SCIENCE AND RESEARCH INTERNAL REPORT 2

KIWI RESEARCH AND CONSERVATION: AN ACCOUNT OF A N.Z. WILDLIFE SERVICE WORKSHOP 20-21 MAY 1986

COMPILED BY

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Two aims of the workshop were to review the current knowledge on the kiwi and to identify aspects of its biology and management where more information was required. Therefore, to promote further kiwi conservation it was considered that it would be helpful to the participants and future workers if a record of the proceedings at the workshop was available. The account was compiled from the tape recordings of the speakers' talks and of many of the discussions, plus notes taken throughout the proceedings. As well, some participants were given the opportunity to comment on a draft of this account.

Agenda

20 May 1986

1. Introductory comments -Malcolm Crawley
2. Current and proposed kiwi research and management programmes.
   Murray Potter -Brown kiwi, Paerata Reserve
   Jim Jolly -Little spotted kiwi
   John McLennan -Brown kiwi, Hawkes Bay; great spotted kiwi
   Charles Daugherty -Genetic differences in kiwi populations
   Peter Jenkins -WRLG kiwi review
   Rogan Colbourne -Brown kiwi, Waitangi State Forest
   Michael Taborsky -Brown kiwi, Waitangi State Forest
   Colin O'Donnell-Stewart Island brown kiwi
   Harold Corbett -Kiwi in exotic forests
   Brian Reid -Preparation of a monograph on kiwi
3. Distribution
   Brian Reid -Present knowledge of kiwi distribution
   Charles Daugherty -Genetic differences among North Island brown kiwi
   Rogan Colbourne -Proposed kiwi survey
4. Census methods
   The need for an accurate and quick method of censusing kiwi abundance; the desirability of a uniform method; methods and drawbacks.
5. Demonstration of techniques
   An area was set aside for people to show equipment and techniques.
6. Techniques for study Radio telemetry, night-vision scopes, video, methods of capture, marking, banding, use of dogs.
7. Kiwi ecology
   Spacing; habitat use and social behaviour; foods; mating system; breeding season; egg production and energetics; incubation; dispersal and survival of young; population turnover; habitat differences in ecology.
8. Summary of deficiencies and possible resolution of problems _ Richard Sadleir

21 May 1986

Management of kiwi

1. Introductory statement by Brian Bell.
2. Threats to kiwi populations
   Logging, poisoning, predation, competition, etc.
3. Problems in kiwi conservation as seen by Commissioners (Dept of Lands and Survey)
   and Conservators
4. Protection of existing habitats
   Size of reserves, reserve design, management of isolated populations, forest management for kiwi.
5. Desirability of kiwi salvage operations.
6. Liberation policy -should kiwi be shifted from one district to another?
7. Liberation on islands -evaluation of success.
8. Role of captive-breeding in kiwi conservation; problems and achievements.
9. Summary
   Overview of deficiencies in research and management, possible resolution of problems -Brian Bell.

1. INTRODUCTORY COMMENTS

Dr M Crawley, Wildlife Service, welcomed the approximately 50 participants (Appendix 1) and noted that a wide range of organisations was represented: Wildlife Service, Department of Lands and Survey, Ecology Division of DSIR, NZ Forest Service, Auckland University, Massey University, Victoria University, Rainbow and Fairy Springs, Otorohanga Zoo and Wellington Zoo. He noted that it was probably the first time that a workshop had been held to discuss the biology and conservation of the kiwi and emphasised the need for an integrated approach to kiwi conservation by researchers and managers. He considered that it was a particularly appropriate time for the workshop to be taking place because of the pace of forest modification and, in some cases, destruction, and the consequent need to review current knowledge of kiwi biology; determine their ability to survive in man-modified environments; and identify needs for further information.

2. CURRENT AND PROPOSED KIWI RESEARCH AND MANAGEMENT PROGRAMMES

[Chairman Malcolm Crawley]

(a) ECOLOGY OF THE NORTH ISLAND BROWN KIWI IN PAERATA RESERVE, TANGITERORIA, NORTHLAND.

Murray Potter, Massey University

Murray is involved in a PhD study of the brown kiwi in the 200 ha Paerata Reserve, Northland. About 100 birds inhabit the reserve and adjoining forest patches. The four main aspects of the study are:

(1) to investigate the social structure and habitat use of the population, using radio-telemetry,
(2) to compare the seasonal time-budgets of birds, using FM transmitters,
(3) to investigate the bioenergetics of the birds, particularly through the breeding season, and to compare the findings from males and females. The technique of investigation will involve the use of doubly-labelled water, and,
(4) in association with Dr J Cockrem of Ecology Division, DSIR, to investigate seasonal changes of hormones in blood samples.

From work during September 1985-May 1986 it was found that some birds fed and roosted in forest patches in gullies outside the reserve and adjacent to farmland. By plotting the extreme locations of his kiwi, Murray has found that while the home ranges of pair members overlap, their ranges are not identical. For some pairs the female's home range was larger than that of her mate. The home ranges of pairs were not exclusive during the study -there was considerable overlap with those of other kiwi.

(b) ECOLOGY OF THE LITTLE SPOTTED KIWI

Jim Jolly, Wildlife Service

Jim described the various avenues of investigation being carried out into the ecology of the little spotted kiwi (LSK). The only known

viable population of this kiwi is on Kapiti Island; in recent times there have been no confirmed records of birds from South Island. The LSK is the rarest of the kiwi species and is endangered.

Work on Kapiti over the past six years has been aimed at determining the size of the population, habitat preferences, diet, breeding biology, whether problems for the bird, whether management of the population is required, and whether transfers of LSK to other islands are feasible. The technique using call counts was developed to obtain an estimate of the number of LSK on Kapiti. Initially, this involved determining seasonal, nightly, and weather-related variation in calling rates. Subsequently, the entire island was surveyed for kiwi using the call count technique. Habitat selection of the population was determined from an analysis of kiwi density in various habitat types. The diet has been investigated from faecal analysis. The diet was found to be diverse and fairly well represented the invertebrate fauna available on the forest floor. The most frequently eaten foods were adult and larval insects, spiders and worms. Vegetable matter was taken, particularly fleshy fruits, grass seed and leaves, but some may not have been deliberately ingested.

Breeding success has been investigated using radio-telemetry and video camera monitoring at the burrow entrance. This work has shown a high loss of eggs, mainly to wekas. Searches at night have located few chicks, but those found were mainly confined to the mature forest covering only a third of the island. Adults have been banded for a long-term study of longevity. However, no information is available on chick/juvenile survival.

Islands thought to be suitable for LSK liberation are being assessed for the presence of predators and the invertebrate fauna. The size of the islands is an important determinant of their suitability for LSK populations in the long-term, and probably Little Barrier Island is the only island of sufficient size that is suitable at present.

Future work will concentrate on determining the viability of the Kapiti population, determining more about its breeding biology, continuing to assess the mortality of banded adults, determining whether other islands are suitable for LSK and monitoring already transferred to other islands.

(c) SOCIAL AND BREEDING BEHAVIOUR OF THE NORTH ISLAND BROWN KIWI IN HAWKES BAY
John Ecology Division

For the past four years John has been studying brown kiwi in Hawkes Bay. Generally, kiwi are restricted to the western ranges of the region, being thinly scattered at c. 1 bird/100 ha. They are rare in areas below 100 m and in pine forests. Few reserves contain kiwi and none contain viable populations. A comparison of the present distribution of kiwi with historical records indicates that the brown kiwi is declining in Hawkes Bay, even in forests unmodified by man.

Brown kiwi in a 770 ha reserve were studied intensively to determine the reasons for the decline and to document their social and breeding behaviour. Eight adults (three pairs and two solitary birds) were located in the reserve and radio-tagged. They had well-defined, non-overlapping home ranges, pairs using 30-40 ha. The birds bred from late June to January, laying 2-egg clutches both initially and as replacements. Both sexes suffered a 30% weight loss during the breeding season. Egg survival was good. The three pairs hatched five chicks over three years, of which two chicks died soon after hatching. The other chicks were not seen soon after hatching and chick survival is suspected to be very poor.

There was no adult mortality during the study even in the presence of ferrets, feral cats and pigs, and cyanide poisoning. Although no gin trapping occurred in the reserve during the study, three of the eight kiwi had toes missing as a result of encounters with gin traps. John considered gin traps were the major cause of adult mortality. Fieldwork is completed and the study is now being written up.

John has expectations of starting a study of the great spotted kiwi to determine distribution, and to compare various aspects of the species' ecology in lowland and alpine populations. In collaboration with Dr C Daugherty, a comparison of the genetic variability of several populations is being investigated.

(d) GENETIC VARIATION IN THE KIWI
Charles Daugherty, Victoria University

A pilot study comparing the blood protein composition of different populations of brown kiwi by electrophoresis has demonstrated that the technique reveals genetic variation. From the limited samples obtained to date, a significant amount of genetic variation at the individual, population and regional levels is evident. It is now hoped to study in detail the genetic variation in brown kiwi populations, because if the variation is high then this will have important management implications. There will be two main methods of study; firstly by comparing blood proteins and secondly, in collaboration with Dr A Baker of the Ontario Museum, to compare their mitochondria1 DNA. The latter technique enables the social structure of a population to be assessed.

(e) WILDLIFE RESEARCH LIAISON GROUP
Peter Jenkins, Auckland University

Peter is a member of a Wildlife Research Liaison Group sub-committee which is producing a report on kiwi species and the priorities for future research. Drafts of the document have been prepared and circulated, but completion has been postponed to include information and research priorities emanating from this workshop.

(f) ECOLOGY OF THE NORTH ISLAND BROWN KIWI IN WAITANGI STATE FOREST, NORTHLAND
Rogan Colbourne, Wildlife Service

Rogan and Ruud Kleinpaste carried out a study of the diet of

brown kiwi in Waitangi Forest in 1981-82. Birds were banded to determine individual ranges and the importance of pine forest and indigenous forest as food sources. Territories of pairs averaged 5-6 ha. An important aspect of the study was to assess the effects of forestry management (logging, burning and replanting) on the kiwi. At present Rogan is involved in the Wildlife Service's LSK project and, in collaboration with Ralph Powlesland, Wildlife Service, is completing an analysis of the diet of Stewart Island brown kiwi. Rogan suggested that more information is required on the present distribution of each species, and the current trends in the status of populations. The latter could be determined by indexing populations using call counts. Also, some birds of about 10 populations could be banded for long-term monitoring of longevity.

(g) REPRODUCTIVE BIOLOGY OF THE NORTH ISLAND BROWN KIWI WAITANGI STATE FOREST, NORTHLAND
Michael Taborsky, Max Planck Institute, West Germany

Michael is studying the reproductive biology of brown kiwi in Waitangi Forest. There seems to be an absence of parental care of kiwi chicks and so reproduction involves mainly an energetic input by the pair. Two questions that Michael is attempting to answer are:

- what is the annual pattern of energy requirements of the kiwi?
- how do females and males cope with the demands of egg production and incubation respectively?

Kiwi are radio-tagged to monitor their movements and use of space. The birds' energy expenditure is measured by repeated weighings and by the doubly-labelled water technique. The reproductive biology of kiwi is poorly known. Aspects needing investigation are the relationship of neighbouring birds to each other, the sex ratio within several populations, and dispersal and survival of young.

(h) ECOLOGY OF THE STEWART ISLAND BROWN KIWI
Colin O'Donnell, Wildlife Service

Colin studied the Stewart Island brown kiwi from 1977-1981 during the August-September period in the Mason Bay -Freshwater River area. An estimate of the population density was calculated from call frequencies and by territory mapping. Casual observations were made of the diet, feeding behaviour, breeding biology and predation by cats. Kiwi diurnal activity was noted and the birds were found to be active at any time of the day throughout the year. Call rates averaged 10 per hour and about 20 birds were found to inhabit a 10 ha block. The maximum distance moved by a bird over a 24-hour period was 500 m.

(i) KIWI IN WAITANGI FOREST
Harold Corbett, NZ Forest Service

In 1978 a survey of the brown kiwi in Waitangi Forest was carried out by Harold, using call counts to index the population's density. It was

hoped that this would be repeated at 3-5 year intervals. The last survey was done in 1985.

(j) MONOGRAPH ON THE KIWI
Brian Reid, Wildlife service

Brian is preparing a monograph on the kiwi, which is expected to total 100,000 words. Two-thirds of the text will contain the available information about the biology and ecology of the various species, the other third will deal with historical and cultural information on the bird. As well, appendices will include a discussion of the aviculture requirements of kiwi and appraisal of kiwi survey techniques.

(k) KIWI SURVEY IN TARANAKI
Janice Molloy, Wildlife Service

Janice is involved in a fauna survey of the Mokau Coal Field in northern Taranaki during winter, 1986. This survey will involve estimating kiwi densities in an area where open cast mining is planned.

(l) KIWI AND 1080 POISONING OF POSSUM
Eric Spurr, NZ Forest Service

Eric proposes to monitor kiwi populations before and after a 1080 possum poisoning operation. He pointed out that it is very difficult to monitor kiwi populations where a routine poisoning operation is to be carried out, such as in the Copland Valley, because usually kiwi are either not present or are in very low numbers. He stated that Waitangi Forest would be an ideal site to carry out such a trial because of the high densities of kiwi and the good roading which provides easy access.

(m) NORTHLAND KIWI HABITAT
Arthur Cowan, Otorohanga Zoological Society

Arthur spoke of the Society's concern at the loss of kiwi habitat in Northland and their wish to see more done to preserve the habitat.

DISCUSSION

Some question time was available at the end of the session. Murray Potter was asked whether there was any overlap in time of the home ranges of brown kiwi at Tangiteroria. He stated that the home range maps he had shown were based on the positions of roosting kiwi and that there was overlap in their use -three females and a male had used the same roost site on different days.

Eric Spurr was asked whether the NZ Forest Service was going to investigate the acceptance or not of coloured baits by kiwi. Eric replied that he did not know whether such a trial was planned.

3. DISTRIBUTION

[Chairman John McLennan]

(a) PRESENT KNOWLEDGE OF KIWI DISTRIBUTION

Brian Reid, Wildlife Service

Maps of the present known distribution of the three species of kiwi in 10,000 m grid squares based on information from the Atlas of Bird Distribution in New Zealand (Bull, Gaze & Robertson) 1985, reports passed to the Wildlife Service and from field work carried out by Wildlife Service personnel were shown (Fig 1). There are three enclaves of the brown kiwi (Apteryx australis) in the North Island; Northland, Taranaki-King Country, and Urewera-East Coast. In the South Island some observers were unable to distinguish the species they heard calling. However, the information indicates that there are also three enclaves of the brown kiwi in the South Island; at Okarito, Haast and throughout Fiordland.

The great spotted kiwi or roa (A.haastii) has a fairly continuous distribution in the North-west Nelson-Paparoa Ranges region. In addition, its distribution extends south to the Haast River, but in a discontinuous manner. About Okarito it seems that the roa is present in alpine areas and the brown kiwi on the lowlands.

No recent records of the LSK (A. owenii) have been confirmed in Fiordland. One bird from D'Urville Island has been transferred to Long Island. Brian believes a kiwi from Westhaven Inlet in 1982 to be a A. o. occidentalis; the skeleton is in the National Museum. Further searches about the inlet have failed to locate more LSK. The present distribution of this species is restricted to Kapiti Island, with some birds having been transferred to Long Island and Red Mercury Island.

(b) GENETIC DIFFERENCES AMONG NORTH ISLAND BROWN KIWI

Charles Daugherty, Victoria University

Blood samples have been obtained from 47 birds (many are captive-held birds whose origins were unknown or are hybrids). The results have shown that blood is a suitable medium to distinguish genetic variation, with 24 genetic loci identifiable. Of these, seven loci have shown polymorphism (genetic variation). There are region differences in the haemoglobin proteins of the brown kiwi and two groups can be defined; the Stewart Island-Fiordland, and the Okarito-North Island.

With five samples from both the Waitangi Forest and Tangiteroria, these two populations can be distinguished at one locus, even though they are separated by only 50 km; they are isolated breeding units.

The results show that:

1. there is a moderate to high amount of genetic variation at the individual, local and regional levels in the brown kiwi;
2. the present taxonomy is suspect; and

3. given adequate samples (20 per site) the techniques developed should be able to define the geographic structure (management units) of the brown kiwi. Also, it should be able to resolve what genetic 'type' of brown kiwi is now on Kapiti Island, because the population was established 60 years ago by liberations of birds from Fiordland and the North Island that are genetically distinct.

(c) GENETIC DIFFERENCES AMONG NORTH ISLAND BROWN KIWI
David Fountain, Massey University

Blood was collected and subjected to a process called isoelectric focusing. From computer analyses of the results, a percentage similarity index was determined from a comparison between the following groups; Northland, Taranaki, Bay of Plenty, South Island brown kiwi, LSK and the great spotted kiwi. This revealed that the Northland and Taranaki birds have a high degree of relatedness and that the Bay of Plenty birds are distinct, having a low degree of relatedness to the previous two groups. Although at a low degree of similarity, the South Island brown kiwi was most related to the Northland and Taranaki birds. Blood from Fiordland birds was subsequently compared with that of an Okarito bird, revealing very distinct differences between the two. Similarly, there was a low degree of relatedness between the two species of spotted kiwi and also of these species to the brown kiwi.

(d) PROPOSED KIWI SURVEY
Rogan Colbourne, Wildlife Service

There are considerable gaps in our knowledge of the distribution of the kiwi species. Land is being cleared and we do not know whether kiwi are present. To rectify this Rogan proposes to introduce a Kiwi Call Scheme. The aims of the scheme are:

(1) to determine the national distribution of kiwi;

(2) to relate kiwi density to location and habitat; and

(3) to assign a kiwi call index at a particular time of year to each listening station to enable the dynamics of the population to be determined. Repeated listening sessions at these stations after 5, 10 and 20 years may indicate whether a population is stable, increasing or declining.

The scheme will give information on the relative abundance of kiwi, not absolute numbers; some birds do not call. Rogan provided an eight page information leaflet describing the aims and methods of the scheme (Appendix 2) and how the cards should be filled in. As well as irregular visits to sites, Rogan hoped that some observers would repeatedly visit specific stations throughout the year so that information on seasonal variation in calling rates can be assessed.

DISCUSSION

(a) What is the relationship of the blood electrophoresis and blood isoelectric focusing techniques to each other?

The former technique distinguishes different proteins on the basis of charge, size and shape, while the latter does so in a pH gradient on the basis of isoelectric point. Charles Daugherty considered that the two similar techniques sampled different parts of the genome and looked at a similar number of loci, with a small amount of overlap. Both techniques had shown there was much genetic variation in the brown kiwi and they had provided similar results: both distinguished the Okarito population from birds further south. Charles also stated that the techniques were conservative; they missed much variation because proteins do not represent all variation.

(b) How could the mitochondrial DNA technique contribute to our knowledge of kiwi genetics?

Charles Daugherty said that michochondrial DNA is inherited maternally. Therefore, as well as determining phylogenies and estimating the boundaries between local populations, it enabled maternal lineages and social structure to be investigated. He gave the example of a specific male kiwi incubating two clutches during the season and using the technique to show whether the clutches were from the same female or not.

(c) It was noted that the Kiwi Call Scheme assumed that observers in the South Island could distinguish the calls of the three species. While experienced people can distinguish between the calls of brown kiwi and spotted kiwi, Jim Jolly considered it was sometimes very difficult to distinguish between those from great spotted kiwi and LSK. Rogan stated that he hoped a tape would be available on which was recorded the calls of male and female of the three kiwi species, plus calls of other animals that often call at night.

It was mentioned that there was much variation in the calling rate at a site and that it might not be a straight line relationship between the calling rate and kiwi density. In reply Rogan stressed the need for a lot of data and that results could not be interpreted as unequivocal. If the calling rate of population A was regularly greater than that of population B, then it indicated that population A was likely to be more dense than population

To help people estimate the distance of a calling bird, it was suggested that a training session was required. While this would be useful, Rogan thought that the exact distance was not important. There was a suggestion that noises made by people and other animals stimulated kiwi to call. Rogan hoped that listeners would not stimulate kiwi to call by making extraneous sounds or by playing a taped kiwi call until after the listening period.

(d) Peter Anderson described other techniques that were used to determine the presence of kiwi in an area when it was not possible to

spend a night listening for calls. These were to ask the locals, look for probes and faeces, or to use a trained dog to locate birds.

4. CENSUS METHODS

[Chairman Eric Spurr]

The objectives of this session were to discuss the various methods and associated problems of censusing kiwi, and whether a uniform method was available. Eric described three types of counts:

population census	- total count of birds in a total area.
population index	- relative density of birds, which relates to the effort expended to count them.
population estimate	- a count of the birds in a sample area, extrapolated to the total area. An estimate of the margin of error can be obtained.

From several consecutive nights spent listening at the Otorohanga Zoo kiwi aviaries, Brian Reid noted that there was an extreme variability in the calling rate of the known number of kiwi from night to night. Richard Sadleir noted that unless there was a fixed pattern of variation in calling which could be then it would be a waste of time to census populations by measuring calling rates.

Jim Jolly described the variation in calling of the LSK on Kapiti Island. The calling rate peaked in late summer-autumn, dropped in winter and rose again in spring (laying begins in September and replacement clutches are laid in November-December). However, it was found that the variation in calling from night to night was enormous, even when conditions were identical. It was stated that reasonable listening conditions were essential when carrying out call counts.

It was evident that there is very little information about how calling rates vary with differences in the density of kiwi. To investigate this relationship was seen as a high priority for future research. The opportunity for such a study is available in Waitangi Forest where kiwi occur at different densities in the various compartments. Rogan Colbourne noted that during his study there 30 birds were marked in compartment 6, but that only 50-60% could be determined to exist from call counts. He stated that birds less than 1.5 years old and non-territorial birds were unlikely to call so that it was not possible to obtain the precise number of kiwi in an area from call counts.

Peter Jenkins described two universal features of bird vocalisations:

(1) that after a long period of silence, a noise will stimulate calling, and
(2) that there is an infectious nature to calling.

Murray Potter noted that blowing a whistle in Hawkes Bay kiwi habitat (1 bird/100 ha) stimulated calling, but that it had the opposite effect at Tangiteroria (1 bird/3 ha).

Jim Jolly described a method of estimating the size of a kiwi population by determining the call rate of a known number of birds in a sample area. Using this information and the call rate over the entire study area, the number of birds in the study area can be estimated. Although it is time-consuming and labour-intensive it has the advantage that error estimates can be derived for an area of known population and then taken into account when extrapolating to a larger area.

Eric Spurr described his monitoring of Stewart Island brown kiwi, which involved eight 5-minute counts at 20 sites for each estimate of population density. He found that although there was wide variability around the estimates, by doing enough counts repeatable results were obtained. There was seasonal variability in the calling of this subspecies, with peak calling in November-February.

5. DEMONSTRATION OF TECHNIQUES

An area was set aside for people to display equipment and to demonstrate techniques for studying kiwi.

6. TECHNIQUES FOR STUDY

[Chairman Jim Jolly]

(a) METHODS OF CATCHING, HOLDING, MARKING AND MEASURING KIWI
Rogan Colbourne

Equipment required: two torches, batteries, pliers, bands, scales, callipers, compass, note-book and pencil.

Methods of catching a kiwi:

(1) Once located they can be chased and caught, but kiwi are strong runners and can out-run a person in dense forest. They will hide and remain motionless for up to 30 minutes when chased.
(2) Kiwi can be attracted by imitating their calls or by playing a tape recording, and captured using a hand net.
(3) Muzzled dogs are often used to locate roosting kiwi. Such dogs should be specially trained for the task and used solely to locate kiwi, not retrieve them.

Once caught, if the bird is held by the legs and its body supported by the arm, it will usually remain still. When weighing brown kiwi it is necessary to tie their legs together to prevent them ripping open the bag.

Reflective tape can be put on the serial band so that individuals can be identified in a torch beam. The tarsi of some kiwi are too big to band with R-sized bands and so a larger size for them is being investigated. Kiwi chicks can be marked by attaching a fish tag to a loose flap of wing skin.

Standard measurements taken from kiwi are:

(1) length of bill from concavity of the cere to the tip, a very reliable measurement to age and sex kiwi;
(2) tarsus width from both front-back and side-side;
(3) tarsus length; and weight; females are usually 16-20% heavier than males, but this measure is not reliable.

(b) RADIO TRACKING
John McLennan

Equipment required: transmitter, battery, directional aerial and receiver.

Problems associated with radio-telemetry studies of kiwi:

1. the signal is line of sight and so occasionally no signal is received from a bird on the far side of a nearby ridge;
2. the 160 MHz signals 'bounce' off rocky faces, etc. giving spurious directions to the transmitter;
3. often there is poor signal transmission from birds in burrows; experience on Kapiti Island in steep, dissected terrain is that a range of less than 200 m is obtained;
4. the transmitter must be light enough for the bird to carry and be water-proof. John initially had problems with aerials (100 lb breaking strain braided fishing wire) breaking at their base, and when this happened water entered the package by capillary action. These problems were overcome by encapsulating the aerial in the transmitter package. However, the disadvantage of this procedure is that the range of the signal is reduced;
5. the safe attachment a transmitter to a kiwi has been difficult. Methods tried have included harnessing, glueing to feathers, and fitting a padded metal clamp around the leg. John currently attaches transmitters to brown kiwi with a plastic hospital identification band just above the joint. They have proved to be sufficiently strong, and yet soft enough to prevent damage to the leg of the bird;
6. three to four hours are needed to open a package, replace the battery and re-assemble the package. John is investigating the possibility of recharging a battery while it is still inside its package; and
7. when recapturing a radio-tagged bird often the last 10 m is the most difficult because of the topography of the site and the idiosyncrasies of the aerial. These problems can sometimes be overcome by disconnecting the aerial and using just the receiver to track the signal.

(c) NEST MONITORING
Michael Taborsky

Michael is quantifying the time incubating males spend in and out of the burrow. Two techniques he used involved:

1. setting up two infra-red light beams at the entrance to the burrow. These were connected to a microchip storage device which recorded the direction and time the beams were broken by the kiwi. The data were transferred by tape recorder from the microchip to a computer; and
2. comparing the temperature of the egg and the environment with two probes connected to a hand-held computer. Both techniques were used on the same nest and showed that they provided reliable data of nest attentiveness.

Other techniques Michael described were:

1. weighing incubating males without handling them by having a balance at the entrance to the burrow with a remote display; and
2. individually marking kiwi by glueing radioactive microlights to their bands which can be seen at a 30-40 m range; these are available in a variety of shapes and colours.

7. KIWI ECOLOGY

[Chairman Jim Mills]

(a) SPACING, HABITAT USE AND SOCIAL BEHAVIOUR

Murray Potter discussed the possible reasons why there was a lack of kiwi territoriality at Tangiteroria. He believed that it was not caused by disturbance associated with land clearance, even though about a quarter of the reserve had had land clearance alongside it. Murray thought that there was a disturbed kiwi population anywhere then it would be in Waitangi Forest, where forestry activities were regularly occurring in the compartments inhabited by the birds. In relation to this, Michael has found, using radio telemetry, that there is considerable overlap in the kiwi home ranges at Waitangi, contrary to the findings of Rogan Colbourne and Ruud Kleinpaste, and that the partners of a pair do not share the same home range entirely. Murray acknowledged that cattle in the Paerata Reserve could be a likely source of disturbance to the kiwi.

John said that three pairs and one unmated female brown kiwi in this study area in Hawkes Bay had non-overlapping contiguous home ranges, but the home range of the second unmated female overlapped with that of the other birds. He considered that they needed their large home ranges and that an increase in density would lead to a reduction in breeding success and survival.

Jim Jolly stated that the mated pairs of LSK on Kapiti Island had territories in the traditional sense. The same birds had occupied the same territories for three years and had not been seen outside them. Territory boundaries were determined from locations of active birds in a breeding season and the locations of occupied burrows. Instances of territorial defence by LSK which had been seen mainly involved the eviction of birds, but a few cases of adults involved in boundary disputes and neighbours being attracted simultaneously to whistles at the same site on the boundary were described.

(b) MATING SYSTEM

Charles Daugherty considered that the Tangiteroria population provided an ideal opportunity to investigate the mating system of the brown kiwi using the mitochondria1 DNA technique. It would identify which birds were maternally related and the level of inbreeding.

(c) DIET

The diet of the LSK reflects the invertebrates available on the forest floor, according to Jim Jolly, except that the faster-moving insects seemed to be able to avoid capture. The most frequent invertebrate foods were worms, spiders, adult beetles (particularly cockchafers), carabids and insect larvae (particularly cranefly larvae). Some plant material was ingested, the most commonly eaten being Coprosma berries and grass seed. Rogan Colbourne noted that the brown kiwi in Waitangi Forest ate some fruit, particularly the tobacco weed (Solanum mauritianum). However, the Stewart Island birds ate very little fruit. Rogan suggested that in cases when large fruit were eaten, for example hinau (Elaeocarpus dentatus), they may act as qizzard stones and so he was unsure of the significance of fruit as a food source. Brian Reid noted that a captive pair of kiwi at the Mt Bruce Wildlife Centre preferred the ripe kahikatea (Podocarpus dacrydioides) fruit that had fallen into their aviary to the provided food.

(d) BREEDING SEASON

The brown kiwi at Tangiteroria lays from June to February, with peaks occurring in July-August and October-November (M Potter). Similarly, eggs of brown kiwi at Waitangi have been found in most months, but the peak laying period is June-September (R Colbourne). The same subspecies in Hawkes Bay had a definite breeding season, with laying occurring from June to January (J McLennan). In captivity a female brown kiwi at Wellington Zoo laid at 3-monthly intervals (R Goudswaard), at Mount Bruce the breeding season was of 9-months duration (B Reid) and at Otorohanga there seemed to be a 6-month long breeding season (A Cowan). It was suggested that the variation in the length of the breeding season may reflect differences in food availability.

The peak of laying of the LSK is in September, with the laying season extending from August to December (J Jolly). A pair of great spotted kiwi at Mount Bruce National Wildlife Centre lays one egg each year; in 1985 it was laid in late December.

(e) WEIGHTS

At Tangiteroria, female brown kiwi have varied in weight from 2.2 to 3.2 kg and males from 1.5 to 2.3 kg. From January to May 1986 several of these birds lost weight (M Potter). R Colbourne stated that females in Waitangi State Forest had exceeded 4 kg in weight, with maximum weights being for gravid females. In Hawkes Bay the kiwi were heaviest in June (females 3 kg, males 2 kg) and they became about 30% lighter over the breeding season (J McLennan). Similarly, LSK on Kapiti Island

increase in weight in autumn and winter, and lose weight over the breeding season Jolly). In contrast, the weights of brown kiwi at the Wellington Zoo are stable (female 2.3 kg, male 2.1 kg). The male receives a restricted amount of food to ensure he does not become too heavy.

(f) INCUBATION

At the Wellington Zoo two male brown kiwi took 71-75 days to hatch their eggs (R Goudswaard). Likewise, a Hawkes Bay kiwi took 75 days to hatch the first egg of a replacement clutch. The second egg hatched 16 days later, but it was not known when the egg was laid. John McLennan noted that although the laying interval between first and second eggs varied from 21-53 days, the hatching interval was shorter; as little as 6 days. This was the case for replacement clutches where incubation began with the laying of the first egg, but for first clutches, incubation was delayed until the second egg was laid. Similarly, the two eggs of a clutch at Wellington Zoo were laid 24-27 days apart, but hatched within 10 days of each other. The minimum time for incubation of a brown kiwi egg has been 70 days in an incubator (B Reid).

Michael Taborsky has noted from the limited number of observations at Waitangi State Forest he has been able to make that the incubation attentiveness varied markedly. In some cases males were absent from the burrow all night and in others the males incubated all night.

LSK eggs have taken 70-80 days to hatch (n = 2 nests). Generally, the males of this species start incubating almost immediately after the egg is laid, but the attentiveness varies through the incubation stage. Early in incubation he leaves the burrow an hour later than if he was not incubating and remains out all night (8 h). Later in the incubation period he comes out at midnight and returns to incubate at dawn (5 h) (J Jolly).

A pair of great spotted kiwi at Mount Bruce Wildlife Centre took only 63 days to hatch their egg. As well as the male incubating, the female covered the egg for 3-4 h per night (D Eason).

(g) DISPERSAL AND SURVIVAL OF YOUNG

Over two years at Hawkes Bay 5 chicks were hatched by 3 pairs. Two of the chicks died soon after hatching as a result of their instability and became tangled in vegetation. One of the other chicks was radio-tagged for a fortnight after it first left the burrow; it did not roost with its parents and received no parental care. That chick and the other two were not relocated

Some juvenile brown kiwi in Waitangi State Forest have remained with their parents for up to 9 months before being evicted from the natal territory. Banded juveniles have been found up to 3 km from the natal area. Rogan Colbourne considered that dispersal in the kiwi resulted from these juvenile movements. In contrast, on Stewart Island juveniles may stay with their parents for 2-3 years Colbourne). Young Stewart Island brown kiwi have been seen foraging near their parents, and

nearly full-sized juveniles have been found roosting with two adult birds.

For at least three weeks after hatching LSK chicks remain loosely associated with their parents and, in some cases, seem to remain in the natal territory for up to a year (R Colbourne). The difficulty in attaching transmitters to chicks makes it difficult to study chick survival and the cause of mortality.

(h) ADULT SURVIVAL

In Waitangi State Forest in 1985, 13 banded kiwi were recovered. All but one, a juvenile, were present in the same locality they occupied in 1981 (G Rasch). Similarly, of 10 pairs LSK censused regularly on Kapiti Island only one pair had disappeared during 4 years (J Jolly). Three brown kiwi taken into captivity as adults have lived for 27 years (Sydney Zoo), 17 years (San Diego Zoo) and 26 years (Nga Manu Sanctuary, bird still alive) (K Muller).

It was generally agreed that more information about the longevity of wild kiwi was needed, and that every effort should be made to regularly census banded kiwi in Waitangi State Forest and on Kapiti Island. In addition, it was suggested that about 10 pairs of kiwi at several sites should be banded and censused every 2-3 years to obtain more information about adult survival.

Following contributions from several participants the following list of desirable sites is put forward for consideration. As well as longevity studies, the initial banding operations at each site would provide an opportunity for a genetic and morphometric study of the brown kiwi, and to determine the influence of kiwi density on calling rate.

A sample of 15-30 birds from two populations in each of the following regions:

Northland-Waitangi, Tangiteroria
Bay of Plantly/Coromandel
Hawkes Bay/Urewera-Halliburtons
Taranaki
Fiordland-Takahe Valley
Stewart Island

One sample of 5-30 birds from the following localities:

Little Barrier Island
Kapiti Island
Okarito
Haast

There was a general consensus that some great spotted kiwi populations should be monitored also. Sites suggested were:

North-west Nelson
Southern Paparoas
Arthurs Pass (Eastern Alps)

(i) DIURNAL ACTIVITY OF THE STEWART ISLAND BROWN KIWI

Colin believed that there was a dense population of kiwi near Mason Bay in fire-induced manuka forest and that the birds undertook wide ranging movements. Reasons suggested for the diurnal activity were poor food availability and the high density of kiwi. Colin wondered whether the same birds foraged in the day and at night. A juvenile kiwi radio-tagged by Rogan Colbourne at Scollay's Flat, southern Stewart Island, foraged in the day and at night. Rogan considered that the diurnal foraging of the Stewart Island kiwi was related to the paucity of invertebrates in the acidic, peaty soils. He commented that although this subspecies is larger than the North Island brown kiwi it weighs less.

(j) KIWI IN PINE PLANTATIONS AND INDIGENOUS FOREST

Rogan Colbourne considered that invertebrate populations available to kiwi were more abundant in Northland than elsewhere in New Zealand and that although invertebrates were less abundant in pine forests than indigenous forest, they were sufficient in the former to sustain kiwi. He considered that Waitangi State Forest was a special site for kiwi because the compartments were small, and indigenous forest and swamps, which abut the pines, were available as retreats or refuges for the birds. Harold Corbett considered that this forest was typical; most Northland pine forests have riparian habitats in gullies. Eric Spurr considered that pine forests in Northland were inhabited by kiwi because the areas had previously been covered in indigenous forest whereas for many pine forests elsewhere this had not been so.

In Taranaki there are few kiwi in pine forests, and those that are live mainly on the periphery, in indigenous forest (Colin O'Donnell). Arthur Cowan considered that pine forests would not be a long-term haven for kiwi in Northland because of the nutrient depletion over successive plantings unless riparian strips through the pines were maintained and the pines were harvested with concern for the birds. In reply, H Corbett said that Waitangi State Forest was in its second production cycle and that phosphates were applied to the soil. R Colbourne noted that kiwi were more dense in Waipara State Forest (1/3 ha) than in Waitangi State Forest (1/5 ha).

Kiwi live in eucalypt forest near Kerikeri, but more sign is encountered in scrubland and regenerating forest in the region than in mature forest (Peter Anderson).

It was recognised that the habitat preferences of the kiwi need to be investigated and that a detailed study of radio-tagged birds in logged areas is required.

8. SUMMARY OF RESEARCH DEFICIENCIES, AND POSSIBLE RESOLUTION OF PROBLEMS

[Richard Sadleir]

R Sadleir outlined the following deficiencies in kiwi research to date.

a. Studies have been carried out mainly where kiwi are plentiful. Now studies need to be attempted at the edges species' ranges to determine whether populations at such sites are declining, stable or increasing, and if they are declining, why?

b. There has been little attempt to relate the call rates of kiwi to the absolute numbers of kiwi present, and so it is not know whether kiwi density influences the rate of calling.

c. Little work has been done to determine whether smell is an important sense for the kiwi. Do kiwi use their faeces as territory markers and do they locate their dens by scent?

d. There is a need to investigate the influence of soil moisture, temperature and pH on invertebrate availability to the kiwi.

e. Little information is available regarding chick behaviour, survival and recruitment owing to the difficulty of effectively marking them, particularly with transmitters. It will be important to overcome this technical difficulty.

f. More information is needed about the predators of kiwi and their influence on kiwi populations.

g. The value of pasture and serial forest to the kiwi needs to be assessed.

h. More information about the sex ratios of various kiwi populations is required.

Recommendations

a. That the relationship of the kiwi to various habitat types (pines, indigenous forest, pasture, scrubland and particularly ecotones, such as riparian strips) be investigated.

b. That a national survey of kiwi at 10 sites be carried out to determine population trends and longevity. This would require banding birds and checking their survival at intervals over 5-10 years.

c. That a high priority be given to population genetic studies of kiwi. This would involve banding, measuring and bleeding birds at 10-15 sites and could be done in conjunction with setting up the national survey sites.

d. That the kiwi distribution scheme using call counts be promoted. Also, that the call rates of populations of known density be investigated at four prime sites (Tangiteroria, Waitangi, Hawkes Bay and Kapiti) and another 10 sites, and that the influence of initiating calls on calling rates be investigated.

e. That the fate of liberated birds be monitored, and that kiwi be liberated into habitats that have the potential to sustain them, but in which there are no kiwi at present, to test theories relating to the species' habitat requirements.

f. That kiwi be maintained in captivity for research purposes.

g. That the calcium requirements of kiwi be investigated. Female kiwi have high calcium needs for egg production, but there seems to be limited sources available to them.

MANAGEMENT OF KIWI

1. INTRODUCTORY COMMENTS

Brian Bell, Wildlife Service, stated that to conserve the kiwi we must:

a. preserve the kiwi in the habitats it exists in now;
b. create reserves to protect a reasonable variety of populations; and
c. manage 'productive habitats' (plantations and pastures) so that kiwi are maintained in them.

Only as a last resort should birds be moved from development blocks where they would otherwise be killed. It will be important to transfer such birds to new mainland sites. Transfers of kiwi to islands should be used as an insurance policy, and mainly involve rare kiwi species. Brian stated there are immediate problems in preserving kiwi habitat and kiwi populations, because of the clearing of forests and the effects of predators, but resolution of these would require research. However, Brian considered it important not to wait for the research to find the solutions before some form of management was begun because the answers may come too late; there must be an on-going and integrated process of management and research.

2. THREATS TO KIWI POPULATIONS

(a) LOGGING

It seems that there is little information on the effects on kiwi of logging in exotic and indigenous forests, and of clearing land. The highest densities of kiwi occur in pine forests when the trees are 30-40 years old and few kiwi inhabit plantations less than 15 years old. Thus, the influence of logging pines on kiwi will depend on the age of the stand and the availability of habitat for birds to move into. Although people are more aware these days of the need to leave refuges for kiwi when logging or clearing land, occasionally these riparian strips and swamps are damaged by the logging. It was considered that clearing land by bulldozing and burning had the biggest impact on kiwi populations, but the extent was not known. Two aspects that need to be investigated in relation to salvaging kiwi from logged areas are:

(1) what proportion of the kiwi survive being transferred? and
(2) what is the minimum viable population size that can be left in a remnant habitat or established elsewhere?

(b) POISONING AND TRAPPING

It was not known whether large scale broadcasting of 1080 baits to kill possums killed kiwi. Eric Spurr stated that there were no obvious kiwi deaths when 1080 was applied to broadleaf leaves to poison deer on Stewart Island. However, there had been kiwi deaths from the use of cyanide. From a survey of possum trappers, Reid said that one kiwi was known to have died per 14,400 possums poisoned in kiwi habitat. Observations at the Otorohanga Zoological Society's centre indicated that kiwi would be curious and investigate baits and so recommendations on the best way to lay poison would help to the hazard to kiwi. Trapping was considered to be more harmful to kiwi than poisoning. Brian Reid stated that one kiwi was caught for every 5,200 possums trapped in kiwi habitat. John McLennan found in his Hawkes Bay study area that three of the eight birds had been caught in gin traps (had lost toes) and that 12 birds were killed by trapping in the area. He considered gin trapping to be a very serious threat to kiwi populations. Jim Jolly commented that intensive possum trapping on Island using traps set at least 50 cm above the ground on a sloping post killed no kiwi.

(c) PREDATION

There is evidence that stoats kill kiwi in the Milford Track area and that cats have eaten kiwi on Stewart Island Dogs were considered to be an important predator of kiwi, especially where kiwi lived near farmland and towns. Pet dogs and farm dogs kill some kiwi, but pig dogs lost and left behind in forests by hunters were considered to be a major threat to some kiwi populations.

(d) COMPETITION

No evidence exists of interspecific interactions interfering with breeding attempts. Murray Potter, working on Paerata Reserve, stated that possums occasionally used a burrow that a kiwi had roosted in, but he had no evidence of a possum usurping a nesting burrow. However, Brian Reid had found a possum and a broken kiwi egg in a burrow at Tangiteroria. Of 21 eggs found by John McLennan in Hawkes Bay, only one was eaten; the culprit may have been a possum. From his experience and that of Jim Jolly on Kapiti Island, possums do not appear to interfere with kiwi breeding by taking over nesting burrows during incubation. There seems to be plenty of burrows.

3. PROBLEMS IN KIWI CONSERVATION AS SEEN BY COMMISSIONERS, DEPARTMENT OF LANDS AND SURVEY

[Chairman Peter Anderson]

Peter introduced the topic by outlining the problems of conserving kiwi habitat in Northland. He explained that kiwi habitat in this area was often scrub and therefore considered by some people as wasteland.

He pointed out that in the recent past there were incentives to landowners, by way of loans, to clear the scrub for forestry or farming, and that kiwi were particularly vulnerable to such land "development". Of 271 forested sites identified and registered as sites of special wildlife interest in 1978, 55% were modified between 1978 and 1983. The bird species most affected by these modifications were the kiwi and fernbird.

Mr Gerry Rowan, Department of Lands and Survey, Auckland

Gerry stated that one of his main tasks was the protection of wildlife habitats and natural resources. Some of the islands under his jurisdiction provided a means of saving kiwi because they acted as refuges, especially for rare species. The salvage of kiwi from forest and scrub in the Bay of Islands region as a "matter of too little, too late". He questioned whether it was correct to relocate kiwi from one district to another, because of the possible effects on the birds and the effect of the birds on other fauna. Gerry was keen to foster applied research that would result in better management of kiwi.

Mr Alistair McIlroy, Department of Lands and Survey, New Plymouth.

Alistair stated the need for baseline information about birdlife in his region, particularly in Egmont National Park. It was not known how widespread kiwi were in the park. He hoped that the Protected Natural Areas scheme would result in the identification and preservation of kiwi habitat. He noted that a block of forested land at Aotuhia was to be developed, but that there was no information available about the kiwi in the area or of general guidelines that could be followed to ensure the survival of the population as development proceeded. He considered that an intensive study of the Aotuhia kiwi was needed to ensure their survival.

4. PROTECTION OF EXISTING HABITATS

In response to questions the Commissioners envisaged that development of Crown lands would continue where it was likely to be economically viable, and that development/management plans would be available for comment before developmentn began. The longterm management of developed sites for kiwi was seen as requiring inputs from both DOC and LMDC. They believed that the legislation did not need changing for the protection or wise management of kiwi habitat, but depended upon the attitude and education of those involved in its management. Gerry stated that it was not good enough to "shut-up" blocks of land in order to protect habitats; resources would be needed to manage these sites, eg. for possum control.

(a) SIZE OF RESERVES

Two reserves have been set aside specifically for kiwi; Paerata Reserve (200 ha) at Tangiteroria and the Ecological Reserve 50 ha) in Waitangi State Forest. There was some discussion of how large a reserve needed to be for a viable kiwi population to persist indefinitely without

management. It was noted that the size would vary markedly depending on the density of kiwi. However, there is no information about what is the minimum number of breeding individuals that constitutes a long-term viable population. If management occurred then it was thought likely that reserve size could be smaller.

Dr Sadleir suggested that the size of remaining blocks of kiwi habitat that were available to reserve may be too small for kiwi populations to persist without some form of genetic management or the establishment of a network of reserves that kiwi could move between. The question then arose, when grassland separates reserves how far apart can they be before movement is inhibited?

(b) RESERVE DESIGN

John suggested that the aim should be to design a reserve that was occupied by kiwis. Examples were given of smaller populations of other species that had become extinct within a short period because of random events, such as random drift of the sex ratio. Although it was recognised that the 500-1000 birds did not have to be in the same reserve, the long-term viability of a population in more than one reserve would depend on genetically managing the population. However, it was considered prudent that all the birds should be in one reserve so that they could look after themselves and not be reliant on management by man, because such "props' may be lost at any time. It was discussed whether the effective size of a reserve could be increased by the establishment of corridors linking patches of kiwi habitat that 'collectively supported a viable population. Although this was considered to be correct in principle, there had been no investigations into the features of a corridor that would ensure its use by kiwi (width, length, vegetation type).

(c) MANAGEMENT OF ISOLATED POPULATIONS

There are cases of small populations of kiwi (fewer than 20 birds) living for many years on small islands. However, it was suggested that such isolated populations had to persist for years to be considered viable. If they were unlikely to persist for such a period and their survival was important, then it needed to be recognised that management would be required. There was a need for research to determine the type of management required to maintain small kiwi populations. The survival of many of the pockets of kiwi left in remnants of kiwi habitat will require not just management, but also the goodwill of the landowners, and a sensible dialogue and compromise between landowners and those responsible for kiwi conservation.

(d) FOREST MANAGEMENT FOR THE KIWI

As a result of his experience with the kiwi in Waitangi State Forest, Rogan Colbourne listed the following recommendations for the retention of kiwi in a production exotic forest.

1. Compartments should be small so that logging and replanting can be staggered in the forest.
2. Other species as well as pines should be grown, preferably species which take longer to mature.
3. Maintain riparian strips and swamps. These refuges should not be damaged during the forestry operations.
4. Maintain thick roadside vegetation.
5. Avoid burning where not necessary.
6. Allow two months before burning of trash after logging to give the ground time to dry and so encourage the kiwi to move elsewhere.
7. Control pests.
8. Evaluate the likely impact of new forest management practices on kiwi. It was suggested that pine forests should be used for the maintenance of kiwi because many are large and occupy land formerly occupied by kiwi (when covered by native vegetation).

5. DESIRABILITY OF KIWI SALVAGE OPERATIONS

In the late 1970s people from the Otorohanga Zoological Society and volunteers tried to salvage kiwi from forests being cleared in Northland. They found it impossible to catch kiwi in the felled forest; it was most productive to catch birds in the adjoining pasture with the use of dogs. They believed that it would have been more successful if they had attempted to catch the kiwi in the forest before it was felled.

Early in the salvage operation birds were released at the new site as soon as possible but it was found that the liberated birds dispersed quickly over a wide area. In later salvage attempts kiwi were held for 10 days in temporary pens with shelters at the release site. While penned the birds fed on provided food and after release they remained in the vicinity. Information about where the birds were released and how many birds were involved is available from the Otorohanga Zoological Society. Arthur considered that the publicity about the salvage operations helped to increase public awareness of the plight of kiwi in Northland.

It was generally agreed that kiwi should not be shifted and that more effort should be put into the retention of kiwi habitat. Developers have to be encouraged to leave the scrubby gullies for kiwi. However, there are some cases when it is necessary to salvage kiwi. Before such operations occur information is needed about their effectiveness.

1 What proportion of birds are caught and moved?
2 Did the shifted birds survive?
3 Did the percentage survival differ between birds released into habitat containing kiwi compared with those released into habitat not containing kiwi?
4 What is the fate of the birds left behind.

6. LIBERATION POLICY

The decision on where to release salvaged kiwi must be a national

decision because of the regional genetic differences between kiwi populations. Whether there are genetic differences between populations within a region needs to be determined before birds are shifted between sites within a region.

Much still needs to be known about the social structure of the kiwi to determine whether kiwi released into an area already containing kiwi will find sufficient space and food. similarly, an evaluation is required to determine whether birds could be released into pine and indigenous forests not presently containing kiwi.

7. LIBERATION ON ISLANDS -EVALUATION OF SUCCESS

Some information is available about the release of brown kiwi onto Kapiti Island (1908, 1912, 1915, 1931, 1935 and Parrot Island Long Island, Dusky Sound (1895-1907) and Harbour Island, Sound and for LSK onto Cooper Island (1903) and Resolution Island (1895-1907). There is no conclusive evidence that LSK were released onto Kapiti Island. In 1981 one Island female and two Kapiti Island males were released on Long Island (110 ha). They have possibly bred. In 1983 six male and six female LSK were released on Red Mercury Island (300 ha). Three to four pairs soon established and successful breeding is confirmed.

There is a lack of large islands without predators where there is a likelihood of establishing a permanent population of LSK. Codfish Island seems to have an impoverished invertebrate fauna and so would not be able to support a large kiwi population. Likely suitable islands are Hen Island (only 500 ha) and Little Barrier Island.

When considering which birds are suitable for transfer, Charlie Daugherty stated that the chances of successfully establishing a long-term population would be by identifying the most heterozygous individuals. The higher the level of genetic variation the better the fitness characteristics of the population.

As a safeguard, it was considered that an island population of the great spotted kiwi (roa) should be established.

8. ROLE OF CAPTIVE-BREEDING IN KIWI CONSERVATION

[Chairman Brian Reid]

(a) Ron Goudswaard, Wellington Zoo

In 1979 the zoo's breeding pairs of brown kiwi were overweight, especially the males. The birds were put on a diet, and egg fertility and hatching success improved. It became evident to the keepers that checks of the breeding kiwi, particularly in the day, reduced the breeding success. The risk of the male damaging the egg or young chick was high. Brian Bell suggested that captive-raised kiwi will not be as nervous as their wild-caught parents, with the former being more likely to tolerate such observations when they breed.

The zoo had problems hatching artificially incubated eggs. New incubators regulated the temperature too precisely; kiwi embryos seem to require fluctuations in temperature to develop normally. Also, there were problems of raising chicks because they had to be fed on unnatural diet.

About two days prior to laying female kiwi have occasionally been seen standing in water. It was suggested that this behaviour helped the bird to thermoregulate. If someone other than the usual person mixed the ingredients of the diet, the birds would often refuse to eat even though the foods were the same. This observation indicates the importance of smell to the kiwi. Banana and raspberry lures used to attract possums also attract kiwi.

(b) Debbie Brown, Rainbow and Fairy Springs, Rotorua.

Many kiwi are brought to the wildlife park for hospitalisation, some of which are subsequently retained for display or breeding. Debbie commented that it was sometimes difficult to sex a kiwi, and that this had resulted in birds of the same sex being housed together as a pair. Birds were checked only at night to minimise disturbance.

Kiwi at the park had been used in research to test responses to various lure baits and blood samples had been taken to determine the genetic variation within and between regional populations. Debbie said that the availability of captive kiwi for experiments should be encouraged.

(c) Kerry Muller, Wellington Zoo

From the variety of conditions and diets zoo kiwi have been subjected to, Kerry said it was evident that kiwi are fairly adaptable. However, he noted that there had been problems to overcome before individual kiwi lived more than a year or two in captivity, especially those hatched in captivity. Part of the problem was that the birds available to zoos were usually wild injured birds.

There has been little success outside New in captive-rearing and only one chick has been raised in a nocturnal house. Generally, in order to get kiwi to breed successfully in captivity, they have to be in an open-air aviary and away from the public view. It has taken many years of trial and error to learn how to incubate kiwi eggs artificially and to raise the chicks. At present the cost prohibits the raising of many kiwi chicks in captivity, but the knowledge is there should it be necessary in future.

(d) Brian Reid, Wildlife Service

Brian has found that captive brown kiwi lay eggs approximately 16% lighter than do wild birds. Although changes in the diet of captive birds have resulted in a gradual improvement in the weight gain and survival of chicks, it is still not know what deficiency in the diet causes captive birds to lay smaller eggs. Chicks from captive-laid eggs

have the same dimensions as wild chicks, but small fat deposits and yolk sacs. When these captive chicks are removed from their parents, they often forage in the day. From the experience of John with North Island brown kiwi and Jim Jolly with LSK, it seems that it is not normal for wild chicks to forage in the day.

Observations of captive kiwi have shown that they eat:

(1) only some species of earthworms;
(2) eels; and
(3) frogs (there is no overlap in the distribution of kiwi and native frogs in Northland).

(e) Roy Dench, Otorohanga Zoological Society

Roy explained that in 1982 it cost about $600 to raise a kiwi to five months of age at Otorohanga, and that it was too expensive to attempt to incubate and raise the chicks from all the eggs laid. However, the publicity that resulted from having reared a kiwi helped to attract visitors.

He stated that the institution had had little success in hatching eggs of either spotted kiwi species. From the experience of the Society and the National Wildlife Centre, there were problems getting wild LSK adapted to captivity. Five of the ten taken into captivity in the last six years have died. Roy considered that the best results would be obtained when known pairs were obtained from the wild. Others suggested changes be made to the spacing, diet and handling of the birds.

Brian Reid stated that pairs of kiwi should not be housed within visual distance of each other. Two pairs of breeding brown kiwi at the Wellington Zoo are separated by a spare aviary. However, it was also recognised that the stimulation of birds not in visual range, but within vocal contact, may be helpful in stimulating laying. The brown kiwi at Wellington Zoo and Rainbow Springs were synchronised in their laying even though they have an extended laying season.

(f) Daryl Eason, National Wildlife Centre, Mount Bruce

Daryl described his experience with the breeding pair of great spotted kiwi at the Centre. Over three years the pair had laid eggs, but checking by day had resulted in the eggs being broken. Last year, to overcome this problem, the birds were checked only at night. The female covered the egg while the male was out of the burrow foraging. The egg was placed in an incubator one week prior to hatching. The chick hatched successfully, but it had to be suspended in a sling for some time because its legs were splayed.

9. OVERVIEW OF DEFICIENCIES IN RESEARCH AND MANAGEMENT AND POSSIBLE WAYS OF RESOLVING THESE PROBLEMS

Brian Bell, Wildlife Service

Brian stated that there was still a lot that needed to be known about kiwi to ensure their conservation, and that a plan was needed to get the answers to pertinent questions. At present kiwi conservationists

were unable to tell managers what the habitat requirements of kiwi were or precisely what managers needed to do to conserve kiwi populations - much more definitive intormation about kiwi is needed. Although information is available about the theoreticai design of a rzserve, considered that this was often of no practical use. More work was needed to test reserve design theories and the uszfulness of corridors. Brian strongly supported the initiative for research into kiwi ecology at Aotuhia because it had the potential to answer several questions about reserve design and land management reiating to kiwi conservation.* Also, he considered that information on the effects of logging, land clearance, salvage operations, and possum trapping and poisoning on kiwi would be best obtained by practical experimental research.

Brian stated that island transfers were important for the establishment of populations of endangered species (LSK) and as an insurance policy for other species (great spotted kiwi). It wiil be important to assess the suitability of release sites, which could include exotic forest, and to select the best genetical types for liberation. We should learn how to maintain and breed all three species, and the subspecies of brown kiwi in captivity. Also, a person should be hired to write long-term management plans for each of the species.

After discussions the following recommendations were put forward.

a) That the kiwi scheme be promoted to determine the distribution and density of the various subspecies and species of kiwi.
b) That 10 monitoring sites be established. At these sites at least 20 birds be banded so that information on longevity, density and genetics of the various populations can be obtained. Also it would enable the frequency of kiwi to be calibrated against known densities.
c) That the distribution and ecology of the great spotted kiwi needs to be investigated.
d) That long-term management plans should be prepared for each kiwi species.
e) That it is important to educate farmers and agencies to set aside reserves for kiwi.
f) That an investigation into the effects of gin-trapping on kiwi populations is required.
g) That studies to determine the extent of genetic difference between and within regional populations of kiwi should continue.
h) That we must obtain through experience sufficient information to be able to maintain and breed in captivity all three species of kiwi.

The meeting closed following the suggestion that a similar meeting should be organiszd in four years time, and an acclamation of thanks to Jim Mills for organising the workshop and to the efforts of the many participants for the of material.

* At the time of writing (November 1987) this study has not commenced because of the transfer from the Department of Lands & Survey to Landcorp. Landcorp has given no indication of the intent to fund the study.

APPENDIX 1.

PARTICIPANTS

Peter Anderson	Wildlife Service, Whangarei
Richard Anderson	Wildlife Service, Wellington
Brian Bell	Wildlife Service, Wellington
Rogan Colbourne	Wildlife Service, Wellington
Matt Cook	Wildlife Service, Stratford
Malcolm Crawley	Wildlife Service, Wellington
Murray Douglas	Wildlife Service, Wellington
Daryl Eason	Wildlife Service, National Wildlife Centre
Alan Hall	Wildlife Service, Papakura
Dick Hutchinson	Wildlife Service, Christchurch
Paul Jansen	Wildlife Service, Rotorua
Jim Jolly	Wildlife Service, Wellington
Sandra King	Wildlife Service, Wellington
Jim Mills	Wildlife Service, Wellington
Janice Molloy	Wildlife Service, New Plymouth
Peter Moore	Wildlife Service, Wellington
Stu Moore	Wildlife Service, Christchurch
Allan Munn	Wildlife Service, Whangarei
Colin O'Donnell	Wildlife Service, Christchurch
Ralph Powlesland	Wildlife Service, Wellington
Craig Robertson	Wildlife Service, Wellington
Hans Rook	Wildlife Service, Napier
Phil Thomson	Wildlife Service, Papakura
Bryan Williams	Wildlife Service, New Plymouth
Murray Williams	Wildlife Service, Wellington
Nikki Wright	Wildlife Service, Wellington
Christine Reed	Ornithological Society of New Zealand, Wellington
Bernie Card	Dept of Lands & Survey, Wellington
Alistair McIlroy	Dept of Lands & Survey, New Plymouth
Gerry Rowan	Dept of Lands & Survey, Auckland
Greg Sherley	Dept of Lands & Survey, Wellington
Ron Goudswaard	Wellington Zoo
Kerry Muller	Wellington Zoo
Arthur Cowan	Otorohanga Zoological Society
Roy Dench	Otorohanga Zoological Society
Debbie Brown	Rainbow and Fairy Springs, Rotorua
David Fountain	Massey University, Palmerston North
Murray Potter	Massey University, Palmerston North
Charles Daugherty	Victoria University, Wellington
Peter Jenkins	Auckland University, Auckland
Harold Corbett	New Zealand Forest Service, Kaikohe
Gretchen Rasch	New Zealand Forest Service, Auckland
Eric Spurr	New Zealand Forest Service, Christchurch
John McLennan	Ecology Division, D.S.I.R., Havelock North
Richard Sadleir	Ecology Division, D.S.I.R., Lower Hutt
Michael Taborsky	Maxz Planck Institute, West Germany

APPENDIX 2

KIWI CALL SCHEME

1. Introduction

Recent logging and burning of forest and scrublands throughout New Zealand, particularly in northern Hawkes Bay and Taranaki, has caused concern about the fate of kiwi resident in the logged areas and raised fears that he kiwi's future may not be as secure as was previously thought. While the kiwi is a bird familiar to most New Zealanders, its nocturnal and secretive nature have ensured that very little is known of its habits and distribution.

An apparent stronghold of the kiwi is the northern half of Northland where it is thought to be common in the huge tracts of Waipoua and other lowland coastal forests. Kiwi are even well-established in some small exotic forests there. Unfortunately, in other areas of New kiwi are not faring so well. Data collected by John show that Hawkes Bay birds need much larger areas of bush to sustain their population than do Northland kiwi. Few kiwi studies have been carried out in the South Island and the status of many South Island populations is largely unknown.

As the kiwi is a long-lived bird, it is conceivable that many small populations in isolated forest remnants are composed of ageing individuals which attempt to breed but with insufficient success to allow the rate of replacement to keep pace with mortality. Such small populations have small gene pools, which makes them more vulnerable to the effects of environmental disturbance than larger populations would be.

The Kiwi Call Scheme described here is being introduced in an attempt to collect data on kiwi distribution and abundance, data which could help to save threatened populations of kiwi.

2. The Scheme

The Kiwi Call Scheme has three main aims:

a. to determine the national distribution of kiwi,
b. to relate kiwi density to location and habitat, and
c. to assign a kiwi call index at a known time period of the year to each listening station to enable the dynamics of the population to be determined with time. Repeated listening at these stations after 5, 10 and 20+ years may indicate whether a population is stable, increasing or declining.

The record card provided is intended for use by interested field staff of conservation organisations whenever they are spending a night or nights in likely The Kiwi Call Scheme will allow only relative abundance of kiwi to be determined; it cannot be used to estimate absolute numbers because not all birds call. It is, however, reasonable to assume that similar proportions of birds in different kiwi populations call, thereby allowing relative abundance to be determined.

Observers from different regions of New will listen from fixed stations at regular (possibly monthly) intervals throughout the year. This will provide information on seasonal variations in calling rates.

Information on the cards will be stored on a computer file, will be easily sorted and accessed, and a print-out from given areas can be made available to all who request it.

3. The Card

The card (Figure 2) is composed of ten main blocks: card number (for official use only); observer, address and affiliation; date (day, month, year in numerals); location and grid reference listening station; notes; number of kiwi calls over the number of minutes listened; listening parameters, including wind, rain temperature, cloud cover, ground conditions, noise, moonlight and listening coverage; major habitat types (name up to four groups in a listening area); the recording of kiwi calls including species of kiwi, sex, time called (in 24 hr notation); compass bearing and estimated distance of kiwi from observer; and other animals heard.

Additional information about these blocks is presented in the following section.

4. How to fill in a card

Card Number

The top right-hand space is to remain blank. If you wish to link the number of a listening station in the area surveyed use the NOTES section on the card.

Observer

If more than one person listens from a listening station during any listening period give the name of the most experienced observer. This eases computer processing. For each new observer give address and affiliation on the first card only. This information is not required on subsequent cards unless addresses or affiliations change.

Location

Give, in order, the name of the Province, and State Forest or Reserve etc. and the nearest named locality. Finally, give a brief description of the exact location of the Listening station (use the NOTES box if you run out of space). This position will be further located by the grid reference. If possible include a photocopy of the map of the area with listening stations marked on. Choose the listening stations with a view to covering the widest listening area within the prevailing climatic and topographical conditions. Choose listening stations with positions that can be easily described. However, do not be put off listening from a campsite in thick surrounding bush, so long as the listening category 'narrow' or 'medium' is stated.

Grid Reference

Wherever possible, use maps of the metric NZMS 260 series or if these are unavailable, the NZMS 1 inch to the mile series. The metric 260 series map number is coded with a numeral followed by 2 digits. The grid reference consists of 5 numbers for horizontal and 5 numbers for vertical positions. Include the smaller figures of the grid number at the corners of the map in these spaces. A sample reference for Mt Robertson on NZMS 260 sheet P27 would be:

Series	sheet	grid	reference
260	P27	25955	59838

The NZMS 1 inch to the mile series map number has numerals only (up to 3 spaces and is prefaces by ringing N S or X (North Island, South Island or offshore island). The grid reference consists of 4 numbers for horizontal and 4 numbers for vertical positions. Include the smaller figures of the grid number at the corners of the map in these spaces. They give the full co-ordinates. A sample reference for Mt Robertson on NZMS 1 sheet S22 would be:

	N			
001	S	22	7308	8186
	X			

Notes

If kiwi are heard in the area, but do not call during the listening period, please note this fact. This information will be important for distribution analysis. If more space is required for notes, continue writing under the entry of the last call heard on the back of the card (at the completion of the listening period).

Noise

This is interference to listening caused by strong wind, talking by non-listening members of the party, or listening too close to a fast-flowing river. Avoid these conditions whenever possible.

Moonlight

Past studies of North Island brown kiwi have shown that these birds call noticeably less often on bright, moonlit nights. However, little spotted kiwi are less affected by moonlight. Plan to survey on dark nights if possible.

Listening coverage

When listening from a ridge on a calm night choose 'wide' as the descriptive term. Conversely, when listening from a campsite in a gully underline 'narrow'. Listening in a gully with a noisy creek in strong wind and pouring rain ..... forget it!

Major habitat types

Mark with a maximum of three categories of vegetation types found within the zone of listening. If other than those types listed are present, ring 17 and explain in notes. Developed farmland is typical New pasture, well-fenced, intensively grazed, and with few trees. Undeveloped farmland has rank grasses, interspersed with manuka and other scrub throughout.

Minutes listened

Total the time listened. The number of kiwi calls heard will eventually be expressed as number of calls per hour. To standardise calculations of this index, confine listening periods to a minimum of 15 minutes and multiples of 15 or 20 minutes thereafter. One hour per station is generally a good continuous period to listen for kiwi calls if in an area for one night only. Kiwi calling is often erratic, varying from night to night. Ideally a more accurate 'hourly index' would be achieved by listening at a station for 15 minutes each night for 4 nights. The order of listening at the stations can be reversed each night. Similarly, 20 minutes could be spent at each station each night during a three day survey. Thirty minutes could be spent at each station per night during a two day survey.

Calls

Being listening no earlier than 30 minutes after sunset (even though some kiwi may call beforehand). Confine listening to within the first 4 hours of darkness. Kiwi call throughout the night but often call more frequently during the first 4 hours.

A study in Northland has shown that the maximum call rates of brown kiwi occur in early winter (their mating season). Data are unavailable for brown kiwi in other areas of New Zealand, but this scheme should help to whether call rates vary seasonally elsewhere also.

Species

Common name	Specific name
North Island brown kiwi	Apteryx australis mantelli
South Island brown kiwi	A. a. australis
Stewart Island brown kiwi	A. a. lawryi
Great spotted kiwi or roa	A. haastii
Little spotted kiwi	A. owenii

Write down the species that called, the time, whether male (M) or female (F), the compass bearing that the kiwi called from and the estimated distance (metres). Because it is the call rate that is important, if the same individual calls twice, write these calls on separate lines. Total up the number of calls at the completion of listening.

Tape Cassette

The calls of both sexes of all species and subspecies of kiwi are represented on a short tape recording. In addition, other calls which could be confused with those of kiwi viz. weka, pukeko, possum, and long-tailed cuckoo are included. If a tape is not supplied, please send a blank cassette and these calls will be recorded and the tape returned. Do not use this tape to stimulate kiwi to call before or during a listening period.

Other animals heard

Refer to the tape if any calls heard are unfamiliar to you. Two spaces are available for noting calls from animals other than morepork, weka, or possum eg. bittern, pukeko etc.

With a wide listening coverage follow these criteria

few	1-2 individuals in listening area
moderate number	3-5 individuals
many	6+ individuals

Subjectively correct where listening conditions vary.

The main points to note in this Kiwi Call Scheme are below:

5. Summary

Try to select a period-for listening that takes advantage of the optimum conditions for kiwi calling viz. start listening no sooner than 30 minutes after sunset; within the first 4 hours of darkness; a dark night; away from excessive river and wind noise; during autumn to spring in the North Island; and over a wide area. Describe listening stations well (even mark the spot if necessary). Do not be distracted from listening in areas with few or no known kiwi -negative results are just as important as positive results.

If any problems are encountered, or if further information is needed, direct enquiries to:

Rogan Colbourne
Conservation Sciences Centre
Department of Conservation
P O Box 10420
WELLINGTON

FIGURE 1

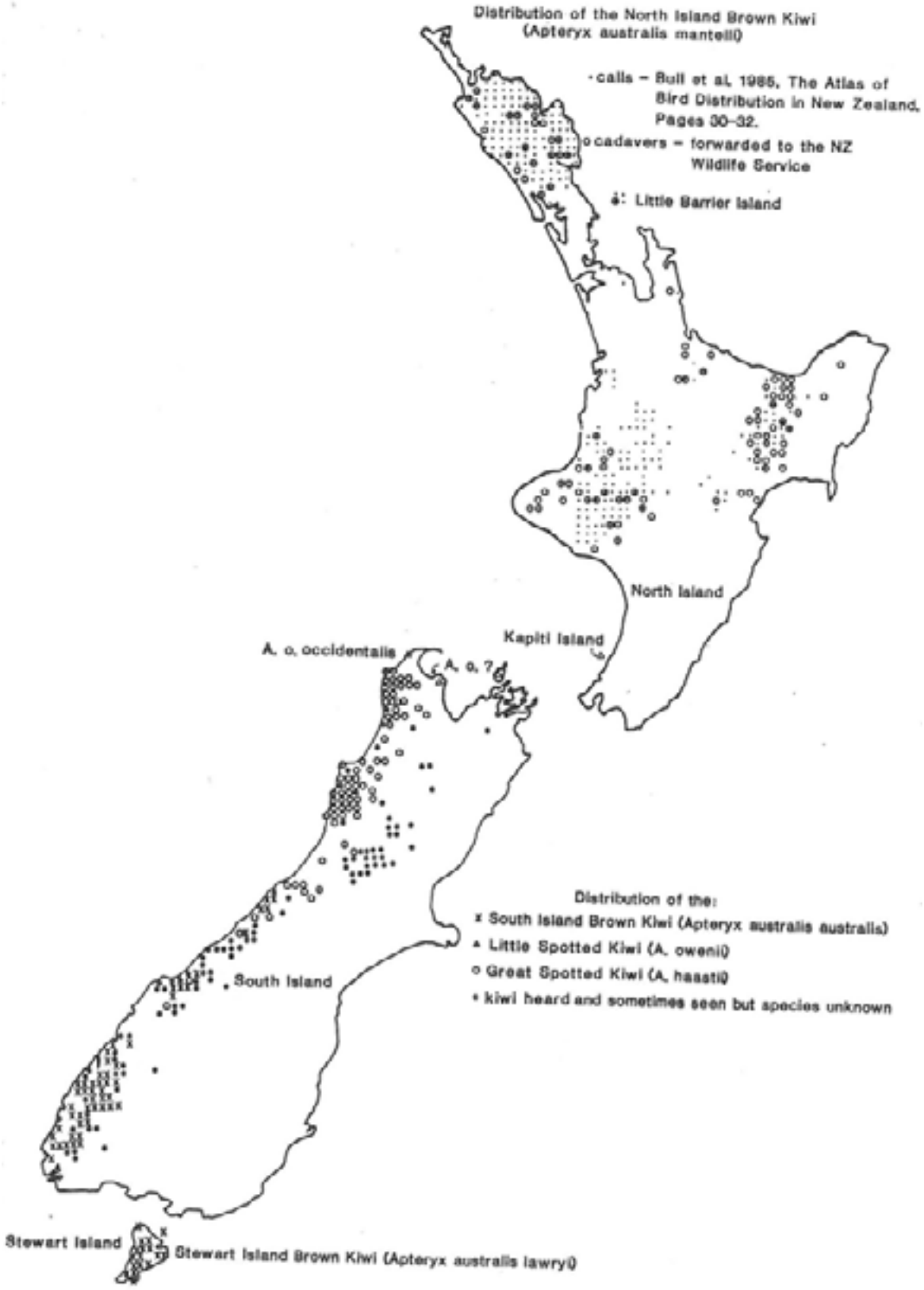
Distribution of the North Island Brown Kiwi
(Apteryx australis mantelli)
· calls – Bull et al. 1985. The Atlas of Bird Distribution in New Zealand. Pages 30–32.
o cadavers – forwarded to the NZ Wildlife Service
Little Barrier Island
North Island
Kapiti Island
A. o. occidentalis
A. o. ?
South Island
Distribution of the:
x South Island Brown Kiwi (Apteryx australis australis)
▲ Little Spotted Kiwi (A. owenii)
o Great Spotted Kiwi (A. haastii)
• kiwi heard and sometimes seen but species unknown
Stewart Island
Stewart Island Brown Kiwi (Apteryx australis lawryi)

FIGURE 2 FRONT OF CARD