Campbell Island teal re-introduction plan

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ABSTRACT

Following the successful completion of rat eradication on Campbell Island, re-introduction of Campbell Island teal (*Anas nesiotis*) to Campbell Island could take place from April 2004. This report uses as a model the trial releases of teal in Whenua Hou Nature Reserve on Codfish Island (Whenuahou) in 1999 and 2000, and productivity and survival estimates derived therefrom, to propose a re-introduction plan for teal to Campbell Island. Population viability analyses indicate that single one-off translocations of teal to Campbell Island can result in population establishment without need for supplementation. However, this is strongly dependent on juvenile survival rates, annual adult survival rates, and female productivity of the founder populations being at least as high as those achieved by Campbell Island teal released in Whenua Hou Nature Reserve. Suggested threshold values are: juvenile survival (year 0–1) >55%; annual adult survival >65%; c. 80% of females hatch 1–3 young. Five indicators of success were defined: (1) post-release survival >33%; (2) evidence of breeding by founders by 2 years post-release; (3) adult and juvenile survival rates exceed thresholds values; (4) breeding productivity comparable to that achieved by teal on Whenua Hou (>60% of adult females breed; >3 eggs per clutch; >75% hatch success; c. 50% fledge success); (5) modelling of the probability of extinction using Campbell Island data indicates high likelihood of population persistence without re-enforcement. A four-year programme of releases and monitoring is detailed, with one-off releases of 60 and of 40 birds into two sites over two years, respectively, and possible releases of 40 birds into two further sites in the third and fourth year. Releases would take place in August/September each year between 2004 and 2007. Monitoring would take place during January/February and August/September each year, and would aim to compile data with which to assess success against defined criteria.

Keywords: Campbell Island, teal, *Anas nesiotis,* translocation, re-introduction, population viability, Whenua Hou Nature Reserve, Codfish Island (Whenuahou), New Zealand, subantarctic islands

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1. Introduction

The Campbell Island teal (*Anas nesiotis*) is one of two species of endemic flightless teal found within the New Zealand subantarctic region, the other being the Auckland Island teal (*Anas aucklandica*). Both species are presumed to have once been widespread within their island groups, but have been eliminated from their respective main islands by introduced predators. They now persist with markedly reduced distributions and at low abundance, as remnant or managed wild populations, and as captive populations. The Campbell Island teal is listed as critically endangered. The Subantarctic Teal Recovery Plan (McClelland 1993) has the long term goal:

> 'To improve the conservation status of (the) Campbell Island teal … from endangered to rare by re-establishing them in their former range so that further intensive management is no longer required'.

The Subantarctic Teal Recovery Plan lists five objectives for Campbell Island teal management, relating to the establishment and maintenance of wild populations, establishment of a captive population, and preparation for the removal of predators (rats) from Campbell Island. Fulfilment of these objectives and completion of an island-wide rat eradication effort by 2002 means that planning for the long-term goal of re-establishment of teal in their former range is required.

1.1 TERMS OF REFERENCE

The Subantarctic Teal Recovery Group, Department of Conservation (DOC), approached the authors to provide advice on undertaking releases of Campbell Island teal onto Campbell Island with the goal of establishing a new population of teal on the island. With the recently confirmed successful eradication of rats from Campbell Island, re-introduction of captive-raised Campbell Island teal to Campbell Island could proceed from April 2004, with further releases in subsequent years. A formal re-introduction plan will be required in accordance with the DOC Standard Operating Procedure and Translocation Proposal template.

Re-introductions, especially those from captivity, are notoriously unsuccessful and so often the reasons for their failure are obscured by poor release design and subsequent monitoring. To maximise the likelihood of success a good re-introduction and monitoring protocol is required, which is formulated on the accumulated experiences of avian re-introduction attempts world-wide.

Using as a model the trial releases of teal in Whenua Hou Nature Reserve in 1999 and 2000, and productivity and survival estimates derived therefrom, a re-introduction protocol for teal to Campbell Island was developed.

1.2 SCOPE AND AIM OF THE REPORT

This report aims to provide specific guidelines and protocols for the re-introduction of Campbell Island teal onto Campbell Island, including requirements and design of post-release monitoring programmes. Using available general guidelines and a review of the available information on Campbell Island teal ecology and behaviour, several release scenarios are presented and recommendations made. Scenarios are based on current knowledge of Campbell Island teal breeding and survival parameters.

The intention is to indicate release and monitoring strategies designed to increase the likelihood of success at defined stages, and to allow rigorous assessment of the reasons for project outcomes.

Although mindful of logistic and financial constraints, scenario costing and work plans are not given: the emphasis is on the formulation of options for an efficient, appropriate and rigorous release and monitoring programme that will meet conservation objectives. Final advice to the lead conservancy on which approach to take will come from the Subantarctic Teal Recovery Group.

1.3 DEFINITION OF TERMS

Translocation—Intentional release of animals for the purpose of re-establishing an extirpated population (re-introduction), establishing a new population (introduction), or augmenting an existing population (re-enforcement) (Griffith et al. 1989).

Re-introduction—An attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct (IUCN 1998).

Conservation/benign introduction—An attempt to establish a species, for the purpose of conservation, outside its recorded distribution, but within an appropriate habitat and eco-geographical area (IUCN 1998).

Re-enforcement/supplementation—Addition of individuals to an existing population of conspecifics (IUCN 1998).

Note that founder animals may derive from either captive or wild populations.

1.4 REPORT STRUCTURE

In 1998 the World Conservation Union (IUCN) Species Survival Commission's Re-introduction Specialist Group (RSG) published *Guidelines for re-introductions* (IUCN 1998) in response to the increasing number of re-introduction projects world-wide and the consequent growing need for specific policy guidelines to help ensure that re-introductions achieved their intended conservation benefit.

These guidelines consider the three principle phases of any re-introduction project: the pre-project activities, the planning, preparation and release stages,

and the post-release activities. This report uses the IUCN Guideline structure to set out a re-introduction strategy for the Campbell Island teal. Because planning for this project is well advanced at this stage, the sections on pre-project activities and preparation serve to provide summary background material. The core sections will relate to the release stages, and the post-release activities. The report is set out in such a way as to facilitate later completion of the DOC Translocation Proposal documents.

2. Pre-project activities

2.1 BACKGROUND RESEARCH

2.1.1 Taxonomic status of individuals to be released

Three teals inhabit the New Zealand region, arising from colonisation of the mainland from Australia. Recent studies (Daugherty et al. 1999; Kennedy & Spencer 2000) accord specific status to the New Zealand teals, as brown teal (*Anas chlorotis*), Auckland Island teal (*A. aucklandica*), and Campbell Island teal (*A. nesiotis*). It remains unclear if ancestors of the Campbell Island teal came from mainland New Zealand, or from the Auckland Islands.

2.1.2 Status and biology of wild populations

Ironically, Campbell Island teal have never been recorded as a breeding population on Campbell Island. It is believed that invasion of Campbell Island by Norway rats (*Rattus norvegicus*) occurred soon after the official discovery of the island in 1810, and was responsible for the rapid extirpation of Campbell Island teal (Miskelly 2000). As a consequence, there is only a single remnant natural population of Campbell Island teal extant, confined to Dent Island, a steep-sided islet approximately 3 km off the west coast of Campbell Island. Sightings of birds at North-west Bay, Campbell Island, are assumed to be dispersing individuals from Dent Island. Estimates of the size of the Dent Island population range from 25 up to less than 100 birds (McClelland 2002).

There has been no study of the biology of Campbell Island teal on Dent Island. To date, knowledge of Campbell Island teal biology originates from studies in captivity (Preddy 1995); post-release monitoring of Campbell Island teal released in Whenua Hou Nature Reserve (see Section 2.1.3), and from extrapolations from studies of *A. aucklandica* (Williams 1992, 1997).

Because of the extremely restricted distribution and small population of Campbell Island teal in the wild, the decision was taken to establish a captive population for protection of the species in the short-term. Eleven birds (in total) were captured on Dent Island between 1984 and 1990. They were the founders of a captive population from which over 60 ducklings have been produced. With the longer-term goal of re-establishment of Campbell Island teal on Campbell Island in mind, it was deemed appropriate to establish a second

wild population on a suitable holding island, and in so doing achieve four objectives:

- Provide the insurance of another wild population until re-introduction to Campbell Island was feasible.
- Provide information on translocation and population establishment processes, including habitat use, dispersal, survival, and breeding performance. Given the paucity of information on this species and the low likelihood of obtaining useful information from the remnant population on Dent Island, establishment of a population on a suitable holding island was potentially the only source of basic biological information. Of particular interest was evaluation of the ability of captive-bred birds to adapt to the wild.
- Acclimatise birds for translocation to Campbell Island. It was never the intention to have a self-sustaining population of Campbell Island teal on a holding island in the long-term. It was envisaged that the translocation of wild-adapted birds to Campbell Island may have a higher likelihood of success (higher post-release survival, faster breeding and better productivity) than that arising from release of captive-bred birds.
- Increase the numbers of Campbell Island teal available for release and thus reduce dependence of the Campbell Island re-establishment on captive production.

The first releases of teal in Whenua Hou Nature Reserve took place in March 1999 (see Section 2.1.3). By early 2002 only 4 of the original 24 founders were confirmed to have died, while breeding on the island had resulted in 5 new adults entering the population. In March 2003 the total Whenua Hou population of Campbell Island teal was estimated to be at least 28 birds.

2.1.3 Lessons from previous re-introductions

The recovery plan for Campbell Island teal (see McClelland 1993) has as Objective 4, the establishment of an additional wild population. This would serve to reduce the risks of extinction in the wild in the event of a decline in the Dent Island population. The establishment of a second wild population would also provide opportunities for a detailed ecological study of the species in the wild; allow assessment of translocation techniques, and would acclimatise birds to the wild in preparation for a second translocation to Campbell Island itself sometime in the future (McClelland 2002).

A review of New Zealand islands suitable for Campbell Island teal failed to identify any with all the desired characteristics, namely, free from mammalian predators, outside the current brown teal range, and containing suitable habitat. Whenua Hou Nature Reserve on Codfish Island (1396 ha) situated 3 km west of the north-west tip Stewart Island, was considered the only available predator-free alternative.

Twelve (4:8) captive-bred Campbell Island teal were released in Whenua Hou Nature Reserve in March 1999, with a further 12 (8:4) released in April 2000. This constituted a benign introduction of Campbell Island teal outside their recorded range. It was always the intention, however, that any established population of Campbell Island teal would ultimately be removed from Whenua

Hou—ideally through a series of translocations to re-introduce teal to Campbell Island.

McClelland (2002) documented the survival, dispersal, habitat selection, and productivity of the Whenua Hou teal introduction, providing the most detailed account of the biology of the species to date.

2.2 RE-INTRODUCTION SITE SELECTION

The long-term goal of the Campbell Island teal recovery strategy is the re-establishment of Campbell Island teal on Campbell Island (McClelland 1993). Campbell Island (11 216 ha) lies within the historic range of the species, if assumptions about the early extirpation of teal by rats are correct. There are no known remnant wild populations of teal on Campbell Island at present, although there is the potential of mixing between any re-established population on Campbell Island, and the relict population on Dent Island.

2.3 RELEASE SITE EVALUATION

2.3.1 Habitat availability

The relict Campbell Island teal population is confined to Dent Island (27 ha), which rises to 200 m a.s.l. and has a predominant vegetative cover of tussock *Poa litorosa*. The coastline of Dent is mainly steep and rocky with very limited access. The north-eastern part of the islet is sheer and bare of vegetation. There is little standing water. Because of these features it was felt that habitat use by Campbell Island teal on Dent would be unlikely to be a useful guide as to optimal conditions for the species.

Possibly the best indication of potential habitat suitability for Campbell Island teal was obtained by examination of their analogue species *A. aucklandica*. Auckland Island teal are at their highest density at Boat Bay, on Ewing Island in the Auckland Islands group. At this site there is easy access to sheltered rocky coastlines, tidal mudflats, and inland waterways. Auckland Island teal have been observed feeding on amphipods within piles of seaweed that accumulate along the more sheltered sections of shoreline. It is assumed that arthropods are an important part of teal diet.

Whenua Hou Nature Reserve on Codfish Island was chosen as the site for the establishment of a holding population of Campbell Island teal, more by a process of elimination, than because it provided ideal conditions. The island is covered by kamahi/podocarp forest, with shrubby wetland areas on the tops and mutton-bird scrub on exposed slopes. There is limited semi-permanent standing water (primarily associated with the larger of the island's two catchments) which flows out to Sealer's Bay in the north-east. Most of the coastline of Whenua Hou is sloping rock platform which is too exposed to allow significant accumulation of seaweed. At Sealer's Bay the teal have been recording using a wide range of coastal and wetland habitats, including dune ponds, ephemeral wetlands, and streams. They have been observed feeding on

the sandy beach and among the isolated and temporary piles of seaweed. The diet of Campbell Island teal is not well known, but is believed to be mainly invertebrates, but also grass seeds and possibly other vegetative matter. The Whenua Hou Nature Reserve on Codfish Island (Whenuahou) was chosen as a holding island because it was sufficiently large, free of introduced predators, and had a range of coastal and freshwater habitats. It did not however, have significant shallow tidal areas or sheltered bays where seaweed would accumulate. Observations of habitat use by Campbell Island teal on Whenua Hou have been taken as an indication of habitat selection plasticity and variability of diet, although a possible reliance on freshwater areas was noted (McClelland 2002).

Campbell Island offers a wide range of habitats, including streams, tidal mudflats, a lake, sandy beaches, and both sheltered and exposed rocky coasts. These encompass habitat types used by the Campbell Island teal on Whenua Hou Nature Reserve. There is the expectation that several sites on Campbell Island could hold sizeable teal populations and that food should not be a limiting factor (McClelland 2002)

Four potential release sites have been identified by the Recovery Group, these are:

- Tucker Cove, Perseverance Harbour
- North-west Bay (including Windlass Bay)
- Six-foot Lake
- North-east Harbour

These sites are all separated from each other by high ridges and long stretches of exposed coast. It is likely that teal will take a long time to colonise all suitable habitat on Campbell Island unless released at all of these sites. Specific release sites are not further considered here. It is assumed that the selection of specific release sites will be made by the Recovery Group.

2.4 IDENTIFICATION AND ELIMINATION OF CAUSES OF DECLINE

Of critical concern is identification, and elimination or reduction, of the previous causes of decline (IUCN 1998). The apparent early and rapid extirpation of teal from Campbell Island following invasion by rats, and the failure of teal to re-establish naturally on Campbell Island despite intermittent immigration from Dent Island, is a strong indication that the presence of Norway rats on Campbell Island was the cause of decline.

New Zealand conservation managers have pioneered techniques for the eradication of introduced mammalian predators from offshore islands, with over 20 successful island rat eradications to date. Campbell Island (11 216 ha) is the largest island on which rat eradication has been attempted in New Zealand. The next largest island from which rats have been successfully removed is Kapiti Island (1960 ha) (Empson & Miskelly 1999). The technique used aerial broadcast of bait pellets containing the anti-coagulant Brodifacoum.

Bait distribution trials started on Campbell Island in 1999 and confirmed that a single application of baits at a density of 6 kg per hectare would be adequate,

providing baits could be spread over the entire island. In mid 2001 poison baits were successfully distributed over the entire island in a co-ordinated operation involving four helicopters. Evaluation of the success of the eradication took place in early 2003, at which time Campbell Island was found to be free of rats. Re-introduction of Campbell Island teal could, therefore, take place from 2004 (Subantarctic Teal Recovery Group 2003).

2.4.1 Habitat restoration

Between 1895 and 1931 Campbell Island was farmed using imported sheep and cattle. The native vegetation was burned to improve grazing conditions. Livestock were removed completely by 1998 when all of New Zealand's subantarctic islands were made a World Heritage Area. Feral cats were present on the island during the farming period, but are believed to have died out naturally following vegetation recovery after the removal of grazing livestock. There is no perceived need to undertake specific habitat restoration to ameliorate the vegetation changes caused by earlier grazing.

Norway rats are believed to have been responsible not only for the extirpation of teal from Campbell Island, but also for the extinction on the main island of snipe and pipits, storm petrels, diving petrels, and prions. Eradication of rats may enable the natural recolonisation of Campbell Island by seabirds, pipits, and perhaps also snipe. In addition, rats have had an impact on the island's vegetation and invertebrate fauna. The nature of these changes is not well understood and there are no plans to undertake specific habitat restoration of these elements.

2.4.2 Predator control

Brown skuas (*Catharacta skua*) are currently perceived to be the principal potential predator of teal adults and ducklings. However, until their impact is confirmed and assessed, control measures are not recommended because skuas are not abundant on Campbell Island. Black-backed gulls (*Larus dominicanus*), and to a lesser extent northern giant petrels (*Macronectes halli*), may also prey on teal.

2.5 AVAILABILITY OF SUITABLE RELEASE STOCK

There are three potential sources of release stock for the re-introduction of teal to Campbell Island:

- Wild birds from the remnant population present on Dent Island
- Wild birds deriving from the releases in Whenua Hou Nature Reserve in 1999 and 2000
- Captive birds held in two facilities: National Wildlife Centre (Mount Bruce), and Peacock Springs

2.5.1 Whenua Hou Nature Reserve teal

It is intended that the teal population established at Whenua Hou should be used as a source of wild-adapted founders for releases onto Campbell Island,

and that ultimately all Campbell Island teal should be removed from the Whenua Hou Nature Reserve. The principal challenge in translocating the Whenua Hou population to Campbell Island will be the capture of free-ranging birds, although it is possible this may be feasible with the use of trained dogs (J. Carroll pers. comm.). Recent (March 2003) estimates of the size of the Whenua Hou teal population indicate at least 28 birds are present on the island, including at least 17 adults (Subantarctic Teal Recovery Group 2003).

2.5.2 Captive teal

The captive Campbell Island teal population available for release is held at two breeding facilities: National Wildlife Centre—27 birds (14:13), and Peacock Springs—4 birds (3:1). Captive management of Campbell Island teal has sought to maintain a self-sustaining population with maximum genetic diversity, through limited breeding. Based on a captive breeding resource of 15 pairs (11 at National Wildlife Centre, 4 at Peacock Springs) and planned and existing holding facilities, an annual captive production of 40–60 birds could realistically be available for releases onto Campbell Island.

2.5.3 Dent Island teal

The Dent Island population is considered to be a source of release stock for a Campbell Island re-introduction only in the case of emergency (Subantarctic Teal Recovery Group 2003). What constitutes an 'emergency' has not been defined, and we recommend that the Recovery Group develops a criterion to cover this point.

2.6 RELEASE OF CAPTIVE STOCK

The IUCN guidelines (IUCN 1998) note that captive-bred animals, particularly mammals and birds, may lack the behavioural survival skills ordinarily obtained through learning and experience gained as juveniles, and that some form of pre-release training may be necessary. McClelland (2002) considered the option of training founder teal to recognise and respond appropriately to any natural predators they may encounter on Campbell Island to be unnecessary. The results of the release of captive teal in Whenua Hou Nature Reserve—83% survival, but probably 33% if missing birds are assumed to have died, and possibly as low as 13% in some sites (McClelland 2002)—suggest that relatively high post-release survival may be possible without pre-release predator recognition training.

Captive-bred teal may need to be introduced to natural food items prior to release to facilitate adjustment to new food types on Campbell Island. Also, if supplementary food is to be provided during the immediate post-release period (as for brown teal releases; see below) then captive birds should be given an opportunity to learn to take feed from standard feeders.

3. Planning, preparation, and release stages

Aim—Re-establishment of Campbell Island teal on Campbell Island (McClelland 1993)

Objective—The persistence of at least two self-sustaining sub-populations of Campbell Island teal at sites on Campbell Island, within 5 years of the first releases.

3.1 IDENTIFICATION OF INDICATORS OF SUCCESS

General agreement on what constitutes a successful re-introduction is lacking, and in many projects criteria for success are not explicitly stated. A variety of definitions have been discussed, including:

- Breeding by the first-born generation
- A three-year breeding population with recruitment exceeding adult death rate
- An unsupported wild population of at least 500 individuals
- The establishment of a self-sustaining population (Griffith et al. 1989; Sarrazin & Barbault 1996)

A major problem in a simple end-point categorisation of a re-introduction as a success or a failure is that, by any criteria, this definition is limited in time. Although the goal of a re-introduction might be reasonably stated as establishment of a self-sustaining population, this is not a criterion for success.

Any re-introduction will comprise a sequence of three objectives (Seddon 1999):

- The survival of the release generation
- Breeding by the release generation, and their offspring
- Persistence of the re-established population

Therefore, the following indicators of success are proposed for the re-introduction of teal to Campbell Island:

- Survival by one-year post-release exceeds 33% at any given site, for any given cohort, based on Whenua Hou post-release survival rates.
- Evidence of breeding by founder birds will be recorded by two years post-release, for each site.
- Annual adult survival at least 65%; annual juvenile survival (from hatch to one year of age) greater than 55% (based on values derived from Whenua Hou and the results of population viability analyses (see later)).
- Breeding productivity comparable to that achieved by teal on Whenua Hou, e.g. on average per year: breeding attempts by > 60% of breeding age females; > 3 eggs per clutch; hatching success > 75%; fledging success c. 50% (McClelland 2002: 51, table 13), with adjustment possible depending on the

age structure of the population to account for lower breeding productivity by one-year old females.

- Modelling of the probability of extinction *Pex* (defined as the frequency with which 100 virtual teal populations fall to zero within 100 years) of teal on Campbell Island, using parameters derived from post-release monitoring, indicate a *Pex* of less than 0.05, without need for population re-enforcement or other interventionist management measures.

3.2 HEALTH AND GENETIC SCREENING

There are two aspects of risk to be considered:

- Disease risks to the founders after release, arising from pathogens present in the environment at Campbell Island
- Disease risks faced by fauna of Campbell Island, arising from pathogens introduced by founder birds

Currently little is known of the disease status of Campbell Island teal in the wild, nor of potential pathogens in the avifauna of Campbell Island. It is recommended that the approved wildlife health management guidelines be followed, with particular attention to: the following (from Reed et al. 1998):

- Section 5.1: routine monitoring and surveillance in captivity and in the wild
- Section 5.2.1: evaluation of health risks before translocation, and minimisation of the risks of transfer of potential pathogens
- Section 5.2.5–7: site specific wildlife health management planning

3.3 CAPTURE OF WILD STOCK

Procedures developed in the capture of teal from Dent Island for captive management should be applied as appropriate.

3.4 TRANSPORT

There may be risks associated with transport of teal which could result in pre-release mortality, or which may weaken birds and possibly reduce post-release survival. In general the time taken to hold and transport the birds should be minimised. Two transport options are available: ship, or helicopter. The choice will depend also on logistic constraints and should be made by the Recovery Group.

3.4.1 Holding

Campbell Island teal exhibit high levels of intra-specific aggression, therefore, individual transport cages will be necessary.

3.4.2 Feeding

Experience with brown teal indicates the possible value of provision of supplementary food at the release site. We recommend that protocols developed for post-release feeding of brown teal are modified and adopted for Campbell Island teal. These protocols include pre-release feeder training, post-release feed periods, quantities of food, and weaning method.

3.5 DETERMINATION OF RELEASE STRATEGY

Using a population simulation modelling approach, this section of the report evaluates which combination of site, release group size, and timing of releases might be expected to yield an acceptably high likelihood of success, as assessed against the indicators set out above.

There were two aims for population-based simulations of Campbell Island teal re-introduction:

- To determine release parameters which maximise the chances of a successful re-introduction of Campbell Island teal to Campbell Island
- To detect parameters which are likely to be limiting Campbell Island teal survival and population growth on Campbell Island

3.5.1 Assumptions

- Up to four release sites are potentially available (see 2.3.1 above), the selection of priority sites will be made by the Recovery Group.
- Limited post-release dispersal means that each release site is to be considered a potential sub-population.
- A total of approximately 20 wild teal could be translocated from Whenua Hou, in a one-off operation in the first year.
- In any year a minimum of 30, but probably 40 captive-bred teal would be available for release.
- For the first year only there would be 60 (40 captive, 20 wild) teal available for release.
- For subsequent years there would be 40 (captive) teal available annually for release.
- Releases could take place over up to four years: 2004–2007, inclusive.
- The sex ratio of released teal is 50:50.
- Captive-bred birds will be released as juveniles (<1 year old), but teal translocated from Whenua Hou may be either juvenile or adult.
- Releases take place in August/September.

3.5.2 Alternative scenarios

The following potential scenarios were examined.

- A single release at a given site, without supplementation. Logistically this option is the easiest, with a focus on a single site each year, and with maximum numbers available per site and potentially no need to undertake re-enforcement via subsequent releases.

- A single release at a given site, with supplementation.
- Releases at two sites in a given year, without supplementation in subsequent years.
- Releases at two sites in a given year, with supplementation in subsequent years. This option gives lower numbers in founder groups and wider spread of operations, but potentially faster establishment over a wider area.

3.4.3 Methods

Vortex 5.1 (Lacy 1993) was used to model population extinction processes. Vortex considers a range of input parameters, and reports multiple simulations of populations in terms of extinction risk, population size and levels of inbreeding. The approach was to fix some input parameters, to vary those parameters that relate specifically to the release programme, or to mortality and recruitment, and to then report changes in population size and extinction probability.

Parameters that were manipulated were chosen because they are the ones that are most likely to be measured and/or controlled by managers. These were:

- Rate of supplementation
- Number of birds released in each supplementation
- Mortality rate in the 0–1 age class (i.e. from hatching age to recruitment)
- Female productivity—measured as number of hatched young per female
- Annual adult survival

Input parameters and the source of that data are given in Table 1. Range of values used in parameters that were manipulated are given in Table 2. Because only limited information is available for Campbell Island teal, as a start point we used data derived by McClelland (2002) from Whenua Hou Nature Reserve, or data based mainly on Auckland Island teal (M. Williams, DOC pers. comm.).

3.5.4 Results

Question 1: Will a single release result in population establishment?

Scenario 1: One release of 60 birds in one site in one year, with no further supplementation.

Variables: 10% of females produce no young; 80% of females produce 1–3 young (30% 1, 40% 2, 10% 3, 8% 4, 2% 5). Juvenile (0–1 years) mortality 63% (derived minimum value Whenua Hou, incorporating fledging success and post-fledging survival).

Outcome: all populations FAIL.

Scenario 2: As per scenario 1, except that female production is that of Whenua Hou (i.e. 7% of females produce no young, 7% produce 1, 50% 2, 22% 3, and 7% each for 4 and 5 young).

Outcome: all populations SUCCEED

Scenario 3: As per scenario 2, but increase juvenile mortality to 84% (derived maximum Whenua Hou value).

Outcome: all populations FAIL

Conclusion 1: A single release of all birds may be successful, but only if hatching rates match or exceed those of Whenua Hou, **and** juvenile mortality is

at the lowest end of the range reported for Whenua Hou. Small variations to hatching rate (both scenarios 1 and 2 have 80% of females producing 1–3 young), or < 20% change in juvenile recruitment can make the difference between success and failure.

Question 2: If scenario 2 works, can more than one site be used?

Scenario 4: Same as scenario 2 except 30 birds released into two sites.

Outcome: PARTIAL SUCCESS (probability of population extinction = 0.72 ± 0.045 S.E.)

Scenario 5: Same as scenario 4, but reduce juvenile mortality to 0.50.

Outcome: SUCCEED

Scenario 6: Same as scenario 2, but increase juvenile mortality to 0.75.

Outcome: FAIL

Conclusion 2: Releases of smaller numbers of teal into two sites in one year (30 per site) may work without supplementation, but juvenile mortality rate will have large bearing on outcome. Juvenile mortality on Whenua Hou, was 63 %, at this rate, releases at two sites would frequently fail.

Question 3: What is the effect of supplementing the initial release for two sites?

Scenario 7: Release at two sites (30 birds per site) in the first year, then in years 2 and 4 release 40 birds into site A, and in years 3 and 5 release 40 birds into site B. Female production as per Whenua Hou, juvenile mortality = 0.84 (as per scenario 3).

Outcome: FAIL

Scenario 8: Release at two sites (30 birds per site) initially, then in years 2 and 4 release 40 birds into site A, and in years 3 and 5 release 40 birds into site B. Female production as per Whenua Hou, juvenile mortality = 0.63 (as per scenario 2).

Outcome: SUCCEED

Scenario 9: Release at two sites (30 birds per site) initially, then in years 2 and 4 release 40 birds into site A, and in years 3 and 5 release 40 birds into site B. Female production at slightly more conservative levels (as per scenario 1), juvenile mortality = 0.63 (as per scenario 2).

Outcome: FAIL

Conclusion 3: Supplementing two sites does not increase the probability of teal establishing, because, as for conclusion 1, impact of recruitment and female production is marked.

Question 4: What is the effect of supplementing the initial release for a single site?

Scenario 10: Release at one site (60 birds), then in years 2–5 add the entire available captive production (40 birds per year). Female production at slightly more conservative levels (as per scenario 1), juvenile mortality = 0.63 (as per scenario 2).

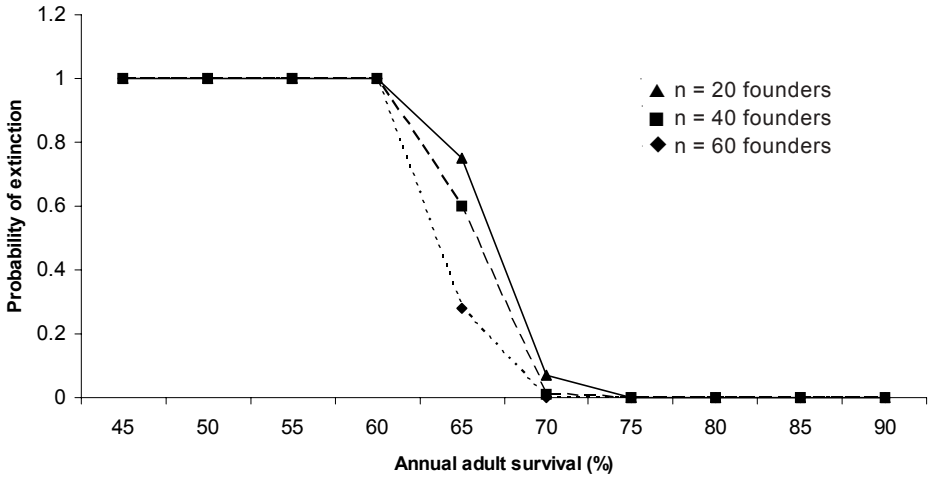

Figure 1. Effect of annual adult survival rate on the probability of extinction (*Pex*) of Campbell Island teal populations. Juvenile survival 0.37; female productivity as per scenario 1 (see text).

Outcome: PARTIAL FAIL. No populations go extinct for the first 38 years, the populations reach 200, then decline to extinction. *Pex* = 0.88 ± 0.0325

Scenario 11: Same as scenario 10, except release 60 birds, then supplement with 100 birds per year.

Outcome: PARTIAL FAIL. No populations go extinct initially, and populations reach 500, then decline to extinction. *Pex* = 0.60 ± 0.049

Conclusion 4: Putting all birds in one site, then supplementing with many birds (40–100) results in initially strong growth and no extinction. But after 30–50 years, these populations are likely to go extinct unless recruitment and/or production increase.

Question 5: What is the effect of annual adult survival rate on Pex?

Scenario 12: Release 60 birds at one site. Female production as per scenario 1; juvenile mortality = 0.63 (as per scenario 2).

Scenario 13: Same as scenario 12, except release 40 birds.

Scenario 14: Same as scenario 12, except release 20 birds.

Outcome of scenarios 12, 13, and 14: At annual adult survival rates of less than 65% the probability of extinction is 1.0 for all founder sizes (Fig. 1). *Pex* drops rapidly to 0.0 between adult survival rates of 60–70%. At 65% annual adult

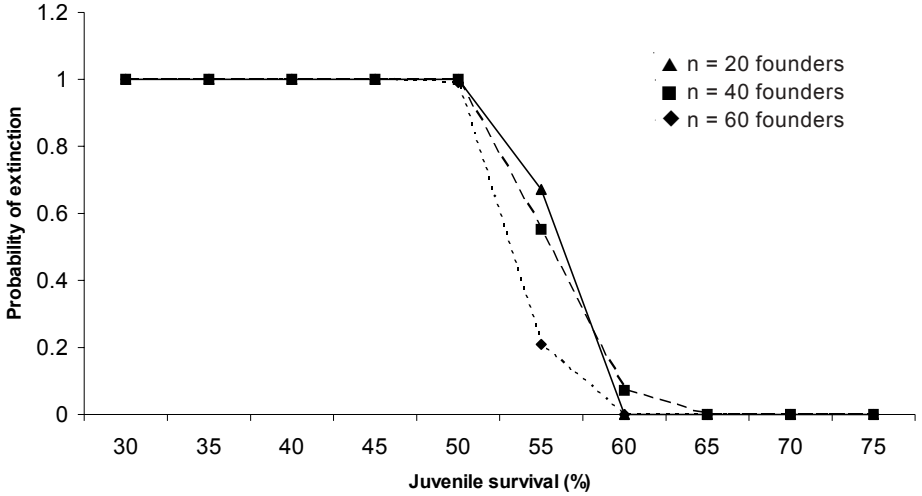

Figure 2. Effect of juvenile survival rate on the probability of extinction (*Pex*) of Campbell Island teal populations. Annual adult survival 0.65; female productivity as per scenario 1 (see text).

survival there was little difference in the *Pex* of releases of 20 (*Pex* = 0.75) and 40 (0.60) teal, whereas at 60 teal the *Pex* was reduced to 0.28. At 70% annual adult survival rate the *Pex* was either zero or negligible (Fig. 1).

Conclusion 5: Annual adult survival rates need to exceed 65% (adult mortality less than 35%) for there to be only a low probability of population extinction. If adult survival exceeds this threshold value of 65%, one-off releases of relatively low numbers of teal may result in population establishment and persistence.

Question 6: What is the effect of juvenile survival on Pex?

Scenario 14: Release at one site (60 birds). Female production as per scenario 1, adult mortality = 0.35 (threshold value from Question 5).

Scenario 15: Same as scenario 14, except release 40 birds.

Scenario 16: Same as scenario 14, except release 20 birds.

Outcome scenarios 14, 15, and 16: At juvenile survival rates of less than 55% the probability of extinction is 1.0 for all founder sizes (Fig. 2). *Pex* drops rapidly to zero between juvenile survival rates of 50–65%. At 55% juvenile survival there was little difference in the *Pex* of releases of 20 (*Pex* = 0.67) and 40 (0.55) teal, whereas at 60 teal the *Pex* was reduced to 0.21. At 60% annual juvenile survival rate the *Pex* was either zero or negligible (Fig. 2).

Conclusion 6: Juvenile survival rates need to exceed 55%, preferably approaching 60% (juvenile mortality less than 40%) for there to be a relatively low probability of population extinction. If juvenile survival exceeds this threshold value of 55%, one-off releases of relatively low numbers of teal may result in population establishment and persistence.

3.5.5 Summary conclusions and recommendations

Our general conclusions are as follows:

If: (a) Adult mortality is less than 0.35 AND
(b) Juvenile mortality is less than 0.40 AND
(c) 80 % of females hatch 1–3 young THEN
(d) Even a single release into a given site results in low probability of extinction.

If: (e) Adult mortality is greater than 0.35 OR
(f) Juvenile mortality is greater than 0.45 AND
(g) 80 % of females hatch 1–3 young THEN
(h) A population is unlikely to establish (even with a focus on only one site, and even with large numbers of birds (100) released annually for up to 10 years).

3.5.6 Recommended release strategy

It appears that, assuming the breeding performance of the Whenua Hou Nature Reserve teal is able to be achieved by teal on Campbell Island, releases of as few as 30 teal without supplementation may result in a self-sustaining population. Of critical importance however, are the realised rates of adult and juvenile survival, and of female productivity.

It is reasonable, therefore, to take the simplest approach of single releases into a given site. It will be important however, to establish and sustain a

comprehensive programme of post-release monitoring to determine whether threshold values for survival and productivity are being achieved. If these are not being reached, it is crucial to be able to assess why not, and whether mitigation of limiting factors may be possible. An adaptive management approach is advocated, whereby there is commitment to two years of releases and three seasons of monitoring at two sites, by which time the programme can be re-evaluated, and the feasibility of establishing populations at further sites can be considered.

If population establishment can be achieved through a single release in a given site, there is no immediate need for follow-up translocations to re-enforce a population. However, there is the potential for reduction in survival or fecundity to result from loss of genetic variation where effective population size is small (but see Craig 1991), and mixing between sites is low. In such circumstances there may be a case made for later population supplementation (Armstrong & Ewen 2001), although it is possible that rapid initial population growth may allow a high proportion of genetic variation to be retained even from small founder populations (Nei et al. 1975).

Therefore we recommend:

Year 1 (2004) Release 60 birds (20 wild-caught; 40 captive-bred) at one site (A) in August/September, and assess immediate survival and dispersal. *Note:* A comparison of survival and breeding is possible between wild versus captive-bred at a single site because resource availability is the same for the two types of founder.

Year 2 (2005) Release 40 captive-bred birds at a second site (B) in August/September, and assess immediate survival and dispersal at site B, and re-evaluate population status at site A.

Year 3 (2006) Possible release of 40 captive-bred birds at a third site in August/September and assessment of immediate survival and dispersal. Monitoring only at sites A and B (see Section 4 below).

At the end of Year 3, re-assess strategy, including analyses of new data, to determine future release requirements and population establishment goals.

3.6 INTERVENTION POLICIES

3.6.1 Supplementary feeding

Seek advice from the Brown Teal Recovery Group about the use and benefits of feeders. Birds should be trained to take supplementary food from standard feeders prior to release. The same feeders should be placed at the release site so that the released birds are free to take supplementary food during the immediate post-release period. By necessity supplementary food provision will cease once monitoring staff leave the area. Approximately 4–6 weeks of post-release feeding is suggested, mainly to allow time for reduction in post-release stress and for changes in gut morphology and/or flora to occur as birds adapt from a captive to a wild diet.

3.6.2 Veterinary care

Post-release veterinary care is not likely to be feasible, nor desirable given the need to assess baseline survival rates and reproductive output.

3.6.3 Predator control

Brown skua and black-backed gulls are the principal potential predators of Campbell Island teal adults and ducklings. It is uncertain to what extent local-scale predator control would be necessary or supported by the stakeholders. Observations during the January/February monitoring period in Year 2 should seek to confirm if these predators are limiting reproductive success at site A, and if so the possibility of local-scale reduction of predator impacts should be considered.

3.6.4 Inter-site translocation

Given the apparently limited dispersal ability of Campbell Island teal, consideration could be given to translocation of birds from burgeoning established populations in one site, to establish populations at new sites on Campbell Island. However, this is beyond the three-year time-frame of this current strategy, and fully dependant on the performance of teal at the initial 2–3 re-introduction sites.

4. Post-release activities

4.1 POST-RELEASE MONITORING

IUCN guidelines stress the need for post-release monitoring of all or a sample of individuals (IUCN 1998). Post-release monitoring will allow assessment of the success of the different phases of the re-establishment process and the timely evaluation of the possible reasons for failures (if any). In this way adjustments to methods or schedules may be possible during the translocation process, or revisions made to plans for any future re-introduction attempts. Given the relative dearth of information on the biology of Campbell Island teal, and the absolute lack of data on the ecology of the species on Campbell Island, detailed and sustained post-release demographic, ecological, and behavioural studies would be productive. Revised estimates of parameters such as age-specific survival rates, breeding productivity, and recruitment are required for modelling of the likelihood of longer-term persistence of any re-established population.

4.1.1 Marking

It is recommended that all released birds are radio-tagged to enable precise estimates of post-release survival and breeding productivity within the first year. Because standard radio-tags for use on teal have an expected life of 12–14 months (McClelland 2002), to extend intensive monitoring of the annual adult

survival rates and breeding performance of the release generation it will be necessary to re-tag a sample (15) of founder birds. It is worthwhile to investigate the possibility of enhancing battery life by turning off two-stage transmitters for long periods when no one is present on the island.

TABLE 1. CORE INFORMATION NEEDED TO ASSESS THE SUCCESS OF CAMPBELL ISLAND TEAL RE-INTRODUCTION.

ITEM	MEASURED AS	CRITERIA/THRESHOLD
Post-release survival	% of founders confirmed alive	Survival 1 year post-release >33%
Annual adult survival	% adults confirmed alive	Annual adult survival >65%
Breeding by founders	Dependent young with females	Any evidence of breeding
Juvenile survival	% chicks surviving to end year 1	Juvenile survival >55%
Breeding productivity	% females with young	>60% females breed
Breeding productivity	Clutch size in sample of nests	>3 eggs per clutch
Breeding productivity	Eggs hatched per eggs laid	>75% hatching success,
Breeding productivity	Chicks fledge per eggs hatched	>50% fledging success

Survival and productivity of founders may be different from that of wild offspring. It would be of use to catch and band juvenile birds located in years 2 and 3, using individually identifiable numbered bands colour-coded by cohort.

TABLE 2. INCIDENTAL INFORMATION WHICH COULD BE COMPILED DURING POST-RELEASE MONITORING OF CAMPBELL ISLAND TEAL.

ITEM	MEASURED AS
Dispersal of founders	Location of founders relative to release sites
Dispersal of juveniles	Location of juveniles relative to breeding sites
Distribution	Location of teal across Campbell Island
Habitat selection	Location of teal relative to habitat features
Diet	Observation of feeding areas, feeding methods, and items taken
Body condition	Adult and juvenile body mass during handling and remarking
Nest site selection	Location of nest sites relative to habitat features
Timing of breeding	Timing of laying, hatching and fledging

Consideration should be given to radio-tagging a sample (15) of the first wild-hatched generation at each site, to assess recruitment rates.

4.1.2 Data collection

The following information, relating to post-release survival, adult survival and juvenile survival, and founder breeding and breeding productivity, is needed in order to evaluate the indicators of success (Table 1).

Information on other aspects of Campbell Island teal behaviour and ecology are not critical to assessment of re-introduction success, but could be gathered incidentally (Table 2).

4.1.3 Collection and handling of dead teal

A standard protocol is required before the first releases take place, to detail the methodology for handling any dead teal that may be recovered. Particular attention should be paid to:

- Collecting swabs off freshly dead birds for later analyses
- Preservation of specimens in a manner that maximises ability to determine the cause of death, including pathological examination (via Massey University, using Wildlife Health funds)
- Application of recent brown teal work that examined wing fat to assess whether birds have starved (Moore & Battley 2003)

4.1.4 Timing and duration

In accordance with the release schedule set out in the previous section, the following monitoring schedule is recommended:

Year 1 (2004) Following the release of 60 birds (20 wild-caught; 40 captive-bred) at site A in August/September, assess immediate survival and dispersal.

Year 2 (2005) Return to site A during January/February the following year to re-assess survival and subsequent breeding. Evaluate breeding parameters.

Following the release of 40 captive-bred birds at a second site in August/September, assess immediate survival and dispersal at site B, and re-evaluate population status at site A.

Year 3 (2006) Revisit sites A and B during January/February to re-assess population status. Re-evaluate breeding parameters and undertake assessment of population persistence at the two sites using revised parameters and population viability modelling.

Assess whether threshold values for survival and productivity are reached or exceeded at both sites, or if values reached at one site, whether mitigation of limiting factors is possible at the other site.

If populations at sites A and B have successfully established according to criteria, consideration could be given to the release of 40 captive-bred birds at a third site in August/September. At that time a decision is needed on the intensity and duration of post-release monitoring necessary.

Note: The Recovery Group should consider the feasibility of extending post-release monitoring from September through to January/February in order to avoid the possibility of missing significant mortality in the period immediately after supplementary food is removed, and also to maximise the data that can be obtained from radio-tagged birds. It is possible that intensive post-release monitoring could form the basis for a student project, or similar.

4.1.5 Evaluation of success

- Analysis of survival rates 1 year post-release, for each site and each cohort. Comparison of survival rates between sites, between years, and between captive versus wild teal at site A.
- Compilation of evidence for breeding by released birds at 1 and 2 years after the initial releases.

- Analysis of breeding productivity annually for each site during the period 2–3 years post-release. Comparisons of breeding productivity between sites, between captive versus wild founders, and by age of female.
- Assessment of population status at the end of year 1, 2, and 3, with a summary of status against success criteria at 3 years after the first releases, and review of the possibility of releases at further sites.
- Assessment of population persistence and probability of extinction at end of year 3 using simulation modelling and parameters derived from post-release monitoring.

5. Summary of recommendations

- One-off releases of teal to given sites on Campbell Island may result in establishment of self-sustaining sub-populations without need for re-enforcement.
- However, this is dependent on exceeding threshold value for juvenile survival (55%), annual adult survival (65%), and breeding productivity; these values approximate those achieved by teal on Whenua Hou.
- If threshold values are not reached or exceeded then any number of releases at a given site are unlikely to result in long-term population persistence.
- It is therefore proposed that:
  - One-off releases of 40–60 birds take place at two sites over two years.
  - Intensive post-release monitoring is used to assess whether threshold values of survival and productivity are being achieved or exceeded.
  - Consideration is given to releases at further sites in the third and fourth years, if success criteria are met at sites A and B.

The proposed re-introduction and monitoring protocol is summarised in Table 3 (next page). Assessment criteria items in parentheses represent subsidiary information, as opposed to core indicators of success.

TABLE 3. PROPOSED RE-INTRODUCTION AND MONITORING PROTOCOL.
(Items in parentheses represent subsidiary information, as opposed to core indicators of success.)

YEAR	MONTHS	SITE	RELEASES	OTHER ACTIVITY	DATA COLLECTED	ASSESSMENT CRITERIA
2004	Aug/Sep	A	60	Assess immediate survival and dispersal	No. seen / no. released	(Immediate survival)
2005	Jan/Feb	A	none	Locate founders	No. seen / no. released	(Interim post-release survival)
				Locate and observe adult females	Presence of eggs, chicks	Evidence of breeding
	Aug/Sep	A	none	Locate founders	No. seen / no. released	Survival 1yr post-release >33%
				Trap and replace radio tags for sample (15)	Adult body mass	(Adult condition)
				Trap and colour mark any unbanded birds	Juvenile body mass	(Juvenile condition)
				Radio-tag sample (15) of unbanded birds	Juvenile body mass	(Juvenile condition)
		B	40	Assess immediate survival and dispersal	No. seen / no. released	(Immediate survival)
2006	Jan/Feb	A	none	Locate all tagged birds (founders)	No. current /no. previous	Annual adult survival >65%
				Locate radio-tagged sample of founders	No. seen / no. released	Annual adult survival >65%
				Locate adult females	No. dependent young/female	Estimate of hatching success
				Follow breeding of tagged females	Clutch size	>3 eggs/clutch
					Hatch	>75% hatch success
					Fledging success	>50% fledging success
		B	none	Locate founders	No. seen / no. released	Survival 1 year post-release >33%
				Replace transmitters for sample (15)	Adult body mass	(Adult condition)
				Trap and colour mark any unbanded birds	Juvenile body mass	(Juvenile condition)
				Radio-tag sample (15) of unbanded birds	Juvenile body mass	(Juvenile condition)
	Aug/Sep	A	none	Locate all tagged birds (founders)	No. current /no. previous	Annual adult survival >65%
				Locate radio-tagged sample of founders	No. current /no. previous	Annual adult survival >65%
		B	none	Locate all tagged birds (founders)	No. current /no. previous	Annual adult survival >65%
				Locate radio-tagged sample of founders	No. current /no. previous	Annual adult survival >65%
		(C+)	40	Locate all tagged birds (founders)	No. seen / no. released	(Immediate survival)
2007	Jan/Feb	A	none	Locate adult females	No. dependent young/female	Estimate of hatching success
				Follow breeding of tagged females	Clutch size	>3 eggs/clutch
					Hatch success	>75% hatch success
					Fledging success	>50% fledging success
		B	none	Locate adult females	No. dependent young/female	Estimate of hatching success
				Follow breeding of tagged females	Clutch size	>3 eggs/clutch
					Hatch success	>75% hatch success
					Fledging success	>50% fledging success

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Appendix 1

PARAMETERS USED IN VORTEX SIMULATIONS

(On following pages)

APPENDIX 1. PARAMETERS USED IN VORTEX SIMULATIONS FOR CAMPBELL ISLAND TEAL.

VORTEX VALUES	SUB-QUESTIONS	START DATA	OTHER VARIATIONS	COMMENT
Simulations		100		
Years to run models		100		
Extinction reports		every 1 years		
Number of populations		1		More than one requires indication of migration rate between them
Migration rate		0		
Inbreeding depression		No		If yes then model decreases first year survival rates
Is EV(reproduction) correlated to EV (survival)		Yes		If yes then a good year for breeding is also a good year for surviving
Catastrophes		No		No data on likely events or impacts
Breeding system		Monogamous		
Age at first breeding	Female	Female 1 year		
	Male	Male 1 year		
Maximum age when still breeding		10		
Sex ratio at birth		0.5		
Maximum number of young per clutch		5		McClelland (2002)
Density dependent reproduction		No		No because space/habitat not limiting, at least initially.
		REALISTIC*	REAL*	
Mean litter size (hatching rate)	% of females with litter size 0	10	7	
	% of females with litter size 1	30	7	
	% of females with litter size 2	40	50	
	% of females with litter size 3	10	5	
	% of females with litter size 4	8	7	
	% of females with litter size 5	2	7	
	SD for % litter size†	5	5	Highly susceptible SD = 0.5 × non-reproductive females ('NRF'), Slightly tolerant SD = 0.25 × NRF, Highly tolerant SD = 0.05 × NRF. We use 'highly susceptible' values
Annual mortality rates (% deaths year)	0–1 age group	0.63	0.84	Juvenile data from McClelland (2002). Juvenile world literature on all teal expect around 0.5; Adult data from literature = 0.35 (Johnson et al. 1992)
	1–2	0.35		
	2–3	0.35		
	3–4	0.35		
	4–5	0.35		

* Figures are from McClelland (2002) for Real, and modified slightly, but conservatively, for Realistic.

† This is calculated for each % of eggs, but we will fix this as being the same variation for clutches of 1–7 eggs.

(Continued next page)

VORTEX VALUES	SUB-QUESTIONS	START DATA	OTHER VARIATIONS	COMMENT
	5–6	0.35		
	6–7	0.35		
	7–8	0.35		
	8–9	0.35		
	9–10	0.35		
SD of mortality due to EV		0		
Impact of catastrophes	Probability of occurrence (1 = will happen, 0 = won't happen)	0		none, set above
	Severity (0 = total, 1 = no effect) for reproduction and survival separately	n.a.		none, set above
Mating system	Are all males in the breeding pool	Yes		Yes for now, because data uncertain. 56–58% male bias typical for other waterfowl (Williams pers. comm.)
Initial population size	Is population structure stable or unstable?		Unstable	It is unstable because all birds are released and will be <2 years old
	Initial population = release size, 20–30		1 site 60, 2 sites 30	
	List of age structure required for males and females separately to add to total population size		20–30 each of females and males aged 0–1 year, nil at other ages	
Carrying capacity	Use K = 1000	1000		At K = 100, capacity limited, at K = a big number (e.g. 10 000), capacity not limiting
SD of K due to EV		0		
Trend in K or stable		Stable		
Trend over how many years		n.a.		
% annual increase/decrease in K		n.a.		
Harvest		No		
Supplementation		Two sites, repeated 2 years	One site repeated 4 years	Run scenarios of 1–3 releases at one site
		Year 2 A, year 3 B, year 4 A, year 5 B	Year 2 A, year 3 A, year 4 A, year 5 A	
	First year of supplementation	1	1	
	Last year of supplementation	3	4	
	Frequency of supplementation	2	1	
	How many males	20	20	50% of total released
	How many females	20	20	50% of total released
Reports	Probability of population persisting	Yes		
	Annual probability of extinction	Yes		
	Total N	Yes		
	Genetic diversity	No		
	Inbreeding depression	No		