Slide 1

An objective, niche-based approach for selecting forest indicator species

Dr Simon Butler
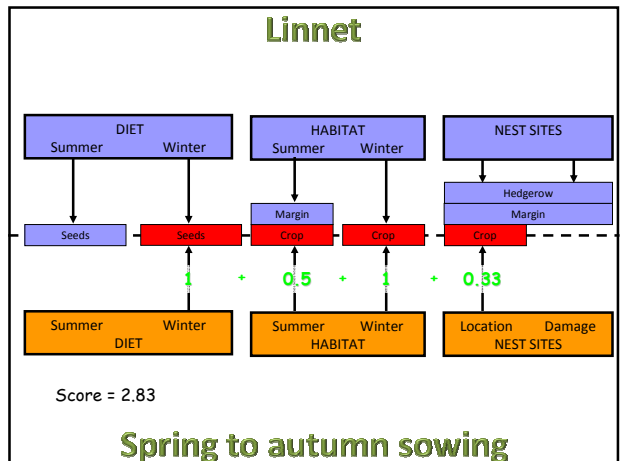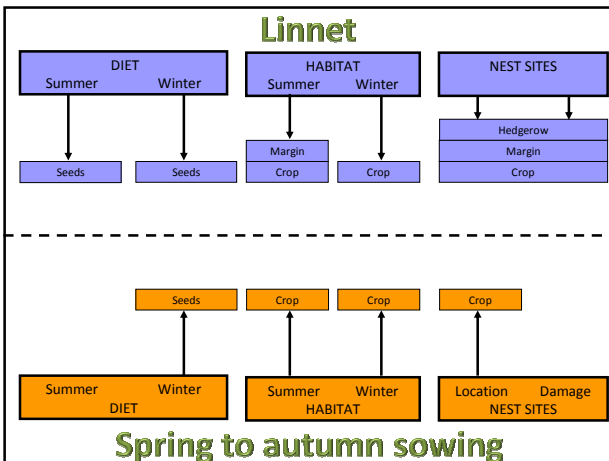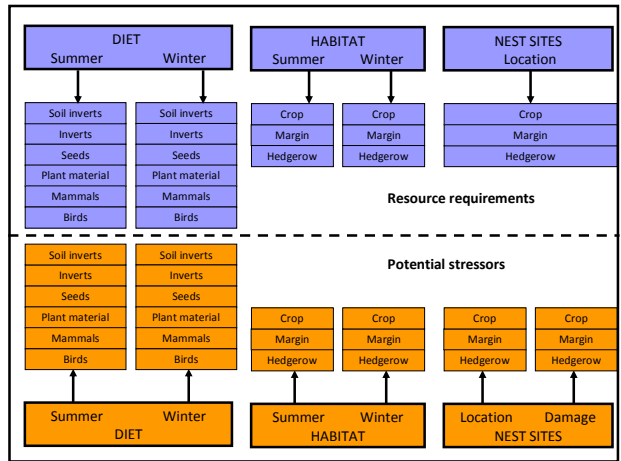## University of East Anglia

Amy Wade, Boris Barov, Ian Burfield, Richard Gregory & Ken Norris

BirdLife INTERNATIONAL BirdLife Europe · RSPB · THE ALLIANCE FOR BEVERAGE CARTONS AND THE ENVIRONMENT

Slide 2

Overview

- Previous work in agroecosystems
  - UK and pan-European
- Forest bird risk assessment
  - Linking resource availability to population dynamics
- Indicator species selection
  - pan-European, regional, forest type

Slide 3

Underlying principles

1. Land-use and management defines temporal and spatial availability of key resources (food & nest sites)
2. Impact of land use change driven by resultant changes in the quantity or quality of resource availability
3. Specialists are more vulnerable to changes in resource availability than generalists
4. Impact related to the proportion of a species' key resources that are detrimentally affected

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Slide 4

Slide 5

Linnet

Spring to autumn sowing

Slide 6

Linnet

1 + 0.5 + 1 + 0.33

Score = 2.83
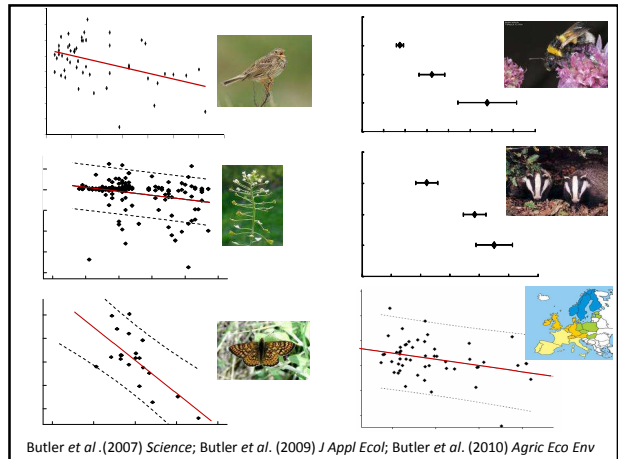
Spring to autumn sowing

Slide 1: Validation

Validation

- Resource requirements matrix – birds (summer & winter diet, foraging habitat and nesting habitat). Also for mammals, butterflies, pollinators and broadleaf weeds

<u>Six major changes in agriculture:</u>

1) Switch from spring to autumn sowing
2) Increased agrochemical input
3) Loss of non-cropped habitat
4) Land drainage
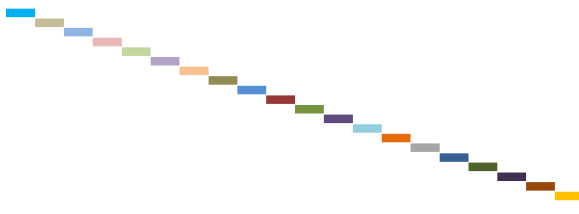5) Hay to silage & earlier harvests
6) Intensified grassland management

Impact on abundance and availability of food, habitat and nest sites

Slide 2

Butler *et al* .(2007) *Science*; Butler *et al*. (2009) *J Appl Ecol*; Butler *et al*. (2010) *Agric Eco Env*

Slide 3: Indicator selection

Indicator selection

Summer diet	Winter diet	Summer habitat	Winter habitat	Nest site

TOTAL NICHE SPACE

The Ultimate Indicator

Slide 4

Summer diet	Winter diet	Summer habitat	Winter habitat	Nest site

Rule 1: Every resource type included in the requirements matrix must be exploited by at least one species included in the indicator set

Rule 2: The indicator species set must be comprised of the most specialised species possible
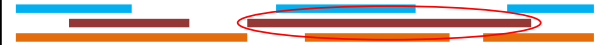
Indicator produced:

Butler *et al*. (2012) *Methods Ecol Evo*

Slide 5: Risk assessment for European forests

Risk assessment for European forests

Resource requirements matrix

Diet (summer and winter)	Foraging habitat (summer and winter)				Nesting habitat				
	Forest type	Successional stage	Horizontal position	Vertical position	Nest type	Forest type	Successional stage	Horizontal position	Vertical position
Below-ground invertebrates	Deciduous	Early	Edge	Ground	Cavity (deadwood)	Deciduous	Early	Edge	Ground
Above-ground invertebrates	Coniferous	Mid	Core	Shrub	Cavity (live wood)	Coniferous	Mid	Core	Shrub
Plant material	Mixed	Closed canopy		Canopy	External	Mixed	Closed canopy		Canopy
Seeds		Old growth					Old growth		
Vertebrates									

- 86 species included – >10% population breeding in forest habitats – recorded in 5+ countries

- Reliance on forest habitat assessed by experts (49 respondents from 20 countries): major = 1, moderate = 2, minor = 3

- Migration strategy: resident, short-distance (region) or long-distance

Slide 6: Key changes to forest habitats

Key changes to forest habitats

		Forest Type
1.	Increased abundance of small predators	C, B
2.	Increased suppression of forest fires	C
3.	Increased grazing pressure	C, B, M
4.	Intensified drainage management	C, B
5.	Intensified soil management	C
6.	Intensified thinning	C
7.	Reduced abundance of broadleaf species	C
8.	Reduced rotation length	C, B
9.	Removal of deadwood	C, B
10.	Reduced area of broadleaf/mixed forest	B
11.	Reduction in management	B, M
12.	Reduced diversity of tree species	B
13.	Increased forest fires	M
14.	Loss of habitat through urbanisation	M
15.	Increased selective logging	M

C – Coniferous dominated boreal and temperate forest
B – Broadleaf and mixed hemi-boreal and temperate forest
M – Mediterranean forest

Linking changes to loss of resources

Key reductions in quantity and/or quality of resources brought about by each forest change were identified

Reduced abundance of broadleaf species in coniferous forest
- Reduction in canopy and shrub food resources (inverts/seeds/plant material)
- Reduction in shrub and canopy nesting sites

Intensified soil management
- Reduction in below ground and ground dwelling inverts in early and mid succession habitat
- Reduction in quality of ground nesting sites in early and mid succession habitat

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Total pan-European risk score for each species

- Risk score calculated for summer foraging, winter foraging and nesting for each forest change based on resource requirements

- In each country risk weighted by area of forest type and use, then summed to give country total

- Migrants accrue either no winter risk (long distance migrants) or from regions where they over winter

- Pan-European risk: each country's risk weighted by breeding population size of the species and then summed

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Risk score vs population growth rates

Residents   Short-distance migrants   Long-distance migrants
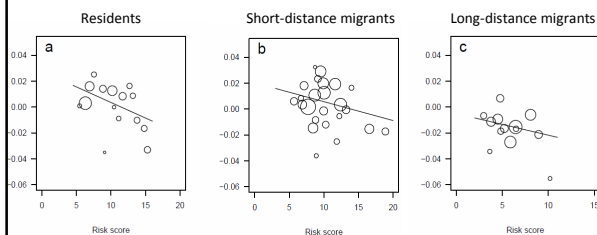
- Demonstrates that changes in coarsely-defined resources can be used to predict population dynamics

- Justifies use of resource requirements matrix to underpin indicator species selection protocol

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Forest indicator species selection

Summer diet	Winter diet	Summer habitat	Winter habitat	Nest site

- Total number of resources (i.e. total niche space) exploited by community (86 species) = 652

- First iteration: include only species covered by PECBMS monitoring (Number species = 60; total number resources = 588)

- 10 non-PECBMS species exploit one or more of 64 resource types excluded

Indicator based only on current PECBMS species not fully representative of forest bird community

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Refining the species pool

- Selection process works by comparing all possible combinations of species against characteristics specified by two rules

- Not computationally feasible to explore all possible combinations of species from a pool of 60

- Based on adherence to two rules (i.e. full resource coverage and most specialised species), refined pool by sequential removal of species with broadest niche

- Pool of 33 species

All possible combinations identified

- A Bayesian algorithm used to search the millions of potential combinations

- All combinations of the 33 species (2 to 33) with full resource coverage were identified
  - 65,542 possible combinations identified
  - A minimum of 17 species needed for full resource coverage
  - This was subset of all other possible combinations

Slide 1 — The main indicator

Species	Reliance	N resources
Sparrowhawk	2	44
Common Buzzard	2	26
Common Cuckoo	2	120
Grey-headed Woodpecker	1	48
Green Woodpecker	2	28
Black Woodpecker	1	60
Great Spotted Woodpecker	1	60
Woodlark	2	24
Winter Wren	1	181
Blackbird	2	211
Fieldfare	3	162
Crested Tit	1	26
Great Tit	2	124
Jay	1	60
Spotted Nutcracker	1	50
Chaffinch	2	90
Greenfinch	3	63

Slide 2 — An alternative: removing succession

- Assigning species to a particular stage can be difficult – stages less discrete than other components of matrix

- Difference between non-forest habitat and early succession stages also not discrete

Diet (summer and winter)	Foraging habitat (summer and winter)				Nesting habitat				
	Forest type	Successional stage	Horizontal position	Vertical position	Nest type	Forest type	Successional stage	Horizontal position	Vertical position
Below-ground invertebrates	Deciduous	Early	Edge	Ground	Cavity (deadwood)	Deciduous	Early	Edge	Ground
Above-ground invertebrates	Coniferous	Mid	Core	Shrub	Cavity (live wood)	Coniferous	Mid	Core	Shrub
Plant material	Mixed	Closed canopy		Canopy	External	Mixed	Closed canopy		Canopy
Seeds		Old growth					Old growth		
Vertebrates									

- Number of resources reduced from 588 to 182

- Irreducible indicator set has 14 species

Slide 3

Species	Reliance	Main indicator	No succession
Sparrowhawk	2	1	1
Common Buzzard	2	1	1
Hazel Grouse	1	-	1
Common Cuckoo	2	1	-
Grey-headed Woodpecker	1	1	-
Green Woodpecker	2	1	1
Black Woodpecker	1	1	1
Great Spotted Woodpecker	1		
Woodlark	2	1	-
Winter Wren	1	1	
Blackbird	2	1	1
Fieldfare	3	1	
Song Thrush	1	-	1
Crested Tit	1	1	1
Great Tit	2	1	
Tree-creeper	1	-	1
Jay	1	1	
Spotted Nutcracker	1	1	1
Chaffinch	2	1	-
Greenfinch	3	1	
Bullfinch	1	-	1
Hawfinch	1	-	1
Rustic Bunting	1	-	1

Main indicator only	
No succession only	
Both indicators	

Slide 4

Species	Reliance	Main indicator	No succession
Sparrowhawk	2	1	1
Common Buzzard	2	1	1
Hazel Grouse	1	-	1
Common Cuckoo	2	1	-
Grey-headed Woodpecker	1	1	-
Green Woodpecker	2	1	1
Black Woodpecker	1	1	1
Great Spotted Woodpecker	1		
Woodlark	2	1	-
Winter Wren	1	1	
Blackbird	2	1	1
Fieldfare	3	1	-
Song Thrush	1		
Crested Tit	1	1	1
Great Tit	2	1	-
Tree-creeper	1		
Jay	1	1	-
Spotted Nutcracker	1	1	1
Chaffinch	2		
Greenfinch	3	1	-
Bullfinch	1	-	1
Hawfinch	1	-	1
Rustic Bunting	1		

Main indicator only	
No succession only	
Both indicators	

Slide 5 — What if non-PECBMS species are included?

- The same indicator selection procedure was followed for full community of 86 species

- Refined pool of 33 candidate species differed by 10 species to that based on PECBMS species only

- Minimum of 20 species required for full coverage

Slide 6

Species out

Sparrowhawk
Common Buzzard
Crested Tit

Species in

Goshawk
Lesser Spotted Eagle
Capercaillie
Eagle Owl
Ural Owl
Boreal Owl

Possible indicator subsets

1. Regional indicators
   (North, East, South, West)
   - East and South identical to main indicator
   - North and West differed by only one species
   - Supports use of one pan-European indicator

2. Broadleaf and coniferous forest indicators
   - Broadleaf indicator: 13 species subset of main indicator
   - Coniferous indicator: 14 species with 2 different species (Willow Tit and Siskin)

Coniferous	Broadleaf
Sparrowhawk	Common Buzzard
Common Cuckoo	**Common Cuckoo**
Black Woodpecker	Grey-headed Woodpecker
Great spotted Woodpecker	Green Woodpecker
Woodlark	**Black Woodpecker**
Winter Wren	**Great spotted Woodpecker**
Blackbird	**Woodlark**
Fieldfare	**Winter Wren**
Willow Tit	**Blackbird**
Crested Tit	**Fieldfare**
Spotted Nutcracker	Great Tit
Chaffinch	Jay
Siskin	**Greenfinch**
Greenfinch	

Conclusions/Discussion points

- Population dynamics of forest birds can be linked to changes in quantity or quality of coarsely defined resources – basis for indicator selection
- An indicator based on PECBMS-monitored species will not be fully representative of forest community
- Should a "forest indicator" include species only linked to early succession stages?
- Regional and forest-type alternatives broadly equivalent to, or subsets of, pan-European indicator set