

Evaluation of Immunocontraception as a Publicly Acceptable Form of Vertebrate Pest Species Control: The Introduced Grey Squirrel in Britain as an Example

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ABSTRACT / We sent out a targeted questionnaire to organizations and private individuals across the UK that have expressed an interest in squirrel management and conservation. Respondents were asked to evaluate shooting, trapping, poisoning and immunocontraception (IMC), according to their perceived efficacy, cost efficiency, and whether they were considered to be humane. The majority of both professionals and enthusiasts indicated support for grey squirrel control to help conserve red squirrels and to reduce economic damage

to timber crops. Respondents' comparative evaluations of current forms of control showed that trapping is the most acceptable method. When IMC is compared with the other methods, it was considered to be more humane and acceptable. In contrast, poisoning was seen as humane or acceptable by the fewest respondents. Furthermore, poisoning elicited the greatest difference in opinion between the professional and enthusiast groups. This difference (34%) may be interpreted partly as concern over the type of death that results from poisoning and partly as due to the possibility of poisoning nontarget species. Our findings indicate a need for more public information regarding secondary poisoning hazards to other species and their predators. Interest and concern about squirrel control correlated with the overlap between contemporary areas of distribution of the two species. It is these areas where consultation and education programs about control methods should be targeted. This research indicates that there would be support for grey squirrel control using IMC from both lay and professional interest groups. It demonstrates the existence of a sound basis for constructive dialog that can lead to the design and implementation of acceptable and efficient control strategies.

The control of mammal pest species is an emotive issue. Traditionally it has been considered in terms of the efficacy and cost of control, such as in the case of the muskrat (*Ondatra zibethicus*), coypu (*Myocastor coypus*) (Gosling and Baker 1989), and rabbit (*Oryctolagus cuniculus*) (Sheail 1991). However, with the increase since the 1980s in media and public interest in environmental issues (Yearley 1996), consideration has also started to be given to the public perception of pest control measures, e.g., rabbit in New Zealand (Wilkinson and Fitzgerald 1997) and badger (*Meles meles*) in

Britain (White and Whiting 2000). Some pest species such as rabbits and squirrels have an innate appeal and often feature large in childhood culture or are kept as pets. The grey squirrel (*Sciurus carolinensis*) could therefore be classed as a "charismatic pest" (Lockwood 1997).

The case of grey squirrel control in Britain highlights the conflicts between wildlife conservation, animal rights and welfare, public perception of science, and management policies that aim to reduce economic damage [notably to timber crops (Dagnall and others 1998 and Lurz and others 2001)]. This nexus of issues is occurring in an era when the value of science is becoming diminished in the public eye (Jasanoff 1997, Lidskog 1996) and in which decision-making appears particularly sensitive to popular and populist views. Yet there is a determination to introduce greater subsidiarity and broader participation into our decision-making

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processes (Holmes and Scoones 2000). Thus the development of an immunocontraceptive vaccine as an alternative form of grey squirrel control (Moore 1997) provides an interesting case study of whether science and public perception of science can reach converging conclusions in a potentially contentious area.

Where introduced in Europe, the grey squirrel has replaced the native red squirrels (Lloyd 1983, Currado and others 1987, Gurnell 1987) and is considered a forest pest as it causes significant damage to deciduous trees through bark stripping (Kenward 1983, Dagnall and others 1998). Grey squirrels were introduced to Piedmont, Italy, in 1948 (Currado and others 1987). The National Wildlife Institute (INFS), with the collaboration of the University of Turin, developed an action plan for eradicating the introduced grey squirrel in the spring of 1997, based on Recommendation No. 57 of the Bern Convention. The plan intended to control a locally defined part of the population in order to develop a procedure for an eradication campaign covering the complete range of the grey squirrel (Genovesi 1998), which at that time was still restricted to a small area in the plain of the river Po, Piedmont (Wauters and others 1997). However, the pilot project was stopped due to legal action from three local animal welfare groups. No steps to control grey squirrels have since been undertaken as a result of the court action (S. Bertolino, personal communication).

In Britain, reports on grey squirrel presence go back to the 1830s, including a confirmed introduction at Henbury Park, Cheshire in 1876 (Middleton 1930). Since then the species has spread and replaced the native red squirrel in most of England, Wales, as well as parts of Scotland and Northern Ireland (Gurnell and Pepper 1993, Teangana and others 2000, Wauters and others 2000). Attempts to control the species through a bounty scheme in the 1950s failed (Thompson and Peace 1962), and more conventional methods involve the control of greys in targeted areas (e.g., vulnerable plantations) by trapping, shooting, and poisoning using warfarin, although the latter is restricted to areas where the red squirrel no longer occurs (Pepper and Stocker 1993, Pepper and Currie 1998). The basis for choice of control methods was, even four decades ago, not entirely founded on scientific research. In the early 1960s, British Ministry of Agriculture research demonstrated trapping to be more efficient than shooting, but foresters' organizations and the National Farmers' Union dismissed trapping as impractical (Sheail 1999).

As in Italy, animal welfare organizations in Britain have criticized the killing of grey squirrels (Bryant n.d.), and grey squirrel control is regarded as a sensitive issue. In addition to existing forms of grey squirrel

control, the Forestry Commission has recently supported the development of an immunocontraceptive vaccine as an alternative method (Moore 1997). In this technique DNA coding for specific sperm or egg antigens involved in fertilization are introduced into the animal via viruses or viruslike particles. This causes the body to produce antibodies against the targeted egg or sperm proteins, creating an immunocontraceptive barrier and thereby rendering the host sterile (Boyle 1994, Bradley 1994, Tyndale-Biscoe 1994). The effectiveness of antigens that target sperm proteins has been successfully demonstrated in guinea pigs (Primakoff and others 1988). Work currently under way involves the study of sperm antigens in primates, rabbits, and foxes (*Vulpes vulpes*) (Boyle 1994). The success of immunosterilization techniques depends on the identification of suitable reproductive antigens, an effective delivery, and an understanding of the ecology of the animal (Boyle 1994, Bradley 1994).

An awareness of the importance of public perception and the need to inform is illustrated by efforts to manage the grey squirrel for red squirrel conservation as part of a Wildlife Trust initiative called Red Alert in Northumberland in the early 1990s. Articles on grey squirrel expansion and the decline of the native red "Squirrel Nutkin" were cloaked in military metaphors describing grey squirrels as "invaders" (*Country Life* 11 February 1993) or attempted to associate the species with vermin by describing them as "tree rats" (e.g., *Mail on Sunday* 7 February 1993).

The need to understand public perception of red and grey squirrels, when planning and implementing grey squirrel management strategies, is demonstrated by the importance given to public opinion in Northumberland, the views of animal welfare groups in influencing management strategies in Italy, and the UK government decision-making process with regard to grey squirrel control in the light of pressure from farming and forestry groups (Sheail 1999). There is unlikely to be a single public perception in these situations, as there will be divergent perceptions and opinions related to different interest groups and stakeholders of the problem. We used a targeted survey to professionals involved in squirrel management and interested enthusiasts to determine public perception on grey squirrel control. In detail we examined (1) under what circumstances grey squirrel control would be considered acceptable, (2) the perception on existing control methods, and (3) whether immunocontraception under development for grey squirrels is considered to be a humane and acceptable form of population control.

Methods

We sent out a targeted questionnaire (see Appendix) using the NPI newsletter *Squirrel Tale*, distributed nationally in autumn 2000 through the Northumberland Wildlife Trust. The newsletter is sent to organizations and private individuals across the UK that have expressed an interest in squirrel management and conservation. The survey results will therefore reflect the views of individuals and organizations with an active concern in squirrel issues in the UK rather than the views of the general public as a whole. A total of 780 questionnaires were distributed.

The questionnaire was anonymous, although 19% of respondents gave personal details and the type of organization for which they worked or of which they were a member. Public presentations on squirrel ecology and red squirrel conservation by the authors have suggested that the opinion of audience members on grey squirrel management may be influenced by whether red squirrels are still present in the area in which they live, and some have expressed the view that the presence of grey squirrels is preferable to no squirrels at all. Similarly, the impending threat to the native red squirrel by colonizing grey squirrels along the dispersal front can also elicit a strong emotional response. We therefore asked whether the respondent lived in an area that contained only red squirrels, both squirrel species, or only grey squirrels, and thus in a broad sense, it was possible to identify the location of all respondents. We therefore analyzed the responses in relation to professional interest in the management of squirrels and the area in which the respondent lived.

The questionnaire elicited respondents' views on the three most commonly used forms of grey squirrel control: shooting, trapping, and poisoning. Respondents were asked to evaluate these control methods according to their perceived efficacy, cost efficiency, and whether they were considered to be humane. Similar opinions were asked for with regard to immunocontraception (IMC). It was explained that IMC will be "a bait delivered vaccine that selectively will reduce grey squirrel fecundity."

Results

Of the 780 questionnaires sent out, 166 (22%) were returned. There were returns from across mainland Britain from the north of Scotland to the south of England and Wales. The majority of returns came from professionals with an interest in squirrel management such as private foresters, game keepers, and officers from organizations such as the Forestry Commission,

Table 1. Number of participants with a professional or personal interest in squirrel management and conservation according to squirrel species present where they live

	Red only	Red and grey	Grey only	Total
Professional	29	61	25	115
Enthusiast	10	21	16	47
Total	39	82	41	162 ^a

^aplus 4 no responses

Country Landowners Association, or the Wildlife Trusts. Just over half of all returns were from areas that contained both squirrel species (Table 1). This indicates that although the area of red and grey squirrel overlap only encompasses a fraction of the available UK squirrel habitat (Gurnell and Pepper 1993), it is in these areas where there is greater interest in grey squirrel control issues.

A power analysis was performed post hoc to determine if our return rate gave us sufficient statistical power to reject the null hypothesis if false. In other words, we wanted to determine if the number of returns was adequate to detect differences in the yes/no answers from the different response groups with confidence. We used the approximation of a binomial distribution to a normal distribution to calculate the power of our tests under different effect sizes. We determined that, with 166 responses, the tests would have only a 25% chance of yielding a statistically significant result if a small deviation of 0.05 from the null hypothesis existed (i.e., 55% of respondents giving the same answer, as opposed to 50:50). However, no response in our questionnaire showed this small effect size (once "maybe" answers were excluded). A medium effect size, corresponding to a 65:35 ratio of answers gave a power of 98% at this return rate, and a power of 100% for large effect sizes (75:25 ratio of answers). The definitions of effect sizes (small, medium, and large) were taken from Cohen (1988). We therefore concluded that the number of returned surveys gave sufficient statistical power for further analysis.

The majority of both professionals (98%) and enthusiasts (91%) indicated support for grey squirrel control to help conserve red squirrels and to protect vulnerable timber crops (Table 2). Although a higher number of respondents from both interest groups expressed a "no" and "no opinion" in relation to the need to control grey squirrels for economic reasons (Table 2), there was no significant difference between them with regard to grey squirrel control for conservation ($\chi^2 = 0.423$, $df = 1$, NS; using Yates' correction) or

Table 2. Views of professionals and enthusiasts on whether grey squirrels should be controlled for conservation of red squirrels or to prevent damage to crops and timber^a

Interest	Need to control grey squirrels for					
	Red squirrel conservation			Economic reasons		
	No opinion	No	Yes	No opinion	No	Yes
Professional	0	2	98	9	9	82
Enthusiast	4	4	92	2	9	89

^aResults are presented as the percentage of answers in each category.

Table 3. Views on whether grey squirrels should be controlled for conservation or to prevent damage to crops and timber in relation to squirrel species present in participant's locality^a

Area	Need to control grey squirrels for					
	Red squirrel conservation			Economic reasons		
	No opinion	No	Yes	No opinion	No	Yes
Red only	3	5	92	7	13	80
Red and grey	1	1	98	8	6	86
Grey only	0	2	98	2	10	88

^aResults presented as the percentage of answers in each category.

economic reasons ($\chi^2 = 0.230$, $df = 1$, NS; using Yates' correction).

The results show that in areas where only red squirrels are present, respondents show less concern for the control of grey squirrels for either conservation or economic reasons (Table 3). However, the statistical analysis shows that in all three population zones there was no significant difference in the pattern of response. (For control for conservation reasons, $\chi^2 = 1.717$, $df = 2$, NS; for control for economic reasons, $\chi^2 = 1.534$, $df = 2$, NS).

Respondents were asked to rank, in order of importance, three criteria for evaluating grey squirrel population control. On average both professionals and enthusiasts ranked the criteria in the same order of importance: effective > humane > cost-effective, and there was no significant difference between the ranks assigned by the two groups of respondents (Kruskal-Wallis test, $N = 498$, $df = 2$, $K = 151.8$, $P < 0.001$). Figure 1 shows the distribution of assigned ranks in each of the criteria for the respondents as a whole. In other words, the effectiveness of grey squirrel control

was considered to be more important than humaneness or cost.

Respondents' comparative evaluations of current control methods showed that trapping was considered the most acceptable (87%), effective (83%), and humane (83%) control method. It was regarded as of average cost efficiency (52%; Table 4).

Consequently, respondents considered trapping to be the most effective grey squirrel control method ($\chi^2 = 18.61$, $df = 4$, $P = 0.001$). Trapping and shooting were both seen to be humane relative to poisoning ($\chi^2 = 92.1$, $df = 4$, $P < 0.001$). However, poisoning was perceived to be more cost effective than either of the other two methods ($\chi^2 = 13.3$, $df = 4$, $P = 0.010$). Overall, shooting and trapping were the most acceptable methods ($\chi^2 = 75.7$, $df = 4$, $P < 0.001$; Table 4).

Over 90% of respondents in all interest groups and squirrel population zones considered IMC to be an acceptable and humane form of grey squirrel control (Table 5, columns headed "I"). When IMC is compared with the other three traditional squirrel control methods, it is generally considered to be more humane and acceptable. In contrast, poisoning was seen as humane or acceptable by the fewest respondents. Furthermore, poisoning elicited the greatest difference in opinion between the professional and enthusiast groups (Table 5).

In a space on the questionnaire for further comments, respondents particularly expressed a need for more information on secondary poisoning risks, red squirrel decline, and the likely impact of IMC. A large proportion of personal comments (15 of 84) stressed the need for species specificity both for existing methods and IMC. They also suggested other forms of grey squirrel control using predators such as the native pine marten (*Martes martes*) and indicated a preference for maintaining a balance rather than grey squirrel eradication. This sentiment was also echoed in some opinions arguing for a recognition of the value of grey squirrels for the public in urban areas. In addition, respondents called for more public education to further an awareness and to help understand the problems posed by grey squirrels.

Discussion

The potential use of IMC as a form of population control has been suggested for a number of vertebrates, including rodents (Moore and others 1997), rabbits (Robinson and others 1997), and deer and feral horses (Kirkpatrick and others 1997). Fertility control has been investigated for badger (*Meles meles*) populations affected by bovine tuberculosis in the UK (White and

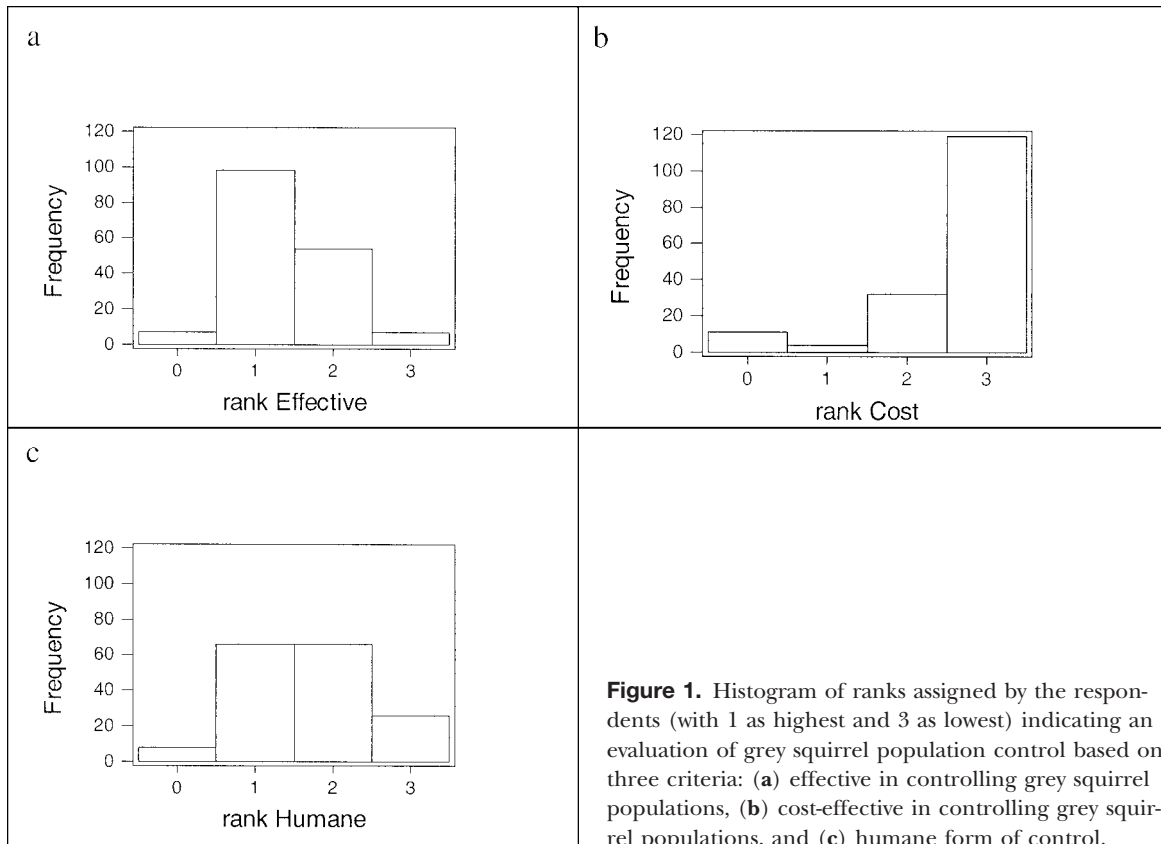


Figure 1. Histogram of ranks assigned by the respondents (with 1 as highest and 3 as lowest) indicating an evaluation of grey squirrel population control based on three criteria: (a) effective in controlling grey squirrel populations, (b) cost-effective in controlling grey squirrel populations, and (c) humane form of control.

Table 4. Respondents' evaluation of current grey squirrel control methods^a

	Effective			Cost effective			Humane			Acceptable		
	S	T	P	S	T	P	S	T	P	S	T	P
Yes	62	83	61	44	53	69	83	83	31	83	88	41
No	36	14	35	52	44	26	15	15	65	17	11	57
Maybe	2	3	4	4	3	5	2	2	4	0	1	2

^aShooting—S, Trapping—T, poisoning—P. Results presented as the percentage of answers in each category.

others 1997, Swinton and others 1997), possums (*Trichosurus vulpecula*) in New Zealand (Barlow 1994), and cats on islands (Courchamp and Cornell 2000). IMC vaccines delivered through bait are being developed for introduced grey squirrels in Britain (Moore 1997) and for foxes [*Vulpes vulpes* (Bradley and others 1997)] in Australia. IMC has the potential to control populations of individual species across large areas, and with respect to animal welfare, it promises clean, humane control without killing (McCallum 1996). However, as argued by Barlow (2000), the method is still in its infancy as a technology and its effectiveness and acceptability are unproven. Hence, one of the greatest needs now is information. Public concerns over the fact that IMC is

genetic engineering, as well as the risks associated with live vector or bait delivered systems, need to be considered. The potential costs and benefits of IMC must therefore be compared to existing alternatives (Cowan 1996, Barlow 2000).

The survey results were surprisingly uniform across interest groups and geographical squirrel population zones. They demonstrated very favorable responses towards the use of IMC from all groups and areas. Efficacy and humaneness of the control method were the primary concerns for all types of respondent. Cost efficiency was of lower concern. When comparing the three traditional methods of shooting, trapping, and poisoning with IMC, it was seen that IMC was consid-

Table 5. Summary table of percentage of respondents responding positively to IMC and traditional methods of control^a

	Humane				Acceptable			
	S	T	P	I	S	T	P	I
Professional	78	81	38	94	82	87	49	90
Enthusiast	94	86	8	91	91	89	15	94
Red only	83	90	46	92	77	96	58	95
Red and grey	85	77	23	98	85	83	32	94
Grey only	79	91	33	93	83	91	45	90

^aShooting—S, trapping—T, poisoning—P, immunocontraception—I.

ered to be the most acceptable and humane control method. This finding was in accordance with other assessments of the acceptability of mammal pest control methods, which include a number of criteria such as humaneness, safety for people and non-target species, public opinion, effectiveness, and use of categorical descriptors such as economical, clean, understandable, and controllable (Macdonald and others 2000, Wilkinson and Fitzgerald 1998).

In interpreting respondents' opinion of the four main control types, "efficiency" may be taken as being the measure of how well the method reduces the grey squirrel population in order to either reduce competition with red squirrels or reduce the economic damage it causes. Interpreting what is humane is more complex. The public is generally not at ease with the concept of killing animals, and the pest control discourse tends to revolve around controlling pests rather than killing them (Wilkinson and Fitzgerald 1997). However, in any cogent debate on pest control it must be assumed that respondents recognize that the issue is one of lethal control. Therefore, while animal welfare can be considered in terms of quality of life, in relation to shooting, trapping, and poisoning, humaneness may be considered to be quality of death, i.e., lethal control that does not cause undue suffering. Macdonald and others (2000) elaborate the difficulties of measuring suffering, yet in the search for publicly acceptable pest control methods, it is less an objective quantification of suffering that is of concern, but respondents' perceptions of the levels of suffering that different methods cause the pest individuals. The morality of killing animals for whatever purpose is beyond the scope of this paper; however, ethically it has been suggested that a humane death should be one that avoids fear or pain for the animal (Luy 2000).

Of the traditional control methods, shooting and trapping were both perceived to be humane by about 80% or more of respondents. Shooting was perceived as

less humane by professionals than enthusiasts. This may be interpreted as professionals with experience of squirrels that were wounded when shot or, based on a personal comment by a respondent, the risk of shooting red squirrels in areas of overlap. Trapping itself is not a lethal control method, although the method of death when pests are released from traps is usually quick. Some forms of traps, e.g., leg-hold traps, are commonly perceived as inhumane; however, the nature of squirrel cage-traps and the method of deploying and baiting them had previously been explained in the *Squirrel Tale* newsletter in which the questionnaire was circulated. This showed that there is little suffering while the animal is in the trap, and as with cage-traps generally, nontarget species can be released unharmed (Gosling and Baker 1989).

Although poisoning is considered the most cost effective control method by respondents, fewest respondents considered it acceptable. This may be attributed to the perception by the majority of respondents that it is not humane. Grey squirrel control using the anticoagulant warfarin is governed by the Control of Pesticides Regulations 1986 (Pepper and Currie 1998) and is used to reduce grey squirrel populations in and around vulnerable tree crops to reduce damage. Warfarin can not be used in areas still containing red squirrels. Wheat treated with warfarin is presented to grey squirrels in specially designed feeding hoppers (Pepper and Currie 1998). The poison disrupts the production of blood clotting factors and essentially causes fatal bleeding (M. Hadler, Sorex Ltd, personal communication). There was a marked difference between enthusiasts and professionals, with very few enthusiasts perceiving it as either humane or acceptable. This finding may be interpreted partly as concern over the type of death that results from poisoning and partly due to the possibility of poisoning nontarget species.

Secondary poisoning hazards associated with warfarin control of rodents on farms have received attention in the UK with regard to the polecat (*Mustela putorius*) and other mustelids (McDonald and others 1998, Shore and others 1999). Furthermore, initial hopper designs for delivering warfarin to grey squirrels allowed access to small birds (e.g., robin, *Erithacus rubecula*) and other rodents (e.g., wood mice, *Apodemus sylvaticus*) (Wood and Phillipson 1977). Hoppers were subsequently modified by fitting flap doors to reduce bait uptake by nontarget species (Pepper 1989, 1993), and practices on minimizing the amounts of warfarin used in grey squirrel control were suggested by Gurnell and Pepper (1988). Research in New Zealand on the public perception of rabbit control methods similarly found poisoning, with aerial-applied poisoned baits, to be the

least acceptable method (Wilkinson and Fitzgerald 1998). This was ascribed to fears about both poisoning of nontarget species and risks to human health. As a consequence, poisons are viewed as unacceptable due a dread fear (Slovic 1987) about the technology, because they are perceived to involve risks with, among others, a low level of controllability and potentially fatal consequences to nontargets. In relation to squirrels, our findings may demonstrate a need for more information flowing to the public on both the mode of action and application of poison, and the risks of secondary poisoning hazard to other rodent species and their predators. Personal views strongly expressed the concerns about risks of nonspecific poisoning and the humanity of existing control methods as well as a desire for acceptable alternatives. A telephone survey on biological control methods for possums in New Zealand (Cowan 1996) similarly indicated that effects on humans, species and location specificity, as well as the humaneness of the control methods were considered important factors by respondents. However, the suggestions by respondents of introducing or translocating a generalized predator such as the pine marten, which is known to take both squirrel species (Halliwell 1997), is unlikely to succeed nor be acceptable from the point of view of the conservation of the threatened native red squirrel.

The uniformity of the responses in the current survey necessitates further examination of the response group. The group was largely self-selected since it consisted of those interested in red squirrels (i.e., members of the *Squirrel Tale* network) and motivated sufficiently by the grey squirrel control issue to complete and return a questionnaire. In relation to self-selection, it is possible to make a simplistic characterization of the issue in line with the current countryside debate in Britain. The professional interest group might be characterized as 'country,' as most grey squirrel management takes place in forested areas. However, it is more difficult to describe the enthusiast interest group as 'town,' as it encompasses individuals from both rural and urban areas. Unlike surveys of public perception of badger (White and Whiting 2000) and rabbit control (Wilkinson and Fitzgerald 1998) that separated urban and rural respondents, our study was not designed to establish societal differences between respondents. Our survey focused on potential differences in perception resulting from the species of squirrel present in areas where the respondents live. Our results (Table 5) do not show a consistent pattern, although a larger proportion of respondents living in "red only" areas found grey squirrel control acceptable for trapping, poison-

ing, and IMC compared to "grey only" and "red and grey" areas.

It is nonetheless worth considering the urban and rural dimensions of grey squirrel control in the context of IMC. Both the professional and enthusiast groups in our survey considered IMC the most humane and acceptable form of control. Grey squirrels are common in parks and gardens in urban areas and are considered an attraction and are enjoyed. These sentiments have been expressed by respondents as well as by animal rights groups (e.g., Bryant n.d.), and the aim of management in these situations should be to manage pockets of grey squirrels, where they provide amenity value, while minimizing emigration into the periurban and rural areas still containing red squirrels, such as in Scotland and parts of northern England. This type of management is particularly difficult to achieve with traditional control methods, whereas IMC, by reducing grey squirrel fecundity, would be more suited to this role. Animal welfare groups in New Zealand indicated that the prevention of breeding was the most acceptable form of pest control (Loague 1993).

The geography of grey squirrel control is further highlighted by analysis of the squirrel population zone of the respondents (Table 1). Slightly more than half of all respondents were from areas with both squirrel species present, although the extent of red and grey squirrel overlap is a small fraction of the total UK squirrel habitat (Gurnell and Pepper 1993). Thus the focus of both professional and enthusiast concern over grey squirrel control for both economic and conservation reasons is in these areas where both species currently coexist. It is thus proposed that waves of concern about the grey squirrel control and the balance of red and grey squirrel populations correlates with the contemporary areas of overlap between red and grey squirrel distribution. It is these overlap areas where consultation and education programs about control methods should be targeted. However, public education about IMC should go beyond explanation of the scope of any control project and how the technology meets various humane criteria. It should also be open about potential practical problems associated with this new technology and be clear about the objectives of its application with regard to red squirrel conservation or damage control in timber crops.

Research on fertility control in possums has observed changes in the animals' mating behavior, mortality, and sex ratios (Ji and others 2000), and data from deer and horses suggest that more than one inoculation may be necessary to prevent pregnancies (Kirkpatrick and others 1997). Rushton and others (2002) discuss possible problems of bait uptake, changes in

squirrel behavior, and the effectiveness and cost effectiveness of IMC in different landscapes. IMC was found to be unlikely to be effective for controlling grey squirrels for red squirrel conservation unless it was integrated with traditional forms of population control. The effectiveness of IMC in reducing economic damage on timber crops has still to be demonstrated. More research is therefore needed on the conservation and economic value of IMC and better information on the efficiency of IMC may alter its overall acceptability since respondents ranked “effective” as a more important criteria that “humane.” Research on public perception of risk, and thus the acceptability of new technologies, has shown that initial perceptions of risk are difficult to change, even in the face of objective evidence (Slovic 1987). This research indicates that there would be support for grey squirrel control using IMC from both lay and professional interest groups.

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Appendix

Opinion Survey on Population Control of Grey Squirrels

Introduction

Within the next few years immunocontraception (reducing grey squirrel reproduction by giving them a contraceptive) may be available as an alternative form of grey squirrel control to the existing shooting, trapping and poisoning methods. We would like to find out your views on grey squirrel control and the various control methods, and would be grateful if you could complete and return this short questionnaire.

Survey

1. Do you have a professional interest in red and/or grey squirrel management? Y/N
(please circle the one that applies)
2. Do you live in an area that has:

red squirrels only	_____
red and grey squirrels	_____
grey squirrels only	_____

 (tick the one that applies)
3. Do you agree in general that, where necessary, we should control grey squirrel populations to conserve red squirrels? Y/N
4. Do you agree in general that, where necessary, we should control grey squirrel populations to reduce damage to crops and timber? Y/N
5. Current methods of grey squirrel control include shooting, live trapping and poisoning. Please complete the box to indicate your views on different evaluation criteria for each of these methods.

	Shooting	Trapping	Poisoning
Effective in controlling grey populations			
Cost effective			
Humane			
Should be used			

In each cell, put: *Y* if you agree
N if you disagree
 Leave blank if you have no view on the matter or do not know

Immunocontraception will be a bait-delivered vaccine that selectively will reduce grey squirrel fecundity.

6. Do you consider this an *acceptable* form of population control? Y/N
7. Do you consider this a *humane* form of population control? Y/N
8. Rank in order of importance the criteria for evaluating grey squirrel population control:

Effective in controlling grey populations	
Cost effective	
Humane	

9. Please use this space to record any further views you wish to give on control of squirrel populations:

Thank you for your time in completing this questionnaire.