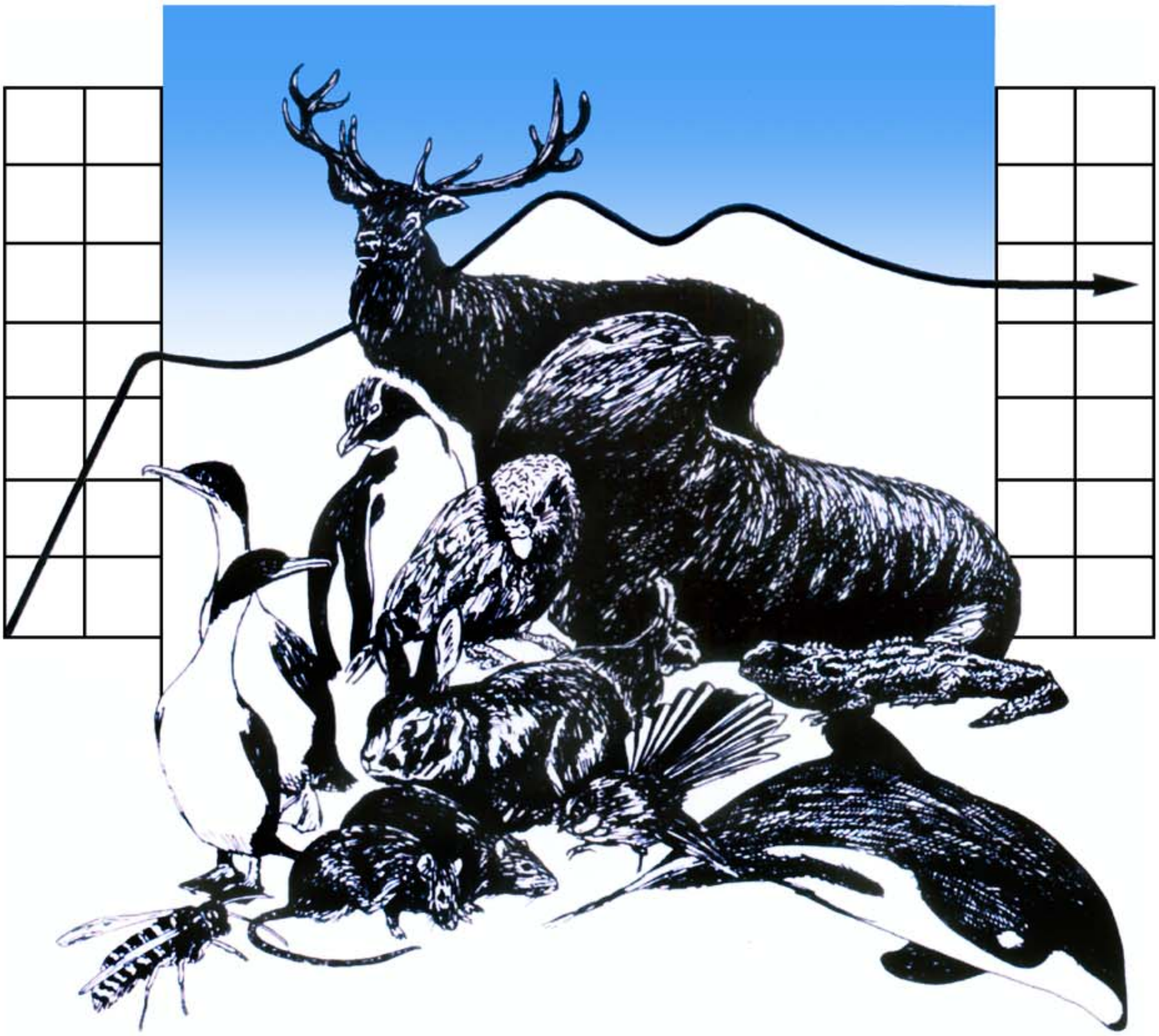
UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

NEW ZEALAND

DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Nest and egg success findings of the Tasman Valley Control Project outcome monitoring for the 2006-07 breeding season for banded dotterels and wrybills

Sandra Soeder-Hunua

A report submitted in partial fulfilment of the
Post-graduate Diploma in Wildlife Management

University of Otago

Year 2007

University of Otago
Department of Zoology
P.O. Box 56, Dunedin
New Zealand

WLM Report Number: 230

Nest and egg success findings of the Tasman Valley Control Project outcome monitoring for the 2006-07 breeding season for banded dotterels and wrybills

By

Sandra Soeder-Hunua

A report submitted in partial fulfillment of the requirements for the Postgraduate Diploma in Wildlife Management

University of Otago

2007

University of Otago
Department of Zoology
PO Box 56, Dunedin
New Zealand

Table of Contents

Executive Summary

The braided rivers of the Upper Waitaki Basin (UWB) are nationally important habitat and principle breeding grounds for many of New Zealand's endemic bird species, including the critically endangered black stilt (kaki). Mammalian predation, however, is one of the primary causes of decline for the native avifauna of New Zealand's braided river systems. Thus, partially funded by the Kaki Recovery Programme, the Tasman Valley Control Project (TVCP) was initiated in 2004 as a five year trial to test the benefits of large-scale predator control for native river bed species.

The focus of this report is to present the egg and nest success findings of the TVCP outcome monitoring for the 2006-07 breeding season for banded dotterels and wrybills. The TVCP is currently employing the conventional method for estimating egg and nest success. However, the conventional method is renowned for over-estimating success and is rarely recommended in the literature. The Mayfield method is considered a significant improvement over the conventional method. Therefore, nest success of banded dotterels and wrybills was re-calculated in this report using the Mayfield method to demonstrate its merit over the conventional method.

Analysis indicates that egg and nest success for banded dotterels and wrybills is reasonably high and could signify that predator control is being effective. The only confirmed predation events on banded dotterel and wrybill eggs and chicks, over the three years of monitoring by the TVCP, have been the loss of three eggs. However, this report highlights how unknown outcomes for eggs and nests, along with applied assumptions in calculating egg and nest success, may be concealing the genuine level of predator impact.

This report concludes with two recommendations to the TVCP; first, to adopt the esteemed Mayfield method for calculating all stages of nest success. And second, to establish definitive predation impact and nest outcomes in future monitoring seasons through video monitoring surveillance.

1 Introduction

1.1 The Tasman Valley Control Project

Extending east from the main divide of the Southern Alps to Lake Waitaki, the Upper Waitaki Basin (UWB) holds some of the most extensive braided river systems in New Zealand (Caruso, 2006). These river systems are nationally important for several native wading and shore bird species, and may now provide half of all New Zealand's remaining suitable braided river bird habitat (Maloney *et al.*, 1997). The UWB is a principal breeding ground for six of New Zealand's endemic bird species; black stilt, banded dotterel, wrybill, black-fronted tern, black-billed gull, and the South Island pied oystercatcher (Maloney *et al.*, 1997). However, this critical habitat has been significantly impacted by hydroelectric power schemes (e.g. damming of glacial lakes), irrigation schemes, sheep and cattle grazing, recreational activities such as off-road vehicle use and fishing, and the introduction of pest plant and mammalian predator species (Caruso, 2006).

It has long been considered that mammalian predation is one of the prime causes of decline for the native avifauna of New Zealand's braided river systems (Maloney *et al.*, 2005). Sanders & Maloney (2002) reported that feral cats, ferrets and hedgehogs were the primary cause of egg and chick mortality at nests of banded dotterels, black-fronted terns, and black stilts breeding in the UWB. Predation by feral cats is especially worrying as they were also recorded killing breeding adults (Sanders & Maloney, 2002). Unfortunately, information is not available on the level of mammalian predation on chicks that had left the nest but not yet fledged, although this knowledge is imperative for gauging the effect of mammalian predation on ground nesting species in the UWB (Sanders & Maloney, 2002).

The black stilt, one of the world's rarest wading birds, is internationally listed as critically endangered (Birdlife International, 2006) and has been intensively managed by the Department of Conservation (DoC) since 1981 (Maloney & Murray, 2002). Predation and habitat loss are considered the primary cause/limitation of black stilt population decline (Maloney & Murray, 2002). The black stilt serves as an umbrella species and many of the management actions in place for their benefit (e.g. predator control, habitat protection and enhancement) may also benefit other threatened river bird species such as wrybills and black-fronted terns (Maloney & Murray, 2002). Thus, partially funded by the Kaki Recovery Programme, the Tasman Valley Control Project (TVCP) was initiated in 2004 as a five year trial to test the benefits of large-scale predator control for black stilts, other native river bird, bush bird, invertebrate and lizard species (Leseberg *et al*., 2005). The TVCP has three chief objectives; to kill mammalian predators with the maximum feasible effort (predator control operation), to assess the effectiveness of this control operation (residual pest monitoring), and to measure the benefits to kaki and other native riverbed species resulting from the predator control (outcome monitoring) (Leseberg *et al*., 2005). The primary river bird species selected for outcome monitoring of the TVCP are banded dotterels, wrybills, and black-fronted terns (Leseberg *et al*., 2005). Benefits to these three populations are measured in terms of fledging success, adult survival, and population growth with targets based on Vortex population modeling (Maloney *et al*., 2005).

1.2 Methods of estimating nest success

A component of population dynamics used as an indirect measure of reproduction is the percentage of nests that hatch, usually termed 'nest success' (Johnson, 1979). The calculation is very simple, involving dividing the number of nests that ultimately hatch by the total number of nests that were found and monitored (Johnson, 1979). For the remainder of this paper this method will be referred to as the 'conventional' method.

The conventional method has been adopted by the TVCP for calculating nest success of Tasman river beds species. However, serious concerns have been raised with regards to the conventional method; primarily that it overestimates nest success because it does not take into account the time span of observation for each nest (See Mayfield, 1961; Johnson & Shaffer, 1990; Dinsmore *et al.,* 2002). Mayfield (1975) illustrated this point with the following scenario; if we were to find a series of nests on the eve of hatching, the hatching success for this group would most likely be 100%. Consequently, nest success would be inflated because any nests that had failed prior to the night before hatching were not included in the calculation (Mayfield, 1961). Or, to look at it another way, imagine this; you go to a horse track to watch the races but arrive late. There were seven horses on the track when you got there. You witnessed one horse lose his jockey and the horse is ejected from the race. Someone rings and asks what proportion of horses finished the race. You answer 83% (6 / 7 = 0.86). Unbeknownst to you, however, one horse had expired at the starting gate and another broke a leg in the first lap. So in actuality, nine horses started the race but only six finished. Thus the true proportion of horses that finished the race is 67% (6/9 = 0.66). There are two things in particular to note from this analogy; first, the proportion of horses you witnessed finishing the race is inflated when you did not see the entire race. And second, the assessment only tells us what proportion of horses finished a given race, from an arbitrary point within the race, when what we really want to know is: what is the probability that any given horse on the entire racing circuit will finish a race this season?

The same thing happens with nest monitoring in that not all the nests that start the incubation 'race' necessarily reach the 'hatch line'. Researchers often begin monitoring nests at variable points after the 'race' has begun, but have no idea how many nests dropped out of the 'race' (i.e. failed) before researchers got there. Furthermore, what the TVCP ultimately wants to know in terms of nest success is: what is the likelihood that any nest in a *population* of river bed bird species will succeed?

Mayfield (1961) developed an alternative method for calculating nest success that overcomes serious biases of nest success estimates by accounting for the fact that nests are often found at various stages of development. In short, the Mayfield method calculates a mortality rate using the number of observed nests lost over the collective amount of time a group of nests was monitored, termed 'exposure'. The mortality rate is then subtracted from 1 to give a survival rate. The survival rate ($1-r$) is raised to power d, which is simply the average number of days of a species' incubation period. This gives the probability that a given nest will persist to hatching. The Mayfield method has several other merits and they will be discussed later.

1.3 Scope:

The objective of this report was to present the nest and egg success findings of the TVCP outcome monitoring for the 2006-07 breeding season for banded dotterels and wrybills. In addition, nest success was re-calculated using the Mayfield method as an alternative to the conventional method.

2 Methods

2.1 Locating dotterel nests

While walking through sections of the riverbed the observer watched for females displaying typical nesting behaviour (appear agitated, call frequently, display headbobbing). When such a bird was located, either with the naked eye or through binoculars, the observer immediately backed away at least 50 m from the female keeping their eye on the bird's movements. It was often necessary to back away 100 m + as females will not return to the nest bowl until they no longer feel threatened by the observer's proximity. The female returned to the nest bowl by making either a short flight, or by a series of short runs in a low crouched position. The observer noted nearby river bed features as points of reference to pin down the nest's exact location and then carefully approached the nest.

2.2 Locating wrybill nests

Breeding female wrybills tend to flee the nest bowl at a much later stage when approached than do dotterels, making their nests generally easier to locate. Often the female was seen running from the nest and the observer backed away 50 m + and waited for the female to return to the nest bowl if the observer was not already confident of the nest's exact location. Occasionally nesting females performed a broken wing display indicating the observer was in very close proximity to the nest bowl. Both banded dotterels and wrybills have very cryptic eggs. Therefore, it was imperative that observers were confident of a nest's exact location before approaching the area to avoid accidentally stepping on eggs.

Once a dotterel or wrybill nest was found the number of eggs/ chicks was recorded along with any other pertinent observations. Nests were marked with a rock cairn placed ~2m north from the nest bowl and all sites were mapped using GPS. Nest checks were carried out every 2-5 days (weather permitting) until the nest either hatched or failed.

2.3 Data Analysis

For the purpose of this report, only data collected from 18 September to 22 December, 2007 was used for analysis. Therefore, the analysis is not necessarily representative of the entire banded dotterel and wrybill breeding season for 2006 -07.

An estimate of egg success (the probability of an egg hatching in a nest known to survive the incubation period) was calculated using;

$$\frac{\text{(Total No. eggs laid where fate known – No. of eggs infertile or died during incubation)}}{\text{Total No. of eggs laid where fate known}}$$

To calculate an estimate of nest success two methods were used;

1. The conventional method where:

$$\text{Nest Success} = \frac{\text{No. of nests where} \geq 1 \text{ egg hatched}}{\text{Total No. of nests with a known outcome}}$$

2. The Mayfield method where:

The probability of nest success = $(1\text{-}r)^d$

where r = Total no. of nests lost / Total nest-days exposure during incubation
and d = the average incubation period for a given species

3 Results

3.1 Banded dotterel and wrybill nests

There were 30 banded dotterel nests and 17 wrybill nests found and monitored for the 2006-07 breeding season. Due to time and resource constraints, no nest searches were conducted on the true left side of the Tasman basin. Accordingly, all 47 monitored nests were located on the true right of the main channel (Fig. 1).

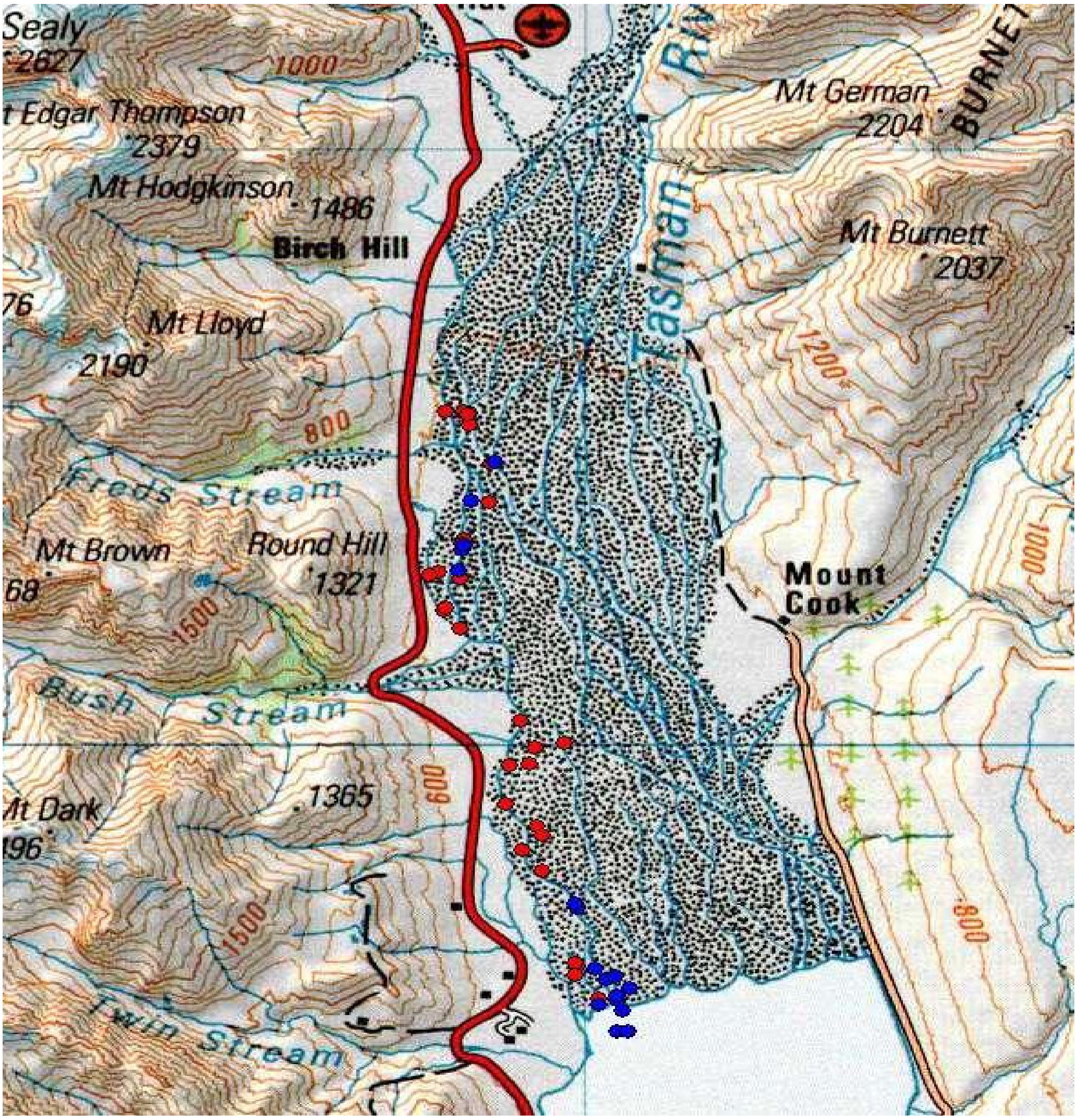


Figure 1. Location of monitored banded dotterel nests (red) and wrybill nests (blue) in the Tasman Valley from 18th September – 15th December, 2006. Scale 1:50000. The water level of Lake Pukaki was lower during the monitoring period than the map depicts thus explaining why three wrybill nests appear underwater.

3.2 Egg Success of banded dotterels and wrybills

Seven banded dotterel nests were excluded from calculations as the outcome of these nests was unknown. Of the 23 nests where the outcome was known, a total of 64 eggs were laid (Table 1a). Of these 64 eggs, the fates of three were unknown, two were infertile, and six were lost of other causes (Table 1a). Of the six lost to other causes, two were found damaged outside the nest bowl, one was found outside the nest bowl intact, and three were lost to flooding (Table 2). The egg success for banded dotterels was 0.97 (n = 64) (Fig. 2).

All 17 monitored wrybill nests had a known outcome, and a total of 34 eggs were laid (Table 1b). Of the 34 eggs laid, the fate of one egg was unknown (Table 1b), two were lost in a flood event, and two were lost to predation (Table 2). The egg success for wrybills was 1.0 (n = 33) (Fig.2).

3.3 Nest Success of banded dotterels and wrybills

Banded dotterels

Of the 30 banded dotterel nests monitored, 23 had a known outcome (Table 1a). Of the 23 nests with a known outcome, one nest was lost during a flood event (Table 3). Thus, nest success for banded dotterels using the conventional method was 0.96 (n = 23) (Fig. 3).

In comparison, 29 banded dotterel nests were used for the Mayfield calculations. Nest-day exposure for banded dotterels was 322 (Table 4a). As mentioned above, one banded dotterel nest was lost to a flood event. Thus, the mortality rate for banded dotterels was 0.00310559 with an average incubation period of 26 days (Table 4a). When calculated using the Mayfield method, the probability of nest success for banded dotterels was lower than the conventional method's estimate at 0.92 (n = 29) (Fig. 3).

Wrybills

The outcome for all 17 monitored wrybill nests was known (Table 1b). Of the 17 nests, one nest was lost during a flood event, and one nest was lost to predation (Table 3). Thus, nest success for wrybills using the conventional method was 0.88 (n = 17) (Fig. 3).

Nest-day exposure for the 17 wrybills nests was 277.5 (Table 4b). As mentioned above, one nest was lost during a flood event, and one nest was lost to predation (Table 3). Thus, the mortality rate for wrybills was 0.007207 with an average incubation period of 30 days (Table 4b). When calculated using Mayfield's method, the probability of nest success for wrybills was lower than the conventional method's estimate at 0.80 (n = 17) (Fig. 3).

Table 1: Number of nests, egg success rates and nest success rates (conventional method) for **(a)** banded dotterels and **(b)** wrybills in the Tasman Valley 2006 – 07.

(a) Banded Dotterels	**2006 - 07**
Total no. of nests	30
Total no. nests with known or assumed known outcome (A)	23
No. of nests hatched ≥ 1 egg (B)	22
No. of nests known to have failed	1
Total no. of eggs laid	87
Of the nests in (A):	
Total no. of eggs laid where fate of egg known or assumed known (C)	64
Total no. eggs laid where fate of egg unknown	3
Of the eggs in (C):	
No. of eggs infertile or died during incubation (D)	2
No. of eggs failed of other causes	6
Nest Success (F)=B/A	0.96
Egg Success (G)=(C-D)/C	0.97

(b) Wrybills	**2006 - 07**
Total no. of nests	17
Total no. nests with known or assumed known outcome (H)	17
No. of nests hatched ≥ 1 egg (I)	15
No. of nests known to have failed	2
Total no. of eggs laid	34
Of the nests in (H):	
Total no. of eggs laid where fate of egg known or assumed known (J)	33
Total no. eggs laid where fate of egg unknown	1
Of the eggs in (J):	
No. of eggs infertile or died during incubation (K)	0
No. of eggs failed of other causes	4
Nest Success (M)=I/H	0.88
Egg Success (N)=(J-K)/J	1.00

Table 2: Causes of eggs loss for banded dotterels and wrybills in the Tasman Valley 2006 – 07.

	Banded Dotterel	**Wrybill**
Total no. of eggs that failed	8	4
Egg failure due to:		
Predation	0	2
Desertion	0	0
Died during incubation	2	0
Damaged during incubation	0	0
Flooding	3	2
Outside nest bowl intact	1	0
Outside nest bowl damaged	2	0

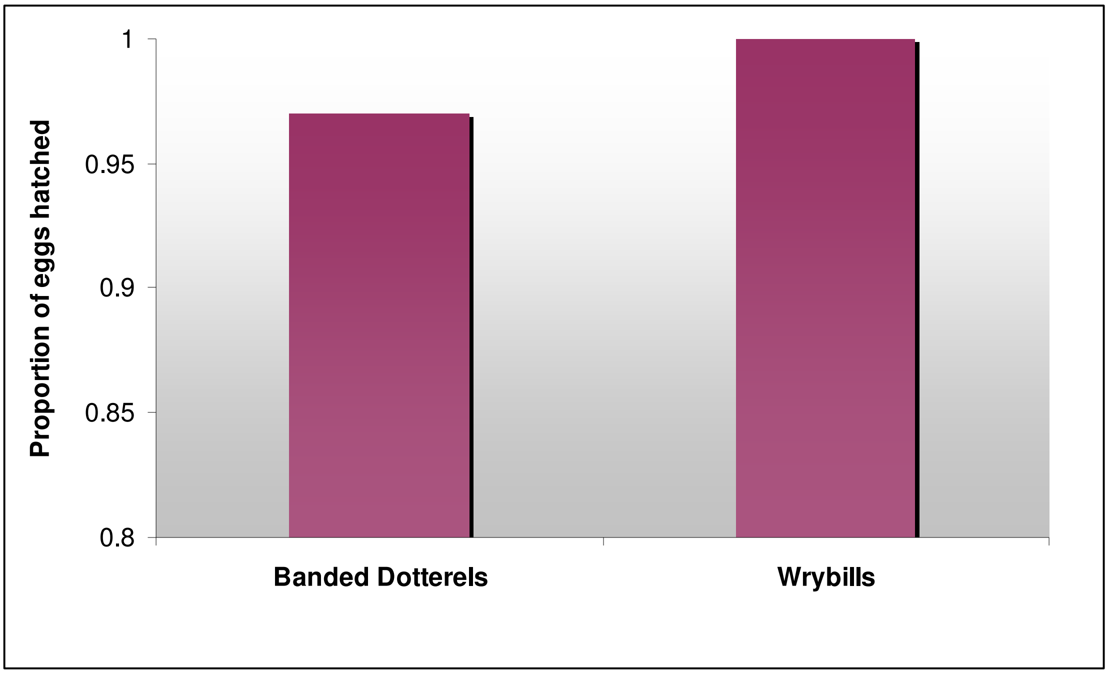


Figure 2: Egg success of banded dotterel (n = 64) and wrybill (n = 33) nests in the Tasman Valley 2006 – 07.

Table 3: Causes of nests failures for banded dotterels and wrybills in the Tasman Valley 2006 – 07.

	Banded Dotterel	Wrybill
Total no. of nests that failed	1	2
Nest failure due to:		
Predation	0	1
Desertion	0	0
Flooding	1	1

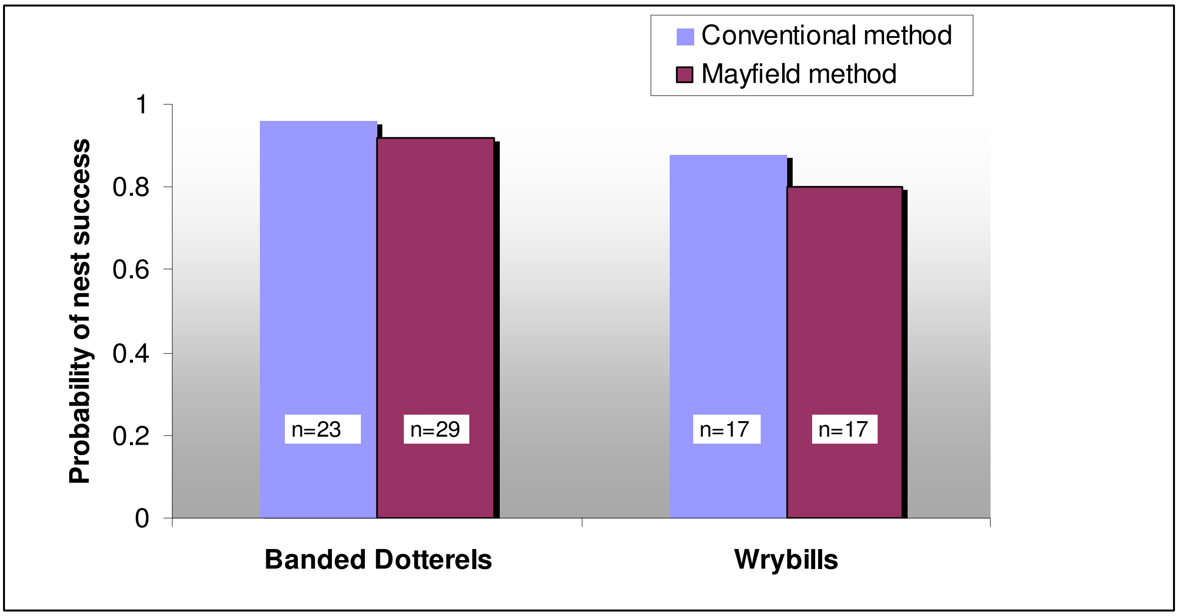


Figure 3: The nest success of banded dotterels and wrybills in the Tasman Valley 2006 – 07. Values are derived from two different methods of calculating nest success; the conventional method and the Mayfield method.

Table 4: Probability of nest success (Mayfield method) for (a) banded dotterels and (b) wrybills in the Tasman Valley 2006-07.

(a) Banded Dotterels	**2006 - 07**
Total nest-day exposure	322
Total no. nests lost	1
Mortality rate (*r*)	0.00310559
Ave. incubation period (*d*)	26
Probability of nest survival $(1-r)^d$	0.92231268

(b) Wrybills	**2006 - 07**
Total nest-day exposure	277.5
Total no. nests lost	2
Mortality rate (*r*)	0.007207
Ave. incubation period (*d*)	30
Probability of nest survival $(1-r)^d$	0.804931

4 Discussion

4.1 Nest Success of banded dotterels and wrybills and the Mayfield method

As expected, the probability of nest success for both banded dotterels and wrybills was lower in the Mayfield method (0.92 and 0.80, respectively) than the conventional method (0.96 and 0.88, respectively). As discussed earlier, the Mayfield method enables researchers to calculate a probability that any given nest in a *population* will succeed, and is widely considered a significant improvement over the conventional method of estimating nest success because it addresses the understated losses and strong survival bias that plagues the conventional method (e.g. Johnson, 1979; Johnson & Shaffer, 1990; Stanley, 2000; Dinsmore *et al.*, 2002).

Another advantage of the Mayfield method is that data from nests where the outcome was unknown can be included in the analysis without threatening to distort the results (Mayfield, 1961). Because Mayfield (1961) recognised that the appropriate sampling unit was not the *nest*, as used in the conventional method, but rather the number of *days* the nest was exposed to hazards (e.g. predation, inclement weather conditions, etc.), the exposure-days for nests with unknown outcomes is simply calculated from the day the nest was found to the last day the nest was observed active. In this way, useful fragments of data for nests whose outcome are unknown need not be discarded. This is a relevant feature to the TVCP as persistent monitoring can be interrupted by foul weather in the Tasman Valley. Consequently, nest checks can be delayed for several days sometimes leaving the outcome of a nest(s) indeterminable. The same result occurs, especially with banded dotterel nests, because the chicks often leave the nest within 24 hours of hatching and can be incredibly difficult to locate. For example, seven banded dotterel nests were excluded from the conventional calculations this year as it was simply not possible to confirm, nor confidently assume, their outcome. The Mayfield method, however, allows much more of the valuable monitoring information to be utilised.

Despite its merit, the Mayfield method does have a couple of underlying assumptions that need to be mentioned. Firstly, the method assumes that the probability of daily survival is constant and homogeneous throughout the stage of nest development being measured (Stanley, 2000). If, for example, there is a higher likelihood of nests failing at early incubation than late incubation, a constant rate of mortality for this stage of the nest cycle would be inappropriate for analysis (Mayfield, 1975). The TVCP would need to investigate whether banded dotterel and wrybill nests violate this assumption. If heterogeneity among nests were to be confirmed, there are alternative models that adjust Mayfield's method to treat such data (See Johnson, 1979; Klett & Johnson, 1982). Johnson & Shaffer (1990) concluded that if mortality occurs catastrophically, the conventional method provides a better estimate of nest success provided repeated searches are conducted and nest detectability is high. Flooding could be considered a catastrophic event in the Tasman Valley, however, collectively only two nests have been recorded as lost to a flood event (both in 2006-07) for banded dotterels and wrybills in three years of monitoring. Thus, there seems little reason to decline the use of the Mayfield method for the TVCP on this account. Secondly, Mayfield (1961) recommended that where a nest was lost between checks, it be assumed that the nest was lost on the day mid-way between checks. Several authors (e.g. Miller & Johnson, 1978; Johnson, 1979; Stanley, 2000) have provided alternatives to Mayfield's mid point assumption, especially where longer intervals occur between nest checks (See Miller & Johnson, 1978). While a great deal of effort is made to check banded dotterel and wrybill nests in the Tasman every two to three days, inclement weather, high flowing rivers, and limited resources can delay checks by several days. Hence, it may be worthwhile evaluating whether applying an alternative to Mayfield's mid point assumption would be appropriate for the TVCP.

While employing Mayfield's method for calculating nest survival during incubation was highlighted in this report, the method can also be applied to calculating egg survival during incubation, and chick survival until fledging. By combining probabilities, it is also possible to calculate the probability that a nest will succeed from the start of incubation through to fledging (See Mayfield, 1961).

Adopting a new method half way through a five year study may be viewed as an unwelcome suggestion by the TVCP, especially given there would be a notably decrease in nest success for 2006-07, especially for wrybills. However, Mayfield calculations are quite straight forward, and it is most plausible that all the data needed for calculation could be extracted from the TVCP database. This would give consistent analysis over the entire project without the need to calibrate for a change in analysis methods.

According to Mayfield (1975), merely counting nests, eggs, and chicks *found* is simply not adequate for precise analysis of mortality and survival; the elapsed time of the observations must also be incorporated in the calculations to alleviate the understated losses and strong survival bias. Consequently, the conventional method is unlikely to provide the TVCP with robust and representative analysis and is rarely commended in the literature. The Mayfield method, however, provides many advantages to the outcome monitoring aspect of the TVCP.

4.2 Egg success of banded dotterels and wrybills

Egg success for banded dotterels this season (0.97) was quite high and reasonably consistent with results from the 2004-05 and 2005-06 seasons (0.95 and 0.99, respectively (Maloney *et al*., 2006)). Wrybills had 1.0 egg success this season. In the previous two years of the TVCP egg success was 0.97 (2004-05), and 0.95 (2005-06) (Maloney *et al*., 2006). Thus, collectively, the results suggest egg infertility is quite low for both banded dotterels and wrybills breeding in the Tasman Valley.

4.3 Predation impact on eggs

Flooding was responsible for the only banded dotterel nest, and one of two wrybill nests, lost this season. The second wrybill nest was lost through predation. Interestingly, for banded dotterels and wrybills breeding in the Tasman Valley, only one other egg has been reported as lost to predation (a dotterel egg, 2004-05 season (Maloney *et al*., 2006)) over the three years of monitoring. This record could imply that predator control in the Tasman Valley has been notably effective in reducing mortality at the egg stage of reproduction. Alternatively, it is possible predation events are not being recognized and/or confirmed. Sanders & Maloney (2002) video recorded mammalian predators often removing intact eggs from the nest leaving behind no telltale evidence such as broken shell or egg yolk. As mentioned earlier, banded dotterel and wrybill chicks generally leave the nest bowl within 24 hours of hatching, and locating these chicks, especially banded dotterels, can be extremely difficult and time consuming. If a nest hatched between checks, as they often do, and chicks can not be sighted despite a concerted effort by the nest observer, than how does one determine the fate of the egg(s)? In calculating both egg success and nest success, the TVCP has applied underlying assumptions; if a nest was checked two days previous with three eggs present, and then checked two days later with a parent(s) displaying chick behaviour, all three eggs are assumed hatched. Likewise, if a nest was checked and two chicks were present, but not the third, it is assumed all three eggs hatched. However, if a nest had not been checked within three days and the nest was empty with no chicks sighted in the vicinity, but the parent(s) displayed chick behaviour, it is assumed at least one chick hatched (pers. comm., S. Cleland).

To put this into context for the 2006-07 season, for example, a total of 30 banded dotterel nests were monitored with a total of 87 eggs laid. Of these 87 eggs, eight eggs were confirmed dead, and we know for certain 40 chicks hatched because they were actually seen. Thus, on a conservative measure, discarding any underlying nest or egg assumptions, that leaves 39 eggs remaining where we could not determine, with certainty, a chick was produced. Did these 39 eggs produce chicks that were simply not sighted by the observer? Or were they removed from the nest site by a predator without a trace? The point being; predation does not appear to be having a significant impact on the survival of banded dotterel and wrybill eggs, however, it is plausible the bona fide predation impact may be concealed through unknown egg outcomes and underlying hatching assumptions.

While it has been confirmed that mammalian predation is one of the prime causes of decline for the native avifauna of New Zealand's braided river systems (Maloney *et al.*, 2005), it is difficult to justify an expensive and labour intensive predator control project over a five year period without being able to confidently determine the effectiveness of the predator control. The use of video cameras stationed at nests throughout the incubation period proved to be a definitive, albeit expensive and labour intensive, method for recording predation events for banded dotterels, black-fronted terns, and kaki at various locations in the UWB (Sanders & Maloney, 2002). For the TVCP, continuous recording of nest activity through the incubation period would capture not only any predation events that may occur, but also determine, with certainty, the actually number of chicks produced from the nest. In addition, information collected from predation events could better direct control efforts in targeting a particular predator(s) should one/they prove prevalent in a given area.

5 Recommendations for the TVCP

5.1 The Mayfield Method

Given the merit of Mayfield's method, it is strongly suggested that the TVCP consider adopting this method for their outcome monitoring analysis. Not only would results be more creditable, hence, more effective in directing management of the project, the TVCP would also be in a better position to defend their findings should their methodology come under scrutiny. Mayfield's method can be applied to all stages of nest development and by combining probabilities, it is possible to calculate the probability that any given nest will succeed from the start of incubation through to fledging (See Mayfield, 1961). As discussed above, several models have since been developed to relax Mayfield's two assumptions (e.g. Miller & Johnson, 1978; Klett & Johnson, 1982; Stanley, 2000; Dinsmore *et al*., 2002; Stanley, 2004). While wading through some of these examples, it was glaringly obvious some of these calculations can become very complex. For the tense and purposes of the TVCP, it is recommended to adhere to the most simplistic method that will provide an adequate level of reliability within the results.

5.2 Video camera monitoring

Admittedly, video camera monitoring is an expensive method to recommend to a project that is already financially strained. However, the advantages in establishing definitive predation impact and nest success under an extensive and expensive predator control programme would outweigh the financial burden in the long run if the substantial financial commitment to a five year predator program can be rewarded with robust and meaningful results. It is, therefore, recommended that a rotation system of video cameras (refer to Sanders & Maloney, 2002 for equipment specifics) be designed that requires the least number of cameras to capture the events at the greatest number of monitored nests. With the ever increasing rate of technology, an investigation into current suitable recording systems may reveal a less expensive and less taxing (in terms of footage analysis), yet equally effective, alternative to the video monitoring equipment used by Sanders & Maloney (2002).

6 Acknowledgements

I would like to sincerely thank Simone Cleland, Richard Maloney, and all the staff from the Twizel area DoC office for making my summer placement interesting and enjoyable. I also extend a genuine thank you to Sean Divers for all his help with MapToaster, Ian McLean for his helpful guidance and draft comments, and Phil Seddon for keeping me on track.

7 References

BirdLife International. 2006. *Himantopus novaezelandiae*. In: IUCN 2006. *2006 IUCN Red List of Threatened Species.* www.iucnredlist.org. Downloaded on 23 March 2007.

Caruso, B.S. 2006. Project River Recovery: Restoration of braided gravel-bed river habitat in New Zealand's high country. *Environmental Management*, **37**(6): 840-861.

Dinsmore, S.J., White, G.C., and Knopf, F.L. 2002. Advanced techniques for modeling avian nest survival. *Ecology*, **83**(12): 3476-3488.

Johnson, D.H. 1979. Estimating nest success: the Mayfield method and an alternative. *Auk*, **96**: 651-661.

Johnson, D.H. & Shaffer, T.L. 1990. Estimating nest success: when Mayfield wins. *Auk*, **107**: 595-600.

Klett, A.T. & Jonhson, D.H. 1982. Variability in nest survival rates and implications to nesting studies. *Auk*, **99**: 77-87.

Leseberg, A., Wahlberg, E., and Maloney, R. 2005. Tasman Valley Predator Control Project Report. March 2004 – February 2005. *Kaki Recovery Project Internal Report 05/04*. Department of Conservation, Twizel.

Maloney, R.F., Rebergen, A.L., Nilsson, R.J., and Wells, N.J. 1997. Bird density and diversity in braided river beds in the Upper Waitaki Basin, South Island, New Zealand. *Notornis*, **44**: 219-232.

Maloney, R.F. & Murray, D. 2002. Kaki (black stilt) recovery plan 2001-2011. *Threatened Species Recovery Plan*, Department of Conseravtion, Twizel.

Maloney, R., Wells, N., Murray, D., Sancha, E., Andrews, I., Leseberg, A., Wahlberg, E., and Nelson, D. 2005. Kaki Recovery Programme Annual Report March 2004-February 2005. *Kaki Recovery Project Internal Report Number 05/01.* Department of Conservation, Twizel.

Maloney, R., Sancha, E., Murray, D., Leseberg, A., Johnston, R., Wahlberg, E., Stevenson, S., Andrews, I, and Nelson, D. 2006. Kaki Recovery Programme Annual Report March 2005- February 2006. *Kaki Recovery Internal Report Number 06/01*. Department of Conservation, Twizel.

Mayfield, H. 1961. Nesting success calculated from exposure. *Wilson Bulletin*, **73**(3): 255-261.

Mayfield, H. 1975. Suggestions for calculating nest success. *Wilson Bulletin*, **87**(4): 456-466.

Miller, H.W. & Johnson, D.H. 1978. Interpreting the results of nesting studies. *Journal of Wildlife Management*, **42**: 471-476.

Sanders, M.D. & Maloney, R.F. 2002. Causes of mortality at nests of ground-nesting birds in the Upper Waitaki Basin, South Island, New Zealand: a 5-year video study. *Biological Conservation*, **106**: 225-236.

Stanley, T. 2000. Modeling and estimation of stage-specific daily survival probabilities of nests. *Ecology*, **81**(7): 2048-2053.

Stanley, T. 2004. Estimating stage-specific daily survival probabilities of nests when nest age is unknown. *Auk*, **121**(1): 134-147.