Chapter (non-refereed)

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29. FACTORS AFFECTING THE BREEDING OF SPARROWHAWKS AND THE OCCURRENCE OF THEIR SONG-BIRD PREY IN WOODLANDS

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Associated with the agricultural use of organochlorine pesticides, numbers of sparrowhawks decreased drastically in most of Britain around 1960. Later, and as the use of these substances was increasingly restricted, populations of this non-migratory species of bird, which nests in woodland and feeds almost entirely on small birds, began to recover in some areas but not in others. To gain an understanding of the factors involved, detailed studies were made, mainly in southern Scotland, of their breeding behaviour and of some of the factors, notably afforestation, affecting the abundance of their song-bird prey.

1. Nesting densities and breeding success of sparrowhawks

Although they usually build new nests annually, sparrowhawks tend to nest in the same localities year after year, their nesting places being characterised by groups of nests of different ages usually within a radius of 50 m. In well-wooded districts, nesting areas were fairly regularly spaced, but distances between nesting areas differed greatly in different districts (Newton *et al.*, 1977). When comparing the distribution of nests in 12 parts of Britain, average distances between nesting areas (measured from the centres of the groups of nests) were found to range between 0.5 km on the low fertile land of the Solway Plain and 2.1 km on high barren land of the Upper Spey and Dee Valleys on the Cairngorm slopes (Table 43). These distances are equivalent to 24 nesting areas per 100 km^2 at the one extreme and 473 at the other. However, in reality overall densities were usually much lower because amounts of woodland suitable for nesting were limited. Numbers of nesting areas in the different districts varied between 14 and 96 per 100 km^2 when the mixtures of woodland and open land were taken into account (Table 43).

Average distances between nesting areas in continuous woodland were strongly correlated with (i) altitude above sea level, and (ii) soil productivity (Figure 55). Nesting areas were further apart on higher and poorer ground probably because there were fewer song-bird prey. When populations of song-birds were counted in different kinds of woods in 3 of the 12 districts studied, sparrowhawk nesting areas were found to be more widely spaced where song-birds were scarcest—a generalisation that is probably applicable throughout Britain. It suggests that numbers of breeding sparrowhawks are limited by amounts of suitable woodland, and numbers of prey (which influence spacing within woodland). The relationship with soil or altitude enabled predictions to be made of sparrowhawk spacing in woodland, merely by reference to maps. Not all nesting areas were used for breeding

TABLE 43 Spacing and densities of sparrowhawk nesting areas in different, but mainly upland, localities.

Locality	Numbers of nesting areas found at each locality	Mean distance to nearest neighbour in 'continuous' nesting habitat (km)	Theoretical* density in continous nesting habitat (pairs/100 km^2)	Actual density in whole district (pairs/100 km^2)
South Solway Plain, Cumberland	20	0.46	473	59
Annandale, Dumfriesshire	121	0.60	278	40
Eskdale, Dumfriesshire	50	0.62	260	79
Windsor, Berkshire	46	0.80	156	96
Lower Deeside, Aberdeenshire	16	0.91	121	89
Mid Deeside, Kincardineshire	36	1.12	78	49
Tregaron, Cardiganshire	22	1.28	61	31
Clashindarroch, Aberdeenshire	13	1.28	61	38
Upper Deeside, Aberdeenshire	9	1.39	52	45
Ae Forest, Dumfriesshire	29	1.55	42	43
Upper Speyside, Inverness-shire	42	2.03	24	14
Mar Forest, Aberdeenshire	9	2.06	24	21

* Assumes that entire 100 km^2 is composed of favourable habitat but this is rarely the case, woodland usually being interspersed with open spaces.

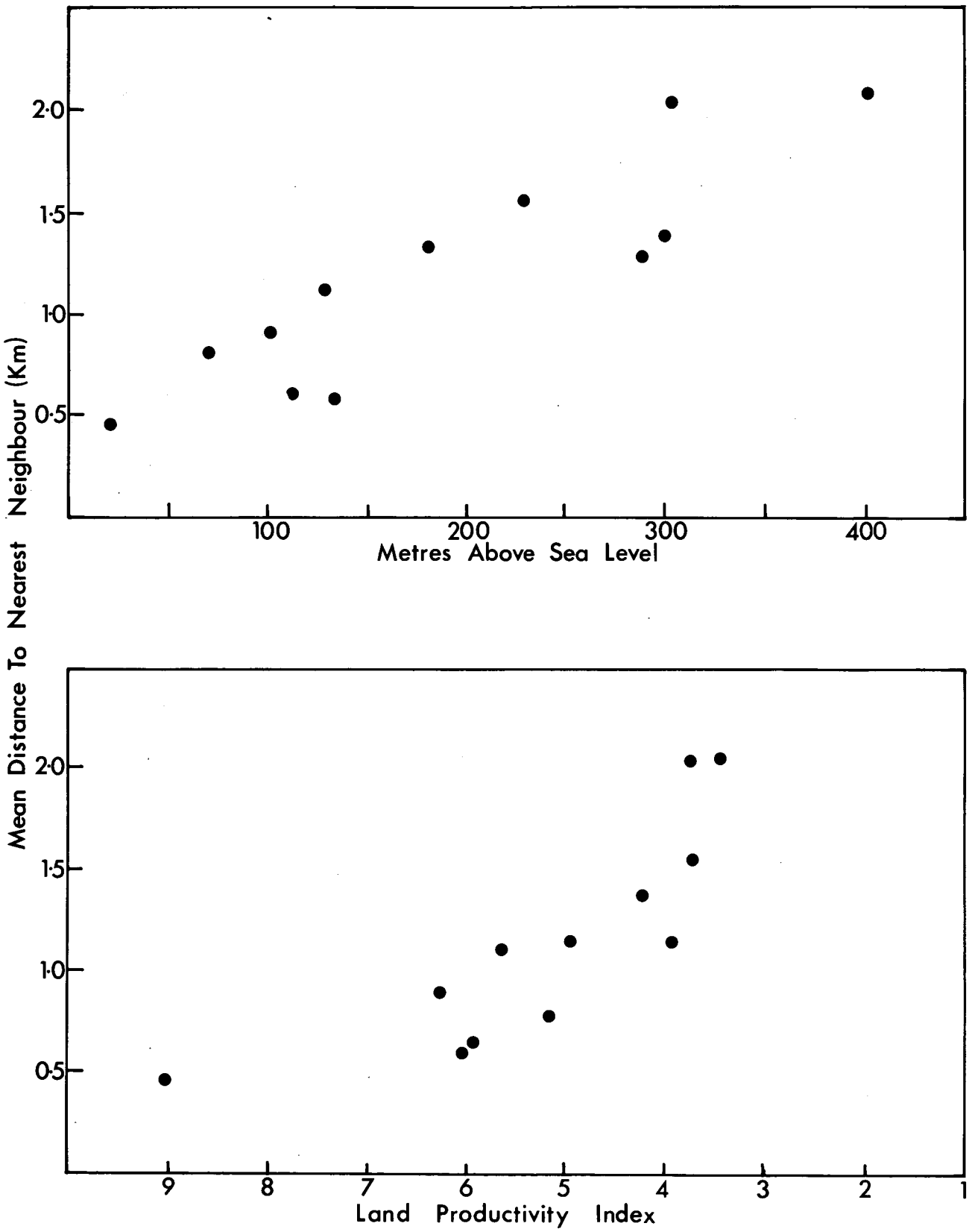

Fig. 55 *Mean nearest-neighbour distances of sparrowhawk nesting territories in continuous nesting habitat in relation to land productivity and altitude above sea level at 12 locations in the UK. The numbers 1 to 9 denote land of increasing productivity (Newton* et al., *1977).*

every year. In most districts the proportion ranged from 60 to 85% with extremes of 32% in one year in Upper Speyside and 91-97% in fair years near Windsor. These differences reflect the status of the different local populations which, in part, depends upon concentrations of organo-chlorine pesticides in prey species.

Before DDT was introduced, when sparrowhawks were more numerous, it seems that virtually all

nesting areas were used every year (Owen, 1916-22), the "space" occurring when a territorial bird was shot being quickly filled by another—this implied the presence of surplus birds in the population able to breed only when a nesting area was made available.

Breeding pairs defend their nesting areas, which could therefore be called nesting territories, but intermingle with other sparrowhawks in their hunting ranges, as was found by use of telemetric devices. They forage regularly in open habitats and in woodland. In rich habitats where prey was plentiful, sparrowhawks regularly hunted at distances of 3 km from their nests, but, in poor habitat, distances were increased to 9 km. Spacing and breeding success were thus influenced by conditions not only immediately around nesting areas, but also those in a much wider area, usually embracing several habitats.

The breeding success of sparrowhawks, like the spatial distribution of nesting areas, differed in different districts, depending partly on the local use of organo-chlorine insecticides and partly on prey abundance (Newton, 1976). The main 'organo-chlorines' found in sparrowhawk eggs were DDE (the principal metabolite of the insecticide DDT), PCB (from the industrial polychlorinated biphenyls) and HEOD (from the insecticides aldrin and dieldrin). The degree of shell-thinning, egg-breakage and addling were correlated with amounts of DDE in eggs; egg addling was also correlated with concentrations of PCB. No correlations were found with small concentrations of HEOD (Newton & Bogan, 1978). Other failures—some sparrowhawk pairs occupied nesting areas for a few days or weeks before leaving them whereas others laid eggs but deserted them—seem to be related to food shortages, being commoner in habitats where prey was scarce. Verification was obtained when the performance from nest-building onwards of sparrowhawks in poor habitats was improved, following the augmentation of their diet with carcasses of pigeons and other birds. These supplements increased the proportion of females laying eggs, numbers of eggs in each clutch and the survival of nestlings.

Summarising, breeding densities are limited by the extent of suitable woodland and the supply of food. However, in many districts populations are below these ceilings, partly because of the effects of organo-chlorines. Within woods, the distances between nesting areas are inversely proportional to the supply of prey. Breeding successes were similarly influenced by prey abundance and by amounts of 'organo-chlorines', which also differed between districts. Together, these factors account for many of the differences in breeding densities and success in different parts of Britain.

2. Populations of woodland song-birds

Partly because of their importance to sparrowhawks, numbers of song-birds were counted in a variety of habitats, including different types of woodland, using the so-called mapping method (Enemar, 1959; Williamson, 1964). Positions of song-birds encountered during each of 8 to 10 early morning visits per 'plot', spread over the period late March to mid-June, were marked on large scale maps and from the groups of positions numbers of territories of each species were estimated following the standardised rules of the International Bird Census Committee (1969).

2.1 Effects of coniferous plantations on populations in natural moorland and grassland

To estimate the effects of afforestation, bird populations on open sheepwalk and heather moor were compared with those in forests at different stages of growth. Nineteen sites (each 10-25 ha) were observed in the forests of Clatteringshaws, Ae and Eskdalemuir, all in south Scotland (Moss *et al.*, 1979), most being censused in at least 2 of the years in the period 1976-78 (Table 44). These results are summarised below:

Unplanted heather moor 2 breeding song-bird species (meadow pipit and skylark), with combined densities of 40-70 pairs/km^2.

'Natural' grassland, grazed by sheep The same common breeding species as on heather moor, but with increased combined densities of 70-130 pairs/km^2.

Plantation forest up to 8 years old These plots of young trees among rank grass or heather had more diverse structures than those of natural moor and grassland. Whereas skylarks were much scarcer, meadow pipits were more numerous, their numbers being augmented by new colonists to give combined densities of 125-200 pairs/km^2.

Pre-thicket plantations 12-14 years old Trees were touching, but closed canopies had not formed. Song-birds were more diverse (8-9 breeding species per plot) and more numerous than in younger plots, with combined densities of 230-290 pairs/km^2. Most incomers were scrub-dwelling species, with willow warbler and wren being the most abundant.

Thicket plantations, 23-27 years old Before thinning but after closed canopies had formed. Woodland species of song-birds, rather than scrub species, predominated, with 6-10 breeding species on each plot, and combined densities of 300-400 pairs/km^2. The goldcrest was the most abundant, followed by the chaffinch, wren, robin and coal tit.

TABLE 44 Densities (pairs/km^2) of song-birds on upland heather moor, grassland and Sitka spruce *(Picea sitchensis)* forests at different stages of growth (Moss *et al.*, 1979).

	Stages of afforestation					
	Unplanted heather moor	Unplanted grassland	Establishment	Pre-thicket	Thicket	Post-thinning plantation
Numbers of sites	2	3	5	2	3	4
Numbers of censuses	3	7	8	3	7	8
Song-bird densities (mean; range)						
Skylark	18*(13-20)*	51*(24-94)*	2*(0-4)*			
Meadow pipit	34*(25-53)*	37*(28-44)*	80*(44-122)*	15*(4-32)*		
Stonechat		1*(0-4)*	3*(0-10)*			
Wheatear		4*(0-12)*				
Wren			6*(0-29)*	69*(41-103)*	49*(28-83)*	89*(22-137)*
Chaffinch			3*(0-24)*	12*(9-17)*	88*(47-170)*	67*(33-91)*
Willow warbler			4*(0-23)*	67*(53-79)*	13*(0-42)*	1*(0-5)*
Redpoll			5*(0-23)*	18*(9-37)*		
Whitethroat			0*(0-3)*	1*(0-4)*		
Whinchat			5*(0-10)*			
Reed bunting			6*(0-17)*			
Grasshopper warbler			2*(0-7)*			
Goldcrest				31*(21-37)*	96*(59-156)*	113*(59-180)*
Robin				30*(21-43)*	42*(21-68)*	37*(14-67)*
Coal tit				8*(0-17)*	37*(28-48)*	47*(28-86)*
Dunnock				3*(0-9)*	6*(0-16)*	2*(0-9)*
Song thrush				3*(0-9)*	4*(0-10)*	3*(0-10)*
Mistle thrush					1*(0-5)*	1*(0-4)*
Chiffchaff					3*(0-3)*	5*(0-28)*
Bullfinch					2*(0-9)*	1*(0-5)*
Long-tailed tit					1*(0-9)*	1*(0-9)*
Crossbill					1*(0-10)*	1*(0-5)*
Siskin					3*(0-10)*	6*(0-22)*
Tree pipit					1*(0-10)*	
Tree-creeper						4*(0-11)*
TOTALS	51 *(38-72)*	93 *(72-130)*	115 *(54-203)*	257 *(231-289)*	347 *(302-443)*	377 *(318-425)*

Thinned plantations, 36-39 years old 6-10 species of breeding song-birds, with goldcrest, chaffinch, wren, robin and coal tit predominating: combined densities of 300-400 pairs/km^2.

As open ground gave way to forest, numbers and variety of breeding song-birds increased. Particular species came, and went, at different stages of forest growth (Figure 56). For example, the skylark began to decline immediately after planting, and had disappeared completely before the pre-thicket stage; the whinchat appeared late in the establishment stage and had gone before the thicket stage while the goldcrest appeared at the pre-thicket stage and became steadily more numerous as the forest grew. No one song-bird was present at all stages from open land to mature forest. Annual total numbers of species holding territories at some stage of forest growth were 24, 26 and 20 in 1976, 1977 and 1978 respectively.

Birds, other than song-birds, were more difficult to study. Several species disappeared at an early stage of forest development: ravens about the time of planting: curlews, other wader species and cuckoos before the pre-thicket stage: and merlins by the thicket stages (Marquiss *et al.*, 1978; Newton *et al.*, 1978). Other species including black grouse, short-eared owl, long-eared owl and barn owl, occurring on open ground or in mature forest, were especially numerous at the establishment and pre-thicket stages. The owls were attracted by the abundance of voles, but the long-eared and barn owls were limited by the availability of above-ground nest-sites, such as large trees, disused buildings or cliffs. From the thicket stage onwards, plantations were additionally colonised by jay, wood pigeon, woodcock, tawny owl and sparrow-hawk, adding to the numbers of crow and kestrel, which depended on openings, and water birds such as dipper and goosander which were present at all stages from open land to mature forest.

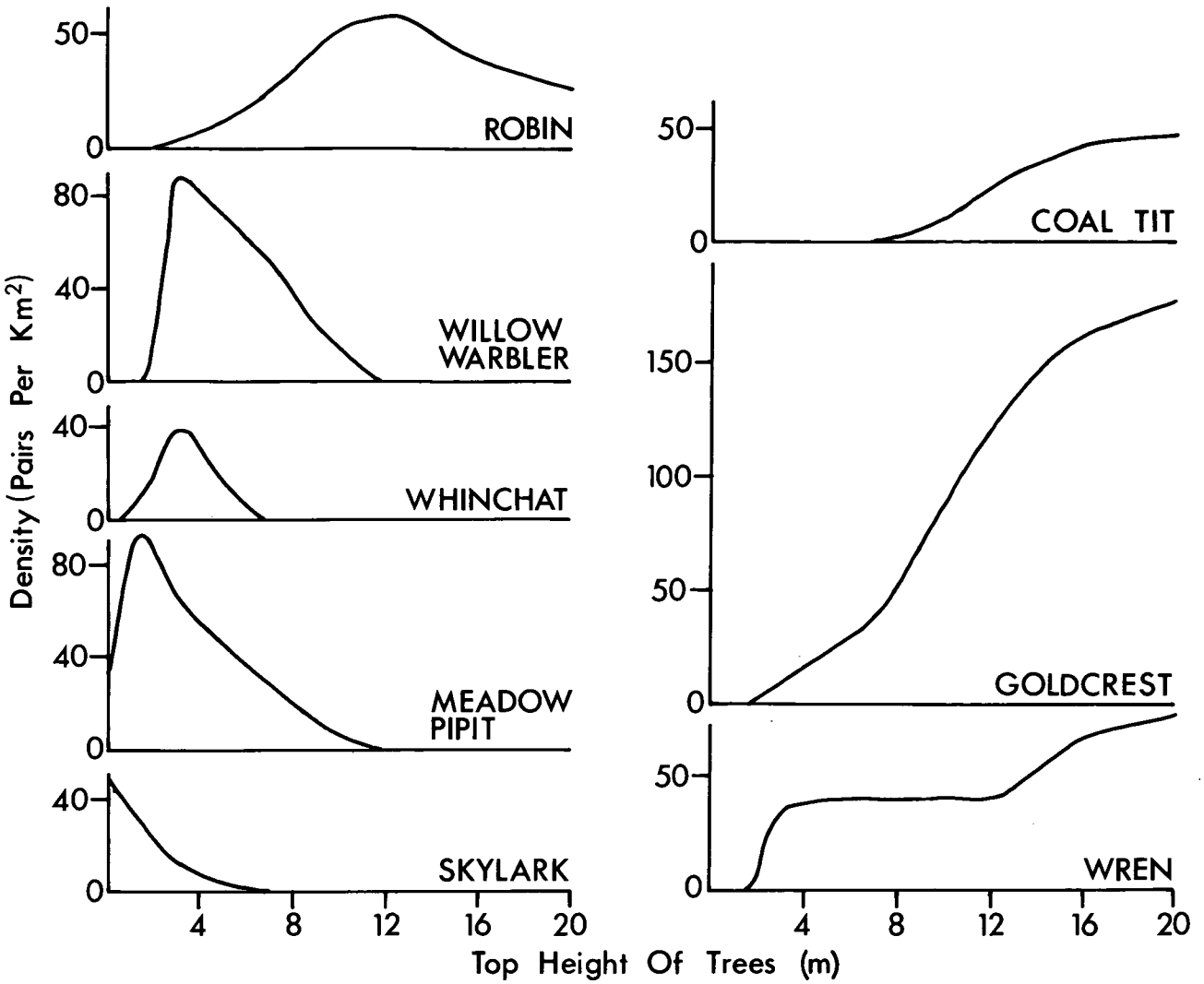

Fig.56 *The succession of song-bird species in ageing plantations of Sitka or Norway spruce, age being directly related to height.*

2.2 Bird populations in different types of mature woods (planted and semi-natural)

Censuses were usually made in 2 or more years of 15 sites (ranging from 4 to 14 ha) in Dumfriesshire and Inverness-shire, with natural or planted pine, larch, spruce or mixed deciduous trees (Table 45).

Even-aged pine stands, aged 40 years With variable ground layers but without a shrub-layer. 6-10 species of breeding song-birds with combined densities of *c* 200 pairs/km^2.

Semi-natural uneven-aged pine The one wood examined had a dense ground layer of heather and an understorey of juniper and birch. Same number of species as in even-aged planted stands of pine, but with *c* 400 pairs/km^2.

Self-regenerating pinewood, with some birch Trees and bushes of varying height and at irregular spacings; some small open areas. Relatively diverse array of song-birds, with up to 18 breeding species; combined densities in range 500 to 900 pairs/km^2 respectively.

Mixed deciduous wood, with few conifers A stand including a well developed understorey of shrubs and young trees, and some dead trees. 18 breeding species of song-birds and a combined density of *c* 1700 pairs/km^2.

Even-aged larch with small areas of spruce and Scots pine Song-bird population comparable to that in even-aged plots of spruce, but with fewer goldcrests counterbalanced by more wrens.

Even-aged spruce plantations, 25-50 years old Numbers of song-bird species, 4-9, similar in plots of Sitka and Norway spruces. Densities were larger in 1973-75 than in 1976-78 because of the greater densities of goldcrests in the earlier years.

The relation between woodland structure and the diversity of bird species in Dumfriesshire woodlands was quantified using (i) BSD, bird species diversity, a measure, calculated by the Shannon formula, of species numbers and the evenness of their distribution and (ii) FHD, foliage height diversity, an assessment of the distribution

TABLE 45 Densities (pairs/km^2) of song-birds in different types of mature woodland (Moss 1978*a*)

	Pine plantation	Semi-natural pine	Regenerating pine/birch	Mixed deciduous	Larch plantation	Spruce plantation
Number of plots	4	1	2	1	1	6
Number of censuses	6	2	4	2	2	11
Song-bird densities (mean; range)						
Blackbird			16*(13-17)*	59*(47-70)*		1*(0-6)*
Blackcap			2*(0-8)*			
Blue tit			19*(11-25)*	151*(116-186)*		
Bullfinch	1*(0-4)*	6*(0-11)*				0*(0-5)*
Chaffinch	55*(26-88)*	81*(66-95)*	103*(45-167)*	279*(256-302)*	78*(73-82)*	90*(59-145)*
Coal tit	39*(26-57)*	49*(46-52)*	29*(8-45)*	82*(70-93)*	56*(47-65)*	39*(20-59)*
Crested tit	4*(0-4)*	14*(11-17)*				
Crossbill		6*(0-11)*	3*(0-11)*			5*(0-11)*
Dunnock	1*(0-4)*	3*(0-6)*	2*(0-5)*			1*(0-9)*
Garden warbler			7*(5-8)*			
Goldcrest	41*(22-60)*	70*(57-83)*	38*(21-58)*	59*(47-70)*	113*(99-125)*	262*(136-417)*
Great spotted woodpecker			1*(0-5)*	6*(0-12)*		
Great tit			1*(0-4)*	82*(70-93)*		
Greenfinch				12*(0-23)*		
Jay			3*(0-5)*		5*(0-9)*	
Long-tailed tit			10*(4-13)*	23*(23-23)*	9*(0-17)*	
Mistle thrush	1*(0-4)*		1*(0-4)*	23*(23-23)*	5*(0-9)*	1*(0-9)*
Redpoll			6*(0-17)*			
Redstart				23*(23-23)*		
Reed bunting			4*(0-8)*			
Robin	15*(4-29)*	46*(43-49)*	89*(63-122)*	175*(140-209)*	39*(30-47)*	25*(5-53)*
Siskin	5*(0-17)*	26*(6-46)*				7*(0-29)*
Song thrush	1*(0-4)*	3*(0-6)*	12*(5-17)*	35*(23-47)*	5*(0-9)*	0*(0-5)*
Spotted flycatcher			1*(0-4)*	23*(23-23)*		
Starling				70*(70-70)*		
Tree-creeper	7*(0-16)*	14*(11-17)*	7*(0-16)*	70*(47-93)*	13*(9-17)*	7*(0-19)*
Tree pipit			1*(0-5)*			
Willow tit			16*(0-29)*	12*(0-23)*		
Willow warbler	4*(0-23)*	51*(46-55)*	196*(105-292)*	244*(209-279)*	9*(0-17)*	
Wren	38*(4-92)*	60*(57-63)*	116*(71-173)*	244*(186-302)*	119*(116-121)*	60*(0-100)*
Yellowhammer			1*(0-5)*			
TOTAL	207 *(151-340)*	428 *(385-471)*	685 *(463-935)*	1669 *(1593-1744)*	446 *(444-448)*	498 *(351-598)*

(spread) of foliage (= bird habitat) at different heights above ground. It was found that bird species diversity was directly proportional to FHD (Figure 57), probably because an increase in canopy complexity provides a greater variety of habitat (Moss, 1978*b*).

In general, the numbers of species and individuals were greater in stands with broadleaved trees than with conifers; among conifers, numbers of song-bird species were greater in spruce than pine. Mixed woods, containing mainly broadleaved trees but with some conifers, were richer than stands with either broadleaved or coniferous species. Other factors being equal, densities of birds were generally much greater in stands of trees growing on increasingly productive soils, the effect being attributable to numbers of individuals which increased and not to numbers of species. Von Haartman (1971) recorded increases of x3-6 in parts of northern Europe with increase in soil productivity. Possibly because of the so-called "edge effect", densities of song-birds in small woods in open land were usually greater than in equivalent areas in larger forests. However, species diversity was often less in small woods than in large ones (Moore & Hooper, 1975).

Compared with other mature woodlands, even-aged stands of conifers have fewer species of song-birds, and fewer individuals of each species, than do broadleaved or mixed woods, or woods of any kind with a shrub layer. However, they have more diverse arrays than are found on moorland and natural sheepwalk. Notwithstanding these conclusions, more observations need to be taken in

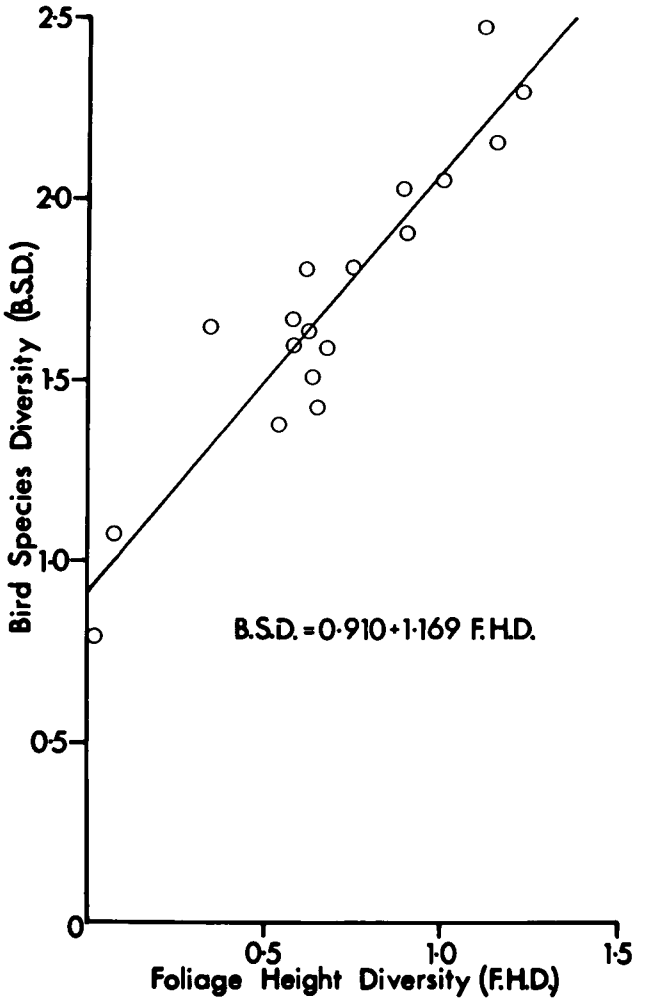

Fig. 57 *Relationship between bird species diversity and foliage height diversity when examining a variety of mature woods with broadleaved or coniferous species or mixtures.*

other parts of Britain including (i) greater numbers of semi-natural woods, (ii) the effects of windthrow and clear-felling and (iii) censuses of waders and other large birds not properly covered in the work already done.

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