Secretary Island Deer Eradication

Scoping Document

SOUTHLAND CONSERVANCY

Department of Conservation
Te Papa Atawhai

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Cover photo: Secretary Island - Graham Dainty

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Background

Secretary Island is part of Fiordland National Park, and is 8140 hectares in size. It is a steep and rugged island, rising to 1196m above sea level. It is separated from the mainland portion of Fiordland National Park by Thompson Sound to the east (minimum distance between the two is c 950m), and by Doubtful Sound to the south.

Secretary Is. was until the late 1950's or early 1960's entirely free of introduced browsing or grazing animals, and was one of the largest and most significant areas of indigenous vegetation remaining free of the effects of such animal pests. Until that time, the stoat was the only introduced animal that had succeeded in crossing the gap between the mainland and the island. The spread of red deer into Fiordland inevitably meant that Secretary Is. would be threatened by this species, a competent swimmer well capable of crossing either Sound to reach the island.

A red deer stag was intercepted and killed as it was swimming to Secretary Is. in 1959, and this was the first recorded evidence of red deer attempting to reach the island, though it is unclear whether individual deer had reached the island before this date. Deer were not present in the southern sector of the island during a visit in 1959/60 by an Otago University botanical team. However, deer could easily have been present on the island in low numbers, especially in the western/northern areas (now known to be favoured areas) where the botanical team never visited.

Sporadic sign was confirmed from the southern end of the island from 1963, though it is unclear whether a resident breeding population was present. A fisherman reportedly saw and photographed a hind and fawn in Grono Bay some time prior to May 1966 (Brown and Evans, 1966) but incredibly the significance of the sighting appears to have been overlooked or dismissed (in one case it was suggested they were probably two stags minus antlers).

By 1970 a small resident population was confirmed in the southern (Gut) area, where 4 adult females were shot and 2 more driven from the island around the 'Gut' area in April 1970 (Paulin, 1970). In all probability deer had extended over much of the island in low numbers by this date. This was confirmed by helicopter hunting and ground observers in 1973-74, when deer were shot in moderate numbers all over the island, with population large enough to have created tracks "over two feet wide and worn down exposing bare earth and roots" in some favoured areas (Evans, 1973). By 1975, deer were well established all over the island (Marks and Baylis, 1975) in sufficient number to have created very obvious tracking.

Details of precisely when a breeding population established on the island will remain unknown. On the basis of the historical spread of red deer into the area, it is probable that deer most likely colonised the island from the east (across Thompson Sound) and could have remained undetected in the (still) favoured western areas for some years. (Note that a survey in 1973 showed no sign of deer, past or present, on Bauza Island). Access to the island at the time was almost exclusively by boat, and as a result field observations were largely confined to the southern sector.

Control measures were implemented between 1970 and 1987 but were never intensive enough or applied widely enough over the island to have major impact on the total population. Methods included aerial helicopter shooting, ground hunting, snaring, a capture pen, and 1080 gel baiting of palatable plants. Table 1 summarises the available deer kill records from 1970-1985.

It became clear that 'eradicating' deer from Secretary Is. was a massive task, and while considerable effort went into the control measures, questions were beginning to arise regarding the viability of the project.

By 1985, the attitude was "even if extermination is unrealistic, it is possible to achieve an extremely low population at a level where animal damage to vegetation is regarded as insignificant" (Sanson and von Tunzelman, 1985).

By 1989, the attitude was more defeatist - "eradication of red deer from Secretary Is. is not an option. The existing technology will not achieve this at any price. Even if it did, continuous control and monitoring would be required to prevent re-invasion by deer swimming across to the island from the mainland" (Chisholm, WAM options paper, 1989).

The control budget was ceased in 1988/89. Some commercial aerial hunting continued into the 1990's but its effect did not achieve a high level of control.

The island was largely ignored until 2001 when Munn (2001) put forward a proposal for restoration of the island through control of deer and stoats to low levels.

Justification for Control

Until around 1960, Secretary Is. was one of the few places in New Zealand that remained free of the influence of any introduced grazing or browsing mammal.

By 1975, the recently arrived but rapidly expanding deer population had already caused major damage to vegetation and soils via tracking – "spongy moss and humus over impervious granite has either been cut or damaged, leaving water gutters". Observers also noted "many deeply worn deer leads…the ground surface is easily damaged and slow to heal over." (Anon 1975).

The small five-finger tree *Pseudopanax colensoi* var *fiordensis* formed most of the sub-canopy layer in sub-alpine silver beech forest, but deer "essentially eliminated this layer" (Mark and Baylis, 1982). It was suggested that this selective browsing, along with trampling and a similarly reduced herb layer, rendered the forest floor prone to sheet erosion as illustrated by photos of dead *Pseudopanax* stems and exposed beech roots. The former significance of this species in the subcanopy is virtually undetectable now.

In places, the hen-and-chicken fern *Asplenium bulbiferum* was the "overwhelmingly dominant" fern in the forest herb layer in the last section to be accessed by deer (talus slopes below cliffs on the SW side) (Mark and Baylis, 1982). Here, hen-and-chicken fern density was estimated at an amazing 25,000 plants per hectare. By contrast areas where deer had prior access (e.g. Grono Bay) the fern "had been severely depleted" and the ground cover of ferns greatly reduced.

Similarly, a number of other species have been impacted on. By 1982, Mark and Baylis reported "clear evidence of the subtle changes that are caused by selective browsing and of the significant loss of ground cover that will follow". Measurements of permanent forest plots on Secretary Is. from 1975 to 2003/04 have detected significant changes in composition and structure in the under storey with declines in most palatable or deer-preferred species (e.g broadleaf *Griselinia littoralis*, mahoe *Melicytus ramiflorus*, kamahi *Weinannia racemosa*), and little or no changes in many non-palatable species (Monks et al., 2005).

Removal of deer will remove the one introduced browsing species present on the island, and will therefore create conditions suitable for the recovery or restoration of indigenous flora and natural vegetative processes.

Setting the Goal and Objectives

It appears that nobody consulted so far is under the illusion that a 'one-off' eradication campaign is all that is required. In this instance the frequent references made to 'eradication' are presumed to mean 'control to a zero population, knowing full-well that re-invasion is almost inevitable and will have to be managed and planned for'. That is, 'eradication' (if feasible) refers to the complete removal of the existing population, but this will have to be followed by long-term 'control' measures to limit re-invasion or re-establishment potential.

In this document the term eradication is defined as control of the population to zero density.

The experimental nature of the operation must also be acknowledged – eradication of deer has never been attempted elsewhere in an area the size of Secretary Is. The successful eradication of deer from Anchor Island (1150 ha) and ongoing surveillance work is the only relevant operation previously undertaken. Part of the value of attempting eradication on Secretary Is., is to see if it can be done and to learn as much as possible from the process.

In short, the project has two linked but quite distinct goals:

1) To protect the general ecological values of Secretary Is.
2) To see if eradication can be achieved in such a large area, and to field test and evaluate control options for future use on this and other islands (e.g. Resolution Is.) and similar conservation areas (e.g. mainland islands).

The project also has two quite separate phases:

1) Eradication to reduce the existing population to as close to zero as possible within practical and financial constraints
2) To then undertake long-term 'maintenance' of the extremely low deer density through prevention of reinvasion (if possible), early and reliable detection, and targeted control responses.

The current goal for Secretary Island is:

"To enhance the ecological values of Secretary Island by eradicating and/or controlling stoats and deer to a level where they no longer impact on the island's ecosystem".

Some debate has already occurred on this goal. While the general intent of the goal is clear, and from a conservation viewpoint it is highly desirable, it is not specific in terms of what 'impact' is, or how we can measure this. It implies that there may be some form of specific performance measures, but does not state these.

It raises the question whether the goal needs to have specific performance measures, or whether the removal of an introduced animal from an important conservation area where control/eradication is potentially feasible is in itself sufficient justification. (There is clear legal mandate for this in the National Parks Act 1980 and the Conservation Act 1987).

Many (probably most) pest eradication programmes from islands in the past have had no specific performance measures – the result (i.e. achieving eradication) is the primary goal, while outcomes (real or expected flow-on effects from the eradication) have often been anticipated but not specifically stated as the goal or as performance measures.

Should the goal be **result driven** (i.e. the goal is to reduce deer as far as possible simply because we know they do [unspecified] damage to natural environments, and that long term reductions in their numbers may be feasible on an island such as Secretary Is.). In this case we must acknowledge the control efforts are experimental in nature – nothing of this magnitude has ever been attempted before, and we cannot confidently predict either the result or the long-term effects with total confidence. The programme would be viewed as a learning experience. While this approach could be seen as a reason not to try, it should be remembered that many successful eradications were in effect 'experiments in action' such as cat eradication from Little Barrier, weka removal from Codfish, and possum removal from Kapiti. Such operations have not only benefited the island in question but have developed experience and confidence for use in much wider applications.

Or should the goal be **outcome driven**, i.e. establish performance measures such as response of particular vegetation or flora or invertebrates. In this case, what do we monitor? We already have well-documented and compelling evidence on the effect of deer on Secretary Is., and this in itself could be seen as sufficient grounds for high level control. The general on-going vegetation monitoring from permanent plots will pick up broad trends in vegetation recovery. In conjunction with paired deer exclosure and control plots a more robust assessment of vegetation changes due to deer could be made (Monks et al. 2005). Although other performance measures have been suggested (e.g. response of invertebrates to improved leaf-litter or humus conditions following reduction of deer numbers), it would be disingenuous to create performance measures not related to the primary reasons for deer control.

Removal of deer may not necessarily promote a return to the pre-deer vegetation patterns, at least in the short term. That is, we cannot presume that vegetation patterns will return exactly to the 'pre-deer' state, and any performance measures based on such presumptions may end up unattainable, regardless of the level of control attained. Coomes *et al* (2003) outline possible factors why, such as:

- periodic re-invasion may be enough to prohibit recovery of the highly palatable species;
- occupation of vacated niches by non-palatable species (e.g. pepper tree, crown fern, some tree ferns);
- extinction or reduction of local seed sources of some species;
- and shifts in ecological processes (e.g. alteration of soil/peat formation processes).

All of these may be applicable on Secretary Is.. Therefore, while some response of vegetation can be presumed following control of deer, the precise effects will be more difficult to predict. It would be simplest, and may perhaps be most efficient simply to record the short and longer-term changes in the established vegetation plots as a way of demonstrating the benefit of deer control.

The 1985 Wild Animal Control plan objective for the island was:

"To reduce wild animal densities to the lowest achievable level on Secretary Island and prevent infiltration from adjacent areas as far as possible within the available constraints of finances and manpower." (Sanson and von Tunzelman, 1985).

It is suggested that the goal for the deer programme be:

"To eradicate deer from Secretary Island and to prevent their re-establishment making it one of the largest areas in New Zealand largely free of all mammalian pests".

Suggested Objectives:

1) Obtain a more accurate population size estimate for deer on Secretary Is. in order to assist with planning and setting performance targets/measures.
2) Eradication by the end of Year 2, and as far as is possible, the maintenance of this zero level to Year 5 and beyond.
3) Monitor through regular field inspections and/or DNA sampling the rate of re-invasion between Years 2 and 5, and beyond.
4) Gather experience and information on those control and detection techniques most likely to succeed and be cost-effective on Secretary and Resolution Island's.
5) Monitor and document recovery of species and communities through broad-brush vegetation monitoring (i.e. the established permanent plots) and wildlife monitoring (include deer exclosure/control plots as recommended by Monks *et al.* 2005).
6) Review the success of the operation, its methods, and stated goal and objectives in Year 4.

Why Did Previous Efforts Fail and What Can We Learn From This?

Before any further attempt at eradicating deer from Secretary Is. is considered, a full appraisal of previous efforts is desirable in order to learn from any mistakes or successes of the past.

It is quite apparent in hindsight that the control efforts on Secretary Is. from 1970 to 1987 were simply not enough, were not strategic enough, and failed to cover the entire island. It is easy to speak in hindsight, but it is painfully obvious from examination of the overall programme that 'eradication' efforts were doomed to failure as a result.

As an illustration of insufficient effort, Sanders (1981) wrote "for some time I have been concerned at the low numbers of animals being destroyed on the island by the NZFS as my own observations led me to believe that we were barely keeping up with the natural increases".

Some key points to take from the previous operations are:

- The reaction to the reality or potential for invading deer was far too slow – deer may have been invading the island by 1959 or earlier, and breeding by 1966 or earlier, but control measures were not implemented until 1970 (and not significantly until 1973), and consequently a widely dispersed and rapidly expanding population was encountered.
- The track system was incomplete and wholly inadequate for island-wide control. Large areas of the island were in effect inaccessible to ground staff, hence little or no control occurred in such areas. Although numerous deer leads were present, these were not universally distributed, and ground-hunting efforts were often hampered by the thick vegetation and consequent lack of silent stalking opportunities.
- Efforts were understandably concentrated around the limited hut and bivvy sites (first established 1977) – there were simply not enough of these, nor were they distributed widely enough to ensure comprehensive coverage of the island.
- Problems with settling on an effective 1080 gel compound – 'trials' wasted time and money as some forms of gel were not effective or could not be used easily in 'Fiordland' conditions. To a lesser extent application techniques were also being learnt as they went (how and when to apply gel, and what to).
- Use of 1080 gel was generally not systematic. It was generally confined to the few tracks then in existence, or to the general areas around base camps. It is probable that some areas of the island were never treated. Where a thorough trial was undertaken (e.g. the northern end, 1987) kill rates appeared high.
- 1080 gel was probably over-used and over-relied upon in some areas, and some development of bait shyness almost certainly occurred in some deer.
- Simply not enough effort was put in. On average, 140 person/days per year occurred for ground teams (hunting or poisoning), and an average of 20 hours helicopter time (for years where information is available) resulting in average known minimum kill of c. 30 animals/year (probably appreciably

higher due to undiscovered 1080 kills). Nevertheless the kill rate was completely inadequate when the population is thought to be in the hundreds.

- Budgets were too small to allow for greater effort.
- There was no clear overall strategy toward eradication.
- The wrong attitude existed in some quarters ('it can't be done'), and there was a subsequent lack of commitment amongst some managerial staff.
- Few hunting dogs were used because of the extensive and repeated 1080 gel use
- There was no systematic hunting or control on the mainland areas opposite to possibly restrict continued re-invasion.
- Aerial hunting was sometimes for commercial use only (carcass recovery or live capture) therefore was financially- not results-driven. Overall, it was not a *co-ordinated* part of control programme.
- Evidence in some instances during the 'live-capture phase' of commercial aerial operations that deer were left alive (for 'next time') rather than shoot them if live capture was not possible (Mawhinney, 1985).
- Ground-hunting was generally a solo rather than a team effort.
- Some double-up of administration etc. with two separate departments – NZFS and L&S – who was in control?
- Responding to criticisms in 1977, it was stated by a senior NZFS staff member that high staff turnover was also an issue in sustaining effective deer control on Secretary Is.

While these comments are critical of the previous operation, it is remarkable what was achieved with a limited budget and with the many problems that went largely unresolved e.g. the on-going issues with finding a suitable 1080 gel, and the relative lack of tracks.

While unlikely to have had any negative effect on the whole operation, it is also known that occasional efforts at control were made or were encouraged by Lands and Survey staff, outside of the NZFS 'official' efforts. A NZFS staff member commented that Lands and Survey hunting in 1981-83 may have disrupted deer in areas 'spelled' by the NZFS prior to 1080 gel baiting. The lesson to take from here is that all control should be integrated and that individual efforts intended to 'help' can often have the opposite effect.

As an example of the consequence of not having an effective track system, in 1981 a hunter was dropped at the extreme northern tip of the island, and 'bush-bashed' along the island to Noon Extreme, and then proceeded up to the main ridge along to Rocky Point hut. The trip took 15 hours (info from Rocky Point hut book). The distance of just over 8 km is now fully tracked and can probably be done comfortably in 6 hrs. This comparison demonstrates that per hunter-day, coverage of the ground will be far more efficient with the track network in place.

Similarly it took two very experienced hunters six hours to travel down from the southern open tops to the south coast, a distance of only 2-3 km (Mark, 1977) because of the untracked nature, especially the almost impenetrable scrub zone.

Advantages We Have Now

While many issues faced in the control work of the 1970's and 80's will be unchanged for the proposed work, there are some key advantages that give a far greater prospect of success:

- A comprehensive island-wide track network and system of huts and bivvies. (see figure 1).
- A larger annual budget and consequently greater control efforts per annum are possible

FIGURE 1: SECRETARY ISLAND TRACK NETWORK AS OF NOVEMBER 2005.

- The benefit of hindsight and experience from previous Secretary Is. work, and work elsewhere e.g. the Murchison Mountains, Anchor Is., and other small island deer control work.
- A chance to develop and apply a far more strategic approach
- A superb boat able to act as a mobile base for hunters, provided it could be made available during the best times for ground hunting.
- VHF repeater on the island will give far better communications for team-hunting, ground spotting for aerial work, etc.
- GPS for navigation, recording of key sites, etc.
- Significantly, a far more positive attitude towards major eradication/control efforts, and a belief based on wider eradication experience that it can be done.

Budget

Whatever course of action is taken, its overall cost needs to be kept within operational budget allocations. Many possible actions and methods are to some degree experimental, and their value to the programme is unclear. This project has effectively dual aims, firstly to reduce and maintain the deer population as much as possible, but secondly to carefully record and assess the experimental aspects of the operation, for longer-term application for cost-effective control on this and other Fiordland islands, particularly Resolution Is.

The existing budget for the Secretary Is. deer work is:

2005/06: Preliminary field trials (general overheads and assistance with delivering this work not included but is covered in the Secretary Is. budget):$15,000.

2006/07 and 2007/08: knock-down phase of $365, 780, or c.$45/ha (general overheads for office, vehicle, MV Southern Winds, salaries for project management, and assistance with delivering this work not included but is covered in the Secretary Is. budget).

2008/09 and beyond: an annual budget of $114,600 for surveillance, on-going control, etc, or c. $14 per hectare.

A crude comparison with funding for the Anchor Is. Deer Project (at $54 per ha) indicates that the project may struggle to achieve eradication within current budgets. Care must be made to ensure funding is not 'wasted' on un-productive research or management techniques. All aspects of the project should be kept under constant review with this in mind.

In contrast knockdown and maintenance of high level control in the Murchison Mountains has been achieved at a fraction of the cost allocated to either of the island programmes (Dave Crouchley, *pers. comm*.). While not directly applicable due to its proximity to Te Anau the success and cost effectiveness of the work undertaken in the Murchison Mountains does give us some grounds for optimism in terms of what can be achieved.

Options for Deer Control

AERIAL BAITING

Previous use:

Only carrot baits are currently registered for aerial 1080 use against deer. Cereal 1080 baits are not registered for this purpose and while they have the potential to kill deer, it is not possible to draw any conclusions about their effectiveness for deer control. Aerial baiting with carrot has not been specifically trialled against deer in Fiordland.

Around the country, deer numbers have been reduced inadvertently through use of aerial 1080 carrots for possums, with kill rates ranging widely and for largely indiscernible reasons, from about 30% to 95%.

Pros:

- Surviving deer remain naive to hunting
- Very time-effective option for field operations
- Suitable for all parts of the island including very steep areas hazardous for foot travel
- Some instances of very high kill rates
- Reasonably weather resistant
- Could prove to be a very useful technique in future with further development.

Cons:

- Would restrict safe use of dogs for stoat or deer work for some time (timing re: use of dogs would need to be factored into programme; dogs would be required to wear muzzles as well as for other reasons e.g kiwi)
- Unknown effect on weka – carrot baits have not been used in weka areas
- Resource consent required – not guaranteed to be smooth process
- Greatest planning time required – AEE (Assessment of Environmental Effects, resource consent, etc.)
- Possible strongest public opposition
- Restricted to use of carrots unless registration occurs for other options
- Considerable costs and logistical difficulties associated with bait purchase, transport, barging etc.
- Highly variable results in possum operations elsewhere – cannot be wholly confident of benefit
- Very costly if all island is to be treated
- Non-target monitoring will probably be required by the Pesticides Advisory Group would for Resource Consent

- Opportunity for DNA sampling may be in part lost (DNA can still be collected from carcasses)
- Pre- and post-monitoring of deer and non-target species will be required
- Requires pre-feeding to be most effective e.g. material/flying costs are doubled.

Unknowns / Key Points:

- Risk of toxin to dogs used for ground hunting - it is unknown how long 1080 will remain within carrot baits – it appears it leaches out slowly, but no field studies have been carried out (A. Fairweather, *pers. comm.*). Leaching from cereal baits is considerably quicker. However, carcasses would still be toxic for as long as it takes for them to break down (unknown in Secretary Is. circumstances). Monitoring of baits and carcasses would be required to determine the interval required before safe use of dogs, and this interval could be considerable.
- Only carrot baits are registered – how palatable are these to Secretary Is. deer? A ground-based trial of the palatability of carrots as bait was conducted in 1984 (von Tunzelman, 1984). On 27-28 August 1984, a total of 100 whole large carrots were placed along the track from the Grono Bay flat to the Hub. Baits were nailed to trees 65cm or more above the ground to avoid interference from weka. In each of the carrots a core was extruded, and a gelatin capsule of 1080 was inserted. The hole was 'capped' with part of the extruded portion of the carrot. Fresh deer sign was observed along the length of the track, but a check of baits 19-21 September and again on 8 October showed no take whatsoever of any carrot baits by deer (or birdlife). The carrots lasted well, only showing initial stages of decay by the latter check. This seems to indicate that at the time deer were totally disinterested in carrots as bait. A simple re-trial may be valuable – if deer take whole carrots it creates possibilities for both aerial and ground-based toxin application.
- What time of year to apply – best acceptance
- What rate to apply?
- Density of deer is unknown – may vary considerably between habitats and seasons

Indications of costs:

A recent possum operation in the Central North Island used a rate of 3 kg/ha for pre-feed and 2 kg/ha for toxic baits, at a total cost of $30/ha. Extrapolating to Secretary Is. these figures would require a budget of $244,000. Given the higher rainfall on Secretary Is. (equates to higher sowing rate), its isolation and therefore the more complicated logistics, the island costs could easily be up to $50/ha. This estimate equates to a budget of $407,000, a figure that is more than the total budget allocation for knockdown on Secretary Is. Moreover, follow-up methods would still need to occur.

Conclusion:

A bait palatability trial using carrots would need to be undertaken. If carrots prove highly palatable, then options for aerial use of carrot baits should be kept in consideration. Otherwise, aerial dispersal of baits appears to have too many unknowns, is prohibitively expensive, and is likely to have added difficulties with either resource consent approval or implications and costs of conditions of consent. Unlikely to be a viable option.

GROUND BAITING (1080 GEL)

Previous Use:

Foliage baiting with 1080 gel began in 1975 on Secretary Is., but was not really effective until tracks and 3 bivvys were established in 1976. Intensified efforts in 1976 led to a significant reduction in the deer population (Bathgate, 1977).

A small trial conducted in 1976 used hen-and-chicken fern (*Asplenium bulbiferum*) for 1080 gel poisoning (ferns were transplanted from areas where deer were not common or could not get access – tops of rocks etc.) (Mark, 1977). Poisoned ferns were partly-to-heavily grazed, but cut stems of *Pseudopanax colensoi* (three-finger) were surprisingly not touched. Other plants were again informally trialled in May 1984, where deer were recorded taking 1080-baited hen and chicken fern and some mahoe (*Melicytus ramiflorus*) along with broadleaf (*Griselinia littoralis*) but apparently not *Coprosma lucida* over a two-week trial (Alan Mark and John von Tunzelman, Stantley Burn hut book).

Pepers (1979) was "disappointed to find that baits laid in February and June [1979] were untouched in known deer areas" (all baits were *Griselinia littoralis*). Also, in July 1986 Mawhinney (1986) noted that only 2 of 50 untreated *Griselinia* baits had been touched over a period of two weeks. However, when deer numbers were low Evans (1976) noted 95% of baits were taken from two lines (each of 50 baits) at SW Point and Rocky Point in July 1976. These instances provide somewhat contradictory evidence of the effectiveness and attractiveness of natural baits for 1080. Deer interest in baits may vary strongly with habitat, time of year, availability of alternative foods, but evidence is not clear enough to make firm conclusions.

Evans suggested a person could dispense 3-5 tubes of gel per day, and the entire island would need 72 tubes of poison (or c.1440 baits, or c. 1 bait/approx 5.5 ha). Actual figures were often much lower e.g. Spiers (1977) reported using only 6 tubes for a 3-4 day trip by two people.

NB. A standard 'tube' of gel is considered to contain enough gel for approximately 20 'baits'.

There is some evidence of prolonged persistence of toxin on baits. Evans (1976) reported the recent death of two spikers near baits laid months prior, and similar reports occurred over the following years. It seems that if the gel is applied in dry conditions, it lasts well despite heavy rainfall.

Gel type was changed in 1979, when petrolatum-based gel was introduced, proving "far superior…especially for ease of use and lasting qualities" than the carbopol gel used previously (Main, 1980).

Cuddihy (1981) evaluated the two gel formulas in a trial near Milford Sound, using broadleaf. Results showed that red deer tended to avoid a gel specially formulated for Secretary Is. (= soya bean-based brew?) while showing almost no difference between control broadleaf (i.e. with no gel) and the Stewart Island (Carbopol) gel. He concluded that for Secretary Is. the "present [special mix] bait will be at best be inefficient and at worst a possible deterrent". Newer (standard) petrolatum/carbopol bait has proved to be far more acceptable to deer (J. von Tunzelman, pers comm)

In review in 1985 it was concluded "to date there has not been a full scale [gel baiting] operation" (Sanson and von Tunzelman, 1985). Problems identified with the gel baiting included bait acceptance, applicability, gel odour and reduced longevity of the gel.

This led to the development of a more systematic trial, in February 1987. For this, 15.6 km of tracks were cut on the north end of the island (nth of Rocky Pt), in an area totalling c. 843 ha (slightly more than 10% of the island). The poisoning operation took a total of 10 people 8 days to lay "a pattern of baits over as much of the feeding zone as possible" (von Tunzelman, 1987; about 50 tubes of gel were budgeted for – not known how many used). By May, indices of deer tracks had reduced by 38%, and pellets by 42%, but the newly-cut tracks were noted to be favoured by immigrant and remaining resident deer, and it is suggested that numbers of remaining deer was overestimated, i.e. kill was probably underestimated. Seven weeks after the poison baiting a survey found thirteen deer carcasses. Some gel baits were still in good condition.

A further check in November 1987 revealed no further carcasses and no live deer seen by von Tunzelman (based at Rocky Pt). However, two deer were taken from the treated area at the time in a commercial aerial operation, 1 deer was shot, and 2-3 others seen within the poison zone by another hunter over 7 days (Graham, 1987). Two other hunters at Noon Extreme camp "found sign of 8 deer using the cut tracks but no animals were seen or heard (Wilson, 1987). On the November trip "a reversal of the downward trend" (i.e. a euphemism for a recovery!) was noted (Chisholm, 1988). This was declared "an aberration caused by the surviving deer and new immigrants favouring the newly established track system along which the pellet counts and track counts were done". The pre-poisoning counts in February were completed soon after the tracks had been cut (10 Oct- 2 Nov), hence deer had by then not accustomed to make use of the track. Gut examination of one animal shot showed it had been eating predominantly broadleaf, but had obviously not taken baited broadleaf, though it may have been a recent immigrant (Chisholm, 1988).

This trial used both carbopol gel (easy to lay, but tended to form blobs rather than film) and 3:1 carbopol/petrolatum gel. The latter was easy to spread, appeared to last very well, even after heavy rain, but again some comments were made on odour. However it was noted in some instances "some leaves appear to have been plucked from the baits by deer and rejected".

A severe rain storm hit the area soon after the poison was first laid – carbopol operators noted baits had been washed almost clear of gel, and John von Tunzelman later reported that the Stewart Is. (carbopol) gel "doesn't last long" in the Secretary Is. environment. However, after 500mm of rain between laying of baits and the rechecks in April some 3:1 carbopol/petrolatum baits still had traces of gel on them that appeared to be lethal doses.

Some 2:1 carbopol/petrolatum gel was also used but it proved not easy to apply, did not adhere well, and seems to have been rejected for further use in the field.

Further poison was laid in early April, but no problems with odour were noted – possibly as a result of cooler temperatures? The question arises as to whether the odour is a real issue (i.e. a deterrent to deer) or is it a subjective human issue – because we can smell it we assume deer will be deterred by it?

In the trial, both cut and tied-down baits were taken by deer, with no noted difference in acceptance rate. Hunters working the poisoned zone in the roar were "very surprised to note the lack of deer" compared with areas outside. Field sign was thought to be a better indicator than the pellet and track counts along the tracks – such as unused wallows (cf. well-used ones outside), lack of stags roaring cf. outside, a hunter shooting 7 deer outside the zone but not seeing a single live animal in 3 days within zone – all in April.

Von Tunzelman (1988) considered the trial "was obviously effective in making significant reductions in an already low population of deer", and Chisholm (1988) agreed, "in spite of the difficulties encountered with poison application..."

Slater and von Tunzelman (1988) reviewed the 1080 operations on the island, and the relevance of the Stewart Is. work. They concluded the Stewart Is. work was a very different situation in that deer densities were high, there was little available feed and climate conditions were more conducive, in comparison to Secretary Is.. "The relative abundance of readily available highly palatable food reduces the effectiveness" of 1080 poisoning on Secretary. Suggested timing any operation to coincide with "the time deer are seeking maximum food intake, i.e. late spring". They estimated that baiting the entire island would require 80 person/days per year once a track system was in place (but notably budgeted for 110 days, plus 50 days monitoring!). In 1989 Chisholm (1989) noted a requirement for 70 p/days and 40 p/days per year for poisoning.

In 1976 "all parties agreed that to lay poison in wet conditions, or when vegetation is damp, is an absolute waste of time" (Evans, 1976).

Von Tunzelman (1987) noted the carbopol gel had a noticeable odour in warmer conditions, as well as the petrolatum (in Feb, but was not an issue in April). He considered that they had a very good kill, and that the bait may have persisted for a couple of months with C/P 3:1 on tied down baits, as fresh carcasses were noted along with well-decayed ones.

The carbopol/petrolatum gel as used in the 1987 trials is considered to be very suitable for continued use on Secretary Is. (J. von Tunzelman, pers comm).

One instance of a non-target kill is recorded – Main (1979) "found a paralysed weka...which died 15 minutes later... little doubt it died from 1080". He assumed the weka had picked up a blob of gel that had fallen from baited broadleaf leaves. As the loss of carbopol gel from baited leaves was a common occurrence especially when the leaves were damp, it can be reasonably assumed that this was not an isolated incidence, but would be under-reported due to the low chance of finding weka (or other bird) carcasses when and if monitoring occurred several weeks or months later. However, use of petrolatum gel rather than carbopol gel may reduce or eliminate this issue.

Ground use of diced carrot baits is impractical. Use of whole carrot or similar bait (as per the von Tunzelman experiment) has merit if baits are attractive to deer.

Main (1979) noted the deer had ravished five finger and surmised that there "appears to be some special food attraction in this species at this time of year [July]".

Pros:

- Potentially a very useful method, however the results have been extremely variable. A reasonable kill-rate could be expected if used according to best practice.
- A good knockdown technique in areas of higher deer density – remaining deer will remain naïve to hunting
- Has been shown to be effective on Secretary Is
- Extensive deer use of tracks means baiting can focus on such easily accessible areas.
- Areas of bait take are obvious, so is rejection/avoidance of baits (i.e. a picture can be built of where deer are, or remain)
- 'On the ground' work – detailed field observations can be made at the same time
- Low material cost cf. aerial applications
- No resource consent required cf. aerial
- Over 18 years since its last use – no poison-shy animals are likely to remain
- Deer densities are currently high (unhunted for many years, likely to be at saturation level) meaning attractiveness of natural bait should be high
- Can be used in selected portions of the island only, leaving other blocks available for concurrent hunting.

Cons:

- Requires licenced operators
- Very labour intensive to achieve full coverage
- OSH/safety issues re handling of toxins
- Would restrict safe use of dogs for stoat or deer work for some time (timing of this option with regard to subsequent use of dogs would need to be factored into programme)
- Non-target trials and monitoring will probably be required by the Pesticides Advisory Group (esp. for kaka)
- Problems re. use in wet conditions need to be considered
- Difficult to cover steep terrain
- Possibly 'once-only' method – many surviving deer will be poison shy
- As deer numbers reduce, attractiveness of foliage baits lessens as alternative (unbaited) foods become available
- Needs to be followed up by other methods
- Ground-based use of 1080 use will probably require an AEE
- Weka kill has been recorded on Secretary Is. as a result of 1080 gel, but properly applied the risk should be small.
- Generally no DNA material would be available unless the carcass is found.

Unknowns / Key Points:

- Risk to dogs used for ground hunting – the 'safe' period between 1080 baiting and use of dogs is unclear. Loss of 1080 from baited leaves is considerably faster for carbopol gel (requiring c. 200mm of rain for most 1080 to disappear) than for petrolatum gel which may remain on leaves for 110 days-plus with much greater rainfall resistance. Treated leaves abscise (fall off) after a month or two but in petrolatum baits especially the fallen leaves may still remain toxic to deer for up to 300 days. Carcasses would also be toxic until breakdown (it is unknown how long this would take on Secretary).
- Source of highly palatable vegetation for bait may be restricted in accessible areas
- Bait plants suitable include broadleaf as the key species but also three-finger and five-finger. Other species such as mahoe or hen-and-chicken fern may warrant further trials.
- Two options exist – use of tied down baits for longer term control – potentially effective for weeks or months, even if no-one is on the island; or use of cut baits – a shorter lasting bait that would enable more rapid follow-up use of dogs on the island?
- Has the potential to be used in conjunction with deer pens.

Indications of Cost:

Operations using 1080 gel on broadleaf baits are generally estimated to be $10-15/ha, based on 2+ baits per hectare (C. Veltman, A Fairweather pers comms). This equates to c.$122,000 for Secretary Is..

The 1987 poisoning trial on Secretary cost 110 person-days (Feb only, re-bait April figures not available) plus food plus transport. Approximately 10 % of the island was covered in this operation therefore 1100 p/days are likely to be required on this basis.

Gel baiting in Motu covered 2 ha/hr. This figure does not take account of lost days due to weather. Secretary Is. at same rate would require 508 p/days, but it is likely to be at least double this (c.1016 p/days, c.$162,000), given the terrain and weather – note this gives a person/day effort remarkably similar to that extrapolated from the 1987 poison trial costs.

However, it should be noted that it is probable that poisoning efforts on Secretary will by nature of the terrain largely be limited to the track system, i.e. the baits will not be on a 'square grid' system. Rather, island-wide coverage would be achieved by use of the tracks as the grid lines. Assuming two baits per 100m of track, total number of baits would be only c. 2400, meaning a far-reduced cost than for a strictly systematic grid. In this scenario it would be assumed that most if not all deer would encounter and make use of track systems over some part of their natural home range, given that no part of the island is more than 1 km from a track. A deer's home range would have to be less than 10 ha to avoid encountering a bait. Costs for this sort of track-only baiting would be greatly reduced, totalling c. 150 p/days or $24,000 (exclusive of weather delays, and exclusive of transportation costs of staff). Even if baiting were increased to 3 or 4 baits per hectare of track (to take account of the lack of baits elsewhere), and other readily accessible areas were also treated (coastal

or river flats, walkable coastline) the overall cost would still be remarkably low. Extra time would be required for weather delays, and it would also be important to have follow-up trips to monitor bait take and estimations of percentage reduction in deer numbers. (Note there is no budget for population monitoring – it would have to come out of control budget).

Conclusion:

A promising option, especially as a one-off knockdown method. Its use may be restricted in some areas due to total lack of or infrequency of suitable bait plants, leaving hunting options more open in untreated areas. It may be an option for use in selected (discrete) blocks of the island, probably those with higher deer density, rather than used island-wide. Its use would also require additional training/certification of field staff. The baits appear to last very well if applied in dry conditions. The issues relating to risks of toxin persistence and subsequent use of dogs for hunting purposes would need to be worked through with hunters.

Given this method wasn't used on Anchor Is., it could be trialled during the initial knock-down on Secretary Is. (e.g. use foliar baits over 1/3 of the island and compare its effectiveness between similar deer-density areas with and without bait). To maximise its trial value, pre- and post-monitoring would have to be very rigorous and would be extremely costly and/or difficult.

One monitoring tool that is currently being developed is FPI (Faecal Pellet Index counts; C. Veltman, *pers. comm.*). This new method of counting deer pellets is similar in approach to RTC (Residual Trap Catch) monitoring for possums and addresses many of the problems that were inherent with earlier deer pellet transect counts. Richard Clayton (Technical Support Officer – Vegetation Monitoring) is of the opinion that this method would be very difficult to apply on Secretary Is. The terrain means that accessing random transect lines across the island would be extremely time consuming, if not impossible in some situations. He also observed that the encounter rate for observing deer pellets was quite low in the areas he searched he searched on Secretary Is. and felt that it may be difficult to detect any variation in deer density in a population which small to begin with.

An alternative to FPI would be to fit some deer with transmitter collars prior to gel baiting to obtain an estimate of kill rates. While this approach would be costly it has the potential to provide reliable information on the fate of individual animals.

AERIAL HUNTING

Previous Use:

Helicopter hunting began on Secretary Is. in July 1973. Live capture and recovery became prominent in 1979. The distinction is unclear from records, but it appears most efforts were commercially based rather than commissioned by the NZFS.

The rate of deer killed on Secretary Is. per flying hour between 1978 and 1984 ranged between 0.83 and 1.6 deer/hour, averaging around 1.3. By 1985 this was basically unchanged, and it was noted that 70% of all animal kills on the island to this time had been achieved by this method (Sanson and von Tunzelman, 1985).

Generally, this method of hunting on Secretary appears to be capable of very high returns on the individual deer encountered. For example, file reports recorded 14 /14 seen were shot on 6-7-74, and 13 deer shot out of 15 seen in a single effort on 28-6-75.

An aerial trial undertaken on Secretary Is. in April 2005 achieved a kill rate of 17 deer in 1 hr and 16 minutes flying time at the island, i.e. 13.6 deer/hunting hour. An additional 44 minutes was spent in travel to and from the island which effectively reduces this rate to 8.5 deer/flying hour. Nevertheless, a rate of 8.5 is still considerably greater than those reported in the mid-70's. The hunters undertaking this work also felt that quite a few more deer could have been shot had they encountered more favourable conditions – The South Easterly conditions experienced prior to the shoot, although bringing generally clearer weather, are known to often mean less deer about in open areas, possibly due to the cooler temperatures. During this trial deer were not seen on many of the slips and the open bush areas hunted, despite there being quite a bit of sign about. No deer were seen on the alpine tops when travelling to or from the island (D. Crouchley, *pers. comm*.). An aerial hunt was also undertaken in October 2005 which achieved a kill rate of 4.7 deer/flying hour. While still acceptable in terms of numbers shot, it was felt that the spring trip should have been undertaken later in the season as the conditions were generally too cool for the deer to be out in the open. It was also agreed that more use could be made of the Automatic Weather Station on Secretary Is. to plan these hunting trips (A. Hay, *pers. comm*.).

Challies (1985) suggests that stags are more susceptible to aerial hunting than adult hinds, and the earlier evidence from Secretary Is. (from late 1981 to 1984) is indicative of this bias (36 stags shot compared to 22 hinds). Challies further suggested that repeatedly aerially hunted populations may be 60-70% female due to the hunting bias, not an ideal situation if you want to limit population recruitment. Results from the April 2005 trial indicated a fairly even split between male and female deer shot with 6 hinds, 5 stags and 1 spiker, and 5 yearling/ weaners. Results from October 2005 show a female bias: 5 hinds, 2 stags, 1 spiker, 1 yearling. Hunting returns from over 40 years in the Murchison Mountains suggests only a slight bias towards males being shot with percentages ranging from 50-60% (D. Crouchley, *pers. comm.*).

It was noted in the annual NZFS report for Fiordland National Park for 1980/ 81 that better results per unit effort were achieved by use of the helicopter dropping off field parties than to organise a separate hunting flight from Te Anau. The report noted 3 kills in 20 minutes of extra flying for 'drop-off' helicopters, while only the same number of kills (3) for 5 hours 10 minutes of total flying for specialist aerial hunting flights from Te Anau. The evidence is scanty, but the logic is apparent – where possible, make use of helicopters when in the area rather than arrange separate hunting flights.

It is obvious that results for aerial hunting will vary from season to season and also according to weather patterns. To get best value for cost, aerial hunting will need to be strongly targeted towards times and seasons considered best for this method. For example, effectiveness of aerial hunting may be best when weather clears after extended wet periods as deer tend to use open areas (slips, beaches etc.) to dry out.

One instance was recorded (Stantley Burn hut book) in 1982, where a (non-hunting transport) helicopter was utilised to successfully drive a stag toward ground hunters, who shot the animal. It is possible that combined helicopter/ground operations have merit in some situations.

Note that earlier helicopter control work all had a focus on commercial recovery to some extent, which would have influenced (reduced) kill rates per hour. Efficiency may be enhanced if carcass recovery is not necessary as was the case for the April trial.

Pros:

- High kill rates i.e. good returns on effort
- Large areas of the island can be covered quickly
- Secretary Is. has a reasonable proportion of above bush line/slip faces and open bush areas that can be aerially hunted
- Additional economic gains if tied in with scheduled helicopter flights to the island, although suitable conditions for aerial hunting should be the determinant of when to go

Cons:

- Only certain areas can be targeted
- A few deer using open areas will probably become helicopter shy and require follow-up or alternative means of control
- There may be a bias toward stags and against adult hinds

Indications of Costs:

The Murchison Mountains helicopter-based deer control costs approximately $277 per deer. There, 60 deer were shot in 15-20 flying hours. While the Murchisons have more open top areas, Secretary Is. has a good number of open slip faces, particularly following the magnitude 7.1 earthquake in 2003, as well as open bush areas. Returns in the Murchison Mountains may be more productive and cost-efficient due to their proximity to Te Anau.

Recent trials on Secretary Is. indicated a cost per deer of $130-$230 per deer during the initial knockdown.

Conclusion:

Probably more valuable as a tool than many people may imagine – considerable areas on the island are open enough to hunt. The fact that in previous control work on the island around 70% of all deer killed were accounted for by this technique cannot be ignored. Additional gains to be made by tying in aerial hunts with staff drop-offs/pick-ups, etc. Aerial hunting should form a regular part of the knockdown control efforts, and the longer-term maintenance/monitoring work.

GROUND HUNTING

Previous Use:

Ground-hunting was used extensively in the previous control efforts.

Early efforts were described as "not very successful as the often dense bush made travel in the bush too noisy" (Spiers, 1977). The opening up of track systems has overcome this problem to a large extent, though hunting off-track may still be awkward in many locations, and near impossible in others.

By 1985, ground-hunting results were described as "discouraging" but continued efforts were made, with recommended improvements being:

- new tracks
- increased use of relocatable bivvies
- increased use of indicator dogs
- strategic timing of operations (roar (April/May), spring (Oct/Nov) and post-fawn (Jan/Feb) periods)

However, control work on the island ceased before many of these recommendations could be implemented.

Chisholm (1989) declared ground hunting had had "mixed success", and further commented "ground hunting has rarely been successful in controlling deer populations to low levels, or eradicating them". The isolation, terrain and bad weather on Secretary Is. would have had a compounding effect. However, Chisholm saw value in ground-hunters in general and also for their on-the-spot observations.

While it is acknowledged ground-based hunters have not had the best results in the past on the island, it must also be acknowledged that they did not utilise certain methods and advantages available now:

- Dividing island into hunting blocks (based on topography, vegetation types, boat access, and the established network of tracks and huts/bivies) will allow for concentrated yet comprehensive efforts.
- A vastly improved system of tracks is in place, greatly increasing access to each hunting block. Moreover, deer will most likely use these cut tracks, assisting with the detection of deer when the numbers are low.
- In the event that group hunting of individual animals is used this tool will be more feasible with better communications systems and tracks.
- Little use was previously made of indicator dogs; there is major scope for use of dogs as a valuable detection method. Bailing dogs may also prove to be valuable as has been the case for Anchor Is. (M. Gutsell, *pers. comm.*).

One instance where a dog was effectively used on Secretary Is. was in 1970, when five female deer were shot and two others swam off the island as a result of one hunter's effort over three days, using a single trained dog for locating the deer. The hunter noted that "without the dog I doubt if I would have located more than two animals" (Paulin, 1970).

Reference to 'team' hunting generally refers here to individual hunters working their own assigned hunting blocks in a co-ordinated and strategic fashion, rather than a group of hunters all hunting the same area collectively. That is, a Murchison 'team' approach rather than that used for Anchor, though the

latter approach may have application on Secretary Is. in the later stages of an operation when individual deer or discrete areas are being targeted.

Four professional hunters (with three dogs) were contracted to spend 6 days on Secretary Is. in March 2005. These hunters were selected based on their previous hunting experience primarily with the Murchison Mountains and Anchor Is. deer work, and in one case earlier experience on Secretary Is. working with NZFS. They worked alongside DOC staff and were asked to evaluate the new tracks, hut upgrades, bivvy locations, communications etc. in respect of undertaking deer eradication work on the island. One hunter was positioned at each of the following locations: Stantley Burn/ Mahoe, North Ridge, and two based on the MV Southern Winds to inspect the South Eastern Block and Eastern Slopes along Thompson Sound as well as some of the adjacent mainland. Time was spent on and off track. The feedback from the hunters regarding the upgraded track system, bivvy locations etc. was very positive and indicative that hunting on the island will be considerably more effective with these things in place (P. Dawson, A. Gutsell, K. Mitchell, D. Wilson, *pers. comm*.).

Pros:

- Highly acceptable technique cf. use of toxins
- Track and hut network will allow all walkable portions of the island to be visited regularly, quietly, and quickly
- Can be used at any stage of the operation, with several different hunting strategies and techniques available to suit individual circumstances
- Excellent means to detect deer sign, especially when in low densities
- Data generally available from most animals shot (e.g. DNA samples, sex and age characters, etc) – as opposed to toxins or aerial hunting where carcasses may not be locatable/retrievable

Cons:

- Labour intensive
- Regular availability of quality hunters and indicator dogs may be an issue, given their commitments and demands elsewhere (Murchisons, Anchor Is, Coal Is, etc.)
- Terrain will place limitations on access to some areas
- A risk of hunting being focussed on tracked areas at the expense of off-track areas
- Returns are low per unit effort
- Efforts get harder as vegetation recovery occurs
- May be biased towards stags in earlier stages
- Risk of pushing deer into the water – boat support required and/or risk of deer escaping to mainland and returning later
- Risks to dogs if used too soon after any 1080 baiting
- If dogs used, they would have to be muzzled to eliminate risks to kiwi, weka, penguins etc.

Unknowns / Key Points:

- The extent to which hunters are able to hunt effectively off track is unclear due to the steepness of the terrain
- Tracks have been installed primarily for stoat eradication, and may not be sufficient or in the right places to meet the needs of the deer work. Further tracking may be necessary.
- Feedback to date would suggest that any additional tracking will be minimal
- The demands on current pool of quality professional hunters and indicator dogs are likely to increase, given the number of ongoing projects and new ones are also coming on line. There is a clear need to build up the number of quality hunters through training and mentoring so that all concurrent deer control projects have sufficient resources at the best possible time. (Secretary Is., as potentially the most arduous project, may be the one to miss out if resources are insufficient to meet demand).

Indications of costs:

Munn (2001) states that a combination of aerial and ground hunting and capture pens in the Murchison Mountains is achieving a reduction of deer numbers for only c. $1 per hectare, through "a systematic application of a range of control measures". However he warns that Secretary Is. will be much more expensive than the Murchisons, at least in the 'knockdown' phase.

In the Murchisons, 105-130 person days hunting resulted in 45 kills (0.35-0.43 kills per day, or c.$400-500 per deer). Unfortunately, details from Secretary Is. ground-hunting have often been combined with ground-based 1080 gel application, so an average kill rate/person-day is not available for most years. However, from 1983-85, 39 deer were shot by ground-hunters in 319 p/days, or an average of 0.12 deer per day.

It appears from the previous work that an average of around 130 hunting days per year were simply not sufficient to make significant enough inroads into the population. More efficient hunting is likely to result from a more strategic approach, and other factors including the better track system. The importance of the "team" on the ground cannot be emphasised enough; sound skills and knowledge, motivation (particularly following the knockdown phase), and excellent leadership are paramount. Team members must listen to the Team Leader and respect the directions that are given (D. Crouchley, *pers. comm.*).

Conclusion:

Skilled operators with indicator dogs will be a vital component of any operation on Secretary Is., as is the case at any point in the operation. It will be particularly critical as the numbers of deer become low.

CAPTURE PENS

Previous Use:

One capture pen exists at Grono Bay, which could be easily repaired to full operational condition.

This pen captured 12 animals (including 8 hinds) in the year between October 1983 and Oct 1984 (Green, 1984). Data from other times is unknown.

Pens were also successfully used in areas of the adjacent mainland.

Pros:

- Have potential to be very effective in certain locations (e.g. coastal flats, well-used tracks along ridges, gaps cut in otherwise impenetrable leatherwood scrub).
- Can be operated in conjunction with other ground-based methods for very little extra cost
- Can be set and operated by any personnel on the island (e.g. stoat trappers, veg monitoring teams)
- No apparent bias toward male deer and may even have a (desirable) bias toward females
- Have best potential if used in conjunction with a lure which is still attractive in the presence of a high number of palatable plant species. The addition of a toxin in the lure combined with a re-setting mechanism on the pen would mean that the pen could be left unchecked for longer periods making it very cost effective to operate.

Cons:

- If unable to be used in conjunction with toxin/ resetting they require regular checking – can be costly and time-consuming for the level of return, unless in the area for other reasons. Alternatively some for of remote monitoring needs to be put in place.
- Very limited areas suitable on Secretary Is., and these are widely dispersed
- Time-consuming and costly to fly materials in and to construct, but very cost-effective to operate after that.

Unknowns / Key Points:

- Number of suitable sites may be limited, but this should be the focus of further evaluation.
- Current pen designs have proven more successful in feed areas rather than tracks
- Increasing technology may mean some scope for grander pen designs, e.g. ones that keep catching through a series of one-way or sensor-operated doors etc. These may have particular value for along main ridges heavily used by deer.

Indicative costs:

Estimated $4300 per pen for materials, transport and construction (Secretary Is budget). A slight reduction is possible if existing structures (mostly on the mainland opposite) are repaired rather than new ones established.

Conclusion:

Of some possible value on the island and possibly for 'preventative control' on the mainland opposite, but returns are low per unit of effort or cost. Needs further evaluation as per cost-effectiveness and how pens may be managed.

Only cost-effective if pens are activated when personnel are on the island and de-activated when they leave, due to excessive costs for returning specifically to check the pens. Alternatively require remote monitoring and/or use of toxin and resetting mechanism.

Will need to be used in conjunction with bait and/or lure as is the case for the Murchison Mountains.

RADIO TRANSMITTER (TX) COLLARS, WINGS AND FENCES

Previous Use:

Efforts to collar deer in the Murchison Mountains yielded some interesting information on deer movement. Attempts on Anchor Is. have had mixed results and little return in terms of deer per unit effort. To be fair a considerable amount was learnt through this process and the use of tx collars has been developed as a result. Further trials need to be undertaken (closer to Te Anau) with the aim to increase collar attachment success.

Indications are that deer have tended to avoid collar-sets established across leads unless they are being pursued. A new development is to establish wing or barrier fences (2-150m) on either side of a deer lead, but to leave the gap incorporating the lead free, to allow deer to continue to use the lead unrestricted for several months. A collar-set will only be established across the gap when active deer control is being undertaken in the area at a later date. Any deer attempting to evade the hunters is likely to use a lead to travel along, and in its hurried or panicked state would push through the collar-set. Once the collar is attached it becomes a relatively very easy task to track and shoot the deer.

Collars therefore have several potential roles:

- a 'research' tool, to study behaviour or kill rates, etc.
- a means to locate groups of deer through a 'Judas' animal
- an option for the latter stages of a programme, when individual deer or discrete areas are being intensively hunted

Pros:

- Considerable value for establishing home ranges, behaviour, etc. of deer on the island
- Considerable value to help gauge kill rate of toxins etc. (if 20 collars are attached)
- Potential value as 'Judas' animals to locate remaining groups of deer
- Substantial merit if used in conjunction with earlier establishment of permanent wing fences on either side of well-used deer leads. A gap should be left between them to keep the lead open and to allow deer to continue using it, and to accustom to the barriers on either side. Later hunting in the area could use the gap between barriers as a site for tx collars, or for ambush hunting and/or capture nets.
- Of potential value late in the programme in conjunction with wing fences and hunting 'drives' to account for elusive or wary individuals
- Provides the potential for a valuable test of the effectiveness of other detection methods and of indicator dogs when a (collared) deer is known to be in an area through telemetry
- Tight vegetation and narrow ridges in some areas and extensive deer use of the cut tracks may mean collar snares are more effective here than on Anchor Is. or elsewhere?
- A long-term option that can possibly be 'set-and-left' on the island, requiring only periodic checking, perhaps increasing in value as deer numbers reduce and vegetation off-track thickens, and the remaining deer hopefully make regular use of tracks. If some of the last remaining deer can be collared, their subsequent location and destruction would be made immeasurably easier.
- Tx collars are very portable

Cons:

- Expensive to use on a large scale
- A large 'experimental' component to the use of collars at this stage
- Reliability of actual transmitter units is still questionable
- Extra labour component required for any monitoring not strictly related to culling (e.g. movement/behaviour studies)
- Time-consuming to catch enough animals to get significant value from data (e.g if used as a tool to monitor kill rates or behaviour, etc. you would need to collar ~ 20 animals)

Unknowns / Key Points:

- Fixed barrier/wing fences to guide pursued deer through a collar set in the gap between fences may be difficult to set up in the steep terrain on Secretary Is. Large numbers of fences would need to be established to ensure an adequate coverage over the island at a considerable cost. These fences would have multiple uses however (e.g use of deer-capture net).
- Probably best to hand-attach collars (using helicopter net guns etc.) to get sufficient sample size if used in trials for 1080 gel kill rate trials or behavioural studies.

- Walk-through arrangements have in the past been of highly variable quality – they appear to deter some deer, and attach wrongly e.g. around antlers or poorly attach and drop off. More work is required on perfecting collar 'sets', but some places on Secretary appear to lend themselves to this technique (e.g. North Ridge).
- If collars are used, hinds will be more important to collar than stags, as they are likely to have smaller home ranges, are less conspicuous (e.g. during roar), and may be biased against with certain control methods such as aerial hunting.
- If measuring effectiveness of certain methods e.g. use of 1080 gel, then meaningful results are only available if a number of deer are collared (20) otherwise information is unreliable and far too open to interpretation.
- A few carefully selected sites could be beneficial in the latter stages of deer control, especially in areas highly favoured by deer and/or where alternative escape routes are limited or concentrated by physical barriers such as cliffs.
- Movable barriers (such as nets) may be of some merit at latter stages of the operation when individual deer are targeted, e.g. team hunting or drives. They may be useful in areas where deer movements and leads concentrate, e.g. narrow passes, gaps in leatherwood scrub zones, etc.

Indicative Costs:

$300 per tx unit, plus labour costs associated with setting collar snares or helicopter netting and follow-up monitoring.

If fixed wing fences were to be used in conjunction with collar-sets, each pair of 50m fixed wire-mesh barriers would cost $700-800 in materials alone, with labour and transportation costs likely to more than double this figure.

Conclusion:

Potentially useful to attach a number of collars prior to toxic bait use (if any) to gauge approximate kill rate. Collar snares could be trialled, and/or deer caught in capture pens or even aerial net guns could be collared to give a sufficient sample size.

Collars are also a valuable later option (when few deer remain) for Judas operations, and potentially in conjunction with wing fences/barriers to collar particularly elusive individual deer.

Could be used as a 'set-and-forget' control option between visits to the island by hunters or other staff, but apparent deer avoidance of sets under normal conditions (i.e. when not being pursued by hunters or dogs) means this may not be viable. The effectiveness of collars used in this manner could be considerably improved with some dedicated development work closer to Te Anau. In year 1 of the knock-down hunters could establish where the best sites are for setting up barrier fences. In year 2 the aim would be to erect these fences as soon as practicable and begin setting up the deer collars.

OTHER METHODS

Snares:

Unlikely to get ethics approval unless vastly improved. Have considerable merit for use along tracks or well-used trails on the island, especially in situations such as a gap in dense leatherwood scrub. There was a recorded successful use of a snare on Secretary Is. in 1973.

Lures or feed stations:

Have some potential merit but have not been effectively field-tested – options include commercial deer farm pelleted feed, salt blocks etc.

There would be little harm in setting up trial salt blocks, particularly in areas away from the coast, to determine their attractiveness to deer. If results are encouraging, options could be explored for incorporation of toxins into the salt blocks, or the feasibility of utilising salt blocks as lures for capture pens, collar sets, or for 'ambush' or spotlighting shooting at saltblock sites. Development work in Murchison Mountains would be advantageous in that the population is at low density, is well known, and the area is much more accessible.

Nightshooting / night vision:

No spotlighting for deer is known to have occurred in previous deer control operations on the island.

Deer were spotlighted along the Stantley Burn coastline while undertaking recent nocturnal gecko searches, and could easily have been shot (M. Lettink, *pers. comm.*.). Walkable sections of coast are limited on the island, but are sufficient (and are in a favoured deer zone) to warrant consideration of this as a secondary control/detection option.

Spotlighting the open tops (e.g. around Secretary Lake, and open alpine areas) and open slip faces may be a useful detection and/or control method, and should be trialled. This may be an effective means of accounting for any deer using open sites that are helicopter-shy.

However, movement around the coast or alpine areas of the island at night has obvious safety issues, and care would be required. Nevertheless, from some vantage points e.g. near All-Round Peak extensive areas of open faces can be spotlighted with relatively little travel required.

Remote cameras:

Motion-sensitive video cameras may be of some value for recording behaviour of deer around baits, capture pen entrances, tx collar sets, etc., which may be of value in appraisal and redevelopment of methods.

They could also be of value in recording continued presence of animals in certain areas when densities get low. However, images won't tell much more than field sign (prints, droppings, etc) will, apart from sex of animal(s) and how many identifiable individuals there are in an area.

Potentially costly and labour intensive to monitor and maintain. The heavy rainfall prevalent in the area could (and probably would?) create reliability issues.

FLIR (FORWARD LOOKING INFRA-RED)

Previous Use:

Has not been trialled in the region as far as known. Used with some effect on Rangitoto/ Motutapu for wallabies (S. Mowbray, *pers. comm.)* and possibly elsewhere.

Pros:

- Potentially extremely valuable late in the programme in locating the last few animals, especially those that are wary of hunting and/or are bait shy.
- If proven practical, it would be of significant long-term value for the Secretary/ Resolution Is. Programme and other similar operations (e.g. Anchor Is., Coal Is., and even Murchisons, Auckland Islands etc.), to detect deer or other large animals in low-density populations.

Cons:

- Very expensive
- Of unproven value in heavily forested and Fiordland environments
- Technology still needs advancing

Unknowns / Key Points:

- Unclear how effective it will be in forested environments
- Local availability?

Indicative Costs:

$1200 per hour, plus helicopter time.

Conclusion:

May be worthy of a trial later in the programme. Further use would be dependent on the results of the trial.

Discussion on Control Measures

Stopping successful recruitment into the population on Secretary Is. is critical for the long-term success of the control programme. While some individual deer will possibly evade control measures on the island and/or will inevitably swim to the island their effect is limited if they are not permitted to breed successfully.

Hunting during the roar may yield reasonable returns for stags, but does little to achieve reduction in recruitment – any single stag remaining will mate with the hind population, and next years production will be largely the same in spite of the hunting effort during a roar. Therefore, while hunting during the roar is an efficient way to target adult males, it is not a particularly efficient way to limit productivity of the remaining population.

What is of far more value is to target, wherever possible, mature (breeding) females and their female young before they in turn reach breeding age. Any method that is particularly effective against female and juvenile deer should be accorded highest priority.

All options are constrained by available budgets. It must be acknowledged that the project is operating to an existing budget, and that whatever can be achieved must be achieved within this allocation. Therefore, while there is appreciable opportunity in this situation for experimental methods to be trialled, the simple fact is that the path of least risk is to pursue tried and true methods. Any action resulting in a step toward zero population should be given priority over research or experimental actions.

Key Issues to Be Addressed

There are many unknowns in the proposed operation. Some questions will only be answered by a 'learn-as-we-go' attitude, carefully observing and recording what is happening over time as a result of the various control methods.

⇒ What is the size of our target population? DNA techniques could be used to obtain an estimate for the number of deer on Secretary Is.

⇒ If we are to seriously consider trialling poison bait how are we to monitor the effectiveness?

⇒ What (if any) control needs to be undertaken on the adjacent mainland?

⇒ What techniques are most efficient, and at what stage of the campaign, to control deer on such steep forested islands?

⇒ Can we firstly detect, and secondly locate and destroy deer in extremely low-density populations (i.e. can individual deer be successfully targeted in such a large and rugged area)? Self attaching tx collars/deer pens/barrier fences will be key tools at this time.

⇒ Further knowledge of 'favoured' areas – where are deer likely to reside when in very low densities? We are currently recording all fresh deer sign along the track network during our stoat trapping trips.

⇒ How far do individual deer, (especially hinds) move on Secretary Is.? (Hinds will be more important to target in terms of long-term control).

⇒ Timing of various methods – what time of year will get best results for the chosen methods?

⇒ Maintenance options – if endangered species are placed on the island in the future, then some limitations may be placed on some control options (e.g. dogs, possibly gel baits). While kakapo are unlikely to be introduced to Secretary Is. this will be an issue for Resolution Is. In this case dogs would not only have to work muzzled, but they would need to be certified for use on kakapo islands. This may not restrict effectiveness of the dog and handler, but may limit available choices.

Deer Population Size

What is the population size of deer on the island? A reasonably accurate population estimate, with reasonable confidence limits, is not essential for the control operation, but may be of considerable benefit for population modelling or measuring effectiveness of certain methods or the overall progress. Knowing the number of breeding females for example would provide a benchmark to measure control results against expected productivity. This information has shown to be of enormous value in the Murchison operations, for the setting of annual targets. It may also be of considerable morale value, giving hunters a target to work towards.

In 1975 the deer density was tentatively estimated to be 1 per 225 ha, or approx. 225 animals, based on pellet densities (Anon, 1975). Bathgate (1977) gave an estimate of 200 animals, but current deer numbers have been estimated by others to be well above this figure (e.g. R. Hayes, *pers comm*.).

According to analysis from pellet counts, a large reduction in deer density occurred between 1975 and 1978 (57% reduction in pellet counts) (Cuddihy, 1978), and a further reduction was noted by 1982 (Cuddihy, 1982). Pellet counts reduced from 3.3% frequency in plots in 1975 to 0.3% in 1982 suggesting the population was in decline.

However, analysis of kill rates showed that the control efforts "show no evidence of a large increase or decrease over what was established in 1973". That is, control efforts between 1973 and 1982 were effectively only holding the population in check. Cuddihy warned that all interpretations on both sets of information be treated cautiously.

It must also be taken into account that in all likelihood deer numbers on Secretary Is. went through an irruptive phase, rapidly increasing in the decade or two following colonisation, only to decline again as prime food resources were exhausted. Numbers of deer present say in the 1970's and 80's may therefore have been considerably different to the current population.

Perhaps the most pertinent information is from Anchor Is. where twenty-eight deer were removed from the 1130 ha island, or 1 deer per 40 ha. By direct proportion, Secretary Is. could be expected to hold around 194 deer. This figure is considerably lower than many estimates, but if correct is favourable for eradication purposes, as annual recruitment (i.e. dictated by number of breeding hinds) is potentially easier to keep below replacement rates.

There is no obvious reason why Secretary Is. deer density would be significantly higher than Anchor Is. In fact deer density on Secretary Is. appears low in many areas, and higher densities are restricted to relatively localised areas on the western coast. In the absence of any real evidence to the contrary the best estimate for deer population on Secretary Is. would be based on the Anchor Is. data.

Preferred Areas

In 1975, Anon (1975) reported heaviest deer use was found in the subalpine scrub habitat (580-720m asl), while moderate use was made of mid-altitude steep faces and gullies of the western coast.

According to Cuddihy (1978) the most highly favoured habitat was the relatively warmer and drier north-west faces between the Gut/Grono Bay and South West Point/Stantley Burn. The highest densities of deer in 1978 were found in the beech-rata/kamahi forest on north-west faces between South West Point and Rocky Point and they appeared to favour the 600-900m altitude zone. Most sign was found on ridges and track systems.

Evans (1973) suggested deer moved up from the lower Gut regions in winter, to nearer the bushline in sunny basins. Any warmer location would probably be favoured over cooler or shaded areas in the colder months.

Chisholm (1988) analysed browse indices from the 43 permanent vegetation plots. He found deer were very common in the coastal mahoe forests. These are found at 0-200m altitude on the western side. There were mixed results from the high-altitude silver beech forest and from the extensive mid-altitude rata-kamahi-mountain beech forests. The lowland beech-podocarp forests around Grono and the Gut had only light browse.

Willemse (in Munn, 2001) notes that the main ridge behind South West Point is a deer highway, extensively used by deer for travel. Similarly Tunzelman (in Munn, 2001) says that deer are making regular use of cut tracks, and by browsing are keeping such tracks open. It is clear that deer will make use of tracks wherever they occur.

Track-cutters and stoat trappers report that deer are currently most common in the Stantley Burn to Mahoe Stream area, and extensively use ridges and open tops accessible from this area. Another concentrated area is on the coastal ridges above Colonial Head and just to the south. Density is clearly much lower in other areas.

In summary, however, it is apparent that the situation may not have been static – preferred areas may have been eaten out early on, and subsequent use may not reflect their original attractiveness to deer, while other areas become increasingly important as food resources dwindle. Also important to note is that very few people have traversed the whole island thoroughly, and comments will often reflect this. During the stoat trapping in July and November 2005 staff recorded fresh deer sign located along the track network over a 10 and 7 day period respectively. This work will continue through each trapping trip in order to build up a current picture of deer preferred areas.

It is recommended that locations of all deer shot/found dead will be accurately mapped (with GPS if possible), with each hunter or field operator responsible for keeping their own records, and the project manager responsible for collating these after each trip. All deer accounted for by other means e.g. found dead through toxins should also be mapped. Where possible, the tail should be removed from all accessible deer as 1) a DNA sample, and 2) an indication the deer kill has been 'recorded' and mapped. Over time, such returns will clearly show favoured areas, vital information for use in cost-effective future monitoring/long-term control work, as it will show where deer are most likely to reside when in very low densities.

Dealing with Re-invasion

⇒ Why do deer swim?

⇒ How often do deer swim?

⇒ Do they actively seek to leave from the closest points (such as headlands or points), or do they just use any convenient launching area such as beaches?

⇒ Can we do anything to reduce the rate of swimming/reinvasion, or are some individual deer 'pre-programmed to swim' regardless of densities?

We simply do not know the answers to these questions. We do not know if deer control on the mainland opposite Secretary Is. will significantly reduce the deer re-invasion rate onto the island, and do not know if the resources invested in 'mainland control' will be of long-term benefit to the island.

We can presume that reducing numbers on the mainland may reduce numbers of 'swimmers' if food resources are a key factor in initiating swims. However, it is also known that hunting sometimes forces deer into the sea to evade capture – On Anchor Is. three deer were shot in the water and there were at least six instances recorded where an animal was observed entering the water when being pursued (M. Gutsell, *pers. comm.).* Hunting on the mainland, unless carefully undertaken, may in fact increase possible invasion rates, as deer seek escape from hunters or helicopters, etc. Mainland hunting may also have no affect whatsoever on swimming rates – olfactory cues (i.e. the smell of highly palatable foods) from the island may promote swimming regardless of density of deer on the mainland. Similarly, the swimming may be an instinctive or learned behaviour amongst certain individual deer and unless that particular deer is targeted, the general reduction of deer on the mainland will have little effect.

A very experienced local pilot has never seen a deer swimming in all his time in Fiordland (R. Hayes, pers comm). This may infer that deer do not swim frequently, or deer tend swim at night or other times when observations are not possible. However, "some deer have been seen swimming by fishermen. It is believed they swim across in small numbers: perhaps two or three at a time" (K. Piddington, quoting unknown sources, in a letter to Minister of Conservation, 1987). It is known that in the past 15 years deer have not reached either Passage Is. (a distance of 1500m from Great Is. which is essentially the mainland) or Te Kakahu just beyond Passage Is. in Chalky Inlet. In fact the last documented report of (old) deer sign on Te Kakahu was by Hunter Shaw in 1982 (Shaw 1983).

Maud Island in the Marlborough Sounds has a very similar gap between it and the mainland (approximately 900m). Deer have been seen on Maud Is. several times over the past 2-3 decades, indicating a fairly regular invasion rate. As some of these deer have been shot on the island it is clearly not just one or two 'regular commuters' but a number of separate individuals.

Based on their presence on a number of Fiordland islands, deer can easily swim distances of a kilometre or more. A stag swimming from Indian Island to evade capture may have swum all the way to Prove Island, a total of 2.4 km (A. Gutsell, *pers comm*), although this record is of a 'chased' deer rather than a naturally dispersing one. The swimming range of deer effectively means Secretary Is. is vulnerable to invasion from all southern and eastern quarters.

It is a fact that deer can and will swim to Secretary Is. from any number of points on the mainland opposite. Also a fact is that currently we do not know if we can significantly reduce the likelihood of it occurring – we can merely assume we might. To significantly reduce deer invasion, all likely launching points will need to be targeted, and the area that must be covered is considerable, a 'front' measuring *at least 25 kilometres*. The effort required to reduce deer numbers to a meaningful extent along such an enormous front will be considerable, to say the least.

Putting appreciable effort into mainland efforts appears rather pointless until it can be proven, by practical control measures, that deer numbers on Secretary Is. can be reduced to zero. It needs to be repeatedly stressed that this target has never been achieved before on an island of this size. The primary goal of this operation, at least initially, should be to focus on successful and cost-effective removal of the existing animals. Only when this goal has been shown to be achievable and sustainable should serious efforts go into evaluating options to restrict re-invasion.

Therefore it is recommended all available efforts go into targeting the island population first. Once - and if - this is achieved, we can gain some idea of the natural 'uncontrolled' re-invasion rate through the regular maintenance programme on the island. Using DNA analysis of deer subsequently shot on the island we can establish (by seeing if the deer are related or not) the likely number of individual invasions that have occurred over a given time period.

Longer-term, mainland control could be looked at if budgets permit. Over a period of time, i.e. a number of years, it could then become clear if mainland control measures were having any effect on reducing the rate of re-invasion, and whether this was cost-effective as opposed to just increasing vigilance and response actions on the island itself.

If mainland control is to occur, some points obtained from prior reports include:

- The Pandora River mouth is "known to have carried a significant population of deer in the past" (Slater, 1982). It is known that "two traps established near the river mouth yielded 19 animals in the first 12 months of operation", while Slater conjectures that "the beach appears to have been an ideal 'launching' place for animals to move across to Secretary Is."
- Deer pens at creek near Espinosa Point, and creek near Pack Point in Pendulo Reach (SE Sec Is) (Main 1979).
- Bauza Island will be treated as part of the Secretary Is. core treatment area, i.e. it will be hunted and monitored as if part of Secretary Is. However, no sign of deer has been detected on the island in recent years.

Comparisons to Anchor Island Deer Control

Control of deer on 1130 ha Anchor Is. in Dusky Sound to November 2005 has taken 3136 hours over 3 years (M. Gutsell, *pers. comm.*).

By extrapolation according to island size, Secretary Is. would take approximately 22,600 hours or 2834 person-days over a similar time period (i.e. 945 person-days/year). NB. Compare this with the *maximum* effort of 256 person-days/year and the average of c.140 person-days/year in the NZ Forest Service control efforts in the 1970's and 80's.

Anchor Is. had an 18 km track network during the time of the eradication, or 1 km of track per 63 ha, and Secretary will have a similar 1 km of track per 60 ha, based on the estimates of a 135km track length total.

By way of differences, Anchor Is. has far fewer prominent ridges etc. for deer travel, whilst Secretary Is. has a large number of apparently highly utilised backbone ridges where deer travel is concentrated. Aerial hunting opportunities on Secretary Is. appear far greater, with a significant area of open tops and a large number of open slip faces.

The Anchor Is. operation used largely ground-based hunting as the 'knock-down' tool. No toxins were used.

The control of deer on Secretary Is. offers an opportunity to learn from comparisons – e.g. the use of a combination of toxin and hunting on Secretary Is., as a test against the hunting only operation on Anchor.

Comparisons to Murchison Mountains Deer Control

The on-going project to control deer in the Murchisons incorporates an area more than six times the size of Secretary Is.

Maintenance or gradual reduction of a low population is being achieved by only 105-130 person-days/year (= .02 hours/hectare or less than a minute per hectare!), at a cost of $1 per hectare (D. Crouchley, *pers. comm.*).

Recent experience gained through trialling aerial hunting on Secretary Is. has demonstrated that Secretary Is. would be similar to the Murchison Mountains.

The Murchison operation is in maintenance mode rather than initial knock-down. The goal of achieving a eradication on Secretary Is. is being far more rapidly targeted than in the Murchisons, where efforts have been on-going for many years and where progress toward a zero population is slow. Trends are not detailed enough to suggest whether a zero-population is achievable in the Murchisons in the current circumstances. In most control/eradication operations, the last few animals are considerably more difficult and costly to account for. The Murchison Mountains Control Programme has achieved outstanding results, but a core population of 350-400 deer remain. Latest data indicate that this core population may still be in decline with current annual harvest levels (G. Nugent, *pers. comm.*). However, such a residual population or even a sixth of this (in relation to size of the areas) would be unacceptable to the goals of the Secretary Is. Programme. To reflect this difference, the Secretary Is. budget is significantly higher per hectare.

How Will We Know That We Have Succeeded / How Will We Measure Results?

Obviously there needs to be a measure by which it can be gauge how well the project is going, and how close it is to its desired goal of a zero population of deer.

This information will be most important near the conclusion of the programme when deer numbers will be low.

Some options include:

RESULT MONITORING

A simple measure of success will be kill returns related to hunter effort alongside the ability to achieve an annual harvest rate calculated from a population estimate (DNA-based)

As (and if) the population gets close to zero, the change of presence/absence of deer sign in each hunting block on the island will further indicate progress.

The FPI technique is still being developed. It may be difficult to undertake on Secretary Is. and not helpful for detecting changes in deer density when the population is already small (compared to the sites that it is being filed tested in.

Print counts and other techniques may be useful indicators, but are time-consuming and may be misleading – surviving deer may learn to avoid use of tracks.

If toxin is to be trialled alongside hunting, tx collars would provide the best tool for estimating kill rates.

PERFORMANCE MONITORING

How will it be established what the benefit is of removing deer from Secretary Island.?

Is a performance measure other than changes in vegetation really necessary? The work of Alan Marks *et al*. from 1977 to 1991 and more recently results from the re-measurement of the permanent forest plots (Monks et al, 2005) provides compelling evidence of the effect of deer on Secretary Is.'s vegetation.

Suggested monitoring would include:

⇒ Re-measuring the NZFS permanent vegetation plots, and those established by Mark et al. at 7-10 year intervals.

⇒ Re-measuring the original 7 and 23 newly established (2005) grassland plots at 5 year intervals.

⇒ Consider establishing paired deer exclosure and control plots (as recommended by Monks et al., 2005).

⇒ Photo points to visually show recovery of soil and leaf litter profiles and ground cover.

Monitoring of other aspects e.g. the response of invertebrates and birds *will not readily be able to be separated* from the beneficial effects of removing stoats.

DETECTION MONITORING

Methods need to be developed to reliably detect deer in extremely low densities. If a zero- or near-zero population level is achieved, detection monitoring needs to be regularly implemented to locate (and adequately respond to) sign of any surviving or invading animals. Key methods may include:

⇒ Prints along all tracks

⇒ Indicator dogs

⇒ Self-attaching collars in key sites (highly favoured tracks, etc.)

⇒ Developing a method for collecting single-animal samples of snagged hair – DNA analysis may tell us how many individuals there are, and whether they are related (i.e. is it a 'remnant' population originating from limited survivors (highly probable that DNA will be linked) or from re-invasion (a presumed wider DNA variance).

⇒ Survey for fresh browse – particularly highly favoured species in selective browsing –*Pseudopanax colensoi, P. linearis, P. crassifolium, Griselinia littoralis*, large-leaved *Coprosma* sp.

⇒ GPS all known wallows – revisit as possible, especially near the roar to determine if any have been recently used.

⇒ Identify and GPS areas where prints are highly visible (e.g. tarn areas), and where prints/tracks are highly favoured.

⇒ Roar index? Number of stags heard each roar. This is probably of more value if initial goals (i.e. eradication) are unable to be met.

⇒ Motion-sensitive fixed cameras – key areas e.g. favoured tracks – as a means of determining activity patterns and for detection/id of animals.

⇒ Helicopter / FLIR runs over favoured areas?

USE OF DNA

The possible role of DNA analysis in the project was outlined by G. Nugent at the Secretary Is. meeting of 16-11-04. Its perceived value would be:

1. assessing how many deer there are
2. monitoring how many have been killed
3. targeting hunting at most important deer places

Point 1.

Of some interest value, but probably very expensive and not essential. Most eradication-type operations do not know how many animals there are prior to the start of the operation yet have still been successful. However it would be beneficial to know the approximate number of deer prior to initiating control, as a way to measure effectiveness of certain parts of the operation (e.g. % kill). This can also be estimated by other means, such as pellet density counts, print counts, tx collars on a number of deer, etc.

Point 2.

This may only be useful for 'non-contact' kills i.e. through use of toxins. Use of tx collars could also provide the same sort of information. Data will be already available for all ground and aerial hunting kills, pen captures etc. through basic reporting by field teams.

Point 3.

Ground returns should establish this anyway. However, for a control-to-zero operation all areas will need to be covered repeatedly anyway. Skilled observers on the ground will largely negate the need for this – all areas with sign will have to continue to be hunted.

Use of DNA may be of more value in the post-knockdown phase. If initial work is successful in reducing deer populations close to zero, DNA analysis of sign after this can help identify the number of individuals still present, their sex, and genetic relationship. (e.g. is the sign of one or two animals, and if two, is it that of a hind and offspring, or of two unrelated animals?). Over time, DNA may identify whether subsequent sign is the result of numerous re-invasions or from breeding from only one or two. Also, as in the Murchison Mountains, there may be some value in identifying mother-fawn relationships i.e. identifying areas where an adult hind may still be.

'Remote' collection of DNA (i.e. without direct contact with the animal) is still of dubious value, and is unproven in such situations. Attempts to extract DNA from pellets is "not a viable option at present" and use of bedding hair "shows promise but needs further testing" (G. Nugent, pers comm). Collection of pellets would not be an issue on Secretary Is., but collection of bedding hair could well be, especially in steep terrain and tight vegetation.

The investigation of the potential for DNA should largely be a standalone project and only if it is compatible with an operational plan. The probable scenarios for an operational plan are unlikely to satisfy the requirement that "all animals are available for genotyping" (G. Nugent, pers comm). Any animals shot by aerial means, killed by toxin or even shot at distances by ground hunters may not be able to be accessed (or will have an unnecessary time/cost associated with retrieval as far as the operational plan stands) therefore DNA may not be readily available.

Where animals are shot or poisoned carcasses found, a voucher DNA sample could be collected for possible later use if this does not impact too much on primary operational plan goal. That is, time and dollars could be wasted locating dead animals if you know they have been shot - deer may fall down cliffs or run some distance before dying etc. and be irretrievable. Where animals are easily accessed, or later encountered by ground teams they should collect the tail from all such animals for possible DNA use – this will also act as a clear method of tallying and mapping all deer found dead – those missing tails will have already been counted.

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TABLE 1. RECORDED DEER KILLS, SECRETARY ISLAND 1970-1985

NB. This table is for NZFS records only. It appears that from time to time Lands and Survey conducted or encouraged occasional small efforts (e.g. 5 deer shot in 1970, isolated hunting efforts c 1981-83). Bathgate (1977) records 15 deer kills by foot hunters from 1970-73 while the table below indicates only 6 of these were by NZFS staff.

YEAR (APRIL-MARCH) PERSON/ DAY	GROUND HUNTING/ BAITING	GROUND KILLS	AERIAL SHOOTING HOURS	AERIAL KILLS	1080 GEL (TUBES USED)	1080 KNOWN KILLS	TOTAL KILLS (MIN)
1970	20	2					2
1971	15	0					0
1972	0	-					0
1973	32	4		21	?	?	25
1974	60	2		28	?	?	30
1975	35	1		26	?	6	33
1976	127	3		2	?	12	17
1977	124	3		5	44	3	11
1978	127	1	5.5 hrs	9	46	3	13
1979	256	9	7.8 hrs	11	44	4	24
1980	141	9	5.5 hrs	6	11	3	18
1981	151	12	15.5 hrs	22	6		44
1982							?
1983	44	14	28.1 hrs	34	0		48
1984	189	11	37.2 hrs	49	0		60
1985	86	14	40.75 hrs	34	0		48
Totals	**1407**	**85**	**140.35**	**165**		**31**	

Appendix 1: Suggested Work Required/Desirable in 2005/06 - 2006/07 Financial Years

Population estimate

- estimate deer population on the island by best available means

General reconnaissance by experienced local hunters (completed March 05)

- identify practicality of ground movement over all areas of the island, especially off-track
- establish relative densities of deer (favoured/unfavoured areas) through field sign
- sensible hunting block divisions
- need for any further tracks/bivvies etc
- possible locations for capture pens
- possible locations for self-attaching collar sets, wing fences/barriers

GPS mapping (underway)

As and when possible – GPS all known wallows or other obvious features (e.g. major areas of antler rubbing, 'yarding' areas, highly favoured tracks or passes, etc) for long-term monitoring of deer presence

Field Observations by all parties (underway)

- Note all species of plants eaten by deer during track-cutting, and any apparent preferences – particular note of broadleaf
- Note key areas of deer use – major (off-track) trails
- Record and map all deer sightings, establish high and low density areas, etc.
- Abundance of broadleaf or other suitable species in all areas of the island, for potential use in 1080.

Trial of whole carrot baits

A simple re-trial of John von Tunzelman's 1984 whole carrot bait trial may provide an indication as to whether such baits have any application as a vector for 1080 gel.