Implications of irregular silviculture for woodland birds, bats and plants in broadleaved woodland

by Daniel Alder

Summary:
Compared with coppicing there has been little attention on the use of irregular silviculture as a way of increasing the diversity and nature conservation value of broadleaved woodland. This paper is a summary of a PhD study that compared the use of coppice, irregular silviculture and non-intervention in terms of stand structure and the richness and abundances of birds, bats and plants. The study was conducted on the Rushmore Estate on the Wiltshire-Dorset border where the history of management for the past 25 years has produced a mosaic of stand types suited to scientific study. In summary, the findings show that irregular stand structures provide suitable woodland habitats for a high proportion of the species studied and are either beneficial or neutral for stand level diversity. The results of the study support the promotion of irregular silviculture as a method of managing broadleaved woodlands.

Introduction

There is increasing interest in the use of silviculture as a method of diversifying forests to address the challenges of climate change, pests and diseases, and multiple objectives of management. In broadleaved woodlands, much recent past attention on diversification has been focused on the effects of coppice management as the primary method of improving their value for nature conservation. However, it can be difficult to sustain coppice management on any scale in broadleaved woodlands (Buckley, 2020). Other approaches to silviculture, such as continuous cover, have the potential to produce stands that have an uneven-aged or 'irregular' structure. However, little is known about their effects on the diversity of the flora and fauna of broadleaved woodlands. Given the declines of many species of conservation concern, improving our understanding of the effects of irregular silviculture on biodiversity is important to defining its wider role in nature conservation.

This article is a 'summary for practitioners' of a pioneering PhD thesis and associated published papers (Alder et al., 2018; Alder et al., 2021; Alder et al., 2023) that studied the responses of woodland birds, bats and plants to irregular silviculture within a substantial block of ancient woodland in the Cranborne Chase AONB on the Wiltshire-Dorset border. Historically, these woodlands were important for their hazel dominated coppice management. Today only 12% of the broadleaved woodlands in the area are managed this way, mirroring the economic demise of coppice nationally since the 19th century.

"There has been little attention on the use of irregular silviculture as a way of increasing diversity."

The conversion of coppice to irregular silviculture, a developing trend in France over the last 25 years (Susse et al., 2011) provided a model for the silviculture practised on a proportion of forest stands at the study site. This involves more frequent interventions than under the coppice regime, and the use of permanent timber harvesting extraction racks (trackways) to avoid increased disturbance to the ground layer particularly on heavier soils (Sanchez, 2017). Irregular silviculture as practised at Rushmore involves interventions every 8-15 years (Poore, 2016). An intervention involves cutting all, or more usually a proportion, of the understorey prior to selective removal of canopy trees as part of timber harvesting.

The presence of active coppice management, limited intervention stands (unmanaged for at least 30 years), alongside stands undergoing transformation to irregular silviculture offered a unique opportunity for a comparison study. The main aim of the study was therefore to examine if irregular silviculture provides a range of important functional resources to maintain species intrinsic with ancient and semi-natural woodland, including those with conservation interest.

Methods

Location and general description

The study was conducted on 442ha broadleaved woodland, most of which is a Site of Special Scientific Interest (SSSI), spread across nine contiguous blocks on the Rushmore Estate in southern England that are between 100m and 200m above sea level. The principal National Vegetation Classifications (NVC) are W8 (ash-field maple) associated with base-rich soils with some W10 (oak-birch) on slightly acidic soils (Rodwell et al., 1991). A characteristic of the area is a large number of veteran trees particularly of oak, ash and field maple along with whitebeam and 19th century beech plantings (Poore, 2016).

Descriptions of stand types

Management over the previous 25 years has produced a mosaic of stand types throughout the estate (Figure 1). Typical structures for the four main stand types are illustrated in Figure 2.

Coppice stands include both simple coppice and coppice with standards with up to 20% cover of upper canopy trees. All stands in this category were being actively worked with hazel cut every 8-15 years and birch either 3-4 years for horse jumps and the remainder on >25 year cycles for wood fuel. There was a broad representation of growth stages across the study site with 10 sites cut 0-5 years ago, 19 sites 6-9 years ago and 11 sites last cut 12-15 years ago. Basal areas were in a range of 2-24m^2 per ha.

Irregular high forest stands had been transformed from unmanaged coppice stands to a high forest structure

Figure 1. Location of Cranborne Chase and study area (bottom left and top), Dorset-Wiltshire border, southern England, UK. Sampling points (bottom right) within stand types: orange = coppice, blue = transitional high forest, yellow = limited intervention, and red = irregular high forest.
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at various times over the preceding 20-50 years. This transformation involves the selective removal of harvestable trees and of weaker growing specimens and cutting the residual hazel and birch dominated understorey to increase light levels reaching the woodland floor. A proportion of the understorey is allowed to re-grow, both for silvicultural reasons (to control seedbed conditions) and in order to create a complex habitat structure where the shrub layer is integrated within the high forest structure. The aim is to increase incremental growth and vigour of the retained trees to increase their resilience, enhance their economic value, promote natural regeneration of trees and shrubs and establish a range of tree size-classes.

With regard to the overall growing stock size, moderate stocking is aimed for with basal areas in the range of 17-24m^2ha^{-1}. Lower stocked areas still in transition can have a range of 10-16m^2ha^{-1}. Understorey is dense in places yet patchily distributed as influenced by previous management and the effects of deer browsing.

Transitional high forest stands are intermediate between coppice and irregular high forest and are developing towards an uneven-aged structure from former coppice or even-aged high forest. Transitional stands have undergone initial interventions within the previous 10-20 years but are yet to develop the range of irregular stand elements i.e. mixed age and height classes of trees and saplings but often with a developed understorey. They are variable with regard to both canopy and understorey density.

Figure 2. Examples of stand types used in study shown clockwise from top left: limited intervention, coppice, transitional and irregular.

Limited intervention stands are closed canopy stands, with a higher tree density and basal area in the range 18-40m^2ha^{-1}, and more limited understorey due to a period of between 30-50 years without any silvicultural interventions.

Data collection

A plot-based sampling approach was used to establish 310 plots from grid coordinates generated in a Geographical Information System that were representative of the four stand types (Table 1). Due to resource constraints a lower (120) number of plots was used for study of bats and plants but the distribution of plots was still representative of the stand types studied. Each plot consisted of a 30m diameter circle (0.07ha) with five subplots of 3m diameter within each (four located at the cardinal points at 10m radii and one at 2m off-centre along a random compass bearing) (Figure 3).

This network of plots was used as the basis for making the following assessments:

Woodland structure

Basal area, vertical structure, stem size-classes and understorey density were used to assess the differences in woodland structure between the different stand types as described above.

Bird abundance

This was recorded using 5 minute point counts (Bibby et al., 2000) at the 310 survey plots across three visit periods: early spring, late spring and late summer. See Alder et al. (2018) for a full description of bird sampling methods.

Bats

Bats were assessed using recordings of acoustic activity as an indicator of the degree of strength of use of a particular stand type and any association with a particular habitat structure. Because these assessments are resource intensive only three stand types were compared: coppice, irregular and limited intervention. For a full description of the sampling methodology for bats see Alder et al. (2021).

Plants

Plants were sampled from within a 20m^2 quadrat and a percentage cover used as an assessment of relative abundance based on the Domin scale (Kirby and Hall, 2019). Plants were categorised into separate groups to reflect firstly if they are on the list of ancient woodland indicators for the region, and then assigned to one of Oliver Rackham's 'coppice-associated' groups (Rackham, 2003) which were used to show how each associated with particular woodland conditions:

- Spring plants; species that flower early in the year and have set seed by mid-summer.
- Summer plants; shade resistant summer flowering species which actively grow even under a full canopy.
- Buried seed plants; species that prolifically germinate following canopy opening.
- Mobile plants; windblown species that move around woodland and are usually more abundant in open conditions.
- Non-responsive plants; which are shade tolerant species and do not respond to canopy openings or may decline in increasing light.

Table 1. Areas of woodland stand types and number of sample plots where stand structural measures and bird community data were collected.

Stand type	Area (ha)	%	No. of sample plots
Irregular high forest	137.1	31	73
Transitional high forest	97.4	22	75
Limited intervention	102	23	61
Coppice	106.1*	24	101
Total	**442.6**	**100**	**310**

* Area in active rotation currently 85ha.

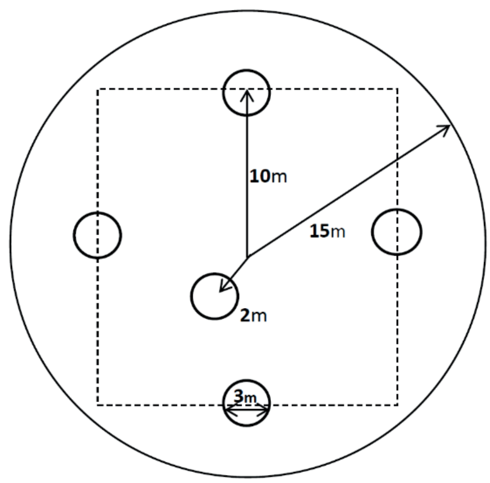

Figure 3. Plot layout depicting the configuration of each sub-plot used to measure several of the habitat structures, and the square quadrat for plant cover within an overall 30m diameter circle. The centre of the plot was used for sampling birds and bats.

As with the bats the work focussed on three stand management types: coppice, irregular and limited intervention. For full details of the plant sampling and assessments see Alder et al. (2023).

Data analyses
Details of the methods of analysis can be found in each of the papers cited in the methods section. The generic feature of the analyses was that each was trying to examine how each of the different characteristics being examined varied between the stand types and, importantly, if there were statistically significant differences between them.

“Ten bird species had highest spring density estimates in irregular stands.”

Results

Habitat differences between stand types
Basal areas were lower in Irregular and Coppice compared to Limited intervention and Transitional stands (Table 2). Canopy openness was greater in Irregular plots than in other stand types and this probably helps explain the presence of generally larger trees. Irregular stand types had more deadwood snags but this effect was not statistically significant. Understorey densities were highest in Coppice and Irregular with Coppice having markedly higher density at 2.0m height. The distribution of stem sizes was as expected from the approach to management: Coppice had lots of small trees, Limited intervention had mostly large trees and Irregular and Transitional had intermediate characteristics. Bramble cover was at least ten times higher in Irregular stand types than the other three stand types. The area of bare ground was highest in the Limited intervention stand type.

Bird densities across stand types and season
Across the 310 sample points, 4,994 bird records of 38 species were obtained. Density estimates were calculated for 16 resident species and 4 spring migrants (Table 3). Three from the 20 species were not recorded in Limited intervention stands, 2 of these species were spring migrants (willow warbler and garden warbler). Six and five species had density estimates >100 individuals km^{-2} in at least one stand type in spring and winter respectively. Blue tit and wren had estimates >100 individuals km^{-2} in all stand types in spring, and blue tit and great tit in all stand types in winter.

There were significant differences between stand types in densities for 12 bird species in spring and 6 in winter (Table 3). Ten species had highest spring density estimates in Irregular stands, with seven being significantly higher than in Limited intervention stands, and three being significantly higher than in both

Table 2. Median values of stand structural measures; capital letters indicate those stand types with which a stand type differed significantly: C = Coppice, I = Irregular, L = Limited intervention, T = Transition.

Habitat variable	Coppice		Irregular		Limited		Transition	
Basal area (m^2/ha)	18.0	L	18.0	L	29.0	T	22.0	L
Canopy openness (%)	10.4		21.3	L	9.9	I	10.9	
Mean DBH (cm)	36.0	I	50.6	C	42.8		39.4	
Largest DBH (cm)	61.0		71.0		67.0		62.0	
No. deadwood snags	8.0		13.0		8.0		8.0	
U-storey density 0.5m (%)	48.0	L T	56.0	L T	7.0	C I	20.0	I C
U-storey density 2m (%)	52.5	I L T	23.8	C	13.8	C	17.5	C
No. stems ≤3cm DBH	9.2	I L T	2.8	C	0.6	C	5.4	C
No. stems 3-7.5cm DBH	3.2	I L	0.2	C	0.8	C	2.2	
No. trees 7.5-17.5cm DBH	9.0	L	9.0	L	69.0	C I T	21.0	L
No. trees 17.5-50cm DBH	2.0	L T	5.0	L	11.0	I C	7.0	C
Bramble % cover	2.8	I	30.0	C T L	0.0	I	0.0	I
Bare ground %	8.4	I	1.4	L	26.0	I	12.6	

Table 3. Density estimates for resident and spring migrant woodland birds by season and stand type.
The highlighted values show the stand types that had the highest density. Also shown are results of pairwise comparisons of density across stand types, where > indicates pairs that differ significantly at P<0.05; the direction of the sign denotes which density estimate is larger. C = Coppice, I = Irregular, L = Limited intervention, T = Transitional.

	Spring				Winter			
	Coppice	Irregular	Limited intervention	Transitional	Coppice	Irregular	Limited intervention	Transitional
Woodpigeon	60.1 (>I)	32.4	74.2 (>I)	66.0 (>I)	17.0	20.0	38.1	47.2 (>C)
GS woodpecker	10.4	12.7	7.1	9.2	5.4	19.0	22.8	16.2
Goldcrest	25.9	27.2	27.7	60.1 (>CI)	48.8	68.8	93.3	47.90
Blue tit	124.7	135.1	129.4	120.5	173.3	244.5 (>C)	197.7	200.5
Great tit	92.4	115.2	128.9	86.4	155.9	182.1	236.0	194.2
Coal tit	22.5	27.0	9.2	17.1	17.3	59.3	62.6	66.1 (>C)
Marsh tit	65.11	123 (>CLT)	53.8	34.9	63.1	76.4	86.3	68.4
Long-tailed tit	66.0 (>L)	56.5 (>L)	0	33.5 (>L)	77.7	65.7	78.7	41.6
Chiffchaff	98.4 (>LT)	82.5 (>IT)	34.9	35.0	Not present (migrant)			
Willow warbler	19.3 (>L)	5.4 (>L)	0	3.0 (>L)	Not present (migrant)			
Blackcap	101.1 (>LT)	120.2 (>LT)	50.4	49.3	Not present (migrant)			
Garden warbler	30.3 (>LT)	18.9 (>L)	0	7.4	Not present (migrant)			
Nuthatch	24.4	31.4	27.9	29.7	20.8	29.4	37.3	29.6
Treecreeper	9.4	30.2 (>C)	25.6	21.1	20.4	48.9	34.4	24.6
Wren	108.6	221.6 (>CL)	148.0	180.1 (>C)	77.9 ± 15	163.5 (>CL)	88.7	106.6
Blackbird	56.2	53.6	46.9	63.2	60.1	82.4 (>L)	31.0	49.2
Song thrush	29.2 (>L)	24.0	11.0	24.6	24.3	21.7	19.5	27.4
Robin	134.0	87.9	132.6	150.3 (>I)	80.9	76.1	96.1	104.2
Dunnock	51.8	61.9	20.9	26.3	67.3	107.6 (>L)	15.1	57.0
Chaffinch	16.1	29.8	25.3	19.7	26.7	25.2	23.7	35.8

Transitional and Coppice. Marsh tit and all four summer warblers had significantly higher densities in Irregular compared with Limited intervention. Coppice had five species with highest spring densities, including three of the four migrant warblers.

There were far fewer significant differences in densities across stand types in winter. Considering the highest density for each bird species (the shaded boxes in Table 3), in spring ten species had the highest density in Irregular stands compared with five, two and two for Coppice, Limited intervention and Transitional respectively. In winter it was much more even and varied between zero for Coppice and six for Limited intervention.

“Bat species richness was significantly higher in irregular stands compared with coppice or limited intervention.”

Bats: species richness and activity differences between stands

Eleven bat species were recorded across all stands from 35,230 bat passes in the two periods of sampling. The most common species were common pipistrelle (78% of passes), soprano pipistrelle (8.1%), Brandt’s (4.9%) and barbastelle (2.9%); all other species were <2% of passes.

Bat species richness was significantly higher in Irregular stands compared with Coppice or Limited intervention in both survey periods (Figure 4). There were also significant differences in activity rates for most bat species between stand types. Six of nine bat species had significantly greater activity in Irregular high forest than in at least one of the other stand management types. Only *M. nattereri* was significantly more likely to be recorded in Limited intervention stands compared with both Coppice and Irregular high forest. The results highlighted the comparatively low activity rates in Coppice stands. A secondary piece of analysis (results not shown here) showed that most bat species were associated with a more open canopy, lower basal area and reduced densities of understorey, with large-girthed trees and presence of deadwood snags.

Plants: differences between stand types and 'coppice groups'

A total of 91 plant species were identified which represented the five coppice associated groups, ancient woodland indicator plants and 'other' species which were not associated with either. While there were differences in species richness between different stand types, this varied depending on the plant group (Table 4). Four of the seven plant groups: all vascular plants; ancient woodland indicators; spring plants; and buried seed plants, were similar between the two active intervention stands while significantly lower in Limited intervention plots. There were no significant differences between species richness across stand types for summer and non-responsive plant groups. The Irregular stand type had significantly more mobile plant species than Limited intervention but the difference was so small it is probably of little practical value.

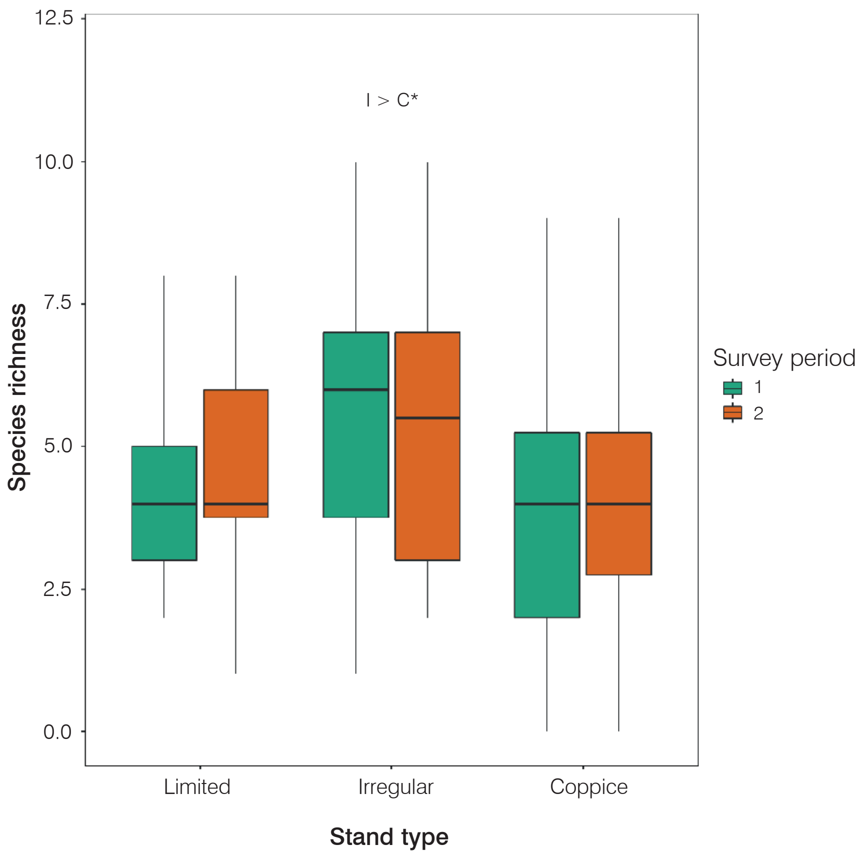

Figure 4. Box and whisker plots of bat species richness across three stand types; the boxes show the spread of the main data (50%), the horizontal black lines indicate the median, with two survey periods shown, early June-mid July (green), and end July-early September (orange). The whisker lines indicate the spread of the remaining data 25% above and 25% below each box.

Discussion and conclusions

There were clear differences between stand types in both plant communities and woodland structure. Unlike other stand types, Irregular structures were characterised by more open conditions with larger trees and a mixture of different ages of trees. Spring bird densities were highest or second highest in Irregular for 15 of the 20 species examined. In contrast, Limited intervention had the lowest or second lowest spring densities for 14 of 20 species, with notably low abundances for species, such as the warblers, that require complex understorey structures. Irregular high forest had the highest species richness and highest activity rates for most bat species, including the IUCN 'near-threatened' *B. barbastellus* (Piraccini, 2016).

Taken overall, the findings suggest that Irregular stand structures can provide suitable woodland habitats for a high proportion of those species we studied in lowland British woodland. Our research suggests that irregular high forest management is likely to be either beneficial or neutral in terms of its effects on these communities. A caveat is that such effects may be context dependent according to region, forest type and the exact stand types and communities being compared (Calladine et al., 2015). Nevertheless, recent studies in conifer woodlands undergoing transformation to

Table 4. Comparison of species richness for seven plant groups between three stand types; medians are given with range shown in brackets. Stand types that differ significantly from pairwise test ($P<0.05$) are shown in bold: L = Limited, I = Irregular, C = Coppice (For example, for summer plants there are no significant pairwise differences. For ancient woodland indicators, Coppice was significantly higher than Limited but there were no significant differences between Irregular and Limited).

Woodland plant group	Limited	Irregular	Coppice
All vascular plants	8 (3-25) IC	18 (10-31) **L**	16 (9-32) **L**
Ancient woodland indicators	2.5 (0-14) C	7.5 (1-13)	8 (2-12) **L**
Spring plants	1.5 (0-6) C	3.5 (0-6)	4 (0-6) **L**
Summer plants	1.5 (0-9)	3 (1-6)	4 (0-7)
Buried seed plants	2 (0-8) IC	6 (2-14) **L**	5.5 (1-14) **L**
Mobile plants	0 (0-2) I	1 (0-5) **L**	1 (0-4)
Non-responsive plants	3 (1-5)	3 (1-6)	2 (0-5)

irregular structures are also promising for woodland bats (Cook et al., 2023).

The value of coppicing to early successional birds and other species associated with dense understorey is well documented (Fuller and Warren, 1991; Fuller and Henderson, 1992) and it has a strong cultural association with many ancient semi-natural woods such as those found in Cranborne Chase (Rackham, 1990). However, irregular stand management as a more widely economically viable system appears to provide resources for many species associated with both understorey and old growth. Given the precarious conservation status of species such as marsh tit (Broughton and Hinsley, 2015) and barbastelle bat (Piraccini, 2016) our results are encouraging.

> "No single silvicultural system can provide the preferred habitat of all species."

No single silvicultural system can provide the preferred habitat of all species. In practice, therefore, a conservation strategy that embraces a dynamic range of management interventions is desirable to enhance habitat heterogeneity and complexity at varying spatial and temporal scales (Fuller et al., 2012; Fuller, 2021a). The use of irregular stand structures clearly has the potential to play an important role in developing this structural heterogeneity and appears to offer a wide 'ecological bandwidth'.

The results of this study support the notion that in a British context, interventions such as thinning neglected woodland benefits many woodland species. Restoration of such stands to a structurally more complex state through canopy opening to stimulate the understorey would be beneficial and, if conducted on a sufficiently large scale, may assist in the recovery of some woodland bird populations and potentially other groups (Fuller, 2013; Fuller, 2021b). An integrated approach to forest management which incorporates stand-level targets for structural attributes e.g. deadwood, as shown by Susse et al. (2011) is an exciting option; particularly if it can be adapted to include measures that provide important functional resources used by woodland birds, bats and plants in the UK (Fuller, 2021b). All are important within a functioning woodland ecosystem acting as useful indicator species and groups to guide woodland managers.

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