Biodiversity in Solar Farms

A Nationwide Field Study

Summary of the Central Study Content

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Rationale

Six years after publication of the study **“Solar Parks - Profits for Biodiversity”** (2019), this new study **“Biodiversity in Solar Farms – A Nationwide Field Study”** represents a **significant further development and update** of the topic. This current study **primarily focuses on facilities** located **on former agricultural land.** While the effects of solar farms on the flora and fauna of agricultural habitats have not yet been comprehensively researched, there is a general **consensus that agricultural landscapes are particularly affected by the decline in biodiversity.** The **insights gained from the current study and the expansion of the empirical database** should serve to provide factual information for practical application, enabling a distinction to be made between proven knowledge versus assumptions and assertions. At a minimum, this will serve to objectify the sometimes controversial debate surrounding the nature conservation value of solar farms.

Procedure and Scope

To this end, data on **fauna and flora** was collected in 2024 at a total of **25 solar farms in ten federal states** and **one facility in Denmark.** The analyses were carried out by the two authors of the study alongside the commissioned experts. The **animal groups recorded** included **grasshoppers, butterflies, reptiles, birds and bats.** Where bodies of water were present in the solar farms they were examined for the presence of **dragonflies and amphibians.** In particular, the **botanical features** and **structural elements relevant** to biodiversity were recorded at all the solar farms. Other randomly recorded species supplement the collected data, while the study also takes into account additional current studies and information provided by the operators, for example on maintenance or construction methods.

Locations of all the solar farms surveyed in the study

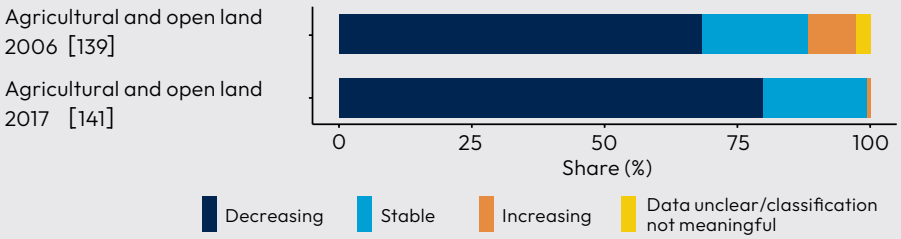
- The study examined
- Existing study from 2023/2024

Results

Within the context of the study, **over 550 species** were identified in the solar farms in around **100 individual investigations.** It is assumed that these studies **only covered some of the species living in the locations.** It can also be assumed that continued and more intensive investigations in further facilities over a longer period of time might well lead to **successively more species or species groups** becoming **detected.**

Comparison with High Nature Value Farmland

A key factor in the **decline in biodiversity** at landscape level is the **decreasing diversity of suitable habitats** for ever greater numbers of animal and plant species. **Intensive forms of agricultural management** are reducing the diversity of utilisation and structure, for example in the form of enlarged arable fields. In these areas, **crop rotations** are practised with **little** temporal or spatial **diversity.** Furthermore, a **decline in structures such as hedgerows, tree groupings, fallow land and small bodies of water** is observed.



Development trends for long-term nationally endangered biotope types in the main group of agricultural and open landscapes, comparing the situation in 2006 and 2017, according to the Red List of endangered biotope types in Germany. Number in square brackets = number of biotope types per main group. Modified according to BfN 2017 from Wirth et al. (2024)

In the midst of this agricultural landscape, **solar farms** form **low-disturbance structures** that remain in place **for decades.** In order to demonstrate the relevance of the habitats and structures identified in the solar farms for the agricultural landscape, they are presented in the study on the basis of HNV survey categories. **HNV farmland** ("High Nature Value Farmland") is understood to be that part of the agricultural landscape that is essentially subject to **extensive usage,** forms a **small-scale mosaic** of utilised and non-utilised areas and which provides a habitat for endangered or rare species. The proportion of HNV farmland is determined using a defined methodology based on sample areas. Technically, solar farms do not constitute agricultural land. However, **due to their genesis,** they are **comparable to HNV farmland,** as the land usage was previously mostly agricultural in nature and the utilisation will have been extensive since the construction of the solar farm. In addition, the **sites chosen for solar farms are often located within intensively utilised agricultural landscapes** and therefore form an integral part of the same.

By listing HNV categories and assigning them to the solar farms surveyed as part of the study, the results show that a whole range of areas and structures valuable for biodiversity are present in solar farms. Examples include **unpaved paths and verges, small bodies of water and ditches as well as fallow land, ruderal, herbaceous and tall grass meadows.**

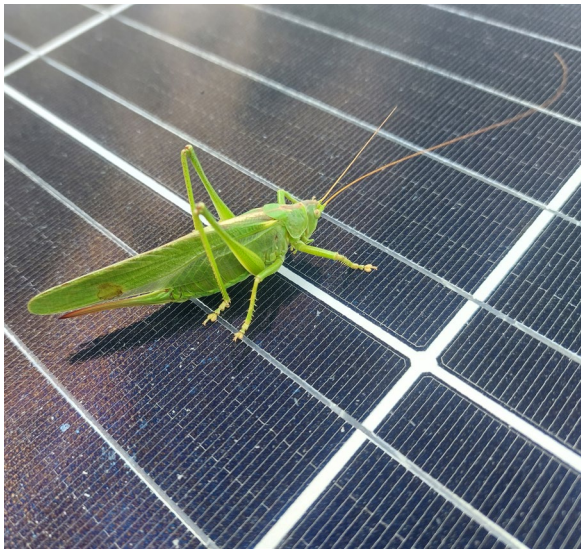
Solar farms therefore offer new, but obviously suitable, habitats for many species in an agricultural landscape lacking in structures. These are **increasingly important for the conservation of biodiversity,** as the "traditional" habitats used by species in the landscape have been in sharp decline for decades. The importance of solar farms for nature conservation is demonstrated by the large number of animals found in the agricultural landscape during the study.

Plants

In 2024, **a total of 385 plant species** were **detected** in the solar parks surveyed. The sites are not characterised by a high number of rare "Red List" species. Indeed, the solar farms analysed represent **diverse habitats for numerous plant species** in a landscape that is largely over-fertilised and often monocropped. This is significant because **"common species" are also increasingly in decline.** From a faunistic point of view, it does not matter whether the plant species are common or rare. The vegetation present is much more relevant due to its **supply of pollen and nectar,** as this is an important prerequisite for the occurrence of numerous insect species. This in turn forms the **food base** for breeding birds, reptiles and amphibians.

Dragonflies

Dragonflies were specifically recorded **in three solar farms** during the surveys in 2024: Georgsdorf, Klein Rheide and Salmtal. A total of **13 of the 79 species previously considered established in Germany** were identified as **resident** (living there, not flown in), i.e. 16.5%. The occurrence of the **Northern damselfly** (Coenagrion hastulatum) is of note as this is a **species threatened with extinction in Lower Saxony** (Red List category 1), and which **is highly endangered nationwide** (Red List category 2). Populations are growing at **the solar park in Georgsdorf.** The site can therefore be regarded as a **source habitat for this dragonfly species,** from which previously uncolonised sites can be recolonised.



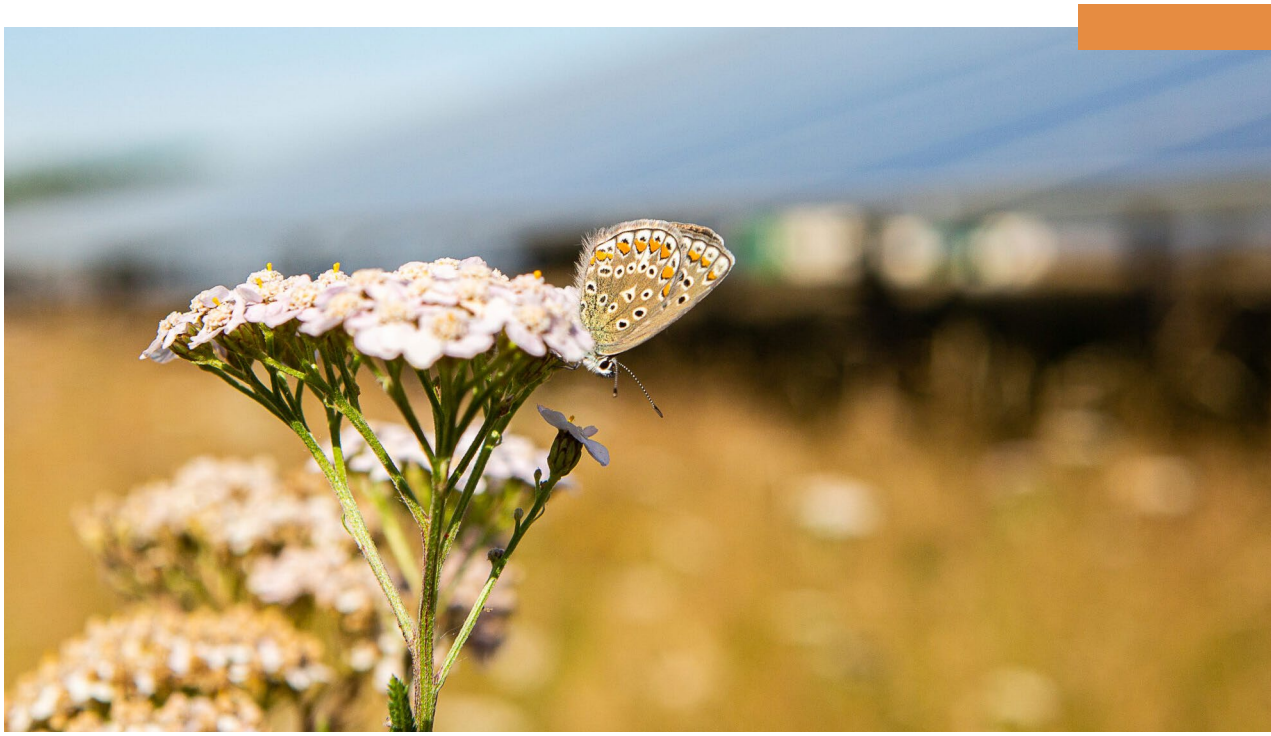
Grasshoppers

Supplemented by surveys from 2023, a total of **30 grasshopper species** were detected across all of the solar farms. This means that **37% of the 82 species considered established in Germany** were detected. With the exception of two species, the **Wart biter** (Decticus verrucivorus) and the **Water-meadow grasshopper** (Pseudochorthippus montanus), these are not endangered or are included in the federal early warning list. If the results of the 2019 study "Solar Parks – Profits in Biodiversity" and other sources are taken into account, it becomes clear that, according to the current state of knowledge, **at least 44 species of grasshoppers have been detected in solar parks to date.** This corresponds to **around 53% of the grasshopper species established in Germany.** This shows that solar farms can act as **important habitats** for this group of organisms. Most of the species recorded prefer **open and sunny habitats,** which they find in solar farms in the form of **unpaved paths** and their edges. For the **Wood cricket** (Nemobius sylvestris) found in some facilities, on the other hand, the **more humid areas under the modules form suitable habitats.** The Salmtal and Melkof solar farms show that solar parks can also provide habitats **for more specialised species** such as the **Large marsh grasshopper** (Stethophyma grossum) and the **Water-meadow grasshopper** (Pseudochorthippus montanus).

Some of the grasshopper species build up **very large populations shortly after the commissioning of a solar farm.** Hundreds of individuals can be found in just a few square metres. Depending on the species and weather conditions, the larvae appear between April and May and the first adult individuals can be observed from the end of May. It is not until the end of August that most species decrease significantly in abundance. This makes them an **important source of protein for breeding birds** and other insect-eating species over a long period of time.

Butterflies

In the 29 solar farms included in the study, **36 species of butterflies and moths** were recorded in 2024. With the exception of **Geranium argus** (Aricia eumedon), these species are not endangered on a nationwide basis or are included in the federal early warning list. This means that **17% of the 208 species considered established in Germany** were detected. The fact that many species were never expected to be found in the locations investigated – those from mountainous and alpine regions, for example – makes it all the more interesting that **some of the butterfly species appeared in such large numbers in certain areas,** providing an additional valuable food source for birds and other species that benefit from them.
In 2019, the study "Solar Parks - Profits for Biodiversity" described how solar farms can harbour far higher numbers of butterfly species. The initial conditions were advantageous in that the areas concerned were not agricultural land, but rather brownfield sites. Taking these results and the findings from the GEO Day of Nature 2021 into account, it can be seen that, according to the current state of knowledge, **55 species have been detected in solar parks to date.** This corresponds to **26% of the butterfly and moth species established in Germany.** The butterfly species observed in 2024 are predominantly undemanding species that are also widespread. However, butterflies are considered **good indicators of habitat qualities such as nutrient content, abundance of flowers or the intensity of utilisation of the herbaceous layer.** They therefore indicate that, in contrast to the intensively farmed agricultural areas in their surroundings, the solar farms studied can make an important contribution to the conservation of butterfly fauna.



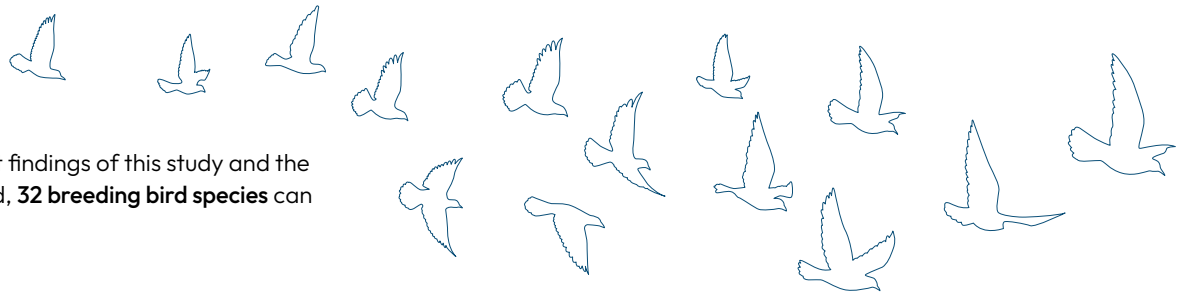
Amphibians

Amphibians were studied in the same solar farms as dragonflies. In addition, data from the Büttel 2 solar farm was recorded, with a total of **eight species** being **detected.** As 21 of these are considered established in Germany, at least a good third of all species could be documented in waters within this solar farm. The findings concerning the specialised **pioneer species, the Alpine newt** (Ichthyosaura alpestris), and the two highly endangered at a national level (Red List category 2) species **Yellow-bellied toad (**Bombina variegata) and **Natterjack toad** (Epidalea calamita) in Salmtal and Klein Rheide are particularly noteworthy.

Reptiles

Three species of reptiles were identified in the study. The main finding is that the facilities, which are often located within the agricultural landscape without any structural connections, **are located by the species more or less by chance.** The situation is different if the solar farm is located close to source habitats.

Birds



Looking at the current findings of this study and the other surveys included, **32 breeding bird species** can be identified.

Species name (en)	Species name (lat)	Presence	Continuity	RL BRD
Skylark	*Alauda arvensis*	19	73,08%	3
Yellowhammer	*Emberiza citrinella*	16	61,54%	+
White wagtail	*Motacilla alba*	14	53,85%	+
Tree pipit	*Anthus trivialis*	8	30,77%	V
Western yellow wagtail	*Motacilla flava*	7	26,92%	+
Black redstart	*Phoenicurus ochruros*	6	23,08%	+
European stonechat	*Saxicola rubicola*	6	23,08%	+
Common whitethroat	*Sylvia communis*	5	19,23%	+
Corn bunting	*Emberiza calandra*	5	19,23%	V
Great tit	*Parus major*	4	15,38%	+
Common linnet	*Linaria cannabina*	3	11,54%	3
Eurasian tree sparrow	*Passer montanus*	3	11,54%	V
Meadow pipit	*Anthus pratensis*	3	11,54%	2
Common blackbird	*Turdus merula*	2	7,69%	+
Eurasian blue tit	*Cyanistes caeruleus*	2	7,69%	+
Little ringed plover	*Charadrius dubius*	2	7,69%	V
Grey partridge	*Perdix perdix*	2	7,69%	2
European goldfinch	*Carduelis carduelis*	2	7,69%	+
Mallard	*Anas platyrhynchos*	2	7,69%	+
Marsh warbler	*Acrocephalus palustris*	2	7,69%	+
Bluethroat (red starred)	*Luscinia svecica*	1	3,85%	+
Whinchat	*Saxicola rubetra*	1	3,85%	2
Chaffinch	*Fringilla coelebs*	1	3,85%	+
Common pheasant	*Phasianus colchicus*	1	3,85%	+
European greenfinch	*Chloris chloris*	1	3,85%	+
Woodlark	*Lullula arborea*	1	3,85%	V
Lesser whitethroat	*Sylvia curruca*	1	3,85%	+
Eurasian teal	*Anas crecca*	1	3,85%	3
Common cuckoo	*Cuculus canorus*	1	3,85%	3
Sedge warbler	*Acrocephalus schoenobaenus*	1	3,85%	+
Northern wheatear	*Oenanthe oenanthe*	1	3,85%	1
Eurasian reed warbler	*Acrocephalus scirpaceus*	1	3,85%	+

Total detections of breeding birds in the solar farms surveyed in 2023 - 2024, with presence and continuity of the detected breeding bird species at a total of 26 analysed locations, sorted in descending order of continuity with information on nationwide endangerment in the Red List of the Federal Republic of Germany (RL BRD) (Ryslavy et al. 2020), + = not endangered, V = early warning list, 3 = endangered, 2 = critically endangered, 1 = threatened with extinction, as well as the presence and continuity of the breeding bird species detected at a total of 26 analysed sites, sorted in descending order of continuity

Feeding guests at the solar farms include not only breeding birds, but also other species. The category includes not only animals that fly in from outside and search for food in the solar farm, but also passing birds. A total of **64 migratory bird** species were recorded. The **grasshopper** group, which sometimes builds up high levels of biomass, is a **relevant attraction factor** in this regard. **Birds of prey** such as the **Eurasian hobby** (Falco subbuteo), Common buzzard (Buteo buteo), **Red kite** (Milvus milvus), **Black kite** (Milvus migrans), **Common kestrel** (Falco tinnunculus) and **Montagu's harrier** (Circus pygargus) were regularly observed hunting in solar farms.
The results show that solar farms are discovered and utilised by numerous birds as a new, suitable habitat. This **development has been observed for at least 15 years** and it is very likely that the process is not yet complete. There are already numerous examples of the process of discovering new habitats in ecology. As all the birds recorded in the solar farms are **synanthropic** – species that have long adapted to human activities – they are **generally able to colonise new and suitable habitats.** Important prerequisites in this regard are **opportunities for reproduction and sufficient suitable food.** Compared to the situation before the construction of the solar park, the number of breeding pairs of relevant bird species such as the skylark usually equals or exceeds the original density. By creating suitable habitats, **extremely high densities of between 21.6 and 46.7 skylark territories per 10 hectares** were recorded in the Weesow-Willmersdorf solar farm.

Bats

In 2024, a total of **13 clearly identifiable bat species** were detected in the solar farms surveyed. Nationwide, six of these are not endangered, one species is on the early warning list, **three are endangered** (Red List category 3), **one species is critically endangered** (Red List category 2) and the data situation is unclear for two species. **Around half of the 25 bat species considered established in Germany were documented.** The areas investigated were used for agricultural purposes before being utilised as solar farms and were therefore not, or only slightly, attractive to bats due to the lack of food. Taking into account further studies, in particular monitoring at the former Allstedt military airfield in Saxony-Anhalt, **at least 19 bat species have been detected in solar farms** in Germany **to date.** This corresponds to around three quarters of all bat species established in Germany.

The **Common noctule** (Nyctalus noctula) and **Pipistrelle bat** (Pipistrellus pipistrellus) were recorded **most frequently** with a continuity of almost **86%.** The **Lesser noctule** (Nyctalus leisleri) was found **in 10 of the 14** facilities analysed. All other species and taxa were recorded far less frequently. Based on the investigations, solar farms can be categorised as suitable hunting and transfer habitats for bats. The animals locate them after only a short period of time and it is possible that so-called (strictly) structure-bound species also have the ability to **discover** and utilise **facilities that are not connected by guiding structures.** This is made clear by the findings from Wörnitzhofen and Bad Liebenwerda (Zobersdorf), with these results standing in contrast to some recent publications. The solar farms analysed do not provide any evidence to suggest that local activity has been displaced by technology or that bat habitats in the landscape have been disturbed.

Source habitats and stepping stones

In particular, the findings related to grasshoppers, butterflies, and, to some extent, reptiles show that the **colonisation** of solar parks by more highly specialised species from these groups is **promoted** if the installations are **located close to suitable source habitats.** Such findings were obtained near the US military training area in Hohenfels in the Upper Palatinate region of Germany from solar farms located in the immediate vicinity, while those located further away have not (yet) yielded any results. At the same time, it was established that the **solar farms can themselves become source habitats due to their extensive utilisation and largely stable conditions. On the other hand, they are stepping stones** for species that are increasingly affected by declines within the cultivated landscape.

Across all groups of organisms studied, it was shown that the **solar farms offer highly individualised living conditions** that can differ significantly in their species composition even at a local level. This could be proven by means of species identity calculations. One of the most important conclusions to be drawn from this is that **maintenance concepts** and, where appropriate, **concepts to promote biodiversity should be developed on an individual basis,** rather than solutions being chosen "off the shelf".

Contribution to the National Strategy on Biological Diversity 2030

In addition to their direct positive value regarding biodiversity in agricultural landscapes, **solar farms** can also make **an essential contribution to the realisation of almost a third of the 21 targets included in the current National Strategy on Biological Diversity 2030.** This primarily includes the following fields of action: species conservation, soil, agricultural landscapes and food, climate change, energy transition and raw materials as well as the economy, financial flows and consumption.

Special Species Protection

The study shows that assumptions and official requirements regarding advanced compensation measures are regularly unfounded, particularly with regard to bird species and especially the skylark. On the contrary: **solar farms form a habitat for an increasing number of bird species, including endangered species;** a trend that has been continuing for years. This can be observed in particular in regions where solar parks are already being used as habitats by the bird species living there. Contrary to the assumption that solar farms are harmful to bats, they actually provide **foraging habitats in often barren landscapes.** These habitats are quickly discovered and utilised by bats.

Maintenance

It is clear that **management is one of the key parameters in the creation and preservation of biodiversity** on solar farms. In this, it is less important whether the grass is mowed or grazed. It is important to have a **target-oriented maintenance schedule** with flexibility recommended based on observations. This is because climate change is causing the growing season to start earlier, which is why fixed maintenance times no longer seem appropriate. Instead, it is proposed that these be **determined by experts depending on the situation.**

Outlook

Solar farms are increasingly establishing themselves **as an integral part of the agricultural landscape** and are being developed and utilised by animals and plants as new habitats. This is illustrated in the present study on the basis of 40 supplementary expert reports. In this way, solar farms are counteracting the long-recognised and well-documented development of the large-scale inhospitability of the agricultural landscape.

The **inclusion of novel habitat structures in the consideration of nature value** (HNV) is particularly necessary if the "traditional" habitats or structures used by species no longer exist in the landscape or cannot be restored, at least in the medium term. It is precisely this development, the **utilisation of new, suitable habitats,** that is currently taking place in solar parks. The Biodiversity Fact Check published in 2024 states the following, "the rapid transformation of our landscape requires constant review of our knowledge and our approaches to biodiversity conservation."

With this in mind, the authors of this study hope that the **opportunities and synergy effects of solar farms and the promotion and protection of biodiversity will be recognised and exploited.**

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