# Can Solar Farms Deliver Significant Benefits for Biodiversity?



**Preliminary Study July-August 2013**

**G E Parker and C McQueen**

Wychwood Biodiversity

Rowsell & McQueen

**Executive Summary**

This study was established to address the question 'can solar farms deliver significant benefits for biodiversity? – a question being increasingly asked by policy makers, planning authorities and the general public.

This study was designed as a rapid assessment of biodiversity at four solar farms in the mid-summer period of 2013. Though limited in scope, this study uses robust survey methodology and contributes to an evidence base from which we can better understand how solar farms affect biodiversity. Further, the study provides a number of pragmatic recommendations for the management of solar farms to benefit wildlife.

Four sites were selected with different approaches to land management: two sites were wild flower meadow and two were pasture with agricultural grasses. Biodiversity was measured using 3 indicator groups: grassland herbs, bumblebees and butterflies. Surveys were undertaken using standardised field methods and a random survey design.

At each site the solar farm and a control plot were surveyed for biodiversity. The control plot was a site adjacent to the solar farm which had the same land use as the solar farm prior to its construction. The control plot was surveyed for biodiversity using identical methods to the solar farm. Comparing the solar farm and control plot provided an indication of change in biodiversity indicators since the solar farm – and associated land management – has been established.

All four solar farms displayed some form of biodiversity increase as compared to their control plots. This indicates that the land management associated with the solar farms was more beneficial to the biodiversity indicators (herbs, bumblebees and butterflies) than the previous arable land use.

Sites re-seeded as wild flower meadows showed a significant increase in all three biodiversity indicators, whereas in pasture sites this change was only evident in one or two of the indicators. The greater abundance of biodiversity indicators in the wild flower meadow areas as opposed to the pasture is a logical result given the greater abundance of flowering plants in the meadow habitat.

A wide range of wildlife was opportunistically observed during the survey, including a number of red and amber listed birds of conservation concern, brown hares, signs of small mammals and a wide range of invertebrates. These observations were made almost exclusively in the meadow areas of sites one and two.

Agricultural weeds were observed in high density in areas of solar farms where there had been bare soil, either where portions had been left to revert naturally, or had been poached by livestock.

The results of this study indicate that solar farms can, *under certain circumstances*, deliver significant and measurable benefits to biodiversity, where suitable land management is in place. These findings are restricted to a small number of sites and only three biodiversity indicators, but observations suggest that the benefits may be more widespread.

The following recommendations are made on the basis of this study:

1. Each new solar farm requires a clearly laid out biodiversity management plan, as outlined in the Solar Trade Association's 10 commitments[1] and National Solar Centre's National Planning Guidance for Biodiversity[2].
2. Every site is unique and biodiversity plans should be made with consideration of the characteristics of the site and with advice from local and national wildlife organisations.
3. Habitat enhancements should be considered for all solar farms. Any enhancements should use appropriate plant species native to the UK and of local provenance.
4. Bare areas of soil should be seeded or planted quickly to prevent weeds from colonising.
5. Consideration should be given to some form of wild flower meadow beneath the solar array, as this habitat can benefit a broad range of wildlife.
6. Fine grasses should be used for grassland wherever possible as this will encourage colonisation by wild herbs.
7. Appropriate management is key to the success of habitat enhancements. Management activities should be established with advice from wildlife organisations.
8. At lower intensity, livestock grazing can contribute to conservation goals whereas at higher intensity, grazing provides greater agricultural productivity but fewer conservation benefits.
9. This preliminary study was limited in scope and it is recommended that a full study be undertaken of multiple sites, and using multiple biodiversity indicators, at various times of year. The study should consider a wide range of possible habitat enhancements, including hedgerows, grassland, field margins, ponds, nest boxes and others.

**Acknowledgements**

G Parker and C McQueen would like to thank Adam Twine for his input to the project concept, Lightsource Renewables, Orta Solar and Westmill Cooperative for access to their sites, Chris Hall for extensive botanical input and Jonathan Scurlock for advice and comments on this document.

**Citation**

Please reference this document as:

Parker, GE & McQueen, C (2013) Can Solar Farms Deliver Significant Benefits to Biodiversity? Preliminary Study July-August 2013. *Unpublished Report.*

**Table of Contents**



## 1. Introduction

Solar farms are becoming a common feature of the UK countryside and more sites are in planning as part of the UK's bid to achieve national targets for renewable electricity contributing 30% of the UK's power needs by 2020[3]. With this expansion has come increased scrutiny of solar farms and the relative costs and benefits they bring to society. Recently this debate has turned to biodiversity, and specifically whether solar farms can contribute benefits to UK wildlife.

Solar farms are usually constructed on lower grade agricultural land which means there is opportunity for biodiversity improvement. By adopting land management that is appropriate for wildlife there is the potential to substantially increase the biodiversity value of a site. Such contributions could be important in light of the significant decline in UK wildlife.

It is estimated that 60% of British wildlife species have declined in the past 50 years. Certain habitats, such as lowland meadow, have shown a startling decline of 97% since the 1930's[4]. On farmland a similar pattern applies, with birds, butterflies and arable plants all displaying 30-50% declines[5]. Most declines on farmland and grassland can be attributed to agricultural intensification (increased use of fertilizer, intensive grazing) and a reduction in habitat diversity (less mixed cropping, larger fields) in the quest for greater productivity.

Studies of agri-environment schemes have demonstrated that simple land management measures can lead to significant benefits for wildlife. For example, wildflower pollen and nectar mixes have been shown to increase the number and diversity of bumblebees[6], while field margins left uncultivated can benefit grasshoppers[7] and farmland birds.

There is some guidance available for solar farms and biodiversity[8], and a growing number of solar farms in southern England have adopted land management measures specifically to benefit biodiversity. There is also evidence that solar farms can host a range of birds and invertebrates[9, 10]. However, limited research has been carried out to date and there is consequently a need for systematic studies which build an evidence base of biodiversity on solar farms. Such evidence will improve our understanding of how solar farms influence biodiversity, and will help to determine how the solar industry could contribute to the conservation of wildlife in the UK.

## 2. Objectives

The goal of this study was to investigate whether, and to what degree, solar farms can deliver benefits to biodiversity.

The specific objectives were to:

1) determine whether measurable increases in key biodiversity indicators could be detected at selected solar farms; and,
2) investigate to what degree land management influenced the patterns observed.

Accordingly, this study has set out to investigate measurable biodiversity changes at a selection of solar farms using robust and repeatable survey techniques that yield statistically testable results.

The study was designed as a rapid assessment of four solar farms in the mid-summer period. It should be noted that the results are not intended to be representative of the solar industry as a whole, but rather seek to address specific objectives using sites selected for this purpose.

The limited sample size and duration of this study restrict the interpretation of these results to the sites in question and the mid-summer period. Nevertheless, this study contributes evidence which enables us to better understand the relationship between solar farms and biodiversity. Further, the results of this study have led to a number of pragmatic recommendations for the management of solar farms to benefit UK wildlife.

## 3. Approach

### Site selection

Four existing solar farms were selected for this study. All four sites were former arable fields on which solar farms had been developed during 2011. Each site had taken a different approach to land management but broadly speaking the sites could be grouped according to grassland management, with two sites establishing wild flower meadows and two establishing pasture with agricultural grasses and clovers (Table 1).

**Table 1. Land management at the four solar farms included in this study**

| Site | Previous land use | Grassland management | Method |
|---|---|---|---|
| 1 | Arable rotation | Wild flower meadow | Reseeding |
| 2 | Arable rotation / pasture | Wildflower meadow | Reseeding and reversion |
| 3 | Arable rotation | Pasture | Reseeding |
| 4 | Arable rotation | Pasture | Reseeding |

## Survey design

Biodiversity surveys were undertaken at each site using a paired plot design with a treatment and control plot surveyed for biodiversity. The treatment plot was the solar farm itself and the control plot was on land adjacent to the solar farm that has the same use as the solar farm prior to its construction (Figure 1).

The purpose of the control plot was to provide an indication of the level of biodiversity occurring if the solar farm had not been developed. Solar farm and control plot survey results were compared statistically to investigate any difference, so providing an indication of any biodiversity changes occurring as a result of the solar development, and specifically, the land management associated with the solar farm.

Control plots were carefully selected following discussions with the landowner to ensure the physical conditions (slope, aspect, soil type, drainage) were as close a match as possible to the solar farm itself. Minimising any such physical differences helps to reduce background variation so any differences in biodiversity observed can be more readily attributed to land management.

**Figure 1. Position of typical solar farm and control plot. Solar farm is shown within green outline, with adjacent control plot outlined in yellow.**


## Biodiversity indicators

The study used three groups as indicators for wider biodiversity:

1. Herb species richness and abundance, recorded using the DAFOR[a] scale along sample transects

[a] DAFOR scale grades each plant species as Dominant, Abundant, Frequent, Occasional or Rare within the area of study. Note – this scale only applies to the surveyed area has no bearing on a species' rarity in the national or global context.

2. bumblebee species richness and abundance, and
3. butterfly species richness and abundance

Both bumblebees and butterflies were surveyed using sample transects on a warm (>20$^{o}$ C) day.

These biodiversity indicators were selected because herbs can be used to determine habitat quality and type[11] and also give an indication of the nectar and pollen available for invertebrates. Bumblebees and butterflies are commonly used as indicators[12] of wider ecosystem health.

Surveys were conducted in the mid-field regions of each treatment and control plot to concentrate on the biodiversity of grassland and minimise the influence of wider land management such as hedgerows or woodland bordering the site. Transects were completed using a randomised systematic survey design which covered approximately 1km linear distance of each solar farm and control plot. The same ecologists were used for each site to minimise the effects of observer bias.

For bumblebee and butterfly survey data the metric 'number of observations per 100m' was calculated for each transect. This metric was compared statistically between solar farm and control plot for each of bumblebees and butterflies using the Mann-Whitney *U* test.

The total number of herb species observed within solar farm and control plot was compared statistically using Chi-square, with Yates' correction for 1 degree of freedom.

The results of this study are separated into 'findings' which are derived from survey data, and 'observations' which are issues of interest noted during the study (e.g. protected species) that warrant further investigation. Results are displayed for each site in turn and then summarised in the final section of this report.

## 4. Survey sites

Four sites were surveyed across eastern and southern England in July and August of 2013. Results are displayed below for each site in turn and summarised at the end of this report.

### 4.1 Site one.

**Site description**

Site one is located in West Oxfordshire and contains 20,000 solar panels producing 5MW of power. The solar farm is built on ex-arable land and became operational in mid-July 2011. The crop of winter barley was sprayed off and the entire site was re-seeded with a wild flower mix containing herbs and fine grasses with the intention of creating wildlife habitat. The site is maintained through sheep grazing in the Autumn and Winter, with no grazing through the Spring and Summer to allow herbs to flower and set seed.

**Survey**

Herb, bee and butterfly surveys were carried out within the solar farm and on the control plot, an adjacent field containing winter barley. The control plot was considered suitable following discussions with the landowner, and considering its size and proximity to the solar farm.

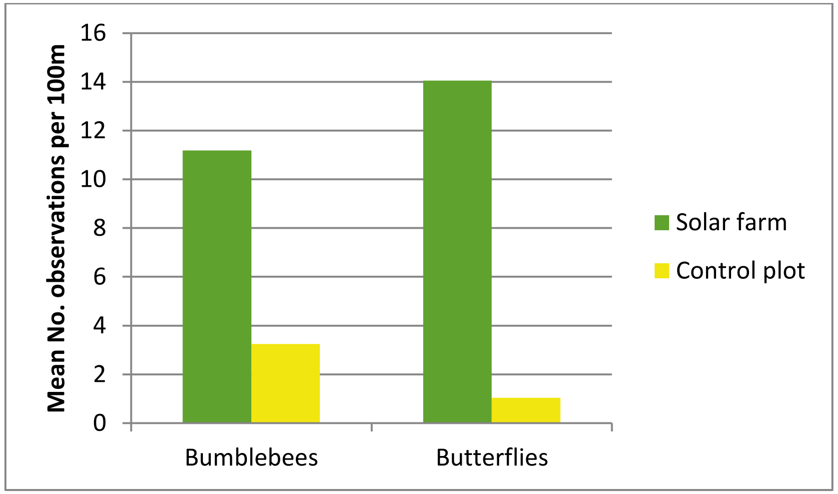
**Photo 1. Layout of Site one.**

**Results**

***Invertebrates***

Bumblebees and butterflies were observed in greater numbers in the solar farm as compared to the control plot on the day of survey (Figure 2), a difference that was found to be statistically significant (Table 2). In addition, the number of species observed was greater within the solar farm (6 bumblebee and 10 butterfly species) as compared to the control (4 bumblebee and 5 butterfly species).

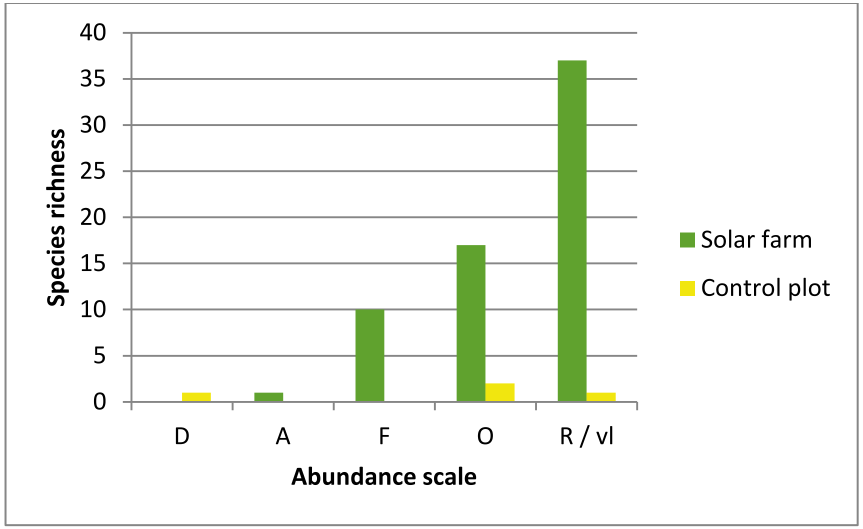
**Figure 2 Comparing abundance of bumblebees and butterflies between control plot and solar farm, Site one**




***Herbs***

The number of herb species counted in the solar farm overall was 65, with the majority (37) being observed only rarely, 17 species being found occasionally, 10 frequently, and one being observed as abundant (Figure 3). By comparison the number of species found within the control plot was 4, with one (barley) being considered dominant, 2 being occasional and one species being considered rare.

**Figure 3 Comparing herb species richness and abundance between control plot and solar farm, Site one**




It should be noted that while barley is not a herb it is included here to help characterise the vegetation of the control plot. The number of species found within the solar farm was significantly higher than in the control plot (Table 2).

**Table 2. Testing the difference between control plot and solar farm for three biodiversity indicators, Site one**

| Species | Data | Statistical test | Statistic | P value | Significance |
|---|---|---|---|---|---|
| Bumblebees | No. observations per transect | Mann Whitney U | U = 4.0 | <0.05 | Significant difference |
| Butterflies | No. observations per transect | Mann Whitney U | U = 1.0 | <0.05 | Significant difference |
| Herbs | Species richness per area | Chi-square | 67.94 | <0.01 | Highly significant difference |

**Photo 2. Wild flower meadow beneath the array at Site one**

## Key findings

- The solar farm displayed significantly greater diversity in herbaceous plants than the control plot. This is logical given that the solar farm was re-sown with herb-rich seed mix. However, the number of herbs was six times greater than the herb species originally sown, indicating a high level of colonisation from the seed bank and/or wider environment.
- Both bumblebees and butterflies were observed in significantly higher numbers within the solar farm in response to a greater abundance of flowering plants. The majority of bees and butterflies observed in barley field were in transit, whereas in the solar farm were feeding.

## Observations

- Though not the focus of any formal survey, several bird species were noted within the solar farm, including a pair of grey partridge, a pair of skylarks (BoCC red[13]) perched on the solar panels and 5 kestrels (BoCC amber) on the perimeter fence.
- A juvenile hare was observed within the meadow along with numerous small mammal runs.
- A wide range of invertebrates was observed within the meadow, including grasshoppers, crickets, harvestmen, moths and spiders.

## 4.2 Site two

### Site description

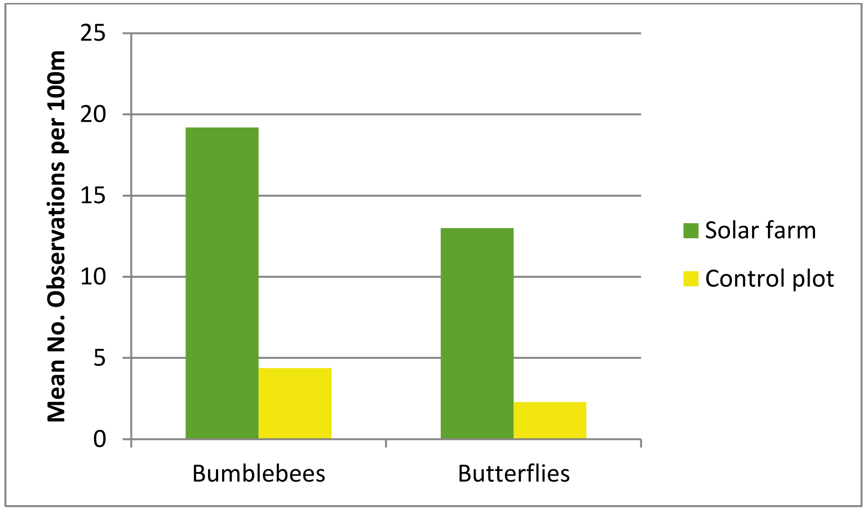
Site two is located in Nottinghamshire and was commissioned in July 2011 and consists of 21,000 solar panels with a potential output of 5 MW. The site was formerly a quarry before being converted to agricultural land which in turn has been converted into a solar farm. Whilst under agricultural production, the site contained areas of arable and areas of horse pasture. Following installation of the solar arrays the vegetation under panels was left to revert naturally whilst the open areas along the southern, eastern and northern perimeter fence have been over-seeded with a wildflower and grass mix. The vegetation across the site is managed through mechanical cutting, with one cut in late spring and one cut in late summer.

### Survey

Botanical and invertebrate surveys were carried out within the solar farm and in the control plot immediately south of the solar farm. The control plot, which was marginally smaller than the solar farm, was planted with oil seed rape and was confirmed as having had the same history of land use as the solar farm.

**Photo 3. Layout of Site two**

**Figure 4. Comparing bumblebees and butterflies between control plot and solar farm, Site two**




## Results

### *Invertebrates*

Bumblebees and butterflies were recorded in greater numbers in the solar farm as compared to the control plot (Figure 4), a difference that was found to be statistically significant (Table 3). In addition, the number of species observed was greater within the solar farm (6 bumblebee and 11 butterfly species) as compared to the control (2 bumblebee and 3 butterfly species).

### *Herbs*

The number of herb species counted in the solar farm overall was 50, with the majority (37) being observed rarely, 8 species being considered occasional and 5 being found frequently (Figure 5). By comparison, the number of species found within the control plot was 9, with one (oilseed rape) being dominant, and 8 species being rare. The number of herb species observed within the solar farm was significantly higher than in the control plot (Table 3).

**Figure 5. Comparing herb species richness and abundance between control plot and solar farm, Site two**

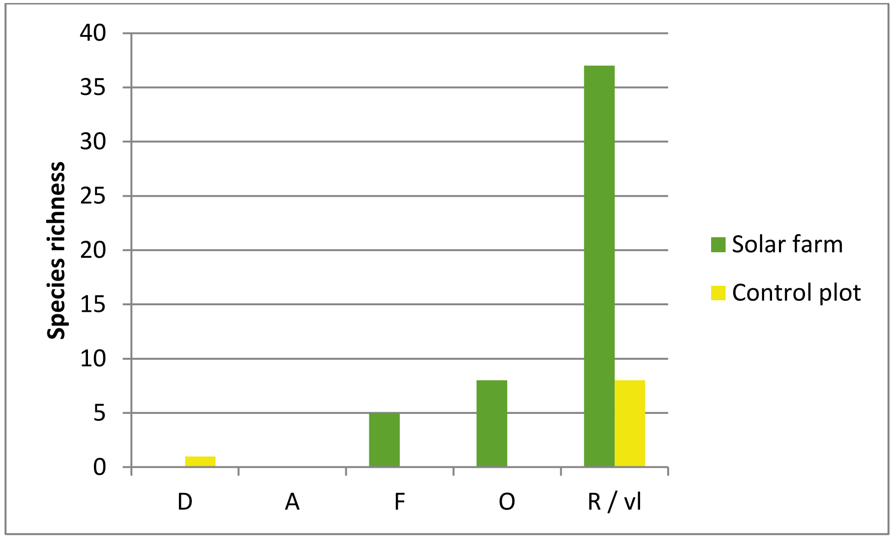



**Table 3. Testing the difference between control plot and solar farm for three biodiversity indicators, Site two**

| Species | Data | Statistical test | Statistic | P value | Significance |
|---|---|---|---|---|---|
| Bumblebees | No. observations per transect | Mann Whitney U | U = 1.0 | <0.05 | Significant difference |
| Butterflies | No. observations per transect | Mann Whitney U | U = 1.0 | <0.05 | Significant difference |
| Herbs | Species richness per area | Chi-square | 63.42 | <0.01 | Highly significant difference |

Within the solar farm herb species richness and abundance varied markedly between the area that was formerly horse pasture and the area previously under arable production. Natural reversion of the arable area has resulted in a greater diversity of herb species than the area of horse pasture, with the bare ground of the arable area affording greater colonising opportunities. However, many of the more common herbs observed in this area were plants regarded as injurious weeds such as thistle, ragwort and dock, as well as common arable herbs such as hawkbit, buttercup and dandelion.

**Key findings**

- The solar farm displays significantly greater diversity in herbaceous plants than the control plot, which is logical given the solar farm was partially re-sown with a herb-rich seed mix.
- Both bumblebees and butterflies were observed in significantly higher numbers within the solar farm in response to a greater abundance of flowering herbs.
- The majority of bees and butterflies observed in the control plot (oilseed rape) were in flight whilst the majority of bees or butterflies observed in the solar farm were feeding.
- Areas of solar farm that were left to revert naturally were more prone to colonisation by weeds, especially the bare post-arable areas of the site. Weeds included spear thistle, creeping thistle and

ragwort which are injurious weeds according to the Weeds Act (1959)[b] and should not be allowed to spread to agricultural land.

**Observations**

- Several bird species of high conservation value were sighted within the solar farm: a covey of grey partridge (2 adults and 5 young; BoCC Red[14]) was seen on both days of the survey, six reed bunting (BoCC amber), and linnet (a flock of 5 birds; BoCC Red) were encountered several times during the survey. There was also a minimum of three hares present on the site.
- The only bird species of medium or high conservation value observed in the control plot was the reed bunting (BoCC amber), with two separate males having been observed.
- Given that the control plot comprised oil seed rape it is possible that had the survey been carried out in May/June (when the crop is in flower) the number of bumblebee and butterfly observations would have been markedly higher in the control plot than was recorded in August. This variability in the timing of flowering between different plants highlights the need to conduct multiple surveys at each site through the summer period.

[b] The Weeds Act 1959 specifies five injurious weeds: Common Ragwort, Spear Thistle, Creeping or Field Thistle, Broad Leaved Dock and Curled Dock. Under this Act the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent their spread.

**Photo 4. Wild flower meadow at Site two**

### 4.3 Site three

**Site description**

Site three is located to the south of Newquay, Cornwall. The solar farm was commissioned in 2011 and consists of 6,000 solar panels with a potential output of 1.7 MW. The site was previously farmed as part of an arable rotation and following installation of the solar array it was sown with a rye grass mix to provide grazing for sheep. The grassland is receiving fertiliser and is subject to periodic intensive grazing (at times prompted by the need to reduce sward height to avoid shading of solar panels). Spot-spraying of spear thistle is an ongoing maintenance task as observed on-site and confirmed by the landowner.

### Survey

Botanical and invertebrate surveys were carried out within the solar farm and in the control plot, a field located adjacent to the solar farm. The control plot was being used as sheep pasture but had a similar history of land use to the solar farm having formerly been part of an arable rotation. At the time of survey no sheep were present in the field.

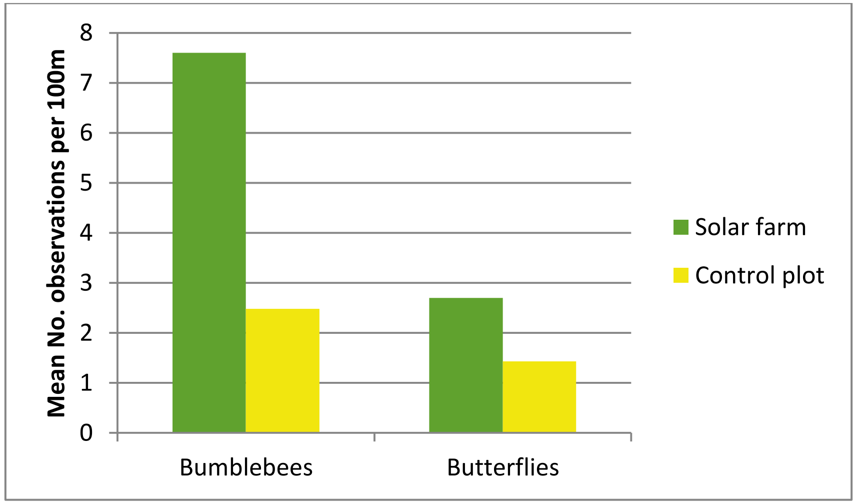
**Photo 5. Layout of Site three**

### Results

#### *Invertebrates*

Bumblebees were observed in greater numbers in the solar farm as compared to the control plot on the day of survey (Figure 6), a difference that was statistically significant (Table 4). However, there was no significant difference in the abundance of butterflies between solar farm and control. Furthermore, the number of species observed was only marginally greater within the solar farm (3 bumblebee and 8 butterfly species) as compared to the control (2 bumblebee and 7 butterflies).

**Figure 6. Comparing bumblebees and butterflies between control plot and solar farm, Site three**



***Herbs***

The number of herb species counted in the solar farm overall was 20, with 12 species occurring rarely, 7 species being considered occasional and 1 species frequent within the area of study (Figure 7). By comparison, the number of herb species found within the control plot was 8, with 6 species being rare and two species being occasional. The dominant vegetation was ryegrass. The number of herb species observed within the solar farm was significantly higher than in the control plot (Table 4).

**Figure 7. Comparing herb species richness and abundance between control plot and solar farm, Site three**

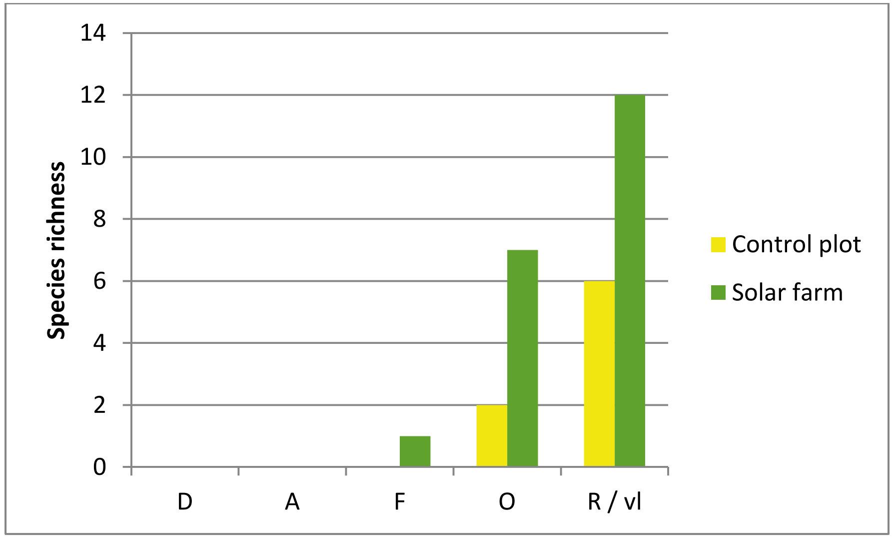



**Table 4. Testing the difference between control plot and solar farm for three biodiversity indicators, Site three**

| Species | Data | Statistical test | Statistic | P value | Significance |
|---|---|---|---|---|---|
| Bumblebees | No. observations per transect | Mann Whitney U | U = 8.5 | <0.05 | Significant difference |
| Butterflies | No. observations per transect | Mann Whitney U | U=14.1 | >0.05 | No significant difference |
| Herbs | Species richness per area | Chi-square | 35.18 | <0.01 | Highly significant difference |

## Key findings

- The number of herb species was significantly higher in the solar farm than the control plot.
- Herb numbers in both solar farm and control plot were lower than in sites one and two, which was consistent with the sowing of agricultural grasses and intensive grazing management at site three.
- Bumblebees were observed in significantly higher numbers within the solar farm in response to a greater abundance of flowering plants. However, there was no significant difference in butterflies between the two areas.
- All bumblebee and butterfly observations in the control plot were of individuals in transit whilst the majority of insects observed within the solar farm were feeding. This was due to the minimal presence of herbs suitable as forage within the control plot.

**Observations**

- Both solar farm and control plot comprised improved sheep pasture, but the area within the solar farm contained a higher profusion of spear thistle in flower which was associated with most of the feeding insect observations.
- Spear thistle was being actively managed with herbicide but the species likely to persist in the farm as some plants had set seed and there were bare patches of ground caused by sheep traffic (e.g. under panels & at the bottom of the slope).
- Spear thistle is likely to have established within the solar farm because rye grass was sown long after the completion of the solar installation, such that the ground was left bare, allowing weeds to colonise. Furthermore, grass seeding beneath the panels was patchy due to technical difficulties, allowing weeds to gain a foothold.
- No bird species of conservation concern was observed in either plot.

**Photo 6. Grassland with thistle on bare patches beneath the panels, Site three**

## 4.4 Site four

### Site description

Site four is located close to Hayle on the north Cornwall coast. The 29 acre farm was commissioned in July 2011 and consists of 21,693 solar panels with a potential output of 5 MW. The site was formerly part of an arable rotation and prior to the installation of the solar arrays it was sprayed with herbicide and sown with a rye grass and clover mix (one section with white clover and one section with red clover). The vegetation across the site is managed through mechanical cutting with three to four cuts required per annum.

### Survey

Botanical and invertebrate surveys were carried out within the solar farm and in the control plot, a field immediately south of the solar farm. The control plot comprised an adjacent field sown with fodder beet and was confirmed as having had the same history of land through discussion with the landowner.

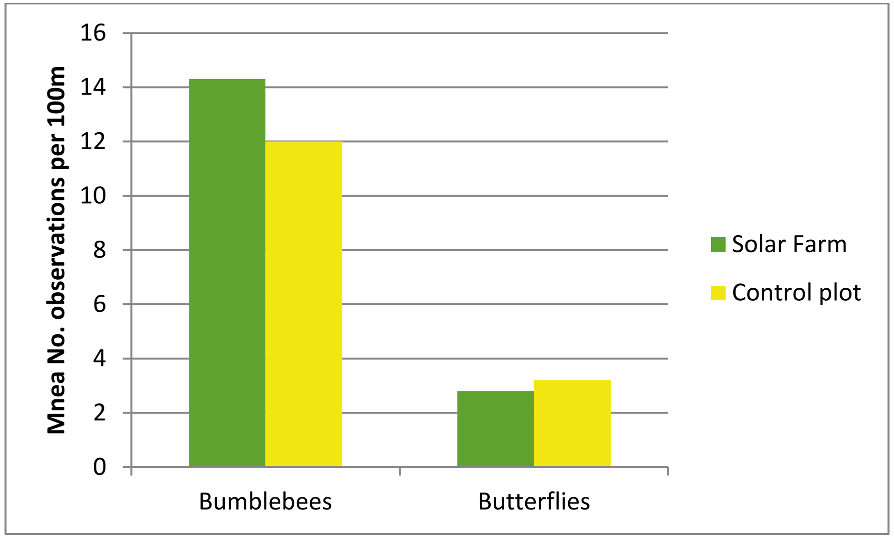
**Photo 7. Layout of site four.**


### Results

#### *Invertebrates*

The abundance of bumblebees and butterflies did not differ between solar farm and control plot (Figure 8; Table 5). The number of species observed was marginally greater within the solar farm (5 bumblebee and 7 butterfly species) than the control (3 bumblebee and 5 butterfly species).

**Figure 8. Comparing bumblebees and butterflies between control plot and solar farm, Site four**




### *Herbs*

The number of herb species counted in the solar farm overall was 22, with 15 being rare, 6 species being considered occasional and 1 frequent (Figure 9). By comparison, the number of species found within the control plot was 11, with one (fodder beet) being dominant, and 10 species being rare. The number of herb species observed within the solar farm was significantly higher than in the control plot (Table 5).

**Figure 9. Comparing herb species richness and abundance between control plot and solar farm, Site four**

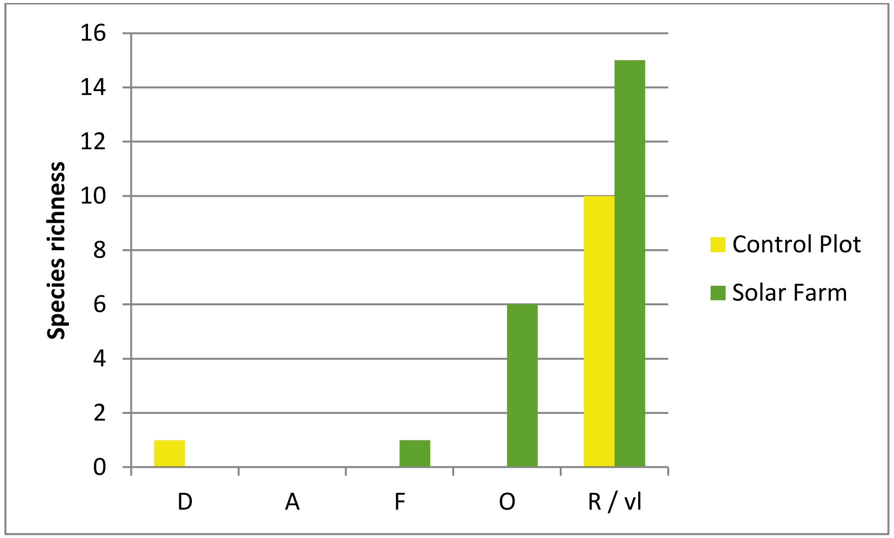



**Table 5. Testing the difference between control plot and solar farm for three biodiversity indicators, Site four**

| Species | Data | Statistical test | Statistic | P value | Significance |
|---|---|---|---|---|---|
| Bumblebees | No. observations per transect | Mann Whitney U | U=22 | >0.05 | No significant difference |
| Butterflies | No. observations per transect | Mann Whitney U | U=31 | >0.05 | No significant difference |
| Herbs | Species richness per area | Chi-square | 45.70 | <0.01 | Highly significant difference |

**Key findings**

- There were significantly more herbs present within the solar farm than the control plot.
- There was no significant difference observed in either bumblebees or butterflies between the solar farm and control plot.
- It should be noted that butterfly abundance was higher in the control plot for Site four than in two of the three other control plots. Butterfly observations were dominated by one species – the large white – which may have been laying eggs on the beet crop

**Observations**

- Site four highlighted the impact of study timing on the results. One half of the transects were in areas sown with a white clover/rye grass mix and the other half were in areas with a red clover/rye grass mix. At the time of survey the white clover had largely finished flowering whilst the red clover was still flowering. This greater presence of forage in the areas seeded with red clover was reflected by the markedly higher number of bumblebee and butterfly observations per metre in this area as compared to transects with the white clover mix.
- Conducting a survey earlier in the year when clover was in full flower is likely to have revealed greater numbers of bumblebees and butterflies within the solar farm.
- One bird species of medium conservation value - the linnet (BoCC Red) - was sighted within the farm. No bird species of medium to high conservation value were seen in the control plot.

**Photo 8. Grassland and clover beneath the solar array at Site four**

## 5. Summary of findings

Below is a summary of key findings from across all four sites.

- All solar farms displayed an increase in biodiversity on at least one of the three indicators as compared to their control plots (representing former land use). These results indicate that the abundance of herbs and invertebrates is significantly greater in response to the land management associated with the solar farm than with the previous arable land management.
- Sites re-seeded as wild flower meadows showed a significant increase in all three biodiversity indicators (herbs, bumblebees and butterflies), whereas in pasture sites this change was only evident in one or two of the indicators.
- All sites displayed a degree of colonisation by herbs, that is, the sward contained a greater number of herbs than originally sown.

## 6. Summary of observations

- In general, bumblebees and butterflies observed in solar farms were feeding whereas those observed in control plots were in transit. This indicates herb-rich grasslands had greater value as foraging sites.
- Though not the focus of a structured survey, a wide range of wildlife was observed within solar farms, including a number of red and amber listed birds of conservation concern within the UK, brown hares, signs of small mammals and a wide range of invertebrates. These observations were made almost exclusively within the meadow areas of sites one and two.
- Non-native wild flowers were found in the meadow seed mix of site one, indicating that herb species not native to the UK may exist in commercially available meadow seed mixes.
- Sheep stocking density was considered too high on the pasture of site three to deliver significant conservation outcomes. At higher stocking density sheep tend to remove herb species. In addition, application of fertilizers and herbicides is not conducive to encouraging wild flowers.
- Agricultural weeds were found in abundance in areas that had been left bare, either areas left to revert naturally post-construction (site two), or areas poached bare by livestock (site three).

## 7. Conclusions & Recommendations

### Conclusions

This study demonstrates that solar farms can provide suitable conditions for grassland herbs, bumblebees and butterflies, and show significant gains as compared to arable land. Returning to the original question this study set out to address, it is therefore reasonable to conclude that solar farms can – under certain circumstances – deliver measurable benefits to biodiversity.

The biodiversity indicators used here – herbs, bumblebees and butterflies – are considered important components of UK wildlife. In addition, they are indicators of wider biodiversity and it is very likely that where these indicators are observed in greater abundance, that other wildlife species will likewise be found in greater numbers.

The type of land management will clearly influence the biodiversity gains; as demonstrated here by meadow habitat displaying greater value than pasture. But pasture land, even at higher stocking levels, can provide moderate benefits in terms of herbs and invertebrates.

Meadows are just one component of a long list of potential habitats that could be enhanced or created on solar farms, for example hedgerows, field margins, heathland, ponds and coppice. So long as vegetation is compatible with solar panels, solar farms present the opportunity to establish a wide range of habitats designed to increase general biodiversity and to support a particular species or complex of species that are considered a conservation priority. Such management approaches often have the side benefit of improved landscape aesthetic with the solar arrays softened by flower rich grassland.

In addition to the land management, solar farms have a number of features which many be inherently beneficial to wildlife. First, they tend to be south facing grassland slopes which provide suitable conditions for herbs and grassland invertebrates. Second, they are relatively undisturbed by human activity once constructed. Third, they are in place for 20 years or more, which is sufficient time for appropriate land management practices to really take effect.

The results of this survey suggest that there is scope for solar farms to play a role in biodiversity enhancement or conservation at a local level, and this benefit could be maximised through careful planning, establishing and managing habitats within the solar farm.

**Recommendations**

The following recommendations are made on the basis of this study:

1. Each new solar farm requires a clearly laid out biodiversity management plan, as outlined in the Solar Trade Association's 10 commitments[1] and National Solar Centre's National Planning Guidance for Biodiversity[2].
2. Every site is unique and a biodiversity plans should be made with consideration of the environmental characteristics of the site, existing biodiversity, and with advice from local and national wildlife organisations, and in consideration of local and national biodiversity targets.
3. Habitat enhancements should be considered for all solar farms. Any enhancements should use appropriate plant species native to the UK and of local provenance. Whichever habitat type is selected, it must be compatible with the solar panels and should not cause shading or require intensive management.

4. Consideration should be given to some form of wild flower meadow beneath the solar array, as this habitat can benefit a broad range of wildlife.
5. Fine grasses should be used in grassland habitat wherever possible as this will enable wild herbs to colonise.
6. Appropriate management is key to the success of all habitat enhancements. Management activities should be established, with advice from wildlife organisations, for the life of the solar farm. All management activities should be detailed in the biodiversity management plan. The management plan should be finalised prior to construction since there may be implications for the construction process.
7. Agricultural weeds are potentially a problem at all sites. Bare areas of soil should be resown with an appropriate seed mix to reduce the risk of weed colonisation.
8. At lower intensity, livestock grazing can contribute to conservation goals whereas at higher intensity, grazing provides greater agricultural productivity. The best conservation outcomes will result from a pause in grazing through the spring and summer to allow herbs to flower and set seed.
9. This preliminary study was limited in scope and it is recommended that a full study be undertaken of multiple sites of different ages, which investigates the impacts of solar farms on a wider range of species (small mammals, birds, bats, reptiles, amphibians, invertebrates) at various times of year to capture variations in ecological conditions. The study should consider a wide range of possible habitat enhancements, including hedgerows, grassland, field margins, ponds, nest boxes and others.

## 8. Reference


[1] Solar Trade Association (2013) 10 Commitments: Principles of Best Practice.
[2] National Solar Centre (2013) National Planning Guidance – Biodiversity. BRE National Solar Centre, Cornwall, UK,
[3] DECC (2013) UK Solar PV Strategy Part 1: Roadmap to a Brighter Future.
[4] Fuller, R.M. (1987) The changing extent and conservation interest of lowland grasslands in England and Wales – a review of grassland surveys 1930–84. *Biological Conservation,* 40, 281–300.
[5] RSPB (2013) State of Nature. www.rspb.org.uk/stateofnature
[6] Carvell, C. Meek, WR. Pywell, RF. Goulson, D. & Nowakowski, M. (2007) Comparing the efficacy of agri-environment schemes to enhance bumblebee abundance and diversity on arable field margins. *Journal of Applied Ecology 44: 29-40.*
[7] Gardiner, T. Hill, J. & Marshall, EJP. (2008) Grass field margins and Orthoptera in eastern England. *Entomologist's Gazette 59: 251-257.*
[8] Natural England (2011) Solar Parks: Maximising Environmental Benefits. Technical Informationy Note 101.
[9] German Renewable Energies Agency (2010) Solar Parks – Opportunities for Biodiversity, A report on biodiversity in and around ground-mounted photovoltaic plants.
[10] Feltwell, J (2013) Observations on the effects of photovoltaic solar panels on invertebrates at Ebbsfleet Farm, Sandwich, Kent 2010-2012. *Unpublished report.* Feltwell, J (2013) Are photovoltaic solar arrays an influencing factor in avian mortality? *Newsletter of the Kent Field Club 77: 18-27.*
[11] Natural England (2010) Higher Level Stewardship. Farm Environment Plan (FEP) Manual. Natural England, Peterborough, UK.
[12] JNCC (2013) UK Biodiversity Indicators in your Pocket. www.jncc.defra.gov.uk/biyp
[13] RSPB (2009) Birds of Conservation Concern 3. The population status of birds in the United Kingdom, Channel Islands and the Isle of Man.


**Photo 9. Wild flowers beneath the solar array, Site one**