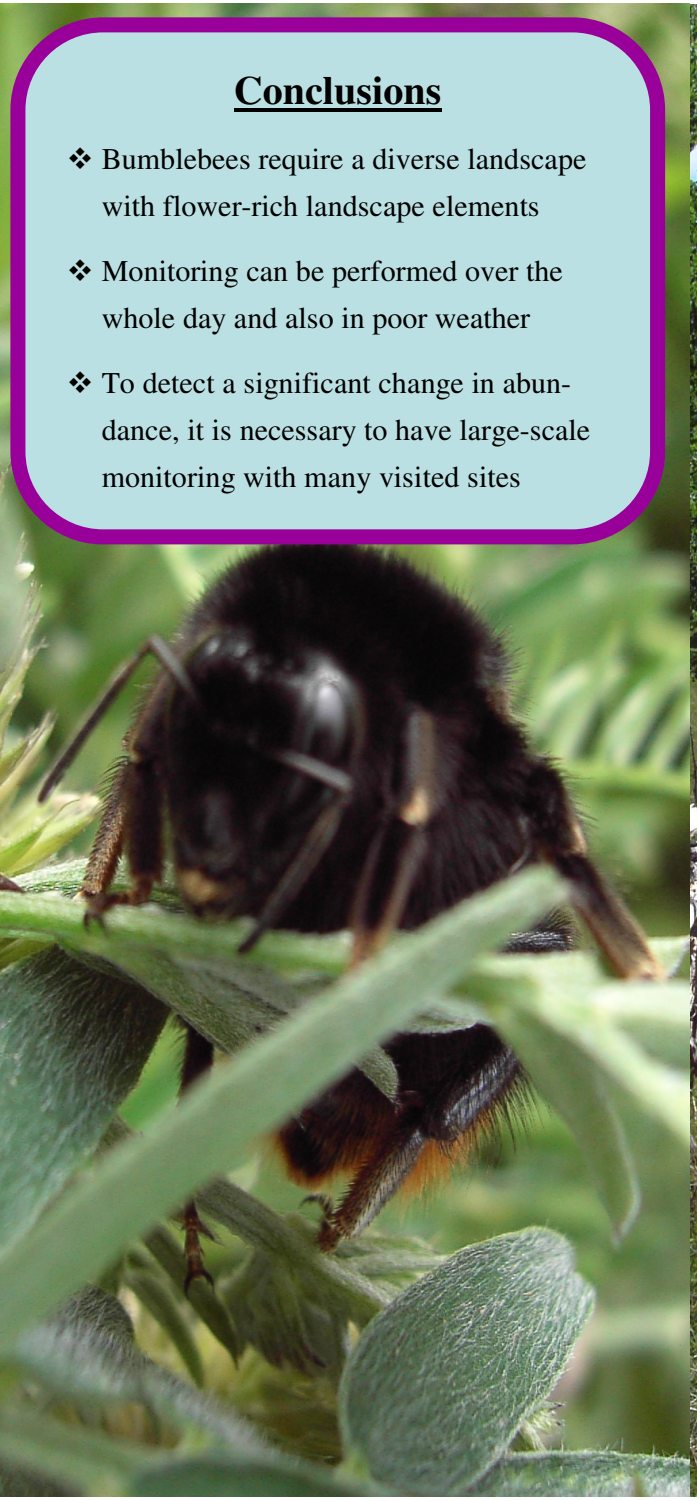
Conclusions

- Bumblebees require a diverse landscape with flower-rich landscape elements
- Monitoring can be performed over the whole day and also in poor weather
- To detect a significant change in abundance, it is necessary to have large-scale monitoring with many visited sites



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Phenology, landscape utilisation and monitoring of bumblebees

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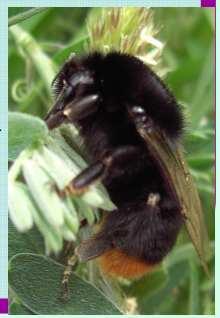
Background

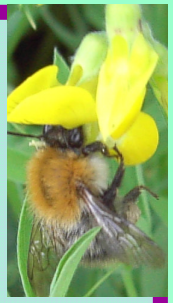
Declining populations
The last decades the number of bumblebees in Europe has declined. This is thought to be because of more intense farming, which causes destruction and fragmentation of flower-rich landscape elements that are important for bumblebees. Because bumblebees do not store nutrients, like honey-bees do, they require a continuous flower supply throughout the summer.

Important pollinators
Bumblebees are important pollinators of several plant species and a decline of bumblebees can cause serious problems for plant species dependant on bumblebee pollination. Not only wild flowers are affected by declining bumblebee abundance, but several crops are also pollinated by bumblebees and therefore economic as well as ecological problems can arise. For these reasons it is important to perform research on bumblebees to understand what kind of landscapes and plant species they prefer and how to best examine species occurrence, species-richness and changes in abundance in these landscapes.

Aim
The aim of this study was to improve monitoring methods and to study the phenology (seasonal change in abundance), the importance of various landscape elements and the impact of weather and daily variation in bumblebee abundance.



Landscape use



Flower-rich landscape elements
I found that flower-rich landscape elements like uncropped field-verges, unfertilised pastures and undisturbed wood verges are important for bumblebee abundance and species-richness. Totally 1053 bumblebees belonging to 17 species were found, and 70% of all observations were made in these three landscape elements (out of six studied landscape elements). If they would disappear due to more intense farming or forestry in the area, it would have serious consequences for the bumblebees. In studies from Germany and UK only six to seven species are commonly found and this low figure may be caused by the high degree of agricultural intensification in these countries.

A diverse landscape
My results also point out the importance of a diverse landscape, because bumblebee species preferred partly different landscape elements and showed a clear seasonal variation in habitat preferences. If the landscape elements with fewer bumblebees, like road verges and leys, would disappear it could cause gaps in the flower supply leading to a decline in bumblebee abundance. Not all plant species available were used by bumblebees, and a few species received almost all visits. The five most visited plant species received over 50% of all visits.

Monitoring

Monitoring is important in order to evaluate the condition of an area in terms of species occurrence, species-richness and changes in abundance. I found that monitoring of bumblebees can be performed over the whole day, as long as the temperature is above 17 ˚C and the wind speed below five on Beaufort's scale (fresh wind).

Timing and number of visits
I used power analyses to examine monitoring methodology. I found that sites should be visited at the beginning of the summer because the variation in bumblebee abundance was lower at that time. The probability of detecting a certain change in abundance was not much affected by varying the number of visits, and as long as it occurs at the beginning of the summer one visit per season is enough.

Number of visited sites
The number of sites had a large effect on the probability of detecting changes. I found that to detect a significant change in abundance, large-scale monitoring with many visited sites is needed. Generally, common species required fewer visited sites than less common species. To detect a 50% change in number of *Bombus pascuorum*, the most common species in this study, 295 sites must be monitored and for less common species, like *B. pratorum,* over 2000 sites must be monitored. These calculations are, however, applicable on very large populations only, e.g. national level.