on three small woodlots on the south-western edge of paddocks within each of the farmlets. The choice of species, comparison of growth rates and tolerance of the climatic conditions have been described in a related paper by Reid *et al*. (2013).

Discussion

As there is relatively little literature available which describes the methodology used within farmlet experiments, especially those involving significant design and operational input from farmers, it was important to report how this farming system experiment and its guidelines and methods evolved, so that

Table 5. Pasture and silage quality results from paddock A1

Sample	Date	Digestibility (%)	Crude protein (%)	Metabolisable energy (MJ/kg DM)	DM (%)
Pasture	25 November 2005	53.4	5.1	7.6	92.8
Pasture	12 December 2005	54.0	5.1	7.7	90.7
Pasture	23 December 2005	54.9	6.2	7.8	83.6
Silage	6 March 2006	55.0	7.3	7.6	46.0
Pasture after regrowth	14 March 2006	69.0	20.0	10.0	18.4

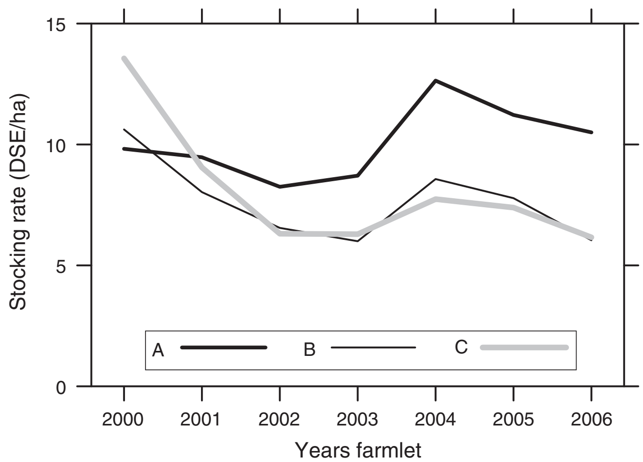

Fig. 4. Annual average stocking rate (dry sheep equivalents/ha) on farmlets A, B and C over the duration of the farmlet experiment.

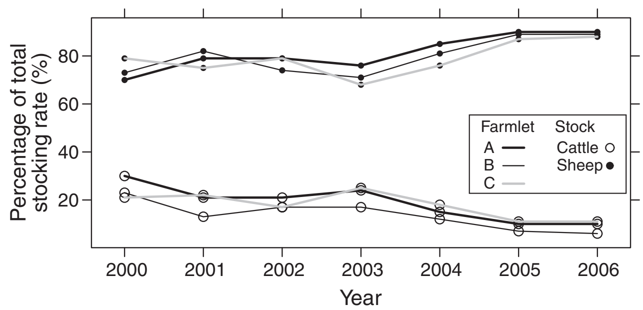

Fig. 5. Percentage of total annual average stocking rate, expressed as percentage of dry sheep equivalents run as sheep and cattle, on farmlets A, B and C over the duration of the farmlet experiment.

others may learn from our experiences. The need for detailed guidelines to operate the Cicerone farmlet experiment is supported by Clark (2010) who noted the need to develop and implement a 'comprehensive set of decision rules' for dairy farmlet studies, in order that they be conducted with sufficient rigour and produce meaningful results.

An important conclusion is that whole-farmlet investigations such as this must have some degree of flexibility. For example, during the severe drought conditions experienced during 2002, a decision was taken to increase the length of the grazing rest period on farmlet C in order to better 'ration' the remaining feed. However, once it became clear that weaner growth on this farmlet was poorer than on the other two farmlets, the grazing rest period was shortened once again. While these changes imposed challenges for the conduct of the research within the farmlets, they nevertheless reflected what the producer-led Cicerone Board regarded as legitimate changes, as they

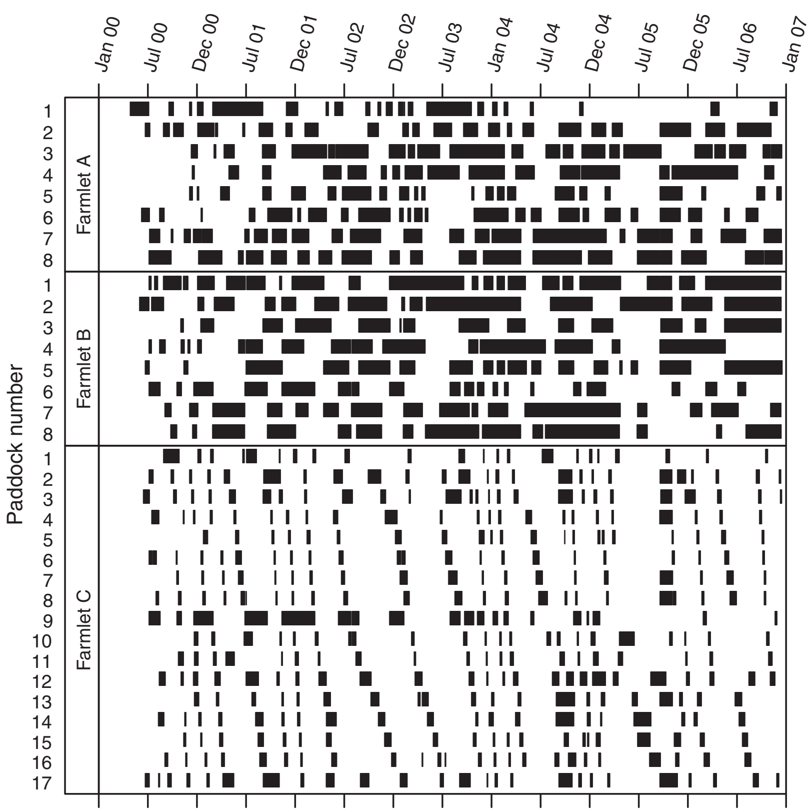

Fig. 6. Daily pattern of grazing practised on each farmlet (A: 8 paddocks; B: 8 paddocks; C: 17 major paddocks). The black bars show grazing periods while white zones indicate rest periods. Grazing records for the 37 subpaddocks grazed on farmlet C have been condensed to the 17 main paddocks on that farmlet in order to simplify presentation of the grazing pattern.

reflected management responses typical of commercially run farms. It is noteworthy that, over much of the experimental period, the management of grazing on farmlet C attracted the most attention of the Cicerone Board. For example, during visits to the farmlets, it was common for the Board to spend more time inspecting the farmlet C paddocks than those on either of the other farmlets.

The outcomes presented in this paper concerning pasture renovation, fertiliser application and grazing management provide convincing evidence that the intended treatments were indeed imposed differentially to create the desired comparisons between the three farmlets. Thus, the inputs on farmlet A compared with the other two farmlets (B and C) and the length of graze/rest periods on farmlet C compared with those on the other two farmlets (A and B) were markedly different.

As noted by Edwards *et al*. (2013), interest in the Project increased over time as more visitors took the opportunity to visit the site. In part, this was because differences between farmlets became clearly and increasingly evident, starting from the first sowing of paddocks which took place in June 2000. Differences became obvious, especially across fence lines separating adjacent paddocks of different farmlets which, at times, showed stark contrasts in species present and/or in herbage mass or quality due to pasture renovation, soil fertility and/or grazing management. Also, throughout the duration of the Project, it was apparent to all visitors to the farmlets that the paddocks had been laid out with great care and the field site created a good impression for all those interested in the experiment.

The principles of establishing pastures through cost-effective means, such as direct drilling, have been explored thoroughly and communicated over many years through successful extension programs (Keys and Orchard 2000). During the Cicerone farmlet experiment, in spite of most years experiencing below-average soil moisture (Behrendt *et al*. 2013), all but one of the pasture renovation efforts were highly successful, thus confirming the value of these principles.

Early in the Project, producer members expressed interest in short-term, so called ‘high performance’ pastures based on annual/biennial ryegrasses, which have been commonly recommended by some pasture seed retailers in the region. However, after two separate paddocks sown to Italian ryegrass (*Lolium multiflorum*) failed to persist beyond 18 months, the focus on the species sown from 2002 onwards on farmlet A, was a simple pasture mixture consisting of persistent, perennial grasses (*Phalaris aquatica* cv. Australian; *Festuca arundinacea* cv. Quantum) and a legume (*Trifolium repens* cv. Huia). In 2004, in an effort to raise the legume component of at least one pasture on farmlet A beyond the relatively low legume content of most pastures to date, one paddock of farmlet A was sown to a novel mixture of lucerne (*Medicago sativa* cv. Aurora), summer-dormant phalaris (*Phalaris aquatica*, cv. Atlas PG), chicory (*Cichorium intybus* cv. Puna) and white clover (*Trifolium repens* cv. Huia). After a harvest of silage, the lucerne proportion increased and contributed substantially to increasing the overall legume composition on farmlet A.

In January 2005, following a generally dry 2004, which had been a challenging year to manage pastures and livestock, a meeting of Cicerone members who reviewed the farmlet experiment pointed out several ways in which the trial could be improved. Some of the recommendations included: to provide access to data summaries of stock movements in a more timely way; to simplify the complex data collected to facilitate management decisions, especially for ewes at joining, shearing and weaning; to improve management of ewe liveweights and fat scores, especially during pregnancy and weaner growth over the summer–autumn period by documenting the relationship between pasture herbage mass, percent green and digestibility using Prograze benchmarks; to explore how stock moves might be better synchronised with soil moisture and temperature; to consider indicators of ‘sustainability’ in addition to ground cover; and to improve the management of internal parasites of sheep by more deliberate grazing of cattle ahead of sheep. However, it was also acknowledged that to understand all of the data collected thus far in a timely way, was beyond the resources available to the Cicerone Project at that time.

As shown by a survey of Cicerone members reported in a related paper by Edwards *et al*. (2013), the way in which each of the three farmlets was managed was thought to have been appropriate and each system was considered relevant to commercial practice. For example, many Cicerone producer members have portions of their farms where high inputs allow stock fattening while other parts are grazed for long periods and yet other parts where they manage parasite control through intensive rotational grazing. Nevertheless, the highest proportion of producer members identified with the ‘typical’ management strategies of farmlet B.

In spite of the problems referred to above, of timely access to data summaries during the trial, having a comprehensive database throughout the trial was found to be of great value as it enabled the delivery of a wide array of data to different participants from a single data repository. In addition, the database was an essential tool which enabled the preparation of publications for this Special Issue. However, it proved to be difficult to maintain and allow access to up-to-date results for multiple users. Other large experiments have benefited from the provision of full-time database expertise (Scott and Lord 2003) and there is little doubt that this would have greatly assisted the conduct and reporting of results from the Cicerone Project.

In contrast to grazing studies conducted largely by researchers, the Cicerone Project was encouraged by its members to create a realistic comparison of grazed systems, at a scale credible to, and with real participation from, livestock producers. Changes to more traditional grazing experiments were called for several decades ago by Murtagh (1975) who saw the need for a ‘second generation of grazing experiments to investigate finer details of the forage-animal complex than can be studied with the classical, long-term, fixed stocking rate designs’. He called for experiments to accommodate the need for different pasture management strategies and stocking rates as well as to include changes in grazing intensity over different seasons so that animal production could reflect the changes in pasture quantity, quality and ‘accessibility for grazing’. Support for this type of whole-farm experimental approach can also be found from Morley and Spedding (1968) who stated ‘Unless experiments are planned with actual systems in mind they may well turn out to be irrelevant’.

The scale of experimentation in the Cicerone farmlet experiment might be considered by some to be large from a research perspective but small compared with commercial farms, which average 920 ha in the Northern Tablelands region (Alford *et al*. 2003). As noted by Spedding and Brockington (1976), larger experiments are better suited to examining complexity and, especially where the examination of the movement of large numbers of animals and the labour involved in such systems, then sufficient scale is essential. They also noted that system boundaries need to be established in such a way that transfers between systems are minimised. Tanaka *et al*. (2008) also highlighted the challenges of undertaking experiments over relatively large areas with large numbers of animals in ways that provide publishable objective data without compromising the many factors which make up a farm system.

The Cicerone farmlet experiment was fortunate to have had a secure lease of the experimental land for its duration. When long-term studies are run on commercial properties, there is the risk that the livestock producer may decide to change enterprises or to sell livestock required for the experiment. There have also been instances where the land has been sold before completion of an experiment (Norton 2008).

Details of the results of the Cicerone Project farmlet study are contained in companion papers in this Special Issue. While too numerous to list here, they include detailed assessments of the effects of climate, and of farmlet treatment on soil fertility, pasture composition and growth, herbage mass and quality, livestock performance and product quality as well as economic and optimisation analyses.

It is to be hoped that the description of the process of selecting treatments for this farming systems experiment, and of the evolution of the methods employed, will provide a valuable legacy for any who choose to go down a similar path of comparing and measuring credible-scaled grazed farmlets in the future.

Acknowledgements

Financial support for the Cicerone Project was generously provided by Australian Wool Innovation, the Australian Sheep CRC and the University of New England. Substantial in-kind support was also provided by the NSW Department of Primary Industries, the University of New England, CSIRO Livestock Industries and Betty Hall Pty Ltd.

Development of the guidelines for the conduct of the Cicerone Project farmlet study was assisted by many people including the Cicerone Board as well as by David Abbott, Evan Barnet, Kim Barnet, Charles Belfield, John Cordingley Snr, Robin Dobos, Murray Fenwicke, Tony Gall, Brian Gream, Doug Laurie, John McKemey, Richard Maclean, Col Mulcahy, Andrew Page, Julian Prior, Ron Shaw, Fay Tully and Glen Tully. Grateful acknowledgement is also due to Warren Nancarrow for the supply of cattle, to Betty Hall for veterinary advice and to Steve Atkinson for assistance with animal ethics compliance procedures. Database support was provided by Jim Cook, Colin Lord and Dion Gallagher while analytical support was provided by Duncan Mackay.

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