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Occurrence of the Red-backed Shrike (*Lanius collurio*) depends on natural factors and mode of land use in the Quillow catchment, Germany

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Abstract: The main goal of the study was to develop a Red-backed Shrike habitat model that could be able to evaluate qualitatively and quantitatively the isolated effects of landscape character and both mode and intensity of land use. The relative abundance of the species was estimated with the point-stop method on five parallel transects. Each transect was 12 km long and consisted of 25 equidistantly distributed observation points. The data were stored together with additional information, such as current vegetation around the observation points, but also soil and biotope information and others in a GIS database. To build the model, detailed information on ecological demands of the birds concerning their habitat was selected from the literature. With the aid of the database it became possible to establish spatial relations and to model the potential occurrence of the species by visualizing their ecological demands within the landscape. Starting from the hierarchy and connections of the various influencing factors, it became possible to formalize the complex habitat demands and to develop a habitat-quality or habitat-suitability model. The different factors and branches were combined by fuzzy algorithms. The results gained with the aid of the model were compared to empirical data on occurrence of Red-backed Shrikes. The conclusion is that their occurrence depends mainly on the distribution of nest sites, especially hedges, shrubs and forest edges.

Key words: habitat modelling, Red-backed Shrike, fuzzy logic, landscape structure, farmland, habitat selection

INTRODUCTION

The occurrence of animal and plant species in agricultural landscapes is the result of the relations between the geomorphological, climatic and biotic factors of the landscape and the intensity of landscape use. Among animals, birds are good indicators of biodiversity because they are widely distributed across habitats and tend to be close to the top of the food chain. In the last few years declines in bird diversity and abundance were often reported in agricultural landscapes (FULLER et al. 1995, DITTBERNER 1996, BAUER et al. 2002). Although research has confirmed that these declines can be explained by changes in agricultural practices, habitat loss, and intensification of human disturbance during the cultivation period, an inherent problem is the understanding of the relative effects of agricultural land use and the ecological factors of climate fluctuation and habitat change. Red-backed Shrikes require special landscape characteristics (SÖDERSTRÖM 1999), which include insect richness and land use (cf. JAKOBER & STAUBER 1987). However, the presence of a species in a certain environment does not necessarily imply conditions that ensure long-term survival and reproduction. Additionally, as suitable habitats are often unoccupied (PULLIAM 1996), animal occurrence and density is not always a sufficient indicator of habitat quality. Therefore it is necessary to supplement bird observations with additional sampling in order to determine the actual reasons for changes in bird occurrence and density in agricultural landscapes. The habitat requirements of the indicator species can help us understand these relationships (HOVESTADT et al. 1993).

This study aimed: (1) to evaluate the Red-backed Shrike distribution in the Quillow catchment with the point-stop method; and (2) to develop a Red-backed Shrike habitat model that can evaluate qualitatively and quantitatively the effects of landscape elements and both mode and intensity of land use.

MATERIAL AND METHOD

Study area

The study area is the catchment of a small river, Quillow. It comprises about 290 km^2, including a buffer zone of 1 km width (Fig. 1). The Quillow catchment is

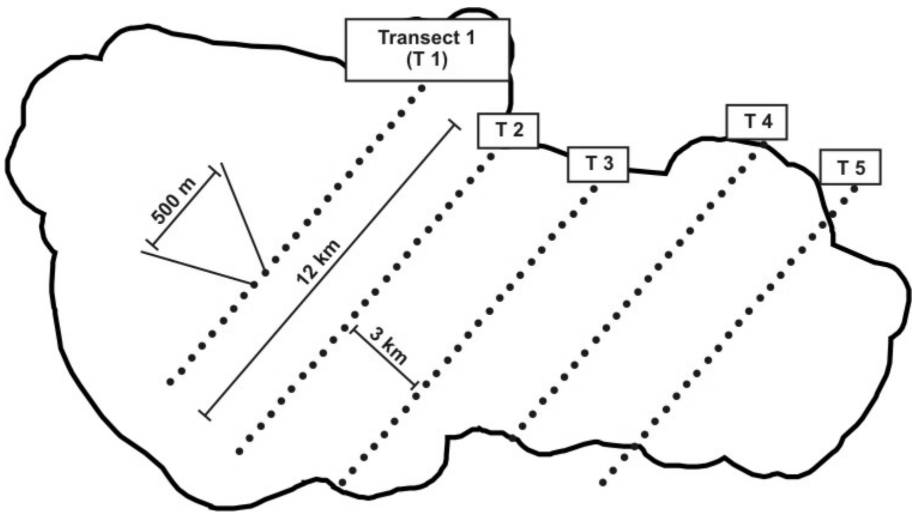

Fig. 1. Distribution of transects and observation points in the Quillow catchment

in the «Uckermark», a typical landscape of the northeastern German plain. The region is of glacial origin and consists of 4.3% water bodies; 2.0% fen; 18.4% grassland; 1% bushes (that means: various hedges, thickets, shrubs and single trees); 12.6% forest and woodland; 58.9% arable fields; 2.6% roads and settlements (numbers based on CIR-biotope mapping, scale 1:10 000, LUA 1995). While farmland is the landscape matrix, abundant lakes and potholes as well as forests are of special interest as habitats. The «Uckermark» holds a wide range of site conditions and land use types and is thus typical not only for northeastern Germany, but for large areas of north-central Europe (SCHULTZ et al. 2003).

Bird counting method

We collected the empirical data with the point-stop method (FLADE & SCHWARZ 1996), recommended by DDA (German regional ornithological societies). The occurrence and abundance of all bird species were recorded 5 times a year (in equal intervals between March and July). At each observation point, birds were registered by hearing or viewing during a 5-minute period. The observation programme was carried out on 5 parallel transects (TROMMER 1996), each 12 km long with 25 observation points 500 m apart (Fig. 1). The transects were planned to sample the average conditions of the biotope composition of the catchment. The data are stored in a Geographic Information System (GIS) database with additional information, such as weather conditions during the observations, current vegetation around the observation points, and soil and habitat information. This enabled complex analyses, including multivariate statistics.

RESULTS AND DISCUSSION

Bird observation results

Table 1 gives an overview of the overall occurrence of birds in 1999–2002.

Table 1. Summary of observations conducted in 1999–2002 in the Quillow catchment, northeastern Germany

	1999	2000	2001	2002
No. of bird species observed	108	114	115	112
No. of species observed in all years		94		
No. of species observed only this year	8	3	6	3
No. of endangered species (Red List for Brandenburg Federal State)	30	32	35	34
No. of Red-backed Shrikes	**21**	**23**	**28**	**29**

Analysis of ecological demands of Red-backed Shrikes

Much scientific information exists about Red-backed Shrikes in the ornithological literature and this can be used to describe the species' habitat requirements.

Knowledge about the home range of a species is important to determine a bird's habitat. MOES (1993) and KUŹNIAK & TRYJANOWSKI (2003) both give 25 ha as the average nesting home range of a Red-backed Shrike pair.

For estimating potential occurrence of birds, knowledge about four main factors is necessary: (1) nest site requirements, (2) prey base for feeding the young, (3) predator avoidance, and (4) negative factors of climate.

Red-backed shrikes prefer to nest in larger bushes or shrubs in rather warm and dry weather conditions (FUISZ et al. 1998). PFISTER & NAEF-DAENZER (1987) give an optimum hedge density of 4000 m per km^2. These places also serve as hunting grounds for adults feeding their young. Food availability is highest on grassland (especially pastures), parks and gardens (BRANDL et al. 1986). Predators on nestlings and adults are mammals, reptiles and other birds of prey (SÖDERSTRÖM 1999).

Fig. 2 shows the ecological demands of the Red-backed Shrike, hierarchically connected, based on the results of our literature analysis. Using a GIS database, it is possible to establish spatial relations of the various parameters included in the analyses and to model the potential occurrence of the species by visualizing their ecological demands within the framework of a landscape.

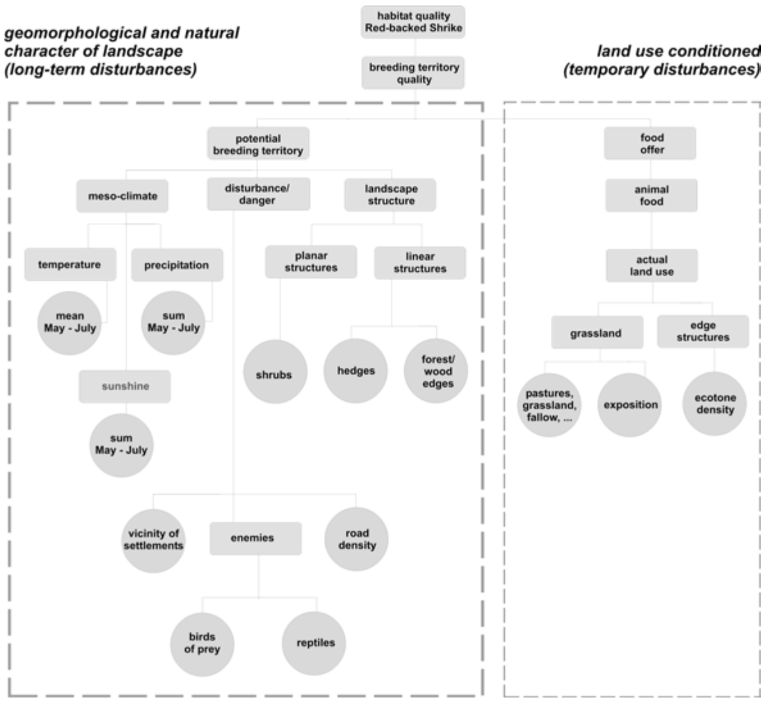

Fig. 2. Hierarchy and connections of habitat factors influencing Red-backed Shrikes. The shaded elements were included in the mathematical modelling

Habitat model of the Red-backed Shrike

Using the relationships of the various influencing factors, it is possible to describe complex habitat demands and to develop a habitat-quality or habitat-suitability model. Such models show which landscapes are suitable habitats for a bird species.

The basic purpose of mathematical habitat models is to establish formal quantitative links between resource conditions and a measure of habitat quality or habitat suitability. Habitat models evaluate the abiotic and biotic attributes of a habitat of the species. They usually produce a range of ordinal classifications from unsuitable to optimal, or from 0 to 1. Because we deal with models, and because additional demographic and synecological factors are important, the actual occurrence of a species cannot be explained completely without the help of the included abiotic (autecological) and biotic attributes (SCHAMBERGER & O'NEIL 1986). So it is expected that comparisons between model forecasts and observations may differ to a certain degree. The model may delineate areas of high suitability which are unoccupied by Red-backed Shrikes. The power of habitat models lies in the ability to determine potential situations and to compare different situations in time or space.

In the model development process the hierarchical nature of the factor dependencies is emphasized (MORRISON et al. 1998). Thus, habitat can be defined as the hierarchically organized totality of environmental factors affecting a species or a community, including the factors caused by the species or the community itself.

The hierarchical structure of the model should always be designed so that the lowest levels of the hierarchic structure consist of relatively simple ecological factors, which can be measured or estimated. Fuzzy algorithms combine the different factors and branches. The model inputs serve as interface variables in order to transform landscape information into relevant model variables. In the case of the Red-backed Shrike these variables are all the circle elements in Fig. 2. So far only the shaded circles are included in the mathematical modelling. Fig. 3 shows a potential habitat-suitability map of the Quillow catchment and the combined field observations for 1999–2002.

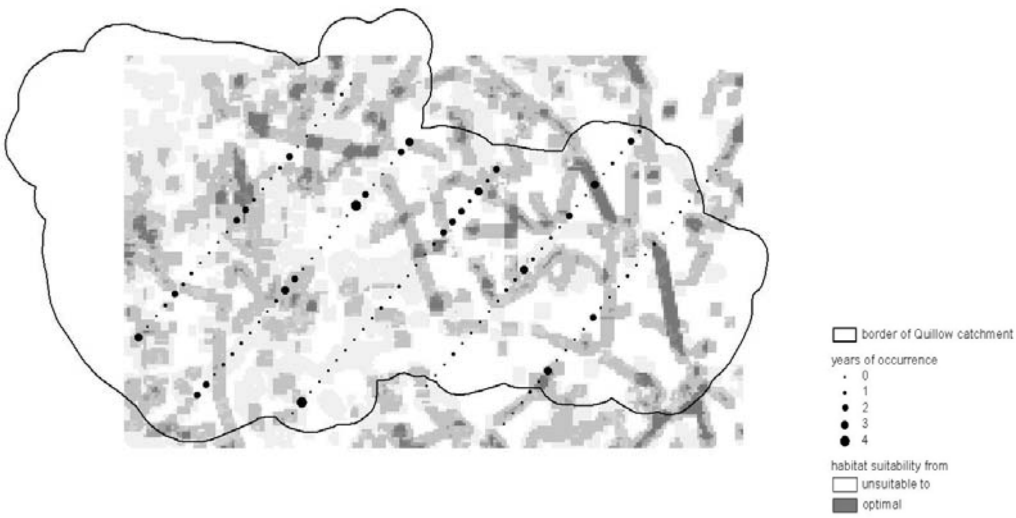

Fig. 3. Modelled potential habitat quality of the Red-backed Shrike in the Quillow catchment and the combined bird occurrence observations for 1999–2002

We concluded that in the Quillow catchment, the occurrence of Red-backed Shrikes depends mainly on the distribution of their nest sites, especially hedges, shrubs and forest edges. As mentioned by BECHET & MOES (1992), these landscape elements are also indicators of insect richness. The main foraging areas in the Quillow catchment are: grassland (pastures, meadows), parks and gardens. Other foraging areas used occasionally include habitat edges and borders of paths and roads.

Using hierarchical habitat models, it is possible to determine the landscape elements that can serve as potential nest sites and evaluate the effects of various land use systems on the occurrence of the Red-backed Shrike. The Red-backed Shrike is a good indicator species to evaluate land use changes in an agricultural landscape in relation to composition and configuration of habitat patches.

As long as habitat richness can be maintained in the Quillow catchment, Red-backed Shrikes should persist. Further investigations will concentrate on the influence of agricultural management on prey availability and on the effects of nest predators.

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