

**Mallard (*Anas platyrhynchos*) and Grey /Parera (*A. superciliosa*)  
presence at ponds in the East Coast Region: a pilot study to identify  
influential pond characteristics**

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## CONTENTS

Summary .....	1
1.0 Introduction.....	3
2.0 Methods.....	5
2.2. Timing and duration of Survey .....	5
2.3 Pond Selection .....	6
2.4 Data collection .....	6
2.5 Data analyses .....	9
3.0 Results.....	12
4.0 Discussion.....	14
4.1 Study Objective.....	14
4.2 Observations .....	15
5.0 Management Implications.....	19
Acknowledgements.....	20
References.....	21

Figure 1: Study Area.....	5
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Table 1. Summary of exposure variables included in models to investigate the relationships of habitat characteristics with the numbers of wildfowl at 21 ponds in the East Coast Region, North Island, New Zealand. ....	7
Table 2 Pond score.....	9
Table 3 Structure of models used to investigate the effects of factors on the numbers of dabbling ducks at ponds.....	11
Table 4: Mann – Whitney test, Score for ponds with greylard and ponds without waterfowl ( $U_{0.05(2),10,11} = 84$ ) .....	12
Table 5: Comparison of individual covariate for ponds with observed greylard and ponds without waterfowl (Student T-Test) and correlation of greylard against pond environmental variable for ponds with observed greylard. ....	13
Table 6: Ranking of fitted models of factors affecting the relative abundance of waterfowl at East Coast ponds ranked by Akaike’s information criterion. Delta AIC is the arithmetic difference in AIC between the preferred and all other candidate models; d.f. = degrees of freedom.....	14

## Summary

The East Coast and Central Hawke's Bay of the North Island New Zealand has numerous (>1200) small (78% are less than 1.5ha), predominately man-made ponds. Many of these ponds appear devoid of mallard (*Anas platyrhynchos*) and grey/Parera (*A. superciliosa*) duck (collectively "greylard") at times of the year. We conducted a preliminary observational survey of 21 randomly selected ponds in central Hawke's Bay during the 2008 breeding season to ascertain whether key pond characteristics were associated with greylard presence. We hoped this information would assist land owners and waterfowl managers enhance wetlands and ponds for dabbling duck. We compared single covariate environmental variables between ponds with and without greylard and used multiple linear regression to test the effects of a range of pond characteristics on observed greylard numbers. We also scored ponds according to subjective assessments of four key habitat features and compared these between ponds with and without greylards.

We found that ponds with greylards had greater mean edge length ( $P = 0.047$ ,  $T_{0.05(2)20}$ ) and were associated with larger nearby ponds ( $P = 0.008$ ;  $T_{0.05(2)20}$ ) than those without greylards. Ponds with greylards also had higher mean subjective scores for the availability of nesting habitat ( $0.02 < P < 0.05$ ) and overhead cover ( $0.01 < P < 0.02$ ). Regression analysis suggested that pond size has a significant effect on the number of greylards observed (partial regression coefficient = 7.63,  $SE_{coef} = 0.2918$ ,  $t_{17} = 3.33$ ,  $p = 0.004$ ), while the effect of total area of islands within a pond approached formal significance (partial regression coefficient = 56.42,  $SE_{coef} = 32.18$ ,  $t_{17} = 1.75$ ,  $p = 0.098$ ). There was some evidence that brood abundance was related to pond size ( $P = 0.012$ ). No broods were observed on ponds smaller than 1ha. We conclude that, despite the small size of the study, our findings were consistent with overseas research. Based on these results and our general observations during the survey, we suggest that New Zealand waterfowl managers and land owners could enhance existing ponds with minor earthworks, strategic planting and fencing. We recommended that a more in-depth study look at greater number of ponds in more detail over the annual waterfowl cycle in the East Coast Hawke's Bay Region.



## 1.0 Introduction

Observations by New Zealand Fish and Game (NZFG) suggest that of the large number of small (< 5 ha) ponds on the East Coast of the North Island of New Zealand, some consistently support populations of waterfowl (primarily *Anas* spp.) while others never appear to<sup>1</sup>. Boosting waterfowl numbers through habitat creation is expensive and it is more cost-effective to improve the carrying capacity of existing ponds and wetlands. NZFG want to ascertain what factors are limiting the carrying capacity on these small ponds for mallard (*Anas platyrhynchos*) and grey/Parera (*A. superciliosa*) (collectively, and henceforth “greylard”<sup>2</sup>). The mallard is the primary game bird in New Zealand (Barker 2008). Developing a better understanding of its habitat requirements in New Zealand will improve managers’ ability to promulgate information and advice on habitat enhancement for this species.

Most published studies of waterfowl habitat preferences are based in the Northern Hemisphere, where waterfowl migration patterns and the availability of different habitat types may limit their extrapolation to the New Zealand situation. On the other hand, habitat characteristics required by greylards are likely to be broadly similar to those required by mallards in other parts of the world. We therefore focus on habitat characteristics in this study.

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<sup>1</sup> The study originated from observations we had made during annual aerial paradise shelduck trend counts in January over the last fourteen years. During these flights we cover large areas of the East Coast down to Southern Hawke’s Bay (McDougall 2009) and have observed numerous small ponds that appear consistently devoid of waterfowl. We have also been conducting a banding study in this area since 1998 and have observed that survival data alone cannot explain the large cyclical deviations in assessed population size of mallard and grey duck (McDougall 2008) suggesting fluctuations in the breeding season are important.

<sup>2</sup> Hybridisation between mallard and grey duck makes it difficult to categorise them in the field based on their phenotypic characteristics hence they are dealt with as one combined type – the greylard.

Dabbling ducks (*Anas. spp.*) require loafing sites (Williams and Imber 1970, Swift et al. 1976, Addy 1951), feeding (Swift et al. 1976, Olsen and Cox 2003, Krapu et al. 1983, Baldassarre and Bolen 2006, Gunnarsson et al. 2004), escape cover, nesting and brood rearing areas (McKinnon and Duncan 1999, Raven et al. 2007, Emery et al. 2005). Clark and Nudds (1991) suggest many waterfowl managers consider low nesting success is the factor limiting duck production. Dzubin (1969) summarises a number of studies in which the authors suggest that waterfowl breeding pair density and resultant production of young may be affected by factors such as nesting cover, availability of brood ponds, spring weather, pond numbers and human activities.

We postulated *a priori* that ponds that had adequate levels of four key constituents:

- i. Nesting cover;
- ii. Feeding potential;
- iii. Loafing areas and;
- iv. Escape cover;

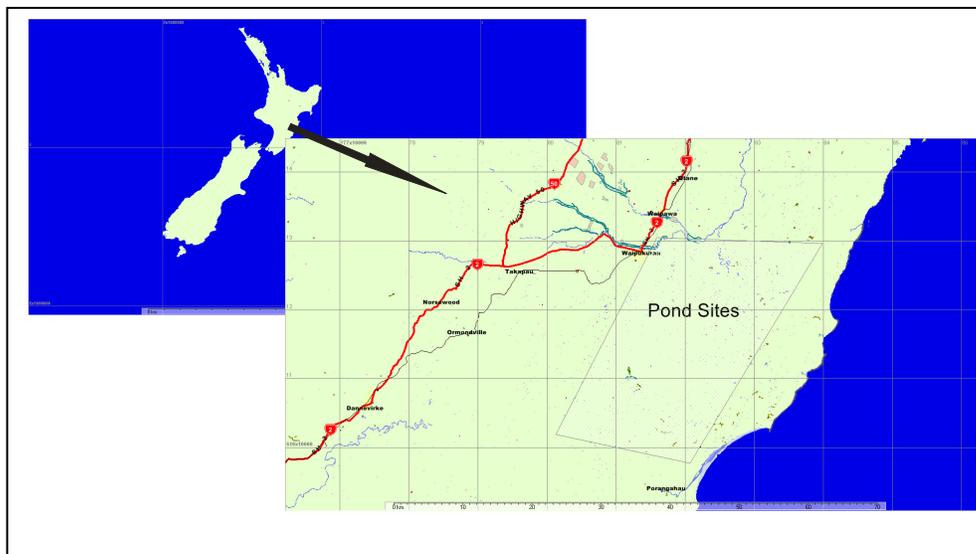
would support ducks and that we may be able to differentiate between suitability of ponds for mallard and grey duck dependant on the availability of these and other key components.

We were also interested in determining if there was a relationship between the size of the pond and greylard brood presence. McKinnon and Duncan (1999) observed 1.1 to 1.4 nests/ha, Belanger and Couture (1988) 2.0 broods/ha, McLandress et al. (1996) 1.1 broods/ha in California and Dzubin (1969) 0.3 – 1.3 breeding mallard pairs per hectare. An understanding of the relationship between size and brood prevalence may help managers prioritise habitat enhancement projects and assist in wetland design.

## 2.0 Methods

### 2.1 Study area

The study was confined to the Central Hawke's Bay Region of the North Island of New Zealand. Latitude was between 39 56.239S - 40 9.588S and Longitude 176 38.454E - 176 53.110E, slightly north of Waipukurau and east towards the coast and north of Porangahau (see Figure 1).



**Figure 1: Study Area**

We limited the random selection of ponds to a single Level II Land Environment (Lethwick et al. 2003) to minimise variation in externalities such as climate, geology, altitude and, topography. This also resulted in the ponds being confined to a relatively small area (approximately 70,000 ha) which reduced travel time between ponds.

### 2.2. Timing and duration of Survey

Survival analysis of mallard duck in the Hawke's Bay suggests population fluctuations may be attributed to productivity variations as much as changes in mortality (M<sup>c</sup>Dougall

2008). For this reason we decided to look at ponds during the breeding season at or near when broods will be evident and females had finished nesting. We picked the end of October beginning of November but weather precluded flying until the 12<sup>th</sup> of November.

The time available for data collection at each pond was limited to a large extent by the helicopter shut down interval. Most data therefore were collected within 20 minutes.

### **2.3 Pond Selection**

Fifty-eight ponds in Central Hawke's Bay were selected randomly from within a similar topographical<sup>1</sup>, geologic<sup>2</sup>, climatic<sup>3</sup>, and altitudinal range<sup>4</sup> (F4 – Level II LENZ; Leathwick et al. 2003). Pond locations were obtained from satellite imagery (1:50000, GIS Data Base, 15m pixel resolution).

Forty-four<sup>5</sup> of these ponds were visited by helicopter on the 12<sup>th</sup> of November 2008 and greylard counted, being careful to avoid disturbing the birds on to nearby ponds. Of these forty-four ponds, the first 11 ponds at which greylard were observed and the first 10 without greylard were revisited within 24 hours and habitat variables were recorded.

### **2.4 Data collection**

Mallard, grey, shoveler (*Anas rhynchos*), paradise shelduck (*Tadorna variegata*), black swan (*Cygnus atratus*) and Canada goose (*Branta canadensis*) were counted from the helicopter using Zeiss binoculars. Where possible, the numbers and sizes of broods were noted.. After forty-four ponds were counted, they were grouped according to the presence or absence of greylards. The nearest twenty-one of these ponds were then revisited and investigated further. Detection probability on all ponds was assumed to be one.

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<sup>1</sup> Gently rolling hill country.

<sup>2</sup> Weathered Tertiary mudstones with some argillite, limestone and sandstone, and older greywacke.

<sup>3</sup> Warmer, higher rainfall deficit and vapour pressure deficit.

<sup>4</sup> 69-270m (GIS Fish and Game Data Base).

<sup>5</sup> At this point we had 10 ponds with greylard and 10 without greylard.

Data were collected on twenty-three exposure variables that were considered as having a potential influence on the presence and relative abundance of wildfowl at ponds. The exposure variables, measurement methods and units of measurement are listed in Table 1.

Sweep net surveys of aquatic invertebrates were carried out and samples were collected and stored. There was insufficient time to identify and count specimens before the submission deadline for this report. This work will be carried out at a later date depending on the availability of staff and funding. It was also planned to survey for the presence of potential mammalian predators at ponds using ink-print tracking tunnels, but this was not achieved due to time and logistical constraints during the survey.

**Table 1. Summary of exposure variables included in models to investigate the relationships of habitat characteristics with the numbers of wildfowl at 21 ponds in the East Coast Region, North Island, New Zealand.**

<b>Exposure Variable</b>	<b>Measurement Method</b>	<b>Units of measurement</b>
Pond length	Leopold range finder	m
Pond width	Leopold range finder	m
Edge length	Tumonz Mapping Software	m
Measured size	Tumonz Mapping Software	ha
Pond depth	Staff gauge (<1 or >1m)	m
Pond type	Man-made/natural	
Location aspect	Valley floor/valley side/hill top	
Distance to nearest 5 ponds	Satellite Imagery 1:50,000; Algorithm based on Grid Reference	m
Combined area of nearest five ponds	Satellite Imagery 1:50,000	ha
Total area of islands	Tumonz Mapping Software	ha

<b>Exposure Variable</b>	<b>Measurement Method</b>	<b>Units of measurement</b>
Aspect	Longest Fetch	degrees
Altitude	GIS	m
DO	OxyGuard Handy MkII	ppm
pH	ph Test kit	
Temperature	OxyGuard Handy MkII	Degrees (C)
Predominant surrounding land use	Description	
Stock access	Yes/No	
Fenced	Estimated visually	percentage of perimeter
Riparian strip surrounding pond	Estimated visually	ha
Hunted	Presence of maimais	Yes/No
Terrestrial vegetation	Species	Percentage
Aquatic vegetation	Species	percentage
Emergent vegetation: open water	Visual assessment	Ratio

Vegetation was surveyed following Clarkson et al. (2004) with the percentage cover of each species estimated visually.

At the end of each site visit, four experienced observers collectively allocated a score for each of the four key requirements: of food availability (based on the observed invertebrates in the sweep net and suitable vegetative feed species<sup>1</sup>); nesting habitat (the amount of rank grass, rushes and raupo within the riparian margin contiguous with the pond); loafing areas (this included islands, pond margins, logs and any other suitable protuberances), and; overhead cover (particularly vegetation such as *Salix babylonica*, *Carex secta and varigata*, *Typha orientalis* and juncas and sedges (Table 2).

<sup>1</sup> Our assessment of food preference was in part based on studies of mallard and grey duck diet carried out by Potts (1976, 1977) in the Manawatu.

**Table 2 Pond score**

<b>Score</b>	<b>Assessment Criteria</b>	<b>Value</b>
Feed Score	Visual assessment of littoral zone, water quality, vegetation and invertebrates	1=poor 2=poor to average 3=average, 4=average to good, 5=good
Nest Score	Visual assessment of ungrazed area relative to water area specifically rank grass/vegetation	0=0, 1=1-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%
Loaf Score	Visual assessment; grazed margin relative to ungrazed, loafing areas, bank topography	0=0, 1=1-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%
Overhead Cover Score	Visual assessment; Percentage of margin with over head cover including rushes and raupo ( <i>Typha orientalis</i> ).	0=0, 1=1-20%; 2=21-40%; 3=41-60%; 4=61-80%; 5=81-100%

## **2.5 Data analyses**

(i) To minimise the issues of non-random treatment allocation in observational studies (Shaffer and Johnson 2007; Riggs et al. 2007) we allocated the ponds to two different groups prior to measuring the environmental variables.

A one-off presence absence survey may incur bias where species are recorded as absent when in fact they were present but not detected (McKenzie 2005), or in our case, utilise the pond but were not there at the time of the survey. Some of the ponds where no waterfowl were observed had sign such as feathers and faeces indicating presence at other

times but were still recorded as not present. A more in depth study would be better placed to estimate this bias.

The limited time available for sample collection and measurement meant some characteristics had to be assessed rather than measured. Vegetation and riparian area were examples of characteristics that may have shown greater differentiation in the analysis had we recorded the area rather than measured them as a percentage.

Time restrictions also reduced the number of characteristics we could assess. Retrospectively we felt that it would have been useful to record pond proximity to utilities. A number of ponds were close to roads, building, and stock yards. There is evidence that the impacts of man (Dzubin 1969) and utilities (van Der Zande et al. 1980, Reijnen et al. 1995) may affect breeding bird density (although Reijnen et al. 1995 did not detect a significant affect of roads on density of breeding birds with mallards it is likely that the more reclusive grey duck would be affected).

(ii) Differences between ponds with and without greylards in: size, edge length, combined distance to the nearest five ponds, combined size of the nearest five ponds, island area, pond temperature, pond pH, percentage of perimeter fenced and percentage of emergent vegetation were tested using the Student T-test. In each case the null hypothesis ( $H_0$ ) was that there was no difference in the mean of each variable between the two groups.

(iii) We tested for differences in our subjectively assigned pond scores in each of the four categories (feed, nest, loaf and overhead cover; Table 2) between ponds with and without greylards using the non-parametric Mann-Whitney test. Tied ranks were averaged (Zar 1996)

(iv) Where greylards were present we used Spearman Rank Correlation (using Statistica 9.0) to evaluate pond score against greylard abundance.

(v) For the multiple covariate models, a series of multiple linear regressions were carried out using the lm procedure in the statistical computing environment `R' (version 2.8.1). Six models were fitted to the data, each based on suggested clusters of similar biophysical variables (Table 3). The response variable in each model was observed number of greylard. The fit of models to the data was ranked using Akaike's information criterion (AIC) which effectively represents a 'trade-off' between the number of parameters used by the model to explain variation in the data and the precision of estimated model parameters, which tends to decrease as the number of parameters increases (Akaike 1973; Burnham and Anderson 2002). Lesser values of AIC indicate a better fit and relative quality of different models can be assessed using 'delta AIC:' the arithmetic difference between the AIC for the 'best' model and each of the others examined. As a rule of thumb, if delta AIC is > 2 a model is of little value compared to the preferred model (Burnham and Anderson 2002). For each model, the statistical significance of individual exposure variables were assessed by single term deletions whereby the significance of each variable is tested after the variation due to the remaining terms is accounted for in the model. Model variables were examined for autocorrelation before model fits were assessed.

**Table 3 Structure of models used to investigate the effects of factors on the numbers of dabbling ducks at ponds.**

<i>Model</i>	Variables
1. Size-proximity	Size of pond, distance to nearest 5 ponds, combined area of nearest 5 ponds
2. Shape	Depth <sup>*</sup> , length: area ratio, area of any islands
3. Vegetation	Floating vegetation, aquatic vegetation, terrestrial vegetation, emergent vegetation
4. Score	Feed score, nest score, loaf score, overhead score
5. Physical	Altitude, dissolved oxygen, pH
6. Hunting	Hunting <sup>*</sup>

Notes: 1. \* indicates a categorical variable;  
 2. stock access, proportion of edge fenced and area of riparian strip had insufficient variation in the data to warrant inclusion in models

### 3.0 Results

(i) Where greylards were present, we observed between 1 and 28 ducks (mean 14.09, standard error 2.87) at the 11 ponds. These ponds had a longer edge ( $p = 0.047$ ) and were surrounded by ponds that were, on average, larger than those ponds ( $P = 0.008$ ) where greylard were not observed

(ii) Feed and loafing scores did not differ between ponds with and without greylards at  $U_{0.05(2),10,11}$  ( $P > 0.2$ ;  $0.2 < P < 0.1$  respectively). However, ponds with greylard had significantly higher overhead cover ( $0.01 < P < 0.02$ ) and nesting cover ( $0.02 < P < .05$ ), scores (Refer Table 4).

**Table 4: Mann – Whitney test, Score for ponds with greylard and ponds without waterfowl ( $U_{0.05(2),10,11} = 84$ )**

Criterion	U	U'	P	Hypothesis
Feed	61	49	$P > 0.20$	Accept Ho
Nest	25	85	$0.02 < P < .05$	Reject Ho
Loaf	77.5	32.5	$0.2 < P < 0.1$	Accept Ho
Overhead Cover	19	91	$0.01 < P < .02$	Reject Ho

Although there was no discernable difference between pond size for those ponds with greylard and without waterfowl the data suggests that if greylard were present that abundance increased with pond size ( $r = 0.57$ ;  $P = 0.054$ ,  $t_{0.05(2)10}$ ). This relationship received even more support for edge length ( $r=0.76$ ;  $P=0.003$ ,  $t_{0.05(2)10}$ ).

**Table 5: Comparison of individual covariate for ponds with observed greylard and ponds without waterfowl (Student T-Test) and correlation of greylard against pond environmental variable for ponds with observed greylard.**

Criterion	$\bar{Y}$ (With Greylard)	SE (With Greylard)	$\bar{Y}$ (Without Greylard)	SE (Without Greylard)	P	H <sub>0</sub>	r	P	H <sub>0</sub>
Pond size	1.015	0.314	0.382	0.099	0.080	Do not reject Ho	0.568	0.054	Do not reject Ho
Edge length	427.000	60.198	255.700	53.749	0.047	Reject Ho	0.761	0.004	Reject Ho
Distance to nearest 5 ponds	5164	475	5004	237	0.774	Do not reject Ho	-0.375	0.230	Do not reject Ho
Combined area of nearest five ponds	3.835	0.331	2.667	0.203	0.008	Reject Ho	-0.200	0.533	Do not reject Ho
Islands	0.032	0.030	0.000	0.000	0.325	Do not reject Ho	0.484	0.111	Do not reject Ho
Temp	22.118	0.871	20.300	0.614	0.109	Do not reject Ho	0.167	0.604	Do not reject Ho
pH	8.136	0.448	8.750	0.430	0.336	Do not reject Ho	0.304	0.337	Do not reject Ho
Fenced	0.166	0.096	0.020	0.020	0.169	Do not reject Ho	-0.390	0.210	Do not reject Ho
Emergent Vegetation	0.104	0.050	0.065	0.024	0.497	Do not reject Ho	-0.243	0.446	Do not reject Ho

(iii) In the multi-covariate analysis, the size-proximity model is the preferred model from the six fitted models as delta AIC between this model and all others tested is much greater than 2.0 (Table 6). This suggests that the other five models explain the variability in the data relatively poorly.

**Table 6: Ranking of fitted models of factors affecting the relative abundance of waterfowl at East Coast ponds ranked by Akaike’s information criterion. Delta AIC is the arithmetic difference in AIC between the preferred and all other candidate models; d.f. = degrees of freedom.**

Model	d.f.	AIC	Delta AIC
Size-proximity	5	151.24	0.00
Shape	5	158.34	7.10
Hunting	3	159.87	8.63
Physical	5	163.59	12.35
Scores	6	164.14	12.90
Vegetation	6	164.48	13.24

In the size proximity model, the only significant variable was the size of the pond (partial regression coefficient = 7.63,  $SE_{coef} = 2.2918$ ,  $t_{17} = 3.33$ ,  $p = 0.004$ ).

(iv) Ponds with broods were no different in size than ponds without broods ( $P = 0.271$ ;  $\hat{Y}_{withbroods} = 1.12$ ,  $0.19 - 2.04$  95% CI;  $\hat{Y}_{withoutbroods} = 0.60$ ,  $-1.35 - 2.5$ , 95% CI). However if we removed pond 10 from the sample (a large 3.84ha ephemeral wetland with no nesting or overhead cover) pond size is quite significant ( $P = 0.012$ ;  $\hat{Y}_{withbroods} = 1.12$ ,  $0.19 - 2.04$  95% CI;  $\hat{Y}_{withoutbroods} = 0.40$ ,  $-0.21 - 0.95$ , 95% CI).

## **4.0 Discussion**

### **4.1 Study Objective**

We believe, despite some short comings of an observation study (Shaffer and Johnson 2007), that the findings are consistent with overseas studies and will assist managers enhance existing wetlands for mallard and grey duck. Further we hope that this study will provide material for a more in-depth study covering the annual waterfowl cycle. We recognize it is difficult to evaluate pond preference based on a single count as pointed out by Dzubin (1969). However we hoped to circumvent some of this concern by visiting the

ponds in the middle of the breeding season when the birds were likely to be more resident and showing a certain degree of fidelity to a particular pond.

## 4.2 Observations

Many of the 1200 or so ponds on the East Coast – Hawke’s Bay are small stock ponds (McDougall pers. Obs.). Dzubin (1969) suggests that one pond does not contain the breeding requisites for a pair unless it is over 3.0 acres (1.2 ha) and even then they are likely to utilise more than one pond. Bélanger and Couture (1988) however found the highest use of ponds by dabbling duck broods on ponds with a surface area of  $\geq 0.5$ ha.

Stock dams in Montana and the western portion of the Dakotas may contribute significantly to waterfowl production (Pospahala et al. 1974). There is a good relationship between pond numbers and waterfowl population figures in the prairie pothole region (Crissey 1963, cited in Anderson and Henry 1972; Karup et al. 1983). About twenty-five percent of the 1200 East Coast ponds are larger than 1.2 ha (GIS satellite imagery; Fish and Game Data Base). Of the 21 ponds we evaluated 20 were manmade.

The average size of the ponds in the study was 0.71 ha (Range: 0.06 – 3.8 ha ) with only five ponds being 1.2ha or larger. Bélanger and Couture (1988) examined the use of manmade ponds by dabbling ducks near Montréal. They found that surface area and shoreline irregularity influenced use of all manmade ponds ( $P \leq 0.01$ ). We found that there was some support for the larger ponds to be more likely to have greylard present at the time of the survey than the smaller ponds ( $P = 0.08$ ;  $\hat{Y}_{\text{with greylard}} = 1.02$  ha;  $-1.3 - 3.3$  ha 95% CI;  $\hat{Y}_{\text{no waterfowl}} = 0.38$  ha;  $-0.33 - 1.09$  ha 95%CI) and if greylard were present then the larger the pond the more greylard were observed ( $r = 0.568$ ;  $P = 0.054$ ). 72% of the observed greylard were on ponds 1.2ha or larger.

We didn’t measure shoreline irregularity however the Edge Length variable to some extent incorporates size and irregularity and there was support for ponds with longer edge

length being more likely to hold greylards at the time of the survey ( $P = 0.047$ ). In the analysis we didn't include the edge length of islands which would have lent greater weight to this outcome as all the ponds with no waterfowl also had no islands. Of the candidate models the Size Proximity model showed the most support reinforcing the concept of larger ponds surrounded by large satellite ponds holding more greylards.

Giroux (1981), states that greater waterfowl production can be achieved on islands as nesting densities are higher and predation is less. Shaffer et al. (2006) found the utility of islands was dependant on habitat of surrounding land. Use of islands by mallard and gadwalls was negatively correlated with the amount of perennial grass cover in surrounding uplands. We were unable to reject the Null Hypothesis in relation to ponds with islands vs. ponds without as there were no islands in the ponds where greylard were not observed. There was limited correlation with island size and greylard numbers ( $r = 0.484$ ;  $P = 0.106$ ).

Shaffer et al. (2006) also suggest shrub cover is a better predictor of island use (nest densities) than percent of tall cover. We didn't differentiate between islands and pond margins when scoring the pond for overhead cover. We did however, observe that ponds with greylard had more overhead cover than ponds where no waterfowl were observed ( $P = 0.035$ ). Williams and Imber (1970) point out the importance of escape cover for dabbling ducks and suggest species that overhang the waters margins such as weeping willow (*Salix babylonica*) have probably played a bigger role than any other plant in providing suitable cover. During brood surveys in the Bay of Plenty we have noticed that most broods are associated with drains where weeping willow is present (pers. obs. McDougall). The only grey duck we observed were on a pond (Pond 16) with good overhead cover (Overhead Cover Score 4) which also included the only pond with weeping willow.

Understandably nesting cover appears important at this time of the year. Ponds with greylard had a higher nesting cover score than with ponds without ( $P = 0.019$ ). Suitable nesting cover may have a synergistic effect on greylard numbers. There is evidence of

philopatry amongst mallard (Doherty et al. 2002; Krapu et al. 1983 and references within), female waterfowl are more likely to return to a successful nesting site in subsequent years (Blums et al. 2003). Nest failure and adult female survival during the breeding and non-breeding season has been attributed to the major contributing factor in population change (Hoekman et al. 2002; Raven et al. 2007). Mckinnon and Duncan (1999) found nest success was higher in dense nesting cover than unmanaged plots ( $P = 0.038$ ) particularly for mallard and gadwall. We did not have enough time to investigate predator numbers but feel that it could be a significant issue for brood and adult hen survival.

None of the ponds we observed had more than 1 brood/ha of mallard but some had broods of other breeding waterfowl present (we didn't observe any grey duck broods). Ponds were relatively discrete units with, in the main, no linking habitat corridors. It is likely that many of the ponds will have to fill all the broods needs until fledging. This suggests a minimum pond size of just over one hectare is required to hold a brood in this area.

We found no relationship between feed score for ponds with greylard and ponds without waterfowl ( $P > 0.20$ ). Feed score was based on observed invertebrates in the sweep net, flatworms (Platyhelminths) and Chironomid larvae in the bottom sample and our vegetation survey. Our casual observations were that feed was not limiting at the time of inspection with many (57%) of the ponds scoring 3 (an average feed score). There was some indications that feed availability may be an attractant to waterfowl; for example the number of invertebrates appeared extremely high in pond 10 (shallow <30cm ephemeral; 2.6ha; natural wetland; *Myriophyllum* dominant, with no overhead cover) which also supported the second highest number of greylards.

Gunnarsson et al. 2004 suggest that food may limit the survival and reproductive output of precocial (young are relatively mobile and mature) birds. Their study revolved around oligotrophic lakes in Northern Sweden. All the ponds we examined were mesotrophic – eutrophic. The predisposition of the Central Hawke's Bay to rainfall deficit (Leathwick

et al. 2003) indicates that food may be a limiting factor for waterfowl at some times of the year. There is strong international evidence for the effect of food availability, particularly invertebrate abundance during the breeding season, on mallard distribution. Mallards are generalist feeders. During the breeding season, a mallard's diet consists of primarily animal food sources including insects such as midge larvae, dragonflies, and caddis fly larvae, as well as aquatic invertebrates such as snails, freshwater shrimp, and terrestrial worms. Outside of the breeding season they eat mostly seeds from moist-soil plants, acorns, aquatic vegetation, cereal crops, and wheat (Marchant and Higgins 1990). Invertebrate protein is important in egg formation and as a food for ducklings (Eldridge and Krapu 1988). The association between mallard abundance and invertebrates is a common feature of many studies (e.g., Joyner 1980; Bélanger and Couture 1988; Elmberg et al. 1993; Nummi et al. 1994; Nummi et al. 1995).

Pond temperature was consistently high (average recorded temperature of 21<sup>0</sup> C; SE = 0.56) and may have had a bearing on invertebrate numbers.

An interesting observation was the presence of *Gambusia* in most of the ponds including the ponds that had no discernable inflow or outlet but rather relied on overland flow and precipitation for water supply. We speculated that they had been introduced by eelers fyke nets which had reportedly fish the ponds in the past. McDowall (1990) points out that the effect of *Gambusia* on New Zealand invertebrates are scarcely studied but they are known to take mosquito larvae and Rowe (1987; cited in McDowall 1990) suggest they predate on dragonfly larvae.

Raven et al. (2007) examined wetland selection in relation to wetland characteristics by mallard broods in the prairie parklands of Canada. They found permanent and semi-permanent wetlands dominated by bulrush (*Scirpus* spp.) were heavily used both early and late in the brood rearing season. There was a preference for wetlands dominated by central expanses of open water compared with wetlands dominated by emergent vegetation. However there was selection of ponds with emergent vegetation located on the periphery (early season there was a 17% increase in wetland selection for every 10m

of flooded emergent vegetation that increased to 27% later in the season). Bélanger and Couture (1988) on the other hand found dabbling duck brood use on man-made ponds was greater on ponds with emergent plants covering  $\geq 30\%$  of the pond surface area and on ponds with emergent vegetation  $\geq 30$  stems/m<sup>2</sup>. We found no difference in emergent vegetation for ponds with greylard compared with ponds without waterfowl ( $P = 0.49$ ). Pond 46 was the only pond that exceeded 30% emergent vegetation (50%), predominately *Typha orientalis* as a central island, with the periphery almost devoid of vegetation. This was one of five ponds of the twenty-one observed with a brood present. There was no difference between the percentage of emergent vegetation of ponds with broods and without ( $P = 0.488$ ;  $T_{0.05(2)19}$ ).

We expected to find more greylard associated with fenced ponds at this time of the year due to the prevalence of nesting cover however we did not have enough evidence to reject the Null Hypothesis ( $P = 0.17$ ;  $T_{0.05(2)19}$ ). This may have been a function of the sample size as the average percentage fence for ponds with greylard was 0.16 (-0.54 – 0.87, 95%CI) compared with 0.02 (-0.12 – 0.16, 95% CI) for ponds without waterfowl. This finding was not consistent with our Nest Score (we found ponds with greylard present received a higher Nest Score than ponds without waterfowl;  $0.02 < P < 0.05$ ) suggesting other factors such as islands may contribute to nest habitat.

## 5.0 Management Implications

For waterfowl managers or land owners that wish to enhance pond utility by greylard then size and proximity to other large ponds matters. It appears that creating a convoluted edge improves carrying capacity and that preference is shown to ponds with good overhead cover. When creating or enhancing a pond, a minimum size of at least 1ha appears to be a requisite to hold at least one brood<sup>1</sup>.

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<sup>1</sup> The ponds we looked at were in the main, discrete habitats with little or no contiguous habitat. It may be that wetland corridors or proximate ponds may relax this criterion.

Nesting habitat also appears important at this time of the year as does the presence of islands particularly if the pond margins are not going to be fenced. Because many of these smaller ponds only support one or two broods only a small area of fenced pond margin may suffice? However, because of the reliance of seed matter in the diet of mallard outside of the breeding season and the abundance of invertebrates associated with emergent vegetation (Potts 1997) creating a good emergent vegetation zone around the periphery (ie keeping stock out of the pond) appears important.

Of the 44 ponds that we surveyed as part of the waterfowl count only 21 (47%) had greylard present and on only 5 (11%) did we observe mallard broods. We believe there is scope to increase greylard numbers in the Central Hawke's Bay through the management of existing ponds.

This study only looks at one point in time, albeit an important time in the life cycle of the greylard, we believe however, that it would provide a useful insight into the limitations of population growth to examine a greater number of ponds over the entire annual cycle.

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## **References**

- Addy C. E., And Macnamara L. G. 1951 Waterfowl Management On Small Areas Wildl. Mgmt. Inst., Washington, D.C. 80p
- Anderson David R., And Henny Charles J. 1972 Population Ecology Of The Mallard. I. A Review Of Previous Studies And The Distribution And Migration From Breeding Areas. United States Dept. Of Inter. Fish And Wildl. Serv. Reso. Publ. No. 105
- Belanger Luc, Couture Richard 1988 Use Of Man-Made Ponds By Dabbling Duck Broods Journ. Wildl. Mange. 52(4): 718-723
- Blums Peter; Nichols James D.; Lindberg Mark S.; Hines James E.; Mednis Aivars 2003 Factors Affecting Breeding Dispersal Of European Ducks On Engure Marsh, Latvia Journ. Animal Ecol. 72 Pp. 292-307
- Burnham Kenneth P., And Anderson David R. 2002 Model Selection And Multimodel Inference. A Practical Information-Theoretic Approach Second Ed. Springer-Verlag New York
- Clark Robert G. And Nudds Thomas D. 1991 Habitat Patch Size And Duck Nesting Success: The Crucial Experiments Have Not Been Performed Wildl. Soc. Bul. 19:4534-543
- Clarkson Beverley R, Sorrell Brian K., Reeves Paula N., Champion Paul D., Partridge Trevor R., Clarkson Bruce D. 2004 Handbook For Monitoring Wetland Condition  
[Http://www.Landcareresearch.Co.Nz/Research/Biocons/Restoration/Docs/Handbook2004.Pdf](http://www.Landcareresearch.Co.Nz/Research/Biocons/Restoration/Docs/Handbook2004.Pdf)
- Dzubin Alex 1969 Comments On Carrying Capacity Of Small Ponds For Ducks And Possible Effects Of Density On Mallard Production. Saskatoon Wetlands Seminar, Pp 138-160  
Can. Wildl. Serv. Rep. 6
- Emery Robert B.; Howerter David W.; Armstrong Llwellyn M.; Anderson Michael G.; Deviers James H. 2005 Seasonal Variation In Waterfowl Nesting Success And Its Relation To Cover Management In The Canadian Praires Journ. Wildl. Mange. 69(3): 1181-1193
- Giroux Jean-Francois 1981 Use Of Artificial Islands By Nesting Waterfowl In Southeastern Alberta Journ. Wildl. Mange. 45(3): 669-679
- Greenwood, Raymond J., Alan B. Sargeant, Douglas H. Johnson, Lewis M. Cowardin, And Terry L. Shaffer 1995 Factors Associated With Duck Nest Success In The Prairie Pothole Region Of Canada Wildlife Monographs 128:1-57
- Gunnarsson Gunnar, Johan Elmberg, Kjell Sjöberg, Hannu Pöysä, And Petri Nummi 2004 Why Are There So Many Empty Lakes? Food Limits Survival Of Mallard Ducklings  
Canadian Journ. Of Zoology
- Hoekman S, Mills LS, Howerter D, Deveries, Jball IJ 2002 Sensitivity Analyses Of The Life Cycle Of Mid-Continent Mallards Journ. Wildl. Mange. 66(3): 883-900

- Krapu Gary L., Klett Albert T., Jorde Dennis G. 1983 The Effect Of Variable Spring Water Conditions On Mallard Reproduction *The Auk* 100: 689-698
- Krapu Gary L., Pietz Pamela J., Brandt David A., Cox Robert R. 2000 Factors Limiting Mallard Brood Survival In Prairie Pothole Landscapes *J. Wildl. Manage.*64(2):553-561
- Leathwick John, Wilson Gareth, Rutledge Daniel, Wardle Peter, Morgan Fraser, Johnston Kirsty, Mcleod Malcolm, Kirkpatrick Russell 2003 Land Environments Of New Zealand Manaaki Whenua- Landcare Research, Ministry For The Environment, New Zealand
- McDougall M 2009 Project 1116 - 2009 Trend Counts. Paradise Shelduck, Black Swan, And Canada Goose Counts For The Hawke's Bay And Eastern Internal Fish And Game NZ Report
- \_\_\_\_\_ 2008 2008 Banding Report For Fish And Game New Zealand, Eastern & Hawke's Bay Regions Internal Fish And Game NZ Report
- Mcdowall R. M. 1990 New Zealand Freshwater Fishes A Natural History And Guide Heinemann Reed MAF Publishing Group
- Mckenzie Darryl I. 2005 What Are The Issues With Presence-Absence Data For Wildlife Managers? *Journ. Wildl. Mange.* 69(3): 849-860
- Mckinnon Donald T.; Duncan David C. 1999 Effectiveness Of Dense Nesting Cover For Increasing Duck Production In Saskatchewan *Journ. Wildl. Mange.* 63(1): 382-389
- Mclandress M. Robert, Yarris Gregory S., Perkins Alison E. H., Connelly Daniel P., Raveling Dennis G. 1996 Nesting Biology Of Mallards In California *Journ. Wildl. Mange.* 60(1): 94-107
- Olsen Richard E., And Cox Robert R. 2003 Body Size And Condition Of Male Mallard During Mid-Winter In North Dakota, USA. *Waterbirds* Vol. 26(4) P: 449-456
- Paul F. Doherty, Jr.A, James D. Nicholasa, John Tautina, James F. Voelzerb, Graham W. Smithb, Douglas S. Benningb, V. Ray Bentleyb, John K. Bidwellb, Karen S. Bollingerb, Arthur R. Brazdab, Elizabeth K. 2002 Sources Of Variation In Breeding-Ground Fidelity Of Mallards (*Anas Platyrhynchos*) *Behavioral Ecology* Vol. 13 No. 4: 543-55
- Pospahala Richard S., Anderson David R., And Henny Charles J. 1974 Population Ecology Of The Mallard. II. Breeding Habitat Conditions, Size Of The Breeding Populations, And Production Indices. United States Dept. Of Inter. Fish And Wildl. Serv. Reso. Publ. No. 115
- Potts K 1976 Pukepuke/Omanuka Limnology Wildlife - A Review No. 7 PP. 57-60, New Zealand Wildlife Service, Dept. Of Internal Affairs.
- Potts K 1977 Food Of Game Ducks Wildlife - A Review No. 8 PP. 28-34, New Zealand Wildlife Service, Dept. Of Internal Affairs.

- R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org>.
- Raven Garnet H.; Armstrong Llewellyn M.; Howerter David W.; Arnold Todd W. 2007 Wetland Selection By Mallard Broods In Canada's Prairie-Parklands *Journ. Wildl. Manage.* 71(8): 2527-2531
- REIJNEN R. ; FOPPEN R. ; BRAAK C. T. ; THISSEN J. ; 1995 The Effects Of Car Traffic On Breeding Bird Populations In Woodland. III. Reduction Of Density In Relation To The Proximity Of Main Roads. *Journ. Of Applied Ecology* (32) 187-202
- Reynolds Ronald E., Blohm Robert J., Nichols James D., Hines James E. 1995 Spring-Summer Survival Rates Of Yearling Verses Adult Mallard Females *J. Wildl. Manage.* 59(4):691-696
- Riggs Michael R. ; Haroldson Kurt J. ; Hanson Mark A. 2007 Analysis Of Covariance Models For Data From Observational Field Studies. *Journ. Wildl. Manage.* 72(1): 34-43
- Shaffer Terry L., Johnson Douglas H. 2007 Ways Of Learning: Observational Studies Versus Experiments *Journ. Wildl. Manage.* 72(1): 4-13
- Shaffer Terry L., Dahl Ann L., Reynolds Ronald E., Baer Kathy L., Johnson Michael A., And Sargeant Glen A. 2006 Determinants Of Mallard And Gadwell Nesting On Constructed Islands In North Dakota. *Journ. Wildl. Manage.* 70(1): 129-137
- Swift John 1976 *Ducks, Ponds And People* The Caxton & Holmesdale Press, Sevenoaks
- Van Der Zands A. N., Ter Keurs W. J., Van Der Weijden W. J. 1980 The Impact Of Roads On The Densities Of Four Bird Species In An Open Field Habitat - Evidence Of Long-Distance Effect *Biological Conservation* 18: Pp 299-321
- Williams Murray; Imber M. J. 1970 The Role Of Marginal Vegetation In Some Waterfowl Habitats *Proc. N.Z. Ecol. Soc.* 17; Pp 126-128
- Zar Jerrold H. 1996 *Biostatistical Analysis* Third Edition Prentice Hall Upper Saddle River, New Jersey