The management of risk in a dryland environment

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Abstract

A group of 24 Hawke's Bay hill country farmers are working with service providers to improve the resilience of their farming systems. An important step in the process was to undertake an inventory of their risk management strategies. Farmers were interviewed about their farming systems and risk management strategies and the data was analysed using descriptive statistics. There was considerable variation in the strategies adopted by the farmers to cope with a dryland environment. Importantly, these strategies had to cope with three types of drought and also upside risk (better than expected conditions), and so flexibility was critical. Infra-structure was important in managing a dryland environment. Farmers chose between increased scale (increasing farm size) and geographic dispersion (owning a second property in another location) through to intensification (investing in subdivision, drainage, capital fertiliser, new pasture species). The study identified that there may be scope for further investment in infra-structural elements such as drainage, deeper rooting alternative pasture species and water harvesting, along with improved management of subterranean clover to improve flexibility. Many of the farmers used forage crops and idling capacity (reduced stocking rate) to improve flexibility; others argued that maintaining pasture quality and managing upside risk was a better strategy in a dryland environment. Supplementary feed was an important strategy for some farmers, but its use was limited by contour and machinery constraints. A surprisingly large proportion of farmers run breeding cows, a policy that is much less flexible than trading stock. However, several farmers had improved their flexibility by running a high proportion of trading cattle and buffer mobs of ewe hoggets and trade lambs. To manage market risk, the majority of farmers are selling a large proportion of their lambs prime. Similarly, cattle are either sold prime or store onto the grass market when prices are at a premium. However, market risk associated with the purchase of supplements and grazing was poorly managed.

Background

North Island East Coast farmers experienced four consecutive years of drought from 2006. Climate change research predicts that farmers will face increasing climatic extremes (Kenny & O'Brien 2007). This suggests that the future survival of farming businesses in New Zealand will depend upon farmers' ability to design and manage resilient farming systems that can cope with climatic extremes and variability (Crawford et al. 2007). In 2009, a group of 24 Hawke's Bay hill country farmers from the Huatokitoki catchment, 28 kms southeast of Waipukurau, began to work together to improve the resilience of their farming systems. With Sustainable Farming Fund help, and input from Massey University, AgResearch and the Hawke's Bay Regional Council, the farmers initiated a 3-year project to enhance the resilience of their farm businesses. Early in the project an inventory of the risk management strategies the farmers currently use to cope with a dryland environment was completed. This paper presents the results of this inventory.

Approach

A detailed questionnaire was completed during a face to face interview with each of the 24 farmers in the catchment. Information on the farmers, the farms' resources, farming systems, physical performance and the risk management strategies they used to cope with a dryland environment was obtained. The data was analysed using descriptive statistics.

Results and discussion

A high level of diversity exists across the farms. Owner-operators run 22 of the farms and managers run the remaining two. Most farmers are in a period of consolidation and debt repayment (17), one farmer was in the entry phase, five are in a growth phase and one in the exit phase. The 24 farms in the catchment are on average 613 ha effective, run 5279 SU (3607 sheep stock units (SSU) and 1659 cattle stock units (CSU)) at a stocking rate of 8.8 SU/ha (Table 1). Effective farm size and total stock units wintered are slightly larger than the Hawke's Bay/Wairarapa monitor farm (MAFPolicy 2010). The range of effective farm area is 220 ha to 1840 ha, and total stock units 2010 SU (962 SSU and 1048 CSU) to 16656 SU (9540 SSU and 7025 CSU). Four farmers own a second farm (mean = 187 ha) outside the catchment that is used to finish stock from the home farm. Farm size data is skewed because of the presence of one large farm in the catchment and this is reflected in differences between mean and median data (Table 1).

Average annual rainfall varies across farms from 837 to 1400 mm/annum. Contour mix ranges from a farm with 11% steep, 47% rolling and 42% flats to a farm with 82% steep, 14% rolling and 4% flats. Olsen P levels vary from 12.0 to 38.0 and soil pH from 5.5 to 6.1. Research into pasture production by slope class and soil fertility levels (Lopez et al. 2003) suggests that there is considerable variation in pasture production across these farms.

Romney is the predominant sheep breed (13 farms), but eight farmers run a form of composite flock, one pure Texel and two a Perendale flock. All farmers except one breed their own replacements and that farmer buys in high quality replacement two-tooths. Hoggets are mated on 71% of the farms and 37.5% of farmers routinely use Androvax to increase ewe ovulation rates. The proportion of farms on which hoggets are mated is higher than the 58% reported for North Island hill country from a survey conducted by Kenyon *et al.* (2004). Lambing dates range from 29 July until 15 September (mean = 21 August), with weaning dates ranging from 10 November to 15 December (mean = 25 November). One quarter of the farmers sell a mix of store and prime lambs and the remainder sell all their lambs prime, although three farmers finish most of their lambs on their second property. A third of the farmers have a lamb trading policy, buying between 250 and 2200 lambs (mean = 894).

Two-thirds of the farmers run a breeding cow herd and the remaining third run a sole trading cattle policy. Some 58% of farmers run dairy beef and 25% run dairy beef in combination with a breeding cow herd. Only 17% of farmers run dairy grazers. Calving date ranges from 14 July to 5 October (mean = 25 August) and weaning date ranges from late January to early May (mean = 12 March). The predominant breed used is Angus, (50%), but 37.5% of the farmers run cross-bred herds to capture hybrid vigour. Only three of the 16 farmers with breeding cow herds buy-in replacements, and breeding cow numbers range from 28 to 600 in-calf cows (mean = 139 in-calf cows). Although the majority of female progeny are finished at 2 years of age and the majority of male progeny are either sold store as R1yr olds or prime as R2yr animals, there is still a wide range of selling policies.

Only a small proportion (21%) of the farmers run traditional beef trading operations. In contrast, 58% of farmers run dairy beef policies and buy replacements in at a range of ages, with bull calves the most common. The farmers sell their dairy beef either prime or store and anywhere from around 12 – 14 months of age through to over 3 years of age.

Productivity varies greatly across the farms (Table 2), although average farm performance is similar to that of the MAF Hawke's Bay/Wairarapa monitor farm (MAFPolicy 2010). The stocking rate ranges from 6.0 SU/ha to 11.5 SU/ha. Sheep performance ranges from 100% to 150% lambing and 21% to 80% hogget lambing on the 17 farms where hoggets are mated. Wool production varies from 36 kg/sheep ha to 64.7 kg/sheep ha and average lamb carcass weight equivalent sold (store stock adjusted to an equivalent carcass weight) ranges from 12.1 kg to 21.0 kg with a mean of 16.7 kg. This is heavier than the 15.5 kg carcass weight achieved by the high performing summer dry hill country farmer in the study by Gray *et al.* (2008). In terms of total production, net meat and fibre production ranges from 155 to 284 kg/ha.

Strategies for managing dryland conditions

The strategies used by the farmers to cope with a dryland environment are considered for three inter-related decision areas: infra-structure, the matching of feed supply and demand, and marketing.

INFRA-STRUCTURE

Infra-structure decisions can be viewed at a range of levels and relate to a farmer's investment decisions about farm resources. At a strategic level, farmers in the catchment had made decisions along a continuum between expansion and intensification. At the expansion end of the continuum, four farmers all with limited flats (≤ 10% effective farm area) had purchased land locally that would enable them to finish more stock. This strategy differs from a risk management strategy of geographic dispersion (Boggess *et al.* 1985) where farmers buy land in a summer safe area. The strategy of buying additional land reduced market risk, but at the same time increased financial risk. At the other end of the scale, farmers had invested in the intensification of their properties rather than buying more land. For example, one farmer had intensively drained 17% of his property, planted 10% into chicory, subdivided the farm into 113 paddocks and improved his Olsen P levels to an average of 38 with the aim of increasing both the quantity and quality of feed harvested off the property. This farm, although ranked 10th for contour mix (22% steep, 71% rolling and 7% flats), is ranked first for net meat and fibre production per hectare, demonstrating the potential of intensification on hill country productivity.

In terms of drought resilience, the farmers identified water supply, shade, access to yards and accurate scales, subdivision, soil fertility, high quality pastures and good quality sheep and cattle genetics as important infra-structure elements. The least important types of infra-structure in terms of drought resilience identified by the farmers were drainage, deeper

Table 1 Farm size comparison across the catchment

Parameter	Catchment average	Catchment median	Smallest farm	Largest farm	Monitor farm[1]
Effective farm area (ha)	613	505	220	1,840	570
Total stock units	5,279	4,590	2,010	16,565	5,209
Sheep stock units	3,607	3,548	962	9,540	3,523
Cattle stock units	1,659	1,227	1,048	7,025	1,886

[1]MAF monitor farm - Hawkes Bay/Wairarapa (MAFPolicy 2010).

Table 2 Farm performance comparison across the catchment

Parameter	Catchment average	Catchment median	Minimum	Maximum	Monitor farm
Stocking rate (SU/ha)	8.8	9.0	6.0	11.5	9.1
Flock lambing %	130	132	100	150	126
Hogget lambing %	45	50	0	80	
Wool/SSU	5.1	5.3	4.0	6.8	4.8
Wool/sheep ha	45.1	44.4	36.0	64.7	43.8
Average lamb carcass weight equivalent[1] (kg)	16.7	17.0	12.1	21.0	
Net carcass weight + fibre/ha	204	197	155	284	

[1]Equivalent carcass weight of store lambs estimated.

rooting alternative species and irrigation. This was interesting because much of the rolling country and flats on these farms comprise heavy clay soils with natural drainage limitations and at risk from pugging by cattle. Importantly, most of the farms have only limited artificial drainage, although some of the farms have a large proportion of their better country drained for cattle wintering and the introduction of alternative and/or high performing pasture species. Similarly, the majority of farmers have no specialty pastures such as chicory, plantain or lucerne, but one farmer has close to 10% of his farm in chicory. No farmers had irrigation, although some farmers were interested and there is scope for water harvesting. All of these options require a significant capital outlay, but with the improved outlook for commodity prices, there is the potential to introduce these technologies to improve flexibility.

STRATEGIES THAT MATCH FEED SUPPLY AND DEMAND

The summer dry starts in a normal year in late November and continues until the autumn rains in late February or early March. Farmers have feed supply and feed demand strategies in place to manage this normal dry period. Droughts can come in three forms. The first is a spring drought, where conditions became dry in October rather than late November. The second is a normal autumn drought, where the rains do not occur in late February or early March and it remains dry until late April. The final type of drought is a late autumn drought, when it remains dry until late May or early June rather than late April. The late autumn drought has the greatest impact and the late spring drought the least impact because of the respective recovery periods before the next season. Importantly, the farmers' portfolios of strategies have to cope with these three drought types. These strategies can be separated into high level strategies that influenced the general feed supply and feed demand patterns, and seasonally focused strategies.

HIGH LEVEL FEED SUPPLY AND DEMAND STRATEGIES

The farmers adopt a range of feed supply strategies to cope with a dryland environment. Seven farmers run an all-grass system primarily because of crop establishment costs, contour limitations and the risk of crop failure during a dry summer. The other 17 farmers sow a forage crop during late spring for grazing over summer and/or winter, early spring and this is then resown into a summer forage crop before being regrassed in the autumn. The winter forage crops are an important strategy for transferring feed from spring to winter, increasing winter stocking rate and removing cattle off wet soils during winter and early spring. The summer forage crops allow flexibility in a dry season and provide a high quality feed when pasture has low metabolisable energy. Importantly, they allow the farmers to finish lambs rather than sell them store, thereby reducing market risk. Farmers on South Island dryland systems also considered winter forage crops an integral part of their drought management (MAFPolicy 1992).

Another high level feed supply strategy is the planting of deeper rooting and/or more drought tolerant alternative pasture species such as cocksfoot, tall fescue, lucerne, chicory and plantain. However, only three out of the 24 farmers grew chicory and one farmer grew lucerne (average area = 3.7%). MAFPolicy (1992) reported that alternative pasture species made up on average, 8.6% of the effective area of South Island summer dry sheep and beef farms. Similarly, a South Island farm in a study by Avery *et al.* (2008) had 23% of the area sown in lucerne. The area in these alternative species ranges from 0.3% to 9.7% of effective farm area. The major benefit from these pasture species was that they allowed the farmers to grow and finish stock more quickly over late spring, summer and autumn than their traditional pastures because they were of much higher quality and they also produced more feed over the drier months. The farmer with the 9.7% of his area in chicory finishes his lambs in half the time it took on pasture and this allowed him to buy in and finish a crop of trade lambs.

The downside of alternative pasture species is that they produce little feed over winter and if the area in these is increased too much, the farming system has to be adjusted (e.g. shift lambing date later) to compensate for this. The farm in the study by Avery *et al.* (2008) used lucerne to obtain high levels of stock performance over the spring, summer and autumn. Similarly, an early modelling study by Korte & Rhodes (1993) reported that alternative pasture species could improve the profitability of hill country farms provided the improved pasture production and quality could be captured by livestock in a profitable manner.

The use of supplements is another high level feed supply decision. Some farmers have little or no flexibility provided by supplements and others gain considerable flexibility from this set of strategies. Farmers in a study by MAFPolicy (1992) identified feed buffers (forage crops and supplements) as one of the important strategies for minimising the impact of droughts. Similarly, Kinnell (1993) and Gray *et al.* (2008) stressed the importance of supplements in the management of a dryland environment with Kinnell (1993) advocating silage as the cheapest form of supplementary feed. However only a third of farmers make supplement on their farms, with an average amount of 6.3 kg DM/SU (range = 2.0 – 18.2 kg DM/SU) harvested per annum. Of these farmers 56% make silage and 44% make hay. Contour limitations for both harvesting and feeding out, a lack of adequate machinery and a preference to utilise feed *in situ* were the main reason farmers gave for not making supplements.

Some 46% of farmers normally buy in supplements, with an average amount of 4.5 kg DM/SU (range = 0.6 – 9.0 kg DM/SU) per annum. Only five farmers maintain feed reserves and these comprise on average 7 000 kg DM of hay and 4 000 kg DM of silage or around 2.8 kg DM/SU (range = 0.6 – 9.4 kg DM/SU). Only seven farmers regularly use nitrogen fertiliser and their average rate of use is 12.1 kg N/ha/annum (range = 3.3 – 21.0 kg N/ha). The total supplements utilised in a year, including nitrogen, ranged from 0.0 kg DM/SU to 25.4 kg /SU (mean = 8.0 kg DM/SU). A high performing summer dry hill country farmer in a study by Gray *et al.* (2008) used around 14.0 kg DM/SU of silage, hay, balage and grain per annum, along with around 17.3 kg N/ha and retained 7.5 kg DM/SU/annum of silage as a reserve. He used the equivalent of 29.6 kg DM/SU/annum and these supplements provided the system with the capability of coping with both market and production risk increasing the farmer's flexibility. Although they were farming in a drought area, few of the farmers use strategies to manage the market risk associated with different types of "bought-in" feed. None of the farmers forward contract feed, and only a small proportion (≤ 25%) organise grazing and supplementary feed (hay and silage) early to reduce the cost and ensure availability. Kinnell (1993) and the farmer in the study by Gray *et al.* (2008) advocated making decisions early about procuring feed and grazing to reduce costs.

The choice of stocking rate is an important high level feed demand decision. Ten (42%) farmers use idling capacity (reduced stocking rate) as a risk management strategy to improve flexibility. This is less than the 63% of farms reported by Martin (1996) in a nation-wide survey of sheep and beef farmers. On average, the farmers who used this strategy estimated that they are understocked by 15% (range = 7.5 – 25.0%), but admitted they have trouble controlling the spring flush, particularly in a good year. Many of these farmers (60%) had adopted summer fallowing as a means of coping with this problem. In contrast, other farmers believe that maintaining pasture quality through higher stocking rates is important for ensuring good stock and pasture performance over summer. Harvie (1989) commented on the problems of upside risk (above average pasture growth rates) on summer dry farms that have been forced to destock due to drought. In contrast to summer fallowing, he advocated sacrificing the better pastures on the farm, because these could be brought back into production more easily. Similarly, Kinnell (1993) argued that farmers should plan their system for an average year, because these occurred with much greater frequency than a drought year.

Another important high level feed demand decision is how many flexible stock will be carried? "Flexible" stock are stock that are non-essential capital stock on hand at the 1 July that can be sold in a drought situation. An important source of flexibility for the farmer in Gray *et al.'s* (2008) study of a high performing dryland system was his trading cattle policy, high proportion of cattle (> 40%) and the large proportion of cattle taken through two winters. An interesting feature of these farms is the high proportion of breeding cow herds (67%) and the high sheep to cattle ratio (30% cattle). Farmers in a MAFPolicy (1992) study identified that to improve a system's flexibility, they would need to reduce the proportion of breeding cows. Similarly, Kinnell (1993) argued that the breeding cow's feed demand profile did not suit summer dry hill country because it was high over summer and autumn. However, he did provide a caveat on this in that a breeding cow can convert low quality feed into good calf liveweight gains. It may be that farmers have made a trade-off between having flexibility and retaining a class of stock that can utilise and convert poor quality feed into productive output. This trade-off may be particularly important on farms with idling capacity and steeper topography. However, this data does suggest that there may be scope to improve the flexibility of many of the cattle systems.

The lack of flexibility in terms of the breeding cow herd is reflected in the fact that only 54% of the farmers rated their cattle system more flexible than their sheep system. Similarly, only 42% of farmers sell the majority of their cattle as 2-year-olds. Some 58% of farmers are selling the majority of their cattle either store or prime before their second winter. Kinnell (1993) argued that trying to finish cattle at 18 months of age on summer dry hill country was difficult because of feed quality constraints over summer. For this reason, the farmer in the study by Gray *et al.* (2008) finished the majority of his cattle as 2-year-olds. Similarly, McRae (2003) argued that a 2-year bull policy provided farmers with greater flexibility than an 18-month bull policy. Two-year bulls also have higher economic efficiency in terms of gross margin per kilogram of dry matter eaten and can be more easily sold pre-Christmas when premiums exist (McRae 2003), a point also made by the farmer in the study by Gray *et al.* (2008).

Importantly, many of the farmers sold R1yr-old cattle store in the spring to take advantage of the premiums from the grass market and to offload stock before pasture growth rates declined in November. These farmers also stated that this type of system allowed them to take advantage of upside risk and carry cattle into summer if feed and/or market conditions are favourable. The farmer in Gray et al. (2008) also took advantage of the spring grass market to offload store bulls before Christmas. The farmers also noted that because of the clay soils and lack of artificial drainage, it was difficult to winter older cattle without causing severe pugging damage. In contrast, the farmer in the study by Gray *et al.* (2008) used forage crops and self-feeding silage to winter older cattle off-pasture to avoid this problem.

The proportions of flexible cattle, sheep and total stock units run by the high performing farmer in the study by Gray *et al.* (2008) were 100%, 1% and 47% respectively. As such, the trading cattle policy provided the bulk of his flexibility. For the catchment, the average proportions of flexible cattle, sheep and total stock units were 64% (range = 5% – 100%), 9% (range = 1% – 34%) and 27% (range = 4% – 51%) respectively. The majority of farms had less flexible cattle systems, more flexible sheep systems, but less overall flexibility than the farmer in the study by Gray *et al.* (2008). The data also suggests that the farmers' cattle systems are a lot more flexible than their sheep systems in terms of their ability to offload surplus stock. The more flexible cattle systems are those that are purely trading stock (traditional or dairy beef), whereas the more flexible sheep systems had a high proportion of trade lambs and/or wintered buffer mobs of surplus ewe hoggets for sale in late winter or as two-tooths. Harvie (1989) advocated the use of buffer mobs to improve flexibility because without such mobs, farmers were forced to sell capital stock and this inhibited their recovery post-drought. What is most surprising is the range of flexible stock across farms (4% – 51%).

Seasonal management of feed supply and feed demand

A useful way of dividing the year within a dryland farming environment is provided by Avery et al. (2008). They split the year into three phases: 1) revenue phase, 2) risk phase and 3) recovery phase. The "revenue phase" is the period of the year when the majority of the reliable pasture growth occurs (August to November). The "risk phase" is the period of the year when pasture growth is least reliable (December to February). The "recovery phase" is the period of the year (March to July) when the reliability of pasture growth rates improves with the onset of the autumn rains in March. The farmers in this study were asked about the management strategies they use in each of these phases for a normal year and a drought year and their responses are discussed in the following sections.

REVENUE PHASE

All 24 farmers aim to utilise pasture growth to best effect over the spring. To meet this goal, they aim to achieve a high lambing percentage and high live weight gains in stock in much the same way as recommended in other studies on dryland management (Harvie 1989; Kinnell 1993; McLaren 1993; Avery *et al.* 2008; Gray *et al.* 2008). Performance data showed that the farmers achieved this goal to varying degrees. The majority of farmers (83%) aim to ensure their ewes wean at their mating live weight and as many lambs as possible are sold before Christmas. Similar goals were reported in other studies on dryland management (Harvie 1989; Kinnell 1993; Avery *et al.* 2008; Gray *et al.* 2008).

In terms of feed demand strategies, 71% of farmers thought their choice of stocking rate and lambing date were important in ensuring adequate feed is on hand over lactation, a point made by the farmer in the study by Gray et al. (2008). In contrast, only 44% of the farmers with breeding cows thought that their choice of calving date was important in this respect. This was because many of the farmers traded off flexibility in terms of spring feed demand by calving early to obtain good calf weaning weights in the autumn.

The majority of farmers (22 of the 24) ensured high quality feed over lactation by controlling pasture quality and used a range of strategies to do this. Interestingly, none of the farmers specifically grew alternative species to achieve this goal, unlike the farmer in the study by Avery *et al.* (2008), but two of the farmers actively managed subterranean clover to improve feed quality over lactation. Several studies have stressed the importance of high feed quality over spring to ensure high live weight gains so that stock can be finished early to reduce summer feed demand and obtain premiums (Kinnell 1993; Avery *et al.* 2008; Gray *et al.* 2008). Grigg *et al.* (2008) reported on the benefits of managing subterranean clover to maximise yields. Through a range of strategies (fertiliser, lime, sub-division, building up a seed bank, avoiding over-grazing seedlings in autumn, spelling for two months pre-set stocking, controlling spring seed head development) the farmer in the study by Grigg *et al.* (2008) increased subterranean clover content to 40 – 60% of sward dry matter content over spring. Over a 7-year period, this increased lamb growth rates from 258 g/head/day to 350 g/head/day, lamb weaning weights from 29.6 kg to 40.0 kg and through improved ewe weaning weights, lambing percentage increased from 108% to 140%. This suggests there may be scope for enhancing productivity in the catchment through the better management of subterranean clover.

In terms of feed supply strategies, five of the farmers make silage and four make hay to control pasture quality. Forage crops (summer and winter) are used by half the farmers as a means of controlling pasture quality, a strategy used by the farmer in the study by Gray *et al.* (2008). Some farmers mentioned that sowing a forage crop reduced feed supply over spring, but others also mentioned that forage crops allowed them to winter more stock which could then be used to control pasture quality, a point made by the farmer in the study by Gray *et al.* (2008). Summer fallowing, a relatively new practice, is used by 25% of farmers to control pasture quality and protect dry north easterly faces. One farmer uses topping and another farmer has a second farm which allows him to run a high stocking rate system on his home farm to control pasture quality and then off-load if feed is short.

Sheep and cattle are set-stocked together to control pasture quality by 50% of the farmers and 71% rotate cattle around their sheep country for the same reason. Grazers are taken on in the spring by 21% of the farmers to increase feed demand and only 17% of farmers buy in stock over this period for the same reason. All of the farmers aim to transfer feed from the spring to periods of feed deficit (summer, autumn and winter). This is achieved primarily through the sowing of summer (63%) and winter (54%) forage crops, but some farmers use silage (25%), hay (21%) and summer fallowed areas (25%).

RISK PHASE

The primary feed supply strategy used by the farmers to reduce the impact of a normal dry summer is to use summer forage crops (71%) followed by buying in feed (17%), grazing roadsides and river banks (13%) and summer fallowed areas (13%). Only 8% of farmers use specialty pastures, feed grain, use willows and poplars as fodder, or graze forestry blocks over summer in a normal year. Interestingly, none of the farmers feed out hay or silage or use irrigation over summer in a normal year. In a drought year, the use of most of these strategies increases, e.g. bought in feed (33%), grazing roadsides and river banks (38%), grazing summer fallowed areas (25%), grain feeding (25%), feeding willows and poplars (25%) and forestry blocks (21%). In a drought year, 25% of the farmers feed silage and 29% feed hay. The farmer in the study by Gray *et al.* (2008) used summer forage crops, barley and irrigation over a normal summer, but in a drought, he also used silage, willows and poplars, bought in additional grain and grazed winter forage crops.

Feed demand strategies used by the farmers to minimise the impact of a summer feed deficit in a normal year included ensuring: 1) ewes are weaned at their mating live weight (88%), 2) as many lambs as possible are sold before Christmas (71%), 3) the bulk of cattle (50%) and cull ewes (88%) are sold before Christmas, 4) stock are grazed off-farm (8%) and 5) replacement stock are purchased later in the season (54%). Other studies (Kinnell 1993; Avery *et al.* 2008; Gray *et al.* 2008) have stressed the importance of ensuring capital stock are in good condition by weaning, and that the bulk of stock sales are made by Christmas. The farmer in the study by Gray *et al.* (2008) also purchased replacement stock later in the season. In a drought year, more farmers grazed stock off-farm (38%) and purchased stock later in the season (63%). Some 63% of farmers weaned and culled their ewe flocks early and 67% of farmers sold lambs earlier and at lighter weights before Christmas. One farmer delayed lamb sales because lambs were lighter. Only 44% of the farmers with cows wean early and 42% of farmers sell cattle earlier and at lighter weights before Christmas. Unlike farmers in other studies that sell the bulk of their cattle pre-Christmas (November – December), many of the farmers sell cattle in early spring, autumn or winter. A MAFPolicy (1992) study on South Island summer dry sheep and beef farms reported that the most commonly used strategies to mitigate the effects of a drought were selling stock (90%), grazing stock off-farm (55%), weaning early (50%) and substituting pasture for supplement (43%). Similarly, Harvie (1989) stated that the most useful strategy in a drought was destocking. Farmers preferred to sell stock rather than incur the cost of buying in feed or grazing stock off. Secondary strategies in the MAFPolicy (1992) study included rotational grazing, buffer flocks, wintering dry ewes, and reducing replacement numbers.

Data on stock sales in a normal year showed that on average, farmers sell or transfer 27% (range = 0 – 100%) and 31% (range = 0 – 100%) of their own sale lambs by weaning and the end of December respectively. (Some farmers transferred store lambs to another property for finishing). Only 25% of the farmers have 50% or more of their lambs sold by Christmas. Average weaning date for all lambs, including ewe and hogget lambs, is the 27 November (range = 10 November – 19 December). Of these, 69% of lambs are sold through summer, autumn and winter. This pattern of sales reflects the target carcass weights many of the farmers are aiming for. Although the average carcass weight equivalent sold is 16.7 kg, 29% of the farmers normally sell lambs at 18.0 kg carcass weight or above. This average includes the equivalent carcass weight for lambs sold store. Only 50% of farmers aim to have the bulk of their cattle sold by Christmas, with many of the farmers selling over summer, autumn and winter.

The general sales pattern for stock differs markedly from other studies. For example, Kinnell (1993) aimed to have all his stock sold by Christmas, Avery *et al.* (2008) obtained 60% of livestock income over spring, and the farmer in the study by Gray *et al.* (2008) sold 50% of lambs by weaning (late November) and 70% of their cattle by Christmas. This is interesting given a comparison of Hawke's Bay (catchment data) and Wairarapa (from Gray *et al.* 2008) hill country pasture growth rates. Hawke's Bay tends to grow less total dry matter per annum and much less in the period November – December, which would suggest farmers would off-load stock much earlier than the farmer in the Wairarapa study by Gray *et al.* (2008). To manage market risk, the majority of farmers are selling a large proportion of their lambs prime. Similarly, cattle are either sold prime or store onto the grass market. Where possible, cattle are sold into periods of high demand and purchased during periods of high supply. These marketing strategies were also used by the farmer in the study by Gray *et al.* (2008).

RECOVERY PHASE

The farmers use a range of strategies to assist their recovery from a normal dry summer when the rains arrived in early March. Their strategies are designed primarily to manage downside risk. In contrast, Avery *et al*. (2008) mentioned buying in cattle or taking on dairy grazers to utilise the feed during the recovery phase and benefit from upside risk. The feed supply strategies used by the farmers include: autumn nitrogen (25%), late winter nitrogen (29%), winter forage crops (58%), silage (38%), hay (38%), grain (8%), willows and poplars (8%), summer fallowed areas (25%), forestry blocks (21%) and roadsides and river banks (4%). In a drought year, more farmers use these strategies e.g. autumn nitrogen (54%), late winter nitrogen (67%), winter forage crops (58%), silage (58%), hay (75%), grain (33%), willows and poplars (42%), summer fallowed areas (25%), forestry blocks (29%) and roadsides and river banks (29%). Importantly, although all of the farmers had considerable plantings of willows and poplars, many did not use these as a feed source because of the effort and debris associated with their use. This may be an area that needs further research. Kinnell (1993) stressed the importance of silage and nitrogen in relation to drought recovery. Similarly, the farmer in the study by Gray *et al*. (2008) used silage, hay, balage, grain, nitrogen, and forestry blocks to recover after a drought. Avery *et al*. (2008) used winter forage crops (Omaka barley) and browse shrubs (saltbush).

The farmers use a range of feed demand strategies to assist their recovery out of a normal dry summer. These included selling surplus stock before winter (83%), grazing stock off-farm (21%), using body condition (63%), lambing late to coincide lambing with the spring growth (50%) and calving late to coincide calving with the spring growth (4%). Similar strategies were used by the farmer in the study by Gray *et al*. (2008). In a drought year, the number of farmers grazing stock off more than doubled (46%) and slightly more farmers sold surplus stock before winter (88%). Interestingly, three of the 12 farmers that normally lambed late, lambed earlier in a drought year. This was because they preferred to mate their ewes before feed supply declined further as conditions became drier.

Resilience

Although this study describes the strategies used by farmers within the Huatokitoki catchment, it is not the individual strategies that are important, it is the portfolio of strategies a farmer adopts that will determine the resilience of a farming system. Although the farmers in this study believe their farming systems are resilient because they have survived several years of drought, further work is required to identify which portfolio of strategies best enhances the resilience of a farming system. Recent work by Rusito *et al*. (2011) has identified that resilience comprises three elements that allow the manager to cope with different degrees of change in the environment: buffer capacity, adaptive capacity and transformability. Buffer capacity is defined as "the constancy of productivity in the face of small disturbing forces arising from fluctuations and cycles in the surrounding environment" (Conway 1993, p. 50). Adaptive capacity is the degree to which the farm system is capable of responding to a change or shift in the environment (Crawford *et al*. 2007), whereas transformability is the ability of a manager to find new ways of arranging resources when changes in the environment are extreme enough to make the current system untenable (Darnhofer *et al*. 2010).

Rusito *et al*. (2011) identified that useful indicators of buffer capacity were *resistance* (resistance to shocks), measured as efficiency, *latitude* (the ability of the system to distort and return to its original state after a shock), measured as liquidity, and *precariousness* (vulnerability to shocks), measured as solvency. They argued that highly efficient farms are more resistant to shocks, and farms with good liquidity have more latitude to cope with shocks. Similarly, farms with lower debt or debt servicing capacity (the amount of money required to meet debt servicing needs) are less vulnerable to shocks. Rusito *et al.* (2011) in a study of the resilience of New Zealand dairy farm business from 2006 – 2009, a period when milk price fluctuated widely, found that these indicators were useful measures of buffer capacity. However, they also found that farmers who took best advantage of upside price risk did not cope as well with downside price risk. That is, the portfolio of risk management strategies these farmers used to take advantage of upside risk were not as suitable for minimising the impact of downside price risk. Importantly, adaptive capacity was also found to be important in enhancing resilience because some farmers changed their dairy systems to take advantage of, or minimise, the impact of a change in the milk price. Rusito *et al.'s*. (2011) results suggest that a portfolio of strategies that maintain productivity, and enhance efficiency and liquidity will be important in a dryland environment. Their work also suggests that it may be difficult to devise a portfolio of strategies that can be equally effective at taking advantage of upside risk whilst also minimising downside risk. The ability of farmers to adapt their systems will also be important for enhancing resilience.

Conclusions

There is considerable variation in the strategies adopted by the farmers to cope with a dryland environment. In terms of infra-structure, farmers can choose along a continuum between increased scale and geographic dispersion through to intensification. The study identified that there may be scope for further investment in infra-structural elements such as drainage, deeper rooting alternative pasture species and water harvesting.

The farmers used a range of feed supply and feed demand strategies to cope with a dryland environment. Importantly, these strategies have to cope with three types of drought and also upside risk (better than expected conditions), and so flexibility is critical. Flexibility is provided by forage crops, idling capacity and supplements to a lesser degree. Farmers who did not utilise idling capacity argued that maintaining pasture quality and managing upside risk was a better strategy in a dryland environment. Only a limited number of farmers utilised subterranean clover despite there being scope for large productivity gains.

Flexibility is also provided through the choice of livestock policy and the proportion of flexible stock carried. A surprisingly large proportion of the farmers run breeding cows, a policy that is much less flexible than trading stock. However, there are a number of farmers who have improved their flexibility by running a high proportion of trading cattle and buffer mobs of ewe hoggets and trade lambs. To manage market risk, the majority of farmers are selling a large proportion of their lambs prime. Similarly, cattle are either sold prime or store onto the grass market when prices are at a premium. The general pattern of lamb and cattle sales is different from what was expected for a summer dry area and requires further investigation. Market risk associated with the purchase of supplements and grazing was poorly managed by most farmers. A portfolio of strategies that maintain productivity, and enhance efficiency and liquidity will be important in a dryland environment. However, it may be difficult to devise a portfolio of strategies that can be equally effective at taking advantage of upside risk whilst also minimising downside risk. A farmer's ability to adapt their systems will also be important for enhancing resilience. An important area of future research is to understand this diversity of strategies, their impacts on systems resilience and what determines the specific portfolio of strategies a hill country farmer adopts to cope with a dryland environment.

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