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Influence of a shrub corridor on movements of passerine birds to a lake littoral zone

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Abstract

A pine forest was separated from a lake littoral zone by a meadow on one area (discontinuous) while these habitats were separated by a shrub strip in another area (continuous). This shrub strip acted as an ecological corridor enhancing the movements of birds between the forest and the littoral reed zone. The number of individuals of non-littoral species that visited the reed zone was higher ($p < .001$) on the area with the connecting shrub strip in autumn but the number of species visiting the littoral zone was not significantly higher. Significantly more ($p < .001$) autumn movements by birds in the continuous area were oriented along paths between the forest and the littoral zone whereas movements in the discontinuous area paralleled the littoral and forest zones ($p < .001$). Movements of birds were concentrated along the edge of the shrub strip. The spatial configuration of the landscape facilitated access by some forest birds to the littoral habitat.

Introduction

A remarkable spatial variety of the landscape, resulting from interactions between intrinsic environmental patchiness and land use decisions, is characteristic of many regions which have been exposed to intensive human activities – *e.g.*, those subjected to urban development (cf. Faeth and Kane 1978, Dickman 1987) or to agriculture (Wegner and Merriam 1979, Opdam and Schotman 1987, Van Dorp and Opdam 1987, Merriam 1988). Landscape heterogeneity is one of the factors shaping the spatial distribution of many animal species. Their occurrence may be limited to the patches suitable for their settlement, separated from one another by barriers which, to various degrees, may impede the dispersal of individuals.

The ability of individuals to disperse within a heterogeneous area, possibly by the use of ecological corridors, can convert isolated subpopulations into a single demographic unit, a metapopulation (sensu Levins (1970)). Enhanced movement through the habitat mosaic may enable different bird populations to use a diversity of resources from various elements of the landscape. Thus, the importance of ecological corridors (*i.e.*, connectivity) among different structural elements of the landscape is one of the basic questions in modern landscape ecology (Forman 1981, Forman and Baudry 1984, Forman and Godron 1984, Merriam 1984, Fahrig and Merriam 1985).

The main aim of this study is to examine the movements to the lake littoral zone of passerine birds which breed outside this zone, and to test the hypothesis that the presence of a strip of shrub habitat between a pine forest and a lake littoral zone affect movements between the forest and the littoral zone by non-littoral passerine birds.

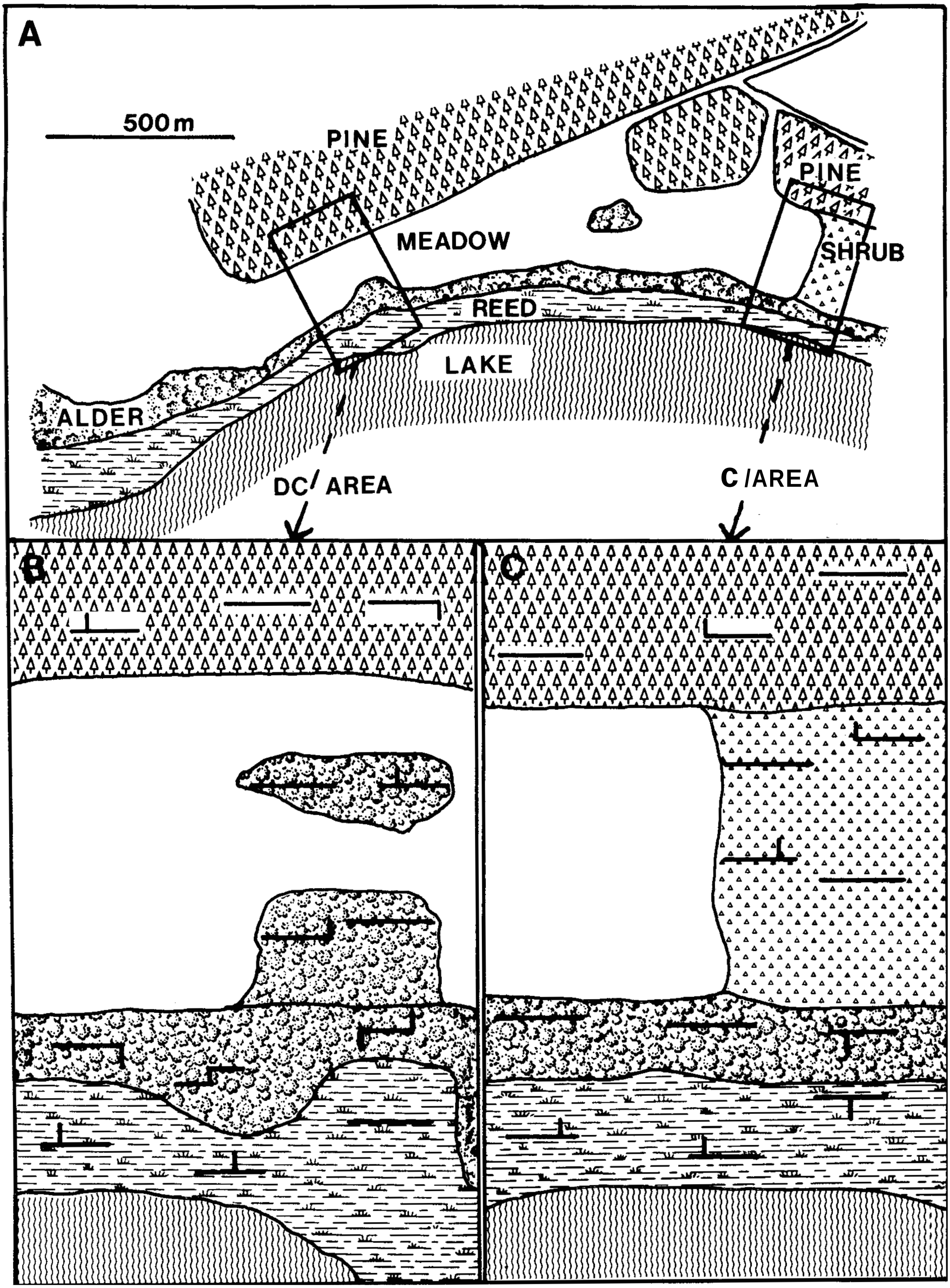

Fig. 1a. Map of study areas: ***b.*** and *c.* distribution of nets in DC and C areas.

Study areas, methods, material

The study areas were two eight-hectare plots at Lake Sniardwy (North-Eastern Poland). The first one consisted of a strip of reeds dominated by *Phragmites*, making up the littoral zone together with the adjacent alder swamp (*Alnus, Salix*), and a fragment of pine forest (*Pinus sylvestris, Sambucus*), separated from the littoral zone by a meadow (*Anthoxanthum, Climacium, Rumex*) on which there was a small isolated alder wood (DC, Fig. 1). Due to the abrupt transition between the forest and the lake littoral, the first area was called "Discontinuous" (DC). The second study area – a "Continuous" one (C) – had a similar habitat configuration, except for the edge of a several hundred square meter complex of willow-birch (*Salix cinerea, Betula verrucosa*) shrub strip connecting the pine forest and the lake littoral zone (Fig. 1). Complete descriptions of the plant communities are available on request.

In both study areas mist nets were operated from the beginning of May until the end of September for 5 day periods at intervals of approximately one month. Each study area had 65 mist-nets set in groups of 5. The distribution of the nets in both areas was similar (Fig. 1). The nets were inspected every 1.5 hour from dawn to dusk; all captured birds were banded.

Overall, 2639 birds of 52 passerine species were captured in the 2 areas. Of these, 15% were recaptures (Table 1). Two groups were distinguished: littoral and non-littoral birds. Littoral birds were those known to be closely confined to extremely wet biotopes during their breeding season, *e.g.*, those using the reed or its edges for nesting. This group included: *Acrocephalus* sp. (except marsh warbler – *Acrocephalus palustris*), *Locustella* sp., *Remiz* sp., reed bunting – *Emberiza schoeniculus* and bluethroat – *Luscinia svecica*. Species which did not breed in the reed zone, or those which bred in this area only occasionally, were considered non-littoral (Table 1).

Results

Species composition and numbers of the passerines visiting the reed zone

During the mist netting in both study areas, 308 non-littoral birds were found in the reed zone (Table 2). The total number of non-littoral birds visiting the reed zone was twice as high in the Continuous area as in the Discontinuous area (Table 2). The non-littoral birds found in the reed included 24 species of which 14 species were caught in the DC area and 19 species in the C area. The same species of non-littoral birds dominated the littoral zone of both areas, *i.e.*, chiffchaff – (*Phylloscopus collybita*), blue tit – (*Parus caeruleus*), robin – (*Erithacus rubecula*), and willow warbler – (*Phylloscopus trochilus*) (Table 2). Other species were represented by fewer individuals. Nine non-littoral species were found in both study areas (Table 2).

Temporal distribution of captures

The frequency with which the reed zones were visited by non-littoral birds varied from pre- to post-breeding periods in both study areas. Captures of non-littoral species in the reeds through the field season declined during the peak of breeding (between mid-May and mid-June). Visits to the reeds began during the pre-breeding season and peaked after the breeding season (Fig. 2).

The occurence of non-littoral species in the littoral zone was highest in the *C* area in September when the number of non-littoral bird species visiting the littoral zone was approximately 2.5 times higher than the number of species breeding in this habitat – compared to 1.5 times in the DC area (Fig. 2). However this difference was not significant ($G = 0.61$, df 1, $0.5 < p < .25$). Large seasonal fluctuations were observed in the captures of non-littoral species (2% in summer, DC area to 28% in autumn, C area) (Fig. **3**).

Between June and July in the C area, the proportion of non-littoral birds in total captures in the pine forest decreased, whereas the number of captures in the reed zone was steadily increasing. By

Table 1. Number of single captures (C) and retraps (R) of passerine birds on study areas between I May and 30 Sept.

Non-littoral species:	DC area		C area	
	C	R	C	R
1. *Parus caeruleus* L.	50	5	47	7
2. *Parus major* L.	59	13	15	–
3. *Parus montanus* Conv.	32	7	29	12
4. *Parus palustris* L.	34	13	13	2
5. *Parus cristatus* /L./	4	1	1	–
6. *Aegithalos caudatus*/L./	2	–	8	1
7. *Regulus regulus* /L./	2	–	20	–
8. *Phylloscopus collybita* /Vieill./	132	34	124	16
9. *Phylloscopus trochilus* /L./	14	2	18	1
10. *Phylloscopus sibilatrix* /Bechst./	13	1	9	2
11. *Sylvia borin* /Bodd./	72	24	21	2
12. *Sylvia atricapilla* /L./	83	16	41	6
13. *Sylvia communis* Lath.	7	1	7	2
14. *Sylvia curruca* /L./	2	–	21	2
15. *Sylvia nisoria* /Bechst./	8	–	–	–
16. *Hippolais icterina* /Vieill./	17	1	3	–
17. *Acrocephalus palustris* /Bechst./	6	3	7	8
18. *Turdus philomelos* C.L. Brehm	27	2	25	5
19. *Turdus merula* L.	28	2	23	6
20. *Luscinia luscinia* /L./	18	8	6	1
21. *Phoenicurus phoenicurus* /L./	2	–	4	–
22. *Erithacus rubecula* /L./	111	23	248	38
23. *Muscicapa striata* /Pall./	8	1	1	–
24. *Ficedula hypoleuca* /Pall./	1	–	5	–
25. *Ficedula parva* /Bechst./	1	–	4	–
26. *Hirundo rustica* L.	1	–	–	–
27. *Fringilla coelebs* L.	73	11	51	9
28. *Fringilla montifringilla* L.	–	–	1	–
29. *Emberiza citrinella* L.	21	1	10	1
30. *Carpodacus erythrinus* /Pall./	1	–	–	–
31. *Carduelis spinus* /L./	3	–	3	–
32. *Pyrrhula pyrrhula* /L./	13	–	9	2
33. *Coccothruustes coccothraustes* /L./	2	–	1	–
34. *Lanius collurio* L.	1	–	–	–
35. *Anthus trivialis* /L./	6	–	2	–
36. *Motacilia flava* L.	1	–	–	–
37. *Prunella modularis* /L./	5	–	21	9
38. *Sitta europaea* L.	2	–	5	–
39. *Certhia familiaris* L.	4	1	7	3
40. *Troglodytes troglodytes* /L./	9	3	30	5
41. *Garrulus glandarius* /L./	1	–	1	–
42. *Sturnus vulgaris* L.	2	–	1	–
43. *Oriolus oriolus* /L./	3	–	–	–
Subtotals	881	173	848	140
Littoral species:				
44. *Acrocephalus arundinaceus* /L./	15	4	–	–
45. *Acrocephalus scripaceus* /Herm./	240	45	96	9
46. *Acrocephalus scheonobaenus* /L./	61	10	50	8
41. *Remiz pendulinus* /L./	15	–	6	–
48. *Emberiza schoeniclus* L.	12	2	6	–
49. *Locustella naevia* /Bodd./	1	–	–	–
50. *Locustella fluviatilus* /Wolf./	5	3	3	–
51. *Locustella lusciniodes* /Savi./	3	1	1	–
52. *Luscinia svecica* /L./	1	–	–	–
Subtotals	353	65	162	17
Totals	1234	238	1010	157

Total initial captures + recaptures 2639

Table **2. Number (%) of non-littoral passerine birds visiting the lake littoral zone in each study plot.**

Species	Plot DC	Plot C
Phylloscopus collybita	56 (54.4)	79 (38.5)
Parus caeruleus	20 (19.4)	36 (17.6)
Erithacus rubecula	8 (7.7)	24 (11.7)
Phylloscopus trochilus	6 (5.8)	14 (6.8)
Regulus regulus	– –	13 (6.3)
Sylvia curruca	1 (1.0)	10 (4.8)
Troglodytes troglodytes	2 (1.9)	5 (2.4)
Parus montanus	2 (1.9)	4 (1.9)
Parus major	2 (1.9)	3 (1.4)
Sylvia atricapilla	– –	3 (1.4)
Aegithalos caudatus	– –	3 (1.4)
Sylvia borin	– –	2 (1.0)
Turdus philomelos	– –	2 (1.0)
Prunella modularis	– –	2 (1.0)
Acrocephalus palustris	1 (1.0)	1 (0.5)
Motacilla flava	1 (1.0)	– –
Hirundo rustica	1 (1.0	– –
Sturnus vulgaris	1 (1.0)	– –
Sylvia communis	1 (1.0)	– –
Phylloscopus sibilatrix	1 (1.0)	– –
Ficedula parva	– –	1 (0.5)
Phoenicurus phoenicurus	– –	1 (0.5)
Emberiza citrinella	– –	1 (0.5)
Hippolais icterina	– –	1 (0.5)
Total individuals (%)	103 (100)	205 (100)
Total species	14	19

July, the number of individuals caught in the reed zone was approximately twice as large as the corresponding number for the pine forest. In September, this divergence was even more conspicuous (Fig. **3).** In the DC area the proportion of non-littoral birds captured in the pine forest tended to be high until (and even during) July, whereas their occurrence in the reed zone was decreasing. It was not until September that total number of captures in the pine forest decreased slightly, with a simultaneous increase of their presence in the reed zone. Even then, however, they were more numerous in the pine forest than in the reed zone (Fig. **3).**

Spatial distribution of captures

In September, in the C area, there was an increase in captures of non-littoral birds along the edge of

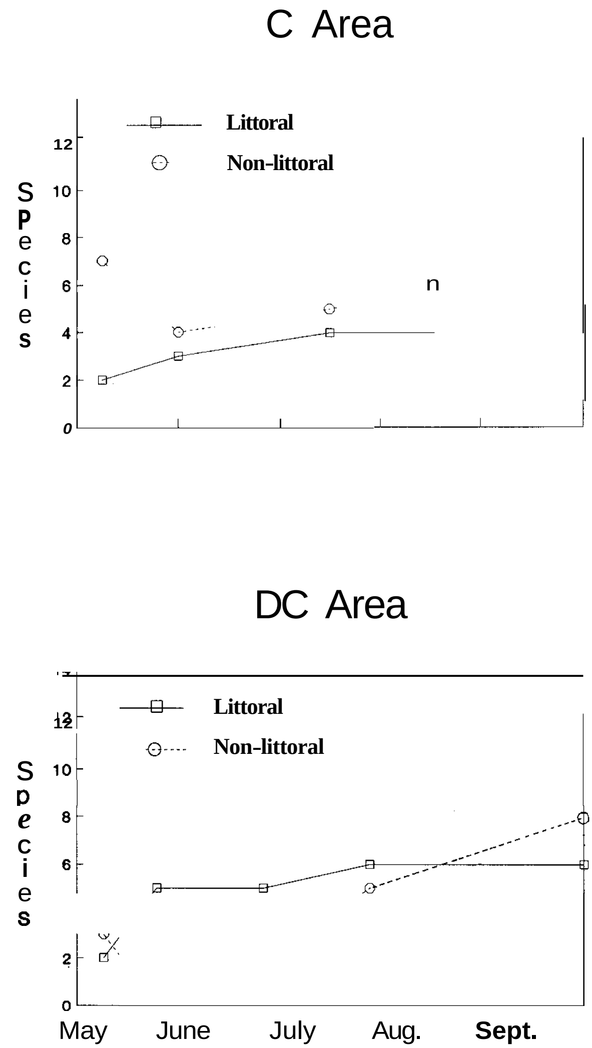

Fig. **2. Fluctuations in number of passerine bird species captured from May to September in the lake littoral zone.**

the strip of shrubs linking the pine forest to the lake littoral zone (Fig. 4b). September mean captures in 10 nets along the edge of the strip of shrubs were significantly different from captures in 10 nets in the interior of the shrub strip (Fig. lc) (t-test, $p < 0.05$).

In the DC area, there was no clear increase in the number of non-littoral birds captured in the zone between the pine forest and the lake littoral zone at any season (Fig. 4a). In September, only a few birds were caught in the forest, and the numbers were similar for both sets of nets between the forest and the lake littoral. Captures in the 10 nets along the

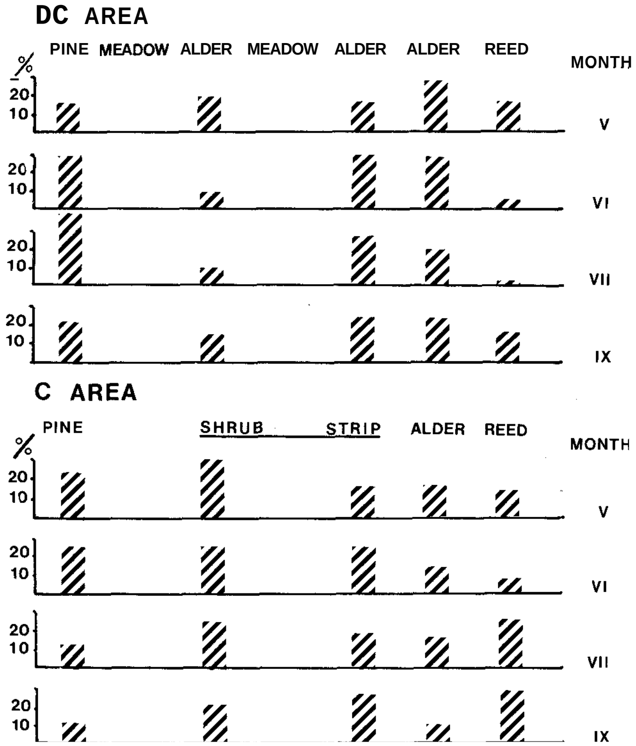

Fig. 3. The percentage of total monthly captures of non-littoral birds in each habitat zone, for each month. No data for month VIII.

edge of the shrub strip in the C area differed significantly from 10 corresponding nets in the DC area (t-test, $p < 0.05$) (Fig. 4a, 4b). During spring and summer, captures in both the C and DC areas, and in the edge nets compared to interior nets in the shrub strip were approximately equal (Fig. 4a, 4b).

The directions of bird movements in the study areas

Two methods were used to analyse the directions of bird movements within the study areas. The first used directions shown by recapture data. The second compared captures in nets parallel to the forest-reed axis with captures in nets perpendicular to the forest-reed axis. This analysis was applied only to the period of the greatest bird activity (September), when more birds visited the reed zone.

Fifteen passerine birds were recaptured during this period. The analysis of the locations of recaptures within the study area indicated the direction an individual was flying. The number of nets perpendicular to the forest-reed axis was several times higher but was comparable in C and DC.

In the C area, 66% of recaptures indicated movement between the forest and the reed zones along the corridor. Of the remainder, 29% indicated that birds were flying perpendicular to the pine forest-reed axis and 5% showed no movement (recaptured in same group of nets) (Table 3). Movements were significantly different in the DC area ($G > 28$, 2df, $p < 0.001$) where only 29% moved between the forest and reed zones while 27% moved parallel to the vegetation zones and 44% did not move (Table 3).

The significant prevalence of movements between the forest and the reed zone in the C area was confirmed by analysis of mean total captures for nets parallel to and perpendicular to the forest-reed axis. In autumn in the *C* area, 82% of all captures were in nets set perpendicular to the flight path between the forest and reed zones, with only 18% of captures indicating flights in the perpendicular direction ($G = 47.1$, 1df, $p < .001$). In the DC area results were reversed; the corresponding results were **38%** and 62% respectively ($G = 384.4$, 1df, $p < .001$).

Discussion

Use of the littoral zone of inland water bodies by small passerines from other breeding habitats has been described by many authors (Tischler 1943, Hawthorn 1975, Stiefel 1976, Hudec and Stasny 1978, Nachtigall 1979). Such visitors have been reported foraging in autumn for cockchafers, spiders and, most of all, the larvae and the pupae hidden in the reed sprouts. Prey reported include dipterans (Chloropidae and Cecidomyidae), hymenopterans (Ichneumonidae and Chalicididae), and certain lepidopteran larvae (Tischler 1943, Fromel 1980).

Among the 43 non-littoral passerines caught in the study area, as many as 24 (56%) were also found in the reed zone (Table 2). A similar inci-

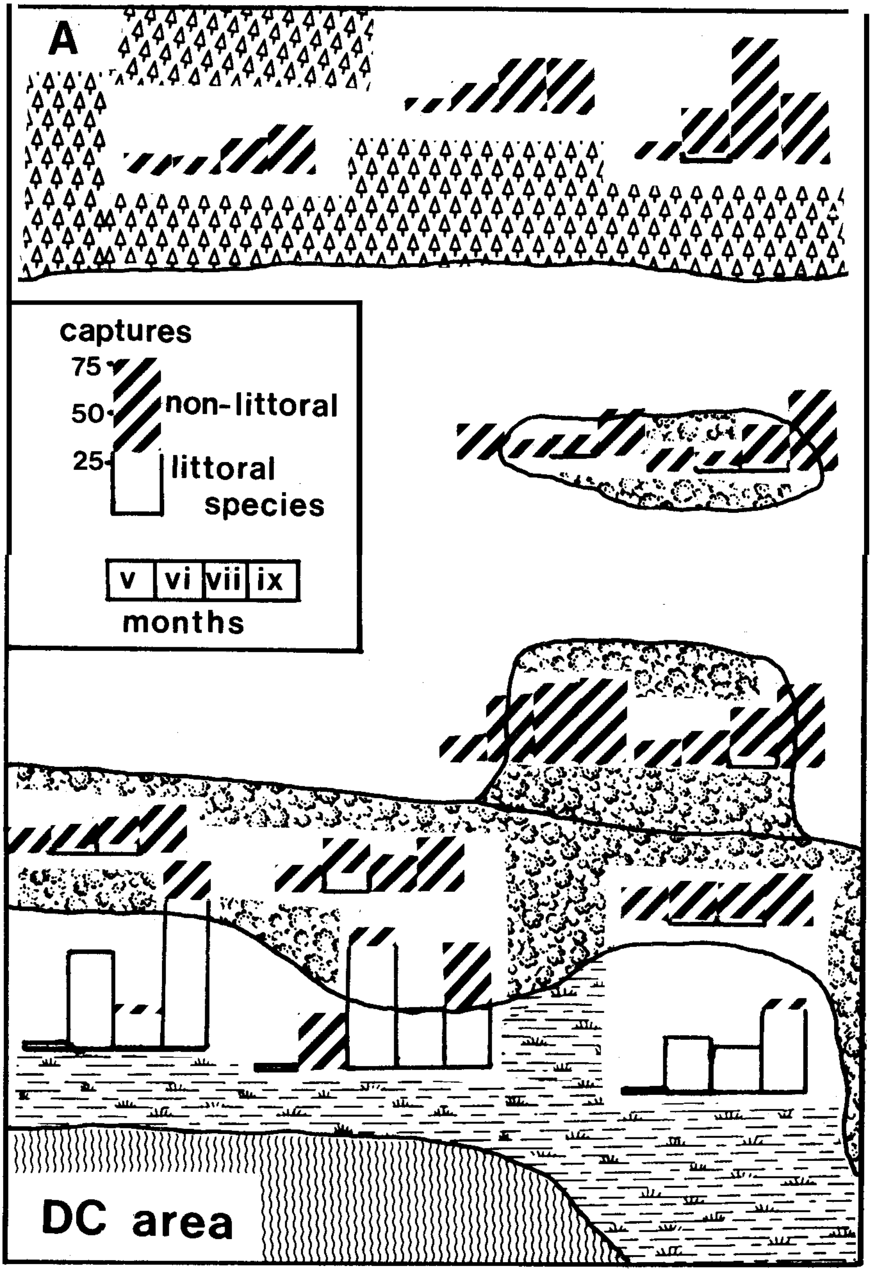

Fig. 4a. Total captures in each group of nets on both study areas. No data for month VIII. Habitats as in Fig. 1.

dence of non-littoral passerines visiting the reed zone was observed by Bairlein (1981, 1983) in autumn net captures on lakes in West Germany and Austria.

The main aim of our study was to test the influence of small scale spatial configuration of a lakeshore landscape on access of forest birds to the littoral zone. The hypothesis that the uninterrupted strip of shrubs in the C area affect the accessibility to the lake littoral zone by passerines from the pine forest is supported by our data. The number of species observed in the reed zone in September was not significantly higher in the C area than in the DC area (Fig. 2, $G = 0.61$, 1df, $p < 0.25$) nor was the

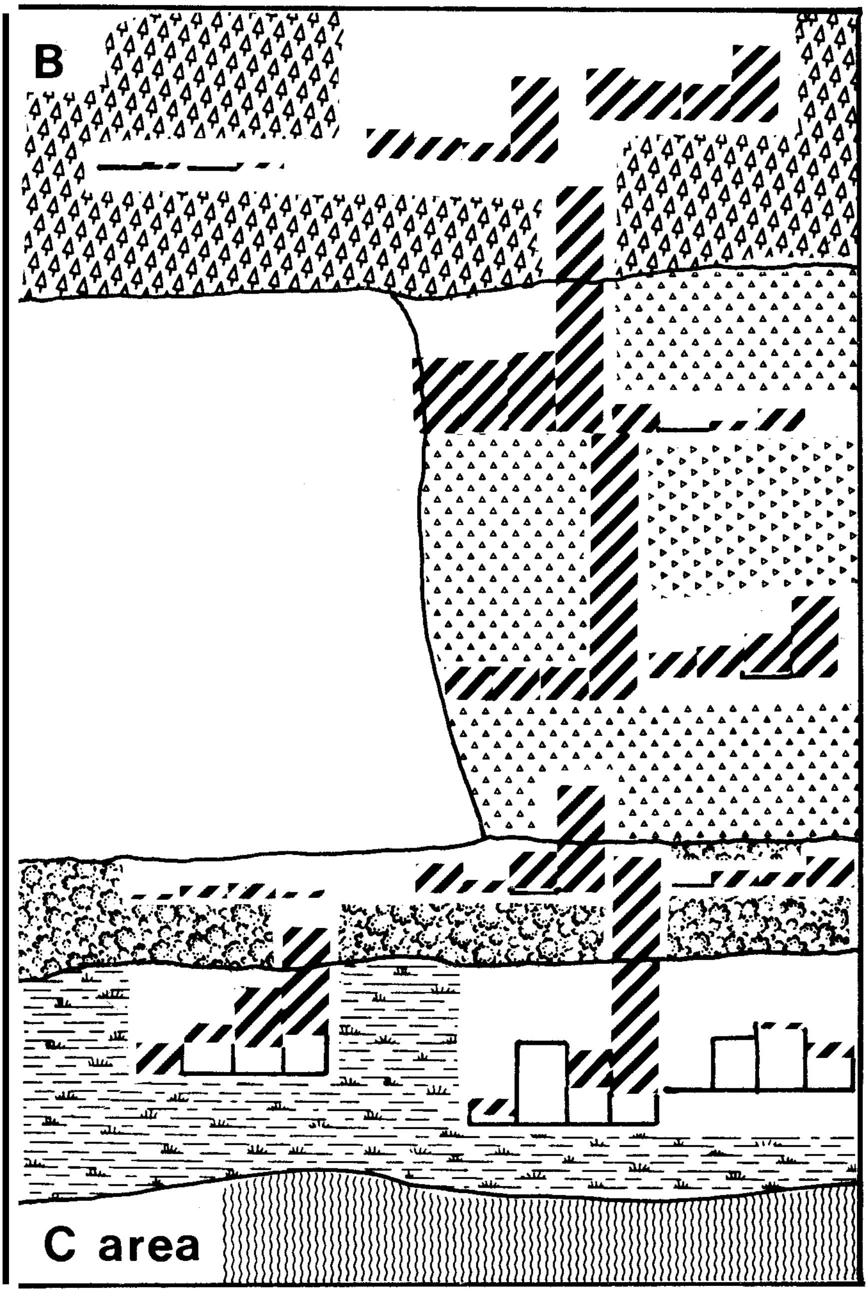

Fig. 4b.

total number of non-littoral species visiting the ***C*** area significantly different (Table 2, G = 0.76, ldf, p < 0.25). However the total number of non-littoral individuals that visited the littoral (Table 2) was significantly higher (G > 34, ldf, p < 0.001) in the C area. Thus, the strip of shrubs linking the forest to the lake littoral zone enhances movements of birds between these two habitats. The presence of this shrub zone, located as it is, effectively changes the mosaic presumably both because of the shrub habitat and because of the effect on landscape configuration.

Although the meadow between the forest and the lake littoral in the DC area intuitively seems an

Table 3. Number and direction of bird movements in study areas based on September recaptures.

Study area	Direction of movement			
	between the pine forest and littoral zones	perpendicular to the pine forest-littoral axis	recaptures in the same group of nets (no movement)	Totals
C	39	17	3	59
DC	15	14	23	52
Totals	54	31	26	111

unimportant barrier, many authors have reported that forest birds are reluctant to fly across open habitats and many isolated local populations have been studied in forest patches surrounded by open space (Diamond 1975, 1984, Martin 1980, 1981, 1985a, 1985b, Opdam *et* al. 1984, 1985, Martin and Karr 1986, Moller 1987, Opdam and Schotman 1987, Van Dorp and Opdam 1987). The role of ecological corridors in enhancing movements across such isolating, open habitats has been emphasized by Gromadzki (1970), Jablonski (1972), MacClintock *et al.* (1977), Wegner and Merriam (1979), Forman (1981, 1983), Forman and Baundry (1984), Forman and Godron (1984, 1986), Simberloff and Cox (1987), and others.

The tendency for movements to be concentrated along the edge of the shrub strip in the C area of this study is in agreement with these earlier observations. If birds used the shrub strip as a corridor, when birds from the interior reached the edge of the shrubs they would follow it to avoid flying over the open meadow. This probably explains why captures in nets deeper in the strip of shrubs were lower than captures in nets along the edge. Thus, it seems possible that the strip of shrubs could have acted as an ecological corridor, not only enhancing bird movements, but also guiding the direction of flights. In agricultural landscapes, this effect can be obtained by planting shrubs or trees along drainage ditches, field roads and hedgerows, or by windbreaks (cf. Forman and Baundry 1984).

Wide ecological corridors can also function as foraging habitats for many animal species from neighbouring habitats (Forman 1983, Forman and Godron 1981, 1986). Access to additional habitats within a mosaic was also reported by Banach *et al.* (1979), Rogers and Myers (1980), Arnold (1983), Kalkhoven and Opdam (1984), Rafe *et* al. (1985), and others. Thus, it seems reasonable to conclude that the wide strip of shrubs between the forest and the littoral in the C area had three possible effects: as a movement corridor, as an additional habitat providing resources itself, and as a means to make the reed zone another available habitat.

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