CLIMATE CHANGE: **BATS AND THEIR CONSERVATION**

COST
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Bats & Climate Change

HOW WILL CLIMATE CHANGE AFFECT BATS?

→ 1 DISTRIBUTION AND SURVIVAL

Changes in temperature and water availability can affect the distribution and survival of bat species across Europe.

→ 2 FOOD AVAILABILITY

Climate change can influence the distribution of prey species, and also affect the timing of their lifecycles. This can mean a shortage of food for bats at critical times of year.

→ 3 BEHAVIOUR

Bats rely on precise timing for migration, hibernation, and reproduction. Altered climate conditions can disrupt these vital life events.

→ 4 ECOSYSTEM CONSEQUENCES

Bats are one of the primary predators of insects. The impacts of climate change on bats and their prey, including crop pests, can therefore have far-reaching consequences for both natural ecosystems and for agricultural.

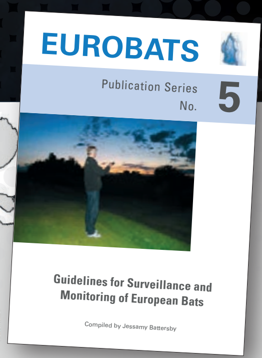


Figure 1. – above
Selected species illustrating the diversity of expected responses to climate change: range expansion, maintenance, and contraction.

Figure 2. – map
A proposed monitoring network for 11 key bat species. The network has been optimised to gather information on species likely to show different responses to climate change, and can act as an early warning system to prompt conservation management.

Figure 3. – Eurobats
Updated guidelines for the surveillance and monitoring of European bats has been produced as part of the COST Action CA18107.

SUMMARY

Climate change has wide-ranging adverse effects on wildlife and the essential ecosystem services they provide. Bats are a diverse and widely distributed group that make up about a fifth of all the native mammal species in Europe. All but one of our 45 species are insect-eaters, and they play a vital role in regulating insect populations. Despite their vulnerability to climate change, bats have received relatively little attention compared to other animal groups. For example, there are only 78 published research papers addressing climate and bats, compared with more than 2,800 papers on birds[1].

Bat populations across Europe have suffered long term declines as a result of habitat loss, pesticide use, and roost disturbance. Because they breed very slowly, with a maximum of one offspring per year, it can take a long time for failing populations to recover. Bats are protected by the Habitats Directive and other legislation, both within and outside the EU, which is intended to improve their conservation status. Climate change adds to the other pressures they face, altering the availability of food and water, and modifying the temperature of roosts.

We know that bats are particularly likely to be affected by temperature alterations and the extreme weather events that are linked with climate change. Their small body size means they cool rapidly, and their babies grow poorly, if temperatures are low. High rainfall in the breeding season can also make it difficult to find food. Cool springs and wet summers, which are increasingly common in northern Europe, are therefore likely to be challenging. On the other hand, their large wing area means that they dehydrate rapidly. Climate change is likely to increase the frequency of heatwaves and droughts, and studies show that these are linked with alarming mass mortality events, as well as with physiological changes that can lower reproductive rates[1].

One of the main ways in which animals can respond to climate change is to shift to higher altitudes or latitudes. This means that where different bat species are found is likely to alter in the future. As part of the Bats and Climate Change COST Action, we have made predictions of where these changes are likely to occur. These predictions can be used to help ensure that suitable habitat is available for them in these new locations, and also to provide an early warning of the potential loss of important insect predators in some parts of Europe.

Bats have a critical economic role through their contribution to pest suppression, and nutrient cycling and distribution. Around the world, people are becoming interested in the role bats can play in agriculture, because insect pests are an important part of bats' diets. In Europe, bats have been found to suppress pests in rice paddies[2] and vineyards[3]. They also eat moths that damage a range of crops including carrots, strawberries, lettuce, tomato, potato, spinach, cotton, and tobacco[4].

Work to understand the role of bats in farming, forestry and natural ecosystems is in its infancy. It is vital that account is taken of climate change when developing strategies for future bat conservation and sustainable agriculture.

HOW IS CLIMATE CHANGE AFFECTING BATS?

THE GLOBAL PICTURE

Range contractions are frequently reported in studies of bats and climate change, either as a consequence of the loss of suitable habitat and foraging, or as a direct result of unsuitable temperature and water availability. In our review of 78 papers published worldwide, nearly 40% reported this outcome. On the other hand, 30% reported range expansions, presumably because some of the more mobile species expand into new locations There were also impacts on birth and death rates, which could have important implications for bat conservation. Negative effects were reported in 61% of studies, though there were also some reports of improved birth and survival with increasing temperature. However, heatwaves were invariably linked with increased mortality.

To improve our understanding of the effects of climate change, it is critical to obtain better data. Of all the studies reviewed, only 44% presented solid evidence of how different bat species' respond to climate change, while most of them relied on model predictions or speculations. There were also relatively few studies that examined experimentally the mechanisms through which climate change could act, with most relying on associative analyses which can be difficult to interpret when many other factors, for example agricultural practice, can be changing simultaneously. Finally, very few long-term studies are available. We have been able to identify just 9 which lasted for more than 20 years. Over the last decade or so, there has been a considerable increase in the amount of bat monitoring conducted in Europe, particularly with the involvement of citizen scientists. If appropriately supported, these projects will provide a critical source of information for the future.

OVERALL PREDICTIONS FOR EUROPE

Using projected climate and land-use change for 2050, we have been able to predict alterations in the likely suitability of habitat across Europe for 37 of our bat species (insufficient information was available for the remainder). If the proportion of carbon dioxide in the atmosphere continues to grow unabated, our models suggest:

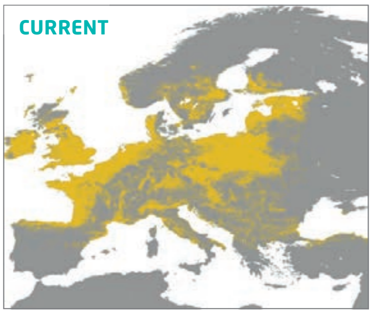
- Nathusius' pipistrelle *Pipistrellus nathusii* is likely to expand its range by about 21%.
- Common noctule *Nyctalus noctula*, Brown long-eared *Plecotus auritus* and Grey long-eared *Plecotus austriacus* are likely to retain a stable range size.
- Seven species are predicted to suffer severe range contractions of over 30% by 2050, with the Pond bat *Myotis dasycneme* experiencing the greatest loss (64%). This species is already of conservation concern, with falling populations in the west of its range and especially in the Netherlands.
- The contracting species are likely to experience range losses in southern Europe. This is particularly worrying given that the Iberian, Italian, and Balkan Peninsulas have historically supported bat populations with higher levels of genetic diversity than elsewhere in Europe. Loss of these populations may therefore result in the simultaneous loss of potential to evolve responses to future challenges.
- All four of the species that are predicted to maintain their overall range size experience losses in parts of their range that are compensated for by expansion, usually northwards, elsewhere.
- The median (average) range contraction predicted across all species is 10%.

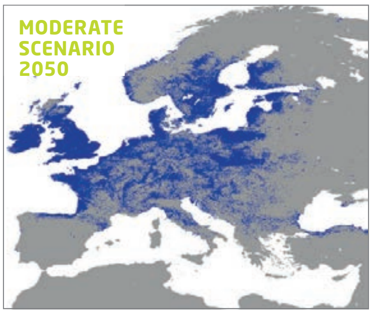
CURRENT AND PROJECTED FUTURE DISTRIBUTIONS OF 4 BAT SPECIES

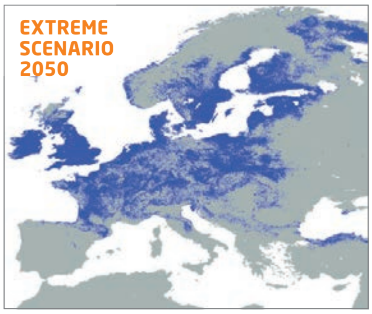
We have predicted the changes in range for the species in the monitoring network under two contrasting climate change scenarios. The first is 'the business as usual' worst-case, or 'Extreme', scenario of no curtailment of greenhouse gas emissions (known as rcp 8.5 by the UN's Intergovernmental Panel on Climate Change (IPCC)). The second 'Moderate' scenario assumes no material implementation of carbon reduction policies but accounts for reductions in the availabilty, and increased costs, of fossil fuels (rcp 4.5, IPCC).

PIPISTRELLUS NATHUSII

Pipistrellus nathusii **gains range overall, but is predicted to experience losses in Spain, Italy and the Balkans, particularly in the extreme scenario.**

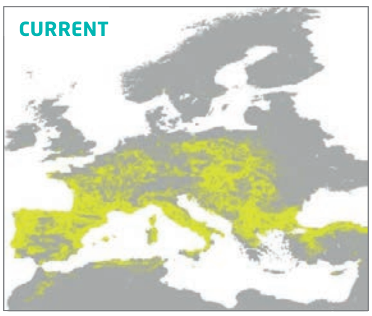


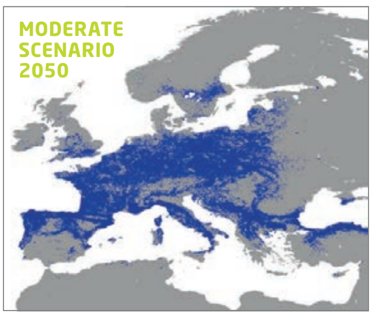


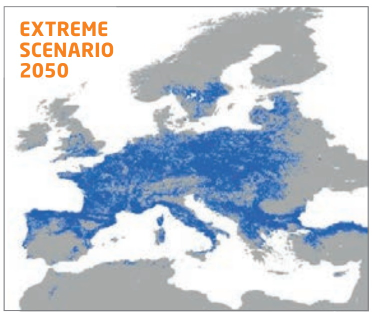


PLECOTUS AUSTRIACUS

Plecotus austriacus **has no net change in the size of its range, but has severe losses in the Iberian Peninsula, which is currently the core of its range.**



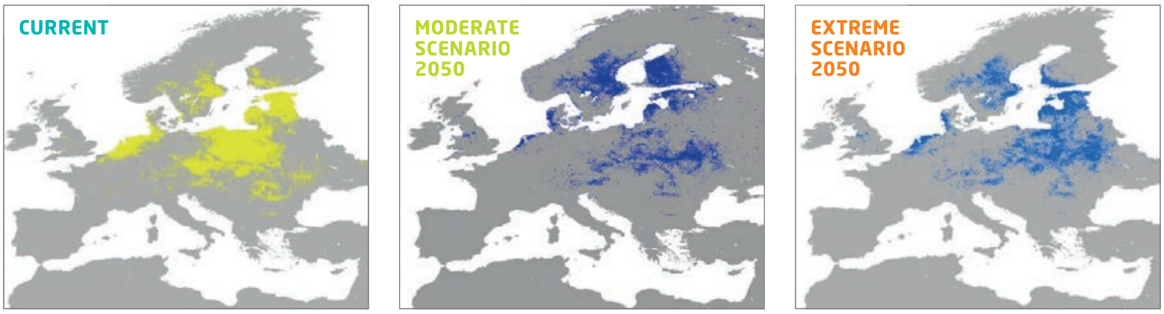




CURRENT AND PROJECTED FUTURE DISTRIBUTIONS OF 4 BAT SPECIES
CONTINUED

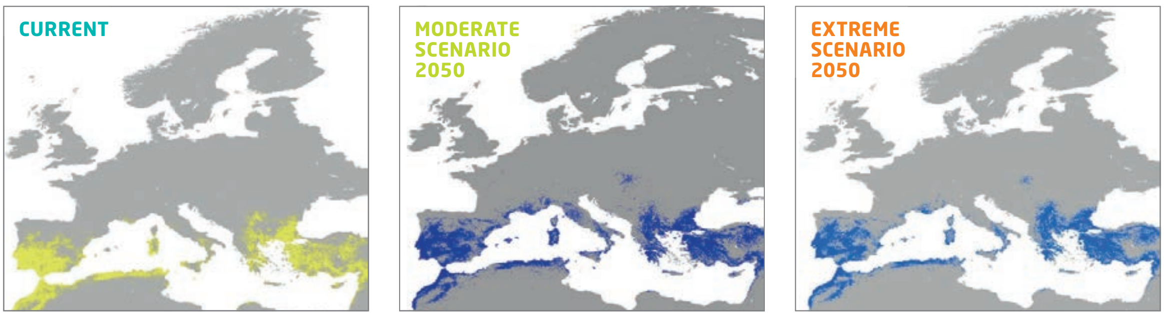
MYOTIS DASYCNEME

***Myotis dasycneme* is predicted to lose c. 64% of its range under the extreme scenario, and slightly less under the moderate scenario.**



RHINOLOPHUS MEHELYI

***Rhinolophus mehelyi* is predicted to lose c. 50% of its range under the extreme scenario.**



Photos: *Plecotus austriacus* by D. Hargreaves, *Myotis dasycneme* R. Janssen, *Rhinolophus mehelyi* by L. Cistrone

ESTABLISHING BAT MONITORING TO ASSESS THE IMPACTS OF CLIMATE CHANGE

At present, we lack essential information to monitor the effects of climate change on bats.[1] There are very few monitoring studies that use the same or "standardized" methods, and even fewer are conducted over extended periods. The recent expansion of conservation projects based on citizen science and the availability of the latest survey equipment at affordable prices has caused a recent increase in bat data collection. To gain a better understanding of the impact of climate change on bat conservation and agriculture, it is crucial to establish a standardized and systematic pan-European monitoring scheme.

We focused on indicator species of bat that responded significantly to climate change across Europe, which allowed us to identify areas where these species might experience gains, losses, or maintain suitable habitats due to climatic changes. Collaborating with researchers and stakeholders across the continent, we designed effective monitoring approaches to track changes in bat distributions and population status. Additionally, we evaluated strategies for collecting and sharing data on demographic variables from bats, providing valuable early warnings to promptly address conservation challenges. Throughout this process, we emphasized nurturing interactions between scientists and stakeholders, enhancing bat monitoring capacity across Europe.

Using a Spatial Conservation Planning method that blends information about where bats live, potential dangers they face, and the logistical challenges faced by people monitoring them, we designed an efficient monitoring network for Europe. This network is designed to spot shifts in bat populations due to climate change impacts. This approach helps us make smart choices about where to protect bats, even beyond specially designated areas.

A group of 11 bat species was selected for the monitoring programme, all of which can be monitored using automatic ultrasound detectors which detect the sounds frequently emitted by bats for navigation. The result is a monitoring network that covers around 1,600 locations. This makes up just 1% of all the places we want to protect in Europe. We planned this network to make the best use of resources and to limit costs: we considered factors like how many roads there are, how long it takes to get from big cities to the sites, and we tried to avoid heavily populated areas. We also gave priority to natural areas, reserves, and parks that are already protected.

In addition, we worked closely with the Monitoring and Indicators Intersessional Working Group from Eurobats to update the guidelines for monitoring bats, which had been published in 2010. The new guidelines have been adjusted to include the latest information about new technologies like bioacoustics and thermal imaging. These updated guidelines aim to be easy to use, especially for new researchers and nature enthusiasts who might not have much experience with bats. This is important because increasing numbers of people are interested in participating in citizen science projects.

ESTABLISHING BAT MONITORING FOR ASSESS THE IMPACTS OF CLIMATE CHANGE
CONTINUED

Despite all these efforts, there are still 10 bat species in Europe that have no established specific monitoring protocols. This means we do not have enough information about these species to assess the conservation status of their populations or to make future predictions.

It is also important for bat biologists to deal with the challenges of effectively gathering, organizing, and storing large amounts of data, managing databases, and enabling researchers from different regions to share knowledge. A team of bat researchers from the BiBio Research Group at the Natural Sciences Museum of Granollers in Spain has created an online platform called www.batmonitoring.org. This platform brings together comprehensive information about bat monitoring programs conducted across Europe. The programme features a dynamic and user-friendly database designed to collect and manage bat research data collected by professional researchers, nature enthusiasts, or volunteers from non-governmental organizations (NGOs). It includes four different protocols designed to cover bat activity in different types of habitat and at different times of year. It can also store information gathered from projects that involve capturing bats.

The need for standardized monitoring of climate change impacts on bats is urgent: the use of diverse approaches has been hindering the opportunities for unified research across Europe. Our efforts, including focusing on indicator species, collaboration, and a well-designed monitoring network, will help us to identify bat population shifts..

www.batmonitoring.org

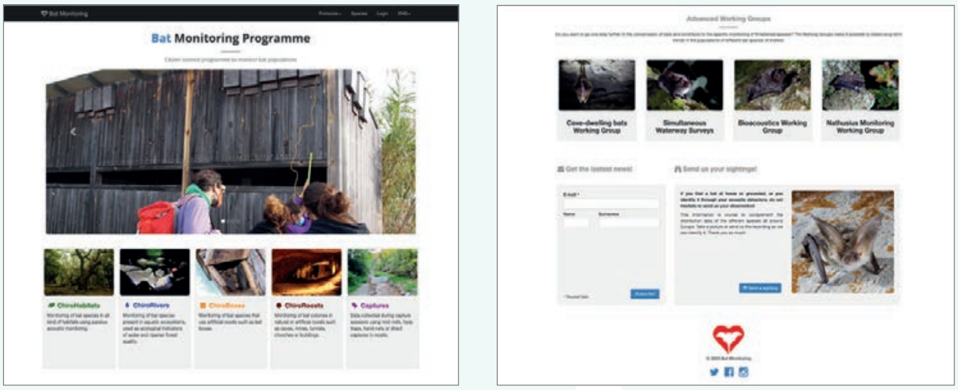


Figure 9.
Bat Monitoring Programme. Online tool to store, handle and manage collected bat data, either from acoustic surveys, traditional captures, waterway surveys, bat boxes or roosts inspections (caves, mines, buildings, etc.). www.batmonitoring.org

CASE STUDY

BATS AS NATURAL PEST CONTROLLERS IN SPANISH RICE FIELDS

Research from the Natural Sciences Museum of Granollers has uncovered the crucial role of bats in tackling rice borer moths (Figure 6), one of the world's most widespread and destructive rice pests. The research showed that these bats not only eat the pests but also scare them away with their echolocation signals.

A study the Iberian Peninsula found that creating bat boxes to attract soprano pipistrelle bats *Pipistrellus pygmaeus* (Figure 7) substantially controlled these moths, reducing the need for insecticides. This was so effective that by 2011, farms using bat boxes did not need insecticides. Further experiments at these farms, in which bats were prevented from feeding on moths by the use of special enclosures (Figure 8), showed that the economic savings from bat activity amounted to approximately 100€ per hectare, and saved 17-146kg of rice per hectare.

Research has also suggested that bats' sounds influence moth behaviour, leading to around 50% fewer eggs being laid by captive moths exposed to the bats' ultrasound. It is anticipated that this effect will also lead to improvements in crop yield.

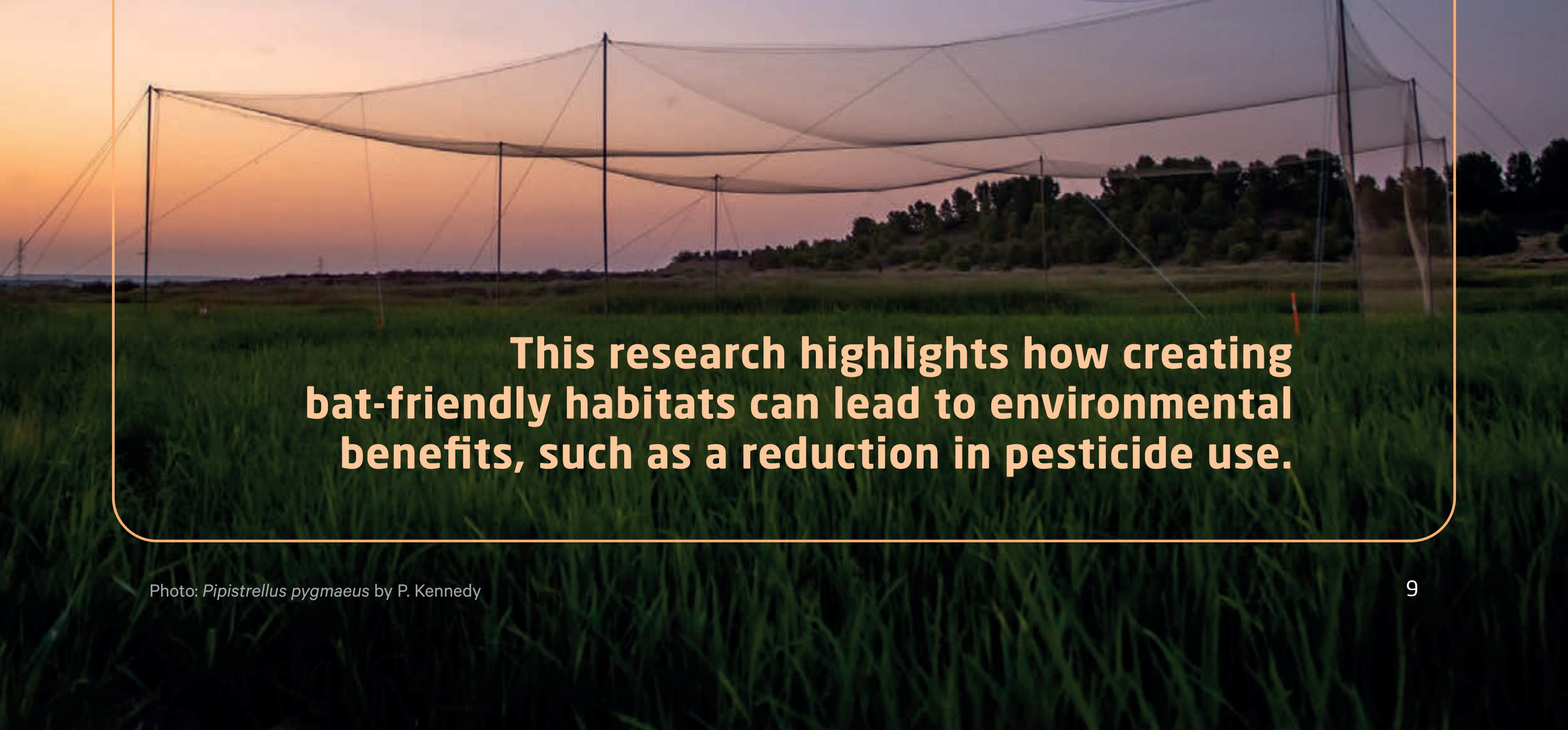


Figure 6. – above
Rice Borer moth
Chilo suppressalis

Figure 7. – right
Soprano pipistrelle bat
Pipistrellus pygmaeus

Figure 8. – main image
2021 experiment excluding bats from rice paddies

This research highlights how creating bat-friendly habitats can lead to environmental benefits, such as a reduction in pesticide use.

Photo: *Pipistrellus pygmaeus* by P. Kennedy

CONCLUSION

Exploring the impacts of climate change on bats highlights both challenges and opportunities. Bats are crucial components of European ecosystems, and providers of services valuable to agriculture. Our research has illuminated their vulnerabilities and responses, underscoring the need for swift action to protect their populations; and our COST Action has fostered collaboration between scientists and stakeholders across Europe. It is now critical to implement a standardized monitoring network across Europe, to learn more about the economic value of bats to agriculture, and to understand the potential impacts of climate change on the services provided by bats.

To stay updated with the Action's progress and insights, you can visit our website at climbats.eu and follow us on Twitter at #batstothefuture. Together, we can cultivate sustainable management practices and preserve the invaluable contributions of bats to our ecosystems and society.

#batstothefuture

NEXT STEPS FUTURE RESEARCH NEEDS

1 DEFINING AND PREDICTING EFFECTS

Further research is needed to find out how bats respond to different climatic conditions and the roles played by life history traits and environmental factors.

2 MONITORING AND POLICY

Establishing a monitoring network to track changes in bat distribution and inform future management and policy decisions is crucial. Identifying responsive bat species as indicators and facilitating collaboration between scientists and stakeholders can enhance conservation efforts.

3 EVALUATING INSECT CONSUMPTION

Assessing the importance of bat insectivory as an ecosystem service for the agricultural economy and society is vital. Modelling scenarios of mismatches between bat distributions and pest prey under future climate change can help evaluate economic consequences.

References

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Action Chair Danilo Russo; Action Vice-Chair Hugo Rebello; Science Communication Coordinator Fiona Mathews.

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