Translocation of great spotted kiwi/roa (*Apteryx haasti*) to Rotoiti Nature Recovery Project

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Executive Summary

Nine adult wild great spotted kiwi/roa (*Apteryx haastii*) were transferred in a trial reintroduction from the Gouland Downs (North-west Nelson) to the Rotoiti Nature Recovery Project area, a Department of Conservation ecosystem restoration project or mainland island in Nelson Lakes National Park. A tenth kiwi was injured during the transfer and was not able to be rehabilitated for release into the wild.

All nine released kiwi remained within the unfenced Rotoiti Nature Recovery Project area during the year after the release, and the majority of kiwi gained weight. One breeding attempt was identified and is considered to have resulted in a fertile egg hatching, although a chick was not seen.

The results of the trial reintroduction suggest that wild-to-wild transfers of adult great spotted kiwi may be an effective way of establishing new founder populations in favourable areas. A second transfer is recommended to allow further study and improvement of the transfer method, and to enhance opportunities for founder population monitoring and management in the future.

1. Introduction

This report describes a trial wild-to-wild reintroduction of great spotted kiwi/roa (*Apteryx haastii*) to an unfenced mainland site. During May 2004 ten adult kiwi were transferred from the Gouland Downs (North-west Nelson) to the Rotoiti Nature Recovery Project (RNRP) area, a Department of Conservation "mainland island" in Nelson Lakes National Park. Nine kiwi were released into the Rotoiti Nature Recovery area and appear to have established a small founder population. One kiwi was injured during the transfer and consequently can not fend for itself in the wild. This bird is now being held at Willowbank Wildlife Reserve, Christchurch, where it may be used in a future captive breeding programme.

The transfer under discussion was a trial because there was no documented precedent to suggest whether or not the reintroduction would be successful. Previous attempts at relocating wild great spotted kiwi to Little Barrier Island in 1915 and wild North Island brown kiwi to unfenced mainland sites late last century all apparently failed, but were not monitored using radio-telemetry. One risk that was anticipated and planned for was dispersal from the RNRP recovery area. In fact, there was no dispersal from the RNRP recovery area during the year following the release. This reintroduction is a milestone for kiwi management and for the project: it is the first wild-to-wild transfer of adult kiwi to an unfenced mainland site to be adequately monitored and documented; and it is the first reintroduction of a protected species to the RNRP recovery area.

A range of activities are covered in this report, including planning for the translocation; kiwi collection, transfer and release; post-release monitoring; and kiwi recaptures and health checks approximately one year after the release. The translocation operational plan specified a set of performance standards to be met during the transfer. The role of performance standards in defining the success of the trial reintroduction is discussed in section 12.2, and the full list of performance standards and the translocation team's assessment of whether the standards were met are set out in Appendix 4. Also discussed in this report are baseline kiwi surveys and post-transfer kiwi surveys at Corkscrew Creek, the source location for the kiwi on the Gouland Downs. This information is used to assess the impact that the translocation had on the source population; but it is of further interest in that it contributes to knowledge about the density of the source population.

It is hoped that the information and recommendations in this report will assist managers to plan future reintroductions to protected areas managed for biodiversity recovery. As sites within the former range of great spotted kiwi are brought under sustained conservation management it may become increasingly important to reintroduce kiwi to those sites, particularly if great spotted kiwi populations continue to decline in unmanaged areas.

The reintroduction of great spotted kiwi to the RNRP recovery area follows thousands of hours of research, monitoring and pest control undertaken by the RNRP team since 1997. RNRP predator control methods are not discussed at length in this report, as that topic is adequately covered by RNRP annual reports. Adult great spotted kiwi are large robust birds, capable of fending off many of the introduced predators found in the New Zealand bush. The reintroduction of adult great spotted kiwi to a new site is reported on here, but the next big step will be to monitor the breeding and offspring of these adults and any others that may be transferred to the RNRP recovery area, to determine if the RNRP recovery area provides all the necessary conditions for a kiwi population to establish and flourish.

2. Background

2.1 GREAT SPOTTED KIWI BIOLOGY AND CONSERVATION

Great spotted kiwi/roa (*Apteryx haastii*) are a large grey mottled kiwi (Apterygidae) endemic to New Zealand's South Island. As with all kiwi species, adult females are larger than adult males. There can be considerable size difference between birds from different sites, most likely due to climatic difference (as described by Bergmann's Rule). Female great spotted kiwi can reach 4.5kg weight in cool upland areas, making them the largest kiwi; however males are usually no heavier than 3kg (Worthy & Holdaway 2002). All kiwi species are more or less nocturnal and feed mostly on invertebrates by probing in litter or soil; however great spotted kiwi apparently consume more seeds and leaves than other kiwi species (McLennan and McCann 1991).

The great spotted kiwi is an avian example of a K-strategist breeder, apparently capable of producing no more than one chick per year. Most of what is known about great spotted kiwi breeding biology is the result of McLennan and McCann's 1987-1990 work at two study areas: the Saxon and Kahurangi Point, Northwest Nelson. Male and female great spotted kiwi form long-lasting monogamous pair-bonds. Females lay a single egg between mid-winter and mid-summer and will seldom replace this if it fails during incubation. The male incubates the egg during the day and part of the night, but the female incubates for about five hours during the night while the male takes time off to feed. Incubation is difficult to observe as great spotted kiwi do not tolerate disturbance at the nest site, and are inclined to abandon the nest. Males may break the egg when humans approach the nest too closely during the early stages of incubation. The egg is incubated for about 70 days before hatching (McLennan and McCann 1991).

Great spotted kiwi utilize a variety of forest, scrub and grassland habitats from warm lowlands to the cool alpine zone[1]. There are three extant populations of great spotted kiwi which were estimated to collectively comprise 22,000 individuals in 1996, but were expected to have declined to some 12,000 individuals by about 2006 (Robertson 2003). McLennan and McCann provided estimates of each population size based on surveys conducted between 1983 and 1994. The largest population was in Northwest Nelson, between Golden Bay and the Buller River, which was estimated to comprise some 10,000 – 11,000 individuals in the north, and 2,000 – 3,000 in the south. The next largest population was in the Paparoa Ranges, and was estimated to comprise some 6,300 individuals. The smallest was the Arthurs Pass - Hurunui population straddling the Southern Alps, estimated to comprise about 3,000 individuals (McLennan and McCann in Overmars 2002).

[1] Great spotted kiwi have been recorded on a range of land environments, as defined in the Ministry for the Environment and Landcare Research "Land Environments of New Zealand" (LENZ) classification system. Great spotted kiwi have been recorded on Level II Land Environments E4, F1, F5, H1, K1, M1, M2, O1, O2, O3, P1, P2, P3, P5, P6 R1 (Source: kiwi records from Department of Conservation "Bioweb - casual observations" database; LENZ analysis, DOC IMU Nelson). The Bioweb data is only a subset of all great spotted kiwi distribution records, and great spotted kiwi are likely to be found on a number of additional land environments.

The historical and prehistorical distribution of great spotted kiwi is not well described. The historical record is sparse, and it is not always clear which kiwi species is being referred to. The fossil record of kiwi distribution has not been reviewed, and the correct identification of great spotted kiwi bones is difficult because there is considerable overlap in size between great spotted kiwi bones and brown kiwi bones, and there are no apparent qualitative differences between them (Worthy & Holdaway, 2002.). Although large kiwi bones (i.e. larger than little spotted kiwi) are common in the cave deposits of western and northern South Island, only some (notably all those from sub-alpine sites on Mount Arthur and Mount Owen) are outside the known size range for brown kiwi bones, and are thus probably great spotted kiwi bones (Worthy & Holdaway, 2002).

The great spotted kiwi is classified as a category 5 (gradual decline) chronically threatened species (Hitchmough 2002). This conservation ranking is assigned to species with moderate to large populations experiencing a small to moderate rate of decline. Qualifiers relating to the great spotted kiwi conservation ranking are HI (human induced) and RF (recruitment failure). The main agent of decline is likely to be stoats, which prey on kiwi chicks weighing less than 1000 grams. Predation by stoats is known to seriously impact on recruitment of juvenile brown kiwi, and there is no reason to suppose that great spotted kiwi chicks could resist stoat attacks. Very few great spotted kiwi chicks have been encountered by kiwi workers. Stoats are widespread in the South Island, but may not be abundant in the western uplands where great spotted kiwi are most common. Known threats to adult kiwi include dogs, possum traps, motor vehicles and vegetation clearance.

In the 1990s McLennan and McCann's work suggested that there may be upland refugia where great spotted kiwi densities are relatively stable, but that great spotted kiwi are most likely in decline in lowland areas (McLennan & McCann 1991; McLennan & McCann in Overmars 2002). This model has found acceptance amongst kiwi workers, and monitoring in the Saxon study area on the Gouland Downs (an upland area) has shown that the study population remained stable over 15 years, and that there has been some population turnover and recruitment (Robertson et al 2005). While great spotted kiwi populations may be stable in some upland areas, there is little known about rates of population decline across the whole range of great spotted kiwi.

There are no conservation programmes focussed specifically on protecting great spotted kiwi; however great spotted kiwi are offered a level of protection in the Hurunui Mainland Island (Southern Alps population); and Operation Ark predator control projects may also benefit the Southern Alps population. From 1997 to 2000 the Department of Conservation's Hokitika Area Office attempted a pilot study to determine the outcomes of nine apparent great spotted kiwi breeding attempts in the Taramakau Valley (Southern Alps population). Improvements were made to monitoring methods during the course of the study, but the most optimistic result from the study was that no more than one third of the potential breeding opportunities could have resulted in a chick being hatched. No information was gathered about chick and juvenile survival, which are the most vulnerable stages of the life cycle (Eastwood 2002).

2.2 ROTOITI NATURE RECOVERY PROJECT

The Rotoiti Nature Recovery Project (RNRP) is a Department of Conservation ecosystem restoration project or "mainland island" located in the montane southern honeydew beech (*Nothofagus* spp.) forests surrounding the township of St Arnaud, Nelson Lakes National Park. The recovery project takes its name from Lake Rotoiti, an adjacent post-glacial lake cradled between the greywacke St Arnaud and Travers Ranges at the northern extremity of the Southern Alps. The lake surface is 620 metres above sea level and the mountain ranges adjacent to Lake Rotoiti exceed 1800 metres above sea level. Southern beech forest cloaks the mountain ranges up to the timber line at about 1400 metres, above which tussock grassland is the main vegetation cover, although there are extensive areas of bare scree and boulder field.

The goal of Rotoiti Nature Recovery Project is to restore a beech forest community, with emphasis on the honeydew cycle (Butler 1998). Honeydew is a sugary substance exuded from the scale insect *Ultracoelostoma spp.* which burrows into the trunks and branches of red beech (*Nothofagus fusca*), black beech (*Nothofagus solandrii*) and mountain beech (*Nothofagus solandrii* var. *cliffortoides*). In certain forests of the northern South Island honeydew scale insects can reach extremely high densities, and honeydew becomes an important ecological driver. Honeydew is an important food source for endemic invertebrates and birds; however it is also sought after by introduced competitors including European and common wasps (*Vespula* spp.), which can reach extremely high densities in honeydew beech forests.

Another important ecological driver in the beech forests surrounding Lake Rotoiti is the periodic full masting of beech trees, in which massive quantities of beech seed become available to indigenous and introduced fauna alike. Full beech masting is not an annual event, but tends to occur at 3-5 yearly intervals (Wardle 1984, Wilson et al., 1998) though there is evidence that its frequency is increasing. Beech flowering and seeding promotes the breeding of several endemic bird species including South Island kaka (*Nestor meridionalis meridionalis*) and yellow-crowned parakeet (*Cyanoramphus auriceps*); however the abundance of beech seed also promotes rodent population explosions and consequent increases in introduced predators, particularly mustelids (stoats and weasels). Rodents and mustelids can have serious impacts on populations of New Zealand's endemic avifauna, and beech masts have been shown to result in endemic bird population crashes (Gaze 2001).

The Rotoiti Nature Recovery Project uses a range of pest control methods to reduce pest abundance and pressures within the recovery area. Much of the effort is focussed on managing the adverse effects of rodents, mustelids and introduced wasps. Work began on infrastructure and baseline monitoring in the spring of 1996, and comprehensive pest control and monitoring began across an 825ha core area in1997. In 2001 the recovery project was expanded to implement predator control across more than 5000ha. Predator control in the recovery area has been shown to benefit a number of endemic bird species, including bellbird (*Anthornis melanura*), tui (*Prosthemadera novaeseelandiae*) and South Island kaka. The RNRP mainland island is the only area in New Zealand to be intensively managed for the restoration of honeydew beech forest values, and it is thus unique.

Kiwi have been missing from the vicinity of the RNRP recovery area for some decades, and the RNRP translocation team has found no reliable historical references to kiwi at Lake Rotoiti. In October 2001 David Butler wrote a paper documenting historical records of kiwi distribution in the vicinity of present day Nelson Lakes National Park surrounding districts. Butler concluded that Nelson Lakes is within the previous range of little spotted kiwi, and that little spotted kiwi would be a candidate for reintroduction to the RNRP recovery area (Butler 2001). Large kiwi were also present between Lakes Rotoiti and Rotoroa in historical times, with the most useful description being of "large grey kiwis – often seen in daylight" in the Buller/Glenhope area in the 1920s. It seems likely that this is a reference to great spotted kiwi. Sub-fossil kiwi bones have been found in a deposit on the Red Hills, fourteen kilometres north-east of St Arnaud. The deposit included bones of little spotted kiwi and those of a larger species of kiwi. The larger bones have not been DNA tested, and could belong to either brown kiwi or great spotted kiwi. No other sub-fossil bone deposits have been found near the RNRP recovery area. The advice of one palaeontologist was that three kiwi taxa are likely to have been present about present-day Nelson Lakes National Park in prehistoric times: little spotted kiwi, great spotted kiwi, and a species of brown kiwi (Trevor Worthy pers. comm.). In modern times, great spotted kiwi is the species that can be found closest to the RNRP recovery area, some 50km to the west.

2.3 PURPOSE OF THE TRANSLOCATION

One of the Rotoiti Nature Recovery Project's three restoration objectives is to reintroduce recently depleted species, and the project's strategic plan identifies several avian taxa including kiwi as candidates for reintroduction (Butler 1998). The transfer of great spotted kiwi to the RNRP recovery area is a milestone for the project, as this is the first attempt at reintroducing any species into the area. Kiwi almost constitute a guild of their own (Worthy & Holdaway 2002); and returning kiwi to the RNRP recovery area is a step towards restoring ecosystem functions and processes that were lost as a result of pest pressures and localised extinctions in honeydew beech forests.

The long-term goal for kiwi recovery is to maintain and, where possible, enhance the current abundance, distribution and genetic diversity of kiwi (Robertson 2003). The translocation of great spotted kiwi to the RNRP recovery area will - if successful - contribute to achieving this goal by increasing the distribution of great spotted kiwi within the species' likely former range. The establishment of a great spotted kiwi population within the RNRP recovery area would also offer a greater level of security to the species by bringing a great spotted kiwi population under sustained conservation management.

The current attempt at translocating great spotted kiwi is ground-breaking because there are no well documented accounts of wild-to-wild translocations of this species, and there is no existing best practice method for establishing new populations. The results of this translocation can contribute to the development of such a method. Great spotted kiwi are relatively abundant at the present time, but current abundance is not a guarantee of future abundance. While translocation is not critical to great spotted kiwi conservation in the short

term, it may become an important technique for conserving the species in the future. As areas within the former range of great spotted kiwi are brought under sustained conservation management, it may become increasingly important to establish great spotted kiwi populations in those areas, particularly if populations decline in unmanaged areas.

The establishment of a great spotted kiwi population within the RNRP recovery area is also expected to benefit great spotted kiwi conservation through research, education and advocacy. If a great spotted kiwi population is successfully established within the recovery area it will be one of the most accessible populations, and this accessibility will enable regular and detailed monitoring. The RNRP translocation team aspires to make a substantial contribution to knowledge about great spotted kiwi breeding biology, management requirements and management techniques. The Rotoiti Nature Recovery Project may also prove to have an important role as a provider of education opportunities for people and groups interested in great spotted kiwi; and may adopt a regional role in advocating for kiwi conservation in general.

All of the benefits that may accrue from this translocation are only possible because of the Rotoiti Nature Recovery Project's restoration goal, and because of the role that mainland island sites have in developing and testing conservation management techniques. At the present time, great spotted kiwi are not regarded as sufficiently threatened to receive single-species conservation effort, and there are no other great spotted kiwi populations currently under intensive conservation management. While the RNRP translocation team cannot predict what the management requirements for great spotted kiwi populations will be in the future, the team does predict that some of the knowledge gained from the current great spotted kiwi translocation will be applicable.

2.4 PREVIOUS ATTEMPTS AT ESTABLISHING MAINLAND KIWI POPULATIONS

2.4.1 Great spotted kiwi wild-to-wild transfers

The RNRP translocation team has found no detailed accounts of wild-to-wild great spotted kiwi translocations being undertaken in the past, although seven pairs transferred from Nelson to Little Barrier Island in 1915 failed to establish (Heather & Robertson 1996). References to Richard Henry transferring roa between mainland and island sites in Fordland during the 19th century are references to southern tokoeka, not great spotted kiwi (Colbourne 2005).

2.4.2 North Island brown kiwi wild-to-wild transfers

Wild-to-wild transfers have been attempted with North Island brown kiwi during the 20th century, but the transfers apparently all failed to establish enduring founder populations, and monitoring was inadequate to determine the reason for failure. The reintroduction specialist group Oceania section website (http://www.massey.ac.nz/~darmstro/rsg.htm) states that in the past there were several attempts to re-introduce kiwi to mainland areas in southern Northland, Hawkes Bay and the King Country using birds salvaged from areas

being cleared or logged in Northland, but that these attempts failed. A reintroduction to the Waitakere Ranges involving a series of wild-to-wild transfers during the 1980s apparently failed; however the kiwi were not radio-tagged and their fate was not monitored (MacMillan 1990).

2.4.3 Monitored attempts at establishing new mainland kiwi populations

Captive rearing is frequently used as a method for producing North Island brown kiwi to supplement existing island or managed mainland populations. Less frequently, captive reared kiwi have been reintroduced to mainland areas where kiwi were lately absent and the management does not depend on wildlife fencing to exclude predators and confine kiwi. In recent years, captive-reared North Island brown kiwi have been used to establish two small populations at unenclosed mainland sites, and in both cases the reintroductions have been monitored using radio transmitters.

Between December 2003 and December 2004 ten captive-reared North Island brown kiwi were released into Pukaha Forest, a predator control area adjacent to Mount Bruce National Wildlife Centre. One kiwi accidentally drowned, but the other nine kiwi appear to have survived and remained within the predator control area, although two kiwi have dropped their transmitters and have not yet been recaptured. Two pairs of kiwi have produced fertile eggs in Pukaha Forest during the 2005 breeding season (Tony Silbery pers. comm.).

A founder population of twenty captive-reared North Island brown kiwi has been established at Boundary Stream Mainland Island, Hawke's Bay. The releases began in 2000 and a total of 34 captive-reared kiwi have been released. Fourteen of the released kiwi were lost to a variety of causes including transmitter failure, predation, accidents and disease. Six of the remaining kiwi have paired, and one pair produced chicks in 2004 (Tamsin Ward-Smith pers. comm.).

2.4.4 Discussion of previous attempts at establishing mainland kiwi populations

Prior to the 2004 transfer of great spotted kiwi from Gouland Downs to the Rotoiti Nature Recovery area, the only kiwi taxa that had been successfully reintroduced to unenclosed mainland sites was North Island brown kiwi, and all of the birds were captive-reared. None of the successful reintroductions to mainland sites were the result of wild-to-wild transfers, and no wild-to-wild transfers have been adequately monitored to determine the reasons for their failure. Furthermore, a transfer of great spotted kiwi to an island site in 1915 was unsuccessful and uninformative. Two reintroductions of North Island brown kiwi to unenclosed mainland sites are succeeding insofar as a substantial portion of kiwi have survived and remained near the release sites, and some are breeding. Although these reintroductions are comparable to the great spotted kiwi reintroduction to the RNRP recovery area in that they are reintroductions to unenclosed mainland sites, the North island reintroductions differ in that the birds are a different taxa and were all raised in captivity. Prior to the RNRP reintroduction, there was a lack of information about the likely outcome of reintroducing adult great spotted kiwi to an unenclosed mainland site.

3. Development of the translocation proposal

3.1 CHOICE OF KIWI SPECIES

The concept of reintroducing a kiwi species into the RNRP recovery area was launched at a meeting of kiwi workers and Kiwi Recovery Group members held at St Arnaud during November 2001. The RNRP translocation team had not decided which kiwi species to reintroduce into the recovery area, although little spotted kiwi and great spotted kiwi were both considered to be possible candidates. The Kiwi Recovery Group advised that it would support a great spotted kiwi reintroduction over a little spotted kiwi reintroduction, because great spotted kiwi are in greater need of management action. Furthermore, a little spotted kiwi reintroduction was considered more likely to fail because adult little spotted kiwi are vulnerable to stoats, whereas adult great spotted kiwi could persist in the RNRP recovery area if the current stoat control programme proved inadequate at protecting small kiwi.

3.2 DEVELOPMENT OF THE OPERATIONAL PLAN

The reintroduction to great spotted kiwi to the RNRP recovery area was guided by an operational plan (Gasson 2004b) which was written and refined over several years. Following the 2001 meeting at St Arnaud (above) the RNRP translocation team decided to attempt a wild-to-wild translocation of adult great spotted kiwi. There is only a very small captive population of great spotted kiwi, and it would not be possible to establish a sizable founder population from captive sources. Operation Nest Egg (O.N.E.) – although successfully used to establish North Island brown kiwi at Boundary Stream Mainland Island — was not favoured. O.N.E. has not been applied to great spotted kiwi yet, and may be technically difficult because great spotted kiwi nests are seldom unattended, and the species has a tendency towards abandoning nests and breaking eggs if disturbed. Implementing a new O.N.E. programme for great spotted kiwi would also be relatively expensive. A wild-to-wild transfer of adult great spotted kiwi would also be untried and involve a level of risk, but this approach was considered to be a less complicated and potentially more cost-effective method for establishing a new great spotted kiwi population.

Between November 2001 and March 2003 the RNRP translocation team wrote a draft operational plan to transfer four or five pairs of adult great spotted kiwi to the RNRP recovery area. The operational plan specified a set of actions for disease management, kiwi collection, transfer and release, post-release monitoring, management of dispersal, post-release management and communication of results. A set of performance standards and a definition of success were also formulated (Appendix 4 and section 12).

The translocation team anticipated that dispersal from the RNRP recovery area was a potentially significant risk, and would need to be managed if it occurred.

In a worst case scenario the "do nothing" approach could result in the loss of all of the transferred kiwi. Kiwi that dispersed from the recovery area might not be effectively monitored by RNRP field staff, and would not benefit from the pest control programme in the recovery area. There has been no previous monitoring of great spotted kiwi dispersal from a release site; hence the translocation team had no ability to estimate the level of risk involved or to predict the pattern of dispersal. Opinions of different kiwi workers varied on whether the kiwi would remain within the recovery area once released.

The RNRP translocation team proposed that the dispersal of kiwi from the recovery area might be limited through releasing a substantial group of kiwi in a short timeframe. This would maximise the chances of social contacts between kiwi being formed or maintained, which would hopefully prevent kiwi from dispersing from the release area. The operational plan aimed to release four or five pairs of great spotted kiwi into the recovery area within a period not exceeding seven days, and also specified a procedure for managing kiwi dispersal from the recovery area. The procedure was designed to balance the advantages of non-intervention (accumulation of dispersal data, and minimal handling of wild birds) against the obvious benefits of returning or relocating dispersed birds to a secure location. Kiwi dispersal would be monitored up to certain temporal and geographical limits, whereupon the dispersing kiwi would be relocated.

The first draft of the operational plan was presented at a kiwi practitioners' hui held at Rotorua in March 2003, where the plan was reviewed by kiwi workers and Kiwi Recovery Group members. Between March 2003 and February 2004 the RNRP translocation team produced three further drafts of the operational plan, and distributed them to Department of Conservation conservancy offices and iwi within the current range of great spotted kiwi.

3.3 CHOICE OF A SOURCE POPULATION

The draft operational plan did not specify a source population of great spotted kiwi for the translocation, as it was considered beneficial to maintain a distinction between the logistical requirements of the operational plan and other local or site-specific issues that might drive the selection of a source population. Thus a separate paper was produced to facilitate selection of the source location: "Options for sourcing a founder population of great spotted kiwi (*Apteryx haastii* / Roroa) for translocation to the Rotoiti Nature Recovery Project". The options paper identified a set of criteria that the RNRP translocation team regarded as either essential or desirable in any potential source location. The criteria included ecological, logistical and community relations considerations, and were identified through planning and consultation within the Department of Conservation. A range of sites that had been suggested as potential source locations during earlier discussions with the Kiwi Recovery Group and other kiwi workers were assessed against those criteria (Gasson 2004a).

The RNRP translocation team favoured taking the kiwi from a high-density upland site rather than a marginal site for two reasons: firstly, the impact on the viability of the local population would be less severe than if the birds were taken from a marginal site; secondly the collection of four or five pairs in the short timeframe specified in the operational plan would be much more practicable in an area of high kiwi density. Upland sites within the range of the Northwest Nelson population appeared most likely to sustain a take of eight to ten great spotted kiwi. The options paper concluded: "…The Gouland Downs area is the best known high-density great spotted kiwi site in Nelson/ Marlborough Conservancy, although particular care would need to be taken to avoid impacting on visitor experience and the existing great spotted kiwi monitoring programme. Subject to consultation with Department of Conservation and iwi stakeholders, the north-eastern Gouland Downs, in the vicinity of Corkscrew Creek, is the preferred option from the RNRP translocation team's perspective." Some 800ha of tussock covered down lands and bush-covered slopes about Corkscrew Creek, north of the Heaphy Track, appeared particularly suitable for a great spotted kiwi collection operation.

3.4 CONSULTATION WITH IWI

The maori authority (manawhenua) for Golden Bay and the north-eastern Gouland Downs is Manawhenua ki Mohua. During February 2004 representatives from the RNRP translocation team met with the Manawhenua ki Mohua management committee to discuss the translocation proposal. The management committee indicated support for the proposed translocation, and identified a range of ways that the mana and kaitiakitanga of Manawhenua ki Mohua could be recognised within it. Manawhenua ki Mohua provided the names for the individual kiwi that were transferred. These names (Mohua, Onetahua, Te Matau, Tai Tapu, Kahurangi, Awaroa, Takaka, Rameka, Tata and Wainui) are drawn from place names within the rohe of Manawhenua ki Mohua.

During February and March 2004 the RNRP translocation team also consulted with iwi who have a territorial interest in the RNRP recovery area. The translocation proposal was distributed to Ngati Apa, Ngati Rarua, Te Ati Awa, Ngati Tama, Ngati Koata, Ngati Toa Rangatira ki Manawhenua, Ngati Kuia and Rangitane. RNRP translocation team members visited representatives of the iwi who expressed an interest in the proposal, in order to present and discuss the operational plan. There were no objections to the proposed translocation, although there was a small amount of concern expressed at the uncertainty of the outcome for the transferred kiwi, and one iwi group sought assurance that there was sufficient funding for the project. Overall there was substantial support for the Rotoiti Nature Recovery Projects' goals, and for the translocation to proceed.

3.5 HEALTH ASSESSMENT OF THE SOURCE POPULATION

The Department of Conservation Standard Operating Procedure for the translocation of New Zealand's indigenous terrestrial flora and fauna states that species should be managed pre-transfer to reduce the risk of transferring pathogens. The RNRP translocation team decided that collecting and quarantining great spotted kiwi prior to the release would be logistically difficult and expensive, and that a lower level of health screening would be justifiable. Catching, radio-tagging and health-sampling specific birds prior to the transfer was considered as an option, but this option was rejected after the translocation team was advised that great spotted kiwi can be very difficult to recapture after they have been handled once. This option will be workable for future transfers if a specialist kiwi catching dog is available to help recapture target individuals.

The translocation team chose a three-step approach to health-screening and managing the risk of introducing diseased birds. The first step was to confirm that there was a low incidence of disease on the Gouland Downs (discussed below). Secondly, the collecting team would select only apparently healthy birds for transfer; and thirdly diagnostic samples would be collected at the time of transfer to retrospectively confirm the health status of the individuals selected. While retrospective sampling would not prevent diseased individuals from being selected, it would enable the translocation team to identify diseased individuals and to manage them after the transfer.

The incidence of disease amongst kiwi on the Gouland Downs was ascertained by referring to recent results from a Department of Conservation kiwi population monitoring programme at the Saxon kiwi study area, about 6km west of the Corkscrew Creek source area. Staff from the Department of Conservation's Research Development and Improvement (RD&I) division (formerly the Science and Research Unit) visit the Saxon study area at approximately five-yearly intervals in order to gather data – including health information — for a long-term kiwi surveillance monitoring programme. A monitoring trip to the Saxon was programmed for March 2004, meaning that there was an opportunity for the RNRP translocation team to access representative health data from kiwi on the Gouland Downs a short time before the transfer to the RNRP recovery area. The Gouland Downs kiwi population is contiguous across the Saxon and Corkscrew Creek, and the translocation team decided to use the assumption that the proximity and physical similarity of both sites meant that they are most likely very similar in terms of kiwi disease status. A translocation team member accompanied RD&I scientists to the Saxon in March to help monitor the kiwi population and to collect diagnostic samples; and results from the 2004 work in the Saxon showed no diseases of concern in the great spotted kiwi population.

3.6 TRANSLOCATION APPROVAL

The final version of the operational plan (Gasson 2004b), the site options paper and the consultation results were all used to support a formal translocation proposal (Gasson 2004c) which was produced and assessed in terms of the Department of Conservation's standard operating procedure for the translocation of New Zealand's indigenous terrestrial flora and fauna. Departmental approval for the translocation was granted in March 2004.

4. Transfer methods

4.1 KIWI COLLECTION METHODS

The transfer operation took place in late autumn after the documented breeding season, in order to avoid impacting on breeding kiwi or their offspring. The translocation team also considered that long autumn nights might benefit the transferred kiwi by providing abundant nocturnal feeding time at the release site. The collection and transfer operation ran from Thursday 13 May to Wednesday 19 May 2004.

The first transfer was scheduled to coincide with a midday ceremony at St Arnaud on 15th May. Kiwi collection effort at Corkscrew Creek was allocated to ensure that at least one pair of kiwi would be ready to be transferred on the 15th. Only one pair was sought on the first night, as the translocation team wanted to have one pair confirmed as soon as possible within the maximum 48 hour holding period, but did not want to hold more than one pair for that length of time. Consequently much catching effort was concentrated into the second night of the operation, immediately before the day scheduled for the first transfer. Kiwi collection began on the night of 13th May, about 42 hours prior to the preferred transfer time. Territory maps produced from the baseline call-count surveys (section 11.2.2) were used to orientate catchers to prospective kiwi catching areas; and during the first two nights of the collection phase up to ten kiwi workers were operating in different teams within the source area. The number of kiwi workers on site was gradually reduced as the operation progressed.

Catching teams employed slightly different kiwi attracting and catching methods, depending on the skills and experience of the teams (for an overview of best practice methods for catching kiwi, refer to Robertson et al 2003). Two main approaches were used, both during the hours of darkness. Two kiwi catchers with a specialist kiwi-catching dog used several automatic audio-cassette players to concurrently broadcast kiwi calls from several sites. The catchers then moved between the sites using the dog to detect and catch kiwi. Other teams working at night played recordings of kiwi calls to attract kiwi into a specific areas where the teams were waiting to catch kiwi by hand or with nets. A small amount of work was done during daytime: three kiwi indicator dogs were available to search during daytime for birds and "hotspots" of scent that could indicate productive areas for a catching team to target at night.

Collecting teams aimed to collect established pairs of adult kiwi; but an adult male and female from different sites were acceptable. Sex was determined by measuring the bill length. Adult male bill lengths at the Saxon range from approximately 90-105mm long, whereas adult female bill lengths are considerably longer, typically 114-135mm long (Robertson et al 2003). The catching teams maintained radio contact during the night, and planned each night of catching to ensure that the same numbers of male and female kiwi were collected. If both members of an established pair were not captured on the same night, the field team artificially paired the available male and female kiwi into a compartmentalised transfer box, ready for transfer in the morning. The

original mates of transferred birds were targeted for capture on subsequent nights. This approach meant that individual kiwi did not experience prolonged waits at base camp while their mates remained uncaught. It also meant that some previously established pairs were artificially reconfigured.

In addition to specifying the sex ratio of kiwi to be collected, the translocation operational plan specified that only adult kiwi were to be collected, and that kiwi in poor condition should not be collected. There was a slight risk that a sub-adult female kiwi could be mistaken for an adult male, as young females pass through a stage when they cannot be distinguished from adult males (Heather & Robertson 1996); however the collecting methods that were used rely on territorial responses from adult kiwi, and are most likely to result in adults being caught.

Only apparently healthy birds were to be collected in order to minimise the risk of transferring pathogens (section 3.5); and the translocation operational plan specified that birds in poor condition should not be collected. In practice, the collecting teams sexed captured birds in the field and visually inspected them, but did not undertake the full procedure of measuring, marking and health-sampling kiwi before the birds had been transported back to base camp.

4.2 MEASURING, MARKING AND HEALTH SAMPLING

The full measuring, marking and health-sampling process was undertaken for each kiwi at base camp, either on the evening of capture or during the following morning. A data sheet was filled out for each kiwi, with each sheet capturing data on the capture time and location, morphological measurements and sex, health screening and diagnostic samples taken and individual marking (transmitter and leg-band) details. Kiwi were weighed before being marked with transmitters and leg-bands, and the weight was expressed to the nearest ten grams. Bill length was re-measured (following initial sexing in the field) and tarsus width, tarsus length and tarsus depth were all measured to the nearest tenth of a millimetre and recorded on the data sheets.

Each kiwi was fitted with a numbered metal leg band (R-series for males and RA series for females and one large male). An individual colour code was fixed to each leg band by applying strips of adhesive reflective tape. These colour codes can be seen in a torch beam at night, and can be used to confirm the identity of birds that are seen but not handled. Each kiwi was also fitted with a radio transmitter. The transmitters were supplied by Sirtrack with two non-standard features: a relatively low pulse rate of 30 pulses per minute, and a "duty cycle" (20hr on/4 hr off). Each transmitter was set to be inactive from 01:00am to 05:00am NZ standard time. These features were designed to extend the battery life of the transmitters to about 24 months. An extended battery life was considered important in case the kiwi dispersed substantial distances from the RNRP recovery area and proved difficult to relocate. The transmitters were also supplied with a mortality mode: the pulse rate doubles to 60 pulses per minute if the transmitter is inactive for 24 hours.

Each kiwi that was collected underwent an external physical examination in accordance with the physical examination form provided in the *Workbook for developing quarantine and health screening protocols for native animal movements within New Zealand* (Jakob-Hoff, R. 2000). Body condition was assessed in accordance with the body condition classes described in the *Kiwi Best Practice Manual* (Robertson et al 2003). A range of diagnostic samples were collected from each kiwi prior to the release, and the results of the tests were used to retrospectively verify the health status of each kiwi after the transfer (section 3.5). The samples included various blood samples, cloacal swabs and faecal samples. Blood smears were prepared from blood collected at Corkscrew Creek and at St Arnaud, and were examined by New Zealand Veterinary Pathology Limited, who reported on white blood cell counts, thrombocyte numbers, thrombocyte morphology, red cell appearance and red cell parasites. Two whole blood samples and four serum samples were also processed and examined by New Zealand Veterinary Pathology Ltd, providing additional haematology and biochemical information. Capillary tubes of blood were collected and centrifuged to determine packed cell volume and total protein (serum protein). Cloacal swabs were taken for bacterial culture. Faecal samples were collected from transfer boxes and transfer bags for parasite egg counts.

4.3 HOLDING AND TRANSPORTATION METHODS

Once a kiwi was caught, someone was allocated the task of transporting the kiwi back to base camp. On busy nights this would be a dedicated "kiwi courier" and on quieter nights it would be a member of the successful catching team. Kiwi were transported from capture sites to the Corkscrew Creek base camp in canvas bags and disposable cardboard pet boxes. Canvas bags were reserved for the more difficult carries across scrubby areas. Cardboard boxes are bulkier and more difficult to carry through forest, whereas canvas bags are more expensive to purchase and – for hygiene reasons – must be washed between uses.

At Corkscrew Creek base camp kiwi were held in plywood transfer boxes. The boxes were divided into two kiwi compartments, each measuring approximately 50cm x 50cm x 45cm. Compartments were covered with lids which hinged on the back wall and latched shut at the front. Ventilation openings were cut into the three external walls of each compartment, and were covered by gauze mesh and ventilation covers. The walls and lids of the compartments were lined with closed cell foam which emitted a strong chemical smell when it arrived from the supplier. The boxes required airing and exposure to sunlight for several days prior to the transfer before the smell from the foam diminished. Before placing kiwi in the transfer boxes, the floors of the boxes were lined with multiple layers of newspaper and paper towels.

The procedure for placing a kiwi into a compartment required two people: one to observe and control the kiwi, and the other to lower and secure the lid. When the lid was nearly closed, the person observing and holding the kiwi withdrew their restraining arm, losing sight and control of the bird as the lid was finally closed. The weather was unusually clear and still, and temperatures

were cold at night and hot during the days. During the night, transfer boxes containing kiwi were stored under cover and off the ground in a portable PVC-covered bivouac, but during the daytime the boxes were moved to breezy shaded sites. Kiwi that were held for more than 24 hours were offered approximately a cupful of earthworms on the floor of the transfer box each night to help keep them hydrated.

Each consignment of kiwi was flown from the Corkscrew Creek base camp directly to St Arnaud in a Squirrel helicopter. The helicopter could comfortably carry two transfer boxes plus several passengers. The operational plan allowed for birds to be driven from the helicopter base near Wakefield to St Arnaud in order to keep costs down, but in practice the budget was able to cover the cost of flying directly to St Arnaud. The flight time from Corkscrew Creek base camp to St Arnaud was approximately 45 minutes. The first two pairs were transferred in plywood transfer boxes; however one of the first kiwi to be transferred sustained an injury inside one of the boxes (section 5.2) and a decision was made to transfer subsequent consignments of kiwi in canvas bags held by field staff. The kiwis' legs were taped together to minimise their struggling in the bags.

Kiwi were checked by a veterinarian on arrival at St Arnaud and were given 15-20ml of NaCl solution to keep them hydrated. They were then replaced into their transport containers (transfer box or canvas bag) and transported by boat on Lake Rotoiti to the RNRP recovery area. From the lakeshore, kiwi were carried uphill to specific release sites by field staff and volunteers on foot.

4.4 RELEASE METHOD

The area chosen for the kiwi release was southern RNRP, south of State Highway 63 and the RNRP "core area". This area was chosen for a range of reasons. Southern RNRP is in Nelson Lakes National Park which offers a higher level of legal protection than northern RNRP, which is in Big Bush Conservation Area. The area south of the "core area" is more than 2km from hazards such as roads and private land with domestic dogs. It is also adjacent to Lake Rotoiti, which provides good boat access to the release area for kiwi monitoring, and forms a natural barrier which may help to limit kiwi dispersal from the recovery area.

Ten release burrows were prepared within the release area. These were clustered into pairs at five different release sites labelled K1 to K5 (Fig. 2 section 8.1). Each release site was no more than a few hundred metres from Lake Rotoiti's eastern shore, but there was alongshore separation of 600-800 metres between sites. Paired burrows were separated by about twenty metres. The reason for pairing burrows and separating release sites was to allow naturally or artificially paired kiwi to remain in relatively close contact with one another, without being uncomfortably close to other pairs.

Each burrow was an artificial or pre-existing cavity in the ground, made large enough to accommodate one adult kiwi. Kiwi were placed in their respective burrows on the day of transfer, and a plywood cover was used to hold each kiwi in its burrow until nightfall. Fieldworkers returned to the burrows

approximately one hour after sunset to remove the covers. This procedure was designed to prevent kiwi from immediately abandoning their burrows and dispersing during the daytime. Daytime dispersal was considered undesirable because it might be more stressful and dangerous for the birds; and kiwi dispersing during the daytime would not establish contact with their mates through calling.

5. Transfer results

5.1 COLLECTION RESULTS

5.1.1. General results

Ten kiwi (five males and five females) were collected between 13th and 18th May 2004 (Fig. 1). A two person kiwi catching team with one specialist night dog accounted for half of the kiwi caught, and achieved this result in only two nights work. Teams of four or more people accounted for the remainder of birds caught.

Eight of the kiwi were considered to comprise four previously established pairs. One male (R-31759 / Kahurangi) was collected without his mate, who evaded the catching team despite being seen; and one female (RA-0444 / Awaroa) was collected without a mate. The field team were unable to find any evidence that the female had a mate at the source area.

Three of the kiwi were assessed as being in poor, poor-moderate or moderate-poor condition prior to transfer, while the others were in moderate or better condition (section 5.4.3). These three birds appeared to be otherwise healthy, and the field team saw no reason for not collecting them.

5.1.2 Catching operation

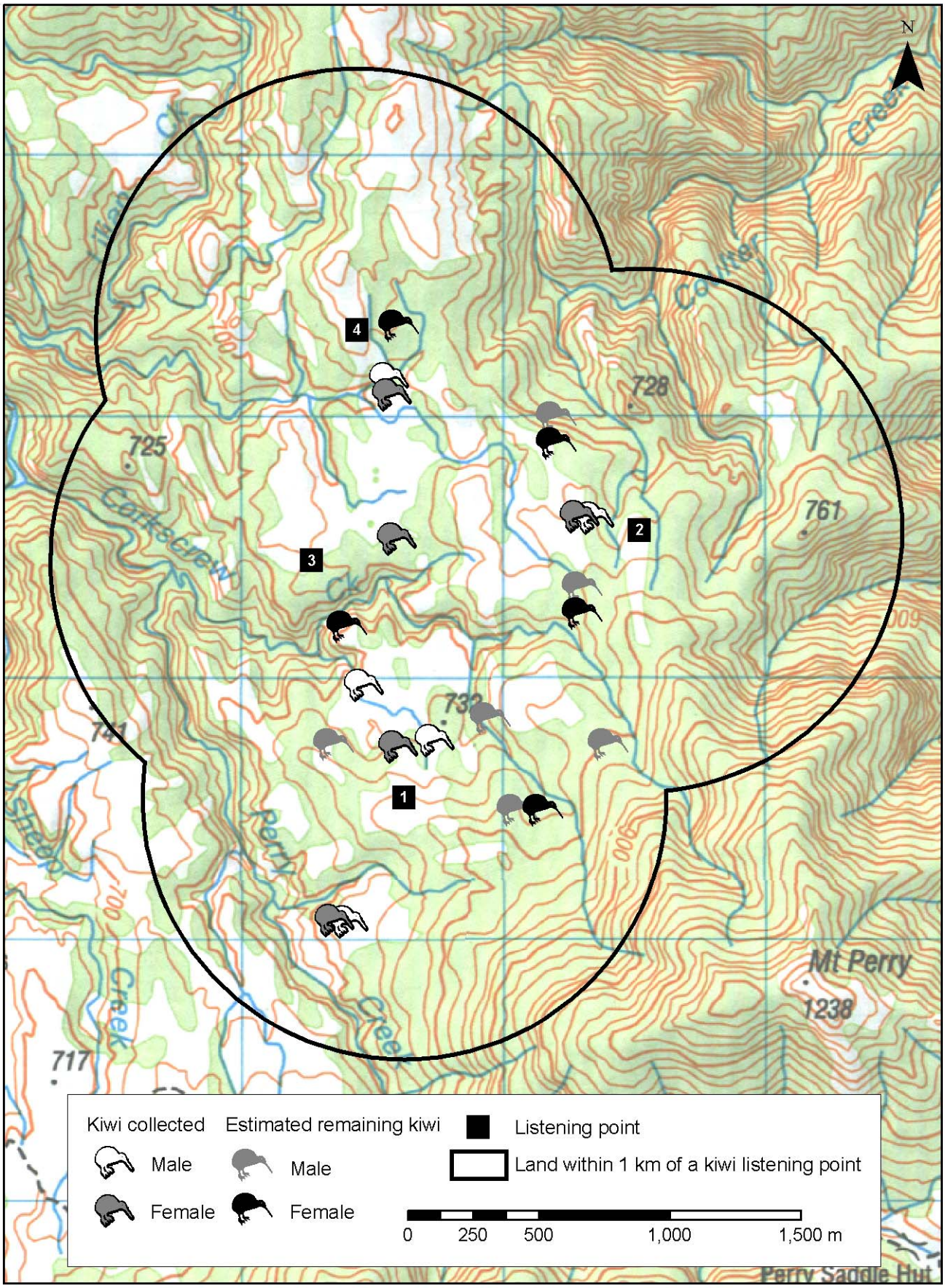
Despite the presumed naivety of the great spotted kiwi at the source location, the birds did not always prove easy to attract to the capture sites. Some kiwi would approach a capture site but would remain under cover where they were difficult to catch, or they would not approach until the catching team had moved away from the site. One team found that it was possible to catch great spotted kiwi by leaving one or two people stationed at a capture site while most of the team departed. Evidently the kiwi were wary of approaching the site when the whole group was present, but were curious enough to investigate the site when the group had apparently left the site. One or two people remaining behind could then ambush the kiwi.

On one occasion a catching team attempted to hold a female kiwi (RA-0444 / Awaroa) near the capture site while resuming catching, however the captured bird reacted violently to the broadcasted kiwi calls, and the team decided that it would be better to send a person back to base camp with the captured kiwi.

5.1.3 Kiwi not collected from the source area

During the collection operation the field team heard or saw a minimum of eleven kiwi that were not collected. Some of the kiwi were not caught because they proved unresponsive or evasive; and others had not been targeted because they were less accessible. At the end of the collection operation the field team pooled their knowledge and mapped the approximate locations of kiwi known to be remaining within the source area (Figure 1): a minimum of six males and five females — including three pairs — were considered to be remaining in the source area.

Figure 1 Corkscrew Creek source of *A. haastii*



5.2 HOLDING AND TRANSPORTATION RESULTS

Five pairs of great spotted kiwi were transferred in four consignments. Three pairs were transferred in two consignments on 15th May 2004, one pair was transferred on 17th May, and the final pair was transferred on 19th May.

Excluding a kiwi that was injured (below) the longest period that a kiwi spent between being caught at Corkscrew Creek and being released from a burrow into the RNRP recovery area was about 46 ½ hours. This was male R-31758 / Onetahua, one of a pair that was held for an extra night before the transfer. Four pairs of kiwi were transferred on the day after they were captured. These birds were held at the source area for periods between 10 and 16 ½ hours.

The first pair of kiwi (male R-31758 / Onetahua and female RA-0441 / Mohua) was collected 40 ¼ hours and 38 ½ hours prior to the predetermined transfer time. Live earthworms were provided (approximately one cup full in each compartment) to help keep the birds fed and hydrated. Both birds consumed the majority of the earthworms provided during the first night they were held at base camp. On the afternoon following their capture the kiwi were checked, health-sampled and marked, and worm supplies were replenished. It was noted that the air temperature inside the compartments felt warm, and that birds being held during the daytime would benefit from additional (perhaps adjustable) ventilation. Heavy frosts prevailed overnight throughout the collection period, and all of the occupied compartments that were opened in the mornings appeared to have low to moderate air temperatures.

The female of the first pair (female RA-0441 / Mohua) was injured in the transfer box, most likely as the hinged lid was being closed on the afternoon before her transfer. The kiwi was found with up to 1 centimetre of the upper bill tip missing on arrival at St Arnaud. This bird was flown to Massey University veterinary hospital for medical care and rehabilitation (section 10). A close inspection of the transfer box revealed a small piece of bill keratin sitting on the top edge of the back wall. Although two people worked together to place the kiwi in the box and lower the lid (section 4.3) it seems most likely that the kiwi inserted its bill into the crevice between the back wall and the lid at the moment that the lid was shut. Field staff noted that the bird was active in the box overnight, but interpreted the activity as a healthy will to escape, rather than a sign of physical trauma. It is possible – but seems less likely – that the injury occurred inside the box later during the bird's confinement or transfer. When the lid was closed, a permanent 1mm gap (wide enough to slide a NZ 5 cent piece into, but not wide enough to allow a NZ 10 cent piece) existed between the lid and the top edge of the back wall. It seems unlikely that a kiwi could squeeze its bill into such a narrow gap.

Once the problem with the injured bill had been identified and reported back to the field team, it was decided that the team would limit the kiwis' exposure to transfer boxes in case the injury had happened in transit and was liable to happen again. Boxes were necessary for holding kiwi overnight, but were not essential for actually transporting them, thus the last three pairs of kiwi were transported to St Arnaud inside canvas bags with their legs taped together, and were held by passengers in the helicopter and boat.

The field team attempted to make the transfer boxes safer for holding kiwi overnight by covering the hinge gap with a broad strip of plastic adhesive tape. It is doubtful whether this plastic strip could have prevented a bill from being pinched: although the tape covered the gap when the box lid was fully open (and the bird fully controllable) it folded into the crevice as the lid was closed, thus lining the crevice, but not covering it. Similar hinged-lid boxes have been used for transferring kiwi in the past without the same type of mishap being reported.

One bird (female RA-0442 / Rameka) was measured and marked during the afternoon shortly before she was due to be transferred in a canvas bag. After processing she was returned to her box for about ten minutes, and when staff opened the box to place her into the bag for transfer she was found lying on her side. It is not known if this was a stress response to handling or to the noise of the helicopter approaching the release site. On arrival at St Arnaud Rameka's behaviour and physical condition appeared normal.

5.3 RELEASE RESULTS

5.3.1 Reconfiguration of pairs

Four pairs of great spotted kiwi and a single male were released into the RNRP recovery area over five days:

- An apparently established pair (male R-31760 / Te Matau and female RA-0443/Tai Tapu) was released on 15th May
- An artificial pair (male R-31759 / Kahurangi and female RA-0442 / Rameka) was matched up during the transfer and released on 15th May
- A single male (R-31758 / Onetahua, mate of the injured female) was released on 15th May
- An artificial pair (male R-31761/Takaka and female RA-0444 / Awaroa) was released on 17th May
- An apparently established pair (male RA-0446 / Tata and female RA-0445 / Wainui) was released on 19th May.

The two artificial pairs included an apparently established pair (Takaka and Rameka) that was split apart as a result of capture on different nights. Rameka was the first to be transferred: she was artificially paired with Kahurangi whose mate at Corkscrew Creek avoided capture. Takaka was collected two days later, and was artificially paired with Awaroa who was not known to associate with a male.

5.3.2 Behaviour at release burrows

Most of the kiwi were placed into the burrows and released without any sign of the birds panicking; however one bird, male R-31760 / Te Matau was noticeably stressed when a newspaper photographer broke with instructions and took a series of photographs of the bird using a flash. The bird tensed up and remained tense for the remainder of the time that it was held (Brian Paton pers. comm.). This resulted in an official complaint to the photographer's employer.

Video cameras were installed inside three of the release burrows. One camera was enabled to transmit real time footage of male R-31760 / Te Matau directly to a monitor at the Department of Conservation's St Arnaud visitor centre on 15th May. Two more cameras were linked to video recorders which simultaneously recorded activity inside two burrows assigned to a previously established pair (male RA-0446 / Tata and female RA-0445 / Wainui) on 19th May.

The real time footage of male R-31760 / Te Matau transmitted to St Arnaud on 15th May was not recorded, but the following observations were made:

- At 18:15 (approximately an hour after sunset) the cover was removed from the burrow entrance.
- The kiwi remained inside the burrow for some hours, at least until 23:00 when observers stopped watching.
- The kiwi shuddered at times during the first few hours of observation.
- Between 22:30 and 23:00 the kiwi became relatively active and began stretching and yawning or gaping
- The burrow was empty when observers checked the monitor on the following morning at 06:00.

Observers considered that male R-31760 / Te Matau appeared to be more stressed (shuddering and gaping) than the other two kiwi observed on camera, and that a possible reason for this was the flash photography that the bird was subjected to immediately before being placed into the burrow (above).

The following observations were made from video footage of male RA-0446 / Tata in a release burrow on 19th May:

- The kiwi was placed into the release burrow at 12:18. For eight minutes following placement into the burrow the kiwi was very active, apparently attempting to escape.
- From 12:26 to 16:10 the kiwi was apparently asleep, but a slight amount of shaking was apparent.
- The kiwi was also active (moving around and probing) from 16:10 - 16:21 and was apparently attempting to find a way out of the burrow.
- The kiwi was briefly active at 17:27 (approximately 15 minutes after sunset) and was again active from 17:52 until the burrow was opened at 18:13.
- Shaking was observed at times, but not as much as male R-31760 / Te Matau.
- The burrow entrance was unblocked at 18:13. The kiwi responded by moving deeper into burrow and lowering its head and bill to the ground, evidently attempting to hide.
- At 18:33 a weta walked across the kiwi's back. The kiwi responded immediately by probing inside the burrow, and continued to actively probe for about seven minutes.
- From 18:40 to 19:07 periods of rest were interspersed with periods of probing.
- 19:07 the kiwi left the burrow. A kiwi was seen at the burrow entrance at 19:09, and camera shake seen on the video at 19:13 suggests that it remained near the burrow entrance until then.

Female RA-0445 / Wainui occupied the release burrow adjacent to Male RA-0446 / Tata, and was videoed simultaneously on 19th May:

- Wainui appeared to go to sleep soon after she was placed into the burrow at 12:20, but a slight shaking was apparent.
- Wainui began probing inside the burrow at 18:03
- The burrow was unblocked at 18:13 and the kiwi departed almost immediately.
- At 19:19 a kiwi entered the female's burrow. Although a leg band is clearly visible in the video footage, it is difficult to be certain which leg the band is on. It appears likely to be on the right leg, which suggests that the visitor to the female's burrow was male RA-0446 / Tata, who had departed his own burrow a few metres away only twelve minutes earlier.

No "victory calls" were heard by field staff removing the burrow covers. Field staff made some additional observations while removing covers from some of the burrows:

- At release site K3 field staff observed that female RA-0444 / Awaroa appeared to be active in her burrow prior to the cover being removed. Telemetry indicated that she left her burrow within ten minutes of the cover being lifted.
- At release site K3 male R-31761 / Takaka appeared to remain inside his release burrow over twenty minutes of observation after the cover was lifted.
- At release site K4, Male R-31758 / Onetahua appeared to remain inside his release burrow over thirty minutes of observation after the cover was lifted.
- Field staff at release site K5 observed that male R-31759 / Kahurangi appeared to exit his release burrow after about ten minutes. Torches were not turned on to confirm the kiwi's activity, but it sounded as if the kiwi walked about in the immediate vicinity of the burrow for a few minutes before moving away towards the female's burrow.

5.4 HEALTH SAMPLING RESULTS

5.4.1 Blood samples

Blood samples were taken from six kiwi prior to their transfer from Corkscrew Creek base camp. A problem was experienced during the processing of the samples at Corkscrew Creek, when some of the capillary tubes leaked in the centrifuge. After this problem became apparent, the centrifuge and blood sampling equipment was sent to St Arnaud, and a range of blood samples were collected there, including two whole blood samples and four serum samples. Exact reference ranges for healthy great spotted kiwi have not been established; however staff from the Institute of Veterinary Animal and Biomedical Sciences (Massey University) provided advice on which results were likely to be normal or abnormal. The data collected will also contribute to baseline information for the species. The results can be summarised as follows, with further details below and in Appendix 1:

- Red blood cells and thrombocytes – results obtained from nine samples, all apparently normal.
- White blood cell counts – results obtained from eight samples, five of which showed elevated white blood cell levels, including one seriously high level.
- Packed cell volume – results obtained from seven samples. Five appear normal and two appear abnormally low.
- Total protein – results obtained from eight samples, none appear abnormal.
- Biochemistry – four birds sampled, one had extremely high creatinine kinase value indicative of stress and two others had high values.

Red blood cells and thrombocytes

Blood smears were prepared from eight blood samples, one of which was apparently lost. The missing smear relate to the injured kiwi (female RA-0441 / Mohua), not to any of the kiwi released into the recovery area. Examination of the blood smears revealed no abnormalities in red blood cell appearance, no red cell parasites, and no abnormalities in thrombocyte numbers or morphology.

The two whole blood samples did not require smearing for analysis. Occasional immature red cells were present in one of the two whole blood samples: this is normal and represents the release of new cells into the circulation (high numbers can indicate recent blood loss or destruction). The morphology and numbers of thrombocytes appeared normal in both samples.

White Blood cell counts

Eight white blood cell counts were obtained from six smears and two whole blood samples. Of the seven blood smears processed by New Zealand Veterinary Pathology, one was too degenerate for a white blood cell estimate and differential. Five of the white blood cell counts indicated elevated white blood cell levels.

White blood cell counts provide a general indication of a kiwi's health: high white blood cell count indicates either infection or inflammation, but abnormalities do not indicate exactly what is wrong with a bird. White cell counts may also be temporarily elevated with stress. A value of 15 cells x 10^9/L is considered abnormal, and any value over 30 is considered to be serious.

One sample from female RA-0443 / Tai Tapu returned a seriously high white cell count of 32.9. Fortunately there were no toxic charges in the cells, and no other signs of disease. Four other samples returned values between 15 and 30 cells x 10^9/L, and three samples returned values below 15 cells x 10^9/L (Table 3 Appendix 1).

Packed cell volume (PCV) and total protein values

Blood samples were initially collected for centrifuging at Corkscrew Creek, but problems were experienced with the centrifuge, and some PCV values were not obtained. A range of blood samples (including whole blood and serum samples) were collected at St Arnaud. Consequently there are packed cell volume results for seven birds, and total protein values for eight birds. Some birds were sampled in more than one way, and in some cases, more than one total protein value was obtained (Table 4 Appendix 1).

There is no existing reference range of PCV values for great spotted kiwi, however a normal range for kiwi could be expected to be 30-50% (Brett Gartrell pers.comm.) Of the seven PCV values obtained, five appear normal at 37% - 42%. Two PCV values appear to be abnormally low at 26% (female RA-0441 / Mohua) and 28% (male RA-0446 / Tata). These low PCV values are not of particular concern as the birds appeared to be otherwise healthy when collected, and the low values did not coincide with any other indicators of poor health.

The total protein values collected during the translocation ranged from 32 to 56 grams/L (Table 4 Appendix 1). Although there is no existing reference range for great spotted kiwi total protein values, these values do not appear to be unusual (Brett Gartrell pers.comm.).

Creatinine kinase (CK)

Plasma biochemistry results were obtained from the last four kiwi to be transferred. This was not part of the compulsory sampling undertaken to manage the risk of disease transfer, but the veterinarian at St Arnaud collected four whole blood samples to extend the amount of reference data available for great spotted kiwi.

A feature of the biochemistry results was the extremely high creatinine kinase (CK) value of 20021 returned for female RA-0444 / Awaroa, and the relatively high CK values (4486 and 3787) returned for two other kiwi (Table 5 Appendix 1). Creatinine kinase is an enzyme that is indicative of muscle cell damage, and in severe cases high CK levels can precede kidney damage and chronic wasting of the affected muscles.

The normal CK value for great spotted kiwi is not known; however Hugh Robertson found that the highest CK value in a sample of 42 North Island brown kiwi was 2194 (Hugh Robertson pers.comm. to Brett Gartrell). The high CK values in the great spotted kiwi sample raises the question of whether great spotted kiwi respond more adversely than North Island brown kiwi to capture and handling.

All of four kiwi tested for plasma biochemistry were transferred from Corkscrew Creek to St Arnaud in canvas bags with their legs taped together to restrain them (section 4.3). The translocation team has subsequently learned that prolonged restraint can cause muscle necrosis, which is consistent with elevated CK levels. There were no plasma biochemistry samples taken from great spotted kiwi transferred in boxes to compare the effects of the different methods.

5.4.2 Culture results

Cloacal swabs were taken from all kiwi prior to transfer. Results were obtained for eight kiwi, all of which returned negative results for Campylobacter, Yersinia and Salmonella. Faecal culture results were not returned: either the samples or results were lost after the samples were submitted.

5.4.3 General condition and abnormalities

The general body condition was correctly recorded for seven of the ten kiwi that were collected. A classification of "medium" was incorrectly used on two occasions, but is assumed to equate to "moderate". An incorrect category ("healthy") was used on one occasion.

Seven kiwi were assessed as being in healthy (sic), medium (sic), moderate, or good condition prior to transfer (Table 7 Appendix 2). Three of the ten kiwi were assessed as being in poor, poor-moderate and moderate-poor body condition prior to transfer, meaning that one disease management performance standard (moderate or better condition kiwi are collected from a great spotted kiwi population with a normal or low incidence of disease) was not unequivocally met (Appendix 4).

Field staff undertook external examinations of all kiwi at Corkscrew Creek, and a veterinarian re-examined all of the kiwi prior to their release. The following abnormalities were recorded for six kiwi:

- R-31758 / Onetahua: right eye slightly opaque, left eye pupil poorly defined, lice in ear, left digit on right foot slightly deformed
- R-31760 / Te Matau: right digit on left foot slightly deformed, skewed claw
- RA-0443 / Tai Tapu: scaly fluted skin on breast, belly with dry scabs and redness, large featherless areas (not brood patch), small tear on left knee, small abrasion on lower left leg
- R-31761 / Takaka: outer toe on each foot curled downwards, large knuckle at bone of middle toe on both feet
- RA-0444 / Awaroa: feathers missing from right side of neck
- RA-0446 / Tata: left eye milky

No abnormalities were recorded for four kiwi (RA-0441 / Mohua, R-31759 / Kahurangi, RA-0442 / Rameka and RA-0445 / Wainui). All kiwi were checked by a vet at St Arnaud prior to their release. The only bird that was not declared fit for release was Mohua because of the injury sustained in the transfer box (section 5.2).

6. Discussion of transfer methods and results

A debriefing session was held immediately after the transfer. Some key themes arising from the debriefing session were: strategies for night catching when a specialist night dog is not available; strategies for minimising stress to kiwi; the need for a better transfer box design, and for the plans to be available in the *Kiwi Best Practice Manual*; media involvement and strategies for managing media personnel. Recommendations made during the debriefing are incorporated into section 13 of this report.

The transfer operation was highly successful in delivering almost all of the required number of kiwi to the RNRP recovery area in less than one week. The specialist kiwi catching dog and handler team was highly successful in the rapid collection of great spotted kiwi for transfer, but teams working without night dogs were also successful, albeit slower.

Although it was apparent from health sampling and other observations that the transfer did place kiwi under stress (sections 5.2, 5.3.2 & 5.4.1), there were no deaths resulting from stress, and there is no evidence that pathogens were transferred with any of the kiwi. High creatinine kinase (CK) levels in three samples highlight the need for ongoing refinement of kiwi handling techniques.

The only serious problem experienced by the translocation team was the injury of one kiwi beak in one of the transfer boxes. This accident was not attributable to bad handling or failure to follow the procedure for placing birds into the transfer boxes: it highlights that there is a risk with placing kiwi into simple hinged boxes. Most of the transfer operation performance standards specified in the operational plan were met during the transfer (Appendix 4), but this injury meant that one performance standard "all transferred kiwi survive until release into RNRP" was not met. The RNRP translocation team believe that there is a need for a better box design to prevent similar accidents from happening again in the future. A viewing window would also be useful for monitoring worm supplies and for monitoring kiwi responses to handling and confinement.

One of the disease management performance standards (moderate or better condition kiwi are collected from a great spotted kiwi population with a normal or low incidence of disease) was not fully met during the collection operation. The field team did not health screen kiwi immediately after catching them (section 4.1); and three kiwi were assessed as being in poor, poor-moderate and moderate-poor condition after they had been taken to Corkscrew Creek base camp. All three birds appeared to be otherwise healthy, and the field team saw no reason for not collecting them (section 5.1.1). In hindsight the specification that birds collected should be in moderate or better general body condition is unrealistic, as rejecting a bird in poor condition may be an unnecessary restriction on the collecting process. The *Kiwi Best Practice Manual* states that if birds look like they are in poor condition then a health check should be carried out before translocating them, but that poor condition could be caused

by lack of food or intense competition amongst birds rather than by poor health in a disease related sense (Robertson et al. 2003). The weights and general body condition of all three birds improved during the year following the transfer (Table 7 Appendix 2).

7. Post-release monitoring methods

7.1 DISTRIBUTION MONITORING

7.1.1 Distribution monitoring objectives

Three research objectives relating to kiwi distribution in the RNRP recovery area were identified in the translocation operational plan:

1. Determine how far, how soon, and in what direction great spotted kiwi disperse from the release area, and whether there is any pattern of dispersal.
2. Determine whether pair bonds survive the transfer
3. Determine the preferred habitats for great spotted kiwi translocated to the RNRP recovery area.

Telemetry monitoring was used to estimate the location of each kiwi at different times after their release into the RNRP recovery area. The changes in individual birds' locations over time allowed the monitoring team to make inferences about dispersal (section 8.1), survival of pair bonds (section 8.2) and habitat usage (section 8.3).

7.1.2 Location plotting method

Whenever a kiwi location was due to be estimated monitoring staff visited various points in the RNRP recovery area to search for the corresponding transmitter signal using a Telonics™ TR-4 telemetry receiver. As time progressed, a set of strategically useful monitoring points were identified within the recovery area and were repeatedly used. Telemetry receivers are sensitive to the direction of transmitters in relation to the observer, and a magnetic compass was used in conjunction with the TR-4 to determine the bearings from various monitoring points to the transmitter in question. The two strongest signals were used to estimate the transmitter location: the relevant monitoring points and compass bearings were plotted onto a topographical map, and the position of each transmitter was estimated to be at the intersection of the two bearings. From early June 2004 to the end of February 2005, every plotted location was entered onto an electronic spreadsheet. Staff from Nelson/Marlborough Conservancy's Information Management Unit used this spreadsheet to produce a series of topographical maps displaying the estimated locations of each released kiwi during each calendar month.

7.1.3 Distribution monitoring frequency

The telemetry monitoring routine was established in accordance with the translocation operational plan, which allowed for the gradual reduction of monitoring frequency if it became apparent that kiwi were not dispersing from the RNRP recovery area. During the first seven weeks after the transfer the position of each kiwi was estimated on most fine weekdays. By early July it was apparent that the dispersal of the transferred birds was relatively minor.

Consequently, the monitoring frequency of most birds was reduced to once weekly during the 2004/2005 breeding season (July to February). One kiwi (female RA-0442 / Rameka) was more mobile than the others (section 8.1) and her location was monitored several times a week until August 2004. After the breeding season, from March 2005 onwards, telemetry was used approximately fortnightly to confirm the general area that each kiwi was in, but the plotting and estimation of specific locations was discontinued.

7.2 BREEDING MONITORING

During the breeding season (July-February) monitoring staff established additional telemetry points in areas that were occupied by male kiwi that shared their home range with females, and were therefore considered potential breeders. The additional telemetry points were substantially closer to the target kiwi than the original telemetry points used for dispersal monitoring, and were consequently much more sensitive to detecting small movements within the males' home ranges. A male was considered likely to be incubating an egg if his transmitter signal was consistently at the same angle to a telemetry point after more than two consecutive weeks. Successive weeks of detecting the signal from the same angle would strengthen the assumption that the bird was incubating. The translocation team did not have a high expectation that kiwi would breed in the RNRP recovery area during the 2004/05 season, as it was considered likely that there would be a long settling in period before breeding began. Hence a specific nest monitoring protocol was not in place for the season, and the monitoring approach was refined as the breeding season progressed (section 8.4).

7.3 RECAPTURE AND PHYSICAL EXAMINATION METHODS

Seven radio-tagged kiwi were recaptured during May 2005. Two birds (male RA-0446 / Tata and female RA-0445 / Wainui) dropped their transmitters prior to the May recaptures, and were relocated during June 2005 with the assistance of a kiwi indicator dog.

The May recaptures were undertaken by a team of kiwi workers, and in some cases staff from the Bank of New Zealand (principal sponsor of Bank of New Zealand Kiwi Recovery) joined the catching team. A kiwi dog was also used to help pinpoint kiwi in their daytime shelters or after they had gone to ground following a chase. The majority of the kiwi were caught inside their daytime shelters, including a pair of kiwi found together deep inside a hollow log. Two of the kiwi recaptured during May were on the move before the catching team was able to find them in their daytime shelters. These birds were followed upslope for several hundred metres and were eventually caught after they had gone to ground.

The 24 month transmitters were replaced with new 12 month (non duty cycle) transmitters on all of the male kiwi, as these are the highest priority to monitor during the 2005/06 breeding season. The 24 month transmitters performed well in the first year, but field staff were mindful of the possibility that the batteries could run down earlier than expected in the second year. The original 24 month transmitters were kept on all of the females, but were re-attached with new harnesses. In each case, transmitters were attached to the leg that had not been carrying the transmitter previously.

Each kiwi handled was also weighed, assessed for general condition, measured (bill length), and visually inspected for abnormalities. Kiwi were weighed to the nearest 10g with transmitters attached, as it was considered best practice to ensure that all kiwi had transmitters on at all times. To compensate for this, 20g was deducted from the gross weight of each kiwi (the average weight of ten 24 month transmitters was 21.4g).

General condition was scored by feeling the amount of fat covering the ribcage, the backbone and tailbone (Robertson et al 2003). The recommendation to score general condition before weighing the bird was not always adhered to; however observers did not refer to previous weights and condition of individual birds before making the assessments. In 2005 bill length was measured using digital callipers. The callipers were precise to two decimal places (0.01m) but this was rounded to the nearest one decimal place (0.1mm) in order to be comparable with the measurements taken with Vernier callipers at Corkscrew Creek in May 2004.

8. Post-release monitoring results

8.1 DISPERSAL

There were no transmitter failures during the first year of monitoring, however two kiwi were without transmitters for part of the year: female RA-0445 / Wainui dropped her transmitter in October 2004, and male RA-0446 / Tata dropped his transmitter in May 2005, shortly before he was due to be recaptured.

All of the released kiwi were recaptured within the RNRP recovery area 12-13½ months after their release date. At the time of recapture, the minimum distance that a kiwi was found from its release point was about 100 metres, and the maximum distance was about 3.27km (Table 6 Appendix 2). The mean distance that kiwi were found from their respective release points was 918 metres, and the median value was 299 metres.

None of the four kiwi that were considered to be partners in established pairs exceeded the median distance (299 metres) from their release points. Four out of five kiwi that were not released with their previous partners were recaptured at a distance from their respective release points that exceeded the median (section 5.3.1 and Table 6 Appendix 2).

Telemetry monitoring indicated that there was no dispersal from the RNRP recovery area at any time during the first year of monitoring; and even the most mobile birds appeared to remain within the RNRP recovery area and within about 1.5km of the eastern shore of Lake Rotoiti.

A limitation of the telemetry monitoring was that the telemetry only relates to daytime shelters and not to kiwi activity during the night. A minor amount of telemetry was undertaken at night time, to monitor kiwi breeding activity (section 8.4). On one night a male kiwi (R-31761 / Takaka) was heard calling, and his transmitter signal was detected more than 1km from the area that he was known to frequent in the daytime. By the following morning the bird had returned to the usual daytime location. Data collected during the daytime had failed to show that this particular male ranged upwards of a kilometre from his known daytime shelter area at night. This isolated observation raises the possibility that daytime locations of the released kiwi are poor indicators of their home ranges.

Based on daytime observations, most kiwi appeared likely to be within contact calling distance of one or more kiwi at most times throughout the year. The behaviour of female RA-0442 / Rameka is puzzling because this bird travelled considerably further than the other kiwi (Figure 2), and was most likely out of calling range of the others while living in the south of the recovery area for about 8 weeks during June-July 2004.

Figure 2 represents the movements of kiwi from release points to recapture points, with three median values for the periods May-August, September-December and January/February calculated from daytime telemetry results. The third period does not include data from March and April 2005 because kiwi

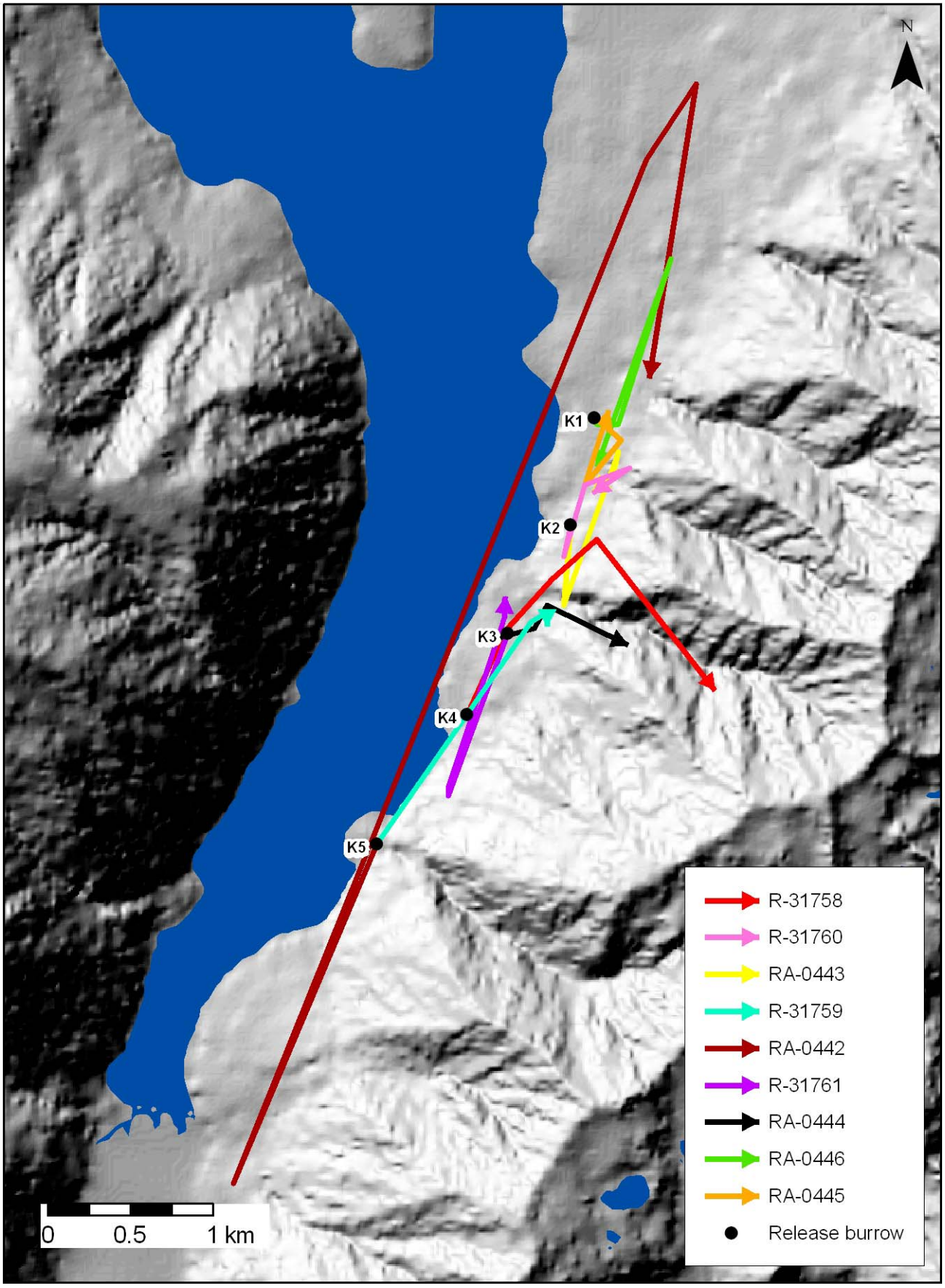
locations were not estimated after the end of the 2004/05 breeding season (section 7.1.3). Results for female RA-0445 / Wainui were affected by the loss of her transmitter part way into the second period: her second median value is affected and the third median value is missing.

Figure 2 was produced using ArcEditor 9.0. Displaying the median values (as opposed to mean values) reduces the influence of extreme values, some of which may not be reliable (e.g. due to observer error or poor telemetry conditions). Median values also have the advantage of being data points that actually exist in the data set. There are limitations in this approach however: the outer limits of each kiwi's travels are further from the release points than the median values indicate; and the variation in dispersal of kiwi daytime shelters about each median value is not quantified.

Notwithstanding the limitations discussed above, Figure 2 provides a general overview of kiwi movements within the RNRP recovery area during the first twelve months following the release, and it shows that there were measurable changes in the daytime locations favoured by various kiwi at different stages of the year. The following observations made by kiwi catching and monitoring staff, are highlighted by Figure 2:

- Female RA-0442 / Rameka travelled substantially greater distances than every other kiwi. The reason for this bird's greater mobility is not known. This individual was a fully grown adult female and there was no significant change in her bill length between May 2004 and May 2005 (Table 8, Appendix 2) so juvenile dispersal can be discounted as a contributing factor.
- Male R-31758 / Onetahua was recaptured substantially further upslope than any of the other kiwi, and was recaptured 1.5km from his release site – the third greatest distance that a kiwi was recaptured from its original release site. On the day of recapture this bird appeared to be moving upslope to evade the kiwi catching team, and it is considered likely that the catching activity caused him to move several hundred metres further upslope from his daytime shelter.
- Male R-31759 / Kahurangi was recaptured about 1.67km from his release site – the second greatest distance that a kiwi was recaptured from its original release site. Telemetry monitoring showed that this male travelled furthest in the first few weeks after his release. By mid-August 2004 this bird was consistently plotted in a confined area, and it was apparent that he was paired with female RA-0444 / Awaroa (section 8.4).
- Female RA-0444 / Awaroa was observed to move a substantial distance upslope immediately after finishing breeding in February 2005. On the day of recapture, this bird appeared to be moving even further upslope to evade the kiwi catching team. It is considered likely that the catching activity caused her to move 100-200 metres further upslope from her daytime shelter.
- Overall, the whole group has shifted slightly northwards and has slightly compressed on the north-south axis. The upslope movement of the breeding pair male R-31759 / Kahurangi and female RA-0444 / Awaroa has extended the east-west dispersal of the group.

Figure 2 Kiwi dispersal during year 1



The average territory size of kiwi established in the RNRP recovery area is not known. In hindsight the performance standard in the translocation operational plan (Gasson 2004b) stating that this statistic will be known was too optimistic. To accurately attribute a numeric value (hectares) to kiwi home ranges would entail much more monitoring during both daytime and night time. The results of such monitoring might be interesting, but this information is not essential for managing the founder population. Notwithstanding lack of information needed to attribute hectare values to each territory, field staff have a good working knowledge of the movements of each kiwi and the places that they use.

8.2 PAIR BOND SURVIVAL

Both of the apparently established pairs that were released into the recovery area intact appear to have remained together relatively close to their respective release points, and this may suggest that pair-bonding has had a role in keeping kiwi within a defined area. The two artificial pairs did not remain intact, and the artificially paired birds tended to disperse further from their respective release sites (section 8.1)

There was very strong evidence that one of the pairs that were released intact in 2004 was intact one year later: during May 2005 Male R-31760 / Te Matau and female RA-0443 / Tai Tapu were found sheltering together in a hollow log.

There is no strong evidence that the other pair (male RA-0446 / Tata and female RA-0445 / Wainui) remains intact, but both birds appear to share common ground about the site where they were released; and during June 2005 they were recaptured within several hundred metres of one-another. There are limited observations for Wainui because she was without a transmitter from mid-October 2004 to late June 2005.

Male R-31761 / Takaka and female RA-0442 / Rameka were considered to be an established pair at the source area, but were not released into the recovery area simultaneously. This pair did not reunite during the year following the transfer, but recent monitoring has shown that Takaka entered Rameka's home range during July 2005. By August 2005 (15 months after the transfer) telemetry monitoring indicated that the birds were sheltering in close proximity and possibly sharing shelter sites on some days.

8.3 HABITAT USAGE

A rapid assessment of habitat usage was undertaken by referring to kiwi distribution maps and assigning each kiwi location data point to one of five broad habitat types. The approach is relatively coarse, but a more thorough analysis of the existing telemetry data with respect to habitat usage is perhaps not warranted, given that the daytime locations of kiwi may be a poor indication of kiwi nocturnal activity (section 8.1).

Between mid-June 2004 and late February 2005 monitoring staff estimated 330 locations for great spotted kiwi in the RNRP recovery area. Telemetry results from early June 2004 were not used for this assessment as the monitoring team was less experienced and a number of anomalies appear to have been plotted. Precise locations were not estimated or mapped after February 2005 (section 7.1).

Five broad habitat types were recognised, and the geographical extent of each habitat was identified with reference to topographical features on the distribution maps and first-hand knowledge of the recovery area. The following five habitat types were used for this assessment:

1. Red beech dominated colluvial slopes lying between Lake Rotoiti and the truncated spurs of the St Arnaud Range;
2. Red beech dominated faces and truncated spurs on the St Arnaud Range;
3. Broken forest or scrub adjacent to the Travers Flats at the head of Lake Rotoiti;
4. High altitude (>1000m) ridge and gully habitats dominated by mountain beech;
5. Open alpine tops.

The number of location data points plotted in each habitat was counted, and the results were expressed as percentages.

Telemetry monitoring from mid-June 2004 to February 2005 suggested that the transferred kiwi have a strong preference for the red beech dominated colluvial slopes adjacent to Lake Rotoiti, and a moderate preference for the red-beech dominated faces and truncated spurs. It is possible that the apparent habitat preference is coincidental, and that the kiwi occurred most frequently on red-beech dominated colluvial slopes not because of a preference for that habitat, but because of a limited tendency to disperse from the release area. All of the release sites were on red-beech dominated colluvial slopes. Further research would be necessary to reach any conclusions about the habitat preferences of transferred great spotted kiwi.

A rapid assessment of kiwi daytime locations during the period from mid-June 2004 to late February 2005 showed that the following percentages of observations occurred in five broad habitat types:

- *Red beech dominated colluvial slopes lying between Lake Rotoiti and the truncated spurs of the St Arnaud Range* - 73% of observations
- *Red beech dominated faces (truncated spurs) on the St Arnaud Range* - 20% of observations
- *Broken forest or scrub adjacent to the Travers Flats at the head of Lake Rotoiti* - 5% of observations (all relating to female RA-0442 / Rameka)
- *High altitude (>1000m) ridge and gully habitats dominated by mountain beech* - 2% of observations
- *Open alpine tops* - Less than 1% of observations

During February 2005 male R-31759 / Kahurangi and female RA-0444 / Awaroa moved a substantial distance uphill immediately after a breeding attempt (section 8.4). Both birds moved onto steep terrain above the colluvial slopes. Awaroa in particular has continued to reside in the steeper areas, apparently using a mixture of red beech dominated faces and high-altitude ridge and gully habitat dominated by mountain beech. Kahurangi seems to spend more time at lower altitudes on a truncated spur in red beech face habitat. The behaviour of this pair suggests that the red beech dominated faces and high-altitude ridge and gully habitat will be able to support kiwi, and that the red beech dominated colluvial slopes should not be regarded as the only areas capable of supporting kiwi.

8.4 BREEDING

One nesting attempt was detected during the year following the transfer. While it is considered likely that an egg successfully hatched, the chick was not found. This nesting attempt was preceded by a period of activity that was initially interpreted as a nesting attempt, but which in hindsight may have been a period of pair-bonding, copulation and other pre-breeding activity, or perhaps a failed nesting attempt.

From mid-August 2004 male R-31759 / Kahurangi was repeatedly plotted in one small area, and female RA-0444 / Awaroa was repeatedly plotted nearby. During subsequent weeks both birds remained in close proximity and RNRP field staff considered it increasingly likely that Kahurangi and Awaroa were paired for breeding, and that Kahurangi could be incubating an egg laid by Awaroa. This was considered to be a new pairing, not previously established at Corkscrew Creek (section 5.1.1). The female was the same bird that was diagnosed with extremely high creatinine kinase (CK) levels during the transfer, and her breeding so soon after the transfer was unexpected because of the health problems sometimes associated with high CK levels (section 5.4.1).

During October 2004 a perimeter line was marked enclosing several hectares around the putative breeding territory. Some new telemetry monitoring points were established on the perimeter line and a nearby spur, and the new telemetry points were visited weekly. The male was considered to be incubating while the bearings remained at constant angles (10 degrees variation was considered insignificant) from the telemetry points. Monitoring staff did not go inside the perimeter line, as great spotted kiwi are known to desert nests and break their eggs if disturbed. This meant that the position of the putative nest within the breeding territory was approximately known, but not pinpointed.

Monitoring staff visited the breeding territory on the evenings of 2nd October and 20th October, in an effort to detect a "changeover" of incubation duty at the putative nest. On both occasions the male and female began the evening inside the marked perimeter, but the female moved a substantial distance beyond the perimeter during the night, while the male apparently stayed within the perimeter, but appeared to leave the putative nest site at times. On one occasion the male visited the observer, and was seen. At no time did the female appear to relieve the male from incubation duty.

On 27th October, the male was recorded inside the marked area for the last time: by 2nd November the male was clearly outside the perimeter. Monitoring staff calculated that the male was present at the putative nest site for a period of at least 72 days (from 17th August to 27th October inclusive), perhaps longer. This was sufficient time for an egg to hatch, but was shorter than the minimum 85 days of parental attendance at the nest that McLennan and McCann used to infer that a great spotted kiwi nesting attempt was successful (McLennan and McCann 1991).

On 15th November monitoring staff visited the breeding territory with a trained kiwi dog to search for a used nest site, and to search for a chick near either parent. This approach was suggested by the discovery of a 350g great spotted kiwi chick sheltering near an adult male on the Slate Range (Northwest Nelson) early in 2004. This technique – if successful – would not rely on predicting a "hatch window" or approaching the nest during incubation. Awaroa was seen abandoning a shelter which did not have the appearance of a nest site, and no chick was found nearby. Kahurangi was observed sheltering in a shallow cavity about 30 metres outside the perimeter line but was not disturbed, and was not viewed closely enough to discount the possibility that a chick (or egg) was present in the cavity with him.

The decision not to disturb the male on 15th November was fortuitous, because from then until 4th February 2005 (a period of 82 days inclusive) the male was consistently recorded in the same cavity. Shortly into this period it was inferred that the male was incubating an egg, and that the supposed breeding attempt from August-October had either been a failed breeding attempt, or pre-breeding behaviour. The male's new position was monitored weekly from a distance of about 30 metres.

On 14th February monitoring staff determined that the male kiwi had left the nest. An inspection of the nest cavity revealed small fragments of eggshell and strips of egg membrane, and this evidence was considered to be consistent with a successful hatch. Telemetry monitoring showed that both parents moved several hundred metres upslope from the nest area immediately after the breeding attempt, and Awaroa has continued to frequent an area substantially upslope of the 2004/05 nesting area (Figure 2). A video camera was installed at the entrance to the nest cavity on 15th February, but loss of battery charge meant that the videoing was ineffective, and no kiwi visits to the nest site were recorded.

A kiwi dog was used to search in the vicinity of each parent kiwi twice during the days after the nest was discovered to be vacant, and to search around the nest site itself. A non-target adult (male R-31761 / Takaka) was found closer to the nest than expected on the slope below the nest site, and was accidentally captured when he abandoned his shelter. The dog indicated the position of the kiwi, but the bird was out of sight. Monitoring staff attempted to detect a transmitter signal, but no signal was found before the bird flushed, and one of the staff caught it before realising that it was a non-target adult rather than the chick that was being sought. The team did not succeed in finding the chick with the parents or near the nest site during February. In June 2005 a modest amount of search effort was spent with the kiwi dog, searching for the chick on the colluvial slopes around the nest, but the chick was not found.

8.5 PHYSICAL EXAMINATIONS

8.5.1 Weight changes

Five males and two females gained weight during the 12-13½ month period between collection and recapture, and two females lost weight (Table 7 Appendix 2). The mean weight gain was 161.4g (median 150g, range 30g-420g), and the mean weight loss was 105g (range 20g-190g). The mean weight change was more positive for males (average gain of 204g) than for females (average loss of 25g).

The female that bred in the 2004/05 season (RA-0444 / Awaroa) lost 20g, whereas her mate (male R-31759 / Kahurangi) gained 150g. The bird who gained the most weight (male R-31760 / Te Matau; 420g gain) is the mate of the bird that lost the most weight (female RA-0443 / Tai Tapu; 190g loss): Tai Tapu had a high white blood cell count at the time of release (section 5.4.1), which may be related to her weight loss during the subsequent year.

8.5.2 General condition

General condition scores improved for six kiwi during the year following the release. One kiwi was scored the same and another scored lower. One score could not be compared because the category used in 2004 was incorrect (Table 7 Appendix 2).

Female RA-0444 / Awaroa was assigned to a lower body condition class in 2005, moving from "good" in 2004, to "moderate-good" in 2005. This was the kiwi that laid in the 2004/05 breeding season, and the minor change in body condition classification is perhaps consistent with 20g weight loss also recorded for that bird.

The other female who lost weight (190g) between collection in 2004 and recapture in 2005 — RA-0443 / Tai Tapu — was assigned to a higher body condition class in 2005. Tai Tapu moved from "medium" (*sic*) in 2004 to "good-very good" in 2005, suggesting a poor correlation between weight and body condition scoring, or perhaps highlighting the subjective nature of body condition scoring, particularly when a range of observers are involved.

8.5.3 Bill length

The length of every kiwi bill was re-measured in 2005 (Table 8 Appendix 2). Three of the 2005 measurements differed from their corresponding 2004 measurements by more than 1mm: one was 2.1mm shorter and two others were 1.7mm and 2.7mm longer. Variation between different measurers measuring the bill length of a kiwi is typically less than 1.5%, and often less than 0.5% (Robertson et al 2003). The three measurements noted above all vary from the 2004 measurements by more than 1.5%, suggesting that there has been a real change in these bill lengths. These differences in bill lengths are not substantial enough to suggest that any of the kiwi were juvenile or wrongly sexed at the time of collection.

8.5.4 Abnormalities

No new abnormalities were recorded for any of the kiwi recaptured in 2005. Transmitter bearing legs were all in good condition, with no skin wounds or irritations apparent. The majority of metal leg bands had opened to some extent, and required closing. The most frequent gap size was 1mm, but one RA-series band had opened by 7mm and two other RA-series bands had opened by 5mm.

9. Post-release kiwi management

9.1 MANAGEMENT APPROACH

The management approach was based on the proposition that the RNRP recovery area already provided many of the conditions necessary for a kiwi population to establish and flourish, by virtue of the ongoing pest control work that was already being undertaken within the RNRP recovery area to protect a range of biodiversity values. Whether or not this proposition is true under the present pest control regime (or future variations of the regime) can be tested in the future, by monitoring the fate of kiwi chicks which are more vulnerable to predation than adults.

In the meantime, the translocation team took the view that the reintroduction of great spotted kiwi to the recovery area should generate a minimum of extra management effort over and above the existing RNRP operations, and that the majority of kiwi work should be monitoring only. Another important management principle was that unnecessary disturbance to kiwi and handling of kiwi should be avoided. This principle was implicit in some of the post-transfer monitoring and management performance standards set in the translocation operational plan (Appendix 4).

While the management approach was to leave the adult kiwi to establish in the RNRP recovery area with a minimum of intervention and extra management effort, several management actions were planned to ensure that the transferred kiwi were not needlessly killed or lost after the transfer. The translocation team planned management actions to deal with kiwi dispersal, the threat of kiwi being killed on Highway 63, and the threat posed by dogs illegally entering the recovery area.

The translocation operational plan also allowed for a small amount of localised possum and cat trapping to be undertaken near kiwi nest sites, to minimise the impact of pests on kiwi nesting activities. Kiwi nesting success is not currently used as an outcome measure for the RNRP pest control programme, and there seemed to be little point to leaving pest activity unchecked near nests during the early stages of the founder population establishment. Such small scale trapping is easy to implement during regular nest monitoring and would have an insignificant impact on overall RNRP predator control and outcome monitoring results. This position may be reviewed in the future to allow for kiwi nesting and recruitment success to be used as an outcome measure.

9.2 DISPERSAL MANAGEMENT

The translocation team anticipated that dispersal from the RNRP recovery area might be a serious problem, and a procedure was specified in the operational plan to deal with dispersal (section 3.2). No kiwi dispersed from the RNRP recovery area (section 8.1) and no management action was necessary.

9.3 ROAD SIGNS

Kiwi are vulnerable to being killed by motor vehicles on roads: for example there were two sightings of a great spotted kiwi feeding at one location beside the Buller Gorge road during August 2002, but the sightings stopped after a kiwi was killed on the road at the same location in the same month (St Arnaud Area Office records). It was not known if kiwi would disperse to from the release area to State Highway 63 to the north of the release area, but the translocation team considered that such dispersal was a possibility, and there was also a chance that kiwi would favour habitats beside the road (e.g. road verges and Black Valley Swamp) for feeding.

The translocation team attempted to reduce the vehicle threat to kiwi by organising for road signs to be installed at the approaches to St Arnaud. The road signs depicting kiwi would warn motorists approaching St Arnaud of the potential for kiwi to be on or near the road, hopefully encouraging drivers to be careful. Opus consultants (acting on behalf of Transit NZ) installed two signs: one was erected adjacent to Black Valley Swamp about 2km east of St Arnaud, and another was erected near the Upper Buller Bridge about 2km west of St Arnaud. Both signs were attached to posts using a "thief-proof" fastening, as kiwi road signs are sought after by collectors.

The eastern road sign proved to be popular with tourists who frequently stopped for photographic opportunities during summer 04/05; but it was also damaged on two occasions, perhaps by wide loads or by campervans pulling back onto the road after photo stops. After some months the signpost was relocated further from the road and the damaged sign replaced, evidently without the "thief-proof" fastening, as it was stolen during the autumn of 2005. Kiwi are not currently using any areas near the road; however the translocation team believes that the signs have advocacy value, and is planning to replace the stolen sign in the future, perhaps coinciding with the promotion of a second transfer.

9.4 DOG MANAGEMENT

Predation of adult kiwi by dogs can cause catastrophic local declines in kiwi populations (Robertson 2003). Domestic and recreational hunting dogs are prohibited from Nelson Lakes National Park, and the translocation team believed that illegal incursions of dogs into southern RNRP were rare. Nevertheless, an isolated event such as a dog killing all or some of the adult kiwi could seriously jeopardise the trial reintroduction, and the translocation team decided to increase advocacy effort to ensure that dogs were not illegally taken into the release area.

Kiwi zone / dogs prohibited signs were installed at public entry points to the RNRP recovery area, and community relations staff ran articles about the potential threat and the need to control dogs in local newspapers and newsletters. DOC staff were made aware of two illegal dog incursions into the RNRP recovery area in the months following the kiwi release. One hunting dog was lost in the RNRP recovery area about 4km from the release area, and one

domestic dog was taken for a walk inside the kiwi release area. In both cases the people responsible for the dogs were intercepted and spoken to by DOC staff; and in one case legal action was taken under the National Parks Act.

9.5 POSSUM CONTROL

One possum was removed from a kiwi breeding territory. A kiwi breeding attempt was confirmed during the year after the release, and field staff spent some time near the breeding territory at night in an attempt to detect birds swapping incubation duty at the nest (section 8.4). During this monitoring one possum was seen. A Warrior™ kill trap was mounted to a tree near where the possum was seen, and a possum was caught in trap one to two weeks later.

10. Discussion of post-release results

The translocation was highly successful in stocking the RNRP recovery area with adult great spotted kiwi. Prior to the transfer the translocation team did not know how much dispersal to expect, but the possibility that all of the kiwi might attempt to disperse from the recovery area was considered. Compared to this worst case scenario, the actual amount of dispersal was extremely limited. It has been suggested by one Kiwi Recovery Group member that kiwi prefer to live in areas where they can hear other kiwi calling, and that this preference would limit the dispersal of adult great spotted kiwi from a release area. The results of this trial appear to support that suggestion.

There is a possibility that the actual transfer methods and the physical characteristics of the release site contributed to the retention of kiwi in the RNRP recovery area insofar as these factors provided the right conditions for kiwi to express the behaviour that they did. If a different release method or a different type of site were used then there might be a greater chance of kiwi dispersing. Perhaps there is a "critical mass" of kiwi that need to be released together in a short timeframe to prevent dispersal; and the pre-existing relationships between some of the birds and spatial layout of release burrows may also be factors that have helped to limit dispersal. The topographical layout of the RNRP recovery area also seems highly suited to a kiwi release, as Lake Rotoiti and the steep slopes of the St Arnaud range may be natural impediments to kiwi dispersal. Different release methods and different sites would need to be tested before we can know the relative importance of these factors.

The apparently successful breeding attempt by one pair of kiwi during the year following the transfer is a good indication that the RNRP recovery area probably has sufficient food resources and environmental conditions to support a breeding population of great spotted kiwi. The breeding attempt was an isolated event during the first year, but it can only be interpreted as a positive sign. The breeding male gained weight during the year, and the breeding female lost only 20 grams. The breeding female was the same bird that was diagnosed with extremely high creatinine kinase (CK) level during the transfer, but her breeding attempt and physical examination results one year after the transfer suggest that she is generally healthy. Only one other kiwi – female RA-0443 / Tai Tapu — lost weight during the year following the transfer. This weight loss may be related to a high white blood cell count recorded in May 2005, which could in turn be the result of stress (sections 5.4.1 & 8.5.1). All of the kiwi appeared to be healthy when recaptured at the end of the year. Overall, the kiwi appear to have recovered from the stress of the transfer and appear to have adapted well to their new environment.

The requirement for additional kiwi management or threat management over and above the existing RNRP management regime was minimal. There was no management of kiwi dispersal or health problems in the RNRP recovery area. Dogs were a slightly bigger issue than anticipated, as there were two illegal

incursions that needed to be responded to. Community relations staff used these incursions to publicise the RNRP kiwi project and the need for dog owners to comply with the prohibition on dogs in Nelson Lakes National Park. The management principle that unnecessary disturbance to kiwi and handling of kiwi should be avoided (section 9.1) was accidentally violated on two occasions: once during August 2004 when an inexperienced staff member flushed a kiwi during radio tracking, and once when the wrong kiwi was caught in a case of mistaken identity (section 8.4). Two kiwi were also disturbed when staff attempted to ascertain whether a chick was sheltering with either bird, but this disturbance was regarded as justifiable.

An unforeseen issue during the year following the transfer was the management of the injured female kiwi. Although Massey University Institute of Veterinary Animal and Biomedical Sciences (IVABS) staff took the lead in caring for and rehabilitating this bird, the rehabilitation process required some co-ordination effort from the RNRP translocation team. This kiwi will not be able to be released into the wild. Although the bill keratin re-grew over the injured area while this bird was under care at the IVABS veterinary hospital, the kiwi required hand-feeding in order to maintain weight. At different times during 2004 the kiwi was hosted by Rainbow Springs Nature Park and Pukaha Mt Bruce National Wildlife Centre, where it was hoped she would begin to feed herself in a more natural environment. During early 2005 the kiwi began to regularly feed on worms, but she failed to maintain weight when she was released into the RNRP recovery area over a trial period of several days in May 2005. In August 2005 the kiwi was permanently settled at Willowbank Wildlife Reserve in Christchurch, where park staff are continuing efforts to rehabilitate her towards feeding herself. There is a possibility that she may be used in a captive breeding programme in the future.

11. Kiwi surveys at the source area

11.1 INTRODUCTION

Standard kiwi call count surveys were undertaken at the source area prior to the transfer to confirm that there was a good density of kiwi from which to collect birds, and to provide baseline data to compare post-transfer survey results against. Information collected during the call count surveys was also translated onto territory maps. The territory mapping method is considered to be relatively imprecise and inaccurate, but the resulting maps proved useful for identifying potential capture sites prior to the transfer.

The translocation operational plan specified that the post-transfer survey should be undertaken 1-3 months after the transfer, to determine the immediate impact that removal of 8-10 kiwi has had on great spotted kiwi density at the source location. In hindsight this performance standard was poorly conceived, as it is the long-term impact on population viability that is of most interest. The kiwi collecting team was able to estimate the number of kiwi remaining in the source area at the end of the collection period (section 5.1.3) and subsequently decided to undertake the post-transfer monitoring about one year after the transfer, to determine whether the removal of kiwi from the source area had significantly impacted on the density of the source population.

The 2005 post-transfer call count survey results were surprising because the post-transfer call rate was higher than the pre-transfer call rate, despite the removal of ten adult kiwi from the survey area. Survey staff wondered if the higher call rate was the result of fewer kiwi calling more often. Once again, territory maps were produced from information collected during the call count survey. The resulting maps suggested that there were about the same number of kiwi calling in the source area one year after the transfer as there were before the transfer.

11.2 SURVEY METHODS

11.2.1 Call counts

Kiwi call rates (calls per hour) are a standard measure of relative abundance of kiwi, but cannot be used to estimate the absolute numbers of kiwi present, because not all birds call. There is a good correlation between kiwi call rates and kiwi density in high density populations, but the relationship is not as good at low population densities (Robertson et al 2003). The call count method used at Corkscrew Creek was adapted from the distribution survey method specified in the *Kiwi (*Apteryx *spp.) Best Practice Manual*.

Four kiwi listening points were selected and marked. The sites were spatially arranged to provide complete coverage of the open flats and ridges surrounding the base camp (Fig. 1). Where possible the listening points were located on high, open terrain. The northern, southern and eastern listening points were all well situated and each of these listening points provided

substantial coverage of the immediate source area and beyond. The topography surrounding the western listening point was more difficult, and less data was obtained from that point. The distance between the northern and southern kiwi listening points was 1.84 km; and the distance between the eastern and western kiwi listening points 1.29km. The mean distance between listening points was about 1.3km (range 0.92km - 1.84km). Kiwi can be heard calling up to one and a half kilometres away in ideal listening conditions (Robertson et al. 2003) but the area effectively surveyed would vary considerably from night to night, depending on weather conditions.

Assuming that all calls within 1km of each listening station would be heard, the area effectively surveyed at Corkscrew Creek would be approximately 850 hectares. Taking into account the limitations imposed by terrain, such as incised gullies and steep slopes facing away from the listening points, the area effectively surveyed is estimated more likely to be about 550 hectares. There was considerable overlap of the one kilometre putative listening radiuses around each listening point, meaning that some kiwi calls could be concurrently counted from more than one listening station (Fig. 1). This overlap may have increased the accuracy of the call rate result by reducing the effect of bias (e.g. observer error or bias imposed by localised noise or topographical conditions). In effect, the overlapping areas were independently sampled from more than one listening station; and bias affecting one station may not have affected others.

The prescribed sampling method was for a surveyor at each listening point to observe and record kiwi calls over two one-hour periods on each night of the survey. On most nights surveyors had a ten minute break between the first and second hours. Ideally, each survey would extend over three fine nights; and by the end of each survey, six hours of kiwi call data would have been collected from each listening point. Individual surveyors were assigned to different listening points on different nights, to avoid the accumulation of individual observer bias at any one listening point. On each listening night, call counts commenced no earlier than one hour after sunset, and largely occurred within the first four hours of darkness.

Surveyors used standard Kiwi Call Scheme cards to record the sex of each kiwi heard, the time of the call, the compass bearing of the call in relation to the listening point, and estimated distance between the calling bird and the listening point. All of this information was used for territory mapping (below). In order to calculate the call rate for a given survey period, the total number of kiwi calls heard within the survey was divided by the total effort (hours), to give a call rate expressed in calls per hour.

11.2.2 Territory mapping

The territory mapping method is considered to be relatively imprecise and inaccurate. The primary reason for undertaking territory mapping was to identify potential kiwi capture sites prior to the transfer; however this information is also of interest as an alternative measure of kiwi abundance in the source area. Data collected during both the baseline survey and the post-transfer call count survey was used to produce various estimates of the number and locations of kiwi territories within the source area at different times.

The best data sets collected during each survey were plotted onto 1:12500 scaled maps. Data sets that were considered inferior (because they were collected on the first night using inexperienced observers, or staffing at listening points was incomplete) were not used. In most cases, observations recorded over a single hour were plotted onto one map. Although it would have been feasible to increase the scale of the maps and plot two hours (= 1 night) of data onto one map, analysis of the data over a longer period would have been increasingly dependant on accurate plotting of the calling birds' locations. Thus the majority of the maps represent one hour "snapshots" of kiwi activity. On one night with a lower overall call rate, two hours of observations were combined onto one map.

To plot kiwi calls onto a map, the magnetic bearing of each kiwi call was converted to a true bearing, and then drawn onto a topographical map as a vector originating from the relevant listening station. The length of the vector was scaled to the estimated distance of the call from the observer. At the end of the vector, the call was plotted as B& (male) or @& (female) depending on the type of call. Vectors were also labelled with the time at which the call was heard.

The data plotted on the resulting maps proved to be difficult to interpret. Given that a substantial number of kiwi calls within the source area should have been heard concurrently from more than one listening point because of the overlap in putative listening radiuses, such observations would be expected to be clustered on the map, with each cluster representing one call. No such clusters were plotted; and yet there were frequent cases of kiwi calls being heard from different listening stations during the same minute. It was considered likely that in some (perhaps many) cases, a lack of agreement between observers was caused by observer error in estimating the direction and/or distance of calls relative to his/her listening point, resulting in a single call being plotted in more than one location. If each of the disparately plotted calls was then accepted as a separate cluster (i.e. a separate call) the result would be an overestimation of the number of kiwi calls heard.

In order to avoid overestimating the number of kiwi calls heard in the source area, the survey team decided to give priority to the time (rather than estimated location) of kiwi calls as the attribute that determined whether observations from different listening points should be attributed to a single call. However, another possible source of error was that some observers may have recorded slightly different times during one kiwi call. A male great spotted kiwi call sequence usually comprises 13-21 whistles (McLennan & McCann 1991) and a call is likely to span from a quarter to half a minute. Greater accuracy in recording when the call occurred would have improved the survey team's ability to determine when different observations should be attributed to the same call. This potential source of error was not recognised until after the April 2004 call counts. From April 2004 onwards, observers recorded the time at which a kiwi call ended, as this was a more specific point in time.

A matrix was made for each period that was mapped, listing every single time (hour/minute/seconds) that a kiwi call was recorded, which listening point(s) the call was registered at, and the sex of the kiwi call. Times were listed in descending chronological order in the left column; listening stations 1-4 headed columns 2-5; and the sex (B& or @&) of every kiwi call was entered into the

resulting matrix. Given that different observers may have assigned slightly different times to one call, those that were considered to be close enough in time to be the same call were grouped together unless there was compelling evidence to suggest that there was more than one individual kiwi involved (e.g. different sexes were heard, two same sex calls originated from substantially different directions, or two same sex calls were registered concurrently by one observer). The resulting groupings enabled the survey team to estimate a minimum number of calls of each sex that were heard during the period in question, without counting one call more than once. The result was a list of calls that were regarded as bona fide separate calls.

By referring back to the maps of plotted call locations, it was possible to assign each call from the list to a broad spatial area, although the lack of agreement between different observations of the same call meant that it was impossible to plot calls with a high degree of precision. Some of the calls fell into apparent spatial clusters, and others were apparently outside those clusters. Territorial boundaries were postulated and drawn between the clusters and outliers. The final step of postulating territorial boundaries involved splitting or amalgamating clusters based on a small amount of evidence and substantial amount of assumption, doubtless further reducing the accuracy of the territory maps. Because of this lack of precision and accuracy, the territory maps are not reproduced in this report. The estimated minimum numbers of kiwi and territories implied by the mapping exercise are stated in sections 11.3.2 & 11.4.2.

11.3 BASELINE SURVEY RESULTS

11.3.1 2004 baseline call counts

The baseline call survey at Corkscrew Creek did not go exactly according to plan. The survey team intended to undertake a three night survey from 13th-15th April 2004; however, on 13th April it took longer than anticipated for the first survey team to mark all of the routes to the predetermined listening points. It was impossible to staff all of the listening points that night, so the team opted to spend one hour together at KLP1, ensuring that all team members could correctly identify male and female great spotted kiwi calls and record observations correctly on the Kiwi Call Scheme cards. Each of the other three listening points was surveyed for an additional hour in May 2004, to more evenly distribute the amount of survey effort spent at each listening point prior to the transfer.

Seventeen hours of survey effort occurred over three nights in the week preceding the new moon in April 2004. Listening conditions were mostly favourable, with calm-moderate winds at most sites on most nights. Two sites experienced strong winds on the third night. On 14th April one surveyor misunderstood the arrangement to have a break between the first and second hours and continued counting, finishing ten minutes earlier than the others. This would not negate the value of the call count result, as each count from each listening point is effectively an independent sample. Three hours of survey (one hour at each of KLP2, KLP3 & KLP4) was undertaken on May 10th, nine

days prior to the new moon. Listening conditions were acceptable, with light-moderate winds and slight-moderate background noise. The total number of kiwi calls heard from all listening points (161 calls) was divided by the total amount of survey effort (20 hours) to give a call rate of 8.05 calls per hour (Table 9 Appendix 3).

11.3.2 2004 territory mapping

Three different territory maps were drawn using data collected on 14 April (first and second hours mapped separately) and 15th April (first and second hours mapped together). On 14th April, one survey team member finished recording calls ten minutes before the others, meaning that several male and female calls that potentially could have been audible at KLP1 between 21:00 and 21:10 were not recorded at that site. Although the resulting maps lacked precision (section 11.2.2) they did prove useful in guiding the translocation team to suitable capture locations. The three territory maps drawn from the call count data suggested that — within the approximately 550 hectares adequately surveyed around the four listening points — there was a minimum of 16-21 great spotted kiwi calling in 9-13 different territories.

TABLE 1: TERRITORY MAPPING RESULTS 2004 - ESTIMATED MINIMUM NUMBERS OF INDIVIDUAL GREAT SPOTTED KIWI HEARD CALLING FROM TERRITORIES IN THREE DIFFERENT TIME PERIODS

MAP	DATE	PERIOD	ESTIMATED MINIMUM NUMBER OF GSK	ESTIMATED MINIMUM NUMBER OF TERRITORIES
1	14/4/04	19:00 - 20:-00	(Male 11; Female 10) = 21	13
2	14/4/04	20:00 - 21:10	(Male 11; Female 8) = 19	12
3	15/4/04	19:00 - 21:00	(Male 9; Female 7) = 16	9

11.4 POST-TRANSFER SURVEY RESULTS

11.4.1 2005 post-transfer call counts

The post-transfer call survey was undertaken over three nights from 31 March 2005 to 2 April 2005. Listening conditions were favourable, with calm or light wind conditions at most listening points on most nights, and a small amount of light rain on the first and third nights. The total number of kiwi calls heard from the listening points (272 calls) was divided by the total amount of survey effort (24 hours) to give a call rate of 11.3 calls per hour (Table 10 Appendix 3).

11.4.2 2005 post-transfer territory mapping

Four different territory maps were drawn using data collected on 1st April and 2nd April 2005. Data collected during the first and second hour of each night was mapped separately. The four territory maps drawn from the call count data suggested that — within the approximately 550 hectares adequately surveyed around the four listening points — there was a minimum of 19-20 great spotted kiwi calling in 13 different territories.

TABLE 2: TERRITORY MAPPING RESULTS 2005 - ESTIMATED MINIMUM NUMBERS OF INDIVIDUAL GREAT SPOTTED KIWI HEARD CALLING FROM TERRITORIES IN FOUR DIFFERENT TIME PERIODS

MAP	DATE	PERIOD	ESTIMATED MINUMUM NUMBER OF GSK	ESTIMATED MINIMUM NUMBER OF TERRITORIES
4	1/4/05	20:00 - 21:00	(Male 9; Female 11) = 20	13
5	1/4/05	21:10 - 22:11	(Male 12; Female 8) = 20	13
6	2/4/05	20:00 - 21:00	(Male 9; Female 10) = 19	13
7	2/4/05	21:10 - 22:10	(Male 12; Female 8) = 20	13

11.5 DISCUSSION OF SURVEY RESULTS

Given that ten kiwi were removed from the survey area in May 2004, the translocation team expected that the post-transfer call rate in 2005 would be lower than the baseline call rate in 2004. In fact, the post-transfer call rate was higher (11.3 calls/hour c.f. 8.05 calls/hour). Likewise, attempts at territory mapping in 2005 did not show the expected reduction in the number of kiwi in the survey area following the collection operation. The 2005 maps suggested that a minimum of 19-20 great spotted kiwi were present in 13 territories – a similar result to the territory map for the first hour on 14th April 2004, which suggested that a minimum of 21 kiwi were present in 13 territories.

There are several likely explanations for the relatively minor difference between the baseline survey and post-transfer survey results. One possible explanation is that kiwi may have immigrated into the survey area after the transfer. None of the kiwi remaining within or adjacent to the Corkscrew Creek area after the transfer were marked, so it is not possible to determine whether there has been a significant amount of immigration into the survey area following the removal of kiwi in 2004.

An alternative possibility is that the baseline surveys underestimated the number of kiwi present in the source area. This could happen if kiwi were present but not calling, or if environmental conditions (e.g. wind) impacted on observers' ability to detect kiwi calls. The 2004 surveys may have underestimated the number of kiwi present if younger or less-dominant birds were present but did not call. Such birds may have called in 2005 after the original territory holders had been removed. The relative timing of the surveys may also have lead to an underestimate in 2004. The baseline call counts were undertaken in mid-late autumn (mid-April and May) 2004. The post-collection survey occurred some weeks earlier in the autumn of 2005 (late March / early April), closer to what is believed to be the peak calling time for great spotted kiwi (November to March - Robertson et al 2003). Observers recorded slightly more wind noise during the baseline surveys, which may have slightly limited their ability to detect kiwi calls (Tables 9 & 10, Appendix 3).

Notwithstanding the possibility that the 2004 baseline surveys underestimated the number of kiwi present in the source area, the collecting team's observations during May 2004 appear to corroborate the April 2004 territory mapping results. In May 2004, the collecting team removed five males and five females from the source area, and estimated that a minimum of six males and five females were remaining (section 5.1.3). This implied that at least eleven males and ten females were present prior to the collection operation. Collectively there were eight apparent pairs and five more birds in separate areas, and it can be inferred from this that there was a minimum of thirteen territories in the source area. Territory mapping in April 2004 also suggested that at least eleven males and ten females were present within thirteen territories (Table 1). It may be unwise to read too much into this apparent agreement: the territory map is only a one hour "snapshot"; and the estimate of birds remaining in the survey area post-transfer is the result of casual observations rather than systematic survey. There is little agreement between the April 2004 territory maps and Figure 1 with respect to the actual locations of specific birds and territories.

Although the respective influences of immigration, initial population underestimation and the different timing of surveys cannot be quantified, the small difference between the 2004 and 2005 survey results strongly suggests that the removal of ten great spotted kiwi from the Corkscrew Creek area did not have a substantial impact on the kiwi population density or viability at that site. The impact on the wider Northwest Nelson great spotted kiwi population would have been negligible.

12. Conclusions

12.1 GENERAL CONCLUSIONS

The transfer operation was highly successful in delivering almost all of the required number of kiwi to the RNRP recovery area in less than one week. This success was partially attributable to the use of a specialist kiwi catching team with a kiwi dog that helped to catch birds at night. The only serious problem during the transfer operation was the injury of one kiwi in a transfer box. This injury highlights the need for a better design of transfer box. Although it was apparent from health sampling and other observations that the transfer did place kiwi under stress, there were no deaths resulting from stress. High creatinine kinase levels in three samples highlight the need for ongoing refinement of kiwi handling techniques, and also highlight the need for a better reference range of CK values and an understanding of how to interpret CK values with respect to great spotted kiwi.

This trial great spotted kiwi reintroduction was highly successful in terms of the retention of released great spotted kiwi within the RNRP recovery area. Approximately one year after the release all of the transferred kiwi were recaptured in south RNRP, generally within the area containing the initial release burrows. Telemetry monitoring suggested that most kiwi were likely to be within calling distance of one or more kiwi at most times throughout the year, and it is considered likely that adult great spotted kiwi are behaviourally predisposed to remaining within calling distance of other kiwi. The transfer methods and physical characteristics of the release site may have contributed to the successful retention of kiwi in the RNRP recovery area insofar as they provided the right conditions for the kiwi to express this behaviour. Two established pairs that were transferred together appear to have remained together at the release area, and one pair that was split up by the transfer appears to have re-formed at the release area after more than a year of separation. Pair-bonds may have helped to minimise dispersal, although the first pair to breed was not considered to be a previously established pair. The retention of kiwi in the release area bodes well for future transfers using similar methods.

Great spotted kiwi appear able to adapt to new environments and to utilise new food resources. Most of the transferred kiwi gained weight and body condition during the year following the transfer; and an apparently successful breeding attempt by one pair of kiwi is a good indication that the RNRP recovery area probably has sufficient food resources and environmental conditions to support a breeding population. Since breeding the pair has resided at higher altitudes on steeper slopes, suggesting that the low altitude red beech dominated colluvial slopes should not be regarded as the only areas capable of supporting kiwi. The breeding activity was notable because the pair was not a previously established pair, and the female was the same bird that was diagnosed with extremely high creatinine kinase levels during the transfer.

It was clear from post-transfer surveys that the Corkscrew Creek area supported a relatively high density of kiwi one year after the transfer. There was little difference between the pre-transfer and post-transfer territory mapping results, and the call count indicated an increase in calling activity. The translocation team does not know whether the Corkscrew Creek site has been repopulated by immigrating kiwi, or if the survey team originally underestimated the number of kiwi at the site. The removal of ten adult kiwi may have provided an opportunity for younger kiwi to take up territories about Corkscrew Creek. It would be interesting to study the effects of removing adult kiwi from an apparently healthy population in more detail. The translocation team believes that the 2005 survey results confirm that the removal of ten great spotted kiwi from the Corkscrew Creek area did not have a substantial impact on the density and viability of the local kiwi population at Corkscrew Creek. The impact of the transfer on the wider Northwest Nelson great spotted kiwi population would have been negligible.

12.2 EVALUATION OF SUCCESS

According to criteria specified in the translocation operational plan, the translocation has met the definition of a partial success. The translocation operational plan specified a set of performance standards (operational targets) that should be met during the course of the translocation (Gasson 2004b). Appendix 4 lists all of the performance standards identified in the translocation operational plan, and includes the translocation team's assessment of whether each standard was met. The translocation operational plan also specified a definition of success to be applied to the translocation. This definition refers to "critical performance standards" which are highlighted in Appendix 4.

The translocation operational plan stated that the translocation will be deemed a SUCCESS if:

- All of the critical performance standards (Table 11 Appendix 4) were met

and

- 50% or more of the male great spotted kiwi and 50% or more of the female great spotted kiwi have settled into defined territories within the RNRP recovery area 10 months after their release.

The translocation operational plan stated that the translocation may be deemed a PARTIAL SUCCESS if:

- Most of the critical performance standards (Table 11 Appendix 4) were met

and

- 50% or more of each sex remain within the combined RNRP recovery area and "Friends of Rotoiti" mustelid control area (eastern St Arnaud Range) 10 months after their release.

or

- One pair of great spotted kiwi has settled into a defined territory within the RNRP recovery area 10 months after their release

Most of the critical performance standards were unequivocally met (Appendix 4), but one critical standard was not met because female RA-0441 / Mohua sustained an injury during the transfer and could not be released into the RNRP recovery area. This means that the translocation cannot meet the specified definition of success (above). There was no dispersal from the release area, and almost all of the kiwi were settled into identifiable areas in the specified timeframe. If none of the kiwi had been injured during the transfer then the translocation would have been highly successful and, arguably should have met any definition of success. In fact, the translocation meets the definition of a partial success.

The translocation operational plan addressed the possibility of a follow-up transfer of kiwi, and stated an operational target: to establish a founder population of ten pairs of great spotted kiwi living within the RNRP recovery area. The operational plan also stated that planning for a follow-up translocation of five pairs would proceed subject to the success of the first translocation; and that if the first translocation proved to be a partial success then it may be appropriate to use the same method again, taking into account any factors that appear to have limited or enhanced the success of the first translocation.

The first translocation was highly successful in achieving most operational targets. Clearly there is a need to improve the transfer box design and to continue refining handling techniques to minimise stress to kiwi; but on the strength of the results of the first transfer, a second transfer is recommended. Lessons learnt from the first transfer are incorporated into further recommendations in section 13 (below).

13. Recommendations

13.1 FOLLOW-UP TRANSFER

A second transfer of wild-sourced adult great spotted kiwi to the RNRP recovery area during autumn (late April) of 2006 is recommended to allow further study and improvement of the transfer method, and to enhance opportunities for founder population monitoring and management in the future.

Another transfer of five pairs will augment the small population currently living in the RNRP recovery area, creating a more robust founder population that may only require infrequent and minimal supplementation to maintain genetic viability.

The follow-up transfer should also be regarded as experimental (with defined research and monitoring objectives) as it is not known how the second release group will interact with the initial release group. In effect, the transfer will be the second part of a two-part experiment.

Subject to the technical recommendations (below) it is recommended that the same transfer method be used in the second transfer as for the first transfer. The performance standards included in the original operational plan (Gasson 2004b) should be reviewed, and a new set of performance standards should be produced to reflect the knowledge and experience gained during the first transfer, and the technical recommendations below.

13.2 TECHNICAL RECOMMENDATIONS

The following are recommended actions for the follow-up transfer of great spotted kiwi to the RNRP recovery area:

Source population, survey and preparation

1. Collect the second group of kiwi from a new source area some kilometres distant from Corkscrew Creek, to ensure that the founder population includes a range of genetic stock.
2. Consider sourcing birds from a site near the Gouland Downs, as health screening prior to the transfer may not be necessary: the same procedure as for the first transfer could be followed.
3. If kiwi are sourced from a different population then advance health screening may be necessary (refer to translocation and wildlife health SOPs). Seek veterinary advice on whether pre-transfer diagnostic sampling for disease screening is essential.
4. Visit the chosen source area no later than February-March 2006 in order to conduct baseline surveys and identify pairs for collection. As a minimum, a standard three-night call count surveys should be undertaken.

5. Only undertake pre-transfer captures for health screening if absolutely necessary, as great spotted kiwi can be difficult to recapture. A specialist kiwi catching dog may be required. A safer strategy may be to collect representative samples from birds adjacent to the source area that are not intended for transfer.

6. If it is considered necessary to collect diagnostic samples from the source area prior to the kiwi collection and transfer, avoid normal night catching (attract-and-ambush) methods that may result in a failure to catch kiwi and are likely to make them more wary of being caught in the future. Use a proven kiwi-catching dog at night to increase the chances of an encounter resulting in a successful capture, or else use a dog to locate kiwi during the daytime. Radio-tag any kiwi that are caught and are likely to be needed for transfer.

7. If pre-transfer captures are deemed necessary then ensure that the opportunity to collect data is maximised. Blood samples (including whole blood samples) are required for establishing baseline reference ranges for great spotted kiwi. Consult Brett Gartrell (Massey IVABS) and the Kiwi Recovery Group.

Collection

1. Use a proven night dog/catching team to collect the required number of untagged kiwi as quickly as possible. Have a dedicated kiwi catcher and kiwi indicator dog available to catch any previously radio-tagged kiwi.

2. Collect established pairs wherever possible as they may stay together at the release site, and this approach minimises the impact on established pairs at the source area.

3. Collect adult birds in any condition (including poor) if they appear otherwise healthy.

4. Do not hold any kiwi at capture sites while playing calls to attract further kiwi: transport captured birds directly to base camp.

5. Birds can be transferred short distances in either cardboard "pet cubes" or canvas bags. Do not tape legs together during transporting.

6. Process kiwi at night to keep them cooler and calmer. Ensure skilled staff are available to process birds, enabling catchers to focus on catching.

Holding and Transfer

1. Redesign the transfer boxes: transfer boxes need a "foolproof" system for preventing bill injuries when the door/lid is being shut. Current proposals include a transparent Perspex internal lid sitting on a rim underneath the hinged lid, a sliding door, a fabric sheet that fits over the top before shutting the lid, or a rubber flap at the back of the hinged lid.

2. Consider halving the existing double transfer boxes: single transfer boxes will be easier to handle than double boxes, although they will need to be well marked to ensure that pairs are kept together.

3. Consider installing viewing ports or transparent lid liners in each transfer box. These would be useful for assessing bird health, behaviour and worm supply.

4. Additional (perhaps adjustable) ventilation should be installed. One ventilation port on three sides of each transfer box is marginal when holding birds on warm days.

5. Hold kiwi in transfer boxes for a maximum of 48 hours. Provide worms to keep kiwi hydrated.

6. Consider collecting blood samples at St Arnaud rather than at the source area, as this will provide a better overview of how well each bird has coped with holding and transfer.

Release

1. Continue to disallow flash photography of kiwi. Provide photographic opportunities for approved media in high-light situations (e.g. during post-transfer health checks at St Arnaud), but not in low-light situations (e.g. near release burrows) where a flash might be used.

2. Continue to use release burrows for containing kiwi during the daytime

3. Release burrows should not be inside known kiwi territories (estimated from daytime shelter locations), but should be about 500 metres from known territories.

4. Consider the possibility that artificially matched pairs of kiwi could roam further than previously established pairs and single birds when allocating release burrows to particular birds. Artificially paired birds and singles may require a greater "buffer" of protected habitat.

5. Have a trained vet available to inspect and hydrate birds before they are placed into the release burrows, and have a plan for dealing with injured birds. Massey IVABS has offered to assist with a second transfer.

6. Open the release burrows no later than 0-15 minutes after sunset (videoing showed that kiwi become active in the burrows 15-45 minutes after sunset).

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References

Butler, D. J. 1998. Rotoiti Nature Recovery Project. St Arnaud's Honeydew Beech Mainland Island Strategic Plan. Department of Conservation, Nelson/Marlborough Conservancy, Nelson.

Butler, D.J. 2001. Kiwi in Nelson Lakes National Park. Unpublished report, Department of Conservation, Nelson.

Colbourne, R. 2005. Kiwi (*Apteryx* spp.) on offshore New Zealand islands. Populations, translocations and identification of potential release sites. DOC Research & Development series 208.

Department of Conservation *Standard operating procedure for the Translocation of New Zealand's indigenous terrestrial flora and fauna,* 2002.

Eastwood, D. 2002. Great spotted kiwi: report on a pilot breeding study in the Taramakau valley, Hokitika area 1997 to 2000. Department of Conservation unpublished report, Hokitika.

Gasson, P. 2004a. Options for sourcing a founder population of great-spotted kiwi (*Apteryx haastii* /Roroa) for translocation to the Rotoiti Nature Recovery Project. Department of Conservation, St Arnaud.

Gasson, P.2004b. Operational Plan for translocating great-spotted kiwi (*Apteryx haastii*) from the Gouland Downs to the Rotoiti Nature Recovery Project mainland island. Department of Conservation, St Arnaud.

Gasson, P. 2004c. Proposal for translocation of great spotted kiwi (apteryx haastii) from the Gouland Downs (Kahurangi National Park) to the Rotoiti Nature Recovery Project mainland island. Department of Conservation, St Arnaud.

Gaze, P.D. 2001. Mohua on Mt Stokes – the rise and fall of a population. Unpubl. report, Department of Conservation, Nelson.

Girardet, S. 2000: Tools for protecting endangered species: eradication; translocation; triangulation. PhD thesis, School of Environmental and Marine Sciences, University of Auckland.

Heather, B. & Robertson, H. *The field guide to the birds of New Zealand*. Viking 1996.

Hitchmough, Rod (comp). 2002. New Zealand Threat Classification System lists - 2002. *Threatened species occasional publication 23*. Biodiversity Recovery Unit, Department of Conservation, Wellington.

Jakob-Hoff, R. 2000. *Workbook for developing quarantine and health screening protocols for native animal movements within New Zealand.*

MacMillan, B.W.H. 1990. Attempts to re-establish wekas, brown kiwis and red-crowned parakeets in the Waitakere Ranges. *Notornis* 37 (1): 45-51.

McLennan, J. A. and McCann, A.J. 1991. *Ecology of great spotted kiwi, Apteryx haasti*. DSIR Land Resources Contract Report No. 91/48.

McLennan, J.A. and McCann, A.J. 2002. Genetic variability, distribution and abundance of great spotted kiwi (*Apteryx haastii*)" in *Some early 1990s studies in kiwi (Apteryx spp.) genetics and management*. Science and Research internal report 191 Fred Overmars ed. Department of Conservation, Wellington.

Robertson, H. A. 2003. *Kiwi (Apteryx spp.) Recovery Plan 1996 – 2006. Threatened Species Recovery Plan 50*. Department of Conservation, Wellington.

Robertson, H. Colbourne, R. Castro, I. Miller, C. Cresswell, M. 2003. *Kiwi (Apteryx spp.) Best Practice Manual*. Department of Conservation, Wellington.

Robertson, H. McLennan, J. Colbourne, R. McCann, A. 2005. Population status of great spotted kiwi (*Apteryx haastii*) near Saxon Hut, Heaphy Track, New Zealand in *Notornis* 52 (1): 27-33.

Wardle, J. 1984. *The New Zealand Beeches: ecology, utilisation and management*. New Zealand Forest service, Wellington.

Wilson, P.R., Karl, B.J., Toft, R.J., Beggs, J.R. & R.H. Taylor. 1998. The role of introduced predators and competitors in the decline of kaka (*Nestor meridionalis*) populations in New Zealand. Biological Conservation 83(2): 175-185.

Worthy, T.H. and Holdaway, R. N. 2002. *The Lost World of the Moa: Prehistoric Life of New Zealand*. Indiana U.P.