Costs of Deer in Northland

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1. Introduction

The potential environmental, economic, and social impacts of deer, should they become widely established in Northland, were quantified, as far as the available data would allow, by Landcare Research for the Northland Regional Council, in November 2006 (Project NLRC5). The project was funded by the Foundation for Science, Research and Technology, Envirolink fund.

2. Background

Six species of deer (Cervidae) have established wild populations in New Zealand, resulting from widespread legal liberations from 1851 to 1923 (Fraser 2000) and in recent decades from farm escapees and illegal liberations (Fraser et al. 2000). A seventh species, moose (*Alce alces andersonii*), is of uncertain status in the Dusky Sound area of Fiordland (Nugent et al. 2001a). Today wild deer, predominantly red deer (*Cervus elaphus scoticus*), are present in most mainland New Zealand wildlands, with notable absences in Taranaki, Coromandel and Northland. Long histories of deer occupation have led to browse-induced modifications to forest understoreys within most of the wild deer range (Nugent & Fraser 2005).

The absence of deer liberations in Northland by early acclimatisation societies, and the region's isolation from occupied deer habitat to the south and east of Waikato, has resulted in the region being largely free of wild deer today. No wild deer herds were known in the region prior to 1990 (King 1990), but at least 30 new small populations (24 red, 4 fallow, 1 sika and 1 wapiti) have since been reported from within Northland Regional Council boundaries (north of a line from just south of Mangawhai to North Head, Kaipara Harbour entrance), arising from farm escapes or illegal liberations (Fraser et al. 2000). All but one of these populations has been eradicated by the Department of Conservation (DOC), but ongoing farm escapes necessitate continued control (G. Coulston, DOC, Whangarei, pers. comm.). Given the frequency of farm escapes and the extent of favourable deer habitat in Northland (450 000 ha, comprised of 325 000 ha in indigenous forest and scrubland and 125 000 ha in exotic forest; http:/www.nrc.govt.nz, accessed 16 Nov 2006), there is considerable potential for deer range expansion in the region. Other than the economic cost of eradicating these new populations, the current cost (both economic and conservation) of wild deer in the Northland Region is probably low. However, the risk is that this cost will grow significantly if new populations are allowed to establish and expand.

Feral goats (*Capra hircus*) have had a long presence in Northland and are currently, or recently have been, present in all major forest areas (Fraser et al. 2000). Some populations are at very low density due to intensive control undertaken by DOC, but other uncontrolled populations attain high densities in and around indigenous forest and scrub (http:/www.nrc.govt.nz/, accessed 21 Nov 2006). The presence of goats will have a strong influence on the density and impacts of wild deer herds in Northland because of competition between deer and goats and considerable overlap in their impacts (see below).

McLeod (2004) assessed the dollar value of economic, environmental and social impacts of introduced pests in Australia. The Northland Regional Council saw the value of a similar assessment for their region and requested Landcare Research, Lincoln, to undertake this study based on the methods of McLeod (2004).

3. Objectives

- Use data available in the literature, Internet, and from Northland land management agencies to identify the potential environmental, economic and social costs of deer in Northland, should they become widely established, and where available data permit, calculate a dollar value of these costs.

The assessment was for the scenario that deer become established throughout the region's forest and scrublands, and that the current (2006) extent of official ungulate control is maintained.

4. Main Findings

4.1 Environmental impacts of deer

New Zealand

All deer species in New Zealand inhabit forest and scrub habitats and have similar dietary preferences and environmental impacts (King 1990; Forsyth et al. 2002). Numerous studies have demonstrated that deer, through selective browsing of preferred species, have modified forest understoreys, setting in train successional sequences toward browse- resistant or -tolerant assemblages, (see Wardle 1984, McKelvey 1995, Fraser 2000, Nugent et al. 2001a for reviews). In general fast-growing, light-demanding species characteristic of early-successional and fertile sites are eliminated and replaced by slow-growing species characteristic of infertile sites. The most deer-preferred species are dominated by subcanopy and seral species while many common long-lived canopy species are of low palatability to deer (Forsyth et al. 2002) and are not significantly impacted until deer populations are near carrying capacity (Nugent et al. 2001a). This selective impact on plant species results in different density-dependent damage functions for plants in different preference classes. In other words, impacts on particular species are not directly proportional to deer density because deer switch feeding to or from progressively less preferred plants as deer density increases or decreases, respectively (Nugent et al. 2001b). An important consequence of these density-dependent functions is that, once depleted, few deer are required to prevent the most palatable plants from recovering (Wardle 1984; Nugent et al. 2001a). For example, little change in forest understoreys outside exclosures over recent decades (Fraser 2000) demonstrates that the combined efforts of commercial and recreational hunters have been insufficient to produce widespread recovery of deer-palatable understoreys despite a 75–90% reduction in overall deer densities since the 1950s (Challies 1985; Nugent & Fraser 1993).

The long-term consequences of these understorey changes may take centuries to eventuate, and have yet to be robustly evaluated. The magnitude of such long-term changes in forest composition may be lessened by the ability of many deer-preferred forest species to establish epiphytically on tree ferns or in tree canopies out of the deer-browse zone (Batchelor 1989; Wardle 2002), or on rupestral (steep banks and bluffs) sites not accessible to deer. Consequently, no widespread plant species have been browsed to extinction by deer (Nugent et al. 2001a).

In the absence of hunting pressure deer also range extensively into grassland and alpine habitats, where they can cause severe depletion of indigenous plant cover and diversity (Poole 1951; Mark 1969; Rose & Platt 1987). These habitats have, however, largely recovered from the impacts of past browsing due to intensive commercial hunting in the past four decades (Rose & Platt 1987; Mark 1989). The condition of indigenous grasslands and herbfields on the conservation estate may again decline if the current collapse in the commercial recovery of wild deer persists.

There are also indirect impacts of deer browsing in natural ecosystems. Direct competition for food resources with vertebrates such as kōkako (*Callaeas cinerea*) and takahē (*Porphyrio mantelli*) has been inferred from dietary overlap (Mills & Mark 1977; Leathwick et al. 1983) and may be a significant, but unquantified, factor in the decline to their current endangered states. Deer-induced changes in forest understorey composition are reflected in litter composition, which changes nutrient cycling regimes and impacts negatively on litter-dwelling fauna (Wardle et al. 2001; Harrison & Bardgett 2003).

Extensive erosion in many New Zealand steep wildlands has traditionally been attributed to overbrowsing by deer and other ungulates, but there has been a growing realisation in recent decades that much of the present erosion is a natural long-term feature of these landscapes, and that any browsing-induced contribution to erosion is difficult to separate out from natural cycles in erosion rates (e.g. Grant 1983, 1989).

Exclosure studies have demonstrated that recovery back to a browse-susceptible state is possible in many areas following removal of deer (e.g. Allen et al. 1984), but such recoveries may not always be achievable or predictable (Coomes et al. 2003), especially where vacated niches have been occupied by unpalatable species.

Northland

The presence of goats in Northland is pertinent to the threat posed by deer. Goats exhibit a similar range of dietary preferences and impacts to deer (Mitchell et al. 1987; Parkes 1993, 2005; Nugent & Fraser 2005), with some exceptions. Deer browse height is slightly higher than for goats (notwithstanding the ability of goats to climb leaning trunks) and their impacts tend to be more evenly spread throughout the habitat compared with goats, which congregate at preferred sites such as bluffs, where their concentrated impacts can eventually lead to the localised elimination of tall vegetation (Atkinson 1964). The dispersed nature of deer means that even at low densities the most palatable plants will be eliminated from all but the most difficult terrain, but the clumped distribution of goats mean that at densities well below carrying capacity large areas of the habitat are seldom used. The environmental impact of invading deer in Northland will be dependent on the goat density and management history of each area invaded. Where goat densities are unmanaged and at high densities, the additional presence of deer may have little impact, as forest understoreys will already be depleted of deer-preferred species. Areas under goat control of sufficient intensity and duration to have permitted vegetation recovery will be at risk of further browsing impacts. Although deer would be targeted in any sustained goat control campaign, their more elusive and dispersed nature means that this hunting effort will be less effective on deer than goats. Deer invasion therefore risks undoing much of the environmental benefits currently accruing to forests from goat control.

Should wild deer become widely established in Northland forests and scrublands in the absence of goats, they might attain the national average density, under recreational and commercial hunting pressure, of 4/km^2 (Nugent & Fraser 1993), which would equate to c. 18 000 animals. All other things being equal, deer might not be expected to attain densities seen elsewhere, due to competition with resident goats (Challies 1990), but the heavily forested and difficult nature of Northland forests and the recent collapse of the commercial wild-deer-recovery industry would reduce hunting pressure and therefore counter any ‘goat effect’. An 18 000-strong wild deer herd would consume c. 8500 tonnes dry weight (34 000 tonnes wet weight) of forage a year, 73% of this from indigenous habitats (derived from data for red deer in Nugent et al. 1997). If, for argument sake, we assume there would also be a similar feral goat biomass, then these consumption data can be doubled. The most immediate and predictable impact of this deer and goat browsing pressure in Northland would be the reduction or elimination of the more palatable plant species from forest understorey and shrub communities. The long-term consequences for forest composition and the flow-on effects for other components of forest and scrub ecosystems are unknown. Widespread palatable species will continue to persist through epiphytic establishment or on rupestral sites inaccessible to ungulates, but ungulate-palatable plants that are already threatened, especially those with restricted distributions, will be at additional risk. The potential risk of browsing ungulates to plants with restricted distributions is demonstrated by the extinction of eight species on San Clemente Island, California, due to goat browsing (Kurdila 1995), and the reduction to one individual each of *Tecomanthe speciosa* and *Pennantia baylisiana* by goats on the Three Kings Islands before goat eradication in 1946 (http:/www.nzpcn.org.nz: accessed 23 Nov 2006).

Northland’s wildlands are botanically diverse and are a centre for regional endemism (Gibbs 2006). This and the extensive habitat destruction seen in the region have produced a long list of endangered plants in Northland. The mainland Northland region has 40 species of acutely threatened plants (Forester & Townsend 2004). Nineteen of these are listed as being threatened by browsing or tramping by animals – including *Hibiscus diversifolius, Olearia crebra, Lepidium oleraceum* and *Atriplex hollowayi*, which are described as highly palatable to ungulates (http:/www.nzpcn.org.nz: accessed 23 Nov 2006). The New Zealand distribution of 10 of these 19 species is restricted currently to the Northland Region. Most of the remaining 21 species are threatened by weed invasion, which can be enhanced by disturbance induced by introduced ungulates. Plants in lesser threatened categories in Northland total 135 species (Forester & Townsend 2004), and are unlikely to be adversely affected by deer unless deer increase to high numbers.

4.2 Environmental cost of deer in Northland

Calculating the potential environmental costs of goats and deer to Northland is problematic. Firstly, the long-term impacts of biomass and biodiversity reduction in forest understoreys is largely unknown, both for the structural makeup of the forests and the indirect impacts on forest fauna. Secondly, values for individual components of forests are not available. Contingent costs (what people are ‘willing to pay’ for retaining biodiversity) have been estimated for birds at AU$1 per bird in Australia (McLeod 2004) and US$30 in the United

States (Pimentel et al. 2000). I am not aware of any estimate of the value of wild indigenous plants in New Zealand or elsewhere. One method for estimating the potential value of Northland's biodiversity is to use the current unit area cost of goat control as an indication of 'willingness to pay'. DOC is currently spending c. $2.20/ha/year to control goats to protect an area of about 80 583 ha in the region (Peter Davis, DOC, Whangarei, pers. comm.). This control is intensive enough to reduce goat densities to very low levels (Glen Coulston and Sara Barber, DOC, Kerikeri, pers. comm.), similar to those permitting significant regeneration of goat-palatable seedlings in Marlborough (Sweetapple & Burns 2002). Taking the simplistic assumptions that areas under control are fully protected, areas without control are fully unprotected (recreational and commercial hunting having negligible benefits), and uncontrolled areas are of at least sufficient value to protect if the resources to do so were available, then the current annual environmental cost of goats to Northland's indigenous forest and scrubland is at least $538,000/year ($2.20 times the 244 500 ha of uncontrolled indigenous forests), or $5.4mill over 10 years. Assuming 'willingness to pay' would be the same for deer, the potential value of the impacts of deer in Northland would be the same as for goats (i.e. $5.4 mill over 10 years). However, the potential costs of deer to Northland forest understoreys should they become established would be lower, because the presence of goats means that a proportion of this cost has already been incurred.

An alternaitve approach is to use the estimate of New Zealand's indigenous terrestrial biodiversity that was valued in 1994 at $30 billion from ecosystem services (such as climate and water regulation, and erosion, pollution and biological control) and $ 7 billion from passive values (preserving biodiversity for its own sake, for future generations, and for future use options; Patterson & Cole 1999). Northland's share of this would be $1.18 billion based on its 3.2% of the country's wildlands. Deer and goats may not impact on ecosystem services significantly because their impacts largely modify species composition rather than cause wholesale destruction of indigenous flora. Northland's share of the national passive value of biodiversity is $224 million, which undoubtedly would be eroded by deer and goat impacts. A conservative 1% reduction in biodiversity equates to a $2.24 million loss of passive value, and perhaps a more realistic 10% reduction equates to a $22.4 million loss. On a national scale, if half the biodiversity passive value is assigned to the indigenous vascular flora, then each of the c. 2100 species has a passive value of $1.7 million. The 10 species of acutely threatened plants restricted to Northland that are threatened by animal browsing then have a combined passive value of $17 million.

The loss of the carbon sink capacity of the region's forests resulting from deer- and goat-induced reductions in forest biomass will affect the global environment, and may be valued using the international carbon credit system, but is not done here due to the lack of data on ungulate-induced biomass reduction in forests.

4.3 Economic cost of deer in Northland

Economic costs will mainly be the costs of undertaking deer control. Goat control currently costs DOC $174,473 annually, to maintain sustained control over 80,583 ha. This is supplemented by $5,000 spent on goat control on private land adjacent to the conservation estate by the regional council (D. McKenzie, NRC, pers. comm.). Deer may cost twice as much to control as do goats; therefore, to maintain the current levels of ungulate control in Northland in the presence of deer might cost $358,900/year. A combined regional council, Animal Health Board and DOC-funded plan to eradicate new deer populations ($80,000–$124,000/year; McKenzie et al. 2004; Gardiner et al. 2006) is therefore justified simply on the basis of the likely increase in cost (*c*. $179,500/year) to maintain the current level of ungulate control should deer become established. This current cost of deer eradication would rapidly escalate should the effort be temporarily relaxed allowing new populations to become more firmly established.

Deer are a valued recreational resource (Nugent & Fraser 1993) and are the main attraction driving demand for the 63 500 hunting permits issued nationally each year by DOC, at an administrative cost of $11 each (Fraser 2000). Permit demand is likely to rise from the current 0.26 permits/km^2 of conservation estate in Northland to around 3.5/km^2 (demand in similar-sized provincial regions with widespread deer; Fraser 2000). This will see permit issuing costs to DOC rise by c. $5,000 annually.

Deer are carriers of bovine tuberculosis (Tb). The Animal Health Board (AHB) spent $60 million in 2006 on Tb vector control over 9 million ha (33% of the country), and an additional $27 million on associated research, herd testing and compensation, giving a total cost of $9.70/ha of vector risk area (AHB 2006). While deer are generally considered spillover hosts rather than vectors, and Tb is not present in Northland, infected deer being brought into the region and escaping provides a plausible means of Tb becoming endemic in Northland wildlife, which would necessitate expansion of the AHB vector control programme. Should Tb become endemic throughout Northland then the cost to the region could total $12.1 million annually. A more likely scenario should Tb be introduced to the region is that Tb would become endemic in wildlife over somewhat less than the whole region; perhaps half, at an annual cost of $6.05 million. The seriousness of this threat is recognised by the AHB, which makes a $30,000–$50,000 annual contribution to the Northland deer eradication programme (McKenzie et al. 2004).

Production losses due to deer grazing on pasture and crops have not been calculated in New Zealand, but in recent decades this would have been minimal as easy access to forest pasture margins means that hunting pressure had all but eliminated deer from these habitats (Fraser 2000). Recreational hunting would likely see a continuation of this trend in Northland should deer become widely established.

In total the economic costs of deer establishing throughout Northland are estimated to range from $184,500 to $6.05 million.

4.4 Economic benefits of deer in Northland

If deer became widely established in Northland the c. $100,000 currently spent annually to eradicate farmed deer escapes would no longer be required. The c. $40,000 annual contribution from the AHB would be withdrawn leaving a balance of $60,000 saved by the region.

A potential commercial wild venison recovery industry would also benefit the region, although currently the industry is not prospering. A deer herd of 18 000 could sustain a harvest of about 6000 deer a year, about half of which might be taken by recreational hunters (Nugent & Fraser, 1993). An average price of $150–$200 is necessary for helicopter-based hunters to break even (capturing five animals per hour) but currently the market cannot support this (G. Nugent, Landcare Research, pers. comm.). Should a sustainable market eventuate then the local commercial harvest could earn up to $600,000 a year at $200 a carcass. However, only 33% of the deer habitat is on conservation estate and it is uncertain whether this and the heavily forested and scattered nature of Northlands forests would enable the required hourly harvest rate to be attained. Consequently likely sustainable earnings from commercial hunting will be somewhat less, and are here estimated at $300,000 a year.

Another potential benefit of deer would be the increase in recreational hunting activity. Nugent (1992) estimated that recreational hunters spent $240 in 1988 for each red deer taken. Expenditure by local hunters would be less (reduced travel and accommodation costs) and would largely represent spending shifts within the local economy, but money spent in the region by hunters from outside the region (e.g. Auckland) would benefit the local economy. The majority of deer would probably be taken by local hunters, who with local knowledge, contacts, and short travel distances would have better access to the best hunting areas (scattered forest and scrub on private land and on the margins of the conservation estate). If 25% of the recreationally shot deer (c. 3000/year) were shot by non-local hunters, and half of their expenditure was within Northland, then the economy would benefit by $90,000 annually.

These estimates of economic benefits of deer to Northland are highly speculative. Commercial deer recovery is dependent on the recovery of the industry as a whole and the ability of operators to attain an economic harvest rate in the difficult Northland conditions. Recreational hunting expenditure is dependent on the actual proportion of non-local hunting and the 2006 level of expenditure per animal. The estimates of $150,000–$450,000 are likely to be maximum rather than minimum values.

4.5 Social costs and benefits of deer in Northland

Deer are highly valued by recreational hunters. A 1994 survey of public attitudes toward introduced wildlife (Fraser 2001) showed that the general public also thought favourably of deer. Ninety-five percent of respondents considered deer as a resource or as a joint pest and resource. A similar percentage enjoyed the experience if they saw deer on visits to native forests. However, 45% considered that these values were not an acceptable trade-off for the impacts caused by deer, and another 13% did not know, suggesting a roughly even split between those in favour and those against deer in native forests.

Rural communities tend to be more sympathetic toward wild deer than are urban communities (Nugent & Fraser 1993), therefore the Northland population, with 48% living in rural areas (http:/www.nrc.govt.nz/ accessed 16 Nov 2006), is likely to be more positive toward wild deer than the New Zealand population as a whole. To counter this there has been a general increase in environmental awareness during the 12 years since the attitudes survey, and increases in voluntary public participation in environmental projects in Northland (D. McKenzie pers. comm., http:/www.savethekiwi.org.nz/KiwisSavingKiwi/CommunityEfforts/ accessed 2 Nov 2006). On balance the overall attitude of the Northland population to deer may be close to neutral.

5. Conclusions

The potential environmental costs of deer to Northland, although difficult to separate out from those already accruing to goats, are estimated to be at least $538,000 a year (Table 1).

The most significant impacts stem from deer being more difficult to control, increasing both the economic cost of ungulate control, even if maintained over a similar area already under goat control, and the environmental costs. Table 1 makes no allowance for the added risk posed by deer to Northland's threatened plants or the passive values accruing to the region's biodiversity, with potential losses in excess of $20 million. Neither are the costs of reduced carbon storage in the regions forests included.

Economic costs are estimated at a modest $185,000 a year if based solely on the additional cost of deer to ungulate control in areas already under goat control, but balloon to over $6 million a year should deer be responsible for the establishment of Tb in the region's wildlife. Potential benefits of widespread deer in Northland are estimated at $150,000–$450,000 a year, arising from the cessation of the eradication of new populations saving $60,000 a year, and increased economic activity due to recreational hunters from outside the region ($90,000 a year) and, possibly, a small commercial wild venison recovery industry ($300,000 a year). However, potential total costs (at least $717,000 a year) far exceed potential benefits (Table 1).

Table 1 Annual cost of deer in Northland ($million) should they become widely established (see text for assumptions).

	Biodiversity	Pest control & research	Other	Total
Environmental cost	>0.538	-		>0.538
Economic cost	-	0.185–6.05		0.185–6.05
Social cost	Nil?	Nil?	Nil?	Nil?
Total cost	>0.538	0.185–6.05		>0.723–6.588
Economic benefits		0.060	0.090–0.390	0.150–0.450

6. Recommendations

- The current effort to eradicate the Russell Forest sika deer herd and new farm-escape populations should be maintained.
- The most appropriate method to value the environmental costs of browsing ungulates should be investigated, and these costs re-evaluated by a bio-economist.
- The environmental impacts of deer, over and above those of goats, need to be better quantified.
- The intensity of ground-based hunting required to maintain deer populations at levels that will permit widespread recovery of the most deer preferred plants needs to be determined.

7. Acknowledgements

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