CHAPTER 1

INTRODUCTION

1.1 AIMS

The aim of this study was to determine the conservation status of Malleefowl Leipoa ocellata Gould in New South Wales, and investigate some aspects of Malleefowl ecology essential to the species' management. These aspects included the distribution, abundance, diet, breeding success and effect of habitat quality on fecundity.

1.2 CURRENT STATUS

Malleefowl are currently listed as endangered fauna in Schedule 12: Part III of the New South Wales National Parks and Wildlife Act of 1974. They are placed on that list because they occur in restricted habitat types, in numbers adequate for their survival, but the habitat has been removed at a rate which gives cause for concern (Llewellyn pers. comm.).

1.3 GENERAL BIOLOGY

The Malleefowl is a member of the family Megapodiidae or mound-building birds which are restricted to the Australasian region (Olsen 1980). The megapodes are notable for their incubating of eggs underground using the heat from geothermal activity, the sun, or decay of

plant material.

The Malleefowl is the only megapode that lives in a semi-arid environment. It has evolved a highly developed behaviour for nest temperature regulation. That behaviour and the breeding biology have been well studied by Frith (Frith 1956, 1957, 1959, 1962a), and is summarised in section 1.4 below.

Malleefowl live in the southern part of the Australian continent, in areas of less than 400mm annual average rainfall that are occupied by mallee, coastal heaths, mulga and pine scrubs (Frith 1962a).

The mallee habitat is composed of tall shrublands dominated by Eucalyptus spp. which grow in a mallee form i.e. have multiple stems arising from a lignotuber or swollen rootstock.

1.4 BREEDING BIOLOGY OF MALLEEFOWL

The breeding cycle begins in April-May with the selection of a nest site, usually a previously used nest mound. The nest is dug out in a crater shape 2.5 - 3.5m across with the base of the hole being below ground level. Leaf litter from up to 50m away from the nest is raked into the nest, until the litter is about 1m deep in the centre of the nest. The litter is dampened by late winter rains and decays, producing heat. If there is a drought the nest can be abandoned at this stage

(Frith 1959). Experiments by Booth and Seymour (1984) showed that litter decay and production of heat could be enhanced by addition of water to drought-affected nests.

When the nest reaches a suitable incubation temperature of 30 - 33°C, the first egg is laid (Frith 1959) in an egg chamber which is a depression about 40cm across and 30cm deep in the litter. The litter and egg chamber are covered in a layer of sand from the margins of the nest, so forming a mound shape. Booth and Seymour (1984) showed that a nest at the correct temperature was insufficient to trigger egg laying in drought conditions and proposed that environmental cues such as food conditions were responsible.

The decay of litter provides most of the heat for incubation and solar heat is only used after mid-summer (Frith 1956). During spring and summer, the layer of sand over the eggs protects them from excessive heat from the sun. Nests are opened at regular intervals early in the day to cool the nest.

When the heat from decay declines the nest may be opened out each day to receive heat from the sun. Warm sand is returned to the nest at regular intervals during the day until the mound is at its full height by nightfall.

Nearly all the work in constructing the nest and regulating the temperature is done by the male with the female assisting more after the last egg has been laid

(Frith 1957). The nest temperature is tested by probing the sand with the bill, the tongue or mouth cavity being used to measure the temperature (Frith 1957).

The nests are abandoned, usually in March, when their temperature cannot be maintained in cooler autumn weather. The nests are dug out into a crater shape, and any eggs that have not hatched may be exposed to the sun and predators (Frith 1959).

When chicks hatch they dig upwards through the mound until they reach the surface. Once they have escaped from the nest they lead independent solitary lives (Frith 1959).

1.5 INVESTIGATIONS IN THIS STUDY

The lack of distribution data and obvious clearing of much habitat since the last study of Malleefowl conservation requirements (Frith 1962a) suggested that it was necessary to find where Malleefowl still remained as a first step in investigating their conservation status. A summary of Malleefowl in conservation reserves (Brickhill 1980) showed that there was a great lack of records of Malleefowl because of a lack of observers. A survey was designed to overcome that problem and its methods and resulting distribution maps are examined in Chapter 3.

Abundance of an animal is the one critical factor used to judge its conservation status. In addition to an almost complete lack of estimates of abundance, I became aware that the ease with which Malleefowl could be seen at well - known nest sites confused many people's perceptions of their abundance throughout the state. My methods of survey for Malleefowl and the resulting estimates of abundance are presented in Chapter 4.

Food available to Malleefowl is likely to affect fecundity and survival (Frith 1962a) and thus food availability can be expected to be a key determinant of habitat quality. Therefore a knowledge of diet is necessary for an assessment of habitat quality. Frith (1962a) made a preliminary study of the diet at Pulletop, near Griffith in southern N.S.W. More detail was required, especially of the importance of the major food types (seeds, herbs and insects), and this is provided in Chapter 5.

Breeding behaviour and breeding success were well studied by Frith (1962a) but the data were collected 23 - 27 years previous to the commencement of this study. Comparisons between Frith's surveys (Frith 1962a) and my own (unpublished data) showed that Malleefowl densities at Pulletop had declined between the 1950's and 1980. It was considered necessary to check that fecundity and breeding success had not changed during that time, and so discount poor breeding success as a cause of

population decline. My study of fecundity, breeding success and major causes of egg loss is presented in Chapter 6.

Malleefowl live in a wide variety of habitats; the habitat quality will vary both between habitats and between home ranges at any one site. The variation in habitat quality may be responsible for the observed differences in clutch size, and these relationships are investigated in Chapter 7.

In Chapter 8 the conservation status of Malleefowl is analysed, and there are suggestions for further research and management of existing populations.

CHAPTER 2

STUDY SITES AND THEIR SELECTION

2.1 SELECTION OF STUDY SITES

Field sites were required for several different purposes during this study. First, sites were needed for the study of fecundity and breeding success. Time constraints meant that for maximum breeding information collection, each site had to have more than one active nest, and had to be close to where I was employed at Griffith. Thus sites within 160km of Griffith which were known from local knowledge or quick field reconnaisance to have one or more pairs of Malleefowl, were chosen. These sites were Pulletop, Loughnan, Mulyan, Yalgogrin, Buddigower and Arcadia. These sites are described in section 2.2.1.

Second, a site was used for development of air survey and nest marking techniques. Nest marking and monitoring was required for management purposes at Round Hill, so that programme was able to contribute information to this study. The Round Hill site is described in section 2.2.2.

Third, sites were required for experimentation with air survey using two aircraft types, and calibration of both methods. Ground searching for nests was required for air survey calibration, but it is a major, time-consuming

task. Joe Benshemesh (Zoology Department, Monash University) was already planning to do such a search in two areas in Wyperfeld National Park, so those areas were obvious choices for this part of the work.

Once the air survey techniques were tested and observers trained, air survey sites had to be chosen. The air survey was funded by a States Assistance Grant from Australian National Parks and Wildlife Service to the N.S.W. National Parks and Wildlife Service, with assistance from the Victorian National Parks Service and South Australian National Parks and Wildlife Service. Therefore the air survey was designed mainly to be over conservation reserves in N.S.W., Victoria and South Australia. The aim of this study was to estimate the population size in N.S.W., but data from Victoria provided useful comparisons to data from the two sites in western N.S.W. Use of a South Australian site on the South Australian/N.S.W. border enlarged the size of the survey block in the Scotia mallee (west of the Darling Anabranch) and at the same time covered part of a conservation reserve.

Each air survey site was selected so that it had boundaries that were easily seen from the air (e.g. roads, firebreaks) for easier planning of transect locations. All air survey sites had a similar age since fire (greater that 15 years, except for Pooncarie) as a precaution against the possibility that age since fire

affected density, and to have similar canopy cover on all sites. The air survey sites were Lysmoyle, Nombinnie, Tarawi, Pooncarie, Pink Lakes, Sunset, Wyperfeld, Big Desert and Dangalli. Descriptions of these sites are given below, in sections 2.2.2, 2.2.3 and 2.2.4.

The sites used covered a range of habitat types or qualities (Frith 1962a) and included floristically rich mallee, mallee with Triodia and few shrubs, and the Scotia mallee and Victorian mallee which are floristically different from each other and the other two site types.

Other Malleefowl habitats in the Dubbo and Pilliga areas of New South Wales were rejected as possible study sites because, on the evidence available, they had low densities of Malleefowl, and so would be inefficiently surveyed on foot, and had tall dense vegetation which would make air survey an unsuitable method for finding nest density.

The Malleefowl of the Goonoo area near Dubbo were being studied by T. Korn (pers. comm.) and his studies were expected to provide information that could be complementary to this study.

2.2 STUDY SITES

The location of all study sites is shown in Figure 2.1.

2.2.1 Sites Between Lachlan and Murrumbidgee Rivers

2.2.1.1 Pulletop Nature Reserve

This area of 145ha, 45km north of Griffith, at 33° 58'S 146° 06'E contains a mallee community of *Eucalyptus socialis* - *E. dumosa* association, with *E. foecunda* and *E. gracilis* common. There is one low aeolian dune, which has patches of *Callitris preissii* ssp. *verrucosa.* Small thickets of *Melaleuca uncinata* occur throughout the area. The whole reserve has not been burnt for more than 60 years. It is surrounded on all sides by wheat fields. The reserve was part of Block A of H.J. Frith's study site, where he studied the breeding biology of Malleefowl in the period 1952-1958 (Frith 1962a).

2.2.1.2 Loughnan Nature Reserve

This reserve of 384ha is 30km east of Hillston, at 33° 34'S 145°50'E. It contains mallee of *E. socialis* - *E. dumosa* association and other mallee species similar to Pulletop. There are some small areas between the low aeolian dunes which have woodland of *Eucalyptus intertexta.* One small area of the reserve was burnt about 15 years ago, and the remainder appears not to have burnt for at least 40 years. There are crop lands

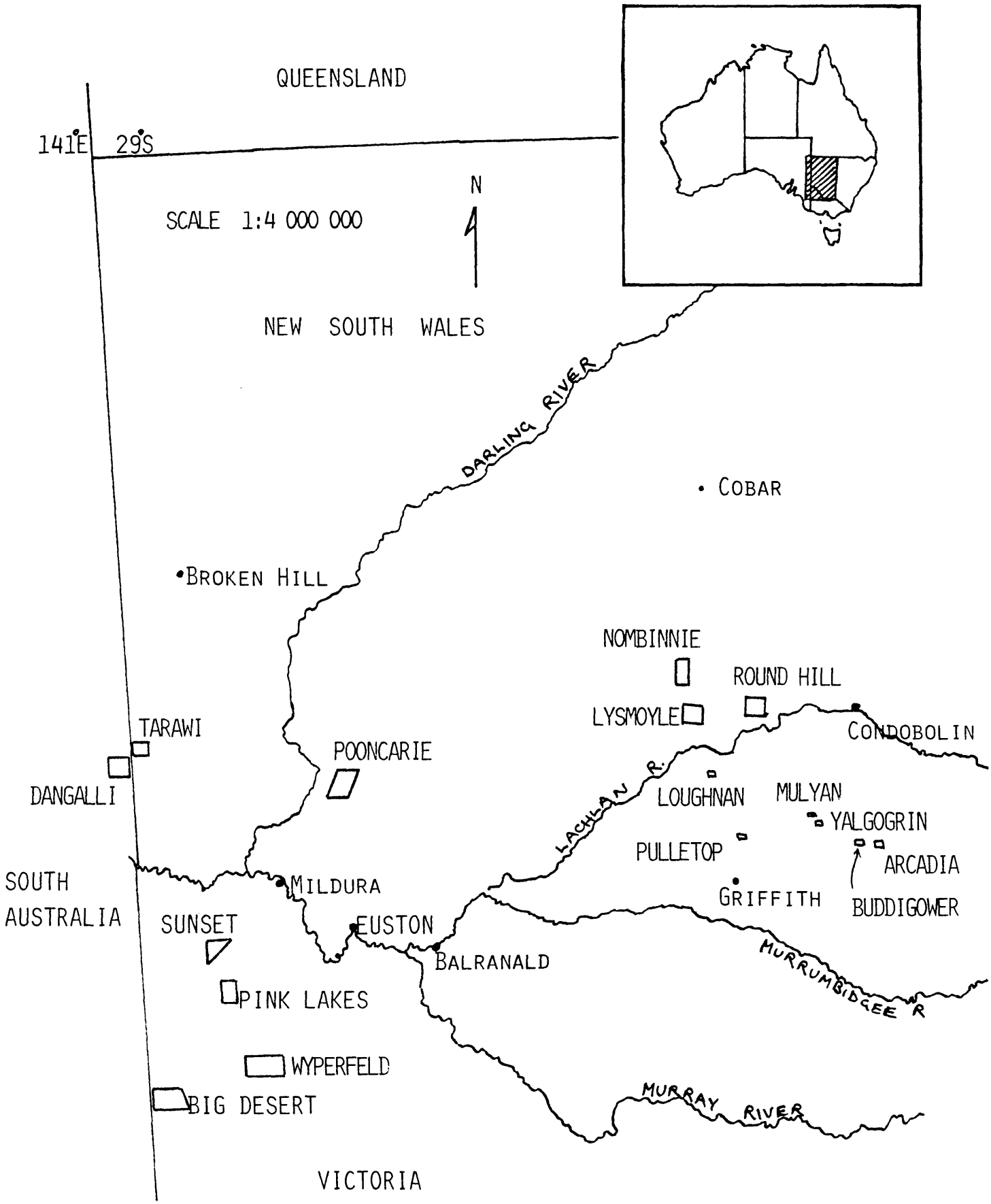

FIGURE 2.1 LOCATION OF STUDY SITES

on all sides of the reserve.

2.2.1.3 Buddigower Nature Reserve

This reserve lies 15km south-west of West Wyalong, at 34°01'S 147°08'E and comprises 327ha of mallee and woodland on very low gravelly ridges. The mallee is *Eucalyptus viridis* - *E. polybractea* association with some *E. behriana* and very dense growth of *Melaleuca uncinata.* The woodlands on lower slopes and shallow valleys is *E. microcarpa* with a variety of *Acacia spp.* and *Santalum acuminatum.* The higher ridge tops have low woodland of *Callitris endlicheri* with some *E. dwyeri* with *Helichrysum semi-papposum* the dominant ground cover. Buddigower is one of a number of small remnants of native vegetation in the district. It is joined by other native vegetation remnants and small areas of cropland.

2.2.1.4 Mulyan

The Mulyan site is part of the property "Mulyan" which lies 45km west of West Wyalong, at 33° 48'S 146° 45'E. The site is an irregularly shaped block of mallee and woodland of 287ha. On low gravelly ridges there is tall mallee of *E. viridis* with thickets of *Melaleuca uncinata* and scattered *Callitus endlicheri.* Lower slopes have woodland of *E. microcarpa* and *Callitris glaucophylla*, with a grassy ground layer. The block is

used infrequently for rough grazing of horses and sheep.

2.2.1.5 Yalgogrin

The Yalgogrin site of 558 ha at 33°49'S 146°46'E is near the locality of Yalgogrin which is 40km west of West Wyalong, and it is 5km south-west of Mulyan site. It is composed of an irregularly shaped remnant of uncleared land containing parts of two mixed-farming properties. The vegetation on the tops of low gravelly ridges is mallee of *E. viridis* - *E. polybractea* with some *E. behriana* and dense *Melaleuca uncinata.* Patches of this community are cut regularly for the production of *Eucalyptus* oil, so that the maximum height of these patches is about 1.5 - 2m. After cutting of the Eucalyptus at ground level, the area is often burnt to remove the *Melaleuca* bushes. Other vegetation on upper slopes is tall mallee of *E. viridis* grading into woodland of *E. microcarpa* and *Callitris glaucophylla.* The areas of recently cut mallee, low mallee and uncut mallee and woodland form a mosaic of vegetation structural forms. In addition there are surrounding crop and pasture lands which contain a variety of grass and weed species. The bush areas are not fenced from adjoining paddocks and so are used by sheep for shelter and shade.

2.2.1.6 Arcadia

This site of 386ha lies on the property "Arcadia" which is 10km south of West Wyalong, at 34° 01'S 147° 12'E. The vegetation is very similar to that at Buddigower site, with *E. viridis* - *E. polybractea* mallee and *Callitris endlicheri* - *E. dwyeri* woodlands. Small areas of mallee have been cut for Eucalyptus oil and/or broombush fence materials (*Melaleuca uncinata*), and an area of about 5ha is old clearing with a thick regeneration of *Acacias*. Adjoining areas are patches of similar vegetation or pasture paddocks, some of which are not fenced from the site, so sheep use the area for infrequent grazing, shade and shelter.

2.2.2 Sites in Central New South Wales

2.2.2.1 Round Hill

The Round Hill site comprised Round Hill Nature Reserve and land adjoining to the west with a total area of 208km^2, located around a point at 33°02'S, 146°07'E. The site is flat red sandy clay loams with mallee 5-6m high of *E. socialis* - *E. dumosa* association. Shrubs are common to sparse, while in other places there is bare ground with light leaf litter under the mallees. Within the mallee are a few small woodland openings of *E. populnea*.

The majority of the site was burnt in 1957, while a fire in 1979 burnt about one fifth of the site (on the western side) temporarily removing all the vegetation before regeneration commenced.

2.2.2.2 Lysmoyle and Nombinnie

These sites are parts of properties of the same name, and they lie 20km west of Round Hill site. Lysmoyle of 163km^2 at 33°02'S 145°50'E and Nombinnie of 92km^2 at 32°53'S 145°42'E are almost adjoining and have similar vegetation. They both contain mallee of *E. socialis* - *E. dumosa* association on flat red sandy clay loams and clay loams. Shrubs are generally sparse to very sparse and the ground layer is usually bare with light leaf litter under mallees. At the time these sites were flown over by aerial survey, there was a moderate growth of grasses, mainly *Stipa sp.* The sites are parts of large grazing leases, but they are not grazed by sheep, having no water points.

2.2.3 Sites in Western New South Wales

2.2.3.1 Tarawi

This site of 180km^2 at 33°50'S 141° 04'E occupied the north-western part of "Tarawi" station and the western edge of "Tarara" and "Ennisvale" stations, and adjoined the South Australian border fence. Low parallel dunes run east and west and contain mallee of *E. socialis* - *E.*

dumosa association with E. incrassata common on the dunes. Between the dunes in some areas are low woodlands or tall shrublands of Casuarina cristata - Heterodendrum oleifolium and there are also patches of low shrubland of Maireana. sp. The site is part of large grazing leases and would be grazed infrequently by sheep. Goats are moderately common in the area.

2.2.3.2 Pooncarie

The Pooncarie site is located on the properties "Lethero", "Petro" and "Arumpo" and lies each side of the "Top Hut" - "Lethero" road with its centre at 33° 41'S 142 43'E. Most of the site is mallee of E. socialis, E. dumosa and E. incrassata on low dunes and swales with some Callitris glaucophylla woodland around Stockyard Tank. Virtually all the site was burnt in December 1974 - January 1975 so the mallee was ten years old at the time of the aerial survey over the site. Most of the site is part of the above properties but is not used for grazing for lack of water points. Part of the site is vacant crown land.

2.2.4 Sites in Victoria and South Australia

2.2.4.1 Sunset

The Sunset site is part of the Sunset mallee which is south west of Mildura. The site occupied a triangular block west of Rocket Lake centred on the point 34° 43'S

141°41'E. Most of the site comprises mallee on low longtitudinal dunes which run east and west. Predominant plant species are E. incrassata, E. socialis and E. dumosa in a mallee formation which was at least 20 years post fire at the time of aerial survey. The land is crown land that is not used for grazing for lack of water.

2.2.4.2 Pink Lakes

This site which is north west of Ouyen, Victoria at 34° 57'S 141°48'E is mainly in Pink Lakes National Park and includes some crown lands to the east. Most of the site is mallee on high irregular dunes, with E. incrassata and E. socialis the most common species. Small areas of the site were woodland, in swales.

2.2.4.3 Wyperfeld

There were three sites in Wyperfeld National Park. Wyperfeld (east) lay between Moonah and Dattuck tracks at 35° 35'S 142°08'E and comprised mallee on irregular dunes of yellow sands. The site had not been burnt for over 30 years at the time of the aerial survey. Predominant species of mallees are E. incrassata, E. foecunda, E. socialis and E. dumosa.

Wyperfeld (west A) site lay within the Nine-mile-square track on the western side of the park at 35° 33'S 141° 56'E. The vegetation on the site was mainly shrubland

of Banksia sp. with patches of Eucalypt mallee on the flanks of irregular dunes.

Wyperfeld (west B) site lay on the southern side of the Nine-mile-square track and adjoined the west A site. The vegetation on this small site was mainly mallee with small areas of Banksia shrubland.

2.2.4.4 Big Desert

This large site lay in the Big Desert Wilderness between the Murrayville track and the South Australian border, between 35°35'S and 35°45'S and between 140°58'E and 141° 21'E. Irregular and parabolic dunes of yellow sands occur throughout the site. The vegetation is predominantly shrubland of Banksia sp. with small patches of mallee Eucalypts on the flanks of larger dunes. Only a small area had been burnt within the last twenty years.

2.2.4.5 Dangalli

This site, centred at 33° 27'S 140° 57'E lay on the south-eastern corner of Dangalli Conservation Park which adjoins the N.S.W. border about 70 km north of Renmark, South Australia. Low parallel dunes which trend east and west occupy the whole of the site. The vegetation is mallee Eucalypts with some areas of woodland in the larger swales. None of the area had been burnt within the last 30 years.

CHAPTER 3

DISTRIBUTION OF MALLEEFOWL IN NEW SOUTH WALES

3.1 INTRODUCTION

Descriptions of a bird's range are usually made from published records and personal observations with interpretation by an author of the extremities of occurrence (Pizzey 1980). The distribution of the bird within the range may be far from uniform and usually cannot be defined on small-scale range maps (Pizzey 1980). The distribution requires a much greater knowledge of occurrence than does the range.

Because definition of range and distribution depend on collation of observations, the distribution will be poorly known for a relatively rare bird that lives in dense vegetation in inland Australia where observers are scarce and visibility is poor.

The current distribution of Malleefowl is obviously less than the original one because of loss of habitat from clearing (Frith 1962a, Brickhill 1980).

The aims of the first part of the study were to determine where Malleefowl still occurred and to gather information on their former distribution. Further aims were to map Malleefowl habitats and to use distribution and habitat records to predict the total distribution of Malleefowl in N.S.W.

3.2 METHODS

3.2.1 Questionnaires

Questionnaires to landholders were used to find properties where Malleefowl were known to occur or had occurred. The questionnaire was set out on a card with a return address to the author on the reverse side. A business reply post permit was used to encourage returns. Landholders were also sent an explanatory letter which included a description of the bird and a black and white drawing of a Malleefowl.

Details requested from informants were: name, postal address, telephone number, property reported on, its distance and direction from the nearest town, the decade the property had been occupied or visited by the informant, the decades when Malleefowl were seen, and names and addresses of other informants. A total of 2611 questionnaires were sent out over 18 months in 1982 -1983;the number sent each Shire is shown in Table 3.1.

Landholders' addresses were selected from Shire electoral rolls. Selection of shires to receive questionnaires was based on the known distribution from texts and examination of maps and Landsat images to detect areas of possible Malleefowl habitat.

The questionnaire cards were also completed by the

Table 3.1 Number of questionnaire cards sent to each Shire.

Shire	Cards Sent
Balranald	161
Bland	472
Carrathool	300
Central Darling	19
Cobar	155
Coonabarabran	200
Lachlan	482
Narrandera	140
Parkes	126
Temora	413
Weddin	47
Wentworth	85
Unincorporated area (Western Division)	11
Total	2611

author when information on Malleefowl was passed on verbally.

Records held by the New South Wales Field Ornithologists Club and the Royal Australasian Ornithologists Union Atlas (Blakers et al., 1984) were obtained and added to the records of sightings from questionnaires.

3.2.2 Mapping of returns

Information received was treated as follows:
Properties and places with Malleefowl sightings were located using Shire and topographic maps and were recorded in blocks with grid-cell size of 10 minutes latitude and longitude. For large properties in the Western Division the location of the homestead, shown on most maps, was used as the point of the sighting, unless other information gave an alternative location. The latitude and longitude of a site were obtained from maps of various scales, from 1:1,000,000 to 1:50,000. Sightings were split into three time periods: before 1950, 1950-1974, and from 1975 onwards. A distribution map was prepared for each time period, and a combination of all records.

3.2.3 Mapping of available habitat

Habitats suitable for Malleefowl are the typical mallee Eucalypt communities on red sands and sandy clay loams, mallee-broombush thickets on low gravelly ridges,

box-pine woodlands on red earths and ironbark-pine woodland on poor sandy soils. These habitats were mapped, at the same scale as maps of distribution, after identification from a range of sources including 1980 and 1985 Landsat images and vegetation maps. The habitats were interpreted for their suitability from results of the questionnaires (section 3.3.1) and personal knowledge developed from surveys by foot and by air (section 4.2) and other property inspections at other times.

Presence of suitable habitat was mapped in units of a quarter of a grid-cell of 10 minutes latitude and longitude. The area of suitable habitat was estimated in units of one tenth of the same grid cell and converted to square kilometres.

3.2.4 Expected distribution

A map of expected distribution was prepared from the current (post-1974) records of Malleefowl and the map of suitable habitats.

This map of expected distribution shows all grid-cells where Malleefowl can be confidently expected to be found because either:

1. there are current records, or
2. over half of the grid-cell has suitable habitat and it adjoins a grid-cell with current records.

The area of habitat within the expected distribution was calculated by addition of the areas of suitable habitat in each grid-cell (see section 3.2.3).

3.2.5 Analysis of distribution

The map of current records of Malleefowl occurrence (Figure 3.1c) was compared to maps of climate, soils and vegetation to find whether these factors related to distribution.

3.3 RESULTS

3.3.1 Recorded distribution

A total of 800 questionnaires were returned by property owners,a return rate of 31%. Of these 205 (7.8% of those sent) provided positive information on Malleefowl occurrence. The RAOU Atlas provided 17 records, the NSW Field Ornithologists Club provided 19 sightings and another 31 sightings were reported directly to the author.

The distribution maps in 3 time periods based on these returns are shown in Figure 1 (a-c). Appendix 3.1 records the localities, observers and dates for all current records (1975-86).

The results of this survey confirm that the distribution of Malleefowl between the Lachlan and Murrumbidgee river, near Condobolin, Balranald and Euston has declined during the 1950-1974 time period. The overall range has not changed since 1950 but a shrinkage in distribution has occurred with the westward expansion of cropping. In the other parts of the state, the distribution is shown as occupying more grid-cells in 1975-86 than previously. It is expected that this result occurs because there were observers in those years than in earlier periods contacted by the questionnaire, rather than an expansion of the distribution.

This survey has recorded Malleefowl for the first time east of the great dividing range, in an area of the upper Hunter catchment.

3.3.2 Malleefowl habitats

The distribution of apparently suitable Malleefowl habitat is shown in figure 3.2. On that map the smallest unit of habitat is shown in units of one quarter of a grid-cell. Malleefowl are known to occur in very small areas, e.g. Pulletop site but mapping of habitat distribution of that small size was not attempted.

The estimates of habitat area in each grid-cell are shown in Figure 3.3. The total area of apparently suitable habitat in the state is 29,800km^2.

3.3.3 Expected distribution

The map of expected distribution is in Figure 3.4. This map shows populations of Malleefowl in NSW isolated into eight zones. Malleefowl may well be isolated in smaller areas within zones, and this certainly occurs in the fragmented habitats in the Lachlan-Murrumbidgee and Condobolin zones.

The area of distribution (based on available habitat) was calculated for five of the seven zones, and estimated for two zones where little habitat remains. See Table 3.2.

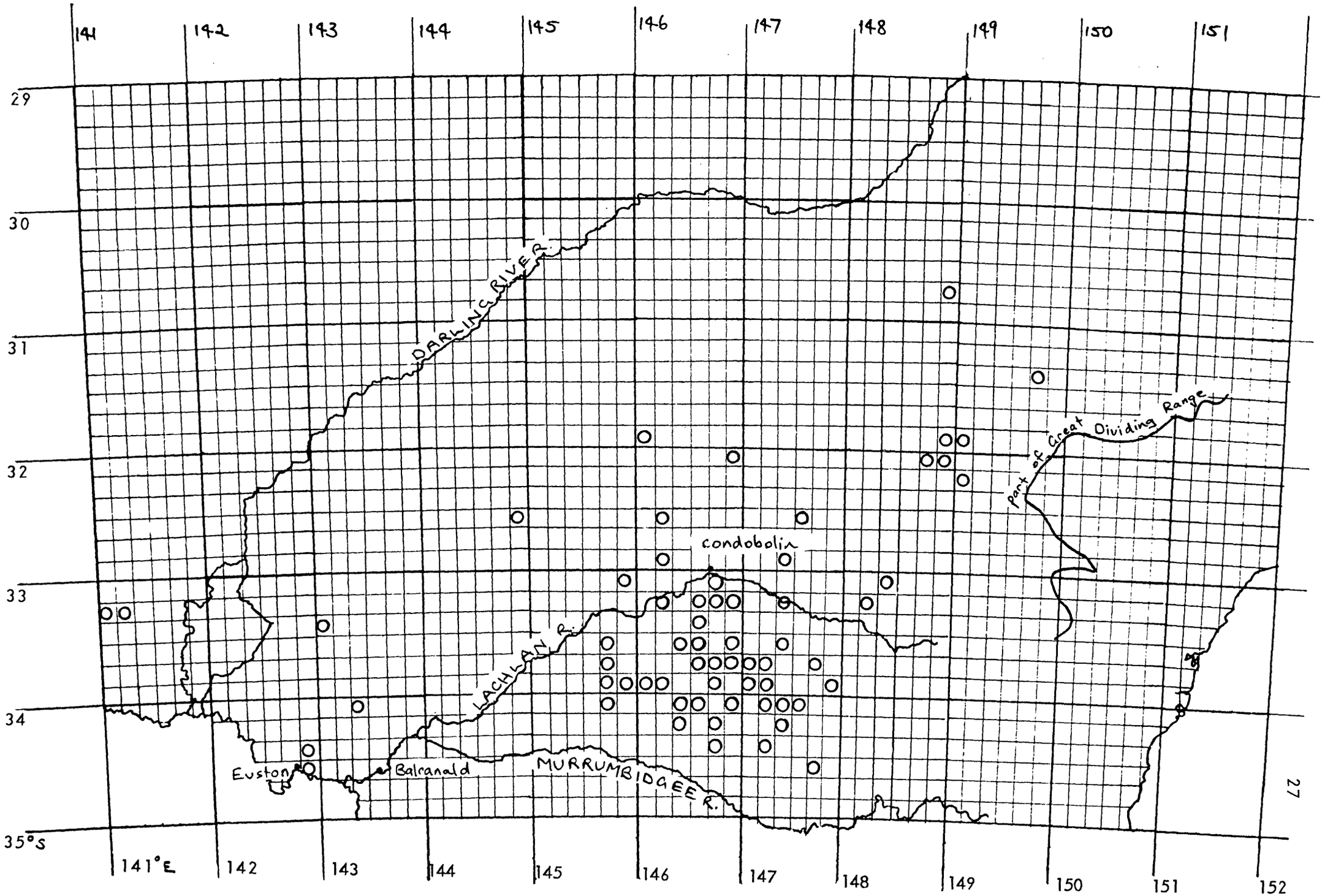

FIGURE 3.1a MALLEEFOWL RECORDS PRE - 1950.

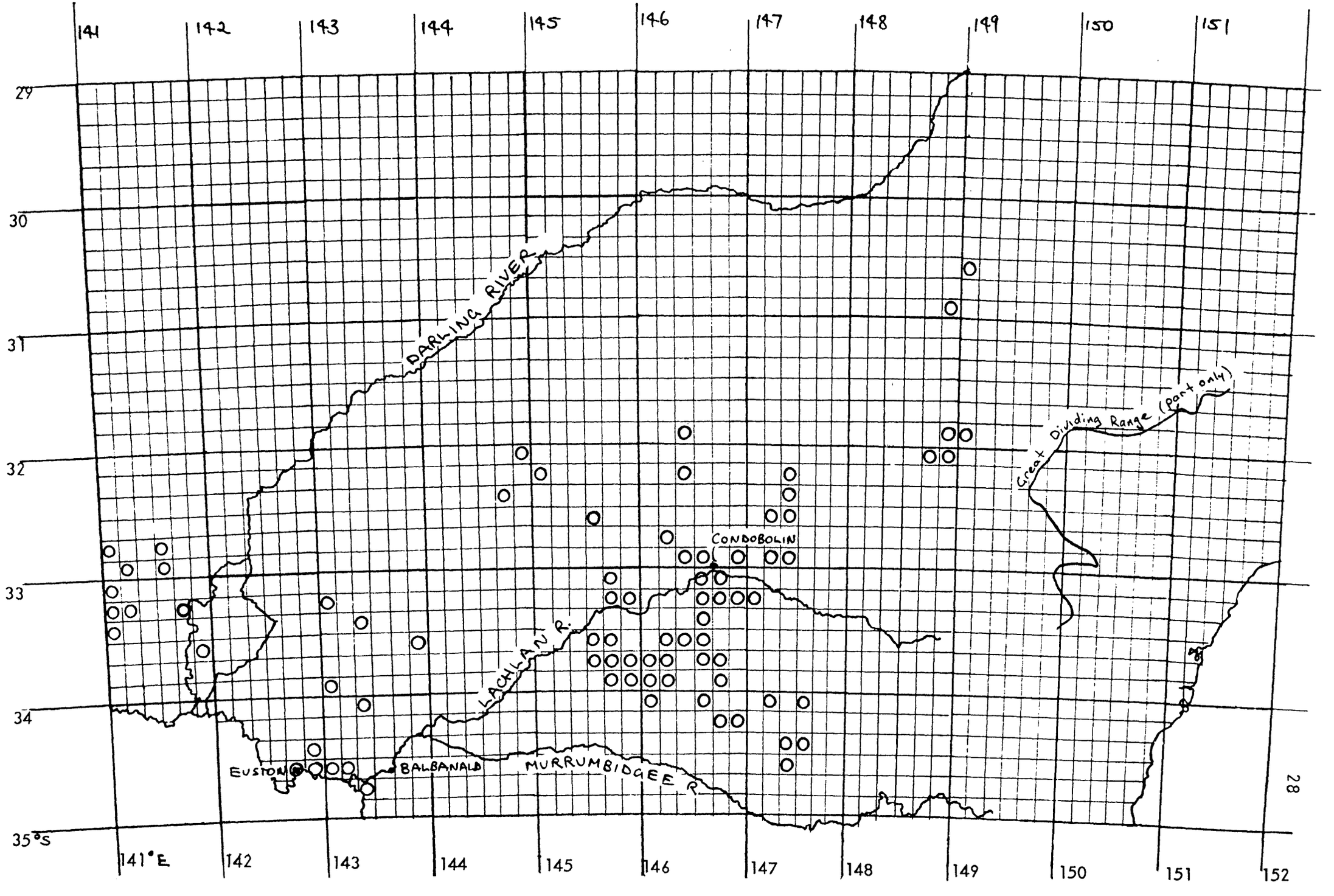

FIGURE 3.1b MALLEEFOWL RECORDS 1950 - 1974.

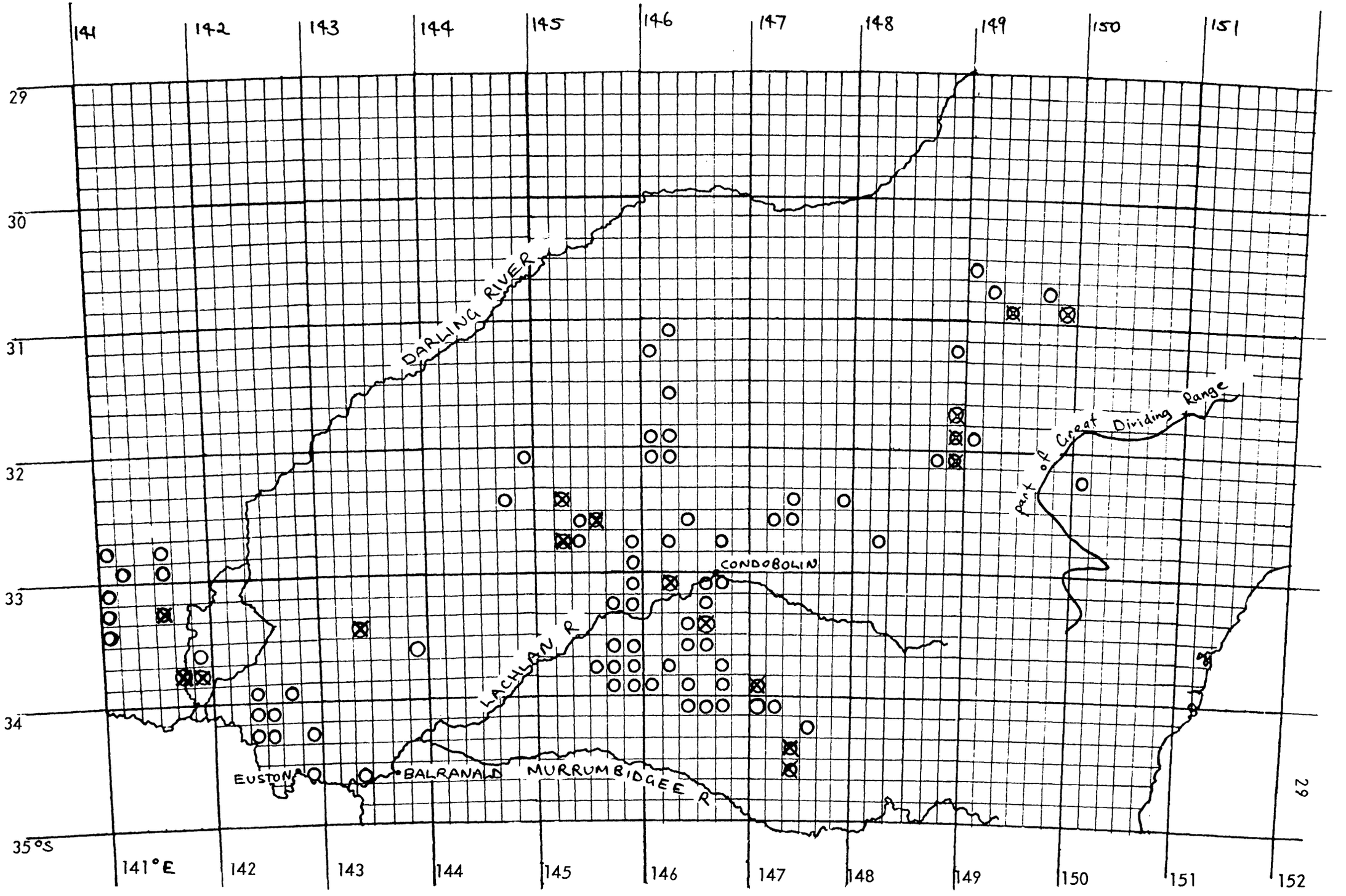

FIGURE 3.1c CURRENT MALLEEFOWL RECORDS 1975 - 1985 (o)

RAOU ATLAS RECORDS 1977 - 1981 (x)

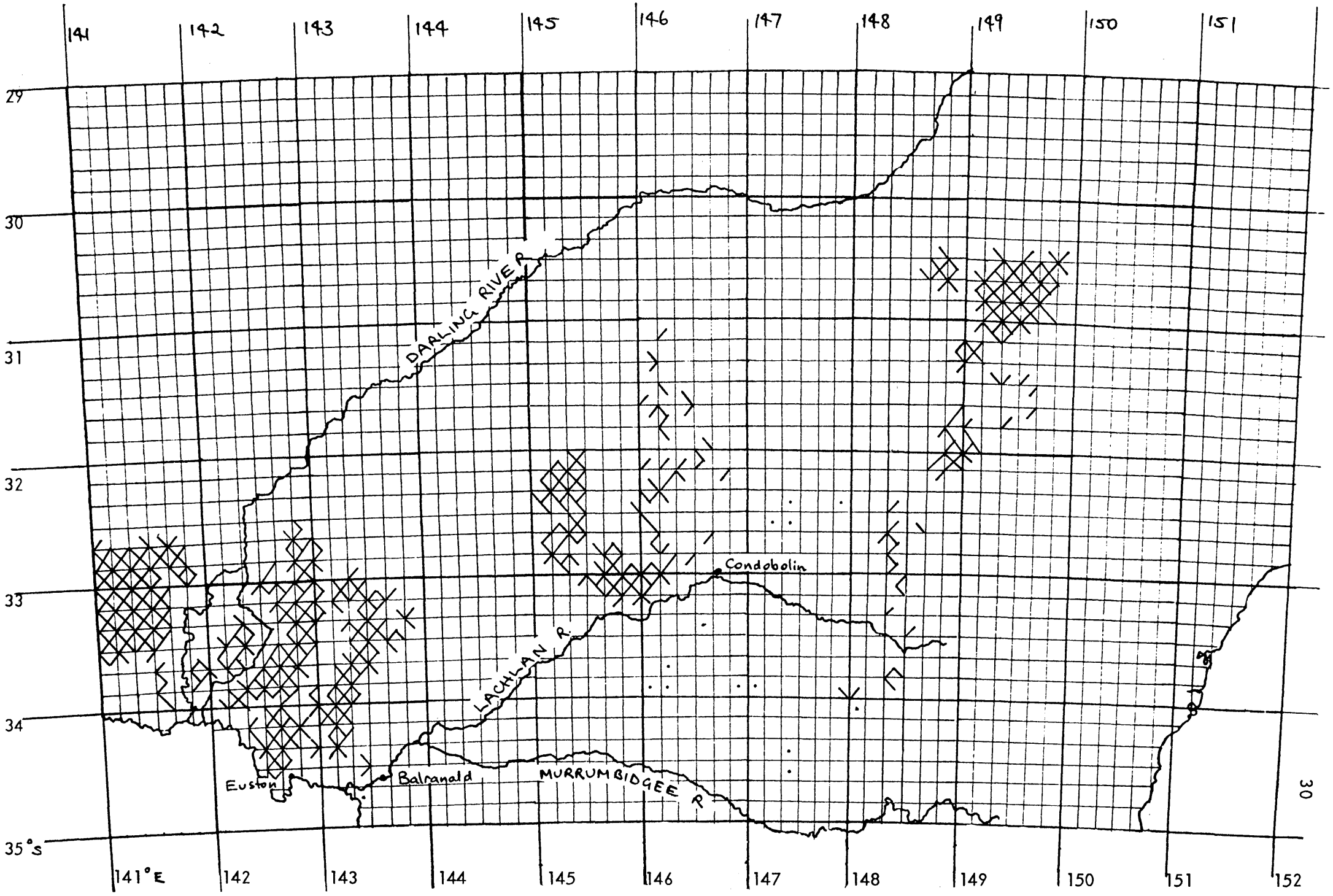

FIGURE 3.2 DISTRIBUTION OF MALLEEFOWL HABITAT IN NSW.

HABITAT IN LESS THAN 10% OF GRID CELL (•)

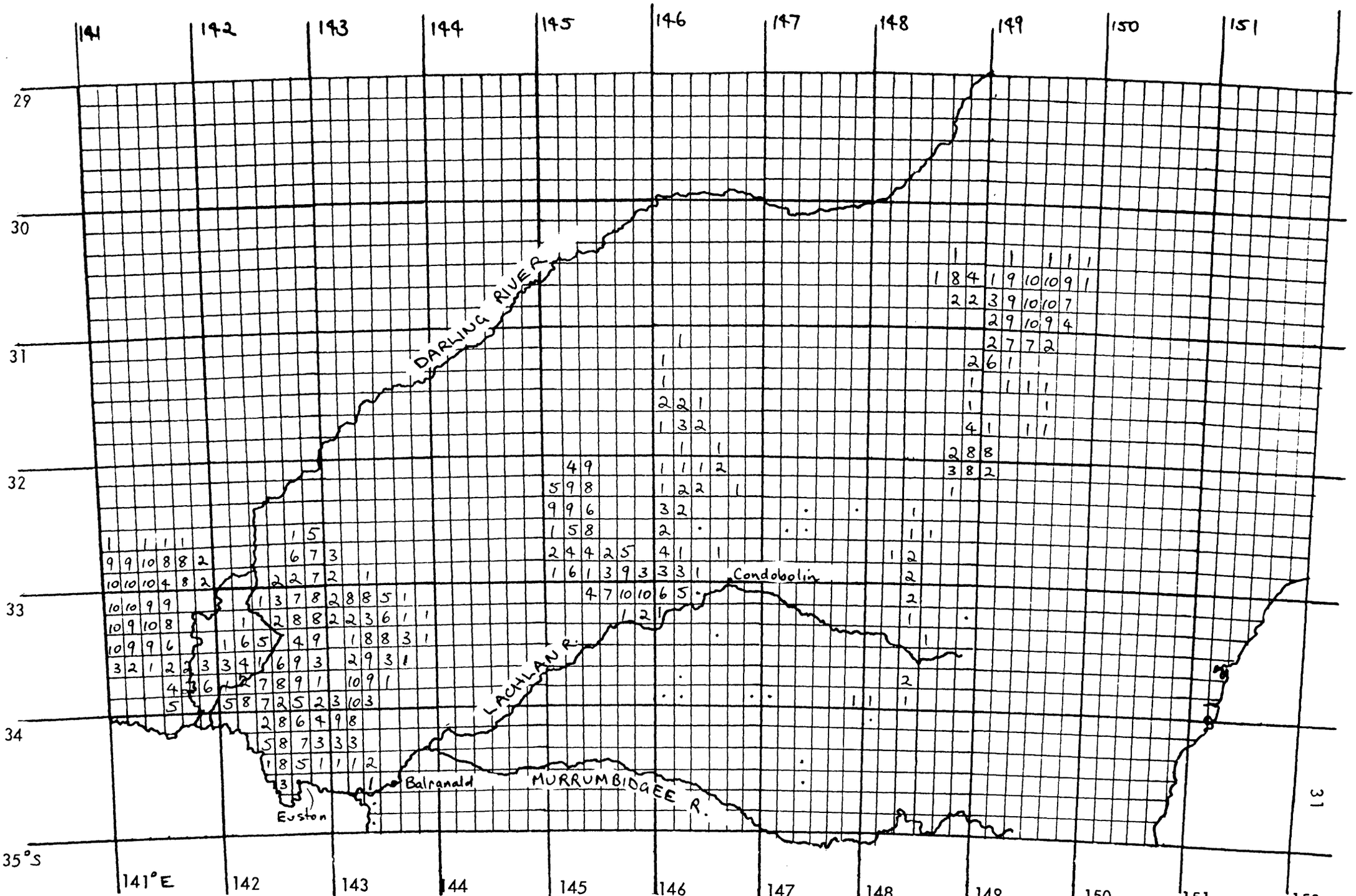

FIGURE 3.3 AREA OF MALLEEFOWL HABITAT (TENTHS OF GRID-CELLS).

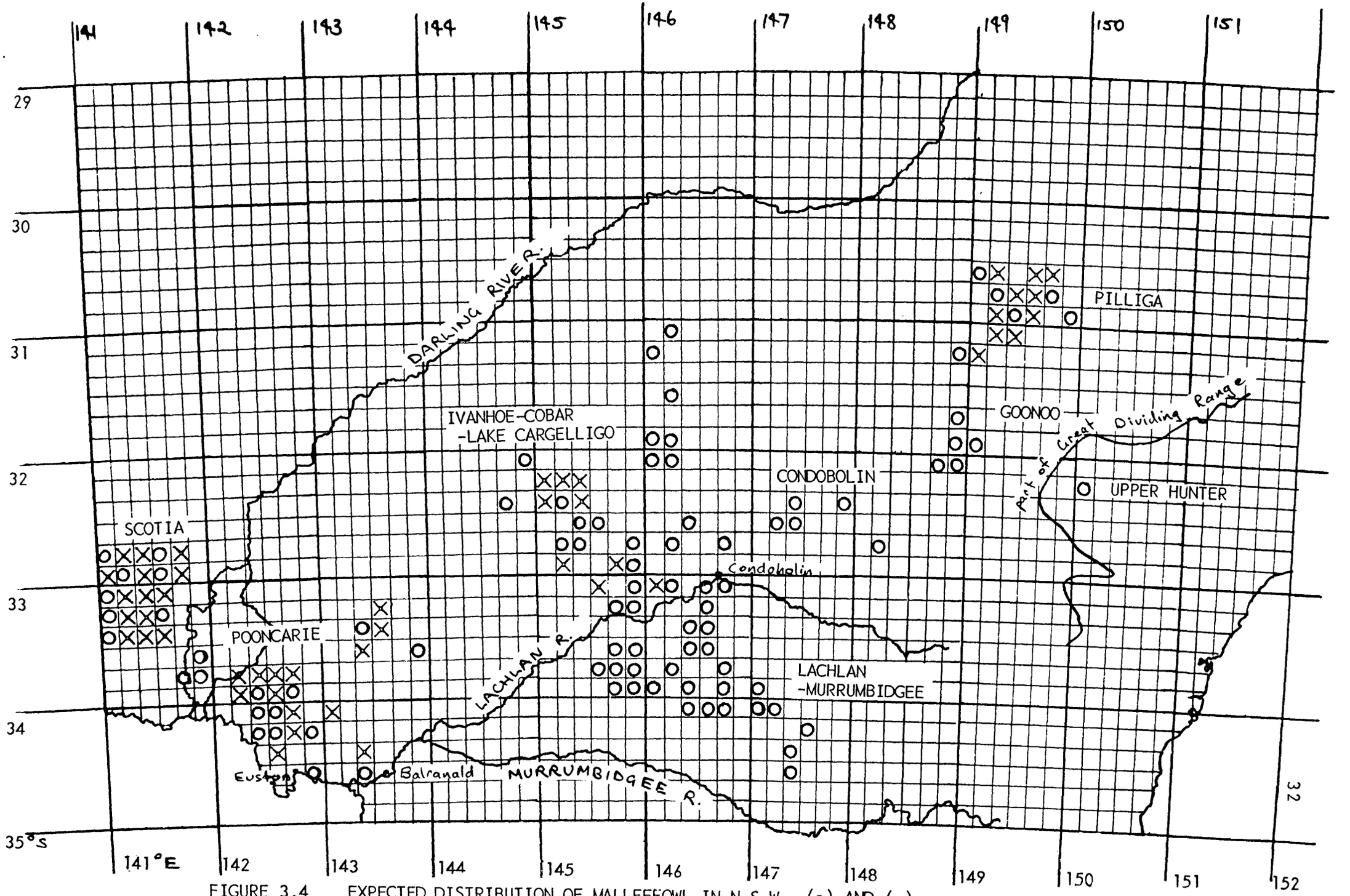

FIGURE 3.4 EXPECTED DISTRIBUTION OF MALLEEFOWL IN N.S.W. (o) AND (x) CURRENT RECORDS (o), GRID-CELLS ADJOINING WITH MORE THAN 140km² (x).

Table 3.2 Area of Malleefowl distribution by zones.

Zone	Area (km^2)
Scotia	5650
Pooncarie - Balranald	4700
Ivanhoe - Cobar - Cargelligo	3500
Lachlan - Murrumbidgee	90
Condobolin - Bebadah	400
Goonoo	880
Pilliga	3300
Upper Hunter	no estimate
Total	18520

The total area of the distribution in those five zones is 18140km^2 which is 61% of the apparently suitable habitat. There are many areas of habitat which have no current records, the largest single area being north of Pooncarie, in the Pooncarie zone.

3.3.4 Limits to Distribution

The Malleefowl distribution in NSW could not be linked in any way with patterns of climate type, rainfall, temperature or soil type but it is very similar to the distribution of mallee (*E. socialis* - *E.* (*dumosa*) as mapped in the Western Division by Beadle (1948). In the Central Division of the state, the distribution is very similar to that of mallee (*E. socialis* - *E. dumosa*) and dry sclerophyll forests of *E.dealbata* - *E.sideroxylon* (tumbledown red gum - mugga ironbark) and *E.fibrosa ssp. nubila* - *E.crebra* (blue-leafed ironbark, narrow-leafed ironbark) associations, as mapped by Hayden (1971).

Where clearing has been extensive, Malleefowl distribution can be linked to the small remnants of mallee and forest which can be identified on Landsat images. The questionnaire returns also tied Malleefowl occurrence to these remnants by name.

From my own general observations, the vegetation associations identified above occur on sandy soils and in their understoreys they contain the wide variety of herbs and shrubs necessary for food supply (Frith 1962a,

this study Appendix 5.1).

The distribution appears to be limited by vegetation associations which, from my own observations, do not have the variety of food plants necessary for Malleefowl. In the Scotia zone, the Malleefowl distribution is limited mainly by Casuarina - Heterodendrum (belah - rosewood) which is an open community with few leguminous shrubs, and partly by Maireana (saltbush) association which is dominated by low saltbushes and has little overhead cover and few food shrubs. Malleefowl in the Scotia and Pooncarie zones are separated by E.camaldulensis (river redgum) woodland which grows on heavy clay soils which are unsuitable for nesting, and which have very few food resources.

In the Ivanhoe-Cobar-Lake Cargelligo zone Malleefowl distribution is limited in the west by Casuarina-Heterodendrum and in the east by E.populnea-Callitris (bimble box-pine). This second association is an open woodland formation with limited overhead cover and has scattered Acacia but few other food shrubs. In all other parts of the state, Malleefowl distribution appears to be limited by woodland associations of E.microcarpa (grey box) E.albens (white box) and E.crebra (narrow-leafed ironbark) as mapped by Hayden (1971). These woodlands are grassy but again do not contain a sufficient

abundance and diversity of food shrubs.

3.4 DISCUSSION

3.4.1 Effectiveness of questionnaire

The questionnaire method is useful because it quickly contacts a large number of people. Farmers and graziers were selected as targets for the questionnaire as they or their families are long-time occupiers of a single property. (There were several returns with observation prior to 1920). People who spend long periods observing are likly to see rare birds. Farmers spend much time "in the field" and during land clearing and mustering operations they have good opportunities to see a large bird or its large nest. Farmers may be unskilled at bird identification but Malleefowl are not easily confused with other species.

In the Pilliga area there are both Malleefowl and Australian Brush-Turkey *Alectura lathami*, but Malleefowl are considered distinctive enough to prevent problems of misidentification. Some sightings of Brush Turkey were received, but there were no records where the bird identified was in doubt.

The use of business reply postage paid, lack of envelope and limited number of questions are considered to be important factors in encouraging returns as they involve minimal effort from the respondent.

Two minor problems were caused by using Shire electoral rolls and selecting rural addresses from them. Retired farmers who lived in towns were not contacted. The Dubbo Shire includes the large town of Dubbo and the electoral roll of over 30,000 people could not be obtained easily causing a gap in the coverage of properties in that area.

Unskilled observers do not keep accurate records of observations but the use of wide time bands overcomes that problem. The decades were grouped into major time periods similar to those used by Blakers et al. (1984) for similar reasons. The 1950-1974 period was the period of greatest expansion of the wheat belt into the mallee areas between the Lachlan and Murrumbidgee rivers.

The explanatory letter with the questionnaire card bore the letterhead of the National Parks & Wildlife Service, the New South Wales government body responsible for wildlife conservation. Some property owners may have been wary of providing information on Malleefowl because they thought their property might be at risk of being bought for establishment of a Nature Reserve for Malleefowl. However, the return rate for cards with useful information was still high, so this problem is seen to be minimal.

3.4.2 Problems of mapping distribution

The maps in Figure 1 use the 10' of latitude and longitude grid cell as the basic unit of distribution. However, for many grid cells Malleefowl occur only in a tiny block of habitat, so even Malleefowl shown as occurring in adjoining cells may be well isolated from one another.

3.4.3 Expected distribution

There are some grid cells on the map of suitable habitats where Malleefowl have not been recorded recently or in any time period. The reasons for this can include:

1. a lack of observers in the area, especially in the central and far western parts of the state where Malleefowl are at low densities and so are unlikely to be seen

2. mapping methods where only the 10' grid-cell containing the homestead of large Western Division properties was mapped even though a property may cover parts of two grid-cells

3. incorrect assessment of suitable habitats from Landsat images and vegetation maps.

The expected distribution map rounds out the known distribution map by accounting for errors caused by reasons 1 and 2 above. If grid-cells where the third reason applies are kept to a minimum then the map of expected distribution based on habitat and current reports will be more useful than either of those maps alone. Care must be taken not to extrapolate the expected distribution further than is warranted by the recorded sightings and that is the reason for only including grid-cells with more than half of their area occupied by suitable habitat and which directly join grid-cells with current records.

The areas of habitat within each zone of the expected distribution are required for the calculation of total population size based on an estimate of density within each zone. This will be attempted in Chapter 4.

3.4.4 Distribution of Malleefowl and habitat availability

Comparison of the maps of expected distribution (figure 3.4) and habitat available (figure 3.2) show that there are some large areas of apparently suitable habitat where Malleefowl have not been recorded since 1975. Reasons for the decline in Malleefowl distribution in any one area have not been examined in this study.

In the Lachlan-Murrumbidgee zone and the Condobolin zone there are Malleefowl records for areas where habitat was not recorded. This is because the smallest unit used in habitat recording was about one tenth of a grid-cell about 28km^2 and habitat remnants in those zones are much too small to be shown. For example, the study sites south of the Lachlan river chosen for breeding studies ranged from 1.45 to 5.58km^2 (see section 2.3.1). The smallest remnant of habitat in which I have observed Malleefowl was about 0.5km^2.