Improved forages to enhance hill country sheep production

T.J. FRASER[1], D.R. STEVENS[2], R.W. SCHOLFIELD[3], B.J. NELSON[4], A.J. NELSON[4] and S.M. SHORTLAND[5]
[1] *P.O.Box 69009, Lincoln 7640, New Zealand*
[2]*AgResearch Ltd, Invermay Research Centre, Private Bag 50034 Mosgiel, New Zealand*
[3]*Whangara Farms, Main Road, Gisborne, New Zealand*
[4]*248 Potaka Road, Aria 3979, New Zealand*
[5] *Farmlands, 390 Childers Road, Gisborne, New Zealand*
fraserpastoral@xtra.co.nz

Abstract
Recently, sheep and beef farms in New Zealand have been out-competed for prime land by dairy and horticulture farming. This means that industry targets to increase sheep and beef production have to be achieved on farms with constraints on pasture production. They are increasingly restricted to hilly and other locations with variable climates and soils, and landscape constraints on farming practices. These challenges lead to the formation of two on farm projects within the Beef + Lamb New Zealand Demonstration Farm programme to improve production from permanent pastures on sheep and beef farms. The first of these was a 4 year evaluation at Whangara Farms North of Gisborne looking at improving forage supply on both non-cultivatable hill and flat to easy country through spraying out existing vegetation and oversowing or direct-drilling with white clover and plantain. The second project at Aria in the King Country concentrated on improving the forage quality and quantity at critical times of the year. Clovers and plantain were established through cultivation. Both projects showed that forage and animal production increased after the introduction of clovers and plantain. However, plantain at Whangara did not persist beyond the fourth year from sowing. Poor white clover establishment at Aria resulted in substituting red and white clover for plantain from the second year with improved forage and animal performance. At both sites the costs associated with introducing new forages was repaid within the first 2 years.

Keywords: hill country development, forage species, forage quality, whole farm systems

Key messages
- Get the basics right using fencing, stock water, fertiliser, and then new forages if needed
- Don't expect miracles. Developing an unforgiving environment with 100 years of reseeding by less desirable species
- Hill country pastures are nitrogen deficient so clover establishment and persistence is key
- There are multiple impacts that mean that the rest of the farm system also needs to adapt. Often, this relieves pressure from the rest of the system and helps it perform better as a result.

Introduction
'It is estimated that currently half of our mixed livestock farming businesses are located on hill land and, from the 6.0 million ha involved, approximately 65% of lamb and prime beef cattle are supplied as store or finished animals. As the easier land classes continue to be consumed by the dairy industry we can expect these percentages to increase. Do not tell me that hill farming is unimportant to New Zealand's red meat industry and supply chains' (Sheath 2011). Since this statement was made even more of the higher producing land has been consumed by the dairy industry, so the problem has become greater.

All-year grazing of livestock on steep, non-cultivatable hill country (>20° slope, <1000 m elevation) is a prominent feature of New Zealand pastoral agriculture. Hill country pastures are in various states of improvement depending on factors such as extent of subdivision, fertiliser inputs, plant species introduction, and grazing management. Numerous introduced grass, clover and herb species are available to match the many micro-sites in steep hill country (Kemp *et al.* 1999). There has been increasing use of the perennial herbs chicory (*Chicorium intybus*) and plantain (*Plantago lanceolata*). Advantages of these species include tolerance of drought and high summer temperatures, highly palatable foliage, enhanced mineral content, and high animal growth rates (Stewart 1996).

Most hill country sheep and beef farms throughout New Zealand have some component of flat to easy land. The total area on any property that is available for intensive forage production varies from farm to farm. However, all too often, hill country farmers will spend considerable effort and money on non-cultivatable hill country while there is still easy land that is not performing to potential.

This paper reports on 4 years of on-farm evaluations on two hill country sheep and beef farms in the North Island of New Zealand. The aim was to demonstrate

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

the impacts of improvement of the forage supply and quality on the non-cultivatable and/or cultivatable parts of the farm and to understand the relative value of these improvements on lactation performance and growing young stock. This understanding should better inform the relative benefits from improving different land classes for overall farm profitability.

Methods

Farm descriptions

Whangara Farms, 30 kms north of Gisborne is a partnership between two Māori incorporations and covers 7100 ha. The 70 000 stock units are made up of 32 500 Romney ewes, 8000 ewe hoggets, 1600 Angus cows and 3500 head of rising-one- and rising-two-year-old cattle. It employs 15 staff and won the 2009 Ahuwhenua Māori Excellence in Farming Award. Rainfall averages 1200 mm and ranges from 800-2000 mm. Altitude ranges from sea level to 280 m a.s.l. Soil types are ash overlay, pumice, sedimentary and clay. Contour is 10% flat, 40% rolling, 40% medium-hill and 10% steep.

On Whangara there were two different approaches to improving the forage supply. The first examined the capability of steep hill country to improve lactation performance of mixed age ewes using clovers and plantain. Secondly, the role of plantain-clover pastures to grow hoggets up to a mating weight of 60 kg as 2th ewes on rolling land, through direct-drilling.

Blair and Anna Nelson farm 1100 ha effective including 60 ha of lease approximately 5 km west-south-west of Aria in the King Country. The average rainfall is 1400 mm. The Mokau river (30 m a.s.l.) is the boundary for approximately 5 km. The farm has 700 ha of hills that are predominately Mahoenui clay, with the best of the flat to rolling country being Mairoa ash. There are three types of flats: ash, clay and sedimentary river flats. Floods can occur every 2-3 years and can cover up to 30 ha. There is about 400 ha that is intensively sub-divided into bull-finishing blocks.

Current winter stock is 4000 ewes, 1350 ewe hoggets and 220 breeding cows including 70 first calvers and 560 2-year-old Friesian bulls. Bulls are finished at 15 months, averaging 280 kg. Bull purchases are based on feed budget from October through to September, to provide flexibility. The aim of the Beef + Lamb New Zealand Demonstration farm programme was to improve farm gross margin by $200 000 annually by increasing gross margin per hectare from $700/ha to $900/ha.

Whangara

A range of paddock scale demonstrations were initiated on Whangara.

Non-cultivatable hill country

The lactation performance of mixed-age ewes was the target of improvements made to non-cultivatable hill country (>15° slope).

Twenty hectares of non-cultivatable browntop (*Agrostis capillaris*) dominant hill country with low clover content was sprayed out with appropriate chemicals and sown by helicopter in April 2012, with a pasture mixture of plantain (10 kg/ha), red (*Trifolium pratense*) (3 kg/ha) and white clover (*Trifolium repens*) (4 kg/ha). The area was subdivided into four 5 ha paddocks. Ewes and cows were used to trample the seed in and 50 kg/ha of urea was applied after the first grazing in spring. Maintenance sulphur superphosphate (0, 8.6, 0, 14.8, 0, 20) was applied annually at 250 kg/ha. An adjacent 5 ha area of resident pasture was fenced and used as a control area. All treatments received the same management over the duration of the trials. Stocking rates during trial periods, derived from available herbage mass measured by rising plate meter at grazing time, was the only variable.

In spring 2012 the plantain area was set-stocked from early August with triplet-bearing ewes at 11 ewes/ha on the plantain/red/white clover area and 5.5 ewes/ha on the old pasture. In spring 2013 the area was stocked with twin-bearing ewes at the same rates as determined by pasture covers at time of set-stocking. Ewe number were adjusted at docking to ensure similar herbage allowance across treatments.

In early spring 2014 a further 20 ha area of steep hill country was sprayed out and sown to summer brassica. A second spray in late March removed the remaining brassica and half the area was sown to a plantain-clover seed mix in early April. The remaining 10 ha was sown to a perennial ryegrass-clover seed mix in late April. This was later than planned, due to late availability of ryegrass seed. Both areas were then stocked with twin-bearing ewes in early spring.

Plant counts from ten, 0.25 m^2 quadrats, were measured at three locations across three altitude and contour aspects in spring 2014 and autumn and spring 2015.

Direct-drilled plantain-clover pastures

To achieve liveweight gain goals for both lactating and growing ewe hoggets, 30 ha of plantain-clover pastures were established in autumn 2012 by direct-drilling with a plantain and white clover mixture following spraying out existing pastures. There was no break crop before establishing the plantain pastures. An existing old pasture was retained as a control. These areas were of rolling contour (<15° slope).

The area was subdivided into blocks of approximately 5 ha with provision to further subdivide with temporary electric fences. A further area of 10 ha of resident

pasture was identified (subdivided into two 5 ha blocks) as the control treatment. Maintenance fertiliser was applied annually with up to 50 kg/ha of nitrogen being applied as urea in spring. Rotational grazing was practiced throughout the year apart from some set-stocking during early lambing.

Three evaluations were carried out to determine the relative benefits of the plantain/clover mixtures for hoggets.

Twin scanned hoggets

In spring 2012 (Year 1) the impact of plantain-clover pastures on lactation performance of twin-bearing hoggets was assessed. Ewes were set-stocked from 2 weeks before lambing and then rotationally grazed from docking to weaning with a minimum regrowth period of 21 days. Stocking rates of 15/ha and 21/ha, on old pasture and plantain, respectively, were allocated based on herbage mass at set-stocking and were adjusted at docking to 13 and 19, respectively, by removing wet/dries. Lamb and hogget liveweights were recorded at weaning at 100 days after the mean lambing date.

Grazing method

In Year 2 rotational grazing was compared with set-stocking during lactation. Twin- and single-bearing hoggets were set stocked before lambing. The rotational grazed treatments commenced at docking, approximately 3 weeks after mean lambing date.

Stocking rates were derived from herbage mass at set-stocking and were adjusted at docking to maintain a similar herbage allowance across treatments.

There were 6 comparisons:

- Plantain pastures: twin-bearing and single-bearing, rotational grazed and set stocked.
- Control pastures: single-bearing, rotational grazed and set stocked.

Achieving satisfactory two-tooth mating weight

In Year 3 the spring growth rates of unmated hoggets of approximately 11 months of age were investigated on plantain-clover mixes. The lightest 430 rising 2th ewes, average weight 34 kg with BCS 2.0, were rotationally grazed around 18 ha of plantain pastures from 7 August 2014 to the end of November 2014. All animals, apart from 50, were treated with a long-acting anthelmintic for internal parasite control at the commencement of the demonstration. Animals were weighed at the start and end of the period.

King Country

Blair and Anna Nelson used a whole-farm systems approach with the aim of improving gross margin from $700/ha to $900/ha by:

- improving feed supply/demand decisions
- improving feed quality through establishing a high performance area.

A high performance area on the cultivatable part of the farm was developed in an attempt to optimise production. The approach aimed to produce more, higher quality feed and use this for:

- growing out young stock so they reach a higher liveweight earlier
- fully feeding 'at risk' ewes during lactation by lifting weaning weights and reducing variation, resulting in fewer light ewes at weaning
- bringing mean lamb drafting date forward so more sold at higher schedule prices.

The planned changes to introduce a high performance forage area and changed stock policies were predicted to affect feed supply and demand and farm cover. Stock policies changed to increase peak demand to 30 kg DM/ha or 91% of potential pasture growth rate, reducing the peak summer cover to 2000 kg DM/ha. Pasture supply potentially increased through summer and autumn to reduce the feed deficit at this time. Farm cover was predicted to be less variable and a lambing cover of 1 500 kg DM/ha was likely to be more achievable.

A 4 year pasture rotation was investigated. Profitability was dependent on achieving lamb growth rates of 220 g/day and increasing the performance of hoggets and triplet-bearing ewes. This short rotation would also enable the farm to:

- increase the area of winter brassicas or fodder beet - to improve the reliability in wintering large numbers of bulls for the spring pasture flush
- improve autumn forage growth rates, including the introduction of annual ryegrass.

A plantain/clover mixture was used in Year 1 but issues with plantain moth and lower than projected animal performance, led to the introduction of red clover/white clover pastures in Year 2 and their use has continued.

Results and Discussion

Whangara

Non-cultivatable hill

The overall establishment of the plantain clover pastures in Year 1 was satisfactory. While there was successful establishment of sown species in areas of medium slope where the death of resident species was complete, the establishment in some of the steep areas was poor. The problem was compounded by uneven seed distribution from the helicopter.

By the end of Year 2 there was ingress of resident grasses and by the end of Year 3 these species dominated the sward. No weed control was applied throughout the trial period. Clover contribution to the overall pastures continued at a satisfactory level but it was not possible

to separate the effects of sowing new seed or improved subdivision and grazing management, or the initial spraying.

In Year 1 at docking, 5 weeks from set-stocking, the ewes were removed from all areas due to low covers so no weaning weights were obtained.

In Year 2 the increase in stocking rate and a small increase in lamb weaning weights increased liveweight weaned by 207 kg/ha (Table 1) and resulted in the recovery of development cost during this lactation period. Costs to spray out the existing vegetation, seed cost and application was $521/ha (2012 costs) while the estimated increase in animal production was $517/ha (2012 prices).

The hill country area that was sown into plantain and clovers in autumn 2014 following a summer brassica crop established successfully but low plant numbers of the introduced species were evident in some areas of steep contour. A future option may be to leave existing vegetation on areas of potentially low production to maintain some cover due to limited potential to establish new plants. The two sprays that were applied, before the summer crop and then before the permanent pastures were sown, killed most of resident species.

Plant counts (Table 2) show a high number of seedlings in October 2014 from the April 2014 sowing, with some decline in numbers through to April 2015. Pasture composition (Table 3) showed a satisfactory contribution from the clovers, but as was the case with the earlier sowings, it was difficult to maintain plantain. Resident grass species were already starting to make inroads and with no chemical intervention it was expected that they will dominate by Year 3. There was no evidence of plantain reseeding in any of the steep contour where initial establishment was poor.

Thistles were the main initial weed problem (Table 2) being prevalent whenever there was desiccation of the existing vegetation. These numbers tended to decline by Year 3.

The area sown to perennial ryegrass pastures in late April 2014 established slowly and by spring carried less than half the stocking rate of the plantain-clover pastures. By spring 2015 this pasture had still not fully recovered and may struggle to ever reach their potential. There were less than half the grazing days on these pastures compared to the plantain-clover pastures over the 12 months from establishment. Delaying autumn sowings of the perennial species must be avoided at all costs.

Direct-drilled pastures

The overall objective for these trials was to improve forage quality and quantity on cultivatable land to improve hogget performance before their inclusion in the flock at 18 months of age. The results from the first 3 years on these pastures has satisfied these objectives. The use of plantain-clover pastures during lactation increased lamb growth rate by approximately 30 g/day and lamb weaning weight by 279 kg/ha (Table 4) and so

Table 1 Results from the Year 2 lactation trial where twin-bearing ewes were set-stocked from 3 weeks before lambing until weaning on old pasture or plantain-clover mixes.

	Old Pasture	Plantain-clover
Stocking rate (ewes/ha)	5.5	11
Lambs weaned /ha	9.2	17
Lamb weaning weight (kg)	25.5	26.0
Lamb liveweight (kg/ha)	235	442
Value of increased liveweight (valued at $2.50/kg)		517
Costs $		521

Table 2 Plant counts in October 2014 and April 2015, after an April 2014 sowing of plantain-clover pastures, at the top, middle and bottom of a hill slope.

	Plant counts			
	Plantain		Thistles	
Plants/m^2	Oct 2014	Apr 2015	Oct 2014	Apr 2015
Top	86	67	2.5	1.1
Middle (flat)	123	92	1.2	0.9
Bottom	125	60	1.1	1.3

Table 3 Species composition, at the top, middle and bottom of a hill slope, of plantain-clover pastures sown in April 2013.

	Species composition (% of DM)							
	Plantain		Clover		Grass		Weeds	
	Oct 2014	Apr 2015	Oct 2014	Apr 2015	Oct 2014	Apr 2015	Oct 2014	Apr 2015
Top	36	32	21	16	25	45	17	7
Middle	61	61	21	14	11	14	7	3
Bottom	48	40	26	21	17	35	9	4

yielded a $697/ha advantage in value of lamb weaned (valuing the liveweight at $2.50/kg).

The cost of establishing the plantain-clover pastures, (spray, direct-drill and seed) was $453/ha; therefore, these costs were recovered from the increase in lamb performance. The ewe hoggets grazing the plantain-clover pastures reached 57 kg at weaning in late December, 3 kg heavier than ewes grazing the old pastures.

The use of rotational grazing from docking onwards was compared with set stocking for hoggets during lactation on plantain-clover mixes and grass pastures in year 2. Rotationally grazed ewes were heavier than those set-stocked (Table 5). Plantain treatment ewes were on average heavier (59.2 kg) than the ewes grazing the old pastures (57.7 kg). Finally, lambs were of a similar liveweight from both grazing methods at weaning. Pasture growth was greater than demand on the plantain-clover mix and so five dry hoggets were added at docking to control pasture covers. Rotational grazing and adding dry stock both provide an opportunity for graziers to control growth and follow best management practice to meet the grazing needs of the plantain-clover pastures.

The performance of the lightest rising 2th ewes was measured on plantain/clover mixes during the spring of 2014 (Table 6). From a starting liveweight of 34 kg, the ewes reached 55 kg by the end of November. The growth rates and improvement in body condition score (BCS) for these light ewes was satisfactory. The ewes were grazed at a stocking rate of 24/ha for the duration of the trial.

Table 4 The performance of lambs reared by hoggets on old pasture or plantain-clover mixtures in North Island hill country from birth to weaning.

	Old pasture	Plantain-clover mix
Ewe stocking rate	15	21
Lambs weaned	24.5	35
Lamb liveweight (kg)	21.6	24.3
Lamb liveweight gain (g/d)	185	214
Lamb liveweight weaned (kg/ha)	431	710

King Country

White clover established poorly in plantain-clover pastures in Year 1 resulting in a high dependence on nitrogen and an open stand. Other problems that emerged over the first 2 years were the invasion by the weed Penny Royal that limited production and proved difficult to control. Pure plantain or plantain with low clover content in the swards required nitrogen fertiliser to maintain productive pastures. This decreased production particularly during hot/dry periods.

Lamb growth rates of 220-240 g/day were anticipated but growth rate on pastures with plantain with a low

Table 5 A comparison of rotational grazing and set-stocking from docking until weaning of hoggets rearing twins or single lambs on plantain-clover or old pasture.

	Plantain-clover pasture				Old pasture	
	RG[1] Twin	SS[2] Twin	RG Single	SS Single	RG Single	SS Single
Stocking rate at docking (ewes/ha)	19	19	21	21	18	16
Ewe liveweight at weaning (kg)	59.1	58.4	60.1	59.2	58.1	57.3
Lambs weaned /ha	32	28	21	21	18	16
Lamb weaning weight (kg)	25.4	24.7	27.5	27.8	25.5	24.5

[1]Rotational grazing;
[2]Set-stocking

Table 6 The liveweight and body condition score change of rising 2th ewes on a plantain-clover pasture.

	Date				Gain
	7-Aug	11-Sep	14-Oct	30-Nov	7 Aug - 30 Nov
Liveweight (kg)	34	39	47.5	55	21
BCS	2	2.5	3.5	3.7	1.7
Liveweight gain (g/d)		137	258	163	183

clover content were 180-200 g/day. Plantain moth caterpillar also caused damage to the swards. Lamb survival and growth from birth to weaning were not improved using the plantain to feed triplet-bearing ewes.

All of these issues led to re-examination of plantain-clover pastures. Red clover swards with a low rate of white clover (to provide ground cover in winter when red clover growth slows) were introduced in Year 2 to better meet the objectives. Red clover provides high production of high quality forage because it is better suited to the heavier soils on this farm. It reduces reliance on nitrogen fertiliser by fixing its own, and weeds can be controlled by a range of chemicals.

Measured pasture production on red and white clover pastures ranged from 12 to 16 tonnes DM/ha, exceeding the ryegrass-based production of 10 tonnes DM/ha from the rest of the farm. The feed has proved valuable for finishing lambs, growing hoggets and lambing hoggets. Lamb growth rates of 300 g/day at 30-46 lambs/ha have been achieved in the first season, though these were not as high during the second summer. Lambing ewe hoggets (scanning 128%) were stocked at 16/ha and weaned 91% lambs at 31.5 kg liveweight at 110 days of age in 2014 (Table 7). Stocking rate increased to 20/ha in 2015.

The use of the high performance area has also eased the pressure on the rest of the farm, particularly in spring during lambing and during dry summer months. This has enabled notable improvements in the ewe flock performance (Table 7) with weaning percentage rising by 10% and lamb weaning weight increasing by 4.5 kg, along with an increase in ewe liveweight.

The use of red clover has not been without challenges. It has caused some bloat deaths in cattle (less than 1%), as well as some copper toxicity (1%) and bearings (3-4%) in ewe hoggets. There has also been some reduction in fertility (8% more dry) and fecundity (50% less twins) in hoggets, though the implementation of a 4-day on 4-day off grazing policy during mating (Keogh *et al.* 1996) has reduced this problem. Unfortunately, the on-off grazing resulted in lower hogget growth rates. In future the aim will be to grow all ewe hoggets to target weights before mating and then avoid mating on clover swards. Any under target weight will be mated on clover to ensure adequate weight gains and the loss in fertility/fecundity will be accepted. No evidence of long term effects was seen in the 2 tooth ewes.

The following assumptions were made in calculating the values presented in Table 7. Stock number were 3 750 mixed-age ewes and 1000 ewe hoggets, valuing extra lambs as store sales at weaning at $2/kg liveweight. Increases in lamb weaning weight were also valued using the same method. The value of heavier ewes and hoggets was calculated as the opportunity cost that was created for summer lamb finishing by not having to gain that weight on ewes and hoggets over summer, at a value of $0.25/kg grass spared, and a discount rate of 6 kg of grass spared for each extra kg of liveweight. The value of earlier slaughter date was $5/head as per average carcase schedule prices. Cropping costs for red clover were $1260 /ha, annual ryegrass $1000 /ha, and fodder beet $2200 /ha. The old cropping system using 40 ha, including summer crops, cost $1200/ha.

Table 7 Impacts of a high performance red clover area on production, cost and net returns of a King Country hill country farm.

	Old System	Actual 2014/15	$ value gain (000)
Lambing %	140	150	22
Hogget lambing %	37	91	25
Lamb weaning weight (kg)- Ewes	29.0	33.5	50
Hoggets	25.0	31.5	11
Weaning wt (kg) - ewes	58	65	34
hoggets	56	67	7
Mean slaughter date (kg)	4 March (17.3)	19 January(17.1)	28
Total value ($)			177
Costs of cropping ($ 000)			
Red clover (23 ha)		31	
Annual ryegrass (23 ha)		23	
Fodder beet (23 ha)		51	
Total costs of cropping	48	105	
Difference in cropping costs		57	
Extra income this year			120

Conclusions

Improving both forage quantity and quality can be achieved through the introduction of new forages on North Island hill country sheep and beef farms. In most cases the cost of development was recovered in the first year. However, results may be disappointing if the basic principles are not followed. Even when correct management practices are put in place in establishing new forages there is still a rapid establishment of weeds (resident grasses and thistles) and sown species may only persist for 4 years.

ACKNOWLEDGEMENT

These on farm projects were funded by Beef + Lamb New Zealand through their Demonstration Farm Programme.

REFERENCES

Kemp, P.D.; Matthew, C.; Lucas, R.J. 1999. Pasture species and cultivars. pp. 83-100. *In*: New Zealand pasture and crop science. Eds. White, J; Hodgson, J. Oxford University Press, Auckland, New Zealand.

Keogh, R.G.; Kramer, R.; McDonald, M.F.; Blewman, A.; Crabb, J. 1996. The use of blood equol values in devising grazing management strategies for red clover-based pastures. *Proceedings of the New Zealand Grassland Association 58*: 265-269.

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

Stewart, A.V. 1996. Plantain (*Plantago lanceolata*) - a potential pasture species. *Proceedings of the New Zealand Grassland Association 58*: 77-86.