The BHU Future Farming Centre

Rongoa Pastures Heathy Animals Resilient Farms

A report prepared for Ngā Pae o te Māramatanga

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Contents

Executive summary

The rongoa pastures, healthy animals, resilient farms report is an introduction to the ideas and the rationale behind the development of mixed pastures that contain New Zealand native species. Agroecology, which is gaining acceptance worldwide as a regenerative method of farming suggests that pastures should be developed and maintained with the minimum of external inputs, using local species that grow well on native soils and improved species that match the climate (Johnson, 2015). Evidence from Europe of the history, the desirability of mixed pastures and the effects on animal health is presented to support the argument for diversity in Aotearoa New Zealand. As a starting point to develop pasture mixes that include native species, herbs and grasses which have some reputation as rongoa rākau in human traditional medicine have been proposed as have species that were preferentially eaten when stock were first introduced into Aotearoa New Zealand.

Rongoa pastures, healthy animals, resilient farms

Introduction

The concept of applying the principles of rongoa to farm management was explored in an earlier report, Adapting the Principles of Te Rongoā into ecologically and culturally sustainable farm practice (Johnson, 2012).The ideas expressed in the report met with approval from a number of land managers but some caution was expressed as to the amount of land that might be taken out of pasture if medicinal shrubs and trees were incorporated into large scale farm plantings. This report extends the concept of rongoa rākau out into the paddock, nurturing the land and encouraging the growth of native herbaceous and graminoid species. Industrial farming methods have increased the carrying capacity of some farms, but at a cost. Many farmers have observed that soil health, particularly biology, is declining; animal health is declining, for example veterinary bills for dairy cattle are now a substantial cost; and biodiversity on productive lands is minimal. By adopting an agroecological approach in which the farm is viewed a whole and the impacts of actions assessed from as many angles as possible the health of our farming systems can be slowly regenerated. With forecast changes in climate, reduction in the availability of fossil fuels and increasing health concerns arising from the applications of pesticides, herbicides and antibiotics to farming systems, adopting an agroecological approach (see Agroecology, Indigenous Agroecology 2015 for a fuller discussion) is both logical and necessary. Agroecology is local and not prescriptive. The value of local knowledge was realised by New Zealand farmers early last century (Holland, 2013), it is a pity it has been forgotten. The suggestions for inclusions of native species into grazing systems given here are general and consideration to local climate and habitat needs to be given before any choices are made. Further research is required to develop planting and grazing management regimes that will promote the diversity of native graminoids and forbs in our pastures.

The aim is not to try and graze animals solely on native pastures; this would likely be an uneconomic proposition (Turner, 1951). A healthy diverse pasture should contain native species and a mixture of improved grasses, legumes and herbs. Although the aim is to include native species in pastures, they must be productive, contribute to animal performance and able to persist in the mix.

Mixed pastures

Mixed pastures should provide a range of forages (grasses, legumes and herbs) that are palatable at different times of the year. They should be nutritious, containing adequate levels of proteins and carbohydrates, minerals, trace elements and allelochemicals. A chemically diverse range of species and a diversity of rooting depths that can bring minerals up from different layers in the

soil will contribute to a balanced diet in grazing animals. Diverse pastures are more likely to withstand climatic events and with sensitive grazing regimes will build soils.

> "*though the cow cannot classify forage crops by variety name or by tonnage yield per acre she is more expert than any biochemist at assessing their nutritive value*"

Albrecht 1958 in Provenza 2008

Foster (1988) reviewing pasture research in the United Kingdom from 1850-1984 lists herb species that are mentioned as being vital components of a healthy pasture. These are summarised in Table 1. In addition to the herbs preferred legumes included kidney vetch (*Anthyllis vulneraria*), birds foot trefoils (*Lotus corniculatus*, *Lotus uliginosus*), sweet clover (*Melilotus alba*), suckling clover (*Trifolium dubium*), trefoil (*Medicago lupulina*), alsike (*Trifolium hybridum*), standard red clover (*Trifolium pratense*), sainfoin (*Onobrychis viciifolia*), lucerne (*Medicago sativa*) and white clover (*Trifolium repens*).

Pasture grasses included fiorin (*Agrostis stolonifera*), meadow foxtail (*Alopecurus pratensis*), tall oat grass (*Arrhenatherum elatius*), crested dogstail (*Cynosurus cristatus*), cocksfoot (*Dactylis glomerata*), tall fescue (*Festuca arundinacea*), hard fescue (*F. duriuscula*), sheeps fescue (*F. ovina*), meadow fescue (*F. pratensis*),Italian ryegrass (*Lolium perenne* ssp. *multiflorum*), perennial ryegrass (*L .perenne* ssp. *perenne*),timothy/catstail (*Phleum pratense*), smooth stalked meadow grass (*Poa pratensis*), rough meadow grass (*P. trivialis*) and golden oat grass (*Trisetum flavescens*).

Herbs noted by various authors as occurring naturally in old pastures include ribgrass (*Plantago lanceolata*), yellow rattle (*Rhinanthus minor*), sow thistle (*Sonchus oleraceus*), knapweed (*Centaurea nigra*), daisy (*Bellis perennis*), nettle (*Urtica dioca*),selfheal, (*Prunella vulgaris*), wild pansy (*Viola lutea*), dandelion (*Taraxacum* spp) and hogweed (*Heracleum sphondylum*).

Table 1 Herbs with health benefits commonly expected to be found in British pastures from 1850 until replaced with ryegrass white clover mixtures.

Species	common name	animal health	comments
Achillea millefolium	Yarrow	tonic	Sheep love it, cattle enjoy it. Drought resistant and long lived. Keep closely grazed or will dominate sward
Carum carvi	Caraway	prevents bloat promotes gut flora	

Species	common name	animal health	comments
Cichorium intybus	Chicory	Contains inulin easily digested carbohydrate minerals	Extremely attractive to sheep, cattle, pigs and hover flies, bees pollinators Deep rooting, drought resistant
Petroselinum crispum	Sheeps parsley	Tonic	Praised as a forage since 1669 loved by sheep and cattle
Plantago lanceolata	Ribwort Plantain	Tonic minerals	Relished by stock Provides feed in autumn and winter
Poterium sanguisorba	Burnet	Cure and preventative for "rot" in sheep good for scouring sheep Flavours butter agreeably	Liked by sheep and cattle

These lists illustrate the importance given to a mixed pasture, containing a variety of species, by an earlier generation of non industrial farmers. An analysis of typical seed mixtures in the early 20th century shows they contained 15-21 species, a combination of grasses, legumes, clovers. Foster provides lists of seed mixtures, which also include herbs; 1874 (16 species), Clifton Park farm 1874 (14 species) and 1882 (15 species). Robert Elliot who owned and experimented on Clifton Park in the late 1800s and early 1900s believed in mixed species with deep rooting systems to bring minerals to the surface, provide resistance to drought and improve the soil structure and aeration. In 1984 Hunter seeds were still selling the Clifton Park Mixture (19 species) but now no longer supply Clifton Park mixes and have decreased the number of species in their pasture mixes. When the Clifton Park mixture was compared to a contemporary ryegrass or ryegrass clover mixture at Cambridge University it was judged to be superior (Foster, 1988). George Stapledon the first director of the Welsh plant breeding station is quoted as saying that despite 20 years of research into super leys animals still sought out the herbs at the bottom of the hedgerow and "if herbs are eaten readily by animals then they are making a handsome contribution to health". Cockle Park, the University of Newcastle research farm investigated the value of common weeds as "cattle seem to find hedgerows and field edges attractive grazing areas"(Foster, 1988). In 1908 Armstrong studied the differences between pastures that were known as first rate old pasture, excellent recent pasture and good feeding quality pasture. The pastures all held a mixture of species and no less than 20 species in each. Interestingly a study of inferior pastures showed that they also held mix of species but they did not contain a mixture of herbs **and** high producing grasses. Many early New Zealand farmers sowed down ryegrass and clover, as they do today, but even late in the nineteenth century Parker was reminding them that the point of mixed pastures was "that stock would always have a bite" and if only one species was grown " say ryegrass ,as was commonly done, there is no succession of food" (Holland, 2013). An analysis of birdsfoot trefoil (*Lotus corniculatus* cv Lotanova), red

clover (*Trifolium pratense* cv Rajah), white clover (*Trifolium repens*), chicory (*Cichorium intybus* cv Spadona), plantain (*Plantago lanceolata*), caraway (*Carum carvi* cv Sylvia) and salad burnet (*Sanguisorba minor*) showed that the forage herbs had higher concentrations of most macro minerals and some micro minerals than grasses and legumes (Pirhofer-Walzl et al., 2011). Kemp et al. (2010) recognise that ryegrass and clover pastures may not provide all the nutrient requirements for growing stock and suggest that the inclusion of other forages may improve livestock performance. Performance may also be improved when an animal is able to temporarily choose different foods from the main nutritional components of its diet to balance its internal state (Villalba and Landau, 2012; Villalba, 2007). Stock which are able to graze widely may not be exploiting the calculated feed value of a pasture, but this is often lower than the dietary intake anyway as, if they have the opportunity, stock will pick and choose the best and most nutritious parts of a plant and the best mixtures (Cosgrove and Hodgson, 2002; Wilson et al., 2011).

In a Swedish study (Smidt and Brimer, 2005) questionnaires were sent to biodynamic and organic farmers asking them if they used herbs in their pastures and if so, which species. The herbs sown and used by farmers are listed in Table 2. Despite farming organically 109 farmers said they lacked sufficient knowledge to use herbs.

Table 2 Herbs grown by Biodynamic and organic farmers in Sweden adapted from Smidt and Brimer 2005

Species	Common name	Comment
Achillea millefolium	Yarrow	Stimulates circulation
Anethum graveolans	Dill	Digestion Antiviral Contains vitamins and minerals Discourages carrot fly
Anthriscus cerefolium	Chervil	
Artemisia absinthium	Wormwood	Anthelminthic*
Artemisia vulgaris	Mugwort	Anthelminthic* Cell counts decreased in cattle fed Mugwort and clover Fed to cattle post calving in summer
Cichorium intybus	Chicory	Anthelminthic action High in minerals
Carum carvi	Caraway	Cattle relish it Prevents bloat Promotes rumen action
Petroselinum crispum	Parsley	Facilitate digestion Prevents bloat Good minerals Cattle enjoy it

Species	Common name	Comment
Sanguisorba officinalis	Burnet	Enjoyed by cattle
Taraxacum sp.	Dandelion	Cattle love it
Tanacetum vulgare	Tansy	Fresh leaves of tansy used in hens nests for ectoparasites or aqueous extract of leaves sprayed on hens
Trigonella foenum-graecum	Fenugreek	Effective against staphylococcal infections used as poultice
Urtica dioica	Nettle	Eagerly eaten by cattle

*Anthelminthic herbs were either pushed into the mouths of young cattle or fed with something nice.

Chris Day is a Veterinary homeopath practicing in Oxford, England (www.alternativevet.org.). He has developed a list of palatable herbs that could be usefully included in pastures to promote animal health, listed in Table 3. These herbs have been introduced and are all to be found growing in Aotearoa New Zealand. They could be usefully combined with native herbs in a pasture. Further research would demonstrate whether related species such as the native chickweeds or plantains which are used for Rongoā rākau in Aotearoa New Zealand have similar activities to the European species.

Table 3 European pasture herbs for healthy animals adapted from Chris Day Herbs for Pastureland 2007. Latin names for species from The Royal Horticultural Society Encyclopaedia of Herbs 2014 reprint(Brown, 2002) and New Zealand Plant conservation Network (www.nzpcn.org.nz)

Agrimony (*Agrimonia eupatoria*)
Angelica (*Angelica archangelica*)
Avens (*Geum urbanum*)
[Lemon] Balm (*Melissa officinalis*)
[Ladies] Bedstraw (*Galium verum*)
Borage (*Borago officinalis*)
Burdock (*Arctium lappa*)
Burnet (*Sanguisorba* sp.)
Calamint (*Calamintha officinalis*)
Centaury (*Centaurium erythraea*)
Chamomile (*Chamaemelum nobile*)
Chervil (*Anthriscus cerefolium*)
Chickweed (*Stellaria media*)
Chicory (*Cichorium intybus*)
Clary Sage (*Salvia sclarea*)
Cleavers (*Galium aparine*)
Coltsfoot (*Tussilago farfara*)
Comfrey (*Symphytum officinale*)
Cornflour (*Centaurea cyanus*)
Cowslip (*Primula veris*)
Cranesbill (*Geranium* sp.)
Cuckoo Flower (*Cardamine pratensis*)
Daisy (*Bellis perennis*)
Dandelion (*Taraxacum officinale*)
Dill (*Anethum graveolans*)
Eyebright (*Euphrasia officinalis*)
Fat hen (*Chenopodium album*)
Fennel (*Foeniculum vulgare*)
Fenugreek (*Trigonella foenum-graecum*) Feverfew (*Tanacetum parthenium*)
Flax (*Linum usitatissimum*)
Fumitory (*Fumaria officinalis*)
Garlic (*Allium sativum*)
Goats Rue (*Galega officinalis*)
Groundsel (*Senecio vulgaris*)
Hawthorn (*Crataegus laevigata*)

Table 4 continued

Hedge Mustard (*Sisymbrium officinale*)
Hemp Agrimony (*Eupatorium cannabinum*)
Herb Robert (*Geranium robertianum)*
Hogweed (Heracleum *sphondylium*)
Hops (*Humulus lupus*)
Horehound (*Marrubium vulgare*)
Horseradish (*Amoracia rusticana*)
Ivy (*Hedera helix*)
Jack by the Hedge (*Alliaria petiola*)
Knapweed (*Centaurea scabiosa*)
Lady's mantle (*Alchemilla xanthochlora)* Liquorice (*Glycyrrhiza glabra*)
Mallow (*Malva sylvestris*)
Marigold (*Calendula officinalis*)
Marjoram (*Origanum vulgare*)
Meadowsweet (*Filipendula ulmaria*)
Medick (*Medicago* sp.)
Melilot (*Melilotus officinalis*)
Milk Thistle (*Silybum marianum*)
Milkwort (*Polygala vulgaris*)
Mint (*Mentha* sp.)
Motherwort (*Leonurus cardiaca*)
Mullein (*Verbascum thapsus)*
Nettles (*Urtica dioica*)
Parsley (*Petroselinum crispum*)
Penny Royal (*Mentha pulegium*)
Peppermint (*Mentha x piperita)*
Pimpernel (*Anagallis arvensis*)
Plantain (*Plantago* sp.)
Primrose (*Primula vulgaris*)
Purslane (*Portulaca oleracea*)
Ramsons (*Allium ursinum*)
Red Clover (*Trifolium pratense*)
Restharrow (*Ononis repens*)
Rosemary (*Rosmarinus officinalis*)
Rue (*Ruta graveolans*)
Sage (*Salvia officinalis*)
Scabious (*Knautia arvensis*)
(Selfheal (*Prunella vulgaris*)
Sheep's Sorrel (*Rumex acetosella*)
Shepherd's Purse (*Capsella bursa-pastoris*)
Sorrel (*Rumex acetosa*)
Speedwell (Veronica *officinalis*)
Sunflower (*Helianthus annus*)
Thyme (*Thymus vulgaris*)
Toadflax (*Linaria vulgaris*)
Vervain (*Verbena officinalis*)
Vetch (*Vicia* sp.)
Water Avens (*Geum rivale*)
Watercress (*Nasturtium officinale*)
Willow (*Salix* sp.)
Witch Hazel (*Hamamelis* sp.)
Woodruff (*Galium odoratum*)
Wood Betony (*Stachys officinalis*)
Yarrow (*Achillea millefolium*)
Yellow Rattle *(Rhinanthus minor)*.

Studies at the Louis Bolk institute showed that the more diverse and herb enriched the pasture the lower the amount of antibiotics given to cattle.

"*Starch and protein equivalent at one end will produce milk at the other end – but the man who discovered this fact forgot the cow in the middle*"

Turner 1955

Parasitism is one of the largest problems facing livestock producers worldwide. There is an extensive literature on European herbs as anthelminthics, particularly those containing condensed tannins and phenolic compounds for example sainfoin (*Onobrychis viciifolia*), chicory (*Cichorium intybus*), lucerne (*Medicago sativa*) and sulla (*Hedysarum coronarium*) (Athanasiadou et al.,

2007a; Athanasiadou et al., 2007b; Athanasiadou et al., 2001; Hoskin et al., 2000; Niezen et al., 2002; Scales et al., 1995; Thamsborg et al., 2003). These species are all grown in Aotearoa New Zealand to varying extents. Bioactive, anthelminthic plants may act in a number of ways to reduce parasite burdens in the livestock foraging on them. The allelochemicals within the plant may act directly on the parasite, or indirectly, by altering the gut environment or reducing the amount of nutrient available to the parasite. In addition by consuming bioactive forages the hosts nutritional status may improve enabling a greater resistance to parasite challenge and an alteration in immune response(Houdijk et al., 2012).

Diets containing a variety of forages promote higher levels of antioxidants in milk (Elgersma et al., 2012) and change the levels of beneficial fatty acids (Kalber et al., 2011). Dairy sheep given access to legumes such as sulla (*Hedysarum coronarium*) or sainfoin (*Onobrychis sativa*) as well as grass ingested more herbage overall and produced more milk. The inclusion of safflower (*Carthamus tinctorius*) into the diet decreased the protein content of the milk (Molle et al., 2008). “The nutritive, health and meat quality parameters offered by wild or diverse native pastures is outstanding” meats and milk contain higher levels of fatty acids, higher levels of beneficial fatty acids, and vitamins and flavour scores are superior (Burke, 2008).

Mixed pastures support animal health and performance, the benefits of which flow onto consumers in improved quality of meat and dairy produce.

Persistence of mixed pastures

Whenever mixed pastures or medicinal pastures are proposed the first objection raised by many farmers is that of maintaining the pasture mix. Dr Allan Savory has developed a grazing method, holistic management , which he describes as an “ecologically regenerative, economically viable and socially sound management of grasslands”, that is extremely successful in many environments (Savory and Butterfield, 1999) . Savory believes that the farmer is a steward of the resources available; soil, moisture, fertility, and diversity of species and needs to pay attention to the relationships that exist between all the elements of a whole. Change one element, other elements are impacted. The method focuses on the pasture and the environment in which it growing. The farm environment is rated on a brittleness scale (how much moisture, how well humidity is distributed and how fast vegetation breaks down) from 1 (rainforest) to 10 (true desert). Brittleness determines how the grazing is managed, according to the soils, climate and farmers ambitions. The mantra “plan-monitor-control- replan”, actively managing as things change, and managing by getting out and walking the land, underpins much of Savory’s advice. By explaining that every time an animal removes the foliage from a plant it has to replace its photosynthetic material from root reserves and those root reserves then die it becomes clear that if an animal returns to the plant too frequently, or too soon, overgrazing of that plant occurs. By matching the rate at which animals move across the pasture to the rate of recovery, the health of the pasture can be promoted. The most solar energy will be captured by pastures if

species with a good leaf area are growing closely together, grow actively at different times of the year and are grazed sympathetically. It is however not only simple passage of stock that is important for pasture health , stock need to be concentrated enough so that dung and urine are returned and trampled in along with seeds and dead matter.

Mathias (2004) describes a lovely method of pastoral maintenance used by shepherding communities in Iran as the animals migrate.

"*Nomads in Iran collect the seeds of preferred forage species and put them in linen bags hung around the necks of the sheep leading the flock. During grazing the seeds drop out of small holes in the bags and are worked into the ground by the hooves of the succeeding animals*"

Selecting livestock to thrive on mixture pastures

The ultimate indicator of forage quality is the performance of the livestock eating it. It is not enough to merely revegetate a farmscape; consideration must also be given to animals foraging across it. Livestock that perform under local conditions and can utilise improved grasses, introduced herbs and legumes and native species should be selected, to match each individual farm environment. At a 2015 symposium on reducing antibiotic use in dairy cattle (www.naturallivestock farming.com) the delegates from Uganda and Ethiopia emphasised the necessity of matching the breed to the locale. They observed that local breeds although producing lesser quantities of milk and meat per animal than imported breeds required far less veterinary intervention and anthelminthic treatments and could produce well on local pastures. A good example of the nutritional wisdom of local breeds is provided by goats in Tanzania. *Veronia amygdalina* is a plant used across sub Saharan Africa to reduce parasite loadings in humans and animals. As in many medicinal plants the difference between a cure and adverse effects is in the dose of *Veronia* ingested. Introduced breeds of goats in Tanzania often eat so much of this plant that they die, indigenous breeds of goats regulate their intake (Engel, 2007). It is of course possible that the introduced goats have such high loadings of parasites that they ingest large quantities without the knowledge of species that could balance the toxins.

As every animal is different the provision of variety in the diet is vital, one animal may have a much higher requirement for a particular nutrient than another. Needs and preferences also change seasonally, daily and when an animal requires a therapeutic (or prophylactic) dose of particular allelochemicals (Manteca et al., 2008; Provenza et al., 2003). Accepting that each animal is different, with a different physiology and experiences is therefore critical when promoting health. Providing a pasture with a wide range of forage options (Shaw et al., 2006) so that each animal can select its own diet will improve performance. Plants express different levels of allelochemicals which can be influenced by growing conditions and experience (Provenza, 2008) and knowledgeable stock will vary their intakes so that they ingest a range of

compounds that meet their physiological requirements and are metabolised using different pathways. The allelochemical arrays in a plant also act to limit the amount of forage that can be ingested in a grazing bout (Provenza and Villalba, 2010). Livestock, given the opportunity, will forage so as to balance the ingestion of allelochemicals and to maximise the benefits of them. Interactions between allelochemicals can affect feed choices and one species may provide the allelochemicals to balance the potentially toxic intake of another species (Papachristou et al., 2007). High doses of secondary chemicals can be toxic and adversely affect an animals metabolism but the same allelochemicals affect any bacteria, parasites and fungi that may be infecting an animal (Provenza and Villalba, 2010). Unwell stock will balance their intake of various allelochemicals to match their requirements and regain health (Villalba and Landau, 2012). Food choices allow animals to reduce possible dietary and health stresses induced by simplistic pastures. In a trial in which steers were given a total mixed ration, designed for the average animal or free choice of the components, no two animals given free choice chose the same mixture, and no animal chose a mixture equivalent to the total mixed ration (Atwood et al., 2001).The results suggest that animals can, if given the opportunity, sense and meet their needs and choose diets for optimal performance. Atwood also suggests that animals only offered a single or minimal choice may also depress their intake if they have an aversion to the feed on offer. In addition to exhibiting species preferences, livestock also express seasonal preferences and will often change their forage choices according the stage of development of the forages on offer. This was demonstrated in a trial by Cruz and Ganskopp (1998) where cattle were tested for their preferences of seven native American species and chose mixtures of different species as growth stages changed throughout the season. An earlier trial demonstrated that cattle returned to their favourite species more frequently and took more bites from those plants (Ganskopp et al., 1997). Ivins back in 1952 noted the preference of stock for plantain, which they chose to graze first before moving on to other species. He also notes that the animals “previous diet seemed not to affect their predilection for ribgrass”. Ivins also records that palatability and preference changed throughout the year (Foster, 1988). Different species make different choices. Sheep and goats for example, grazing the same natural pastures in the Cameroon were observed to behave and select very differently, although both species ate flowers and fruits and would not eat dangerous plants even when hungry (Ngwa et al., 2000). Deer in New Zealand demonstrate highly selective food choices with definite preferences for certain species (Moloney, 2003).Given a choice of red clover and grass deer chose red clover ahead of the grasses (Hunt and Hay, 1990). Young deer will accept mixed pastures more readily, or individual species such as chicory, if they have been exposed to them with their mothers (Moloney, 2003).

Herbivores foraging behaviour is influenced by early life experiences (Provenza, 2008) and responses to previous behaviours (Villalba and Landau, 2012). If stock learn to forage for and digest a range of foodstuffs and are encouraged not to just target the most palatable but to eat an assortment of plants with varying levels of nutrition and allelochemicals, they are more likely to balance their diet and be healthy. (Villalba and Provenza, 2001). Sheep in the Falkland islands grazing native pastures have learned to select herbs, finer grasses rushes and sedges while they are available during the warmer months and then subsist through to the next growth period (Miller and Thompson, 2005).

Grazing management influences how stock select their diets , long term residence in an area encourages eating out the 'ice cream' species (Moloney, 2003) or 'eating the best and leaving the rest' (Provenza et al., 2003) rather than choosing a balanced diet. If a mixed pasture is grazed correctly so that animals cannot simply choose the 'choicest' species then the pasture will also remain healthy. Grazing managers must therefore have a good knowledge of the nutritional values and palatability of the various species in a mixed pasture and how they are likely to be utilised by various classes of stock.

"Herders in France use an understanding of the biochemical diversity to stimulate food intake and more fully use the range of plants available by herding in grazing circuits. The circuit includes a moderation phase, which provides sheep access to plants that are abundant but not highly preferred to calm a hungry flock; the next phase is a main course for the bulk of the meal with plants of moderate abundance and preference; then comes a booster phase of highly preferred plants for added diversity and finally a dessert phase of palatable plants that complement previously eaten forages"

In Provenza 2003

Livestock can be moved to new pastures, offered access to herb strips or underwire grazing to emulate the herders' circuit and encourage a broad intake of plant species. Turner (1951) recommended pastures should contain at least some plantains (*Plantago* ssp.), chicory (*Cichorium intybus*), burnet (*Sanguisorba* ssp.), sheeps parsley (*Petroselinum crispum*) and yarrow (*Achillea millefolium*). He noted than when the cows were moved from a simple sward to a herb rich sward their milk production went up. If grass and clover were sown in strips, intake in sheep was increased by 25% compared to a grass and clover mixture, as animals had choice and didn't have to search for the proportions they required (Provenza et al., 2003). Turner also experimented with allowing cattle to access their favourites under a wire so that he could achieve some control over intake and they could access them when needed. 'Hospital' paddocks are an option for providing access to a selection of herbs for sick animals. But if herbivores can sense when they are sick, before a human observer notices (Engel, 2007; Hart, 2005; Villalba and Provenza, 2001), they may be unable to modify their diet early enough to avoid illness.

Potential New Zealand native pasture plants for animal health

Maori used native grasses for weaving and whare construction. Kāretu, Scented or holy grass (*Hierochloe redolens*) was used to make scent and for strewing as it has a sweet smell (Brooker et al., 1989).

When livestock were introduced into Aotearoa New Zealand sustenance was provided by the native grasses, forbs and shrubs. Many early pastoralists regarded *Danthonia* sp.as weeds (Hilgendorf, 1919) others thought them a useful grass (Guthrie-Smith, 1907) and if improved might contribute to an increased carrying capacity on native pastures (Star, 2004). Sheep ate snow

grass and horses adored the seed heads. Guthrie Smith observed that after fire Danthonia, *Rytidosperma sp.* was one of the first grasses to produce new shoots followed by forbs and cocksfoot (*Dactylis glomerata*). Sheep didn't eat the silver tussocks (*Festuca novae-zelan*diae) unless they had been burned then the regrowth was very palatable but cattle grazed them happily and because of overgrazing silver tussock disappeared in many areas (Hilgendorf, 1919). *Microloena stipoides* was the only grass that could survive competition with the regrowth of manuka after a burn (Hilgendorf, 1919) and stems of 5ft and more were noted amongst the trees on Tutira (Guthrie-Smith, 1907). Although *M. stipoides* is regarded as native it is probably of Australian origin (A. Stewart pers.com.). Blue tussock (*Poa colensoi*) and blue wheat grass (given as *Agropyron scabrum* but probably *Anthosachne solandri*) were considered good sheep feed (Hilgendorf, 1919; Peden, 2011) and in many areas were eaten out of existence. By the 1860s European settlers were being encouraged to trial imported species of grasses as it was recognised that the native pastures and ecosystems would not carry large numbers of stock (Brooking and Pawson, 2011). Stock numbers increased 247% between 1861 and 1871 largely on native pasture with no management (O'Connor, 1982).
In 1899 Kirk declaimed that "great wealth was being destroyed annually in consequence of the absurd craze for the clearance of our indigenous natural herbage and the sowing of so called English grasses regardless of the fact that the latter were in many instances quite unsuited to the locality and conditions" (quoted in Star 2004). John Buchanan had previously published a manual of the indigenous grasses of New Zealand in which he extolled the virtues of many species. Guthrie-Smith (1907) describing the grasses on Tutira station also notes that many of the exotic pasture species had disappeared and the pastures 'deteriorated' as native species once again took over. Stock numbers increased as farms expanded onto new lands but the carrying capacity of native pastures was limited and in many cases exceeded so stock numbers decreased again(McIntyre, 2007). Of the 21 native grasses identified on Tutira Station only six species were valued as stock feed. The palatability of *Microloena stipoides* changed with the season, the early shoots were eaten by sheep, late in the season it was avoided. *M.avenacea* was browsed intermittently by wild cattle and *Dichelachne crinita* and *D. intermedia* are classed as useful grasses. *Trisetum antarcticum* was a very palatable grass, very closely grazed and Guthrie Smith notes, often only occurring on the station where sheep could not reach it. He called *Danthonia semiannularis* a "species of first rate importance."
William Travers is quoted (Brooking and Pawson, 2011) as saying that "all stockmen agree on praising the feeding quality of the native grasses….the secret of the value for feeding purposes of old pastures lies in the fact that they contain a great variety of grasses of varying times of maturity".
Value is in the eye and management characteristics of the beholder and the land with which they are associated.

The advent of chemical fertilisers tipped the balance in favour of exotic grasses as their major nutrient requirements could be provided from a bag. The range of species encouraged in pastures in Aotearoa New Zealand dwindled as did the number of cultivars offered to farmers. Daly et al. (1996) suggest that the use of multi species pasture in New Zealand is limited but anecdotal reports of animals grazing multispecies pasture (not necessarily containing native grasses) would indicate better stock health and animal performance.

The danger of relying on single cultivars and a few species was emphasised by Hampton et al. (1990). The authors' list 19 herbage legumes, 11 grasses and 3 herbs that they feel could have potential in New Zealand pastoral systems, none of them native and note that even for these species seed might be difficult to obtain in large enough quantities. They draw particular attention to alsike (*Trifolium hybridum*), caucasian clover (*T. ambiguum*), zigzag clover (*T. medium*), suckling clover (*T. dubium*), white sweet clover (*Melilotus alba*) and hairy canary clover (*Dorycnium hirstutum*), crown vetch (*Coronilla varia*) birdsfoot trefoil (*Lotus corniculatus*), perennial lupin (*Lupin polyphyllus*), velvet grass or fog (*Holcus lanatus*), pubescent wheat grass (*Agropyron trichophorum*), tall oat grass (*Arrenatherum elatius*), yarrow (*Achillea millefolium*) and sheeps burnet (*Sanguisorba minor*) as possible species that could be grown in different lower fertility areas of the country.
Cows on the dairy unit at Massey were observed to eat dandelion (*Taraxacum officinale*), hairy buttercup (*Ranunculus sardous*), broad leaved dock (*Rumex obtusifolius*), Yorkshire fog (*Holcus lanatus*) and Californian thistles (*Cirsium arvense*) in addition to the pasture provided (Harrington et al., 2006). The authors describe the species listed as "unwanted" in the pasture, but the cows are preferentially eating them so the epithet "unwanted" is debateable from the perspective of the cow. Analysis of these species showed them to be significantly higher in many minerals than rye grass and white clover, no measurements of allelochemicals were made but it was concluded that weeds may have some value. Aston (1911) writing on the relationship between introduced stock and native plants comments that although naturalised (1855) storksbill (*Erodium cicutarium*) provides sweet herbage, yet another species that might be useful for sheep and cattle.

Species used in the practice of rongoa that might contribute to a healthy pasture

Aotearoa New Zealand has rich culture of traditional medicine of which rongoā rākau (plant medicine) forms a part. A good starting point for healthy pastures would be the inclusion of herbs and grasses that have a history of medicinal use, implying that they produce a range of allelochemicals. Table 4 lists species used in the practice of rongoā that might form part of a mixed pasture.

Table 4 Species native to Aotearoa New Zealand - with a recorded use in Maori traditional medicine - which could be encouraged in a pasture situation.

Latin name	Maori names	Common name	Health aspect	Comments
Acaena anserinifolia	Piripiri Hutiwai Piriwhetau	Biddybid	Tonic Kidney digestive support	21 native species Extensive before introduction of grazing animals *A .buchananii* can be locally common in central Otago in grazed un improved pastures
Althaea officinalis		Marshmallow	Demulcent	Long naturalised and used in rongoa
Anaphalioides spp (previously *Gnaphalium*)	Puatea	Cudweed	Tonic Nausea	Another cudweed *Gnaphalium luteo-album* is known as Pukatea (not to be confused with *Laurelia novae-zelandiae*)
Anthosachne kingiana subsp. multiflora	Tūtae Kuri	Wheat grass	Steam baths heal burns	Used to be *Elymus multiflorus Agropyron multiflorum*
Anthosachne solandri	Patiti	Blue wheat grass	Styptic	A Kiwiherb remedy
Apium prostratum	Tutae koau	Maori celery Wild celery	Antiscorbutic Tonic	Two species occur on mainland NZ *Apium prostratum subsp. prostratum var. filiforme* is regarded as the indigenous species. *Apium prostratum* subsp. *denticulatum* or Chatham island celery is very much at risk
Atriplex patula		Orache	Antiscorbutic	Regarded as naturalised since 1853 but often quoted as native. *Atriplex australasica* is the indigenous species only found on Rēkohu

Latin name	Maori names	Common name	Health aspect	Comments
Brassica rapa	Pohata Kōrau	Wild turnip	Tonic Forage	Kōrau regarded by some as pre European origin under special protection of patupaiarehe (fairy folk) possibly the original plant has disappeared
B. rapa var *oleifera* previously *Brassica campestris*	Nani	Maori turnip	Tonic Laxative	Some Maori sources claim that cabbage and turnip were known and grown long before Europeans came. A plant called nani by Maori was cultivated on the borders of the forest
Brassica oleracea var *oleracea*	Kāpeti	Maori cabbage Wild cabbage cabbage	Colic Stomachic	Evidence that a species of cabbage was present long before European arrival
Bulbinella angustifolia	Riki	Maori onion		Not usually eaten
Brachyscome radicata	Ronui	Grassland daisy	Scented	Valued plant
Cardamine debilis	Panapana	New Zealand bitter cress	Antiscorbutic	
Celmisia spectabilis	Tikumu	Cotton plant	Chest	There are 5 sub species of *Celmisia spectabilis*, 3 given below *Celmisia spectabilis* subsp. *spectabilis* cotton plant *Celmisia spectabilis* subsp. *magnifica* shepherds tobacco *Celmisia spectabilis* subsp*. Lanceolata* not particularly threatened by browsing animals seen to be spreading in some rough pastures

Latin name	Maori names	Common name	Health aspect	Comments
Chenopodium album	Huainanga	Lambs quarters	Tonic Blood purifier Ulcers	Long naturalised and absorbed into rongoā practice Used as a vegetable
Chenopodium triandrum	Poipapa	Pigweed		Previously *Einadia triandra*
Chionochloa sp	Wi	Snow tussock	Rheumatic pains	
Conyza Canadensis	Porerarua Hāka	Canadian fleabane Horseweed	Astringent Styptic Gout	Probably introduced by Europeans on the East Coast
Epilobium sp.			Anthelminthic	
Euphrasia cuneata	Tutumako	New Zealand Eyebright		One of 16 species of native eyebrights
Gallium propinquum	Mawe	New Zealand bedstraw		
Geranium brevicaule		Native geranium	Septic wounds	5 species of native geranium All eaten by sheep
Geranium microphyllum		Small leaved geranium	Tannins	Frequently the non - native *Geranium dissectum* Cut leaved cranesbill, is identified as *G. microphyllum*
Geranium molle	Namunamu	Doves foot cranesbill	Antiseptic	Naturalised 1852
Geranium solandri	Matua kumara	Cut leaved geranium		Previously *Geranium australe* Roots eaten Flowered when kumara due to be planted Overtopped by exotic pastures
Geranium traversii		Chatham Island geranium		
Geum urbanum	Kopata	Herb Bennet Clove root	Anthelminthic Astringent Tonic	Contains tannins and eugenol
Gingidia montana	Kohepiro, Koheriki	Maori anise	Diuretic	10 species of *Gingidia*
Haloragis erecta subsp. *erecta*	Toatoa	Shrubby haloragis Fireweed	Good for sick horses	Not to be confused with Toatoa or celery pine in the South island

Latin name	Maori names	Common name	Health aspect	Comments
Lagenophora petiolata	Papataniwha niwha	Native daisy	Ulcers in mouth	Previously *Lagenifera petiolata*
Leucopogon fraseri			Edible berries	Previously *Cyathodes fraseri* Scented
Lepidium oleraceum	Nau	Cooks scurvy grass	Antiscorbutic	Pot herb Before human occupation it was more widespread away from coastal situations.
Lepidium rekohuense		Chatham Islands scurvy grass	Antiscorbutic	Restricted to 4 sites *Lepidium oligodontum* also occurs on the Chathams
Lepidium solandri	Matua cress	Alexander cress Inland cress	Antiscorbutic	Less than 1000 plants are known in the wild. All sites threatened by weed competition, animal browsing, and for most sites changes in land-use management.
Mentha cunninghamii	Hioi Hihoi	Maori mint NZ mint	Tonic Stimulant	
Oxalis spp	Tutae Kahu	Native Sorrel	Oxalic acid can be toxic to sheep	*Oxalis exilis* creeping oxalis no underground bulbils *Oxalis magellanica* white oxalis Used as vegetable contain oxalic acids
Pelargonium inodorum	Kopata,Kapurangi, Kurakura, Porewarewa		Antiseptic Bruising	
Plantago sp.	Kopakopa, Pārerarera	Plantain	Minerals Healing	11 native species and 9 introduced. *Plantago major* and *Plantago lanceolata* the most common are introduced
Poa cita	Wi	Silver tussocks	Arthritis rheumatism	Previously *Poa laevis*
Ranunculus hirtus	Maruru Kopukapuka		Abrasions Inflamed eyes	*Ranunculus rivularis* Waoriki **TOXIC** to stock

Latin name	Maori names	Common name	Health aspect	Comments
Rorippa palustris	Hānea, Poniu	Marsh cress	Tonic	
Rumex flexuosus	Runa	Native dock	Blood purifier MR Anthelminthic	Not to be confused with marsh ribbonwood *Plagianthus divaricatus*
Rumex obtusifolius	Pauwhenua	Broad leaved dock	Bloat	Waghorn and Jones 1989
Senecio rufiglandulosus	Panara		Styptic	
Senecio radiolatus subsp. radiolatus				Found only on the Chatham Islands
Sonchus asper	Puha	Prickly Sow thistle	Antiscorbutic Iron	Non native vegetable
Sonchus grandifolius		Chatham island sow thistle		Previously *Embergia*
Sonchus kirkii	Puha	New Zealand sow thistle		Native species
Sonchus oleraceus	Puha	Sow thistle	Antiscorbutic Iron	Naturalised 1832 Vegetable
Sonchus novae-zelandiae	Puha		Antiscorbutic	Native species
Stellaria decipiens var. angustata		New Zealand chickweed	Minerals	At risk one chickweed species now extinct
Stellaria gracilenta		Slender chickweed		Kiwiherb remedy
Stellaria parviflora	Kohukohu, Kaikākā	New Zealand Chickweed	Minerals	Only weed to grow in kumara patches
Taraxacum magellanicum	Tohetaka	Native dandelion	Calcium Blood purifier	Vegetable
Tetragonia tetragonioides	Kohiki	NZ spinach	Antiscorbutic	**TOXIC** to sheep up to 12%oxalates

The inclusion of native species in our pastures benefits biodiversity. As farmers move to agroecological management they are likely to plant more shrubs and trees for browse, shelter and land protection. Plantings of shrubby and arboreal species provides habitat for smaller plant species and all provide nectar and pollen for native insects, habitat for native invertebrates (Wouts and Yeates,

1994) and other fauna. The soil below shelter belts and browse bars is often very friable and fertile (Turner, 1951) and with its higher levels of humus and bacterial activity warms sooner and holds heat longer (O'Gorman personal communication).

The three spring annual herbs native to Aotearoa New Zealand, can all be found on farmed land and all are vulnerable, particularly to competition from introduced and more aggressive native species (Rogers et al., 2007). *Ceratocephala pungens*, *Myosotis pygmaea* var *minutiflora* and *Myosurus minimus* subsp*. Novae-zelandiae* are likely to be best protected on farmed land that is carefully grazed to decrease competition but not to eliminate the herbs.

There are a number of proponents of banning grazing of native species but as Rogers has indicated controlled grazing may help species survive the competition from exotics. Rose et al. (1995) reviewing 25 years of grazing in short tussock grasslands concluded banning grazing may not curtail the changes, particularly the increase in *Hieracium* species and that grazing may be beneficial as it controls the exotic species and gives inter tussock vegetation a chance to re-establish. Meurk et al. (2002) agree and suggest managed grazing may be beneficial and hieracium control is more important than banning grazing.

All the early livestock imported into Aotearoa New Zealand survived a long sea journey on which their nutritional needs were unlikely to have been fully met. The early flocks and herds were then marched and spread across the country with no form of controlled grazing and thus many species were eaten out of existence on farmed lands. If however the animals and grazing intervals are managed with both the welfare of the pasture and the animals to the fore, mixed pastures will survive and nourish livestock. Table 5 presents suggestions of native species that might be included in mixed pastures, species that were noted by early graziers as being particularly attractive to livestock.

Table 5 Native grasses and forbs - recorded as being attractive to livestock in Aotearoa New Zealand – which could be used in a pasture mix.

Species	otherwise known as	Stock class	Reference
Aciphylla dissecta	previously known as *Ligusticum dissectum*	Cattle	Aston 1911
Aciphylla squarrosa	Taramea, Speargrass, Spaniard	Stock	Aston 1911
Anthosachne aprica	blue wheat grass, only central Otago	Stock	NZPCN
Anthosachne solandri	Blue wheat grass	Stock	Peden 2011 Aston 1911 Cockayne Armstrong 1906 Connor 1993
Brachyglottis greyi	previously known as *Senecio greyii*	Stock	Aston 1911

Species	otherwise known as	Stock class	Reference
Carmichaelia sp	Native broom	Horses Cattle	Aston 1911 Wybrow 2013
Celmisia lyalli	False spaniard	Stock	Aston 1911
Celmisia holosericea	Mountain daisy	Stock Deer	Tanentzap 2009
Celmisia verbascifolia		Stock Deer	Tanentzap 2009
Chionochloa australis	*Danthonia raoulii* subsp. *australis* Carpet grass May perhaps be referring to *Danthonia raoulii var. cheesemanii* narrow leaved bush tussock now known as *Chionochloa cheesemanii*	Horses sheep	Aston 1911 Hilgendorf 1919
Chionochloa pallens	mid ribbed snow tussock	Deer	Tanentzap 2009
Chionochloa rigida	narrow leaved snow tussock	Deer	Tanentzap 2009
Connorochloa tenuis	Possibly the grass previously known as *Agropyrum scabrum* or *Agropyron scabrum* prostrate blue grass	Stock Horses	Aston 1911 Cockayne Armstrong 1906 Connor 1993
Cotula coronopifolia	Bachelors buttons, yellow buttons	Sheep	Aston 1911
Dichelachne crinita	Long hair plume grass	Stock	Guthrie Smith
Dichelachne micrantha	Previously *D. crinita var intermedia* Purple plume grass	Stock	Guthrie Smith 1907
Dolichoglottis lyallii	Yellow snow marguerite	Deer	Tanentzap 2009
Dolichoglottis scorzoneroides	White snow marguerite	Deer	Tanentzap 2009
Eryngium vesiculosum	Sea holly	Sheep	Aston 1911
*Festuca novae-zelan*diae	Fescue tussock	Cattle Sheep shoots	Hilgendorf 1919
Geranium brevicaule	Native geranium	Sheep	Guthrie-Smith 1907
Geranium microphyllum	Small leaved geranium	Sheep	Guthrie Smith 1907
Geranium molle	Doves foot cranesbill	Sheep	Guthrie Smith 1907

Species	otherwise known as	Stock class	Reference
Geranium solandri	Cut leaved geranium	Sheep	Guthrie Smith 1907
Gingidia grisea		Stock	NZPCN
Gingidia montana	Maori anise	Stock	Riley 1994 Aston 1911 Peden 2011 MacDonald 1974 Stark 1979
Haloragis erecta subsp. *erecta*	Toatoa Fireweed	Cattle	Riley 1994
Hibiscus diversifolius subsp*. diversifolius*	Native hibiscus	Cattle	Cheeseman in Aston
Koeleria sp.	identified as *K. kurtzii* but this is a South American species	Sheep	Aston 1911
Lepidium oleraceum	Scurvy grass Nau	Stock	Aston 1911 Riley 1994
Lepidium solandri	Alexandra cress		NZPCN
Lepidium tenuicaule var *minor*	Shore cress, now extinct North island	Sheep	Aston 1911 NZPCN
Microlaena avenacea	Oat grass Bush rice grass	Cattle	Guthrie Smith 1907
Microlaena stipoides	Meadow rice grass	Sheep	Guthrie Smith 1907
Myosotidium hortensia	Chatham Island forget me not	Cattle	Eyles 2012
Plantago sp.	11 native species	Stock	Riley 1994
Poa billardierei	Previously *Poa triodiodes* Pouaka sand tussock	Cattle	Riley 1994
Poa colensoi	Blue tussock	Stock	Peden 2011
Poa litorosa	Also known as *Festuca scoparia* Meadow grass	Cattle	Aston 1911
Puccinella stricta	previously *Atropis stricta* salt grass	Sheep	Aston 1911
Ranunculus acaulis	Shore buttercup	Sheep	Aston 1911
Ranunculus lyallii	Mount Cook Lily	Deer	Tanentzap 2009
Rytidosperma sp.	*Danthonia semiannularis* and sub species. Oat grass	Stock	Guthrie Smith 1907 Peden 2011 Hilgendorf 1919
Sellieria radicans	Remuremu	Sheep	Aston 1911
Spinifex sericeus	previously known as *Spinifex hirsutus*	Stock	Aston 1911
Stilbocarpa polaris		Sheep	Aston 1911
Trisetum antarcticum		Sheep	Guthrie Smith 1907

Species	otherwise known as	Stock class	Reference
Daucus carota	Wild carrot (naturalised 1854)	Stock	Peden 2011
Pastinaca sativa	Wild parsnip (naturalised 1867	Stock	Peden 2011

* "at Havelock the estuarial mudflats are covered with *Samolus* and the cattle laboriously drag themselves through the mud to obtain the plant"(Aston, 1911)

Conclusion

Diversity in pastures is essential to maintain a high level of animal health. Within a farmscape it is possible to grow a variety of pasture species some highly nutritive, some mineral rich and others high in a variety of allelochemicals. It is vital to have a wide diversity of species on offer, not only from the point of view of the livestock grazing them, but to slow the development of resistance in pathogenic organisms to the allelochemicals presented by the plant.
It may take some time for our livestock to adapt to a different regime. Provenza (2008) gives examples of ranchers who have changed their grazing systems and all state that a minimum of three years is required for both animals and farmers to adapt. Once the next generation of livestock starts coming into the herd or flock it becomes part of the culture to graze and browse widely and the animals thrive. Turner (1955) reminds us of the contribution that the psyche makes to animal health and suggests that stock that have some leisure to graze and browse widely are healthier than animals that are harried on limited grazing. Change also requires effort from land managers, respectful learning, relationships and dialogue (Sewell et al., 2014). As ideas and change are discussed, developed and instituted an acknowledgement of equal ability and varying strengths and knowledge amongst all participants is vital for good communication and success. Too often farmers grin behind consultants or academics backs as a totally unworkable 'solution' is foisted upon them. They haven't been recognised for their local knowledge and their abilities, or asked for their ideas and solutions.
The farmers in Aotearoa New Zealand who have diverse pastures and undertake an agroecological approach are already reaping the benefits in healthier stock, high production and low animal health bills (Graham, Moss, Purnell, Tipene personal communication). These farmers have pastures containing simple mixtures of European herbs, legumes and grasses and in two cases access to native bush. In certain extensive farming situations livestock could be produced on purely native mixed pastures – this would be an excellent marketing opportunity. At this point in time however for most farmers native species should be incorporated into mixed pastures containing herbs legumes and grasses and manged carefully. The native grasses did not evolve under a grazing regime and do not compete well with aggressive imported species (Alan Stewart

personal communication), so pasture mixes would have to be selected very carefully.

The flavour and composition of both meat and milk are affected by the diet of an animal. There is scope in future research to improve the fatty acid content of milk and meat, promoting consumer health and of course to produce meat with indigenous flavours, a highly marketable product.

Mixtures of native species need to be grown and evaluated in pasture situations. At present harvesting the seed of native species in any quantity is difficult and establishment can be uncertain. Research is required to select cultivars that are amenable cultivation and to learn how to manage native species so that they persist. From an animal health and production aspect, mixed pastures providing nutrient dense nutrition should include native species and introduced herbs, legumes and grasses. The contribution of healthy pastures to animal health could be assessed through health status recording and changes in production levels and parasite loadings. Studies in the farmed environment might include the effects of diverse mixed pastures on soil biology, invertebrates and vertebrates, water quality and farmer health and satisfaction, demonstrating the regenerative nature of the system. Mixed pasture systems designed with diversity and health as a focus have the added benefit of including deep rooting and therefore often drought tolerant plants, these pastures will become increasingly important in the face of climate change.

More weight should be given by the academics, policy makers and sections of the farming community to well documented experiences of those land managers who are truly whenua whanau rather than relying on short term narrow trials in which the correct questions may not be being asked.

It is always advisable to ‘consult the cow’. (Newman Turner 1955)

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