Giant buttercup (*Ranunculus acris*) management in dairy pastures – profitability of control

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CONTENTS

1. EXECUTIVE SUMMARY

- AgResearch has been contracted by Dairy NZ (Schedule number OF1001) to determine the effect of giant buttercup, and its control, on the profitability of a dairy farm. This analysis is part of a larger project aimed at providing options for dairy farmers to achieve control of this weed.

- A series of 14 FarmaxDairyPro® models was developed to examine the effect of giant buttercup on whole-farm profitability and the impact of herbicide application (with variable efficacy) including a mycoherbicide.

- The key findings are:

    - The presence of giant buttercup significantly constrains profitability. On the ‘typical’ farm modelled, with giant buttercup cover peaking at 12% in November, profit was $1040 per hectare less than where giant buttercup was absent: $1830 vs $2870.

    - The use of herbicides to control giant buttercup has a positive effect on profitability but only where the ‘kill’ (reduction in % ground cover of the buttercup) is better than ~30% with MCPA or ~60% with Preside.

    - Modelling the effects of a mycoherbicide with a hypothetical 50% kill of giant buttercup suggests that profitability improves by $485/ha.

- This report should be read along with the others from the project (Bourdôt 2011; Hurrell & Bourdôt 2011) as a basis for discussions on how to manage giant buttercup on dairy farms in the Golden Bay region.

2. BACKGROUND

The Giant Buttercup Management Group, based in Takaka, was successful in securing an On Farm Innovation Fund Grant from Dairy NZ in 2010 (Schedule number OF1001) to conduct "Stage One" of a project on giant buttercup in dairy pastures. Stage One will identify options for controlling the weed, including the economics of doing so, and thereby provide the foundation for "Stage Two" which will evaluate the options and develop best management practice.

The objective of the project overall is to provide dairy farmers with tools and information enabling them to return dairy pastures affected by the weed giant buttercup (*Ranunuculus acris*) to full grass production. To this end Stage One of the project aims to:

1. further develop the biological "mycoherbicide" methodology to a stage where it offers an effective and readily available product, and

2. collate information about existing and potential new chemical control options and deliver these options to farmers as clear and freely available information.

3. quantify the economic benefit from control of giant buttercup on a dairy farm.

The current report fulfils the requirements of (3) above, and specifically, as per the agreement with Dairy NZ, provides an analysis of "*The profitability of controlling giant buttercup in infested dairy pasture ....using the dairy farm model, FarmaxDairyPro. This analysis will be based on giant buttercup cover and control costs on representative dairy farms in Golden Bay"*

3. METHODS

The approach adopted in this analysis was to first construct a 'base' model of a 'typical' farm affected by giant buttercup and then develop a range of models to explore scenarios around this. The models were constructed in FarmaxDairyPro® (see www.farmax.co.nz), which requires detailed information on the farm system, including pasture, forage and other supplementary inputs as well as animal enterprise information and milk production figures. The models explicitly consider the costs of the inputs and outputs so that the profitability of a given farm system can be calculated. Following development of this base model, 12 further scenarios were developed around giant buttercup impact and the application of a range of herbicides (including a bioherbicide); profitability of each farm system can then be compared.

The farm chosen as the basis from which the first model was developed was Waterford Farm, near Takaka, owned by Greg Fellowes. This property is considered by the Giant Buttercup Management Group (of which Greg is a member) to be reasonably representative of the farms in the area that are affected by giant buttercup. The level of infestation of this property was assessed by AgResearch staff in November 2010 – giant buttercup was present in nearly every paddock and the average cover was 11.8%. Individual paddock data was recorded (see Appendix 1) but it is important to note that the farm was modelled as a single block.

3.1 Development of base models

The farm was visited by Warren King and Graeme Bourdôt on December 14th 2010 and Greg Fellowes was interviewed to obtain details of his farm enterprise. Physical descriptions of the farm were also recorded, along with other data such as fertiliser application and milk production for the last three years. This information was used to develop the first simulation model (Table 1: 'TakakaBase') and was a reasonably accurate depiction of Waterford Farm.

There were, however, some particular features of this farm that we considered might interact negatively with the development and interpretation of scenarios. Analysis of the TakakaBase model suggested that, with the silage cuts and maize supplementation as specified, both feed shortages and surpluses were likely to occur in late spring. In addition, the Body Condition Score of the dry stock was unreasonably high and the pattern of milk production atypical. Since this model was to be used as the basis for all further model development, some generalisation was undertaken. The resultant model ('TakakaBaseOptimised') is essentially the same as TakakaBase but with the changes noted below. TakakaBaseOptimised should be considered typical of farms in the area but not strictly representative of any particular farm. The pattern of pasture growth through the year closely resembles that recorded during 10 years of pasture growth measurement by DairyNZ at Takaka (see http://www.dairynz.co.nz/file/fileid/33418).

3.2 Incorporation of giant buttercup effects in model

The TakakaBaseOptimised model does not explicitly recognise the impact of giant buttercup. The approach adopted to include this effect was to:

1) Reduce Pasture Utilisation in the model in line with the data of Bourdôt et al. (2003). That is, Pasture Utilisation was reduced by the actual cover of giant buttercup (in this case, 12%) multiplied by either 1.1 (Model 3) or 1.25 (Model 5). This incorporates the grazing aversion of giant buttercup determined by Bourdôt et al. (2003), which was 25% greater than that expected from cover alone (×1.25), as well as a more conservative approach, 1.1 to test the sensitivity of the model to this assumption.
2) Pasture Growth was then increased in the model to make the farm system 'feasible' and produce the appropriate volume of milk.

The Pasture Utilisation values used in the model varied by month (Table 2) to reflect the seasonal growth pattern of giant buttercup (Appendix II). For example, the calculation outlined above, for a nominal 12% giant buttercup cover, resulted in a 13.2% (12*1.1) reduction in Pasture Utilisation in November at the peak of giant buttercup abundance (87=100-13) and was scaled back in other months according to the pattern detailed in Bourdôt et al. (2003) (Appendix II).

Table 1. Description of the FarmaxDairyPro® models developed for evaluating the profitability of controlling giant buttercup (*Ranunculus acris*) on a dairy farm

Scenario/ Model Number	Scenario/ Model name	General description
	TakakaBase	Base farm as described by farmer
1	TakakaBaseOptimised	Base model generalised to be representative – approx System 2/3 (moderate intensity; see http://www.dairynz.co.nz/page/pageid/2145861231/The_5_Production_Systems)
2	TakakaGB10	Takaka farm with 12% giant buttercup and 10% extra grazing aversion
3	TakakaGB10 NoGB	Value of removing buttercup
4	TakakaGB25	Takaka farm with 12% giant buttercup and 25% extra grazing aversion
5	TakakaGB25 NoGB	Value of removing giant buttercup
6	TakakaGB25 NoGB + 15 cows	Using a 5% increase in cow numbers to eat the extra grass grown
7	TakakaGB25 NoGB + 29 cows	Using a 10% increase in cow numbers to eat the extra grass grown
8	MCPA GB25 100% kill	Using MCPA to reduce giant buttercup
9	MCPA GB25 50% kill	Losing the ability to use MCPA to reduce giant buttercup
10	MCPA GB25 10% kill	Lost the ability to use MCPA to reduce giant buttercup
11	Preside GB25 100% kill	Using Preside to remove giant buttercup
12	Preside GB25 50% kill	Losing the ability to use preside to remove giant buttercup
13	Myco GB25 50% kill	Using a mycoherbicide to reduce giant buttercup

Notes on each scenario:

1. *TakakaBaseOptimised:*
   Start point: *TakakaBase*. Milk production profile was modified to give more of a milk peak during the start of the season. Removed a silage crop and moved another to reduce the feed shortage in late spring. Removed spring maize supplementation – there was enough grass at this time of year. Reduced some end-of-season supplementation to more typical amounts. Reduced Body Condition Score in the dry animals to more typical values by reducing supplementation. Reconciled the supplements, reduced the growth rate slightly from the Farmax Takaka default growth rate. This has resulted in a model that is closer to that of a 'typical' Takaka dairy farm system.

2. *TakakaGB10*:
   Start point: *TakakaBaseOptimised*. Modelling the pasture lost with giant buttercup present by reducing the pasture able to be eaten. Pasture grown is then increased to ensure the current milk production is achieved. Pasture Utilisation in the model was decreased to the "*12% GB with 10% aversion"* profile (Table 2). Then, Pasture Offered was increased to return milk production to the level of *TakakaBaseOptimised*. Pasture Growth was then increased using the "Modify Tool" to make model 'feasible' again (i.e.

feed supply meets or exceeds animal feed requirements year-round). The decrease in Pasture Utilisation is: giant buttercup ground cover percentage ×1.1 (i.e. 10%) – a more conservative figure than that estimated by Bourdôt et al. (2003) – see Model 4.

3. *TakakaGB10 NoGB*:
   Start point: *TakakaGB10*. Returned Pasture Utilisation to Farmax default (Table 2). Utilise the extra pasture production when there is no giant buttercup in the pasture. Maintain the same cow numbers but feed them more to maximise efficiency.

4. *TakakaGB25*:
   Start point: *TakakaBaseOptimised*. Modelling the pasture lost with giant buttercup present by reducing the pasture able to be eaten. Then increasing pasture grown to ensure the current milk production is achieved. Uses a 25% increase in ground cover not available for grazing as in Bourdôt et al. (2003). Decreased Pasture Utilisation to the "*12% GB with 25% aversion"* profile (Table 2). Increased Pasture Offered to return milk production to the level of *TakakaBaseOptimised*. Increased Pasture Growth using "Modify Tool" to make model feasible.

5. *TakakaGB25 NoGB*:
   Start point: *TakakaGB25*. Utilising the extra pasture production when there is no giant buttercup in the pasture. Maintain the same cow numbers but feed them more to maximise efficiency. The increased feed offered (and eaten) was considered realistic due to relatively low per cow milk production in *TakakaBaseOptimised*. Returned Pasture Utilisation to Farmax default (Table 2).

6. *TakakaGB10 NoGB + 15 cows*:
   Start point: *TakakaGB25 NoGB*. Realistically, most farmers will increase cow numbers to eat the extra feed. Increase cow numbers by 5% and feed them better. The increased feed offered (and eaten) was realistic due to low per cow milk production in *TakakaBaseOptimised*. Increase the cow numbers by 5% (15 cows) Using the Pasture Allocation in *TakakaBaseOptimised,* the allocations are increased to account for the remaining feed.

7. *TakakaGB10 NoGB + 29 cows*:
   Start point: *TakakaGB25 NoGB* . Realistically most farmers will increase cow numbers to eat the extra feed. Increase cow numbers to a level that they are fed the same as in *TakakaBaseOptimised* (10% increase). Using the pasture allocation in *TakakaBaseOptomised* the stock numbers are increased until the extra feed is eaten. Pasture offered was slightly reduced at the end of the season. A total of 29 extra animals were added.

8. *MCPA GB25 100% kill*
   Start point: *TakakaGB25 NoGB*. The use of MCPA to kill giant buttercup was modelled assuming a 100% kill rate of giant buttercup. The related 100% kill of clover was modelled with a 0.2 drop in pasture ME over spring and summer. Reduced the metabolisable energy of the green pasture component by 0.2 units Sep – Feb (Table 3). Added spray costs of $80/ha to expenses ($40/ha contractor costs + $40/ha MCPA cost).

9. *MCPA GB25 50% kill*
   Start point: *TakakaGB25*. The current resistance of giant buttercup to MCPA was modelled using a 50% kill of giant buttercup and a 100% kill of clover modelled with a 0.2 drop in pasture ME over spring and summer. Reduced the metabolisable energy of the green pasture component by 0.2 units Sep – Feb (Table 3). Added spray costs of $80/ha to expenses ($40/ha contractor costs + $40/ha MCPA cost). Changed the Pasture Utilisation to the "*6% GB with 25% aversion"* profile (Table 2).

10. *MCPA GB25 10% kill*
    Start point: *TakakaGB25*. The potential resistance of giant buttercup to MCPA was modelled using a 10% kill of giant buttercup and a 100% kill of clover modelled with a 0.2 drop in pasture ME over spring and summer.Reduced the metabolisable energy of the green pasture component by 0.2 units Sep – Feb (Table 3). Added spray costs of $80/ha to expenses ($40/ha contractor costs + $40/ha MCPA cost). Changed the Pasture Utilisation to the "*10.8% GB with 25% aversion"* profile (Table 2).

11. *Preside GB25 100% kill*
    Start point: *TakakaGB25 NoGB*. The use of Preside to kill giant buttercup was modelled using a 100% kill of giant buttercup and a lower (20%) kill of clover modelled with a 1% drop in pasture ME during spring. Reduced the metabolisable energy of the green pasture component by 0.1 units Sep – Nov (Table 3). Added spray costs of $117/ha to expenses ($40/ha contractor costs + $77/ha Preside and uptake oil cost).

12. *Preside GB25 50% kill*
    Start point: *TakakaGB25 NoGB*. The potential resistance of giant buttercup to Preside was modelled using a 50% kill rate of giant buttercup and a lower (20%) kill of clover modelled with a 1% drop in pasture ME during spring. Changed the Pasture Utilisation to the "*6% GB with 25% aversion"* profile (Table 2). Reduced the metabolisable energy of the green pasture component by 0.1 units Sep – Nov (Table 3). Added spray costs of $117/ha to expenses ($40/ha contractor costs + $77/ha Preside and uptake oil cost).

13. *Myco GB25 50% kill*
    Start point: *TakakaGB25 NoGB*. Assuming a mycoherbicide would have a 50% kill of giant buttercup (Bourdôt et al. 2007), no effect on clover and would have a contractor cost similar to the spraying of a herbicide ($40/ha) this model shows the benefits of use (not including the cost of the product). Changed the Pasture Utilisation to the "*6% GB with 25% aversion"* profile (Table 2). Add $40/ha to expenses for spraying costs.

Table 2. Pasture Utilisation values used in FarmaxDairyPro® to reflect the impact of giant buttercup (GB).

Utilisation pattern	Farmax Default	12% GB with 10% aversion	12% GB with 25% aversion	10.8% GB with 25% aversion	6% GB with 25% aversion
Pattern No.	**1**	**2**	**3**	**4**	**5**
January	100	92	91	92	95
February	100	93	92	92	96
March	100	93	92	93	96
April	100	93	92	93	96
May	95	90	89	90	92
June	90	86	85	86	88
July	90	88	87	88	89
August	90	86	85	85	87
September	95	87	86	87	90
October	100	89	87	89	94
November	100	87	85	87	93
December	100	89	88	89	94

3.3 Herbicide application

The effects of MCPA and Preside were modelled by including the additional costs (product cost + cost of application) and assuming a range of efficacy: 100%, 50% and 10% kill for MCPA and 100% and 50% for Preside. It was assumed that the herbicides had no effect on the grass component of the sward and that the pasture growth rate was unaffected.

3.4 Modelling of clover loss following herbicide application.

Loss of clover due to the application of MCPA was incorporated into the model by reducing the metabolisable energy (ME) of the pasture during spring and summer (Table 3). The change in ME due to clover loss has been modelled for MCPA by Popay et al. (1989) as a reduction by 2% during spring and summer. This was based on a 40% reduction in a 40% clover sward content, i.e. dropping from 40% clover to 24 % clover in the sward. It would be very unusual to find 40% clover in a modern dairy sward so we have used the 2% drop in ME for a loss from the sward of 16% clover to 0% clover. This value is also comparable to that derived from simple energy content calculations.

Loss of clover due to the application of Preside was incorporated into the model by reducing the metabolisable energy of the pasture during spring by 1%. This is the limit of resolution of the model and was only reduced during spring following herbicide application.

Nitrogen replacement

With a likely reduction in N fixed due to the loss of clover, additional applications of fertiliser N were added to the model. The model does not incorporate a response from fixed nitrogen so no response to the N application was allowed. The amount of N added was calculated using 25 kg N fixed per ton of clover DM. This required approximately 50 kg N over 2 applications for the MCPA scenarios at a cost of $76/ha and 10 kg N in one application for the Preside scenario at a cost of $15/ha. This includes the cost of application which may not be required in practice.

Table 3. Pasture metabolisable energy (ME) content changes from default used to model the loss of clover due to herbicide use

ME of green pasture component	Farmax Default	With application of MCPA	Following application of Preside
January	11.4	11.2	11.4
February	11.2	11.0	11.2
March	11.5	11.5	11.5
April	11.7	11.7	11.7
May	11.8	11.8	11.8
June	12.0	12.0	12.0
July	12.1	12.1	12.1

4. RESULTS AND DISCUSSION

For the purposes of this report, the key output from FarmaxDairyPro® is profitability, expressed here as Operating Profit per hectare (Table 4). The base model showed a profitability of $1,830 /ha and other scenarios ranged from $1,620 /ha (Scenario 10 – MCPA with only 10% kill of giant buttercup) to $2,870 /ha (Scenario 5 – hypothetical zero cost complete removal of giant buttercup)

Table 4. Summary statistics for the 13 scenarios

Scenario	Milk solids per cow kg MS/cow	Pasture production (tonnes DM/ha)	Utilisation pattern (Table 2)	Operating profit/ha
1	331	13.2	1	$ 1,830
2	331	14.8	2	$ 1,830
3	382	14.8	1	$ 2,728
4	331	15.1	3	$ 1,829
5	390	15.1	1	$ 2,870
6	365	15.1	1	$ 2,609
7	331	15.1	1	$ 2,131
8	378	15.1	1	$ 2,521
9	350	15.1	5	$ 2,017
10	328	15.1	4	$ 1,620
11	387	15.1	1	$ 2,685
12	328	15.1	5	$ 1,647
13	361	15.1	5	$ 2,315

4.1 Effect of giant buttercup on farm profitability

The process of model development began with a somewhat generalised version of Waterford Farm (Scenario 1). Sensitivity analysis of the effect of grazing aversion indicated that the model was relatively insensitive to this: using a factor of 1.25 resulted in an operating profit per hectare within 5% of the result when using 1.1. Therefore, 1.25 was used in all subsequent analyses as per the results of Bourdôt et al. (2003).

Adding the effect of giant buttercup by reducing Pasture Utilisation and increasing pasture growth rates to compensate (Scenarios 2 and 4) reveals an effective loss of pasture of between 1.6 and 1.9 t DM/ha. Expressed another way, the elimination of giant buttercup (Scenarios 3,5,6,7) would result in a hypothetical increase in profitability of up to 57% (>$1000/ha), depending on how the extra grass is utilised.

The base model developed in this report used a maximum groundcover value for giant buttercup of 12% (in November). This was the average of the values measured across each paddock on the farm (APPENDIX I). Bourdôt et al. (2003) reported giant buttercup groundcovers measured in 10 paddocks in the Takaka district over 2-5 years in the late 1980s averaging 20%. These measurements were made in May when we assume giant buttercup to be at only 40% of its maximum (APPENDIX II). By comparison, the Waterford Farm would have a giant buttercup groundcover of around 5% in May (40% of the 12% November peak). It appears therefore that Waterford Farm may not be as affected by giant buttercup as other farms in the district, although perhaps not by as much as the 15% (20%-5%) suggested here since the 20% was measured on the untreated control plots of herbicide comparison experiments in which the sites were selected for uniformity of cover rather than at random on each farm (Bourdôt & Hurrell 1990).

4.2 Herbicide control of giant buttercup

The reality of herbicidal control of giant buttercup includes a variable kill of the target, collateral clover damage and the cost of product and application. Use of both MCPA and Preside improve profitability if the kill is 100% (Scenarios 8, 11). At 50% kill however, MCPA use still improves profitability but the use of Preside is not supported (Scenarios 9, 12). Using a 10% kill of giant buttercup with MCPA to represent the development of herbicide resistance (Scenario 10) results in the least profitable scenario, nearly $200/ha less than the base scenario in which no attempt is made to control the buttercup. The 'break-even' points of these herbicides with respect to their efficacy can also be calculated: a 31% kill for MCPA and a 59% kill for Preside. Finally, the use of a putative mycoherbicide with a 50% kill (Scenario 13) results in an increase in profitability of $485 /ha (29%) from the base scenario. Given that the cost of the mycoherbicide itself was not included in the model (only the cost of application), this suggested that mycoherbicide use would be profitability-positive provided that the cost of the product is less than $485/ha.

5. ACKNOWLEDGEMENTS

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7. APPENDIX I

Percentage ground cover of giant buttercup (*Ranunculus acris*) on the dairy farm owned by Greg Fellowes, Takaka, Golden Bay as measured by visual observation by two observers (Geoff Hurrell and Carrie Lusk, AgResearch) on 18-20 November 2010. The farm was divided into four strata: pasture early in grazing cycle (short grass – recently grazed), late in grazing cycle (long grass – soon to be grazed), silage and maize.

Early in grazing cycle		Late in grazing cycle		Silage		Maize	
Paddock #	**% cover**	**Paddock #**	**% cover**	**Paddock #**	**% cover**	**Paddock #**	**% cover**
76	40	67	30	74	30	3	0
26	35	44	20	72	20	19	0
39	35	82	20	73	15	55	0
21	25	17	18	31	10	68	0
78	25	4	15	63	10	100	0
8	20	5	15	85	10		
54	20	62	15	1	6		
59	20	66	15	83	6		
65	20	77	15	28	2		
2	15	88	15	35	2		
87	15	95	15	41	2		
43	12	6	12	71	2		
102	12	10	12	86	2		
34	10	58	12	7	1		
48	10	64	12	12	1		
61	10	79	12	24	1		
81	9	93	12	27	1		
32	8	9	10	36	1		
52	7	20	10	40	1		
51	5	23	10	47	1		
98	3	42	10	53	1		
18	2	45	10	69	1		
49	2	97	10	70	1		
33	1	80	8	84	0		
50	1	16	6				
56	1	30	6				
91	1	96	6				
92	1	22	5				
101	1	37	5				
13	0	29	4				
14	0	46	4				
		25	3				
		38	3				
		89	3				
		90	3				
		11	1				

Early in grazing cycle		Late in grazing cycle		Silage	Maize
		15	1		
		57	1		
		94	1		
		99	1		
		60	0		
		75	0		
Mean % cover	11.8		9.2	5.3	0.0
Min % cover	0		0	0	0
Max % cover	40		30	30	0
SD % cover	11		7	7	0
# paddocks	31		42	24	5
% paddocks infested	94		95	96	0

8. APPENDIX II

The annual pattern in the % ground cover of giant buttercup (*R. acris*) in dairy pasture in Takaka as used in the *FarmaxDairyPro®* model. The data in column "%"are mean monthly values of cover averaged over four farms in Takaka (Bourdôt et al. 2003). The data in column "Prop. Max" are the monthly cover values as a proportion of the maximum.

	Ground cover pattern	
	%	Prop. Max
July	8.1	0.17
August	15.9	0.34
September	28.3	0.60
October	39.3	0.84
November	46.8	1.00
December	38.3	0.82
January	28.3	0.60
February	26.3	0.56
March	24.6	0.53
April	25.4	0.54
May	18.8	0.40
June	14.5	0.31