Trends in high country pastoral farming
3. Developing and directing emerging options

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Abstract

The integration of investigations into usable farming packages involves both development of particular technologies and conceptual frameworks. This is illustrated for the high country in the particular technologies of hay winter feeding, legume rhizobia seed coating, irrigation, mid-rainfall low input development with perennial lupin, in-situ winter feed systems, ultra-fine wool production, and rabbit and hieracium control. Attitudes or concepts are illustrated by the changing views on high country erosion, environment gradients and specie niche, feed banks, special purpose pastures, farm monitoring, product specification and computer expert systems.

Keywords: concepts, high country, New Zealand, technologies

Introduction

The previous paper in the series listed, and assessed, the importance of some of the technological options used in high country farming. That showed that many of the apparently simple procedures or techniques of today had a complex development history, some known, some unknown.

This paper looks at more recently developed options which can be integrated into existing or changed pastoral systems. Their adoption is influenced by many factors. One is that a change in context or concept within which a technology is seen, can be as important as the technology itself, and some of these concepts will be discussed. A larger and more fully referenced version of the paper is available on request.

Technologies

Hay for winter feed

The provision of winter feed is the main limiting factor in high country pastoral production, and means of supplying it one of the continuing topics of investigation. Summer-saved pasture and hay from "special purpose" paddocks are probably the chief current method of providing winter-feed. Like all good technologies, what seem common and obvious now, were in their time major innovations. The first recorded use of hay for winter feed in the Mackenzie Country was in 1928 or 1929, using sown pastures, imported horse drawn mower, field-dried, fork-lifted and dray-carted, and requiring 2 or 3 years' accumulation to be an emergency ration for young stock.

Legume rhizobia seed coating

Pasture improvement in the high country is based on nitrogen fixation by introduced clover and legumes, for which the associated nodulating bacteria were critical. The use of rhizobia coating of legume seed should now be standard practice. This was preceded by decades of research into importing and isolating the most effective strains by field testing for each legume species; developing mass culture methods; developing coating technologies to retain the viability of the rhizobia while protecting them from the adverse effects of both the aerial environment and the seed coat during preparation and storage; but to establish advantageous micro-environment pH conditions for root inoculation once the seed were in the ground.

Mid-rainfall low input development with perennial lupin

An example of a moderately well researched technology awaiting industry uptake is the potential of perennial lupin as a low-input pasture development option for mid rainfall high country zone.

The development of the potential of perennial or Russell lupin as a high country pasture legume has been outlined in a number of papers. The first indication of the potential of perennial lupins was their success as a roadside introduction, and as a revegetation species on sub-alpine eroded soils. The main indication came from two long-running trials in which lupin was included as one of 20 or so species sown as mixtures under 60 contrasting S and P fertiliser rates and types, grazing intensities and grazing managements. At low fertiliser inputs of 50 kg/ha/year S super-phosphate it became the dominant species relative to all other sown species, and had more sheep grazing days per year than other species at higher fertiliser rates. This is presumed to be owing to its roots having aluminium tolerance and exuding citric acid to release soil nutrients.

A further 5-year trial showed that although the daily liveweight gain on perennial lupin and alsike clover were 53% and 70% respectively of that on red clover at equivalent feed-on-offer, the total fed-on-offer of perennial lupin was nearly double that of the other two species. There is some difficulty in obtaining consistency in establishment from seed, but the main limitation to its uptake appears to be the lack of the conceptual switch from seeing it as a horticultural species or weed, to seeing it as a pasture legume, and the indirect pressure from the conservation lobby who are reluctant to see its increase close to national parks and reserves.

Irrigation potential

Three factors led to consideration of irrigation in the high country in the 1960–70s. There was the known low rainfall in many of the areas; the engineering possibilities of water availability from hydro-electricity developments and previous gold-mining activities; and the realisation that the trend of summer success of legumes in oversowing and topdressing was tending to increase the disparity between summer and winter feed supply.

Irrigation can have moderate to high impact on farm performance, particularly as a means of ensuring winter feed supplies Investigations show that the water component, as compared with the fertiliser component, of irrigation development can increase pasture production 2 to 3-fold. The relative increase is greater in the lower rainfall area and on the shallower soils (moderately deep upland yellow-grey earths – Poolburn soil x3.1; Streamlands soil x3.4 legumes, x2.0 grasses; shallow and stony yellow-brown earth – Mackenzie soil x2.4-7.2; moderately deep upland yellow-brown earth – Pukaki soil x2.6).

There are very high potential annual yields from deep unweathered soils of the brown-grey earth zone, but relatively low yields, even with irrigation and fertiliser, from the shallow outwash soils, which make up many of the inland basins.

In-situ winter feed systems

The scale of high country runs, the often great distance between soils capable of development and existing current infra-structures, and the consequent time and transport costs, has emphasised in-situ winter feed systems. In developing the technologies, there has been investigation of the species to use, the closing dates and times necessary to accumulate adequate reserves before winter, and the feeding value and frosting tolerance of the accumulated material.

With the greater success of legumes relative to grasses in the initial fertilising and oversowing of tussock country, the first investigations were on the extent to which frost-sensitive legumes could be used for winter feed before losing their feeding value. These showed that the alsike clover and tetraploid red clovers, in contrast to white clover, had sufficient frost tolerance to be used to increase sheep bodyweight in early winter, thereby reducing hay requirements for the main part of the winter. Subsequent work has indicated that perennial lupin could be added to the list.

Grasses have greater frosting tolerance than legumes and accordingly a better basis for in-situ winter feed systems. Pasture growth is generally limited by the lack of summer and autumn rain, and even with partially or fully developed pastures, it is necessary to accumulate feed from November or December to have adequate pre-winter standing yields. The best species for retaining their feeding value and frost tolerance in the rank state are timothy, perennial bromes, cocksfoot and tall fescue, though the total available dry matter is more determined by summer–autumn differences in growth rate, with cocksfoot generally the superior species.

A further option is the replacement of legumes by N fertiliser, a high-producing species like tall fescue, in combination with irrigation, to achieve a high-producing single hay crop, some summer grazing, followed by autumn accumulation, and break feeding the stored hay and in-situ standing herbage together during the winter.

Ultra-fine wool

The premiums paid for the finest wools have encouraged Merino growers to breed and select for finer fibre diameter of their flocks. The Ultrafine Merino Joint Venture is consistently producing ewe fleece wools of less than 17 microns, with the potential of whole flocks producing 14 to 15 micron wool. This involved large scale screening of the commercial flocks to identify the finest individuals, which were transferred to a nucleus flock at Tara Hills. Performance records have been used in the nucleus flock to further reduce fibre diameter without loss in fleece weight or liveweight. Processing trials have confirmed the superior performance in high quality fabrics, and are challenging some long-held views over the importance of crimp in these very fine wools.

To increase the rate at which elite individuals in the flock are multiplied genetic markers are being sought and artificial insemination, multiple ovulation and embryo transfer are being used.

Rabbit control

That new technologies do not necessarily solve problems is well illustrated by the rabbit problem. Historically many successive methods have been tried, e.g., rabbit predators (cats, ferrets, hunting dog packs); poisons (strychnine, cyanide, arsenic, 1080, pindone);

manpower (rabbiters, rabbit boards, aerial bating, "killer policy"); district and farm rabbit-proof fencing; shooting; destroying warrens by ploughing, ripping and blasting; viral biological control agents (myxomatosis with flea vector). The current hope is the rabbit calicivirus which is already spreading in Australia. Research is investigating immuno-contraception methods.

It easy to be critical of any of these, as there still are rabbits. But each would be regarded as having been a technological breakthrough in their time, in being more efficient or effective than its predecessor, and we have no way of knowing what the present scene would be without them.

Hieracium control

There are similar trends in concerns and technologies with weeds, e.g., briar and matagouri in earlier periods and the current concern with hieracium species. Five control methods for hieracium have been investigated: differential grazing in different seasons; competitive species; herbicides; oversowing and topdressing; and biological control. Only the last two appear to be practical technologies.

On most of the high country deeper soil the most troublesome mouse-ear hawkweed can be controlled, or at least cease to be a stock management concern, by the fertiliser and oversowing undertaken as part of general pasture development. However, the two requirements are that the pasture species used is appropriate to the level of fertiliser use, and that the fertiliser levels are maintained. The evidence is that hieracium can increase under nil or fluctuating fertiliser inputs.

For the poorer soils and the large conservation estate the only viable option is biological control. Two decades of work have located a rust affecting mouse-ear hawkweed and this is currently being dispersed throughout the high country. Insect control agents are also under investigation. The general comment is that biological control agents for plants do not have the spectacular affect attributed to the rabbit viruses. Most take several years to build up, and their effect may be not to eradicate the weed or pest, but to reduce it to a level that is not of economic importance.

Others

With the increasing value of wood fibre and decreasing value of wool, commercial forestry is being seen as an option for the moderate and high rainfall high country areas, with past and present farm plantations showing high growth rates of douglas fir, ponderosa pine and corsican pine. A mosaic of timber stands and grazing blocks would be preferable to attempting to produce quality timber from shelter belts or agro-forestry stands.

Concepts and viewpoints

Our actions and options are as much influenced by how we see the world, as by the actual tools and technologies that we then use. This is the importance of concepts.

Supply or demand?

One of the most fundamental views that may vary is whether high country agricultural output should be resource-supply driven or product-demand driven, e.g., whether to work forward from the agricultural options for each class of land in developing a viable farming system, or work back from desired product and allocate resources as suits that objective. The outcome will always be some compromise between the two, but the final mix will differ according to which stance predominates, e.g., should a super-fine wool enterprise have priority on any high quality soils that may occur within a run boundary?

High country erosion

This topic illustrates how the concepts or interpretations can change over time and lead to implications for high country farming. The high frequency of gravels screes in the mountain lands and the amount of bare soil in the semi-arid areas was being commented on last century, and was interpreted as being due to burning and overgrazing by rabbits and stock. There was also much effort this century in developing flood protection works for the agricultural development of the lowland soils adjacent to rivers. With the development of the soil conservation movement in the 1940s there was a shift in perception that these lowland problems might be better managed from a consideration of upstream source areas.

The New Zealand soil conservation movement inherited its concepts principally from the United States: rain falling on a surface initially infiltrated, but where rainfall intensity exceeded infiltration, water moved across the surface, causing soil erosion, and being the source of flood waters in rivers. This view saw plant cover as being critical and a large effort was spent in the 1950–70s investigating and implementing revegetation programmes for mountain catchments. The same view also saw the adoption of the American land class system, with strong moves to retire class 7 and 8 country. This was also the period when replacement of sheep by cattle was being advocated as a means of reducing grazing pressure on those high altitude lands perceived as eroding and being a source of floods.

Subsequent investigations question these earlier concepts. The first was that on a geological time scale, the Southern Alps was a very rapidly rising mountain range, and that on the time scale of many millennia there is generally approximate equilibrium between uplift and erosion, so that the Alps also had a very high rate of natural erosion. On a lesser time scale and from examination of the weathering rind of stones in screes, it also became apparent that the movement of screes was much less than expected, and that a lot of their movement dated back to the ice ages.

The second feature that became apparent was that while the New Zealand rainfall amounts were high by world standards, their intensities were low, so that in the high country most rain infiltrated the soil, and that surface run-off was relatively uncommon. Also, calculation on the time course of floods showed that the flood water generally could come only from rain falling within waterways or a few metres from them. Thus the control of downstream flooding was more related to the management of the riparian strip, than of the large eroding mountain basins. In particular calculation shows that grazing cattle in the riparian zone has major adverse effects on stream flooding.

Another feature was that the relatively rare events, on a human time scale, like local “cloud bursts”, caused the major erosion events, and that it is doubtful whether mitigation of their effects are manageable by land use practices.

Even more recently there has been concern with the dust storms originating from inland valleys. While fluctuating hydro-lake levels may have changed their frequency, they are unlikely to have changed the amounts, and they are the source of soils of the Canterbury Plains and the high phosphate soils of the lake moraine soils. The soil evidence is that dust storms, like those from the hieracium-infested rabbit-prone lands, has been a feature of past millennia. However, there is general recognition that wind is probably a much more important component of the New Zealand erosion processes than previously thought.

There is a pastoral management component on observed erosion rates, but that is probably small in magnitude and time scale relative to other natural erosion processes that have to be considered.

Environmental gradients and species niche

One of the difficulties in applying science to the high country is the vastness of its area, diversity of its environments, and differences between native and developed pastures. To overcome this, the concept was developed of seeing the relationship between sites in terms of four environmental gradients, with each pasture and animal species having a particular niche or role within that continuum.

The first gradient, soil moisture, is principally related to the high rainfall near the main divide. It decreases down through the gorge runs to the lake zones where rainfall is moderate, and continues to decrease to the low rainfall area of the inland basins and Central Otago. There is also local variation in soil moisture which is related to soil depth and drainage. The influence of the rainfall gradient on the rates of S and P fertiliser, and their ratio, required for pasture development has already been noted.

The variation attributed to altitude, aspect and slope is in reality variation in temperature. While the relationship between sites can be seen in the moisture and temperature gradients generally they cannot be altered in a management sense. The exception may be the small areas capable of changes of moisture status by irrigation or drainage, and as such are often important “special purpose” pastures.

The second two environmental gradients, of soil fertility and grazing management, are more amenable to management, and provide the link between native and developed pastures. The soil fertility gradients related to the natural variation related to soil depth and rainfall leaching, but more particularly to applied S and P fertiliser. The grazing management gradients are related to the effect of timing, intensity and degree of grazing utilisation as it affects the regrowth potential and persistence of different pasture species.

In combination, these four gradients show the variation in potential pasture productivity across the high country, with its logarithmic decreases associated with decreasing moisture and temperature, and the near 5-fold increase in productivity when moving from low to high soil fertility status, and a 2-fold increase from irrigation. Within those gradients, the best niche for each pasture species in terms of productivity and persistence can also be indicated.

A derived concept is that potential pasture productivity is seen as a function of environment, not species, but that for each combination of environmental conditions there is only one or a few species which will realise the potential.

Using these concepts it is possible to see the relationship between different high country sites and make at least a very good first approximation of the potential productivity under different development scenarios, and the pasture species that will best achieve those potentials.

Care is needed to avoid confusing different environmental gradients. There is a current vogue among “natural” ecologists to ascribe all the historical changes in the high country, from forest to tall tussock to short tussock and hieracium infestation, as degradation owing to burning and overgrazing. But in trying to support that position they use ordination of contemporary vegetation data from a range of sites, which can also be interpreted on the basis of moisture, temperature and fertility gradients, and as disturbance and management gradients.

Special-purpose pastures
With the large scale of high country runs there is advantage in considering any development as “special purpose pastures”. The use of the term strengthens the mental shift that a particular need has been identified, and that the consequent development may be of a relatively small area, requiring concentration of resources, and needing special preparation and management to achieve. Ultimately a whole run can be seen as combination of these “special purpose pastures” integrated into a year-round feed supply system.

Feed banks
In milder pasture environments the concept of “rotational” grazing has developed to incorporate the desirable management strategies of uninterrupted pasture regrowth to some stage just past optimum leaf area, rapid grazing to limit damage to auxiliary bud regrowth, and leaving sufficient residual as the basis for regrowth. For the limited growth period of the high country and the low pasture productivity of much of its land, the attention should focus on these plant growth requirements rather the regularity of grazing. For the high country the concept is better expressed as a “feed bank”, in allowing pasture to build up ahead of stock requirement, whether that take a couple of weeks or a year.

Farm monitoring
Quantitative monitoring is considered to be an essential part of modern management. For the high country, at the present stage, it is more a concept than a practical technology.

Some of the information for relatively stable site factors for particular runs and blocks is now generally available, to at least the first approximation, in the general national inventories of topography, soils, climate, erosion, land classes, etc. To this will need to be added monitoring of the more dynamic variables. In addition to the usual monitoring of annual and monthly cash flows, annual and seasonal stock reconciliations, annual production, and some rainfall measurements, it is being suggested that there is objective assessment of grazing charts, herbage-on-offer, composition, ground cover, weed and pest counts, and soil physical, chemical and biota characteristics. It is being suggested that this may be needed at monthly intervals, for each land class in each paddock, and in many instances down to individual animals, as in sire breeding or the ultra-fine wool production.

We consider monitoring to be highly desirable, but we believe that many of the monitoring techniques have not been developed to a level of time and effort efficiency suitable for the spatial and temporal frequency of monitoring thought desirable, and within the resources that could be allocated to them. With the present wish lists, some stations would have to employ one or two full time “monitors”. The need will be to determine more precisely what needs to be monitored, and more efficient methods.

Product specification
In agriculture in general there is a swing away from general commodity trading towards niche marketing and specific contracts. This can reduce the number of links between the producer and manufacturer, with agreed up-front specifications required and price advantages given, to aid continuity in supply for both parties.

There are a number of examples of this type of arrangement for high country Merino wool. One is the Ultrafine wool contract with NKK Japan, to supply wool of known origin, genetics, volumes and specifications (micron, style, length, counts, colour, soundness, VM and crimp) and prior agreed pricing structures. Besides the prior specification there is a detailed feed-back from the manufacturer of an evaluation of each wool lot as it passes through the manufacturing process.

Expert and decision support systems
The paper would seem remiss if it did not discuss the impact of computer-based “expert” and “decision support” systems. In our view the technology is in its very early days and hardly qualifies as adoptable packages at this stage, which is why this discussion is placed in the concept section. But it is is a practical technology going to have a large impact on high country run management in the next few decades.

There will be some development of systems specifically for the high country, but most will be based on those from other areas or contexts. Financial and book-keeping packages are likely to be the first and best. Most are likely to be more than adequate for farm management, and any difficulty is more likely to be the selection between the relative merits of different “brands”.

There will be slow development of the environmental-fertiliser-pasture management-stock computer “expert” systems that can be used in day-to-day run management, in spite of what we may say in other contexts. The challenge of developers will be to first understand the processes involved, their quantification from past and present studies, and their incorporation into computer models. The second is to make these computer models or decision support systems sufficiently user friendly so that the users can use the system at whatever level of complexity they choose, e.g., a current

New Zealand dairy farm system monitors the milk output of each cow, each milking and adjusts the feed allowance accordingly. This ability to act at different levels will require compatibility between the institutional "deep knowledge" systems, packages for district or long-term farm feasibility studies, and the hip-pocket day-to-day stock movement package. Farm monitoring will be crucial to such computer-based management systems.

Discussion

A successful practice can be either a "wigit", a procedure, or a concept in a changed way of looking at things. Such adopted technologies quickly become the standard culture and to discuss them in learned terms often seems trite. The earlier developed technologies, like hay for winter feed, or the concept of variation in fertiliser rates and type with rainfall, might seem to be in that category. But readers will know that others, like legume seed coating and "special purpose pastures", have progressed in recent history from novel innovation to near standard practice. The suggestion is that the other new packages of technologies and concepts discussed here have been sufficiently well researched to become widely adopted within a couple of decades.

While missionary zeal is often needed to get a new technology considered, it has also to be recognised that only a few will finally become accepted, and that many will in turn be superseded by others. This is particularly true of concepts which become belief systems and extrapolated beyond their empirical base – as the adage says "there is a lot of bull in most sacred cows".

The conclusion is that the integration of the results of high country investigations into usable farming packages involves both development of particular technologies and conceptual frameworks.

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