Studies in Avian Biology No. 6:114–118, 1981.

LIMITATIONS OF THE MAPPING METHOD

HANS OELKE[1]

ABSTRACT.—The evaluation of bird territories by means of the mapping method has a number of serious limitations: the excessive effort; the rather sophisticated, nearly "bureaucratic" recommendations (= international and national rules of mapping); and the variety of personal and bird- or bird-community specific mapping errors. My discussion of errors is focused on the difficulties of mapping small study plots in tropical woodlands, on the inappropriateness of maps per se (through problems of scale, symbols and saturation) and on the limits set by time and memory for the interpretation of the mapping.

The traditional method of area-specific, quantitative bird surveying in central and northwest Europe (Germany, Czechoslovakia, Poland, part of Austria, Switzerland, Denmark, Sweden, Norway, and the United Kingdom) is the so-called mapping method (reviewed in Palmgren 1930, Enemar 1959, Oelke 1966, Williamson 1972, Berthold 1976, Zenker 1980). The numerous and mosaic-like, man-made habitats in these parts of Europe are normally suitable for the mapping method.

COMMON LIMITS OF THE METHOD

There are a great number of limitations of the mapping method which recently became apparent because of experience with ever increasing and lasting environmental impacts, and because of the results of studies on the population biology of several species. There have been a large number of mapping recommendations published after the 1969 Ammarnäs-Symposium of the International Bird Census Committee (IBCC) and nationally modified in many ways (for the Federal Republic of Germany see Oelke 1970, 1974; for the United Kingdom see Williamson et al. 1976). This proliferation is becoming an increasing obstacle. The detailed recommendations will not only distract participation or cooperation of new bird watchers, they are limiting the number of study areas. The atlas and grid net programs, although mostly qualitative, must be regarded as a solution to the difficulties of the mapping method because of their simplicity and efficiency. More data from more observers may be summarized for wider geographical areas on clear maps within a relatively short time. For examples in central and northwest Europe see Yeatman (1976), Dybbro (1976), Rheinwald (1977), Bezzel et al. (1980), Schifferli et al. (1980).

METHODOLOGICAL DIFFICULTIES

The methodological difficulties of mapping are summarized by Berthold (1976):

1) Song registrations cannot be used as basic mapping units because song activities are highly influenced by (a) inter- and intraspecific differences; (b) seasonal, yearly, and daily changes; (c) by weather conditions; (d) by differences in abundance of birds; and (e) by simultaneous singing of neighbouring territory holders. This results in marked mistakes that are masked in the registrations.

2) The plotting of bird territories using the registrations of singing males or calling birds is hindered by: (a) the extreme territory areas occupied by some species; (b) the simultaneous occupancy of several territories; (c) the displacement of territorial border lines; (d) the territorial behaviour of migrants and of unmated, non-territorial birds, and abnormal and variable pair bonds.

3) Quite normally the efficiency of detecting species differs species-specifically.

4) The size of the study area is not precisely laid down either internationally or nationally with the result that study areas differ in size and thus they differ in the accuracy of the bird population estimates.

5) Day by day activity differences are not only characteristic of song but of the behavior, especially the movement activities as a whole.

6) Maxima of certain species due only to phases of migration can lead to wrong conclusions.

7) As with any set of observations, there are large observer deviations, and even errors.

8) The evaluation of data is too susceptible to subjective interpretation.

9) Usable or reliable correction coefficents more or less do not exist.

Unfortunately, these difficulties and inconsistencies are even surpassed by the disadvantages of the nest search method favoured by Berthold (1976) (see Oelke 1977). On the basis of long experience in the practical use of the mapping method, Tomialojć (1980) has added additional weak points. For example, he discusses the limitations with the differences between territorial and non-territorial songbirds and other species; the standardization number of visits for each observer; the undescribed or overlooked duration of visits within the recommendations; and especially to the thesis that birds are singing in the center, not along the pe-

[1] Zoologisches Institut, Universität Göttingen, D-34 Göttingen Federal Republic of Germany.

TABLE 1
DIFFERENCES BETWEEN A PRAGMATIC AND A THEORETICALLY NECESSARY TERRITORY MAPPING OF A TROPICAL WOOD (KAKAMEGA FOREST[a], KENYA, EAST AFRICA, 1978, 1979)

	Achieved	Theoretically necessary
Area (ha)	2.25	10
Edge length (m)	600	1265
Quotient 2/1	267	127
Number of visits	9	10
Duration (min/ha)	100	100–150
Daily distribution between:		
Sunrise and sunset (in h)	07:30–19:00	03:00–22:00 (Arctic/Temperate Zone)
Sunrise–sunset (h)	06:30–19:00	24 (Arctic)
Maximum observation time (h)	appr. 12	up to 24
Form of control routes	fixed on trails	unfixed

[a] Characteristics of the tropical study plot: Kakamega Nature Wood Reserve, neighbouring north side of Kakamega Forest Station (sheet 102/4 Kaimosi, East Africa, Kenya, coordinates YR 707.5/026.5); semitropical rainforest, elevation 1580 m with luxuriant tree, shrub, ground cover, numerous epiphytes and lianes, approximately 25 km N of the equator; 23 tree species with a height of 38.5 m (diameter up to 101 cm), a cover of the tree layer of 51%, of the shrub layer of 50–75%, of the ground layer of 84%, on the average; approximately 2740 shrubs per ha.

riphery of the territories. Tomialojć (1980) suggests: a greater flexibility in the international rules; the inclusion of all species of the bird community; the more accurate determination of territories by contemporary contacts; more tests on the reliability in extreme mapping situations; increase of length of each visit; a revival of the discussion of edge territories; and a revision of the international recommendations of the IBCC to improve the effectivity of the mapping method. Some additional mapping experiences of mine favor this revision.

SPECIAL PROBLEMS

PLOT SIZE AND MORE COMPLEX HABITATS

The IBCC recommends that the minimum size of a study plot should be 40–100 ha in an open habitat, and 10–30 ha in a more complex habitat. These recommendations are based on experiences in holarctic study plots such as the tundras, steppes/prairies, woods/forests and man-made habitats in North America and Europe. However, these recommendations are met by nearly unsurpassable methodological difficulties

TABLE 2
COMPARISON OF BIRD CENSUSES CARRIED OUT BY ZIMMERMAN (1972) AND OELKE (1978 AND 1979) IN THE KAKAMEGA WOOD RESERVE, KENYA, EAST AFRICA

	Zimmerman	Oelke
Size of study plot (ha)	8.1	2.25
Year(s) of study	1963, 65, 66	1978, 79
Time spent (in h)	431	17
Time factor (h/ha/a)	17.7	4.1
Number of control (days/a)	appr. 16	9
Methods	spot-mapping, mist-netting, tape replay	mapping, mist-netting
Mist nets, number, length	6 × 14 m	2 × 6 m
Operation time	continuously	2–3 h/day
Abundance (pairs resp. males/10 ha)	165	196
Territorial species (*n*)	64[a]	32
Total of identified species (*n*)	125[b]	73[c]
Proportion (%) of species occurring (206)	60.7	35.4
Woodland bird species (*n*)	92	64
Percent of occurring species (154)	60.0	41.6

[a] Minor human interference as lacking road and trail nets, more distant settlements, reduced cattle grazing, minor poaching, no bird collecting incl. bird studies should be kept in mind to get higher bird species numbers in 1963–66.
[b] Zimmerman includes even species of open woodland and outside the woods.
[c] Edge species, feeding or visiting species are included. The species numbers of the Kakamega area are from the lists of Cunningham-van Someren (1979).

TABLE 3
DIFFERENTIATION OF METHODS FOR STUDYING BIRD POPULATIONS OF A TROPICAL STUDY PLOT (KAKAMEGA NATURE WOOD RESERVE, KENYA, EAST AFRICA, SEE TABLE 1, 2)[a]

Dominant method	1978		1979		"Normal" mapping results[b]	
	No. species (%)	No. territories (%)	No. species (%)	No. territories (%)	% species	% territories
Registration of singing males	2 (8.3)	6 (12.4)	2 (8.3)	7 (17.5)	50	50(–70)
Song/sight observations	12 (50.0)	31 (64.0)	11 (45.8)	20 (50.0)	30	(10–)30
Sight observations only	1 (4.2)	1 (2.1)	5 (20.8)	5–6 (12.5)	10	10(–20)
Nest records	—	—	—	—	—	10(–30)
Mist netted	9 (37.5)	11 (22.7)	6 (25.0)	7–8 (17.5)	—	—
Other identifications[c]	—	—	—	—	5	5
Sum	24	48–49	24	39–41		
Additional unproved records	5	5	2–3	3–5		

[a] Only the stationary birds of the population are included, not feeding species, visitors, and migrants.
[b] Based on bird censuses in more complex woodland study plots in North American and Germany (Oelke 1963, 1967, 1977b).
[c] e.g., feather samples, pellets, fecal rests, tracks left from running, swimming, or feeding birds.

in monitoring populations of tropical woodland bird populations (see Tables 1–3).

The examples discussed below from Kakamega Forest area are derived from study plots with previous ornithological inventories. Thus, the results of Zimmerman's (1972) population studies, the bird skin collections of the National Museums of Kenya, Nairobi, and the experiences of British banding groups have contributed supplementary and necessary information.

Without tape recorders and mist nets for catching the birds of the ground and shrub layer, an exact identification of bird species is nearly impossible. The upper canopy of the wood reaching 60 m in height in the Kakamega Forest area restricts, too, the identification of smaller birds, mostly passerines. Small study plots also present difficulties in censusing tropical woodland areas. These difficulties are (a) acoustic and visual species identification problems due to extreme species diversity and complex differentiation of habitats, (b) temporally non-fixed or nearly unknown territorial periods, and (c) unknown interspecific relations between resident bird populations and palaearctic migrants. Methodological tests on the effectiveness of the mapping method as carried out recently by Svensson (1978) or in a number of important German dissertations (Cyr 1977, Blana 1978, M. Erdelen 1978, B. Erdelen 1979) are still lacking in the tropics, at least of Africa. These tests are increasingly important along with the need to monitor population size and dynamics of birds in western industrial nations. Tropical areas are more or less affected by pollution affecting birds both during migration and on their migratorial rest grounds. The task of monitoring has not yet really started.

MAPS FOR MAPPING

The IBCC recommends maps scale 1:1250–1:2500 for mapping in woodland. In open country maps scale 1:2500–1:5000 may be used. (The German recommendations are based on maps scale 1:5000–1:10,000; see Oelke 1974.) Even when using an optimal scale and by use of special markings for orientation, putting down any location of a bird on a map is subject to error (Table 4). These difficulties increase in dense habitats or densely populated areas such as woodlands with more than 100 breeding pairs or territorial males per 100 ha with a greater number of mappings even during one visit. Each mapping (daily visit) is limited by the capacity of mapping symbols within one map. De facto, this capacity is even lower, probably 25–50%, as calculated in Table 4. This is because there are always concentrations of birds in some parts of the plot and therefore on the map, or simply because intervals must be left between the symbols/numbers for interpreting purposes.

The optimum of mapping with maps of a scale of 1:1250 can only be reached in a few instances because these maps are unwieldy. The normal map format generally coincides with the commercial typewriter formats (in Germany it is

TABLE 4
MAP SIZE (IN CM) OF A 10 HA STUDY PLOT QUADRATE IN REGARD TO DIFFERENT MAP SCALES[a]

Scale	Paper size of study plot (in cm)	Area cover of an abbreviated symbol (in m)	Differences (in m) when moving the symbol for			Capacity for mapping symbols[a]	
			1 mm	5 mm	10 mm	In theory *n*	In reality *n*
1:1250	25.4 × 25.4	2.5 × 3.75	1.25	6.25	12.5	1344	1000
1:2500	12.7 × 12.7	5 × 7.5	2.5	12.5	25	336	250
1:5000	6.34 × 6.34	10 × 15	5	25	50	83	60
1:10,000	3.17 × 3.17	20 × 30	10	50	100	21	15
1:25,000	1.3 × 1.3	50 × 75	25	125	250	4	3

[a] Area cover (in m × m) of a normal written, abbreviated species symbol (e.g., B = Buchfink—*Fringilla coelebs*, appr. 2 × 3 mm) and area differences (in m) when moving the abbreviated species symbol 1/5/10 mm on the map.
[b] Area of a symbol inclusive details on bird activities: appr. 4 × 6 mm; the same area is calculated for the interval between the symbols necessary for reading (interpretation).

29.5 × 21 cm). Normally an observer does not carry with him any further enlargements of the maps but tries to complete the registrations on *one* single map of the study plot. Rarely 1000 registrations (scale 1:1500) can be put down on such a map the size of a typewriter paper. The scale 1:1500 is sufficient in most cases for one visit (100–200 registrations on the average, in my own experience); difficulties arise during prolonged visits, and because of clustering of bird symbols on some parts of the map. In these cases even the normal daily visit map is marked by unclear and hardly interpretable parts.

Not only do the daily visit maps offer some problems, but more often the species maps, summary and combination of all daily registrations of one species per observation period, result in problems. The main purpose of the species map is to determine territories. This cannot, or can only arbitrarily, be solved in the case of high densities or clusters of registrations. For example, it is unclear in which way Erdelen (1978) and Blana (1978) established territories with a maximum of 23 visits to a 10 and 5 ha thicket and 33 visits to a 25 test study plot in mature oak forest. Both authors, however, made use of their registrations to evaluate possible additional errors as correlations between territory numbers and number of visits as well as intraspecific differences in daily and seasonal registrations.

TABLE 5
DIFFERENCES BETWEEN FIRST AND REPEATED TERRITORY EVALUATIONS (1980) FROM SPECIES MAPS OF THE CHAFFINCH DERIVED FROM MAPPING A 10 HA MATURE MIXED DECIDUOUS WOODLAND PLOT (STAATSFORST HÄMELERWALD, COMPARTMENT 128/129, PEINE COUNTY, LOWER SAXONY, FEDERAL REPUBLIC OF GERMANY, 1968–1977)

Year	Number of territories		% differences	New territory boundaries (*n*)
	Study year	Reanalysis		
1968	7	5	−29	2
1974	5–6	8	(+)25–(+)60	5
1975	4–5	4	0–(+)20	1
1976	4	3–4	0–(−)25	2

LENGTH OF INTERPRETATION OF REGISTRATIONS

The territorial mappings are normally summarized in a few parameters such as number of species, territories or territorial birds, abundance, dominance, frequency, and diversity indices. The process of interpretation has to start with these data for the normal reader. Normally, access to the primary registrations of the field data is not possible. Many raw data are lost forever because the census takers are no longer living. But it is often not sufficient even if all raw data are made available, and the necessary personal knowledge of a habitat is achieved. The census taker himself is always in the best position to analyze data because of a bulk of unmentioned, unwritten "intimate" details of a mapping process. This is quite normal and is due to: a lack of space and time; difficulties of transforming the complex of behavioural activities into graphical symbols; and very often because of the ever changing locations of birds. These unwritten details are available during the period of active research and shortly afterwards when analyzing the territories. But they will be forgotten in the course of time. After 2 or more years, perhaps even earlier, the observer hardly remembers the intricate reasons for his decisions to determine the territories. This is especially true in study plots with many registrations, or with high bird densities. I have found major differences between my species maps from 1968 and 1974–1976 of the Chaffinch

(*Fringilla coelebs*), a species with rather good detectability. This species was mapped on a 10 ha plot in mixed deciduous forest (Table 5). The discrepancies are even higher when determining the size and border lines of the Chaffinch territories.

CONCLUSION

Regardless of all attempts to register "absolute" density figures of birds, territorial mappings have to be regarded as good or sometimes better approximations. A wide spectrum of different errors will always be inherent in this ecological field method.

ACKNOWLEDGMENTS

The African (Kenya) field data were enabled by the support of Drs. G. R. Cunningham-van Someren, A. W. Diamond, H. Hagen; Mrs. J. F. Horne, Forester J. R. Oruko, Drs. H.-U. Reyer, J. Steinbacher; Mr. D. A. Turner, but especially, too, by my field assistants J. Gutwa and J. R. Ocholla. I am grateful to these persons and the Government of Kenya which issued the necessary research permit.