

GORSE AND GOATS:  
CONSIDERATIONS FOR BIOLOGICAL CONTROL OF GORSE

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## PREFACE

The Entomology Division of the Department of Scientific and Industrial Research have been following a research programme for some time designed to identify potential biological agents which might be used to influence the level of gorse growth in New Zealand. This programme has advanced to the point where it is considered that a suitable agent has been identified and, following the completion of remaining tests, is likely to be introduced to New Zealand.

During 1985, the Agricultural Economics Research Unit was asked to carry out an analysis of the economic impact of gorse in New Zealand and to assess the likely costs and benefits to New Zealand if an agent was introduced to naturally regulate gorse. The conclusion from this work was that, "providing all reasonable steps were taken to ensure the agents are host specific, the introduction of these agents is economically efficient. The potential benefits outweigh the costs." (Research Report No. 172, November 1985). Following publication of this Research report, considerable discussion and debate began on the potential of gorse as a basis for an expanding goat industry. It was claimed that the inclusion of the benefits of using gorse as a food source for goats would increase the economic benefits of gorse to such an extent that the cost of gorse presence would be exceeded, leading to the conclusion that the introduction of a biological agent would be undesirable.

This Discussion Paper reviews the evidence available on the use of gorse as a fodder source for goats and further refines the assessment of the likely impact of a biological agent on the level of gorse presence. The conclusions established are that it is most unlikely that the goat industry would be adversely affected by the introduction of a biological agent to regulate gorse.

This Discussion Paper provides a valuable contribution to the analysis of the particular issue. It also provides an example of the way in which such issues should be analysed through the use of probability and discounting techniques and the interpretation of scientific results within the parameters of the experimental design.

J.G. Pryde  
DIRECTOR



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## SECTION 1

### Introduction and Problem Statement

Recent proposals have been made to introduce biological agents to naturally regulate gorse (*Ulex europaeus*) in New Zealand (Hill, 1986). Gorse is a serious scrub weed to both farmers and foresters, but does provide some economic benefits. A comparison of the costs and benefits (Sandrey, 1985) led to the recommendation that, provided all reasonable steps were taken to ensure that agents are host specific, the introduction of these agents is economically efficient. However, several limitations of the study were noted, including the issue of goat enterprises on land containing gorse.

Research into using goats to control gorse has been conducted over the last 6 years at Ballantrae, Palmerston North and Loburn, Canterbury. This research has clearly demonstrated that goats can effectively control gorse (Lambert et al., 1981 and Radcliffe, 1983, 1985). The economics of using goats for this purpose has been documented using data from trials at Ballantrae (Krause et al., 1984). With the expansion of the New Zealand goat industry interest in a low input system growing gorse to sustain goats has been expressed (Radcliffe, 1986). This is an extension of using goats to control gorse, and may present an alternative to conventional sheep and cattle production on marginal hill country in the future.

The problem is that control of gorse by biological agents may preclude the development of a gorse-for-goats farming system.

If the agents establish "successfully" and have a major impact on the gorse plant, the cost of controlling these same agents may make such a system uneconomical. Thus, an irreversible situation.

Interestingly, the New Zealand Goat Council is less concerned than many other people about the consequences of biological control of gorse. In a submission to the Department of Scientific and Industrial Research, the Goat Council writes:

"... we think that reasonable people would be unlikely to support the retention of prickly gorse purely because it has potential to feed goats.

... gorse is not required as a roughage for goat farming, and even if it was, other plants could take its place.

On balance we do not consider that the goat industry can offer a reasonable argument against introducing further insect gorse control agents". (Batten, 1986 p. 108)

The objective of this paper is to examine the concept of irreversibility and the consequences of making an irreversible or irrevocable decision using natural regulation of gorse and the goat industry as an example.



## SECTION 2

### Economic Considerations

#### 2.1 Definitions

Irreversibility is so-called "non-market value", where benefits of decision's made now cannot be changed and impose a cost to society in the form of a potential benefit foregone.

Dasgupta and Heal (1979) consider that "a process is irrevocable if it prevents a system from ever returning to previous attained state" (p. 149). This definition, although technically correct, is rather imprecise. As Randall (1981) points out, no choice is reversible at zero cost, and many seemingly irreversible choices may be reversed at some less than infinite cost. However, the concept remains valid, as some decisions may only be reversed at an extremely high cost. Extinction of species and soil erosion are perhaps classic examples of irreversible acts, but other examples exist where the decision may be physically reversible, but economically irreversible. In this case some definitive value can be assigned to irreversibility - the cost of making a decision now, which with the advent of more knowledge or changing situations, would prove to have been the wrong decision. As Kennedy (1987) writes, "if in a cost-benefit analysis the expected returns from releasing a biological control agent are compared with the expected returns from non-release, and at a later stage further research findings will give a more reliable estimate of the efficacy of release, then some additional value should be placed on non-release". This does not preclude the release of agents, but cautions the analyst to consider all implications of possible outcomes.

Obviously all decisions have an element of irreversibility, and may prove to be the wrong decision. After being run over by a car while crossing the street, it is difficult to reverse the original decision to cross the street! The relevant issue is: what is the implication for a decision maker? Is the "additional value" which Kennedy places on non-release enough to delay or stop the release of biological agents to naturally regulate gorse?

#### 2.2 Economic Issues

At the start of any particular season we have an area of land with some gorse cover. For a traditional livestock production system, this gorse cover imposes a cost. Either total usable production from the land is reduced, or some direct cost is involved in containing or controlling the gorse. This can be either chemical control or non-chemical control such as crushing and burning. The total annual cost to New Zealand is a very debatable issue. Sandrey (1985) estimated the direct costs to be in the order of \$17 to \$18 million to farmers and farming, with a further \$8 million annually to foresters. There is little doubt that gorse is considered to be a major problem over a range of farming situations in New Zealand. Costs arise from gorse because (a) it limits pasture production and/or (b) it requires

control, albeit for legal and maybe not economic reasons. If the agents are introduced, the benefits will accrue from (a) a reduction in gorse and/or (b) a reduction in chemical and other controls.

The problem is that we need to know several relationships before benefits of introducing agents to control gorse can be quantified. Firstly, the loss from the gorse in reduced production. Secondly, the impact on the gorse from the agents and subsequent change in total production. Finally, what change would result in inputs, both chemical and non-chemical, in any time period following introduction of agents?

A different situation may arise under the considered option; a low input gorse-for-goats farming enterprise. Total potential plant production has to be non-decreasing with respect to gorse production, and/or cost in the form of chemical and other inputs would need to be lower with a goat production system before a cost resulted from the introduction of biological agents.

Previously potential benefits resulted from the controlling agents. With a goat enterprise, it is hypothesised that costs arise from these agents. Potential costs arise from the introduction of the biological agents if:

- (1) the agents establish "successfully"
- (2) the effect is to lower usable total potential plant production per unit area - ie. gorse has production potential for goats;
- (3) the economic effect of this is accentuated at lower fertiliser inputs levels;
- (4) the goat industry has the potential to become an economically important livestock production system;
- (5) the decision to introduce biological agents is economically irreversible

These are the questions the study will address.

## SECTION 3

Biological Considerations3.1 Probability of "Successful" Introductions of Biological Agents

Introducing biological agents to naturally regulate gorse is not a new concept to New Zealand. In 1931 the gorse seed weevil (Apion ulicis F.) was released in New Zealand for gorse control. This insect attacks the seeds of the plant, and although it has become one of New Zealand's commonest insects it has not controlled the spread of gorse, because it is only active in the spring. Over half a century ago it was considered that gorse was too valuable as a shelter hedge to introduce agents which would attack the plant directly, hence the seed weevil alone was introduced.

History shows that biological control can provide stable long-term control of weeds. However, despite some notable success stories such as the prickly pear moth Cactoblastis cactorum in Queensland, there remains a very low probability of any single biological agent establishing in a new habitat and then achieving natural regulation of the host species.

Dr M.J. Crawley, Imperial College, University of London, has summarised the history of biological weed control worldwide. In a personal communication, he considered the likelihood of an agent establishing in a new habitat at 60 per cent. He then estimated that, once established, the following degrees of control (ranging from zero to complete removal) were likely:

0% control	25%	50%	75%	100% removal
79% likelihood	11%	5%	5%	0% likelihood

Weighting these likelihoods by the 60 per cent probability of the agents even establishing suggests that there is a very low likelihood of "successful" biological control or natural regulation of gorse occurring. Furthermore, Dr Crawley considered that it is impossible to predict the likelihood of an individual agent's degree of control before introduction. Four to six potential control agents are known for gorse, and although additional agents would achieve better results their effect would not necessarily be strictly additive.

The problem with the likelihood approach is that it is an estimate based on all historical data back to 1880-90. Since the 1930's Hokkanen shows an increasing percentage of "complete success" as a percentage of "all biocontrol successes". This is due, in part, to a "maturing of the discipline" as opposed to an enthusiastic "trial and error" period of earlier times. Weeds have yielded more "complete successes in relation to the total number of successes" than the attempts to control insect pests, although this may reflect the

intensity and screening for potential agents for weed control (Hokkanen, 1985). However, success still remains low - "Of all introduced biocontrol agents only about 35% have been reported to have become ecologically established in the new ecosystem and in only about 60% of these establishments was there any kind of economic or biocontrol success" (Hokkanen, 1985, p35). This appears to be consistent with results reported in Julien et al., 1984.

Another major problem exists in trying to define "degree of control". In mature gorse stands control can be equated to reduction in plant vigour and aggressiveness. In immature plants where there may be less capacity to compensate for damage, even low densities of control agents could reduce plant vigour. The greater the reduction in vigour, the more susceptible gorse plants would be to additional grazing competition, climatic and edaphic stress and herbicides.

Gorse occurs commonly in the British Isles and on the Western European seaboard. It is a minor problem in North-West Spain, but elsewhere it is not aggressive and is valued as a wildflower. This suggests that even if some "successful" control of gorse occurred, it would still remain, both as a weed or potential fodder source. In fact, if older stands are broken down by natural regulation, benefits to both traditional users and potential goat farmers may result. Traditional farmers may find gorse easier to control, while goat farmers may find stock access to green fodder is improved.

In discussing the likely consequences of the introduction of biological agents, Hill (1986) outlines 5 possible scenarios describing possible levels of control. These are:

- Level 1            Insect damage has no effect
- Level 2            Insect damage obvious. In some cases a reduction in gorse growth and reproductive vigour, but elsewhere apparently unaffected.
- Level 3            Insect damage sufficiently severe to cause reduction in growth and reproduction everywhere, and in some cases gorse to die.
- Level 4            50 per cent reduction in gorse density and a reduction in vigour in most areas.
- Level 5            75 per cent or more of gorse plants destroyed throughout its range, and stable control at this level from year to year.

These correspond roughly to the likelihood figures suggested earlier, although the probability or likelihood estimates may not correspond.

Establishment of a programme against gorse would take many years. If control agents were released in New Zealand in 1987, it is unlikely that they could have any impact on gorse vigour and density nationally before 1992 or 1997. In fact, as outlined earlier, it may well prove impossible to establish these particular gorse insects at all in New Zealand.

It is very difficult to predict the impact of biological control on either mature stands or regenerative gorse because of uncertainties in:

- (a) Establishment of control agents;
- (b) Population responses of control agents in New Zealand without their natural enemies;
- (c) The impact of New Zealand climate on control agent performance;
- (d) The role of other plants (including weeds) as competitors with weakened gorse; and
- (e) The impact of native parasites and predators on the introduced control agents;

Unfortunately there doesn't appear to be any meaningful way of statistically using the likelihood function to establish expected probabilities of any given outcome. To do so implies more certainty about the likelihoods than is justifiable. However, we do know that eradication has a zero per cent likelihood of happening.

Associated with this problem of expected probabilities is the question of the time path of a "successful" introduction. Investment analysis requires that the net income stream be discounted before a decision is made on the viability of a particular investment. Cost-benefit analysis differs from investment analysis in that all costs and all benefits must be included, regardless of who bears the costs or reaps the benefits. However, the same concept of discounting must apply. The appropriate rate of discounting is a continuing debate in economics. I agree with Kennedy (1987), who states:

"If Government money is to be used to research, administer and monitor weed control, such as the release of biological agents, it is desirable on efficiency grounds to use the same rate of discount as is used for appraising any other public project."

Usually in cost-benefit analysis the costs are incurred early in the project and the benefits are generated later. This particular case study is different - the potential costs do not occur until later. How much later, or how large a cost we do not know. The principle of discounting must remain, and discounting future costs back to present day values lessens those costs considerably. In a similar manner, the benefits to farmers and foresters are extremely uncertain. We know neither the extent nor timing of these benefits, or any expected values of potential benefits. It is likely, however, that for at least two reasons benefits to farmers and foresters will occur earlier than costs to goat farmers. Firstly, it is likely that possible changes to gorse stocks would be such that benefits from reduction in vigour would reduce control measures from farmers and foresters at or before a time when goat production was affected, and secondly, the time path of the goat livestock industry is still expanding, thus changes to potential fodder sources lie some time in the future, probably after gorse is affected. This implies a greater weighting must be given to earlier benefits rather than later costs.



### 3.2 Potential Plant Production

Recent trials by the Ministry of Agriculture and Fisheries (MAF) at Loburn (Radcliffe, 1985) and the D.S.I.R. at Ballantrae (Lambert, 1985) have shown that goats can control and even eradicate gorse. For rapid and effective gorse control, a high density of goats is required. Results show that 3 years after burning a goat-dominated stocking system reduced gorse to negligible levels in Canterbury (Radcliffe, 1985).

During the course of research on using goats to control gorse, Dr Radcliffe and others found that goats readily eat gorse at all times of the year. Green gorse was always actively selected, although brown foliage was also eaten. Gorse flowers were always preferentially eaten, while white clover flowers were generally ignored. These findings prompted further research into the feasibility of gorse as a resource for goats. Some results of this extension to the original work are presented in Radcliffe, 1986. There is, of course, nothing new in the idea of gorse as a fodder plant. The early European settlers brought gorse along as a fodder source. What has changed is a new emphasis on the domestic goat livestock industry.

Whether gorse can provide a valuable fodder source for goats depends upon several points. These include:

- 1) The net production from gorse;
- 2) The green foliage production;
- 3) The digestibility of the gorse; and
- 4) The animal performance on a gorse diet.

Seasonal net productivity depends on rates of growth and decay, and the growth rate depends on the height, intensity and frequency of defoliation. Net annual production of gorse (green and brown) varied from 11.3 t DM/ha to an estimated 46 t DM/ha (Radcliffe, 1986). This appears consistent with Egunjobi, who estimated annual gorse production of 15 t DM/ha in the first 5 years after burning. This was similar to fertilised pasture production (13 t DM/ha) on the same soils, but considerably better than unfertilised pastures (6 t DM/ha) (Egunjobi, 1971)

The net growth of green gorse is of particular interest in assessing the value of gorse as stock fodder. In a wet summer at Loburn, net production of green gorse was estimated at 15.8 t DM/ha from a total initial biomass of 9.7 t DM/ha (green and brown gorse). In the following drier season, net production of green gorse fell to 11.3 t DM/ha from a much higher total initial biomass of 24.9 t DM/ha (green and brown gorse) (Radcliffe, 1986).

These figures are supported by MAF research at Mangamahy, north of Wanganui. Dr Ian Popay provided the following information from their plots for the 1985/86 growing season (in kg DM/ha of gorse green matter production):

	Grown	Grazed (by goats)
24.05.85 - 20.09.85	709	0
20.09.85 - 17.10.85	2310	0
17.10.85 - 26.11.85	2668	407
26.11.85 - 08.01.86	258	3143
08.01.86 - 28.02.86	899	2619
28.02.86 - 28.05.86	2569	1133
	<hr/>	<hr/>
Total	9413	7302

Almost all the new growth was made in the spring, with the apparent increase in dry matter in the autumn being largely due to lignification of new growth. On a low fertility site, Popay estimated that "gorse productivity was probably about 50% higher than the estimated pasture production of 6000 kg DM/ha year" (pers comm). The trials were measured using 2.4m harvested plots, protected by cages.

Dr Popay summed up his results by stating "my current thinking is that gorse is probably not very useful as a supplementary feed for goats. It produces all its growth in spring, and it is only useful as a fodder during late spring and early summer, when there is a pasture surpluses in any case" (pers comm).

Radcliffe (1986) reports that gorse digestibility, even in spring 1981 when green shoots were abundant, was considerably lower at 65 % than spring pasture (75-85%), or winter swedes or turnips (90 %). The lower values for gorse were also below those of meadow hay or cereal straws, because gorse has more lignin. Gorse is most digestible and nutritious in late spring and early summer when new shoots are being formed and foliar N concentrations are high (3.0 - 3.5 % N). Popay once again confirms these results, with the digestibility of gorse to goats being about 66% in November, 60% in February and about 49% in both April and June on the Wanganui trial. Gorse foliage at Loburn tended to have lower mineral concentrations than did leafy pastures at the same site or other typical ryegrass - white clover pastures in New Zealand.

Jobson and Thomas (1964) also report that gorse is a "useful source of protein of good digestibility" but "proved to contain inadequate amounts of phosphorus and of the more important trace elements" (p652).

Radcliffe considers that evidence from Loburn shows that non-lactating goats with abundant gorse browse, perform just as well as similar groups of goats confined to pasture. Indeed an extended supply of gorse in 1984, delayed the normal decline of body weight over winter. Recent research on the same area, has examined similar groups of first cross Angora x feral wethers confined to either pasture, a gorse - pasture mixture (Block B), or a gorse dominant area (Block C). Fleece growth rates over one year were comparable between goats confined to pasture (723 +/- 60 g), or a gorse-pasture mixture (805 +/- 79 g), but were lower from goats in dense gorse (537 +/- 47 g) (Radcliffe, pers. comm.). Thus some gorse browse has not been detrimental to fleece growth. If these results are confirmed

elsewhere, they will have important implications for the goat fibre industry. The fleece weights from dense gorse are considerably lower than those from either pure pasture or gorse-pasture mix. The livestock system of using goats to control gorse is different from growing gorse for goats, and care must be taken in using these results to estimate a sustainable system.

Radcliffe (1986) concluded that gorse stands can be used successfully for overwintering goats, while summer growth rates of gorse suggest that it could be used as a renewable, productive feed source for goat farming enterprises, provided browsing damage to gorse stands can be controlled. However, the highest quality fodder is grown during late spring - early summer. The most productive management systems which accommodate both gorse and goats still need to be defined. It might be kept in mind, however, that research at Loburn was conducted using feral-cross wethers. These same results may not be applicable to lactating goats.

### 3.3 Low Fertiliser Inputs

Much of the concern expressed regarding future gorse-for-goats livestock systems is predicated upon the potential of gorse as a sustainable low input requirement fodder source. Fertiliser requirements in traditional swards are mainly for the clover, which in turn provides nitrogen for the grass. Gorse, with this supposed lower fertiliser requirement may have the potential to break this economic cycle with its nitrogen fixation ability.

In response to claims that fewer gorse seedlings established in pasture treated with lime, Phung et al (1984) tested the effect of lime on gorse seedling generation and subsequent seedling growth. Results showed that although lime reduced seedling emergence slightly it encouraged seedling growth. The effect of lime in suppressing seedling establishment was probably "due to increased pasture competition or greater grazing pressure on the pasture due to increased legume content".

Thompson (1974) found that gorse demonstrated very marked responses in weight, height and density to phosphate, while potash increases plant vigour only. Nitrogen inhibited seedling gorse but established plants, especially in the juvenile stage, "responded very significantly to it" (p 9-10).

Egunjobi (1967), cited in Hill (1986), concluded that gorse is a phosphorus demanding species, and that growth was probably limited by the availability of phosphorus. This was confirmed later in trials by Mlowe (1978) and Hill (1982), both of whom are cited from Hill (1986).

Unfortunately we have limited information to work from. A medium to long term trial evaluating gorse as a low input, sustainable system would provide more answers to these issues. The question of both the economic importance of this work and who should fund it in today's research climate remains a moot point.

### 3.4 The Goat Industry

Substantial changes have occurred in the New Zealand goat industry during the 1980's. The industry has progressed from a small domestic base and a large feral population to the new glamour livestock. Information on numbers of goats on New Zealand farms is shown in Table 1, and this shows dramatic increase.

Table 1: Goats On New Zealand Farms

Year	Angora*	Dairy	Other	Total
1980	N/A	N/A	N/A	52,607
1981	19,354	9,979	38,728	68,061
1982	25,780	17,250	49,717	92,747
1983	37,437	21,938	91,132	150,507
1984	60,658	28,803	140,904	230,365
1985	109,082	33,264	284,541	426,887

Source: New Zealand Department of Statistics

\* Denoted as Angora and Angora crosses prior to 1984  
N/A Not available

The dynamics of a new livestock industry, while constrained by biological factors, are driven by economic considerations. As Yerex (1986) notes, "... the feral goat has achieved a new status only because it can, by some miracle of breeding, be turned from a smelly pest in the bush into a gleaming white creature with a luxury price tag on it". (p.7.). This has been motivated by the sale of some goats at extremely high prices. However we are in an expansionary phase, moving towards some desired industry position. What the equilibrium level of the goat herd is and when that level will be reached is impossible to predict.

Driving this expansion of the goat herd is the demand for goat fibres. These are mohair and cashmere, although recently interest has also been shown in cashgora fibre.

Mohair is from the Angora goat, and it is considered to be a luxury, high fashion fibre. World production in 1984 was estimated at some 18,650 tonnes, with South Africa (8,200 tonnes) and USA (4,800 tonnes) being the principal producers (Rumble, 1985). Over the past 30 years, total production has fluctuated from around 30,000 tonnes in 1965 to just over 13,500 tonnes in 1976 (Coopers and Lybrand 1986). A good commercial angora in New Zealand should be producing as much as 4 kg annually, however MAF (1985) consider that a realistic average yield of purebred does at 2.5 kg and crossbred does at 1.2 kg can be expected up to 1990. Coopers and Lybrand (1986) project a 100 fold increase (to

10,000 tonnes) in New Zealand's mohair production by the year 2000. This is in contrast to a 50 percent increase in the rest of the world, excluding Australasia. Reasons given for the rest of the world not increasing production include, with respect to the USA, "the overall economic conditions facing farming". One is left wondering why mohair production in New Zealand should increase 100 times, while the USA production remains static because of "the overall conditions facing farming"!

Cashmere is the fine undercoat of a feral or cross-bred goat, but unlike the angora goat which produces mohair, there is no "cashmere" breed of goat. Any goat producing 100g of cashmere is considered above average in New Zealand, although some animals are producing 300g (Yerex 1986). MAF(1985) consider that cashmere yields are between 30-40g per animal, but improved breeding may increase this to 100g by 1990. World production of cashmere is less than that of mohair, with China being the main producer. Rumble (1985) considers that "world production is thought to be 4,000-6,000 tonnes annually", although Coopers and Lybrand (1986) estimate world production at "approximately 8,000 tonnes". New Zealand's 1985 production was 9 tonnes (Restall 1986), with some 14 tonnes being produced in Australia (Rumble 1986). Dawsons International of Scotland are thought to be interested in buying 100 tonnes from Australia and New Zealand as soon as possible. Forecasts for estimates of 4 million goats by 1995 have been made, but Restall (1986) considers these estimates to be optimistic.

Recently interest has been shown in the Cashgora fibre, which is between mohair and cashmere in fineness. This is produced mainly from using angora bucks over feral does or bucks with low fibre diameter over cross bred does. At this stage it is uncertain as to how the cashgora industry will develop, but this may be important for the gorse and goats issue. As Yerex (1986) states, "Such goats would be better suited to rough conditions, such as gorse country than Angoras".

The role of feral goats has been as a breeding pool to rapidly increase the herd. Offspring by angora bucks from feral does can be classified as G4 progeny. Registered angoras can be obtained in the 5th generation of crossing, with G4 the 1st cross and G1 usually the 4th cross. Some of the G4 does will not be suitable for further crossing to angora, and crossing these back to ferals results in a cashmere goat. The cashgora is an intermediate cross, with ferals upgraded to G3 status and then crossed back to a selected G4 buck.

With the goat industry in such a dynamic phase it is impossible to predict the future role of goats. However, there is little doubt that a large industry will develop, but it is uncertain at this stage as to which fibre type or types will become the most important. Quality mohair production from angora goats requires quality feed (Lambert 1985), and although angora goats can eat gorse, it is unlikely that gorse will be a major dietary item. The cashmere and cashgora animals are those most likely to be used in the first instance for weed control and possibly in the second instance for a gorse supplemented diet. This goat industry must be kept in perspective. As Coopers and Lybrand report "...it is important not to over-stress the contribution that goats can make. By 1995, if the projections are correct, the volume of mohair produced will be only 4,000 tonnes, compared to a current wool clip of 375,000 tonnes".

In a crystal ball grazing exercise, Irvine (1986) looks at the year 2000. He considers that many dairy farmers will run some goats for weed control, and that more than half of all sheep farmers will also be running goats. This is because of the economic returns from goats, and of the weed controlling ability. Cashgora presents some interesting issues for the future, but Irvine considers that the market is untested for the fibre and the future breeding programme is uncertain at this stage. However, the feral characteristics of cashgora goats should ensure they will do well on hard hill country in a low cost farming system "reducing scrub weed reversion".

No discussion on the future of the goat industry is complete without looking at meat (chevon) and milk production. Restall (1986) considers that chevon production is not fully appreciated in New Zealand, but MAF (1985) consider "it is expected that meat production will have an increasingly important role in the industry's future, although it is unlikely that meat production will develop as the main objective on farms". This is because "the relatively slow growth rate of goats compared to say, sheep means that goat farming with the main objective of meat production will not be competitive with other farming types" (MAF 1985). However, this is disputed by Irvine (1986), who considers "by year 2000 there will have developed a substantial goat meat industry, quite possibly exporting 30,000 tonnes a year", (p173).

The bulk of New Zealand's goat meat exports are sent to lesser developed countries, with Trinidad/Tobago and Fiji being our largest markets. The f.o.b. value of goat exports for 1983/84 were some \$1.7 million (Restall 1985). It is generally considered that the value of goats for weed control and/or fibre production is greater than the meat value (Rumble 1985).

High goat milk powder prices in the 1970's encouraged the development of the dairy goat industry. Marketing difficulties arose in 1982/83, which lead to Government intervention in the form of seasonal loans (MAF 1985). Restall considers that, although New Zealand has the potential to produce 7,500 tonnes of milk powder by 1990, export demand is likely to limit production to 1500-2000 tonnes. Given that the 1983/84 production was 310 tonnes, this could be extremely optimistic. Few advocates of the goat industry appear to be hitching their wagons to either the meat or milk stars.

### 3.5 Is the Introduction of Biological Agents Irreversible?

From an economic point of view, we would need to consider the decision to introduce biological agents as irreversible. Theoretically, a spray regime could be devised to mitigate the effects of these insects. However, the cost of this is likely to defeat the original proposal - that of using gorse as a low input, sustainable fodder source for goats. Therefore, we can consider the introduction of biological agents to naturally regulate gorse as being an irreversible decision.



## SECTION 4

Policy Implications of Introduction

Given that the introduction of these agents is irreversible, then what is the potential benefit from not introducing these same agents? - i.e., the cost of irreversibility.

We have looked at the issue sequentially. Firstly, it is not possible to calculate an expected probability of "successfully" introducing the agents. Also, considerable uncertainty exists in the time path of benefits and costs, although it is likely that benefits will accrue before costs.

Early research indicates that gorse is potentially an adequate source of fodder for goats. Digestible dry matter production is high and goats selectively choose gorse as a fodder, but food quality is questionable. Although the research which has been conducted has studied the ability of goats to control gorse, animal thrift and production on these trials has reinforced the value of gorse as a renewable resource.

Although gorse responds to at least phosphate fertilisation, its ability to tolerate acid soils and to fix nitrogen in these acid soils suggests potential value as a low input resource. Gorse plants could potentially play the role traditionally filled by white clover as fodder source and nitrogen fixer for grass species. This may be especially attractive for a goat and sheep or goat and cattle livestock system. Unfortunately, there is no information to support this hypothesis.

The goat industry is well on the way to becoming a major livestock industry, but where some equilibrium level will be reached is impossible to predict. This new industry will most likely concentrate on high quality fibre production. With the expansion of the purebred herds, the role of feral goats as a breeding base will diminish, although cashgora type goats may have a role in the future for weed control.

Will the introduction of biological agents to naturally regulate gorse affect the growth of the goat industry? The answer to that in the short to medium term must be an emphatic no. Goats are able to thrive under a wide range of vegetative systems from bracken and scrub to prime Waikato pastureland. The industry growth will certainly not be influenced in the medium term even by the unlikely event of a dramatic reduction in gorse following the introduction of biological agents.

What then are the long term implications? Firstly, even the eradication of gorse would have limited influence on the "top of the market" type of fibre production from purebred animals. As Lambert (1985) points out, goats require a high quality diet for high levels of performance. Gorse does not appear to be a "high quality diet", as



discussed earlier in the report. The "second level" type of goat farming involves the use of goats to control weeds and grasses unpalatable to sheep and cattle. This role will remain even if gorse is "successfully" regulated. Other weeds are going to remain for the goats to control. A medium to long term type of goat farming using cashgora and cashmere type animals seems likely, and it is in this area that gorse would present the best possibilities as a fodder source. This would essentially be a low input system, and could conceivably evolve using gorse. However, a reduction in gorse would not preclude such a system evolving, but may raise the cost structure to an unknown degree.

New Zealand has around 1 million hectares of land at present containing some gorse. This gorse could be grazed by goats, thus avoiding some of the direct costs now needed to "control" the gorse. However, the introduction of biological agents to "control" this same gorse will have little medium-term impact on the goat industry. Long term, some complementarity between these insects and goats may exist, as both are biological agents which can be used to naturally regulate gorse.

Some additional points must be made. The first concerns uncertainty. We do not know what effect agents will have on gorse and what the interactions of agents and grazing may be. The second is the time path and the role of discounting. Gorse is undoubtedly a major scrub weed at present, and Sandrey (1985) contains a discussion on the cost to farmers and foresters. Costs from the irreversible decision to introduce agents are not likely to occur for several years, and these potential costs will have a lower relative weighting than earlier benefits to farmers and foresters. That is the role of discounting future income streams.

The objective of this paper was to examine the concept of irreversibility and the consequences of making an irreversible decision. Yes, there would be a cost involved in introducing biological agents to naturally regulate gorse. The plant is selectively chosen by goats, and preliminary research shows they can grow well on a diet containing some gorse. Indications are that goats will become a major livestock industry in New Zealand. The reduction in gorse availability will not diminish the ability of goats to control other pasture weeds or the establishment of a relatively large purebred angora goat system producing quality mohair fibre. However, a cashgora livestock system could evolve. This is the most likely system to benefit from gorse as a sustainable low input fodder source.

This author has little to argue with the New Zealand Goat Council regarding the submission made to Hill (1986) and reported earlier in this paper, which concludes that "the goat industry can (not) offer a reasonable argument against introducing further insect gorse control agents" (Batten, 1986).

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