Eco-grazing – the use of diversified grazing ecosystems as part of integrated weed management

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Summary This paper argues for a more diversified grazing system that includes animals that eat weeds left by sheep and cattle. This system is called eco-grazing. Using goats as the example, the potential to control weeds of national importance and other pasture weeds are discussed. The ecological reasons for the success of goats relative to sheep in controlling weeds is examined. Published Australian examples of the successful use of goats in weed control are given. References are made to the few economic analyses of the use of goats for weed control, all of which are positive. Benefits of the use of eco-grazing are provided and contrasted with problems encountered with chemical means of weed control. Strategies for the successful adoption of this technology are summarised along with potential areas for further research and development of eco-grazing.

Keywords Eco-grazing, goats, sustainability, chemical-free, risks, biological control, blackberry, serrated tussock, thistles.

Background

Since European settlement of southern Australia the predominant grazing pressure on pastures have come from sheep, cattle, horses and rabbits. Numerous exotic weeds have established, most without their natural insects and mammal predators and consequently some weeds have expanded their range over large areas. Weeds in pastures are plants that provide little economic benefit to land managers. Weeds usually impose costs by way of reduced or suppressed pasture production, product contamination or tainting, may be toxic to livestock, invade land removing it from production or by blocking access, are expensive to control (e.g. chemicals and labour) and provide harbours for vermin. Pasture weeds can also spread to other areas reducing biodiversity and environmental values. In many cases, pasture weeds are basically plants that occur in monocultures of sheep and cattle, animals that avoid eating these plants for as long as possible.

High risks of chemical methods of weed control

While chemical methods for controlling weeds have been advocated for many years there is general agreement that chemical methods often fail, sometimes with great financial loss for farmers. For example, in New South Wales the average chemical kill of scotch thistle is now only 60% (personal communication Jim Dellow NSW Agriculture). Advocates of chemical control often overlook reasons for the failure of chemical methods of weed control (Table 1). Chemical methods of pasture weed control have large inherent risks. It is not surprising that some farmers have given up on the chemical option as they either do not have the skills, persistence or resources to adequately carry out these complex activities or they seek organic methods of production.

Eco-grazing for pasture weed control

What is possible in many areas is a more dynamic approach to pasture weed control, using methods which are more persistent, less prone to the vagaries of the weather, equipment and terrain and which do not endanger the health of operators, produce quality nor livestock. Clearly the classic use of biological control by the importation of diseases and insect parasites of weeds is an established part of integrated weed management. This paper suggests a wider approach be considered by the use of grazing animals that consume the plants that sheep and cattle leave flourishing as weeds i.e. a more biologically sustainable weed control strategy, here referred to as 'eco-grazing'. The farm animal considered will be the use of goats.

While dairy goats arrived in Australia in 1788, mohair and cashmere goats did not arrive until the middle of the nineteenth century and Boer goats arrived only in the past decade. Since 1970, renewed interest in farming goats for mohair, meat and cashmere production has prompted investigations into their dietary habits and potential for weed control. There is good technical knowledge available about the commercial farming of goats in Australia (Simmonds 2001). As early as 1920 McFadzean (1920) noted the value of goats for the control of blackberry. Since then, weed control authorities have shown little interest in using goats for weed control despite numerous inquiries and programs to control weed expansion in Australia. This may suggests some sort of 'speciesism' or live stock prejudice exists.

Ecological adaptation of goats for weed control

Goats and sheep have a common ancestor, and are still similar sized animals. Goats and sheep have evolved and adapted to use the environment differently. In southern Australia, most of the grazing pressure on pastures comes from sheep and cattle, and most farmers and advisers compare enterprises with sheep production so this discussion will follow the same tradition.

There are three ecological adaptations that differentiate goats in their dietary selection compared with sheep and cattle.

Morphological adaptations

Goats have a narrower muzzle compared with sheep, a curved front lower jaw, a split mobile upper lip and relatively longer legs. These attributes allow goats to nibble young shoots and leaves of prickly bushes providing a higher nitrogen and

Table 1. Common reasons for the failure of chemical methods of weed control

Inappropriate equipment
Inappropriate chemicals
Application in windy weather
Equipment failure
Failure of chemical to fix to leaves
Application prior to rain or frost
Poor maintenance or inaccurate calibration of equipment
Failure to store, handle or mix chemicals properly
No application in steep, rocky or inaccessible portions of pasture
Long germination period making a single application ineffective
Failure to apply chemical at correct concentration
Not all weeds killed resulting in continued flowering and seeding
Incorrect timing of application
Development of resistance
Unacceptable residues in products

energy diet than that obtained by sheep. Goats can strip the bark from stems more easily than Merino sheep.

Biochemical and physiological adaptations

Goats are able to tolerate a wider range of plant chemicals than sheep including alkaloids, sour and bitter tastes. Goat's superiority in urea recycling via increased salivary production provides higher levels of rumen buffering leading to higher digestibility of lignin and cellulose compared with sheep. They are able to neutralise the negative effects of tannins providing a wider range of palatable herbage. Goats also have specific rumen microorganisms which are absent in sheep and cattle that are more tannin tolerant and improve digestion of lignin and cellulose in high tannin diets.

Behaviour

There are many behavioural adaptations used by goats to help control weeds. Goats can stand for long periods on their hind legs to reach up 2 m into plants. Goats also use their legs to cause mechanical damage by bashing down plants. Goats are inquisitive and investigate many new plants. Goats are agile being able to climb into some plants and also easily navigate rocky areas, a habit not appreciated if appropriate fencing is not erected. Three aspects of the behaviour of grazing animals were used by Demment and Longhurst (1987) to show how the behaviour of goats differs from the behaviour of sheep:

- **Selectivity** Generally goats are more selective compared to sheep. Goats often demonstrate their ability to pick out plant parts left by other animals when grazed on both pastures and scrublands.
- **Degree of grazing/browsing** *Browsing* refers to the consumption of shrub and tree herbage while *grazing* is consumption of herbs and grasses near ground level. Goats tend to browse more than sheep but are better described as intermediate or mixed feeders. Goats can be grazed on pastures without browse. In my studies, when goats and sheep were grazed together on annual pastures, the species showed different selectiveness (McGregor 1990, Gurung *et al.* 1994), but at very high unsustainable grazing pressures when the pasture was short and in very limited supply, the sheep out-competed the goats (McGregor 1990). On annual improved pastures goats spent more time grazing than sheep during winter but spent less time grazing during summer than sheep (McGregor 1987). Studies in environments where there is plenty of browse have shown that increasing the stocking rate of goats leads to a reduced intake of browse as the more palatable plants are eaten and animals spend more time grazing. **It is not correct to describe goats as browsing animals and sheep as grazers.** Sheep can be kept on browse pastures such as salt bush and mulga. Why are sheep kept out of plantations if not to protect the growing trees and shrubs? Why do pastoralist fell trees for sheep during drought? The fact that goats can browse more than sheep does not mean goats are exclusively browsers, any more than the fact that sheep can browse means sheep are exclusively browsers. Browsing is a better description for the behaviour of giraffe, koalas and some antelope. Goats are best described as intermediate or mixed feeders.
- **Flexibility** Goats consume a wider variety of plants including very prickly plants and some bitter tasting plants compared with sheep and cattle. Goats are far more flexible in their feeding habits than sheep and cattle. Goats can change their preferences quite quickly. For example goats may avoid a growing plant but will eat the plant when it begins to flower. These flexible habits apply to both selectivity and grazing/browsing. Goats can eat with high or low selectivity on browse plants and with high selectivity on pasture, very flexible! The ecological adaptations that enable goats to be flexible are described above.

Studies of the nutritional value of thistles and blackberries have shown that the nutritional value of these 'weeds' can be as high or higher than the nutritional value of spring pasture (McGregor 1992). In almost **all cases the goats selected the most digestible part,** with the highest digestible energy, with values for thistles ranging from 10.5 to 11.0 MJ ME kg^{-1} DM (Table 2). It is misleading to claim that goats will eat anything, unless the animals are being deprived of adequate feed resources. Such a claim is a misinterpretation of the inquisitive behaviour of goats that results in a high frequently of sampling potentially new feed resources. Their ability to be selective, to browse and to be flexible has enabled goats to survive in many environments. So why don't sheep and cattle eat the nutritious parts of weed plants? The answer is that they have evolved to primarily graze. The issue is that in goats we have a farm animal that has evolved to eat plants that are now classified as weeds.

How do goats control weeds?

Holst (1980) has described the principle methods used by goats to control weeds as follows:

- Preventing flowering and subsequent seed development and dispersal;
- Preferentially grazing the weed and placing it at a competitive disadvantage relative to other plants;
- Mechanically damaging plants by ringbarking or structurally weakening or destroying the plant.

Australian examples of the successful use of goats in weed control

Goats, have successfully controlled and assisted in the elimination of a wide variety of exotic weeds in Australia including:

- serrated tussock (*Nassella trichotoma*, Campbell *et al.* 1979);
- gorse (*Ulex europaeus*, Harradine and Jones 1985);
- blackberries (*Rubus* spp., McFadzean 1920, Vere and Holst 1979, McGregor 1996a);
- briar (*Rosa rubiginosa*, Vere and Holst 1979);
- scotch broom (*Cytisus scoparius*, Allan *et al.* 1995);
- saffron thistle (*Carthamus lanatus*, Pierce 1986);
- variegated thistle (*Silybum marianum*, Campbell *et al.* 1979, Stanley *et al.* 2000);

Table 2. Nutritive values of introduced weeds grazed by goats in southern Australia (adapted from McGregor 1992)

Weed	Plant part	Energy (MJ ME kg^{-1} DM)	Crude protein (%)
Saffron thistle *Carthamus lanatus*	Leaves	12.1	14.4
Artichoke thistle *Cynara cardunculus*	Leaves	11.5	14.8
Boxthorn *Lycium ferocissimum*	Leaves	12.4	28.3
	Stem	9.2	11.6
Horehound *Marrubium vulgare*	Leaves	10.9	23.3
Spear thistle *Cirsium vulgare*	Leaves	11.3	20.2
Sweat briar *Rosa rubiginosa*	Leaves	10.5	20.7
Blackberry *Rubus fruticosus*	Leaves, young stems	10.6	21.0
	Old stems	7.4	6.1
	Dead stems	6.4	7.9

- nodding thistle (*Carduus nutans*, Allan *et al.* 1995);
- spear thistle (*Cirsium vulgare*, McGregor *et al.* 1990, 1996b);
- Illyrian thistle (*Onopordum illyricum*, Torrano *et al.* 1999); and
- artichoke thistle (*Cynara cardunculus*, McGregor *et al.* 1990).

Goats can effectively stop regeneration of some species of indigenous Australian plants such as *Acacia armata, A. diffusa, A. pycnantha* that 'invade' recently cleared 'pasture' (McGregor and Couchman 1988a). The role of goats in some of the semi-arid plant communities of Australia has been investigated but usually with the focus on control of indigenous woody 'weeds' following damage to the pasture caused by poor management of sheep or cattle (Holst 1980). Heavy grazing of some indigenous plant communities can result in animal production losses and welfare problems (McGregor and Couchman 1988b).

Goats have also been used to assist in the management of *Pinus radiata* forests by reducing herbage growth to allow easier access during pruning and thinning and in reducing the amount pruning required (Browne 1990). Goats also offer the potential to control weeds in forage crops such as lucerne and for pasture seed production.

Goats as a potential agent in serrated tussock control

Serrated tussock is a weed of National economic importance. Campbell *et al.* (1979) and Holst and Campbell (1987) reported on the use of goats in controlling serrated tussock on tablelands in central New South Wales. Goats were grazed with cattle initially at high stocking rates. Over a three year period stocking pressure was reduced by about 50%. Grazing with goats reduced the height of the serrated tussock from 40 cm in 1975 to 7 cm in winter 1978. Goats damaged the root system of serrated tussock plants in winter 1978 by partly pulling sections of the plant up and breaking the attached roots. This allowed the subterranean clover pasture, to over grow the weakened serrated tussock reducing their light supply and eventually killing 80% of the plants. The goats reduced the seed head production of serrated tussock in summer by up to 95%. Holst and Campbell (1987) concluded that serrated tussock is only controlled by goats if the weed constitutes a small portion of the total pasture, presumably less than 20% based on their data (Table 3).

Given the ability of goats to substantially reduce serrated tussock seed production at low levels of infestation, and the knowledge that there are many varieties of serrated tussock in Australia, opportunities may exist elsewhere in Australia to evaluate goats to develop improved technologies for the control of serrated tussock. Given the:

- differences in environmental conditions between the tablelands of NSW and southern Victoria;
- major advances in our knowledge of the husbandry requirements of goats over the past 20 years; and
- improved fencing technology;

it appears justified to undertake appropriately resourced demonstration trials to evaluate methods for control of serrated tussock by using goats in association with other control agents. The impact of goats on Chilean needle grass, another weed of National importance in the Nassella family is unknown.

Table 3. Effect of goats on the ground cover of pasture species and on seed head production by *N. trichotoma* compared to that on the adjoining paddock grazed by sheep at a lower stocking rate (Campbell *et al.* 1979)

Date	*N. trichotoma* (% ground cover)	Improved species (% ground cover)	Reduction in summer seed heads (%)
Start 10/75	18	52	
9/76	12	43	80
11/77	10	42	77
10/78	4	65	95

Goats as a control agent for other weeds of national importance

Gorse (*Ulex europaeus*) and blackberries (*Rubus* spp.) are readily controlled using grazing goats (Harradine and Jones 1985, McFadzean 1920, Vere and Holst 1979, McGregor 1996a). Control of these weeds is improved using integrated methods of grazing, pasture management and fire (e.g. Allan *et al.* 1995). Goats have destroyed unmanageable and expanding infestations of blackberries in hillside and undulating pastures in Victoria and New South Wales (Vere and Holst 1979, McGregor 1996a). It has been demonstrated that goats preferred to eat the nutritious leaves and growing new stems of blackberry (Table 2) destroying the plants as soon as 18 months after introduction.

Eco-grazing turns weeds into a valuable resource

In Victoria, graziers and land managers spend tens of millions of dollars destroying weeds that have a forage value equivalent to at least $50 million annually. The application of eco-grazing will provide a more sustainable environmentally friendly, chemical free method of weed control. Land managers seeking more sustainable production systems should evaluate the potential benefits of using eco-grazing (Table 4).

Table 4. Potential direct and indirect benefits from weed control programs using goats

Continual dynamic control
Prevention of seed set
Delays need for pasture renovation
Control in inaccessible country
Improved product quality
Access to inaccessible areas
Residue free production system
Improved pasture quality
Turn weeds into feed resource
Control bush invasion of pastures
Reclamation of pasture land
Harbours for vermin eliminated
Reduced labour and machinery costs
Increased stock carrying capacity
Reduces chemical usage

Requirement for further development of goats as a weed control agent

As with all technologies, just because goats can do the job in one environment does not mean that the technology is right for direct transference to another environment. There needs to be refinement of the technology. Important issues relating to the management of goats in plantations need to be clarified, current knowledge documented and deficiencies researched and developed for practical use. The best methods of introducing these practices onto farms also need to be refined.

Economic use of goats for weed control

The limited number of economic studies of using goats for weed control incorporate only some of the benefits listed in Table 4 and not all include the production of agricultural products such as fibre and meat. Vere and Holst (1979), Krause *et al.* (1984), Arnott (1985) and Davies (1996) provided estimates of economic performance for various enterprises and all indicate reasonable managers can achieve profitable outcomes. Krause *et al.* (1984) concluded that goats offered the most economic method for gorse control in New Zealand hill country. The introduction of goats onto a property does require provision of appropriate infrastructure and on some sheep properties complementarity of facilities exist. Little attention has been

paid to using goats for weed control in cropping systems in drier regions. The following issues must be attended to for an efficient production system: 1) farmers need to be educated and trained into managing goats; 2) fencing and yards must be appropriate before goats arrive and be properly maintained; and 3) appropriate stocking rates, herd health and animal welfare practices must be used.

Strategies for the successful adoption of eco-grazing

This article argues that a more diversified grazing ecosystem will provide benefits in sustainable weed control. The use of goats as part of integrated weed management has been used as the example to demonstrate the principles of eco-grazing. Managers in Government Departments (DPI), the CRC for Weed Control (CRC) and in catchment management authorities (CMAs) should seriously consider their professional position regarding eco-grazing and the use of goats to achieve sustainable long term practice change in weed control. To further develop eco-grazing the following strategies are suggested:

1. Train appropriate DPI, CRC and CMA staff in the use of goats for effective weed control.
2. Alter DPI, CRC and CMA recommendations and advisory material to include adequate advice on the use of goats to control weeds.
3. Incorporate the use of goats for weed control into Landcare and Water Catchment and Land Management Boards programs.
4. Develop targeted cultural change problems for landholders and staff of government authorities.
5. Invest in and evaluate the use of goats to control weeds in all regions by including appropriate treatments in field experiments.
6. Undertake economic studies on the use of goats for weed control.

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