Article

Scientific research on introduced wildlife in New Zealand: For whom and at what cost?

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In his keynote address to the 2015 New Zealand Association of Scientists Annual Conference, Professor Peter Gluckman offered a timely reminder to New Zealand scientists: that their legitimacy within public discourse and decision making is ultimately founded in integrity and trust (Gluckman 2015). Reflecting on the growth of new information and media sources in the last few decades, and the erosion in trust in the more established ones, Professor Gluckman urged scientists to adhere to the features that distinguish science from other epistemologies. He also asked New Zealand scientists to consistently recognise and acknowledge the limits of scientific knowledge and the unhelpful biases that can creep into its production (also see Gaston 2015).

With these thoughts firmly in mind, this article traces a short history of natural science research on introduced wildlife in New Zealand. Through this history, I argue that a maintenance of public trust in New Zealand natural scientists will require (1) more consistent self-reflection to identify and communicate the assumptions and predispositions of their research and (2) more active endorsement and support for research that investigates the questions that are not considered useful to ask. I argue that if these points are not considered and adequately addressed, New Zealand's natural scientists risk substantiating the claim that their science is compromised by undisclosed value frameworks or that their analyses are simply another tool being used to further the agendas of their employers.

To narrow what might otherwise prove a formidably broad topic, I focus my history on a subset of introduced game species – specifically mallard ducks (*Anas platyrhynchos*), deer and trout (various species). I employed a critical discourse approach (Phillips & Hardy 2002) to interviewing and documentary research, grounding this approach in a broad social constructionist perspective (Burr 2003). For a full explanation of my methodology and information sources refer to Steer (2015). I do not intend this analysis to be comprehensive. It is offered merely as a contribution to the discussion of how the New Zealand natural science community, in particular, might choose to refine their practice and thereby maintain a credible seat at the decision-making table.

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Scientists' support for introductions

While Polynesian colonists introduced species to New Zealand from as early as the 13th century (Walrond 2012), the most systematic and large-scale efforts at acclimatisation occurred from the mid-19th century with the establishment of Acclimatisation Societies around the country and the importation of dozens of new species each year (McLeod 2007). Thomson (1922, p. 2) lamented that this acclimatisation effort had been 'carried out in the most haphazard and irresponsible manner [with] districts, societies and individuals acting quite independent of, and often in direct opposition to, one another.' He characterised the history of acclimatisation in New Zealand as a series of 'bungles and blunders' undertaken 'with zeal unfettered by scientific knowledge' (*Ibid.*, pp. 3, 22). Most subsequent histories of New Zealand acclimatisation have been no more complimentary (e.g. Aramakutu 1997; Walrond 2012).

According to Davies (1996), acclimatisation was undertaken with little thought or analysis, and it is clear that there *was* little effective coordination of introductions. Failed initial introductions were often followed by multiple subsequent liberations, without regard for overall rationale (Walrond 2012). A common perception was that if the conditions suited the introduced species, they would thrive, and if not they would perish (see McDowall 1980). The lives of the animals themselves were largely immaterial. Much like contemporary ecological restoration initiatives, concern was for populations, with individuals routinely sacrificed for the common purpose.

Although questions may remain over the *interpretation* of science, suggestions that early acclimatisation efforts in New Zealand had *disregarded* science are probably inaccurate. As Sullivan (1990, p. 311) wrote, while:

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> *...most historians today decry the lack of knowledge and the woeful ignorance of the early Acclimatisation Societies…they contained many men with scientific or background education in the related disciplines and who were conversant with the most up to date findings about them.*

In fact, there is little evidence that early acclimatisers acted in opposition or disregard of scientists. Rather, many Acclimatisation Societies included prominent scientists among their foremost members (Star 1997). Despite this, few scientists in New Zealand had considered the consequences of acclimatisation in the early to mid-19th century. In part, this was because there were few scientists in New Zealand at the time to consider the matter. Moreover, those that *were* present, and disposed to studying the biota, were predominately natural philosophers, schooled in the romantic descriptive tradition of Gilbert White (1977 [1789]). They were hardly 'wildlife managers' and with the bulk of arrivals after 1840, they barely had time to begin describing the local biota, anyway, let alone commenting on or analysing the ramifications of introductions.

The view of the scientists that *had* considered acclimatisation, however, was generally supportive. They were guided, in this respect, by the 'displacement' theory that had been introduced to them by Charles Lyell (1830). This theory taught that, under colonisation from 'new and more vigorous' European forms, native species were impermanent features in New Zealand (Gillies 1877, p. 306). The 'displacement' of native species with British and Continental species was inevitable: 'Just as the Māori would be replaced by 'Pakeha,' so too would native birds be replaced by stronger northern hemisphere avifauna' (Aramakutu 1997, p. 70). According to Charles Darwin's (2009 [1859]) theory of evolution, only the 'fittest' would survive. As native species declined in the face of European expansion in New Zealand it was 'obvious' that they were inferior to European species and that their extinction was 'inevitable' (Galbreath 1993). For Gillies (1877, p. 306) 'ancient races' would 'pass away' as naturally as a geriatric on their death bed. Assistance for native species was thus constructed as 'hopeless,' a conception accepted by prominent New Zealand scientists of the day such as James Hector, Julius von Haast and Frederick Hutton, in addition to 'almost every other scientist in the colony' (Star 1997, p. 114). The accepted scientific theory of the day thus only provided justification for the work of colonists. As scientists in New Zealand mostly saw it, their role was to document the 'natural' process of displacement, not to hinder it. The remaining natives could not be saved and should instead be catalogued in museums for posterity (see Martin 1885). Indeed, this was scientists' 'sacred duty' (Moncrieff 1949, p. 4). The appropriate focus at the time, however, was on the future of the biota, and this was clearly to be a European-dominated one.

The pendulum swings against introductions

From around the 1870s, however, some scientists began to entertain a revised view of the concept of 'displacement' in New Zealand. It was becoming increasingly evident, for instance, that there was no universal biological imperative guiding the replacement of natives with exotics. Many native species were, in fact, surviving and in some cases flourishing. As a result, by 1890 'extinction was now seen not as the result of immutable scientific law but as the result of more mutable human practice' (Star 1997, p. 244). Just as introduced species had prospered under a raft of protective measures, it was discovered that native species could survive too, should similar measures be directed in their favour. This theoretical revision coincided with a growing awareness of the worth of native species. It was not *just* introduced game animals that lured international tourists to New Zealand, for instance, but also the unique native-dominated scenery they encountered while pursuing them. The creation of parks and reserves in New Zealand around this time was initially dominated, not by nature conservation, but by the identification of forests and mountainscapes as tourist resources for development (Coombes 2003; Star 1997). The rejection of displacement was thus not only scientifically justifiable but also increasingly useful.

The scientific consensus in the late 19th century began to move in favour of a more cautious approach to introductions and an emphasis on the conservation of native species. The introduction of mustelids in the 1870s and 1880s, for example, was opposed by the majority of scientists in New Zealand who, by then, foresaw the effects of such taxa on native birds (Young 2004). Nevertheless, very little scientific work was undertaken to actually quantify the effect of introduced species on native species in the 19th century. Early fisheries scientists, for instance, devoted most of their efforts to documenting the success of trout liberations, rarely making observations on native freshwater fish (Crowl *et al.* 1992). In 1895 a paper in the *Transactions of the New Zealand Institute* concluded that 'there is no evidence to show that the few native freshwater fishes have suffered from the introduction of…the trout' (Kirk 1895, p. 7). This 'lack of evidence' was widely taken as an indication that there had been no effects of trout on native freshwater fish (e.g. see Hamilton 1904). It was, however, merely descriptive of the state of scientific knowledge in this area. Indeed, a scientific understanding of most freshwater species in New Zealand was severely limited at this stage (McDowall 1991). What *is* clear is that research into the effects of trout on native fish at this time was not considered useful. As the president of the New Zealand Institute, P. Marshall wrote, 'it is natural and inevitable that in this country research should tend to be centred…round those industries upon which the prosperity of the country depends' (Marshall 1926, p. 1). Aside from taxonomic work, most wildlife science in New Zealand, until well into the 20th century, was thus focused on how to grow and release game species, largely because they were one of the primary sources of revenue in the country (Bathgate 1897).

Wildlife management as a scientific discipline in New Zealand did not develop until the mid-1930s (Westerskov 1957). At that time, it was focused on 'the development of natural resources for the benefit of mankind,' rather than the advancement of scientific knowledge *per se* (*Forest & Bird* 1937, p. 15). Again, the emphasis was on the health of game populations, often at the expense of native species. This focus on 'natural resources,' moreover, necessitated the destruction of 'those parts of Nature – and they are in the majority – which are not of immediate use for economic ends' (*Ibid.*, p. 15). Nonetheless, even for game species that were *relatively* well studied, there remained significant deficiencies in knowledge. Pellett (1935), for instance, noted that attempts to apply scientific knowledge to the propagation of trout was limited by a dearth of scientific literature on the topic in New Zealand. He lamented that '…there has been almost no knowledge of what to do, and what results

might be expected, from any effort expended' (*Ibid.*, p. 11). This was, in part, because of an enduring reluctance 'to accept the word of the trained research man if it conflicted with the general opinion or with general observations' (Lumley 1937, p. 4). For example, it was not until 1939 that the Department of Internal Affairs appointed a fisheries biologist to work in Rotorua, one of the most important fisheries in the country. The appointed scientist, a woman by the name of A.L.K. Welch, was not taken seriously and her superior did not think that scientific research was necessary (Galbreath 1993).

A 1941 editorial in *Forest & Bird* entitled 'Research – An Urgent Need' argued that research on wildlife in New Zealand, in general, remained in its infancy: 'In New Zealand it has always been a practice to make decisions on wildlife matters without expert research and biological knowledge' (Editor 1941, p. 1). Study continued to be directed almost exclusively to those species that were deemed most useful. Indeed, 'the truth is that nobody in New Zealand knows much about the more common species of wildlife inhabiting this country, because proper research and study by trained observers has never been considered worth payment' (*Ibid.*, p. 2). As Galbreath (1993) concurred, even in the relatively established areas of fisheries science and deer ecology, growing practical experience was backed up by little scientific investigation. Holloway (1950, p. 123), for example, reported that by 1950 'a very considerable amount of information is now on file' regarding the effects of deer, 'although it is not yet possible to make any detailed analysis of it.' Having bemoaned the lack of scientific research into wildlife, the Royal Forest and Bird Protection Society took it upon themselves to rectify this deficiency by undertaking highly unscientific 'data' collections. The Society considered the introduced magpie (*Cracticus tibicen*), for example, to be an aggressive 'butcher bird,' that was detrimental to native wildlife (Editor 1950, p. 1). In the absence of scientific evidence they set about 'proving' the magpies' 'guilt' themselves by setting up a 'dossier of crimes,' and asking members to submit any observations that supported the Society's hunches (*Ibid.*, p. 1). This was subsequently taken as the evidence needed to support widespread killing of magpies.

With some exceptions, it was not until the 1960s that any substantial quantitative research began to be undertaken on wildlife in New Zealand. Following wider international trends, natural history was no longer deemed sufficient as science in New Zealand. Rather, results from around this point would have to be substantiated with quantifiable evidence. The 1960s, for example, marked the start of large-scale ornithological research in New Zealand – finally moving beyond the taxonomic and descriptive work of Walter Buller and others. It was also the beginning of scientific work on wild mammals such as deer. As Graham Nugent (Interview, Deer Ecologist, May 2013) commented, 'reasonably scientific publications [on wild deer] started in the 1950s until it came to be more quantitative in the [19]60s and [19]70s.'

Work in developing a scientific understanding of freshwater fish, particularly the native species, finally commenced too (McDowall 1991). Lakes were particularly poorly researched: 'Before 1966 there had been scant investigation of New Zealand lakes…only a few general limnological studies had been carried out and fewer still had been published' (Burns 1991, p. 359). This dearth of study began to be redressed with the appointment of limnologists to the staff of universities, the formation of the New Zealand Limnological Society, and the establishment of a Freshwater Section in the Department of Scientific and Industrial Research. An emerging emphasis on scientific research, however, did not mean that *any* questions could be assessed; only those that were approved. A young R.M. McDowall, for example, was forced to shelve his investigation into the potential ecological effects of introduced largemouth bass (*Micropterus salmoides*) until the departure of a disapproving superior. As he later explained, 'my analysis…was completed somewhat after the senior fisheries scientist promoting the introduction left New Zealand for overseas, and so I was no longer in danger from criticising my superiors' (McDowall 1999, p. 52).

Case studies

Deer and erosion

Many of the scientists working on the ecology of deer through the early 20th century were predisposed to proving the impact of deer on New Zealand soils and vegetation. The question of *whether* they had an impact was generally not scientifically considered. Leonard Cockayne, a prominent botanist, was foremost in the scientific castigation of deer (Cockayne 1926). Noting early that deer ate the plants he had devoted his life to studying, he developed a 'passionate hatred' of them (Caughley 1983, p. 68). According to Caughley, he 'used every argument he could muster to urge their extermination,' some of which were 'less than impeccable scientifically or logically' (*Ibid.*). Importantly, Cockayne argued, with others, that deer caused 'vast areas of mountain-side [to] be turned into moving debris' (in *Ibid.*, p. 63). Rather than assessing the effects of deer on native vegetation and soils, Cockayne, like most New Zealand scientists of the time, was content to move his scientific reasoning straight to questions of extermination and how it could be undertaken. Scientists present at the Deer Menace Conference in 1930, for example, accepted unanimously that deer were an environmental problem. They thus aimed only to provide 'practical suggestions as to the best method of carrying out deer destruction' (Figgins & Holland 2012, p. 41).

For Grant Nugent (Interview, Deer Ecologist, May 2013), 'the intuitive link in the [19]30s and [19]40s was that where there was no forest there was lots of erosion and you just had to look at the Southern Alps to see that.' The scientific work that should have gone into proving that deer caused damage to vegetation, and thus brought about erosion, however, was never undertaken. In fact, such basic research was deemed unnecessary by most scientists at the time. For example, in 1934 the New Zealand Forestry League wrote to the Royal Society of New Zealand asking for support in a request to the Commissioner of State Forests to set up a Royal Commission to inquire into the effects of deer and other introduced mammals on native forests. The Native Bird Protection Society wrote on the same subject, 'but expressed the view that there was no need to incur the expense in the setting up of a Commission, as there was abundant evidence of the destruction caused by these animals' (Royal Society of New Zealand 1934, p. 375). However, there were only two papers dedicated to the issue, Walsh (1892) and Hutchinson (1930), both of which provided only anecdotal reports of 'damage.' This was deemed sufficient for the Royal Society, nonetheless, who duly commended

the Department of Internal Affairs 'for the measures taken to reduce the number of deer, and urge[d] that its efforts be increased' (Royal Society of New Zealand 1939, p. 24).

The case for a link between deer and erosion was further expressed through the mid-20th century. In his Presidential Address to the New Zealand Institute of Forestry, C. Biggs (1946, p. 214) argued that the 'delicate balance' of geological erosion was being upset by deer and that they should therefore be considered to be 'the most serious enemy.' Writing in the *New Zealand Science Review*, McKelvey (1959, p. 28) furthered the proposition that any animal effect on vegetation could cause accelerated erosion and flooding. This was seconded by Holloway (1959, p. 21) who considered 'acceleration of erosion as an inevitable consequence of [vegetation] depletion.' Suggestions to the contrary were swiftly rebuked. William Graf, a visiting American biologist, disputed claims that erosion was the inevitable consequence of deer browsing. His report, however, was dismissed by A.L. Poole, Assistant Director of the New Zealand Forest Service, who persisted with the claim that exposed faces of bare shingle in mountainous areas of the South Island, in particular, were 'entirely unnatural' (Poole 1958, p. 5). He suggested, somewhat improbably by this stage, that 'Dr Graf evidently did not see any forest that was not frequented by [grazing] animals' (*Ibid.*, p. 5). In an article in the *New Zealand Journal of Forestry*, McKelvey (1960, p. 325) continued to claim that there was 'much evidence' that deer browsing was an important cause of erosion. This was backed up by the New Zealand Forest Service which printed regular educational advertisements to that effect in magazines such as *Forest & Bird* and scientific journals, including the *New Zealand Science Review* (New Zealand Forest Service 1960, 1962a, 1962b).

By 1956, Thane Riney, another American biologist, considered research on introduced animals such as deer in New Zealand to still be in 'an early phase of development' (Riney 1956, p. 16). Taking up a position at the Department of Internal Affairs, he was commissioned to undertake some of the first formal research on wild deer in New Zealand (Department of Conservation 1998). There, he was highly innovative and energetic, producing around 25 published reports and papers (Caughley 1983). Nevertheless, he 'was soon in hot water with the Department because he…set about examining [the Department's] assumptions [about deer] as if they were hypotheses' (*Ibid.*). One of his papers, for example, showed that the areas prone to erosion had little overlap with the areas in which the Department were shooting deer. As Caughley noted, 'hard facts are as often an impediment to attaining a goal as they are a help. If the goal is clear and the cause is just, information is not so much right or wrong as it is convenient or inconvenient' (*Ibid.*, p. 119). As a staff scientist, Riney was expected to produce science that supported the Department's objectives. When this was not manifest, his position became untenable. He resigned and departed the country in 1958.

By the 1970s, doubts began to creep into the thesis that deer were responsible for erosion rates (Holloway 1993). Orman (1979 in Holden 1987), for instance, observed that slips apparently caused by deer might just as easily have occurred without them. Noting the presence of such conflicting evidence, Holloway (1970, p. 11) accepted that 'depending on which pair of spectacles we choose to wear and which piece of country we choose to look at, we can find evidence that can be used to support almost any argument that may be advanced.' Indeed, Holloway had noted as early as 1959 that the rate of normal geological erosion in many parts of New Zealand was 'spectacularly high before grazing animals were introduced' and therefore not necessarily a correlate of deer herbivory or trampling (Holloway 1959, p. 22). In the 1970s and 1980s, 'people began to realise that what looked like current erosion in the form of screes were often very old' (Interview, Graham Nugent, Deer Ecologist, May 2013). The earliest photographs of some of the mountainous headwaters of the Southern Alps, for example, showed that most of the screes and erosion gulleys were there in the 1860s and 1870s, when deer populations in New Zealand were in their infancy and largely restricted to the lowlands (Caughley 1983). The pre-human rate of erosion was found to be much higher than earlier suspected.

Although the Forest Service had conducted much research into the effect of deer on erosion rates, its starting assumptions were flawed. At no point, moreover, were these assumptions measured. Rather,

> *...all through the period that [both the Department of] Internal Affairs and [the New Zealand Forest Service] expended large sums of money on killing deer, no research was launched to discover how much this effort retarded erosion. The simplistic formula went: fewer deer means more vegetation, which means less erosion, which means less flooding. How much less was neither known nor investigated* (Caughley 1983, p. 73).

Caughley noted that there was a reluctance of research staff to question what a department had already promulgated, suggesting that although,

> *...it can be done, and no insurmountable barrier will be placed in the way of doing it…it leads to hassles and ill-feeling that most researchers can do without. Far easier to tackle a problem whose purity is guaranteed by its answer having been anticipated officially* (*Ibid.*, pp. 72–73).

By the early 1980s it was established that the major determinant of erosion rates in mountain country was simply rainfall. The effect of plant cover 'was so slight as to be virtually unmeasurable' (*Ibid.*, p. 76). The idea that forests absorb downpours and release them slowly over several days was applicable only for light to moderate rainfalls. The torrential downpours that cause flooding quickly saturate the thin forest floor and the vegetation is largely powerless to stop or even slow it down. The effect of deer on forests, therefore, was only very loosely related to erosion rates. The 'final death knoll' of animal control as a solution to erosion sounded in 1986 when Patrick Grant presented a talk at the annual conference of the New Zealand Geological Society (Hunter 2009, p. 267) which showed that erosion rates had little to do with introduced animals, but rather were a consequence of long-term geological-scale weather patterns. In a subsequent paper in the *New Zealand Journal of Ecology*, he concluded that 'even in the absence of humans and [other] animals, [New Zealand] vegetation would be in a dynamic

state of imbalance and change' (Grant 1989, p. 143). The thesis that deer caused erosion had survived for at least five decades without being scientifically tested. Despite this, it was regularly and often forcefully endorsed during that time by scientists. Again, this shows the ways that science can be employed to answer some questions to the detriment of others, and how the ways that scientific research is funded can unhelpfully predetermine outcomes.

Mallard science, or a continuing lack thereof

Despite the rising numerical importance of mallards in the early 20th century and the broader importance of waterfowl to hunters nationally, scientific research on waterfowl was similarly underdeveloped and not officially instigated until 1947 when Ron Balham was appointed to the Wildlife Branch of the Department of Internal Affairs (Galbreath 1993). Because the Wildlife Branch's research was funded by levies on game licences it focused mostly on game birds (*Ibid.*). Between 1947 and 1961 more than 30,000 wild native grey ducks (*Anas superciliosa*) and introduced mallard ducks were leg banded as part of research on movement patterns and survivorship (*New Zealand Outdoor* 1961). Work on waterfowl habitat began in 1949 in conjunction with the Department of Scientific and Industrial Research and the Marine Department (Galbreath 1993). Despite these initiatives, few scientific results were published (Balham 1952).

As late as 1963, Jenkin lamented that, '…there [had] never [even] been an official duck census taken' (Jenkin 1963, p. 12). The principal tool used to collect information on waterfowl from the late 1960s to mid-1980s was the National Waterfowl Diary. This was a New Zealand Wildlife Service scheme instigated by Tom Caithness in which shooters recorded their daily 'bags.' Few of the resultant data were ever scientifically assessed. This lack of accurate quantification has promoted ongoing confusion as to the status of the mallard population in New Zealand (e.g. see Barker 1989; Muller 2010; Moriarty *et al.* 2011) and most estimates over the years have relied on 'educated guesswork' (Creasy 1987–88, p. 41).

However, mallard populations throughout New Zealand, were thought to have increased rapidly from the mid-1960s through the early 1980s (Buchanan 1990; Hayes 1989; Marchant & Higgins 1990), so much so that concerns began to be expressed about their effects on horticultural interests, particularly the seeding stages of grain and root crops which were sometimes partially consumed by mallards (Buchanan 1990; *New Zealand Outdoor* 1978). The response was a general loosening of regulations on mallard harvest. A 1986 Wildlife Branch, Department of Internal Affairs, internal report perceptively titled 'Mallard Management – A 'People' Problem or a 'Duck' Problem?' noted that:

> *Expanding mallard populations in the late 1970s and early 1980s led many districts toward an increasing liberalisation of conditions to allow hunters to take full advantage of high mallard numbers. The adoption of three month seasons and large or even no daily bag limits on mallards became acceptable practice* (Buchanan 1986, p. 3).

However, any sense that mallards *were* in high numbers *or* expanding was not based on any accurate quantitative assessment with 'no real attempt made to monitor the effects of changing regulations on harvest rates, nor to understand the relationship between hunting and population status' (*Ibid.*).

Data from the diary scheme seemed to show, however, that the mallard duck population was levelling off in the mid-1980s (Poynter 1986). One equilibrium-inspired theory was that the population had reached its 'carrying capacity' at this stage and was declining to a lower but stable, sustainable level. Barker (1989, p. 4), for instance, wrote that:

> *...the pattern of mallard population change has followed the classical form for an animal moving into a new environment. There are countless examples that illustrate that in a new environment, animal population levels increase rapidly, overshoot, then oscillate about a stable equilibrium, at a point somewhere below peak levels* (also see Buchanan 1990).

This ignored the fact that most waterfowl introduced to New Zealand did not follow such a 'classic' trajectory, instead declining rapidly to extinction (Thomson 1922; Williams 1962). Nor did it take into consideration the work of acclimatisers over the previous 100 years (Dyer & Williams 2010, 2011; Veltman *et al.* 1996). The mallard's supposed favourable ecological niche, for example, did not appear nearly as favourable in the 1930s when they were mostly abandoned as a future sporting proposition (Dyer & Williams 2011). Nor did it incorporate changes in hunting regulations or the substantial provision of new habitat by hunters from the 1950s onward (Galbreath 1993). The thesis posited that the reputed changes in mallard numbers were simply to be expected, ignoring the fact that they were actually quite extraordinary and, if accurate, certainly influenced by a wide range of factors, most of which were poorly understood.

Murray Williams (Interview, Waterfowl Biologist, January 2013) described the current system of monitoring waterfowl in New Zealand as an 'inexact science' at best, and 'absolutely fraught' at worst. He suggested that Fish and Game New Zealand,

> *...do not have a reliable or even a nationally applied technique for monitoring game bird numbers. That may come as a surprise but it's absolutely true […] Fish and Game don't employ any biologists as such to do that sort of work, even though they have some quite competent field staff. All the decisions are made around a council table by lay people. Often they will use their own observations or prejudices to guide hunting and the [only] thing that saves them is the fact that the number of hunters is declining year by year […] They get data, but they've got no way of checking what they get (Ibid.).*

Indeed, general scientific research on mallards in New Zealand, of any kind, remains underdeveloped. Despite being the most populous species of waterfowl in New Zealand, not a single scientific study (excepting the issue of hybridisation) has addressed their effects on the environment. In fact, it is only in the last decade that *any* questions about the effects of mallards in New Zealand have been raised in the scientific literature. Some studies suggested that mallards may be vectors for introduced plant species both from Australia and within New Zealand (de Lange *et al.* 2011; Heenan *et al.* 2004). A recent study in the *New Zealand Journal of Marine*

and Freshwater Research suggested that mallards may act as reservoirs of faecal contamination (Moriarty *et al.* 2011). Murray Williams (Interview, Waterfowl Biologist, January 2013) noted that mallards may also physically displace other waterfowl from breeding habitat (also see O'Connor *et al.* 2007; Williams & Basse 2006). Such suggestions continue to await quantification.

The low importance placed on mallard research is reflected in the fact that most of the research, to date, has been undertaken by just one researcher. As Nathan Burkepile (Interview, Field Officer, Fish & Game (Northland), February 2013) exaggerated, 'If it wasn't done by Murray Williams it really hasn't been done.' This is partly a consequence of the legislative arrangement that vests responsibility and management of mallards solely with Fish and Game New Zealand. Their mandate is to provide game birds for hunters. There is little incentive to fund research looking into any potential negative effects of mallards. Even research on the extent of hybridisation between mallards and native grey ducks has never been adequately funded. As Rob Pitkethley (Interview, Regional Manager, Fish & Game (Eastern), January 2013) noted, Fish and Game New Zealand is 'an under researched organisation […] if you looked at our percentage research spend against total budget we would be right down the low end' compared with other 'natural resource managers.' What little research *is* undertaken, moreover, is not typically directed at questions that could potentially undermine the public perception of hunters' quarry. This again demonstrates the way that scientific information can be both used, and not used, to promote certain arguments and understandings of wildlife to the detriment of others. Equilibrium theory, though now considered deficient (see Pickett *et al.* 2007), is used as a way of suggesting that the mallard population is stable and under control, while very little scientific work has actually gone into proving this supposition. This underlines the need to explore and contextualise the motives of those in control of the science on different species of introduced wildlife to ensure that the full scope of questions are being asked.

The increasingly contested role of science in wildlife management

Although further effort was directed towards ensuring the veracity of scientific research on wildlife in New Zealand in the late 20th century, there remained significant gaps in basic knowledge. Holloway (1993, p. 287) noted that despite the millions of dollars spent on the management of introduced species over the preceding one hundred years, much expenditure 'had little long-term effect because of persistent failure to understand the biology of the target animals.' Writing on trout stocking policy in the Rotorua Lakes in 1984, Principal Wildlife Officer N.B. Ewing, for instance, noted that methods of imposing regulations on anglers were based less on scientific knowledge and more on 'knowledge at the time, commonsense and gut feelings' (Ewing 1984, p. 3). He felt that scientific knowledge in fundamental areas such as fish population, 'crop' available and trends in angling were 'very weak' (*Ibid.*). Moreover, although it was considered 'likely' that introduced species in freshwater environments were having adverse impacts on native species, few studies had quantifiably documented them (Collier 1993, p. 341). In lakes, there had been 'few studies…of nutrient cycling, trophic interactions, and production that include vertebrates' (Burns 1991, p. 371). Burns ascribed this omission partly to the 'institutional separation of governmental scientists engaged in research on plankton, fish and wildlife' (*Ibid.*). She also noted, however, that research on freshwater fauna had been largely 'management-oriented,' as it had since the late 19th century (*Ibid.*, see above). In other words, it had tended to be used for the purposes of promoting certain favoured species and little else.

From around the 1970s both the employment of scientific research, and its supposed impartiality, came under renewed scrutiny in New Zealand. An editorial in the *New Zealand Science Review* observed that:

> *The name of the game is business. Its creed is profit (which is the only alternative to loss), its Bible is the balance sheet, its emblem is the dollar sign, and cost is its watchword…The day is gone when one could invoke "science for the sake of knowledge," nominate a project, and research the life out of it for the next twenty years. Science is now an investment, a business venture as vulnerable to an unfavourable annual report as any manufacturer. Clearly the message is getting through, for the [National Research Advisory Council] Annual Report notes, no doubt with some amusement, that 'no organisation admits to doing pure research.'* (Editor 1970, p. 88).

As this passage suggested, scientists' research interests were seen to be tied inextricably to the interests of their financial backers, whether government or the private sector, necessarily limiting the direction of their results should they wish to expect future employment or funding. Rather than question the repercussions of this departure from objectivity, scientists were invited to see their work as a business transaction with results tailored to suit the objectives of their 'clients.' Any diversions from this formula would be swiftly punished through marginalisation and the withdrawal of funding.

Partly as a consequence of this solidifying approach to science, certain 'omissions' in knowledge frequently seemed to correlate with information that was not useful to the parties funding research. The lack of studies on the effects of trout on native freshwater biota, for example, was typical of this selective use of scientific research. Freshwater science was devoted to understanding how to grow more trout, bigger, and faster because this was what the authorities tasked with managing freshwater 'resources' were asked to achieve (McDowall 1991; McIntosh *et al.* 2010). Questions that might disrupt the flow of research aimed in this direction were not only inconvenient, but potentially damaging.

Noticing the increasingly vested interests of scientists, criticisms of the use of government science to advocate for the control or removal of deer in New Zealand became commonplace in many New Zealand hunting periodicals. An offering by McArthur (1985/86, pp. 16-17) in *New Zealand Wildlife* is typical:

> *Now one of the things which makes the environmental movement so credible is that its recommendations seem to be well founded scientifically. After all we live in a scientific age and people often take for gospel the pronouncements of scientists just as they used to believe*

> *what the church told them in previous generations…Well a scientific degree may be one thing – but a scientific attitude is another. A university degree by no means guarantees the graduate will attempt to be impartial.*

McArthur noted that, just as religion has come to suffer ignominy through distortions of truth and other injustices, science too may be heading for a similar place of disrepute. He encouraged readers, therefore, to question the word of scientists just as they had justifiably questioned the word of religious leaders. Understandings of science as simple and unproblematic were, like understandings of religion, becoming complex and often ambiguous. In an article in *Fish & Game New Zealand*, Speedy (1996, p. 75) engaged with a now common summation of the use of science in wildlife management in New Zealand, noting that it is 'as much about value judgements as it is about good science' – values that are not necessarily those of the scientists themselves.

Investigations over the 1980s and 1990s, furthermore, showed that there was good reason to be sceptical of some of the earlier faith placed in scientific understandings in isolation. Even introduced species that seemed to have been proven to be 'bad' by scientists, for example, were shown to require further consideration. Despite widespread castigation of 'introduced predators,' apparently well-founded in research, King (1985, p. 130), New Zealand's foremost mammologist, argued that 'even after considerable research effort, there is still no firm information on the effect that any common predator, such as the stoat (*Mustela erminea*), has on bird populations in contemporary times.' She offered, as perspective, the realisation that of the 153 distinct populations of birds known to have disappeared from the islands of the New Zealand group since 1000 AD, stoats [as one example] could have come into contact with only five that are now extinct and 11 that are still threatened' (*Ibid.*). To King, the level of invective routinely directed at them, and other introduced mammals, was therefore misdirected and certainly not well substantiated by the scientific evidence of the time. The introduced possum (*Trichosurus vulpecula*), was also widely seen as demonstrably 'bad' for native wildlife. A study in 1999, however, showed that the long-term effects of possums on floral biodiversity, virtually unconsidered at that time, deserved further study (Bellingham *et al.* 1999). They found 'no substantial changes in species composition' in conifer/broadleaf forests inhabited by possums over periods of 14–25 years (*Ibid.*, p. 5). Indeed, many species palatable to possums 'remained relatively unchanged' (*Ibid.*), casting doubt over some earlier cataclysmic predictions of forest collapse (e.g. Editor 1969; Kean 1953). This finding is supported by further recent evidence (e.g, see Department of Conservation 2012, pp. 108–109).

Reflecting on scientific assessments on the effects of deer in the early 20th century in New Zealand, in particular, Graham Nugent (Interview, Deer Ecologist, May 2013) contextualised the work that was undertaken. Conceding apparent inadequacies of science at that time from a contemporary perspective, he suggested that,

> *...while it was not quantified, it was reasonably good natural history of that sort of post-Darwinian [kind] […] We can cast aspersions about it now because it wasn't quantitative, but that's what they had access to. That was the way they were trained. It was the most systematic observations they were able to make* (*Ibid.*).

Whilst this is undoubtedly true, it bypasses an important realisation: that what is considered to be 'good science' changes. The methods used to indict introduced species in the 19th and early 20th centuries frequently no longer stand as 'reasonable' evidence. Typically they are now negatively characterised as 'anecdotal' or 'circumstantial' (e.g. see McDowall 1991, on the effects of trout on native fish in New Zealand). Furthermore, as the standards of good science change, there is no reason to suspect that many modern appraisals may suffer similar falls from credibility, if not respectability, in future. Again, I highlight this, not in an attempt to discredit the use of science to assess issues in relation to wildlife in New Zealand, but to maintain that a healthy discussion on how scientific research is being employed and interpreted is not only justified, but demonstrably sound.

Seek and ye shall find?

Regardless of the above, much scientific research on introduced wildlife in New Zealand remains in its infancy. According to Tony Beauchamp (Interview, Technical Advisor Threats, Department of Conservation (Northland), February 2013), ongoing insinuations of 'guilt' attributed to many introduced species (e.g. see Camp 1997; *Forest & Bird* 1951, 1956) often remain based in 'folklore and ignorance more than anything else.' Only recently have studies even begun to quantify the effects of many widely castigated introduced birds in New Zealand (e.g. see *New Zealand Hunting & Wildlife* 2003). In addition, much research on introduced wildlife remains based on short-term studies whose conclusions may not apply long term. As Graham Nugent (Interview, Deer Ecologist, May 2013) noted on research into deer in New Zealand:

> *There's a lot of detail gaps that are missing […] In terms of vegetation lifetimes, it's all pretty short-term stuff. It's decades or less and yet most of the trees we're working with have millennial or semi-millennial turnover times.*

Indeed, until Forsyth *et al.* (2011) there had been no long-term studies of ungulate population dynamics in New Zealand. According to Dave Rowe (Interview, Freshwater Ecologist, January 2013), there similarly remain many unknowns about the long-term dynamics of freshwater ecosystems that contain trout in New Zealand. For example, although Fish and Game New Zealand have long historical records dating back to the mid-1960s in Rotorua (Interview, Rob Pitkethley, Regional Manager, Fish & Game (Eastern), January 2013), much of it remains unanalysed or otherwise tied into the overarching management of the lakes (Interview, David Hamilton, Chair of Lakes Management and Restoration, Bay of Plenty Regional Council, February 2013).

It is important to note, nevertheless, that the current state of knowledge is not necessarily opposed, particularly by game advocates. This is because the available information – that determined from a fisheries science perspective – tends to uncritically support the persistence of trout in New Zealand. Further ecological-oriented science on trout may not provide the same answers and, from the perspective of anglers, may not be desirable at all. This may be one reason why science on the effects of introduced trout on native ecosystems in New Zealand (and elsewhere in the Southern Hemisphere) only began to be seriously addressed in the 21st century (Garcia de Leaniz *et al.* 2010). This is mirrored in science on mallards which has almost invariably been conducted 'from the perspective of the fishing and hunting fraternity' which has little interest in 'actually

looking ecologically at where [mallards] fit in the processes' (Interview, Tony Beauchamp, Technical Advisor Threats, Department of Conservation (Northland), February 2013).

Government authorities dedicated to conserving native wildlife, such as the Department of Conservation and its precursor the New Zealand Wildlife Service, are effectively discouraged from scientifically questioning the status quo. They are placated by the protection and enhancement of wetlands by Fish and Game New Zealand (McLeod 2007), just as the New Zealand Wildlife Service was by the Acclimatisation Societies. As Ian Hogarth (Interview, ex-Department of Conservation (Northland), April 2013) reasoned,

> *...you've gotta understand that [Fish & Game New Zealand] are very very strong supporters of wetland preservation and wetland management. And the Department of Conservation is fully behind that. And that's one of the major reasons why we're in that supporting role.*

Close social links between the two organisations also carry important weight. Staff at the Department of Conservation, for instance, are often keen hunters and anglers. Ian Hogarth (Interview, ex-Department of Conservation (Northland), April 2013) recalled his experiences working for the New Zealand Wildlife Service in Northland:

> *One of the big parts of the job was actually hunting with the local acclimatisation fraternity. So we were going out hunting with them and participating in some of their programs [...] The [New Zealand] Wildlife Service, in particular, had very close connections with the acclimatisation societies. We were very close*.

Promoting science that might devalue favoured quarry and sour relations with the Acclimatisation Societies was not a high priority. Investigating any possible impacts of introduced mallards was therefore a question that was not politically suitable to ask.

In contrast, much of the science on deer has been conducted from the perspective of conservationists that are opposed to them. Rather than finding ways to enhance deer populations, science on deer tends to be focused on discovering potential negative attributes and quantifying perceived ecological harm. This was highlighted by Clyde Graf (Interview, Hunter/Anti-1080 activist, February 2013). He suggested, for instance, that the Department of Conservation,

> *...have got [a Departmental scientist] doing a project at the moment trying to prove that deer are a pain in the arse. But, once again, that sort of research is not research. It's just advocacy science – predetermined outcomes* (*Ibid.*).

He wondered if opinions on deer might change if the research was directed toward answering different questions:

> *Who's doing the research on what good deer are actually doing? You know. All the research on deer in this country is 'OK, go and prove that they're bad.' Let's do some research to see if they're actually doing something good* (*Ibid.*).

Reflecting on the science on introduced mammalian 'predators,' Tony Beauchamp (Interview, Technical Advisor Threats, Department of Conservation (Northland), February 2013) made a similar reflection. Although much research is directed to assessing their potential negative effects, 'there's not a lot of work that's actually being done to prove benefit. I'm not saying that there isn't some benefit, but [rather] it's not actually an area of enquiry' (*Ibid.*). This may explain why there is so much scientific evidence for the negative attributes of many non-game introduced species and so little for any positive contributions. The latter question is simply not asked.

A consequence of this imbalance is that the perceived impartiality of science on wildlife in New Zealand now suffers from a legacy of advocacy and agenda setting. As Ian Hogarth (Interview, ex-Department of Conservation (Northland), April 2013) commented, although scientists may sometimes enter their research with 'pure' intentions, 'the objectivity disappears as they get into the subject.' Most ecologists in New Zealand, moreover, enter their fields already well-schooled on the value of native species and the disvalue of many introduced species, meaning that any sense of impartiality is typically disavowed from the outset (Steer 2015). Others have become disillusioned with the pace of research or with changes and reversals in policy. Pete Shaw (Interview, ex-Department of Conservation (Northern Te Urewera), March 2013), for example, offered a jaded view of the value of science. He advocated a pragmatic approach: 'Do the best with what you've got now and never mind the theoretical arguments' (*Ibid.*). As a result, contributions to New Zealand hunting and fishing magazines continually point to a now-enduring mistrust in scientific authority. A letter in *New Zealand Hunting and Wildlife* is typical – Hanson (2004, p. 12), furthering the now 'traditional' lamentation of deer as 'pests' in government legislation, asked detractors to avoid using science altogether: 'Please don't quote recent "science" as evidence against this. Science has been so tainted by the privatisation agenda and bidding for contracts, that much of it lacks integrity today' (also see Watson 2006). This overarching scepticism of scientists is a poor outcome as it undermines their credibility, making it difficult for future studies to receive the resonance they may well deserve.

Concluding remarks

These findings do not discount the importance of science, but rather reinforce the understanding that scientific information on introduced wildlife needs to be assessed in the context of its production. Understandings of science in New Zealand are beginning to move from the somewhat naïve accounts of the past that presented scientists working in a political, social, and economic vacuum, to more nuanced understandings that incorporate the many factors that underlie the production of scientific knowledge. In the case of introduced wildlife, these understandings demonstrate that scientific assessments of ecological effects need to be more cautious and explicit in communicating the assumptions of that research and the predispositions of its funding sources. While scientists are often confident of their own objectivity and the vetting process of scientific peer review, others are not quite so convinced and need to be given as much information as possible to ensure that the conclusions of scientists can be fairly considered alongside other literatures.

I have also demonstrated how the standards for 'good science' change. Prior to the 1930s there was no formal wildlife science in New Zealand and assessments were largely based on what would now be considered expert opinion. Only from around the 1960s did assessments of wildlife begin to fully quantify those opinions. However, for most introduced species in New Zealand, a full consideration of their effects (both positive and negative) on the environment remains in its infancy.

Importantly, I have emphasised the extent to which science on introduced wildlife has also regularly been employed as an advocacy tool to 'prove' certain predetermined positions. Thus advocates for introduced game species fund and endorse research showing how to improve the survivorship and fecundity of favoured game species, but fail to fund any research on the effects of game species on native species. In contrast, work funded by conservationists commonly investigates the impacts that introduced species have on natives, but fails to ask whether they might be providing benefits. In both cases, scientific research is paraded as an impartial arbiter of truth to an, at times, justifiably sceptical public. A consequence of this ongoing science as advocacy is an erosion in the credibility of science itself.

Ultimately, I suggest that New Zealand's natural scientists need to be given the opportunity to, at least occasionally, ask the questions that no one else will support or pay for because otherwise their science risks being reduced to a blunt tool for those that fund and therefore direct it. I would argue that there may be some truth in the view that asking a conservation biologist under the employ of the Department of Conservation to determine if deer have positive effects on biodiversity, or a fisheries or waterfowl biologist under the employ of Fish and Game New Zealand to determine if trout or mallards have negative effects on biodiversity, is a little like asking a scientist working for Imperial Tobacco to investigate the ways that smoking damages people's health. Such questions, although possible, are generally not politically sensible to ask within these organisations. If no one else can afford to fund different questions, is it surprising that the same questions keep meeting with the same answers? At its worst, I am concerned that the death of 'science for the sake of knowledge' in New Zealand may, without conscious intervention, also prove the death of the very objectivity that natural science relies on for credibility. I hope this article will help, in some small way, to pique this concern in other New Zealand natural scientists.

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References

Aramakutu, E. 1997. Colonists and colonials: Animals' protection legislation in New Zealand 1861–1910. Masters Thesis, Massey University, Palmerston North.

Balham, R.W. 1952. Grey and mallard ducks in the Manawatu District, New Zealand. *Emu 53(3)*: 163–191.

Barker, R.J. 1989. Mallard management in New Zealand. *Flight*: 4–5.

Bathgate, A. 1897. Notes on acclimatisation in New Zealand. *Transactions of the New Zealand Institute 30*: 266–279.

Bellingham, P.J.; Wiser, S.K.; Hall, G.M.J.; Alley, J.C.; Allen, R.B.; Suisted, P.A. 1999. *Impacts of possum browsing on the long-term maintenance of forest biodiversity*. Wellington: Department of Conservation.

Biggs, C. 1946. Forests and erosion. *New Zealand Journal of Forestry 5(3)*: 210–214.

Buchanan, I. 1986. *Mallard management – A "people" problem or a "duck" problem?*, AANS W3832 Box 16 25/4/4, Department of Internal Affairs, Research: Wildlife – Ducks 1984–1988, Wellington, National Archives.

Buchanan, I.M. 1990. Mallard habitat management. *Flight*: 8–10.

Burns, C.W. 1991. New Zealand lakes research 1967–91. *New Zealand Journal of Marine and Freshwater Research 25*: 359–379.

Burr, V. 2003. *Social Constructionism.* 2nd edn, New York: Routledge.

Camp, K. 1997. A magpie in the cage worth tui in the bush? *Forest & Bird*: 7.

Caughley, G. 1983. *The Deer Wars: The story of deer in New Zealand*. Auckland: Heinemann.

Cockayne, L. 1926. *Monograph on the New Zealand beech forests*. Wellington: New Zealand Forest Service.

Collier, K. 1993. Review of the status, distribution, and conservation of freshwater invertebrates in New Zealand. *New Zealand Journal of Marine and Freshwater Research 27*: 339–356.

Coombes, B. 2003. *Making 'scenes of nature and sport' – resource and wildlife management in Te Urewera 1895–1954*. Auckland: University of Auckland.

Creasy, H. 1987–88. New approach to management urged. *New Zealand Outdoor 50*: 41.

Crowl, T.A.; Townsend, C.R.; McIntosh, A.R. 1992. The impact of introduced brown and rainbow trout on native fish: The case of Australasia. *Reviews in Fish Biology and Fisheries 2*: 217–241.

Darwin, C. 2009 [1859]. *The Origin of Species* 150th anniversary edn Alachua: Bridge-Logos.

Davies, B. 1996. Acclimatisation in New Zealand. *New Zealand Outdoor 58*: 37–40.

de Lange, P.J.; Rolfe, J.R.; Townsend, A.J. 2011. *Crassula natans* var. *minus* Crassulaceae) a new trans-Tasman natural weed arrival to northern New Zealand. *New Zealand Journal of Botany 49(3)*: 361–366.

Department of Conservation. 1998. *Issues and Options for Managing the Impacts of Deer on Native Forests and Other Ecosystems: A public discussion document*. Wellington.

Department of Conservation. 2012. *Department of Conservation annual report for the year ended 30 June 2012*. Wellington.

Dyer, J.; Williams, M. 2010. An introduction most determined: Mallard *Anas platyrhynchos*) to New Zealand. *Notornis 57*: 178–195.

Dyer, J.; Williams, M. 2011. Mallards – A century in the making. *Fish & Game New Zealand*: 48–52.

Editor. 1941. Research – An urgent need. *Forest & Bird*: 1–2.

Editor. 1950. Removing protection from New Zealand's 'butcher bird'. *Forest & Bird*: 1–2.

Editor. 1969. Opossum damage to bush and birds is appalling. *Forest & Bird*: 3–5.

Editor. 1970. The name of the game. *New Zealand Science Review, 28(5)*: 88.

Ewing, N.B. 1984. *Stocking Policy – Rotorua Lakes*, AFKC A1700 243a 16/0/2 2), Research 1982–1984, Auckland, National Archives.

Figgins, G.; Holland, P. 2012. Red deer in New Zealand: Game animal, economic resource or environmental pest? *New Zealand Geographer 68*: 36–48.

Forest & Bird. 1937. Making of a white man's country. *Forest & Bird*: 15–16.

Forest & Bird. 1951. Protection removed from magpies. *Forest & Bird*: 4.

Forest & Bird. 1956. The myna. *Forest & Bird*: 12.

Forsyth, D.M.; Thomson, C.; Hartley, L.J.; MacKenzie, D.I.; Price, R.; Wright, E.F.; and others. 2011. Long-term changes in the relative abundances of introduced deer in New Zealand estimated from faecal pellet frequencies. *New Zealand Journal of Zoology 38(3)*: 237–249.

Galbreath, R. 1993. *Working for Wildlife: A history of the New Zealand Wildlife Service*. Wellington: Bridget Williams Books Ltd.

Garcia de Leaniz, C.; Gajardo, G.; Consuegra, S. 2010. From best to pest: Changing perspectives on the impact of exotic salmonids in the southern hemisphere. *Systematics and Biodiversity 8(4)*: 447–459.

Gaston, N. 2015. Empowering informed voices. *New Zealand Science Review 72(1)*: 3–6.

Gillies, R. 1877. Notes on some changes in the fauna of Otago. *Transactions of the New Zealand Institute, 10*: 306–324.
Gluckman, P.D. 2015. Trusting the scientist. *New Zealand Science Review 72(1)*: 7–13.
Grant, P.J. 1989. Effects on New Zealand vegetation of late Holocene erosion and alluvial sedimentation. *New Zealand Journal of Ecology 12*: 131–144.
Hamilton, G.D. 1904. *Trout-fishing and Sport in Maoriland*. Wellington: Government Printing Office.
Hanson, L. 2004. Resource – not pest [Letter to the editor]. *New Zealand Hunting & Wildlife*: 12.
Hayes, N. 1989. The mallard in New Zealand. *Flight*: 3.
Heenan, P.B.; de Lange, P.J.; Knightbridge, P.I. 2004. *Urticularia geminiscapa* Lentibulariaceae), a naturalised aquatic bladderwort in the South Island, New Zealand. *New Zealand Journal of Botany 42*: 247–251.
Holden, P. 1987. *The Deerstalkers: A history of the New Zealand Deerstalker's Association*. Auckland: Hodder & Stoughton Ltd.
Holloway, J.S. 1993. Conservation pests – How can national values and objectives be quantified. *New Zealand Journal of Zoology 20(4)*: 285–293.
Holloway, J.T. 1950. Deer and the forests of western Southland. *New Zealand Journal of Forestry 6(2)*: 123–137.
Holloway, J.T. 1959. Noxious–animal problems of the South Island alpine watersheds. *New Zealand Science Review 17(2)*: 21–28.
Holloway, J.T. 1970. Introduced animals and the protection forests. In: A.L. Poole (Ed.) *Wild Animals in New Zealand* pp. 11–17. Wellington: A.H. & A.W. Reed.
Hunter, K. 2009. *Hunting: A New Zealand history*. Auckland: Random House.
Hutchinson, F.E. 1930. Forest protection and wildlife in New Zealand. *Te Kura Ngahere 2(5)*: 9–18.
Jenkin, J. 1963. What's the answer? *New Zealand Outdoor 28*: 12–13.
Kean, R.I. 1953. Aliens in the forest 2. The opossum. *Forest & Bird*: 4–6.
King, C. 1985. *Immigrant Killers: Introduced predators and the conservation of birds in New Zealand*. Auckland: Oxford University Press.
Kirk, T. 1895. The displacement of species in New Zealand. *Transactions of the New Zealand Institute 28*: 1–27.
Lumley, E.D. 1937. The record of wildlife control by hunters: Some species extinct, others dwindling. *Forest & Bird*: 4–5.
Lyell, C. 1830. *Principles of Geology 1*. London: John Murray.
Marchant, S.; Higgins, P.J. (Eds) 1990. *Handbook of Australian, New Zealand & Antarctic birds – Ratites to ducks* Vol. 1. Melbourne: Oxford University Press.
Marshall, P. 1926. Presidential address. *Transactions of the New Zealand Institute 56*: 1–8.
Martin, H. 1885. The protection of native birds. *Transactions of the New Zealand Institute 18*: 112–117.
McArthur, A. 1985/86. Eco conned! – Just as we were 'soil conned'. *New Zealand Wildlife 10(77)*: 16–17.
McDowall, R.M. 1980. Charles Douglas, explorer: His notes on freshwater fishes. *Journal of the Royal Society of New Zealand 10(4)*: 311–324.
McDowall, R.M. 1991. Freshwater fisheries research in New Zealand: processes, projects, and people. *New Zealand Journal of Marine and Freshwater Research 25*: 393–413.
McDowall, R.M. 1999. We know so darn little. *Fish & Game New Zealand*: 48–52.
McIntosh, A.R.; McHugh, P.A.; Dunn, N.R.; Goodman, J.M.; Howard, S.W.; Jellyman, P.G.; and others. 2010. The impact of trout on galaxiid fishes in New Zealand. *New Zealand Journal of Ecology 34(1)*: 195–206.
McKelvey, P.J. 1959. Animal damage in North Island protection forests. *New Zealand Science Review 17*: 28–34.
McKelvey, P.J. 1960. Condition assessment of protection forests. *New Zealand Journal of Forestry 8(2)*: 325–334.
McLeod, C.M. 2007. Dreadful/delightful killing: The contested nature of duck hunting. *Society & Animals 15(2)*: 151–167.
Moncrieff, P. 1949. The destruction of an avian paradise. *Forest & Bird*: 3–5.
Moriarty, E.M.; Karki, N.; Mackenzie, M.; Sinton, L.W.; Wood, D.R.; Gilpin, B.J. 2011. Faecal indicators and pathogens in selected New Zealand waterfowl. *New Zealand Journal of Marine and Freshwater Research 45(4)*: 679–688.
Muller, W. 2010. Hybridisation, and the conservation of the grey duck in New Zealand. PhD Thesis, University of Canterbury, Christchurch.
New Zealand Forest Service. 1960. Animal damage [Advertisement]. *New Zealand Science Review 18(5)*: 79.
New Zealand Forest Service. 1962a. Animal damage [Advertisement]. *Forest & Bird*: 15.
New Zealand Forest Service. 1962b. Forestry and mountain-land management [Advertisement]. *Forest & Bird*: 15.
New Zealand Hunting & Wildlife. 2003. Fewer magpies may mean more native birds. *New Zealand Hunting & Wildlife*: 36.
New Zealand Outdoor. 1961. Duck banding is research aid. *New Zealand Outdoor 26*: 14.
New Zealand Outdoor. 1978. Mallard duck becoming cunning. *New Zealand Outdoor 42*: 5.
O'Connor, S.M.; Maloney, R.F.; Pierce, R.J. 2007. *Pateke (Anas chlorotis) recovery plan 2005–10* (59). Wellington: Department of Conservation.
Pellett, J.W. 1935. The evolution of brown trout: The problem of stocking the rivers and conditions necessary for success. *New Zealand Fishing and Shooting Gazette 8*: 9–12.
Phillips, N.; Hardy, C. 2002. *Discourse Analysis: Investigating processes of social construction*. Thousand Oaks: Sage Publications.
Pickett, S.T.; Kolasa, J.; Jones, C.G. 2007. *Ecological Understanding* 2nd edn, Elsevier.
Poole, A.L. 1958. *Comments on report by Dr William Graf, Division of Fish and Game, Territory of Hawaii, Board of Commissioners of Agriculture and Forestry, Honolulu*, AADY W3564 Box 42 90/1–3, Department of Internal Affairs – New Zealand Forest Service, Deer policy 1958–1963, Wellington, National Archives.
Poynter, M. 1986. Northland looks to the future. *New Zealand Outdoor 49*: 45–46.
Riney, T. 1956. Comparison of occurrence of introduced animals with critical conservation areas to determine priorities for control. *New Zealand Journal of Science and Technology 38(1)*: 1–18.
Royal Society of New Zealand. 1934. Annual meeting of the Royal Society of New Zealand. *Proceedings of the Royal Society of New Zealand 64*: 367–378.
Royal Society of New Zealand. 1939. Minutes of the annual meeting of the Council, 23rd May 1939. *Proceedings of the Royal Society of New Zealand 68*: 5–25.
Speedy, C. 1996. The great ecology debate. *Fish & Game New Zealand*: 72–75.
Star, P. 1997. From acclimatisation to preservation: Colonists and the natural world in southern New Zealand 1860–1894. PhD Thesis, University of Otago, Dunedin.
Steer, J.E.S. 2015. The reconciliation of introduced species in New Zealand: Understandings from three 'exceptional' case studies. PhD Thesis, University of Auckland, Auckland, http://hdl.handle.net/2292/27449
Sullivan, W.A. 1990. *Changing the Face of Eden*. Hamilton: Auckland/Waikato Fish & Game Council.
Thomson, G.M. 1922. *The Naturalisation of Animals and Plants in New Zealand*. London: Cambridge University Press.
Veltman, C.J.; Nee, S.; Crawley, M.J. 1996. Correlates of introduction success in exotic New Zealand birds. *American Naturalist 147*: 542–557.
Walrond, C. 2012. Acclimatisation. Retrieved November 7 2012, from http://www.teara.govt.nz/en/acclimatisation/print

Walsh, P. 1892. The effect of deer on the New Zealand bush: A plea for the protection of our forest reserves. *Transactions of the New Zealand Institute 25*: 435–439.

Watson, S.M. 2006. Response to DOC [Letter to the editor]. *New Zealand Hunting & Wildlife*: 10–11.

Westerskov, K. 1957. Training for the wild-life profession. *New Zealand Science Review 15(9–10)*: 67–75.

White, G. 1977 [1789]. *The Natural History of Selborne*. London: Penguin.

Williams, G.R. 1962. Extinction and the Anatidae of New Zealand. *The Wildfowl Trust*(15th Annual Report): 140–146.

Williams, M.; Basse, B. 2006. Indigenous gray ducks, *Anas superciliosa*, and introduced mallards, *A. platyrhynchos*, in New Zealand: processes and outcome of a deliberate encounter. *Acta Zoologica Sinica, 52*(Supplement): 579–582.

Young, D. 2004. *Our Islands, Our Selves: A history of conservation in New Zealand*. Dunedin: University of Otago Press.