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Effects of Observer Variability on the Census of Birds

ROD KAVANAGH and HARRY F. RECHER

During surveys of the avifauna of south-eastern New South Wales, five persons were involved in the counting of birds using a strip transect method. Although efforts were made to standardize procedures and to ensure that each person had about the same ability to identify birds, there were differences between observers which affected census results. In this paper, the differences between observers are described and discussed with respect to their effects on census results. These data indicate that differences between observer search patterns and their individual behavioural traits may considerably affect census results. Observer variability is an important source of error in bird census work and survey teams in particular need to be aware of the problem. Procedures for reducing observer error are presented.

The number of birds registered during a census is a function of the number of birds in an area (density), and the probability that each bird present will be recorded (detectability) (Shields 1979). All census work is subject to two basic errors: bias (the failure to detect all species equally) and lack of precision (variability in recording conditions). Bias can be reduced by keeping the probability of detection for each species constant among habitats (Folse 1979). This can be achieved to some extent by varying the size of area censused between different habitat types or by determining the effective limits to the distance at which each species is detected (Emlen 1971, 1977). Species differences in behaviour, calling frequency and sound attentuation, as well as time of day, season, weather and differences between observers, affect the repeatability or precision of census estimates and confound interpretation of data. Of these, observer variability is potentially the most serious source of error as it is usually overlooked. This problem is particularly important in broad area survey where there are often pressures to complete surveys quickly and to accomplish this by using multiple observers.

In south-eastern New South Wales, we have used a number of observers since 1975 to census birds in forest affected by an intensive logging operation. The census technique used throughout was the method described by Recher *et al.* (1983). The objectives of this study were to determine broad differences in the avifauna between forest types and to apply those data to the management of forest wildlife (Recher *et al.* 1980). Census results were found to be variable for each plot during any one sample period. The extent to which this variation was due to differences between observers was unknown but it was hoped that any such errors would be equalized between census plots by the rotation of observers. However, doubts were raised about the use of multiple observers in future studies where more precise data were required. It was decided, therefore, to measure the variability between observers and to determine the reasons for individual differences. Our goal was to refine our census procedures to substantially reduce errors arising from differences between individual observers.

In this paper we present the results of testing five experienced observers against each other.

Differences between observers are identified and procedures suggested which will reduce observer variability in broad area surveys.

Methods

Standardization of procedures

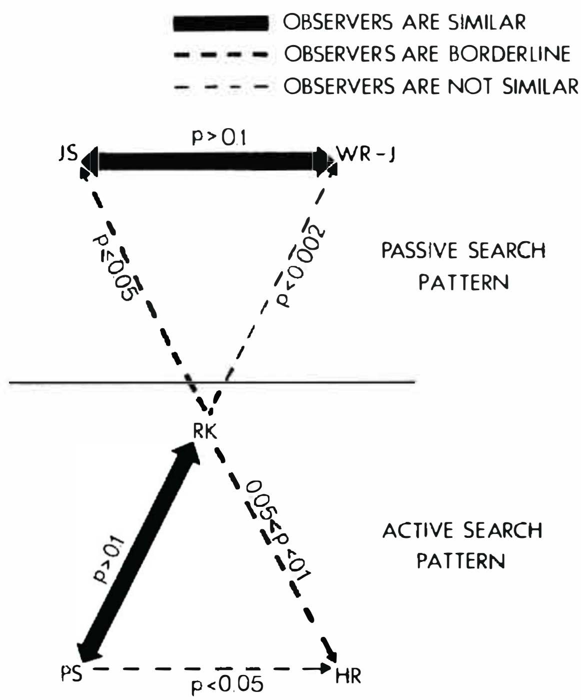
Observers were experienced in the identification of birds by sight and call. Each had been part of the census team for at least two years and was familiar with the strip transect technique. In addition to the authors, observers participating in the study were Messrs Jim Shields and Wyn Rohan-Jones of the Forestry Commission of N.S.W. and Dr Peter Smith of the N.S.W. National Parks and Wildlife Service. Observer variability was measured using a series of simultaneous counts on two study plots near Bombala, N.S.W. The plots are part of a detailed study of avian ecology and were well known to each of the observers. All had participated in monthly censuses on both areas since 1978. The plots were in a peppermint-gum open forest association, primarily *Eucalyptus radiata* and *E. dalrympleana* with *E. viminalis, E. ovata, E. pauciflora* and *E. stellulata* components. Foliage height profiles were complex but patchy and there were a number of small clearings in each plot.

Each plot consisted of two parallel strip transects. Transects were 420 m long by 120 m wide and were divided into three portions (Recher *et al.* 1983) which enforced an average rate of travel, if moving in a straight line, of 0.3 km/h over two-thirds of the transect and 0.12 km/m in the central one-third or spot point. Counts were two hours long and were conducted during July and September 1980. Observers were instructed to map all birds and to record whether the birds registered were first heard, heard then seen, or seen. Otherwise, they censused according to their own pattern. For some this meant "searching actively" for birds, while others moved "passively" forward at a metered pace, stopping at regular intervals and deviating little from the transect line.

Birds flying through over the plot were not counted unless foraging in the airspace above the forest. Other situations were left to the discretion of the observer. These included determining new individuals to be counted and distance estimates regarding whether a bird was in or out of the transect.

Simultaneous censuses

All observers were compared to one person (RK). Rather than have all five persons census simultaneously, comparisons were made in groups of two or three. This was done to reduce the probability of one observer distracting another. There was no communication during counts. Observer combinations were RK/HR and RK/JS in July, and RK/HR/PS and RK/JS/WRJ in September. The results of counts are purely relative between the observers. No comparisons have been made with actual population



● Figure 1. *RK, HR and PS are active searchers while JS and WRJ are passive searchers. Arrows indicate the degree of difference between observers within each group and between all observers and RK with respect to the numbers of birds each observer recorded during censuses. The Friedman test was used to determine whether the rank totals differed (Siegel 1956) and thus whether the differences between observers were significant. Wilcoxon Matched-pairs Signed-ranks Test was used to determine where these differences lay and which observers were different from the others.*

densities as estimated by combinations of other procedures such as territory mapping, mist netting and nest searching (see Shields and Recher in press, for a comparison of these methods). Comparisons betwen observers consisted of eight hours censusing (four two-hour counts) on four transects (two in each study area) per sample period.

Results and Discussion

Differences between observers

Differences were found between all observers in their estimates of bird numbers (Table 1). In September, when the five observers were tested together, JS and WRJ were similar to each other but different from RK, whereas PS and RK were similar but different from HR (Figure 1). Differences between RK and JS and between RK and HR for September were considered borderline because they occurred just either side of the 5% significance level. That is, HR may have been similar and JS may have been different from RK but more confidence is needed. The results of comparisons between these three observers were different to those in July. In July the census results of JS were similar to RK but those of HR were clearly different. The apparent differences between JS and RK in September can be partially explained by the increased number of birds on the plots (there were almost double the number of species present in September compared to July), which highlighted differences in the number of individuals recorded by each observer. In September RK scored more birds than JS even though similar species counts were recorded. Conversely, the differences between HR and RK changed from one of a highly significant difference in July to September when this difference was not significant (but borderline). This change can probably be explained by the attempts of HR in July to census and simultaneously record other observations on birds (foraging behaviour, nesting) during which time he consequently failed to register many birds.

In general, the differences recorded between observers were consistent with the impressions of individual variation obtained over several years of census work. HR and WRJ tend to record fewer birds and fewer species than RK and PS. JS recorded fewer individuals but as many species as RK and PS (Table 1). Some of these differences can be explained by the observ-

TABLE 1

The number of species recorded by each observer in July and September together with the mean number of species and individuals (standard error) recorded per two-hour count over the four plots. The proportion of mean number of species per census to the total number of species recorded for all observers is given as an index of species detection.

	July (Total species = 29)				September (Total species = 51)			
	Total Spp. Recorded	$\bar{x}$ Spp.	$\bar{x}$ Ind.	% of Total Spp. **	Total Spp. Recorded	$\bar{x}$ Spp.	$\bar{x}$ Ind.	% of Total Spp. **
RK	25	16.0 (1.1)	78.5 (11.2)	55	41	24.0 (1.0)	137.5 (8.4)	47
HR	23	11.0 (1.6)	46.0 (5.6)	38	36	20.0 (1.9)	124.0* (23.0)	39
PS	—	—	—	—	40	26.3 (1.1)	140.5 (8.7)	51
RK	24	15.3 (1.5)	80.3 (15.0)	53	41	27.3 (1.4)	137.0 (17.0)	53
JS	25	16.8 (2.4)	67.5 (13.8)	58	42	26.3 (2.2)	116.8 (9.9)	51
WRJ	—	—	—	—	37	22.5 (2.5)	112.3 (14.9)	44

* Excluding the excess numbers counted for one species (Red Wattlebird) in one census, HR mean individuals was 112.5 (14.5).
** Total species is the cumulative number of species recorded by all observers.

TABLE 2

Differences between observers in their estimates of abundant species. Mean counts (standard error) from four transects in each study period.

	JULY				SEPTEMBER					
	RK	HR	RK	JS	PS	RK	HR	WRJ	RK	JS
White-naped Honeyeater	10.5 (4.7)	2.3 (1.5)	15.0 (4.5)	6.0 (2.5)	33.5 (3.8)	35.3 (8.5)	36.8 (14.8)	26.3 (4.5)	33.5 (3.0)	30.8 (4.6)
Yellow-faced Honeyeater					14.3 (3.8)	22.3 (5.2)	17.8 (8.5)	15.3 (5.7)	12.3 (2.3)	2.8 (0.5)
Red Wattlebird					12.5 (7.7)	2.3 (0.5)	4.5 (1.9)	2.3 (0.9)	5.8 (2.1)	8.8 (4.1)
Striated Thornbill	20.0 (2.9)	17.3 (2.1)	17.0 (3.5)	18.8 (3.0)	4.5 (1.8)	6.0 (2.4)	5.0 (2.1)	5.3 (3.5)	6.3 (3.5)	7.0 (3.7)

TABLE 3

Differences between observers in their counts of some low density species. Mean counts (standard error) from four transects in each study period.

	JULY				SEPTEMBER					
Species	RK	HR	RK	JS	PS	RK	HR	WRJ	RK	JS
Ground Thrush	2.8 (1.0)	1.5 (0.7)	3.0 (1.2)	2.8 (1.1)	0	0.8 (0.8)	0.3 (0.3)	0	0.5 (0.5)	0.3 (0.3)
Scarlet Robin	0.8 (0.5)	0.5 (0.5)	1.3 (0.8)	0.8 (0.8)	1.5 (0.7)	1.3 (0.8)	0.5 (0.5)	1.0 (0.4)	1.3 (1.0)	2.3 (0.5)
Eastern Yellow Robin	3.0 (0.4)	1.5 (0.7)	2.0 (0.4)	1.8 (0.9)	3.5 (0.5)	4.3 (1.1)	2.3 (1.3)	1.3 (0.5)	3.5 (0.9)	2.8 (0.7)
Crested Shrike-tit	1.0 (0.6)	0.3 (0.3)	0.5 (0.5)	0.5 (0.5)	1.0 (0.4)	0.8 (0.3)	0.5 (0.5)	1.0 (0.6)	1.5 (0.3)	1.0 (0.4)
Rufous Whistler	0	0	0	0	3.5 (0.9)	4.0 (1.2)	2.5 (1.2)	6.8 (2.0)	6.0 (0.3)	6.3 (0.8)
Golden Whistler	0.8 (0.5)	0	0	0.8 (0.3)	2.3 (0.5)	1.8 (0.7)	2.0 (0.7)	1.8 (0.7)	2.5 (0.5)	1.5 (0.5)
Grey Shrike-thrush	1.3 (0.7)	0.5 (0.5)	1.3 (0.5)	1.3 (0.5)	1.5 (0.3)	1.0 (0.7)	1.5 (0.9)	1.5 (0.3)	2.0 (0)	1.3 (0.7)
Superb Blue Wren	3.0 (0.7)	2.3 (1.3)	4.8 (2.5)	7.5 (1.3)	3.8 (0.8)	3.0 (1.0)	3.5 (1.3)	2.8 (0.3)	4.0 (0.8)	5.5 (1.5)
White-browed Scrubwren	3.0 (0.6)	0.5 (0.3)	0.5 (0.5)	1.0 (0.4)	1.3 (0.8)	1.0 (0.7)	1.0 (0.6)	0	0.5 (0.5)	0.3 (0.3)
Brown Thornbill	10.0 (1.2)	7.3 (0.5)	8.0 (1.8)	3.0 (1.1)	4.3 (1.3)	3.0 (0.6)	4.3 (0.7)	0.8 (0.3)	4.0 (0.8)	2.5 (1.2)
Varied Sittella	0	0	0	0	2.5 (1.7)	0.5 (0.5)	0	0.8 (0.8)	0.5 (0.5)	1.0 (1.0)
White-throated Treecreeper	4.0 (0)	1.8 (0.5)	2.3 (0.5)	1.5 (0.3)	2.5 (0.7)	2.0 (1.2)	1.3 (0.5)	3.8 (1.1)	2.8 (0.8)	1.5 (0.3)
White-eared Honeyeater	3.8 (1.3)	3.0 (1.3)	4.5 (2.6)	4.0 (1.2)	0.8 (0.5)	2.3 (1.5)	0.3 (0.3)	1.0 (0.6)	2.5 (0.7)	1.0 (0.6)
Brown-headed Honeyeater	2.0 (2.0)	2.0 (2.0)	5.3 (1.3)	1.5 (1.0)	1.0 (0.7)	2.0 (1.2)	1.0 (1.0)	0.3 (0.3)	0.5 (0.3)	1.0 (0.7)
Striated Pardalote	0.5 (0.5)	0.3 (0.3)	0.5 (0.3)	0.8 (0.3)	6.0 (1.3)	5.3 (1.5)	4.0 (1.5)	4.0 (1.7)	6.0 (2.0)	2.3 (0.9)
Silvereye	0	0	0	0	1.5 (0.9)	0	3.0 (3.0)	1.0 (1.0)	1.3 (1.3)	0.5 (0.5)

ers' search patterns. HR, PS and RK were 'active searchers' and often moved away from the transect line to locate birds. JS and WRJ were 'passive searchers'. They rarely deviated from the line and moved at a measured pace with set pauses. The two passive searchers adhered more closely to the original census guidelines Recher *et al.* (1983).

It was apparent from this study that observers differed in their interpretations of the guidelines in a number of respects. The active searchers considered each transect to be a strip which was to be thoroughly searched whereas the passive searchers regarded the transect to be a line from which birds within the strip width were recorded. Other points of difference between the observers included whether to record birds behind the direction of travel and how far ahead to record new birds.

Abundant species

In this study much of the variation between observers could be attributed to estimates of White-naped Honeyeater *Melithreptus lunatus*, Yellow-faced Honeyeater *Lichenostomus chrysops* and Red Wattlebird *Anthochaera carunculata*. Each was abundant during one of the sample periods (Table 2). White-naped and Yellow-faced Honeyeaters are common breeding birds on both study areas, but move about in small flocks which include numbers of non-resident individuals. During a census, it is difficult to keep track of these flocks and it becomes a matter of individual judgement whether a group has been previously counted; this is a particular disadvantage of long-censuses in Australian forests (Recher *et al.* 1983). Three observers (HR, WRJ, JS) tended to be more conservative than the others (RK, PS) and included fewer flocks in their counts. However, the relative estimates between and within observers may differ substantially between individual censuses (Table 2). This table shows that the means for the three active searchers (PS, RK, HR) were quite similar for counts of White-naped Honeyeater in September, but HR was much more variable in his results. HR actually differed quite markedly from PS and RK on individual censuses.

A related problem is encountered with birds migrating through the study area in large flocks. During September the Red Wattlebird, which is also a breeding resident, passed through the census plots in large numbers. Most flocks passed over, but from time to time, individuals or small groups landed and foraged in the canopy. As foraging birds they should be counted in the census, but observers differed in their estimates of whether or not birds had landed within the limits of the transect.

The problems of censusing abundant species are probably most related to flock size, flock structure and composition, and rate of travel. It is instructive to consider another flocking species, the Striated Thornbill *Acanthiza lineata*. This breeding resident, unlike the honeyeaters considered above, forages slowly in small, tight flocks among foliage from the understorey to the forest canopy. Striated Thornbills were abundant on our study plots in July 1980 (Table 2) yet close estimates of bird numbers were achieved by the observers tested. It is suggested that estimates were more precise for Striated Thornbills because their group behaviour made it easy to keep track of them and flocks seldom moved faster than observers walked.

Low density species

Although there were differences between observers in their counts of abundant species, relatively greater differences were recorded in the estimates of less common species (Table 3). Because they concern a larger proportion of the avifauna (most species are not abundant), these differences may be more important than discrepancies in the numbers of abundant, widely distributed birds.

Detectability is highly variable among low-density species and this was evident from the precision of estimates between and within observers. Species such as Rufous Whistler *Pachycephala rufiventris* and Grey Shrike-thrush *Colluricincla harmonica*, frequently utter loud, distinctive calls and are readily seen and good agreement occurred in counts of these species (Table 3). In contrast, observers differed in their counts of the equally conspicuous and vocal White-throated Treecreeper *Climacteris leucophaea* and the White-eared Honeyeater *Lichenostomus leucotis*. Other species call less frequently and are hard to see (including Striated Pardalote *Pardalotus striatus*, Crested Shrike-tit *Falcunculus frontatus*, female Golden Whistler *Pachycephala pectoralis*, Eastern Yellow Robin *Eopsaltria australis* and Scarlet Robin *Petroica multi-*

color). Observers found it difficult to count these species and there appeared to be considerable variability in counts (Table 3).

The different search patterns of observers affected their estimates of many less abundant birds. Active searchers covered more ground at a higher average speed than passive observers. They therefore detected (flushed) more cryptic species (e.g. Ground Thrush* *Zoothera dauma*) and intersected more groups of species which are clumped in their distribution (e.g. Brown Thornbill *Acanthiza pusilla* and White-browed Scrubwren *Sericornis frontalis*) than passive searchers (Table 3). Thus the higher average counts of RK and PS are partially explained by their rate of movement.

Species identification

A major source of error in census work is an inability to detect or identify particular species. As expected from experienced observers, none of the observers consistently failed to identify particular species and the species totals for each observer in any sample period were similar (Table 1). However, some species represented by few individuals were missed. These species were not normally associated with the plots, or were birds thought by some observers to be flying over or otherwise off the plots. They included Square-tailed Kite *Lophoictinia isura*, Yellow-tailed Black Cockatoo *Calyptorhynchus funereus*, Gang-gang Cockatoo *Callocephalon fimbriatum*, Welcome Swallow *Hirundo neoxena*, Tree Martin *Cecropsis nigricans*, Rose Robin *Petroica rosea*, Red-browed Finch *Emblema temporalis*, Starling *Sturnus vulgaris*, Satin Bowerbird *Ptilonorhynchus violaceus*, White-winged Chough *Corcorax melanorhamphus*, Magpie Lark *Grallina cyanoleuca* and Australian Raven *Corvus coronoides*.

Some observers consistently counted fewer birds of some species than other observers but this could not reasonably be explained by search pattern. For example, HR's counts of White-naped Honeyeater were generally lower than other observers and highly variable. Similarly, JS's counts for Yellow-faced Honeyeater were low (Table 2). These two species have a 'chip' call which is similar and tend to call constantly which may confuse observers. WRJ did not record any Crescent Honeyeater *Phylidonyris pyrrhoptera* during the study period in which he was involved and this seems inexplicable apart from these birds being in low numbers. At least one case of mistaken identity was revealed. In September PS and HR recorded a Leaden Flycatcher *Myiagra rubecula* while RK and JS recorded a Satin Flycatcher *M. cyanoleuca*. During the past four years, only Satin Flycatchers were known to occur and breed on the study plots but in this case the one or two birds involved were Leaden Flycatchers migrating through the plots.

Observer perception

As previously discussed, observers differed in the number of birds recorded during a count. Some of these differences have been explained in terms of observer search pattern. In addition, visual and hearing acuity together with numerous other factors relating to observer condition, have long been recognised as sources of variability in census results (Enemar 1962; Robbins 1978). Ability to hear and see was not tested between observers in this study, but none of the observers was known to have problems. It was considered unlikely that ability to hear and see were major causes of difference between the observers Other factors, however, may be relevant. These include differences in motivation, fatigue and personality.

We assume that all observers were equally motivated but even with a single observer, levels of alertness and fatigue will influence daily results (Shields 1979). This can be illustrated indirectly by HR's July census results which were affected by the additional data he collected during censuses.

The personality or individual differences of observers may be expressed in terms of their tendency to over or under-compensate during bird censuses. HR and WRJ tend to be conservative in their counts of birds while RK, PS and JS are less conservative in their estimates of numbers (Table 2). HR and WRJ were inclined to exclude birds close to the edge of the transect, while RK, PS and JS added them to the count. In effect, the two groups of observers sampled slightly different sized areas. As JS recorded proportionately more species than in-

* English names of some species refered to in text do not conform to List of Recommended English Names. This has been accepted for publication in this form as the paper is one of a series published in a number of journals.

dividuals compared to other observers (Table 1), it is suggested that greater awareness or attention was given to birds of new species within or on the borders of the transect strip than to new birds of species already recorded. For this reason JS and the 'conservative personalities' of HR and WRJ may have tended to record second (and subsequent) detections of a species as repeats of birds already counted while RK and PS recorded them as new individuals.

These differences between observers can be illustrated in two ways. If observers differ in their estimates of numbers, it should be consistent between species. The less conservative person will tend to score more individuals for all species than a conservative observer. Comparisons were made between the number of species over or under-estimated between pairs of observers. In September, RK, PS and JS scored more birds over all species than HR and WRJ (Table 4). RK and PS, and JS and WRJ were equal in terms of the number of species in which one or the other estimated higher numbers of birds. Similar results were obtained using a 'species detectability' score. On average RK, PS and JS recorded more than half of the total number of species present on the plots after each two-hour census. In contrast, HR (38% in July and 39% in September) and WRJ (44% in September) consistently recorded fewer species (Table 1).

TABLE 4

Differences between observers in terms of the number of species for which one observer counted more birds than another observer. ($\chi^2$0.005, 1 df. = 3.84).

Census Period	Observer Comparisons (No. of Species)	Significance Level	χ^2 value
July	RK (20) HR (2)	$P < 0.01$	14.73
	RK (11) JS (8)	$P > 0.1$	0.47
Sept.	RK (26) HR (10)	$P < 0.01$	7.11
	RK (26) JS (14)	$P > 0.05$	3.60
	RK (14) PS (18)	$P > 0.01$	0.50
	RK (28) WRJ (7)	$P < 0.01$	12.60
	PS (21) HR (9)	$P < 0.05$	4.80
	WRJ (17) JS (21)	$P > 0.1$	0.42

Conclusions

Our observations and those of workers in New Zealand (Dawson *et al.* 1978) and Tasmania (Ratkowsky and Ratkowsky 1979) as well as studies in the Northern Hemisphere (e.g. Enemar 1962; Robbins 1978) illustrate the significant effects that observer differences can have on census results. The major factors causing differences between observers in this study in probable order of importance were:

(1) type of searching patterns

(2) individual behavioural traits of observers

(3) difficulties in estimating numbers of birds

(4) differences in estimation of distance to the boundary of the transect.

(5) difficulties in detecting or identifying particular species.

(6) differences in visual acuity and hearing ability of observers.

All of these factors differ between observers and must be compensated for in the design and conduct of censuses. It is for this reason that guidelines on censusing recommend the use of a single observer and caution against the comparison of census data obtained by different persons (e.g. Järvinen and Väisänen 1977, Cullen 1980). In regional surveys, however, it is often necessary to use more than one person as political and environmental demands commonly prevent a leisurely approach to such work. Therefore multiple observers must be used and the persons responsible for these surveys need to design their programme to minimize the effects of observer variability. In this regard, it is important to know the degree of variability between observers and to rotate observers between study plots to balance for these effects.

There is no single method of counting birds which is 'best' and the methods used will be determined by the kinds of data required and the individual preferences of the persons responsible for the work. Regardless of the methods used, it is necessary to standardize procedures and ensure that all observers work in the same way. Most census techniques provide only relative counts of birds so the aim should be to rigidly standardize procedures to maximize the degree of precision or consistency of counts between observers.

As a result of the work presented in this paper, we make the following recommendations:

- All observers should have an equal ability to identify birds by sight and sound.
- The search pattern of observers needs to be standardized. Ideally, all observers should not deviate from the transect line or census point depending on method used.
- The speed of the observers as they traverse the transect needs to be closely regulated.
- Take steps to ensure that observers do not suffer fatigue by censusing for prolonged periods.
- Observers need to be thoroughly trained. Strict guidelines need to be laid down for observers regarding all facets of census procedures including maximum distance ahead over which to record birds, whether to record birds behind the direction of travel and what to do regarding birds near the edges of the study plot.
- Observers should be trained to estimate distances (if this is required by the census method used), otherwise the edges of the transect or spot point should be clearly marked.
- Observers should be trained to estimate the numbers of birds in flocks or groups, and to count only those birds which were positively identified as being on the plot.
- Observers should not attempt to perform more than one observational task simultaneously.
- Observers should be regularly tested to ensure that each is detecting all species, estimating distances and numbers accurately, and using the same procedures.
- Observers should be calibrated and rotated among the study plots.

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R. Kavanagh,
Forestry Commission of New South Wales,
West Pennant Hills, N.S.W. 2120.

H. F. Recher,
The Australian Museum,
6-8 College Street,
Sydney, N.S.W. 2000.