Chapter 2

Methods for Biological Survey of the Bungle Bungle Area

by
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OUTLINE

The methodology that we employed was based on that used during our wildlife study of Stage III of Kakadu National Park (Woinarski *et al.* 1989a). Representative sites were surveyed intensively for all vertebrates over a period of six days. Marked quadrats were used in order to assess abundance and relate vertebrate records to detailed environmental information.

SITE SELECTION AND SURVEY PERIOD

We selected 10 sites on the basis of (i) geographic spread throughout the Bungle Bungle area (including the Conservation Reserve and areas in Osmand Valley and Texas Downs Stations), (ii) representation of major habitats and land systems, (iii) accessibility, and (iv) avoidance of Aboriginal sacred sites. The location of the sites selected is given in Figure 3, and further details of sites are in Table 2. Seven sites were surveyed between 13 June and 30 July 1989 ('dry season') and three sites between 21 November and 10 December 1989 ('wet season'). Both survey periods were notable for their lack of rainfall, to the extent that conditions in the 'wet season' survey were probably more typical of the late dry season.

A further seven days field work preceded the survey of our last three sites. During this period, we made more extensive searches of Winnama Gorge, Wulwuldji Springs, Turkey Creek (near Osmand Valley Station), Three-ways, Echidna Chasm and 'Frog Hole' Gorge. Mammal traps and mist-nets for bats were set at these sites for periods of one to two nights.

ANIMAL SAMPLING

At every survey site we established three transects, all of 900 m length (Fig. 4). For every transect, we marked five equally spaced core quadrats of 80 m x 20 m, making a total of 150 quadrats for the whole survey. These were the areas used for trapping of small mammals, reptiles and amphibians and for censuses of reptiles and amphibians. The core quadrats were nested inside larger (100 m x 100 m) quadrats marked for bird censuses and observations of larger mammals. In every core quadrat we placed 20 mammal traps (16 small Elliott, 3 large Elliott and 1 cage (20 mm x 20 mm x 56 mm)) and three pitfall traps (28 cm diameter x 36 cm depth), arranged as in Figure 5. These were all set for a period of four successive days and nights. Every pitfall trap had 8 m of 25 cm high driftline fence. Elliott traps were baited with a mixture of peanut butter and oats. Cage traps were baited with figs or apples and jam. All traps were checked in early morning and late afternoon. Elliott traps were rebaited every afternoon.

We searched quadrats systematically for reptiles and amphibians (three censuses per quadrat during daylight and two censuses per quadrat at night, every census for 5 minutes) and birds (eight instantaneous censuses per quadrat during daylight and two at night with numbers of each species present within quadrats recorded at every census). Larger mammals were recorded incidentally during these censuses, or their presence inferred from tracks, scats or other signs.

At every survey site, we set three harp traps (Tidemann and Woodside 1978) over four nights to sample bats. Additionally, we used mist-nets for variable periods on at least three nights per site.

Abundance measures were assigned for every species in every quadrat, by tallying the number of individuals caught and the total number recorded in all censuses for that quadrat. We assigned an abundance value of 0.1 to animal species known to be present in quadrats by tracks or other signs or recorded in incidental observations but neither trapped nor recorded in that quadrat during censuses.

For every survey site, we also recorded incidental observations, of animals seen or heard in the general area encompassed by the end points of all transects, or within about 2 km of the campsite. Scats or pellets of dogs, cats, owls and pythons were collected and hairs or bones in them examined and identified.

Fishes and other aquatic vertebrates were not surveyed systematically by this study, but incidental observations were noted and sampling was undertaken opportunistically. For fishes, methods used for such sampling included cast nets, hook and line, and scoop netting with spotlights at night.

Voucher specimens of mammal, reptile, fish and amphibian species were retained and deposited at the Western Australian Museum.

HABITAT DESCRIPTION AND VEGETATION SAMPLING

We completed a proforma of habitat variables for every quadrat. We measured basal area of every woody plant species present, number and height of termitaria, litter depth and presence of feral animals and their signs. We estimated rock cover, rock size, canopy height, canopy cover, distance to permanent water and cover of life forms in the categories trees >8 m, trees 2-8 m, shrubs >2 m, shrubs <2 m, palms, chenopods, cycads, tussock grasses, spinifex, sedges, forbs, ferns and vines. We recorded topographic position, whether the site had been burnt recently, diameter at breast height frequency distribution, rock type and plant species flowering and fruiting. Soil was assessed for gravel content and texture. Vegetation structure was described using Specht's (1970) classification, land system units described according to the description and/or map of de Salis (1982) and habitat type categorized according to the description of Forbes and Kenneally (1986). Within every quadrat, we marked five plots of 2 m x 2 m, and within these all plant species less than 1m in height with cover of at least 10 per cent were identified and scored for canopy cover. The number of plant species occurring in every plot was recorded by category (woody plants, tussock grasses, hummock grasses, sedges, forbs and ferns). For every plot we also estimated total cover, grass height and grass cover. Surrounding these plots was a 5 m x 5 m plot inside which all plants >1 m and <8 m were identified and scored for canopy cover.

Complete plant species lists were compiled for every quadrat. Duplicate voucher specimens were collected and lodged with the Northern Territory and Western Australia Herbaria.

PERSONNEL

The field team was based on a core of three persons. Primary responsibilities were:

Nick Gambold:
reptiles, amphibians.

Karina Menkhorst:
vegetation and habitat description, bats.

John Woinarski:
birds, small mammals (excluding bats), fish.

Field work was assisted at various times by Dick Braithwaite, Ian Cowie, Garry Cook, Gus Wanganeen, Pip Masters, Pavel Zborowski, Bert Herold, Kay Dyson, Lynn Lowe, Therese Patterson, Glenn and Robyn Colledge, and the very obliging CALM staff of the region: Paul Butters, Gordon Carrington, Chris Done, Dave Milne, Neil McGinty, Mark Pittavino, Alex Rogers, Bob Taylor and Jim Wolfenden.

ANALYSIS

Values for all environmental variables, plant species presence, basal area and cover, and animal species abundance for all quadrats were stored and manipulated using the program DECODA (formerly ECOPAK: Minchin 1986). This large data set was analysed using the multivariate classification TWINSPAN (Hill 1979a) which forms groups of quadrats of similar species composition. This classification was based on the presence of plant species in quadrats.

The distribution of animal species by quadrats was analysed separately by relating to survey sites, land units (the groups recognized by de Salis 1982) and to floristic groups. Animal species were also classified into groups based on their similarity of distribution across quadrats. Results are presented as ordered two-way tables.

A degradation measure was calculated for every quadrat, as the sum of four separate indices of disturbance: percentage of introduced plant species (0 = 0 per cent, 1 = 1-5 per cent, 2 = 6-10 per cent, 3 = 11-25 per cent, 4 = 26-50 per cent, 5 = >50 per cent), percentage of introduced plant cover (0 = 0 per cent, 1 = 1-5 per cent, 2 = 6-10 per cent, 3 = 11-25 per cent, 4 = 26-50 per cent, 5 = >50 per cent), number of scats of feral stock (0 = 0, 1 = 1-5, 2 = 6-10, 3 = >10) and erosion score (0 = no erosion, 1 = some bare ground, 2 = up to 50 per cent bare ground, some gullying, 3 = >50 per cent bare ground and/or extensive gullying). For all those floristic groups and all those land systems that were sampled by at least ten quadrats and which had a range of at least three units in this degradation score, we examined for relationships between degradation and animal distribution and abundance by correlating degradation score with the abundance of vertebrate species.

Species lists for the Bungle Bungle area were compared with other available lists for north-western Australia (Table 3; Fig. 6). Firstly, the similarity between the Bungle Bungle lists (separately for mammals, birds, reptiles and frogs) and lists for other areas was calculated, using the formula

$$200w/(a+b)$$

where w = the number of species found in both the Bungle Bungle area and the other area, a = the number of species known for the Bungle Bungle area, and b = the number of species known from the other area. A value of 100 indicates that the Bungle Bungle list is identical to that of the area compared, a value of 0 indicates that no species are shared between the Bungle Bungle area and the other area compared. Results are presented in a network diagram linking sites to the Bungle Bungle area by lines whose thickness varies according to the similarity in species composition. For every surveyed area, the number of species whose distribution is predominantly Eyrean (desert), Torresian (tropical) or widespread (restricted to neither Eyrean nor Torresian) is also shown on these network diagrams.

These species lists were analysed further to examine biogeographical trends across north-western Australia, using the ordination procedure DCA (Hill 1979b) and TWINSPAN classification. Results are presented as scatter graphs of sites on the first two axes of the ordination. In the space defined by these axes, areas with similar species composition are clustered close to each other, and directional change in species composition is reflected in the position of sites along these axes. In most cases the first axis is by far the most important gradient. The relative importance of the second axis is measured by the ratio of its eigenvalue to that of the first axis. These analyses of species lists at various sites are confounded to an extent by varying survey intensity (duration, censusing during different seasons), size, methodology and habitat heterogeneity. Results from Stage III of Kakadu provide a direct comparison, as this survey used the same personnel, methodology and sampling intensity (Woinarski *et al.* 1989a).

This report can be read without the need to understand these analytic techniques. They simply provide reasonably objective means for compressing a large body of sites-by-species data into a, hopefully, comprehensive summary. The data are receptive to more detailed statistical enquiry yet, but this report is probably an inappropriate vehicle for such fine-scale analysis.

PRESENTATION OF SPECIES LISTS

For mammals, birds, reptiles, frogs and fish, we present annotated lists of species recorded from the Bungle Bungle area. For mammals, birds, reptiles and frogs, we list the study sites where these were recorded, the land system unit in which the average abundance per quadrat is greatest (descibed for convenience as 'Preferred') and also the floristic group in which this abundance is greatest.

Information from the few previous sources is incorporated where relevant. We also describe a regional context for these species, by reference to previous surveys in the Kimberley area (especially those of the nearby Ord River area (Kitchener 1978) and Argyle areas (Dames and Moore 1982), and overviews of the Kimberley fauna (e.g. Storr 1980).

In some cases these regional references suggest the likely occurrence within the Bungle Bungle area of species not recorded by us. Such species are listed where appropriate in either the annotated species list (where denoted by square brackets) or in a section for additional species following that list. These species are not included in analyses or in biogeographic comparisons.

For a few animal and several plant species, identifications remain tentative subject to more detailed taxonomic study. Several species recorded here have not yet been taxonomically described.

Preliminary results from our first survey period (June-July 1989) were given in a progress report to CALM (Woinarski *et al.* 1989b). This present report supersedes that progress report. We note that more detailed taxonomic study or further information has changed the identification of some species listed in that earlier report. These changes are: *Egernia striata* should be *Egernia slateri*, *Lerista bipes* should be *Lerista greeri*, *Ctenotus* sp. should be *Ctenotus decaneurus* (although possibly an aberrant specimen), *Peradorcas concinna* should be *Petrogale brachyotis*, *Pseudomys nanus* includes both *P. nanus* and *P. desertor*, and *Sminthopsis youngsoni* should be included with *S. macroura*.

Nomenclature and taxonomic authority used follow standard texts as given at the beginning of our annotated species lists. We introduce one common name, Kimberley Mouse for *Pseudomys laborifex*, the only mammal recorded here without an established vernacular name. This name aptly describes its distribution, is consistent with geographic descriptors for other species in this genus (e.g. Alice Springs Mouse *P. fieldi*, Shark Bay Mouse *P. praeconis*, Hastings River Mouse *P. oralis* and Pilliga Mouse *P. pilligaensis*), and recognizes the lack of distinctive physical features of this species.

Table 2

Location of survey sites. Abbreviations for status: NP = National Park, CR = Conservation Reserve, TDS = Texas Downs Station, OVS = Osmand Valley Station.

Site No.	*Area*	*Status*	*Dates visited*	*Lat(s) Long(E) Grid Reference*
1	Bull Creek	NP	14-18 June	17°19' 128°27' 4563-424845
2	Osmand Spring	NP,CR	19-24 June	17°16' 128°31' 4663-495893
3	Goosehole Breakaway	NP	28 June-2 July	17°34' 128°31' 4662-490568
4	Piccaninny Massif	NP	3-7 July	17°26' 128°24' 4563-365725
5	Blue Holes	CR	11-15 July	17°33' 128°15' 4562-208587
6	Turner	CR	16-21 July	17°44' 128°09' 4562-118394
7	Mt. John	TDS	25-30 July	17°10' 128°44' 4663-723013
8	Bream Gorge	OVS	21-27 Nov	17°15' 128°18' 4563-258933
9	Kitty's Knob	NP	30 Nov-5 Dec	17°25' 128°46' 4663-764730
10	Cathedral Gorge	NP	5-10 Dec	17°29' 128°22' 4563-340662

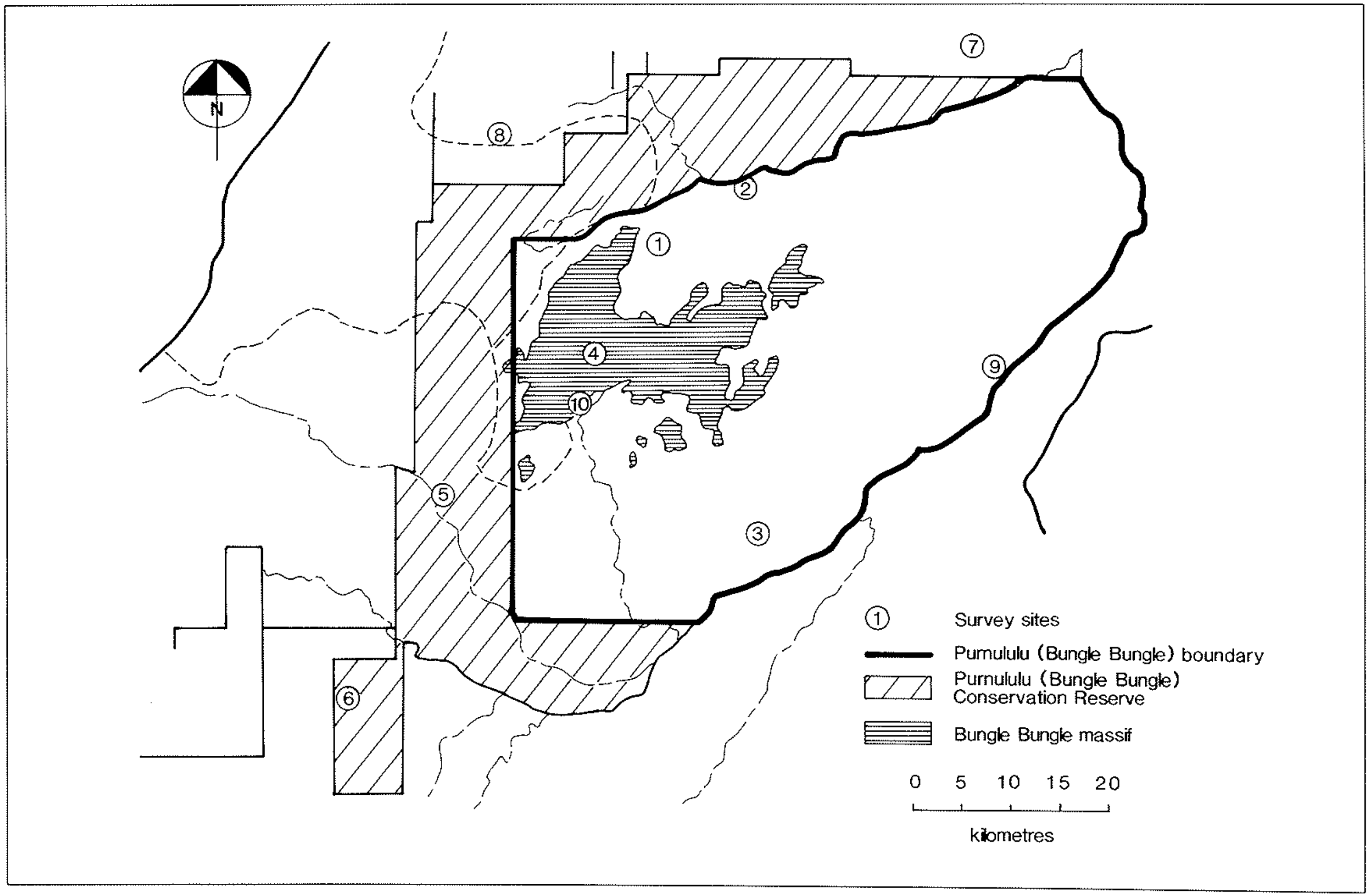

Figure 3

Location of the ten study sites. For further details see Table 2.

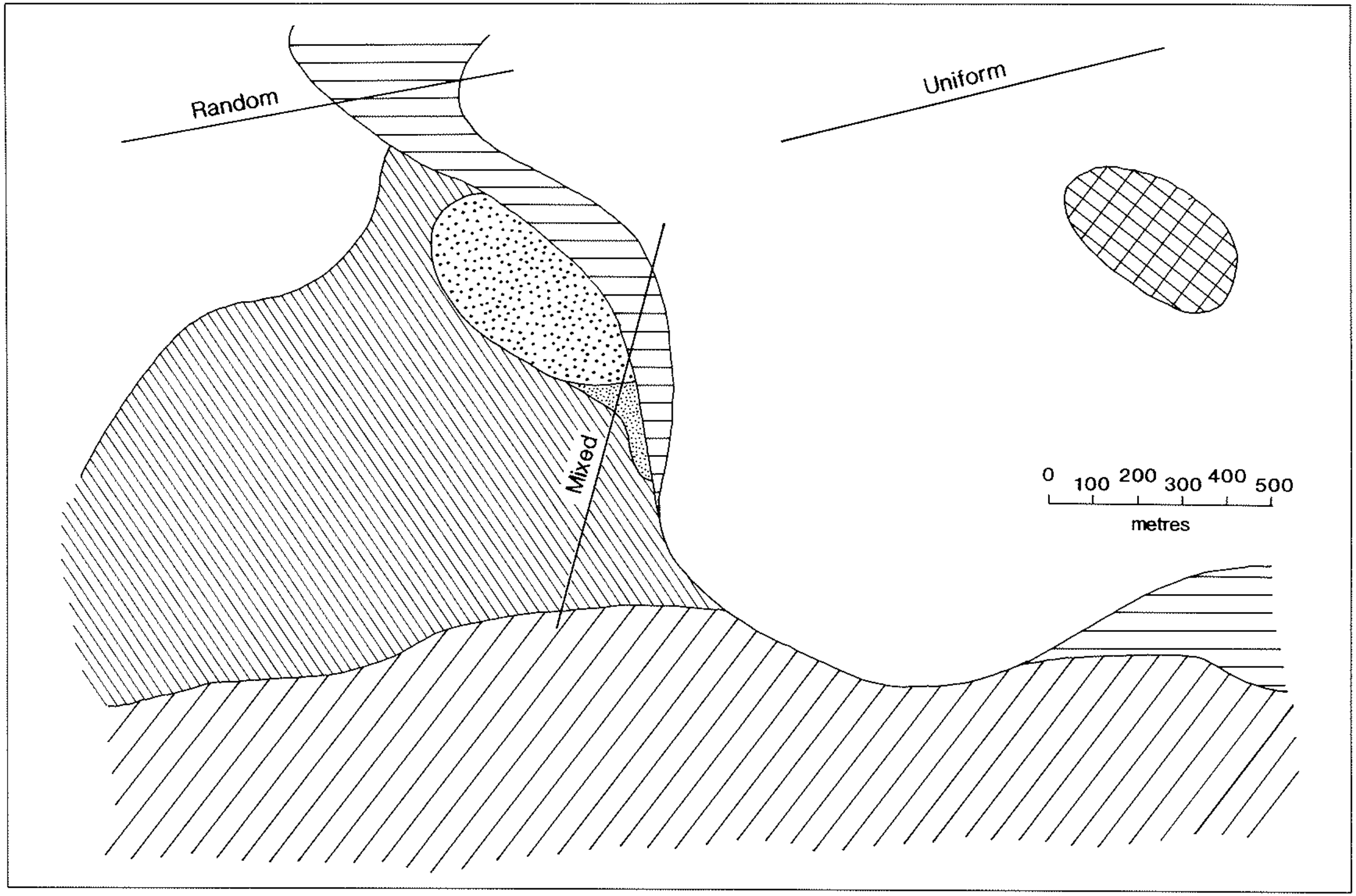

Figure 4

Schematic representation of placement of the three transects at one study site. Vegetation types present are illustrated by different symbols.

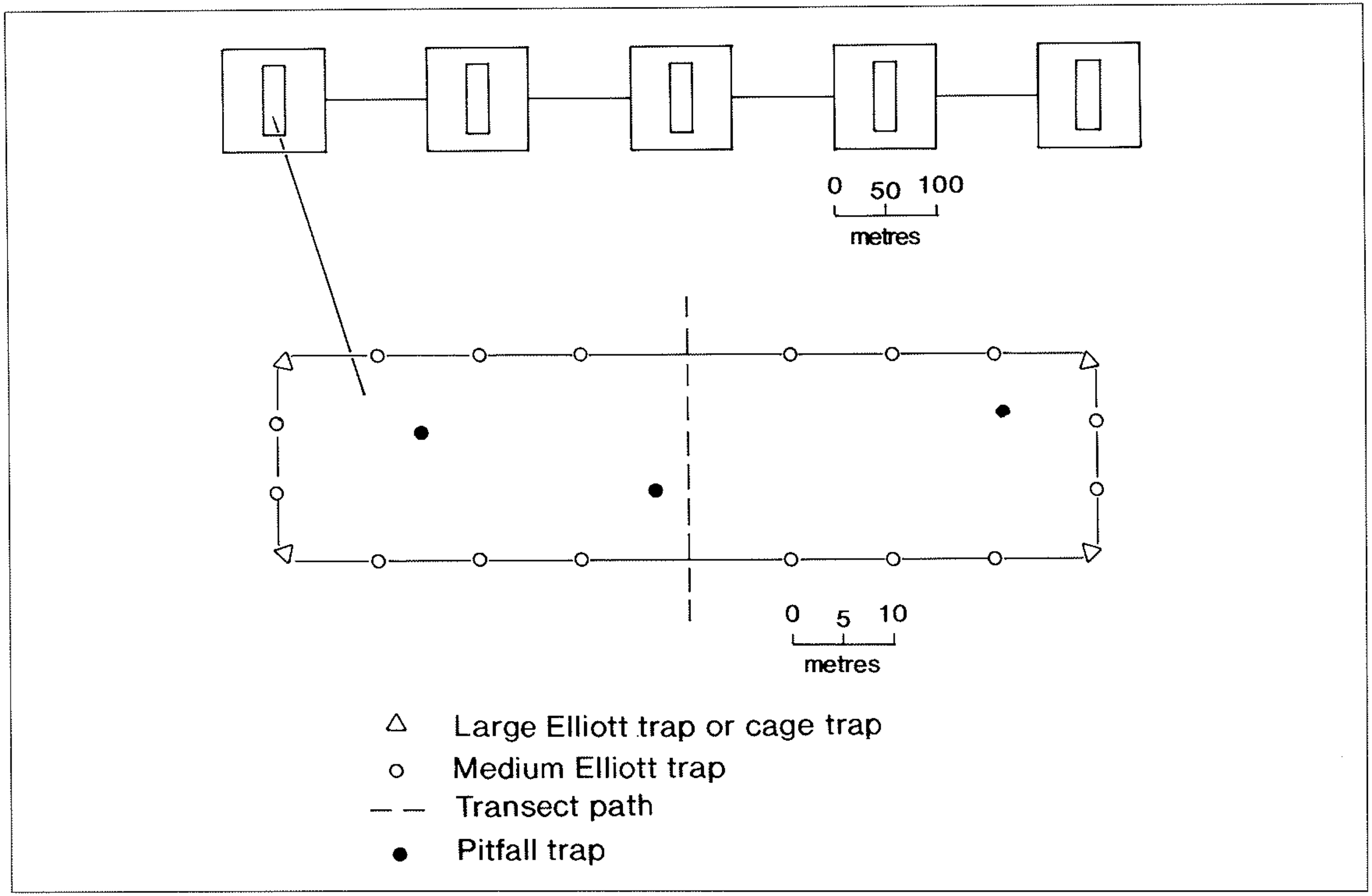

Figure 5
Layout of quadrats and traps along one transect.

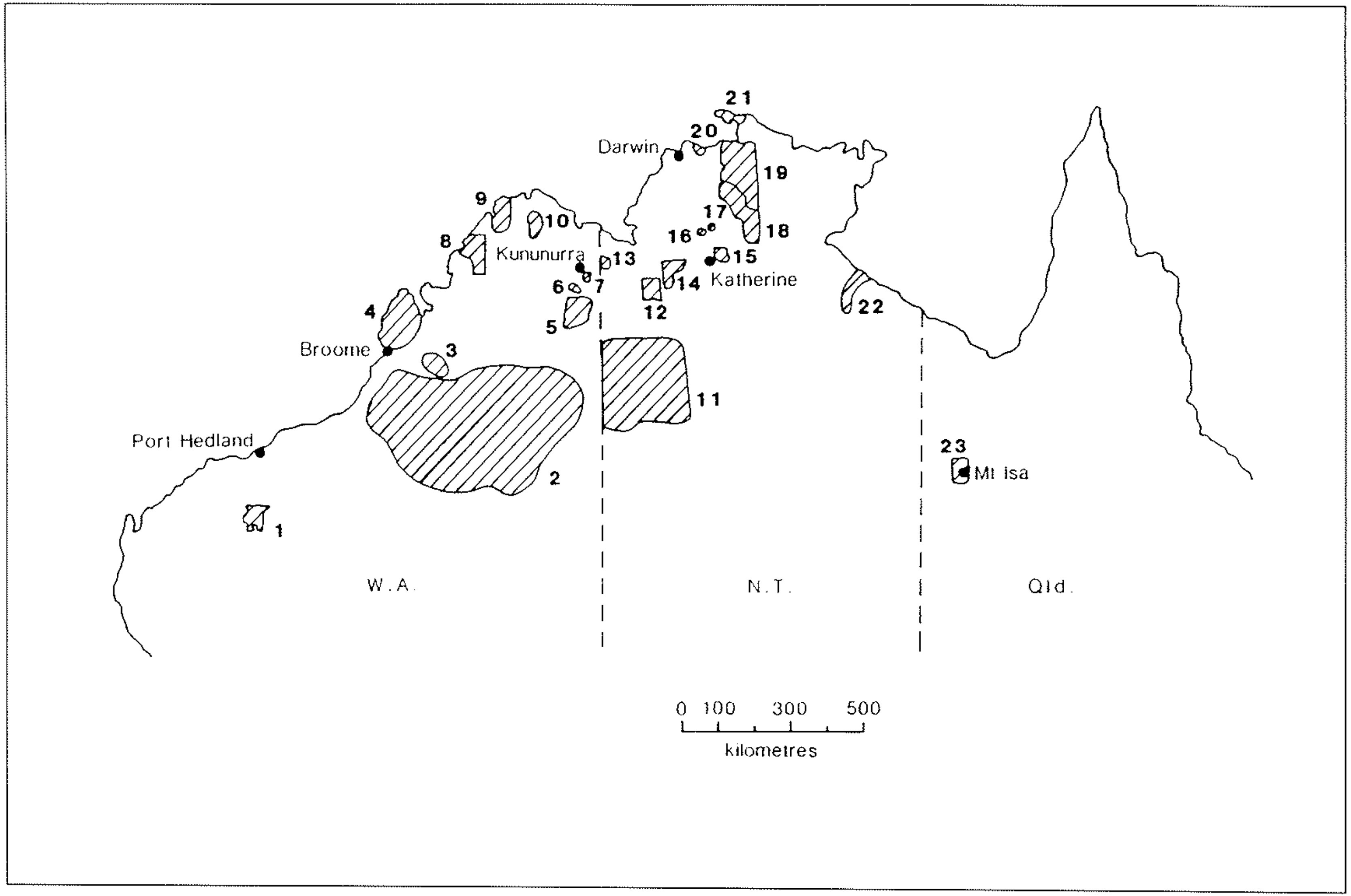

Figure 6

Location and Site Nos of surveyed areas [hatched box] across north-western Australia. For further details see Table 3.

Table 3

Sites of biological surveys and species lists used in biogeographic comparisons of Bungle Bungle fauna. Site No. as in Figure 6. No. of survey years is number of calendar years in which observations were made. Survey months: DJF = December - February, MAM = March - May, JJA = June - August, SON = September - November. Survey area = approximate size of survey area: * <10 km^2, ** = 10 -100 km^2, *** = 100 -1000 km^2, **** = 1000 -10 000 km^2, ***** = 10 000 - 100 000 km^2, ****** = >100 000 km^2. Fauna considered is the information used in biogeographic comparisons: M = mammals, B = birds, R = reptiles, F = frogs. Survey effort = approximate No. of person days: * = <100, ** = 100 - 250, *** = 250 - 500, **** = 500 - 1000, ***** = > 1000.

		RAINFALL (mm)	SURVEY YEARS (NO.)	SURVEY MONTHS *DJF*	*MAM*	*JJA*	*SON*	SURVEY AREA	FAUNA *M*	*B*	*R*	*F*	SURVEY EFFORT	SOURCE
1.	Hamersley Range	330	1(4)	?	X	?	?	****	X	X	X	X	**	Muir (1883)
2.	Great Sandy Desert	200-400	4		X	X		******	X	X	X	X	****	Burbidge and McKenzie (1983)
3.	Edgar Ranges	500	3			X	X	*****	X	X	X	X	**	McKenzie (1981a)
4.	Dampier Peninsula	550	3		X	X	X	*****	X	X	X	X	***	McKenzie (1983)
5.	Pumululu	600	1	X		X	X	****	X	X	X	X	**	This report
6.	Argyle	630	2	X	X		X	***	X	X	X	X	*	Dames and Moore (1982)
7.	Ord	650	3	X			X	***	X				***	Kitchener (1978)
8.	Prince Regent River	1300	1			X	X	****	X	X	X	X	**	Miles and Burbidge (1975)
9.	Mitchell Plateau	1600	2		X		X	****	X	X	X	X	***	W.A. Museum (1981)
10.	Drysdale River	1100	1			X		****	X	X	X		**	Kabay and Burbidge (1977)
11.	Tanami	200-400	9		X	X	X	******	X	X	X	X	****	Gibson (1986)
12.	Victoria River Downs	550	2	X	X	X	X	****		X			*	Boekel (1980)
13.	Keep River	700	?	?	?	?	?	***		X			?*	McKean (1986) - CCNT file notes
14.	Gregory	700	?	?	?	?	?	****		x			?**	CCNT file notes
15.	Katherine Gorge (Nitmiluk)	1000	?	X	X	X	X	****	X	X	X	X	***	CCNT file notes
16.	Umbrawara Gorge	1100	?	X	X	X	X	*	X	X	X	X	**	CCNT file notes
17.	Pine Creek	1150	1		X		X	**	X	X	X	X	*	Schulz and Menkhorst (1984)
18.	Kakadu Stage III	1200	2	X	X		X	****	X	X	X	X	**	Woinarski *et al.* (1989a)
19.	Kakadu Stages I & II	1300	4	X	X	X	X	*****	X	X	X	X	*****	Braithwaite (1985); - ANPWS file notes
20.	Howards Peninsula	1650	1		X			***		X			**	Woinarski *et al.* (1988)
21.	Cobourg Peninsula	1700	4	X	X	X	X	****	X	X	X	X	****	Frith and Calaby (1974)
22.	Lower MacArthur	1000	4	X	X	X	X	****	X	X	X		***	CSIRO (1976)
23.	Mt. Isa	380	24	X	X	X	X	****		X			?***	Horton (1975)