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Changes in density and territory size of the Tawny Owl *Strix aluco* along an altitude gradient: the effect of forest types and wood cover

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Abstract. The authors correlated the percentage cover of forested areas with Tawny Owl *Strix aluco* density and territory size measured in deciduous woodlands along the elevation gradient in central Italy. They calculated the amount of wooded areas per owl territory on the basis of four forest types (urban woods, sclerophyllous woods, mesophilous woods, and montane beech woods). Breeding density differed 3-fold among forest types and suggests that wood quality has a direct effect in determining spatial patterns. The amount of wooded areas per territory is fairly stable in all forest types, and indicates a mean requirement of ca. 10 ha per territory. The smallest territories were in ca. 5 ha sized. Minimum habitat requirement may depend locally on wood quality. Management strategies based on the forest type should be undertaken to protect the local high-density populations of this owl.

Key words: *Tawny Owl, Strix aluco,* density, territory size, wood cover, central Italy.

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I. INTRODUCTION

The proportion of habitat suitable for a certain species plays a greater importance than its spatial arrangements, and this is especially true for landscape with a high proportion of the suitable habitat remaining. A simple explanation for describing the effect of habitat fragmentation is that small habitat fragments are random samples from large ones (ANDRÉN 1997). The random sample hypothesis suggests that the only consequence of habitat fragmentation is loss of habitat (e.g. ANDRÉN 1997; 1999). The correlation between forest cover and species occurrence or population density provides information concerning habitat suitability when different wood categories are compared (e.g. ANDRÉN 1999; MONKKONEN & REUNANEN 1999).

The Tawny Owl *Strix aluco* LINNAEUS, 1758, is a rodent-eating raptor widely distributed in different forest types throughout Europe. Despite considerable interest in Tawny Owl ecology (e.g. SOUTHERN 1970; WENDLAND 1984; HIRONS 1985; PETTY 1989; GALEOTTI 1994; REDPATH 1995;

RANAZZI et al. 2000), the relationship between population size and forest cover has not been explored in a wide range of density, habitat proportion, and wood type. In this study the authors determined the dependence of breeding density and territory size on forest cover and calculated the amount of wooded areas per owl territory in four wood types along the elevation gradient in central Italy. Sclerophyllous and mesophilous forests in the Mediterranean landscape represent unique example of continuous wooded habitat containing an ample plant and animal biological diversity, exemplified by the large number of tree species as compared with Nordic forests (SCARASCIA-MUGNOZZA et al. 2000). Despite the explanatory limitations imposed by the descriptive nature of this study, the data may provide information useful for owl conservation and management planning of wood stands.

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II. STUDY AREA

This study was carried out from 1995 to 2001 in selected areas (see SALVATI et al. 2002) along an elevation gradient from coastal sclerophyllous oak woods to mountain beech woods in Latium and Abruzzo, central Italy. The coastal sub-region bordering the Tyrrhenian sea shows a typical Mediterranean climate with three-four months of summer drought and a mean annual precipitation less than 700 mm. The hilly sub-region shows a more temperate climate, with one-two months of summer drought and mean annual rainfall ranging from 800 mm to 1100 mm. The Apennine mountain region shows a temperate climate, with mean annual rainfall above 1100 mm (PENTERIANI & FAIVRE 1997; BLASI et al. 1999). Here were considered 42 census plots with forest cover ranging from 6% to 99% of the whole census area (e.g. RANAZZI et al. 2000). Elevation of forests ranged from 10 m to 1500 m a. s. l. (see SALVATI et al. 2002). The size of most forests ranged from 100-500 ha, with only a few > 2,000 ha. All the forests previously had been cut within the last 200 years. However, older forest patches with 50 years of age are extremely common, and all the forests are now included in protected areas.

III. METHODS

Occupied territories were censused by nocturnal playbacks and passive hearing for adults and young along transects of various length, depending on forest size. The whole wooded surface was covered by transect routes. In homogeneous forests > 500 ha only a part of the wooded area was censused, according to route facilities. Playback stations were generally located at 250m-distance (SALVATI et al. 2002).

Playbacks of a stranger male 'hoot' calls lasting five minutes were performed from January to August (9 p.m.-2 a.m.), using a SANYO portable stereo with 2 × 6 W loudspeakers. Playbacks were not performed in autumn because the occurrence of fledglings able to hoot in the parent's territory may cause an overestimation of the number of occupied territories (RANAZZI et al. 2000). To reduce disturbance by the acoustic stimulation to adults and owlets, no more than three visits during the same breeding season, were performed in the same area the rapid male response to playbacks reducing the likelihood that any territorial owls were missed (REDPATH 1995). Furthermore, contacting Tawny Owls for many consecutive years from the same playback stations may reduce *bias* in territory overestimation.

Calling owls were located using 1:10,000 maps. In different visits, all neighbouring owls were stimulated when an unknown territory was located. Simultaneous male contacts and disputes along boundaries, as well as female calls were taken into due consideration. Fledglings uttering the typical "ptziè" call often allowed the researchers to locate the nesting area (e.g. WENDLAND 1984). The centre of each territory was determined as the nesting area or the diurnal resting site (e.g. for single birds or for pairs that failed to breed) by searching for individuals resting on trees, as well as for feathers, drops, and other traces, or by collecting pellets and prey remains. Census validation using individual recognition of hooting males by spectrogram analysis was described by RANAZZI et al. (2000).

The authors used the nearest-neighbour distance (n.n.d.) method (see RANAZZI et al. 2000) to estimate breeding density. Spacing was assessed using the centre of occupied territories. This method was chosen to achieve comparable estimates of density and to correlate them to forest cover. Although the area of each census plot depends on the size of the homogeneous wood patches, it was prefered to include plots with at least 10 independent territories to reduce the effect of census area on density estimates. Territory size figures were obtained for a restricted sample using data collected monthly during the years 1999-2000 and analysed by the minimum convex polygon method (GALEOTTI 1994).

Forests were classified (e.g. BLASI et al. 1999) according to the dominant vegetation type as follows: (i) urban mixed woods (stands of *Platanus* sp., *Quercus ilex*, *Pinus pinea*, *Cupressus sempervirens*, and exotic vegetation; arbustive layer almost absent; monumental trees occurring especially in urban parks; (ii) mountain beech woods, distributed in Apennine areas up to 1000 m a. s. l. (almost pure stands of *Fagus sylvatica*; arbustive layer generally absent; old and dead trees scarce); (iii) mesophilous oak woods (mature stands of *Q. cerris*, *Q. frainetto*, *Q. robur*, and *F. sylvatica*, distributed between 200 m and 1000 m a. s. l.; arbustive layer (0.5-1.0 m-tall) mainly composed of *Pistacia terebinthus*, *Phillyrea latifolia*, *Rubia peregrina*, and *Ruscus aculeatus*; old and dead trees fairly common); (iv) sclerophyllous oak woods, distributed along the coastal belt and in neighbouring lowland zones (mature stands of *Q. ilex* and *Q. suber*; arbustive layer (1-3 m-tall) composed of *Laurus nobilis*, *Erica arborea*, *Pistacia lentiscus*, *Hedera helix*, *Arbutus unedo*, *Rhamnus alaternus*, and *Myrtus communis*; old and dead trees, especially oaks, widespread).

The proportion of forested areas, used as descriptor of the amount of nesting habitat suitable for Tawny Owls, was measured in each census plot across the whole 'n.n.d. area' using aerial photographs, 1:10,000 maps, graphical tablets, and the VIDEOPLAN KONTRON PC package. The amount of wooded areas per owl territory was calculated by dividing the total area of woods by the number of territories occupied across the whole 'n.n.d. area' (RANAZZI et al. 2000).

To verify that the amount of wooded areas per territory estimated by means of the n.n.d. method resembles the average proportion of suitable habitat in individual territories from the same area, the total surface of wooded areas was measured in thirteen 300m-radius occupied plots and in seventeen control plots of the same size in a highly fragmented, low owl density area of inner Rome. The size of circular plots (= 28.8 ha) was comparable to the mean size of Tawny Owl territories in the same area (= 29.8±10.8 ha, n = 20, RANAZZI et al. 2000). The average value of the total extent of wooded areas in occupied plots (= 6.4±2.5 ha) resembles the size of wooded areas per territory estimated by means of the n.n.d. method (= 6.9 ha), whereas it is clearly higher than the average value of the total extent of wooded areas in control plots (= 2.8±0.9 ha).

It is assumed that the total number of individuals living in the original habitat has a one-to-one relationship with the proportion of the original habitat in the landscape (ANDRÉN 1997). This assumption was tested by regressions between the log (population density) and the log (% original habitat in the landscape). The random sample hypothesis predicts a regression slope of 1 (ANDRÉN 1997). The dependence of breeding density and the amount of wooded areas per owl territory on forest cover was assessed by means of linear regression models. According to the random sample hypothesis applied to individual species, it was assumed that the change in population size in relation to habitat fragmentation would be linearly related to the change in proportion of suitable habitat in the landscape. The slopes of linear regressions were compared between forest cover and breeding density, testing the null hypothesis that slopes were identical among wood types (ZAR 1996). Minimum territory size was estimated in each wood type as 1/slope. Curve fits were obtained using PRISM 2.0 (GraphPad Software, 1995) PC package.

IV. RESULTS

The lowest densities were recorded on average in urban woods, and the highest in sclerophyllous oak woods (see Fig. 1). Out of a total of 560 territories censused in 42 study areas, regressions between the log (population density) and the log (% forested areas in the landscape) have a slope close to 1 in all wood types (beech woods: $Y = 1.19x - 1.68$, $r^2 = 0.98$, $p < 0.001$, df = 4; urban mixed woods: $Y = 0.97x - 1.0$, $r^2 = 0.93$, $p < 0.001$, df = 13; mesophilous oak woods: $Y = 1.20x - 1.47$, $r^2 = 0.97$, $p < 0.001$, df = 9; sclerophyllous oak woods: $Y = 1.0x - 0.85$, $r^2 = 0.98$, $p < 0.001$, df = 8). The difference between slopes was not significant ($F_{3,37} = 2.82$, $p = 0.054$).

The correlation between population density and forest cover (Fig. 2) was significant in all the habitats studied (beech woods: $Y = 0.05x - 0.57$, $r^2 = 0.94$, $p < 0.001$, df = 4; urban mixed woods: $Y = 0.08x + 0.33$, $r^2 = 0.95$, $p < 0.001$, df = 13; mesophilous oak woods: $Y = 0.10x - 1.22$, $r^2 = 0.91$, $p < 0.001$, df = 9; sclerophyllous oak woods: $Y = 0.14x + 0.07$, $r^2 = 0.99$, $p < 0.001$, df = 8). The difference between slopes was significant ($F_{3,37} = 18.7$, $p < 0.001$). Estimated from linear regression,

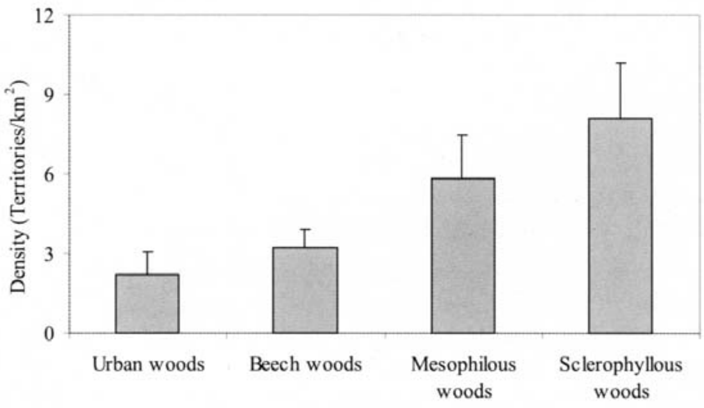

Fig. 1. Average values (±SD) of Tawny Owl density in four different forest types in central Italy.

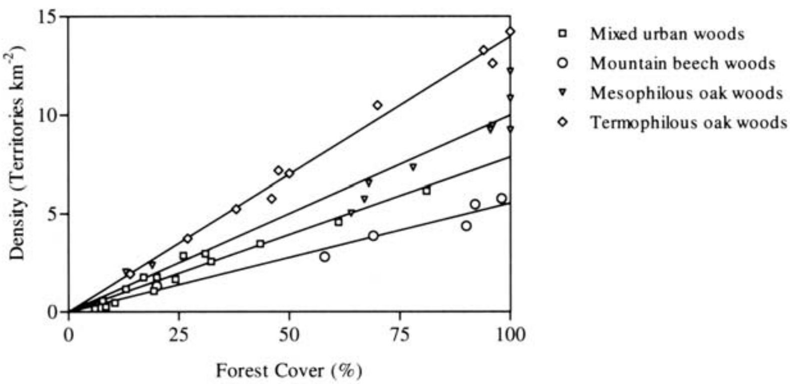

Fig. 2. Correlation between forest cover and breeding density of Tawny Owls in four wood types in central Italy. For graphical reasons, the Y-intercept value of each regression line was substracted to density values in order to obtain regression lines with intercepts set to zero.

minimum territory size was 7.2 ha in sclerophyllous oak woods, 10.0 ha in mesophilous oak woods, 12.7 ha in urban mixed woods, and 18.1 ha in mountain beech woods. Conversely, forest cover did not affect the amount of wooded areas *per territory* but in mesophilous oak woods (beech woods: Y = -0.09x + 29.18, r^2 = 0.64, p = 0.06, df = 4; urban mixed woods: Y = 0.02x + 0.15, r^2 = 0.06, p = 0.84, df = 13; mesophilous oak woods: Y = -0.07x + 18.32, r^2 = 0.71, p = 0.001, df = 9; sclerophyllous oak woods: Y = 7.11, r^2 = 0.0, p = 0.99, df = 8) (Fig. 3). In eight selected census plots (Fig. 4), mean territory size correlated with the proportion of forested areas (Y = -0.22x + 33.17, r^2 = 0.62, p = 0.02, df = 6).

V. DISCUSSION

The proportion of suitable habitat in the landscape affects the spatial distribution of Tawny Owls (e.g. HIRONS 1985; PETTY 1989; REDPATH 1995). In urban Rome, the proportion of wooded areas contained alone 80% of the total variance in determining Tawny Owl density (RANAZZI et al. 2000). Different landscape types may affect the colonisation probabilities of a habitat fragment (ANDRÉN 1999; MONKKONEN & REUNANEN 1999). Differences in breeding density of Tawny Owls suggest that forest quality affects density and regulates territorial defence (GALEOTTI 1994; REDPATH 1995). The highest densities recorded in sclerophyllous oak forests of Latium reflect their peculiar

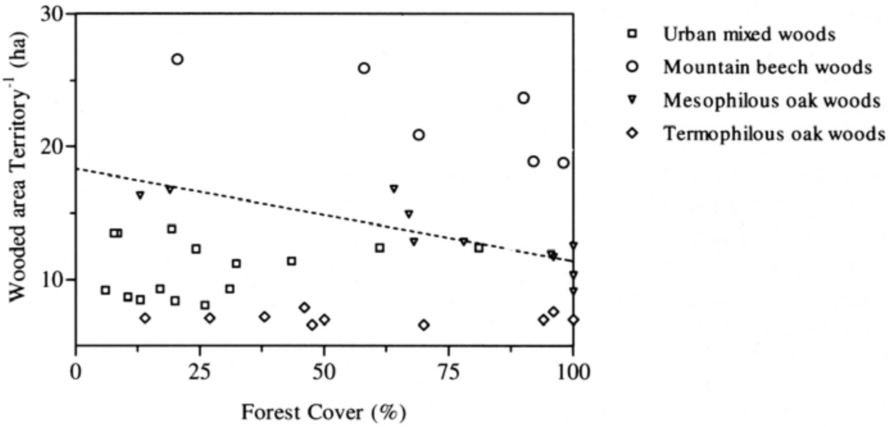

Fig. 3. Correlation between forest cover and wooded area *per owl territory* in four wood types in central Italy.

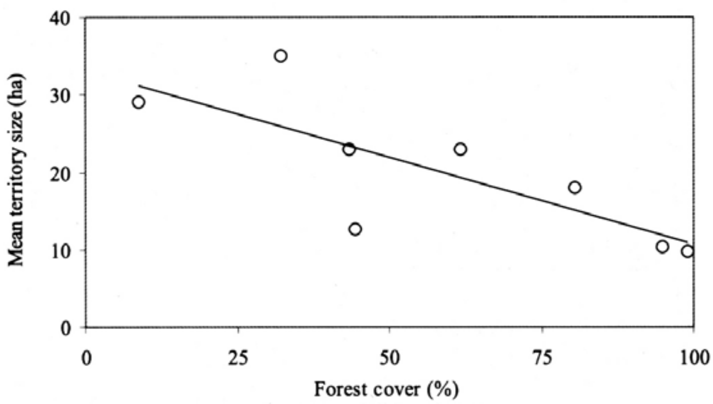

Fig. 4. Correlation between forest cover and mean territory size in eight census areas in central Italy.

characteristics, including high prey productivity, low wood fragmentation, high vegetation diversity, low human pressure, and an exceptionally large number of natural nest sites due to the occurrence of many monumental trees (e.g. PENTERIANI & FAIVRE 1997; BLASI et al. 1999; SALVATI et al. 2002).

On average, minimum territory size (measured both on the field and estimated from linear regression analysis) is similar or slightly lower than those recorded in apparently optimal habitats (e.g. Oxford Wytham wood, Mesola wet-flat oak wood, see HIRONS 1985; BOLDREGHINI et al. 1987), confirming the exceptional features of the sampled forests.

The amount of wooded areas per territory was unaffected by forest cover in all the wood types except mesophilous oak woods. Moreover, the average requirement of wooded areas per territory differed among forest types, being high in "poor" forests with low prey abundance and reduced nest-site supply (e.g. beech woods). On the other hand, the weak negative correlation between the amount of wooded areas per territory and forest cover in mesophilous woods could reflect different vegetation and climatic characteristics of woods belonging to this forest type as they are distributed along a wide elevation range in central Italy (200-1000 m at the sea level).

In this study, Tawny Owl appears to be affected both by forest quality and the availability of forested areas more than by their fragmentation level (e.g. HIRONS 1985; PETTY 1989). ANDRÉN (1999) estimated critical threshold levels for many mammal and bird species as ranging between 10% and 30% of suitable habitats, but this result alone cannot be interpreted as a guideline in forest management for species with different habitat preferences and distributive patterns (MONKKONEN & REUNANEN 1999). A threshold in the proportion of suitable habitat in the landscape below which the species loss or decline in population size was greater than that predicted from the random sample hypothesis, is barely detectable in species with a broad habitat distribution such as the Tawny Owl (e.g. MONKKONEN & REUNANEN 1999).

The wide variation in density here reported suggests that different management strategies in preserving local high densities of this owl should be undertaken strictly according to the forest type (e.g. PETTY 1989). Regulation of water reservoirs for agricultural purposes and prevention of summer fires represent useful tools in the maintenance of good habitat quality of coastal forests in southern Europe, whereas nest-sites, when scarce, should be supplied with suitable nest-boxes and by preserving isolated stands with old and dead trees in low-quality forests, such as urban woods and mountain beech woods.

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