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Response of Least Flycatchers *Empidonax minimus* to Forest Disturbances

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ABSTRACT

Least flycatcher Empidonax minimus *distributions were studied in northern Michigan (USA) from 1984–85 in large (>100 ha) continuous hardwood forests adjacent to forest disturbances of 0·8–21 ha. This species occurred in dense aggregations ranging from 3·06 to 8·71 birds ha^{-1}. Flycatcher response to forest disturbances was evaluated by measuring the distance from the perimeter of an aggregation to the nearest forest opening and by monitoring breeding bird density within aggregations near disturbances. A gradient in flycatcher response to forest openings is hypothesised, ranging from no changes in breeding bird density and spatial distribution of aggregations near small disturbances to reductions in breeding bird density and spatial shifts in aggregations into the forest interior for large disturbances. A significant positive relationship was obtained for size of a forest opening and the distance aggregations were displaced into the forest interior. Displacement distances asymptotically levelled off at 200 m for openings ≥ 10 ha. No relationship was found for breeding bird density and forest opening size. Vegetative comparisons of utilised and unutilised habitat indicated that a well-developed canopy and large-tall trees may be important in the selection of habitat by aggregating flycatchers.*

INTRODUCTION

When a large forest is reduced in size, avian communities typically experience declines in breeding densities (Robbins, 1979; Aldrich & Coffin,

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1980; Howe, 1984; Lynch & Whigham, 1984) and species number (Moore & Hooper, 1975; Forman *et al.*, 1976; Galli *et al.*, 1976; Robbins, 1980; Whitcomb *et al.*, 1981). Observations of this process have been limited to bird response along a gradient of different forest sizes. However, it is not known whether avian declines also occur when a large continuous forest is exposed to different degrees of disturbances. Furthermore, since most studies of forest fragmentation have concentrated on solitary nesting birds, information on the response of aggregating birds to forest disturbances is lacking.

Least flycatchers *Empidonax minimus* are known to nest in dense aggregations (Bent, 1942; Kendeigh, 1947; MacQueen, 1950; Breckenridge, 1956; Davis, 1959; Sherry, 1979); densities as high as 5·6 birds ha^{-1} have been reported (Sherry, 1979). Response of least flycatcher to logged forests (Webb *et al.*, 1977; Noon *et al.*, 1979; Freedman *et al.*, 1981) suggests that this species should react adversely to forest disturbances that disrupts the continuity of a large forest. A gradient in flycatcher response to forest disturbances is therefore hypothesised, ranging from no detectable changes in breeding bird density and spatial distributions near small areas of disturbances to declines in breeding bird density and shifts in spatial distribution into the forest interior for large areas of disturbances. To test these hypotheses, this study characterised the variation in breeding bird density within flycatcher aggregations and the spatial distribution of aggregations in relation to forest disturbances.

STUDY AREA AND METHODS

Field work was conducted in the Pigeon River Country State Forest located in the north central portion of Michigan's lower peninsula (lat. 45° 10′N, long. 84° 20′E). Northern hardwood forests occur throughout this area in a matrix of large (> 100 ha) patches alternating with small (< 1 ha) and larger (2–21 ha) areas of forest disturbances. Small forest openings were the result of petroleum drilling activities, while larger ones were produced during commercial clearcutting operations. Openings were maintained as grasslands, resulting in a sharp contrast in vegetation communities along the forest edge.

A pilot study in 1984 revealed least flycatcher aggregations in continuous hardwood forests adjacent to areas of disturbance. In 1985, forest cover maps were used to select potential study locations within the forest. Ten sites were selected at random from maps that included tree species composition, forest age, topography, location and size of forest openings. Dominant tree species at each site included sugar maple *Acer saccharum*, basswood *Tilia* *americana*, white ash *Fraxinus americana*, American beech *Fagus grandifolia*, and hophornbeam *Ostrya virginiana*. Most of the understorey vegetation occurring at the sites consisted of saplings and seedlings of the above tree species. Sites were approximately 75 years old with a well developed canopy ($>94\%$ coverage) and sparse undergrowth. Prior to this study, forest habitat was logged using selection cuts on 12-year rotations with the most recent cut occurring in 1972 (see DellaSala (1986) for a more detailed description of these sites).

Sampling flycatchers consisted of a reconnaissance to locate and map aggregations, followed by a breeding bird census within the utilised habitat. Sampling was accomplished from 31 May to 17 June between 0600 and 1100 h EDT. Aggregations were mapped using four parallel transects, 200 m apart. Transects were centred on the edge of forest openings and overlapped with adjacent forest habitat. Each transect included 10 stations at 100-m intervals. The starting point for each reconnaissance mapping was chosen randomly. Observers remained stationary for 3 min at each station, and recorded least flycatchers up to 100 m from where they stood. Using this sampling design, a total of 88 ha was mapped. Each site was mapped twice to obtain reliable estimates of boundary locations. Boundaries of aggregations were delineated by connecting peripheral least flycatcher locations to form a polygon. Flycatchers were then censused within this area using line transects (Emlen, 1971). Time permitted only one census of each aggregation. The highest count obtained from the two mapping exercises and the follow-up census was used as an estimate of the density of breeding birds.

An aggregation was defined as a collection of individuals (>2 birds) within 100 m of nearest neighbours. To determine if the location of an aggregation is influenced by a forest opening, distance was measured from an individual bird along the boundary of an aggregation to the nearest forest opening. When more than one aggregation was located in a study plot, only the aggregation closest to a forest opening was included. Furthermore, when an aggregation was near several forest openings, distance was measured to more than one opening using individual bird locations along the aggregation boundary.

A circular plot method (James, 1971), was used to sample vegetation at random locations within habitat occupied by aggregations for comparisons with similar unoccupied habitat that was also selected randomly. Stepwise discriminant analysis with forward selection was used to separate vegetation variables according to sample location and to determine habitat features important in the selection of preferred sites. A linear discriminant analysis was performed to obtain discriminant coefficients for significant variables, and to determine the percentage of correct reclassifications of vegetation measurements using these coefficients.

Linear regression was used to test whether aggregations occurred at greater distances into the forest interior as size of opening increased. An inverse transformation of the independent variable (i.e. size of opening) was performed to determine if distance from an opening reaches an upper asymptote (Neter *et al.*, 1983). Density of birds within aggregations was also regressed on size of opening to determine if reductions in density are associated with the extent of forest disturbances. The level of significance used in all analyses was $P < 0{\cdot}05$.

RESULTS

A total of 13 least flycatcher aggregations were located at the 10 study sites. At three sites, more than one aggregation occurred and these aggregations were not included in the regression analyses that follow.

Variation existed in the density ($\bar{x} \pm$ SE, $n = 13$) of breeding birds within aggregations ($5{\cdot}06 \pm 0{\cdot}61$ birds ha^{-1}, range = 3·06 to 8·71 birds ha^{-1}) and in the amount of forest habitat occupied by aggregations ($18{\cdot}05 \pm 3{\cdot}38$ ha, range = 1·65 to 38·5 ha). Most flycatchers were included in aggregations, however, on four occasions 1 to 2 individual birds were discovered outside aggregation boundaries. These 'satellite' birds were territorial, but it was not known whether they acquired mates during the nesting season. Detailed maps depicting the spatial distribution of aggregating birds can be found in DellaSala (1986).

Breeding bird density within aggregations was not related to opening size ($r^2 = 0{\cdot}01$, DF = 9, $P > 0{\cdot}75$). Opening size, however, was a good predictor of nearest boundary distance from forest openings. This relationship was significant when only one distance measurement was used for each

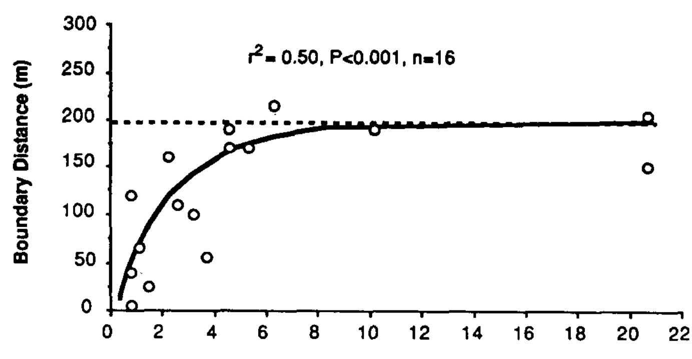

Fig. 1. Distance from aggregation boundaries of least flycatchers to nearest forest opening. The upper asymptote is indicated with a dashed line.

TABLE 1
Vegetation Comparisons ($\bar{x} \pm SE$) between Utilised and Unutilised Least Flycatcher Habitat

	Utilised area ($n = 42$)	*Unutilised area* ($n = 58$)
Tree dbh (cm)		
8–15	16·43 ± 1·08	24·07 ± 1·35
15–23	10·55 ± 0·72	12·19 ± 0·63
23–30[a]	7·14 ± 0·58	4·45 ± 0·32
30–38	2·90 ± 0·31	1·64 ± 0·22
>38[a]	1·67 ± 0·21	0·59 ± 0·11
No. tree species	3·78 ± 0·16	3·76 ± 0·14
% canopy cover[a]	98·17 ± 0·39	93·88 ± 0·71
Canopy height (m)[a]	28·50 ± 0·60	24·93 ± 0·33
Shrub density	2336·90 ± 209·77	1888·60 ± 131·40
No. maples	25·24 ± 1·33	24·71 ± 1·18

[a] Discriminant analysis $P < 0{\cdot}001$.

aggregation ($r^2 = 0{\cdot}60$, $DF = 9$, $P < 0{\cdot}02$) and when distance to several nearby openings was measured to more than one bird along an aggregation boundary (Fig. 1). For openings ≥10 ha, distance from an opening reached an upper asymptote at approximately 200 m. The variability associated with this estimate, however, was high and included distances of 195·9 ± 190·5 m for forest openings ≥ 10 ha. Furthermore, the asymptote was based only on three flycatcher aggregations for openings ≥10 ha.

Significant differences in several vegetation variables were found between utilised and unutilised habitat (Table 1). The most important variables separating the two groups included large trees (23–30 cm dbh and >38 cm dbh), percent canopy cover, and canopy height. The habitat where flycatchers were found contained more trees in these size classes and a more developed canopy. A discriminant model using only these four variables was able to reclassify correctly 84% of the sites.

DISCUSSION

Response of least flycatchers to forest disturbances elsewhere indicates an inverse relation between breeding bird density and logging intensity (Webb *et al.*, 1977; Noon *et al.*, 1979; Freedman *et al.*, 1981). Results obtained here do not support a similar pattern expected for size of opening and density of breeding birds within aggregations. Instead, flycatcher response to forest disturbances in large tracts of forest was apparently associated with shifts in the spatial distribution of aggregating birds into the forest interior.

By moving away from forest disturbances, aggregating birds may avoid adverse effects associated with edge conditions (i.e. predation, Gates & Gysel, 1978; Wilcove, 1985; and brood parasitism, Brittingham & Temple, 1983). Whenever suitable interior habitat is available to accommodate spatial shifts, we would not expect to find declines in breeding bird densities. However, in highly fragmented forests that have lost most of their interior habitat, the capacity to accommodate spatial shifts is expected to decline and aggregations may contract to a threshold level beyond which bird densities would also be affected. This situation may be further compounded if reductions in reproductive success of individuals within aggregations also occur. Under these conditions, we predict that spatial shifts will occur in association with declines in breeding bird densities and local extinctions of aggregations from isolated forest fragments.

Prior studies of habitat selection in least flycatchers indicate a preference for an open subcanopy (Breckenridge, 1956; Hespenheide, 1971; Johnston, 1971; Sherry, 1979). In this study, however, flycatchers apparently selected habitat with a well-developed tree canopy and large-tall trees. These findings suggest that habitat structure, rather than the avoidance of openings, was responsible for the observed pattern in flycatcher spatial patterns. However, the history of forest management practices at each study site is well known and does not suggest that preferred habitat was rigidly defined at specific distances from the forest edge. Instead, preferred habitat should occur randomly throughout the forest and if aggregating birds were spatially tracking these resources we would not expect to find non-random patterns for aggregation distances and size of forest opening. Aggregating birds may therefore select habitat that is removed from forest disturbances and birds within aggregations may then select specific features of the preferred sites as individual territories. As a test of this prediction, the model could be validated at other locations where flycatchers occur in large forests adjacent to forest disturbances. The location of aggregations could be predicted from size of nearby openings and matched with observed locations. In areas where birds are not found at expected distances, habitat features could be checked to determine if preferred vegetation occurs at densities lower than expected for occupied sites.

Conservation implications

Regional declines in least flycatchers have been reported for the northeastern United States (Tate & Tate, 1982; B. Noon, personal communication). Should these declines continue, this study has identified several key habitat features important in the management of least flycatchers. Management of least flycatcher habitat should include large continuous forests with a minimum of forest disturbances. If, however, openings are created they should be as small as possible. Larger openings should be clustered together rather than dispersed uniformly throughout a forest. This would minimise their impact by limiting effects to a specific area of the forest. 'Buffer zones' should also be provided to allow for the movement of aggregations away from a disturbance. The size of these zones will depend on the size of nearby forest disturbances and the distance aggregations are displaced by openings. Small openings, for example, may require only thin 'buffer zones' surrounding the disturbance, whereas large ones may require more extensive 'bands' of habitat. Estimates of 'buffer zones' should be included in recommendations for reserve size for this species, especially if reserves are adjacent to forest clearings. Furthermore, 'buffer zones' should include a dense canopy and large-tall trees to encourage habitat use along the forest edge and to mitigate habitat loss associated with forest disturbances.

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