INSTITUTE OF ACOUSTICS SECONDARY SCHOOLS' COMPETITION 2023 - THE CONNECTION BETWEEN ACOUSTICS AND ECOLOGY

D Holden*, Balshaw's Church of England High School, Church Road, Leyland PR25 3AH
D C Waddington, Acoustics Research Centre, University of Salford, Salford M5 4WT

*Corresponding author: D.Holden@balshaws.org.uk

ABSTRACT

This paper presents the experience and findings of pupils and staff from Balshaws High School who participated in the Institute of Acoustics Secondary Schools' Competition 2023. The study investigated the acoustic ecology of bird song in three acoustically different areas in the local area of Balshaws School in Leyland, UK. The areas investigated were a park, a road, and a residential area.

The pupils used the BirdNET app to identify birds in the three areas, and they also used ISO/TS 12913-3:2019 to assess the quality of the soundscape from a human perspective. The results showed that the park had the highest diversity of bird species, while the road had the lowest. The soundscape of the park was dominated by the songs of birds, while the soundscape of the road was dominated by the noise of traffic. The soundscape of the residential area showed the highest number of birds, dominated by the House Sparrow (Passer domesticus). However, the quality of the soundscape from a human perspective was considered 'annoying' and 'monotonous' due to the repetitive nature of the House Sparrow's song. Time and frequency analyses of acoustical measurements are used to illustrate features that may explain this human response.

The team's findings are important because they highlight the need to consider the acoustic environment when planning and developing new roads and improving residential biodiversity. By improving greening in residential areas and reducing road traffic noise, we can help improve the overall quality of life for people living in urban areas and protect bird populations.

The pedagogy of the project was designed to engage pupils in hands-on learning about the acoustic ecology of bird song, which is a STEM-related topic. The pupils developed skills in critical thinking, problem-solving, and collaboration. The project was well-received by the pupils, and they were enthusiastic about participating.

The implications of this work are that the Institute of Acoustics Secondary Schools' Competition 2023 provides a valuable model for other projects that aim to engage pupils in learning about STEM. The project was designed to be inquiry-based and collaborative, and it helped the pupils to learn much about different factors that influence the acoustic ecology and soundscape.

Keywords: acoustic ecology, bird song, noise pollution, ISO/TS 12913-3:2019, pedagogy

1 INTRODUCTION

The acoustic ecology of birds is a complex and fascinating subject. Birds use their songs to communicate with each other, to attract mates, and to defend their territories. The soundscape of an area can be influenced by a variety of factors, including the presence of different bird species, the amount of human activity, and the surrounding environment.

In this paper, we present the results of a study conducted by pupils from Balshaws School in Leyland, UK. The soundscape of an area can be influenced by a variety of factors, and these factors can change over time. This study provides valuable insights into the acoustic ecology of bird song, and it highlights the importance of protecting bird habitats. Performing the competition also provides

valuable pedagogical insights that will be of value to other schools aiming to engage pupils in learning about STEM.

2 METHODOLOGY

The study was conducted by pupils from Balshaws School in Leyland, UK. The pupils used the BirdNET [1] app to identify the bird species. The app uses AI machine learning to identify bird songs, and it provides a list of possible matches for each recording.

A preliminary study was performed in which the performance of the BirdNET app was assessed in the presence of controllable background sound, a simple water feature to represent broadband road noise. The performance of the AI was investigated with and without the background noise. In addition, during the preliminary study the pupils also recorded the background noise levels. They used a sound level meter (01dB Symphonie) to measure the noise levels, and they logged the results in decibels ($L_{Aeq,T}$ and L_{Cpeak}). The data was analyzed using a statistical software package (dBTrait). The data used to determine the frequency content of the bird songs and the number of bird calls in a given time period.

For the main study, the pupils used the BirdNET app to identify the birds present in three acoustically different areas in their local area. The areas they investigated were:

1. A residential area with a mix of houses and road traffic
2. A road with heavy traffic
3. A park with a large amount of green space

The pupils then analyzed the data to determine the diversity of bird species in each area.

In addition to using the BirdNET app, the pupils also used ISO/TS 12913-3:2019 [2] to capture human soundscape impressions. This standard provides a framework for assessing the subjective, emotional, and aesthetic qualities of soundscapes. The assessment was performed by the team leader.

3 RESULTS

3.1 Preliminary study

3.1.1 Effect of background noise on BirdNET

A preliminary study was conducted to investigate the effect of background sound source on BirdNET detections. The study took place in a suburban back garden on 30/05/2023. Two consecutive 10-minute sampling periods were conducted, one with a water feature on and one with the water feature off.

Table 1 Effect of background source on BirdNET detections

Time	Background sound source	Birds detected on App	Confidence	Detections
1158	On	House Sparrow	Almost certain	3
1204	On	European goldfinch	Highly uncertain	1
1212	Off	House Sparrow	Almost certain	6
1214	Off	Eurasian tree Sparrow	Almost certain	2

The data in Table 1 shows that the presence of a water feature had a significant impact on BirdNET detections. During the 10-minute period with the water feature on, the number of detections was lower as was the confidence in the identification of these species. During the 10-minute period with the

water feature off, twice as many birds were detected, and the confidence in the identification of these species was high, with all detections being classified as "almost certain".

These results suggest that the presence of background noise can interfere with BirdNET's ability to detect birds. This is likely due to the fact that the sound of running water can mask the sounds of bird song, but it is also possible that the AI confuses the sound of running water with the bird song. The study suggests that the confidence in BirdNET's identifications is higher when there is less background noise, and this has implications for detecting birdsong in the presence of high levels of traffic noise. Further research is needed to confirm these findings and to investigate the effects of other background sound sources on BirdNET detections.

3.1.2 Measurements of bird noise

Acoustical measurements of bird noise are illustrated in Figures 1, 2 and 3. Figure 1 shows the sound level time history for 24 hours of bird noise in the residential area running from midnight to midnight. Highlighted by the two red cursors is the onset of the dawn chorus starting around 4:30. It is seen that the sound level rises from ~30dBA to ~65dBA within around 30 minutes. The sound level dies down and continues at ~50dBA until after 20-30 in the evening.

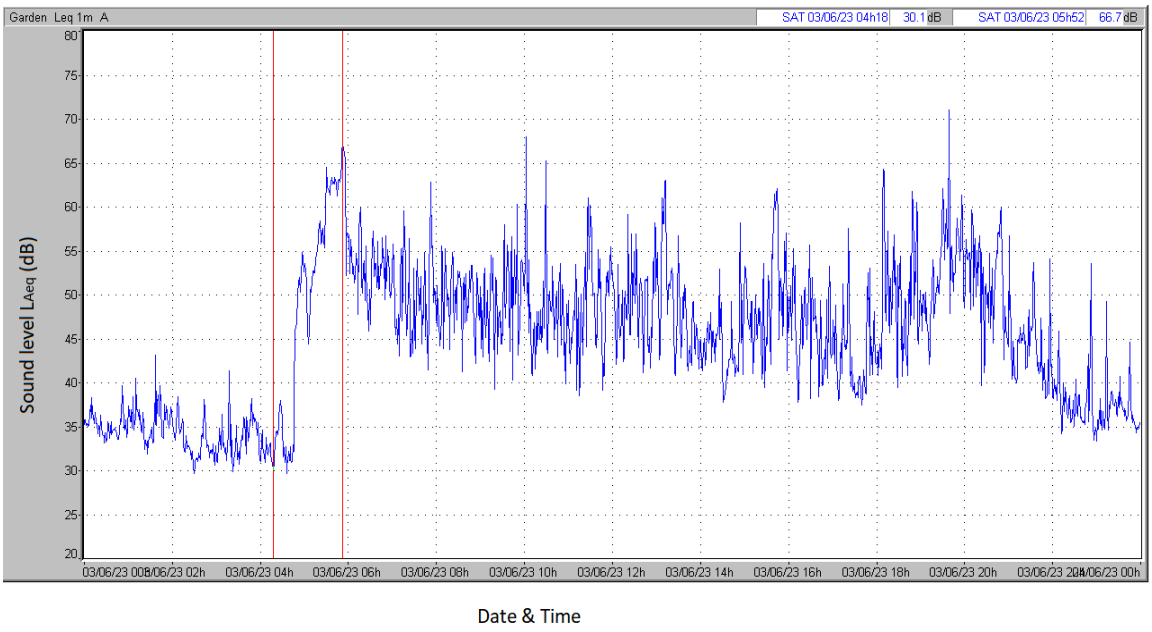

Figure 1: Time history showing 24-hours of bird noise in the residential area

Detail of the dawn chorus is shown in Figure 2 which shows the C-weighted peak sound pressure level over 1 minute. More than 80 tweets are seen, most exceeding 80 dBC peak. A frequency analysis of House Sparrow tweets is shown in Figure 3. The sound levels of this analysis are A-weighted to illustrate how the different frequencies are sensed by the human ear. It is seen that the tweets dominate around 4 kHz, the frequency range in which the human ear his most sensitive. These acoustic features are likely to be responsible for making the House Sparrow's song ‘annoying’ and ‘monotonous’ from a human perspective.

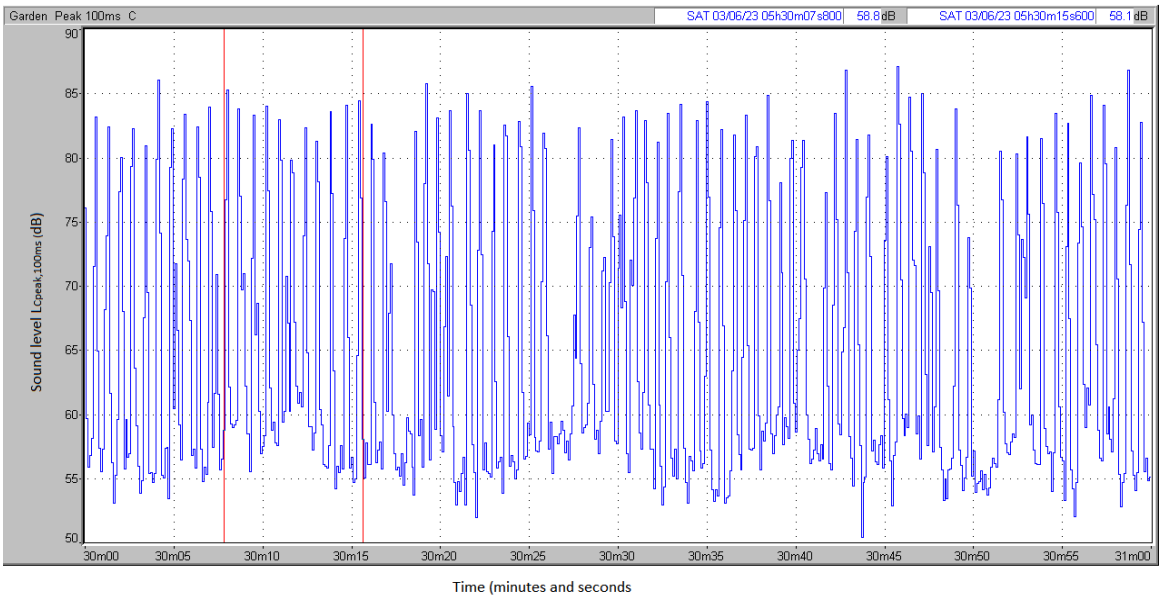

Figure 2: Detail of 1 minute showing peak sound levels of House Sparrow tweets

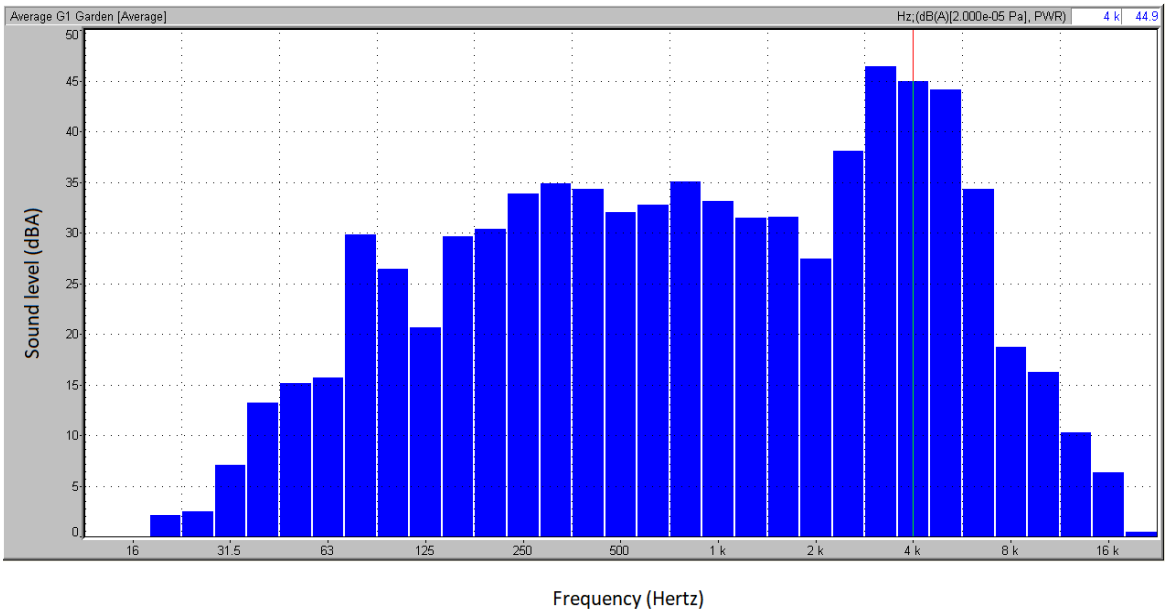

Figure 3: Frequency analysis of House Sparrow tweets

3.2 Main study

3.2.1 Bird numbers and diversity

An example of a pupil observations in the park over one 10-minute sampling period is shown in Table 2.

Table 2: Example of pupil observations. One 10-minute sampling period in the park.

Time	Birds detected on App	Confidence
1156	Eurasian bluetit	Almost certain
1158	Eurasian Blackbird	Uncertain
1200	Common chaffinch	Almost certain
1201	Common chaffinch	Highly likely
1201	Eurasian bullfinch	Uncertain
1203	Eurasian wren	Uncertain

The list of all birds identified by all pupils in the park is shown in Table 3.

Table 3: All birds identified by all pupils in the park

Common Name	Latin Name
Blue Jay	Cyanocitta cristata
Cedar Waxwing	Bombycilla cedrorum
Common Chaffinch	Fringilla coelebs
Common Wood Pigeon	Columba palumbus
Eurasian Blackbird	Turdus merula
Eurasian Blue Tit	Cyanistes caeruleus
Eurasian Nuthatch	Sitta europaea
Eurasian Robin	Erithacus rubecula
Eurasian Wren	Troglodytes troglodytes
European Goldfinch	Carduelis carduelis
European Magpie	Pica pica
Field Sparrow	Spizella pusilla
Great Black-backed Gull	Larus marinus
Great Spotted Woodpecker	Picoides major
House Sparrow	Passer domesticus
Long-tailed Tit	Aegithalos caudatus
Mistle Thrush	Turdus viscivorus
Pygmy Cupwing Crow	Perisoreus infaustus
Short-toed Treecreeper	Certhia brachydactyla
Slender-footed Tyrannulet	Phylloscartes sylviolus

The list of all birds identified by all pupils in the residential areas is shown in Table 4.

Table 4: All birds identified by all pupils in residential areas

Common Name	**Latin Name**
Common Blackbird	Turdus merula
Common Cuckoo	Cuculus canorus
Common Raven	Corvus corax
Eurasian Blue Tit	Cyanistes caeruleus
Eurasian Goldfinch	Carduelis carduelis
Eurasian Oystercatcher	Haematopus ostralegus
Eurasian Skylark	Alauda arvensis
European Starling	Sturnus vulgaris
Heermann's Gull	Larus heermanni
House Sparrow	Passer domesticus
Lesser Black-backed Gull	Larus fuscus
Northern Lapwing	Vanellus vanellus
Sedge Warbler	Acrocephalus schoenobaenus
White Wagtail	Motacilla alba
Yellowhammer	Emberiza citrinella

The following table summarizes the results of the study:

Table 5: Summary of all observations by location

Location	**Number of bird species**	**Dominant sounds**
Park	21	Bird songs and people
Road	0	Traffic noise
Residential area	15	House sparrows and traffic noise

Our study found that the number and diversity of bird species present in the three areas differed. The park had the highest diversity of bird species, with 21 different species identified. The soundscape of the park was dominated by the songs of birds such as the Common Chaffinch, European Goldfinch and Eurasian Blue Tit. The soundscape of the road was dominated by the noise of traffic, and the bird songs were difficult to hear. The road had the lowest diversity of bird species, with none identified and only one faintly heard. The residential area had a moderate diversity of bird species, with 15 different species with a dominance of House Sparrow songs on the recordings. The soundscape of the residential area was a mixture of bird songs and traffic noise.

3.2.2 Human response to soundscape

Our study also found that the soundscape of the three areas differed significantly. The park had the most complex soundscape, with a wider variety of bird songs and other natural sounds along with passing people. The road had the simplest soundscape, with almost entirely traffic noise that was unpleasantly loud. The residential area had a soundscape that was intermediate between the park and the road, with a mix of bird songs, traffic noise, and other human sounds.

The park had the highest rating for overall pleasantness, followed by the residential area and then the road. This was likely due to the park's greater diversity of bird species and lower noise level. The road had the lowest rating for both pleasantness and diversity, due to its high noise level.

The residential area had the highest number of birds, but the soundscape was dominated by the House Sparrow (Passer domesticus). The repetitive nature of the House Sparrow's song made the soundscape ‘annoying’ and ‘monotonous’ from a human perspective.

The results of the ISO/TS 12913-3:2019 assessment suggest that the soundscape of an area can have a significant impact on human perception. The park, which had the highest rating for overall pleasantness, was also the area with the highest diversity of sounds. This suggests that the presence of birdsong can contribute to a more pleasant soundscape.

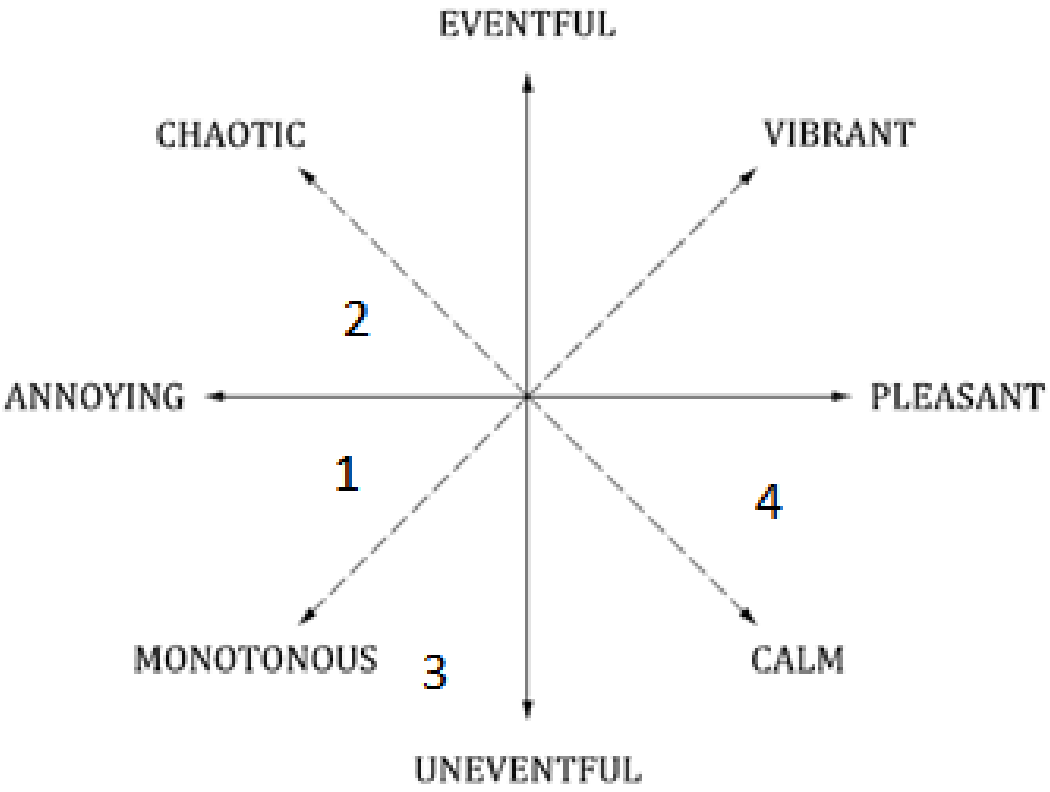

Figure 4: Subjective soundscape assessments for four scenarios. 1) Residential garden with water feature on. 2) Residential garden with water feature off. 3) Roadside. 4) Small wood in park.

4 DISCUSSION

4.1 Ecological findings

The acoustic ecology of bird song is a complex and dynamic system that is influenced by a variety of factors. These factors include the presence of different bird species, the amount of human activity, and the surrounding environment, all of which change of time.

The results of this study are consistent with previous research on the acoustic ecology of bird song. For example, a study by Slabbekoorn and Ripmeester (2008) [3] found that the diversity of bird species in an area is negatively correlated with the amount of traffic noise. This is because traffic noise can mask the songs of birds, making it difficult for them to communicate with each other.

Our findings have implications for the conservation of bird populations. As human activity increases, the soundscape of many areas is becoming increasingly dominated by noise from traffic, construction, and other sources. This noise can make it difficult for birds to communicate with each other, attract mates, and defend their territories.

The loss of viable bird habitats can also lead to a decline in bird diversity. This can have a negative impact on the ecosystem, as birds play an important role in pollination, seed dispersal, and pest control.

Our study provides further evidence of the importance of considering the acoustic ecology of bird song when planning and developing new areas. By reducing noise pollution and creating more suitable habitats, we can help to protect bird populations and ensure that they have a healthy environment to live in.

4.2 Pedagogy of the Project

The pedagogy of this project was designed to engage pupils in hands-on learning about the acoustic ecology of bird song. The project was inquiry-based, and pupils were encouraged to ask questions and explore the data. It also involved collaborative activities, which helped pupils learn from each other.

The project was successful in engaging pupils and helping them to learn about the acoustic ecology of bird song. Pupils were enthusiastic about the project and learned a lot about the different factors that influence the soundscape. They were also able to develop critical thinking, problem-solving, and collaboration skills by collecting data, analyzing data, and drawing conclusions.

The project was a valuable model for other projects that aim to engage pupils in learning about STEM. It was designed to be inquiry-based and collaborative, and it helped pupils learn much about the acoustic ecology of bird song.

5 CONCLUSIONS

The results of this study highlight the importance of protecting bird habitats. The park had the highest diversity of bird species, while the road had the lowest. This suggests that areas with more green space and less traffic noise are more likely to support a diverse range of bird species.

The high diversity of bird species in the park is likely due to the abundance of food and shelter in this habitat. The park provides a safe place for birds to build their nests and raise their young. The exceptional number of house sparrows in the residential area is likely due to the abundance of food and shelter well suited to this type of bird in these locations.

The low numbers and diversity of birds by the road have implications for the conservation of bird habitats. As human activity increases, the amount of noise pollution in the environment is also increasing. This can have a negative impact on bird populations, as it can make it difficult for them to communicate and find mates.

Our study suggest that the use of ISO/TS 12913-3:2019 can be a valuable tool for understanding the impact of noise pollution on human well-being. By using this standard, we can better understand how noise pollution affects our perception of the environment, and we can take steps to reduce noise pollution and improve the quality of our soundscapes.

Planners and architects should consider the acoustic ecology of bird song when designing new developments. This study suggests that bird ecology is a complex and dynamic system. This means that by modifying areas to introduce more green space and less traffic noise, we can help to protect bird populations and improve the overall quality of life for people.

The pedagogy of this project is a valuable model for other projects that aim to engage pupils in learning about STEM. The project was designed to be inquiry-based and collaborative, and it helped pupils learn much about the acoustic ecology of bird song.

6 FURTHER WORK

The following are some recommendations for further work in this area:

1. A more detailed study of the impact of noise pollution on bird populations.
2. Conduct further studies to investigate the effects of noise pollution on bird populations in different habitats.
3. A study of the effectiveness of different methods for reducing noise pollution.
4. Develop more effective methods for assessing the impact of noise pollution on bird populations.
5. Identify and implement strategies for reducing noise pollution in areas with high levels of human activity.

7 REFERENCES

1) Pérez-Granados, C. (2023). BirdNET: applications, performance, pitfalls and future opportunities. Ibis. https://doi.org/10.1111/ibi.13193
2) ISO, T. (2019). 12913-3: 2019—Acoustics—Soundscape Part 3: Data Analysis. *ISO: Geneva, Switzerland*.
3) Slabbekoorn, H., & Ripmeester, E. A. P. (2008). Birdsong and anthropogenic noise: implications and applications for conservation. Molecular ecology, 17(1), 72-83. https://doi.org/10.1111/j.1365-294X.2007.03487.x