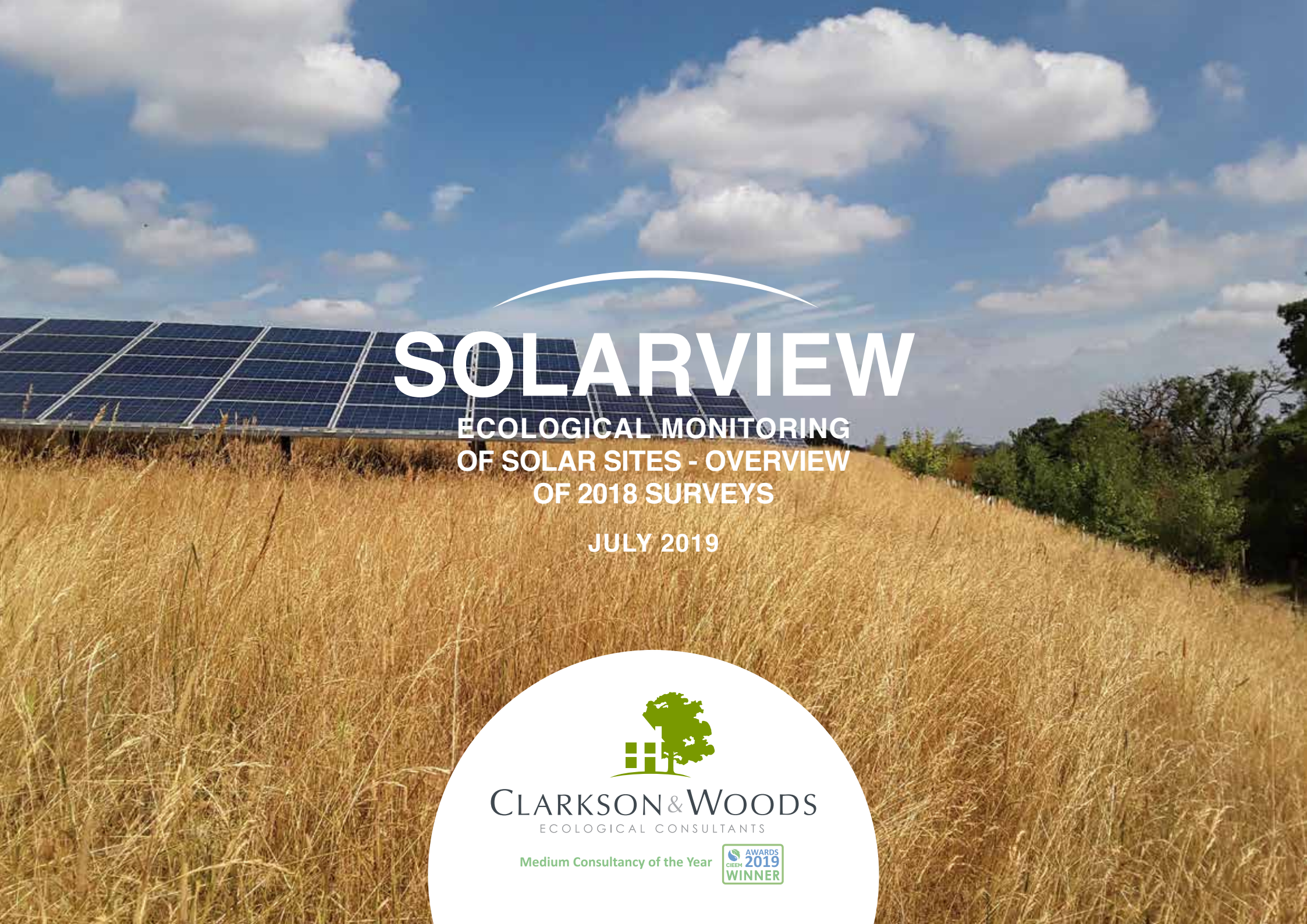


SOLARVIEW

ECOLOGICAL MONITORING OF SOLAR SITES - OVERVIEW OF 2018 SURVEYS

JULY 2019

CLARKSON & WOODS
ECOLOGICAL CONSULTANTS

Medium Consultancy of the Year

CIEEM AWARDS 2019 WINNER

Welcome to the overview of all solar sites monitored by Clarkson & Woods in 2018, or the 2018 Solarview.

Clarkson & Woods monitor a large number of ground mounted solar PV sites across the country and this has given us an excellent insight into how large scale PV arrays are managed and how biodiversity is affected. By using standard approaches we are building up a substantial database and the time seems right to produce an overview of our findings so far. Principally, this report aims to highlight how solar arrays are being used by wildlife and to provide evidence based responses to many of our most frequently encountered questions we get asked by clients, councils and members of the public. We have highlighted common management issues and positive or negative impacts of solar farms where we have found them. We hope that this report will be helpful for site operators, local authorities, ecologists, farmers and the solar trade industry alike.

This report is not intended as an in depth scientific analysis, however, the large dataset we have gathered as part of this work provides us with an exceptional opportunity to provide an overview on how solar arrays might be influencing the biodiversity on the sites in which they are located. We intend to produce further annual reports as additional data is gathered and hope to provide a picture of how biodiversity and the ecological importance of solar arrays develops over time.

All data and photographs used within the report was gathered during ecological monitoring of solar farms by Clarkson and Woods and has been anonymised. If you have any queries regarding this report or have any sites which you would like us to add into our monitoring portfolio and include within next years' Solarview report, please feel free to contact Tom Clarkson or Belinda Howell.

Clarkson and Woods work on a range of solar sites throughout all stages - their design, construction and operation; undertaking the necessary ecological surveys for planning, ecological clerk of works during construction, creation of management plans for operational sites, installation of habitat enhancement measures and post construction ecological monitoring. We feel that our involvement throughout the lifecycle of these projects gives us an insight into how solar arrays are developed and the issues/opportunities which occur at each stage. We can then use the findings of our monitoring surveys to inform future impact assessment and management plan design to ensure that we are able to provide appropriate advice aimed at maximising the biodiversity of sites. Additionally, we have found that ecologically sensitive management regimes are often less intensive and require less intervention than non-ecologically driven management and so can reduce ongoing management costs.

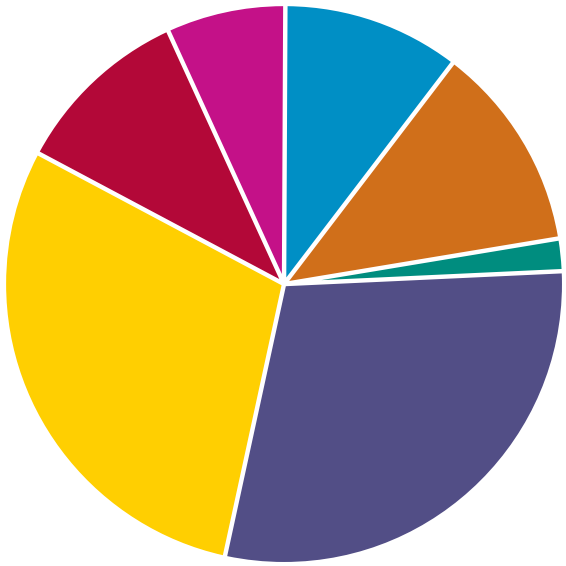
During 2018 Clarkson and Woods conducted ecological monitoring of approximately 6% of all ground mounted solar farms (of >3kw) in the UK, with more lined up for 2019.

We have developed a standardised botanical monitoring protocol which encompasses quadrat surveys within different areas of the array, as well as conducting a general walkover survey taking ad-hoc recordings of plants, invertebrates, birds and mammals. We also conducted internal inspections of bat and bird boxes installed at 30 solar sites. Bespoke surveys were conducted on a small selection of sites with particular requirements; including breeding bird, dormouse, great crested newt, reptile and fungi surveys.

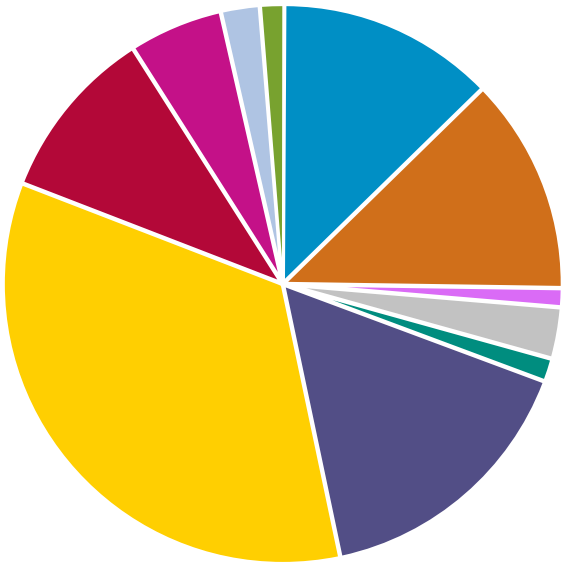
[1] **Renewable energy planning database monthly extract – September 2018 www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract last updated 29th October 2018.**

As can be seen from the adjacent map, in 2018 we undertook ecological monitoring of 59 solar farms across Great Britain. 34 of the sites monitored were within the South West and the South East, which represented 58% of our data set; this is unsurprising given both our location and the distribution of UK solar sites. According to the Renewable Energy Planning Department data base approximately 50% of all UK ground mounted solar farms, operational before 2018, are in these regions. Our database comprised a 50:50 split between the South West and South East, with each region accounting for 29% of sites in the database. We did not monitor any sites in Northern Ireland, Greater London, the North East, North West or Yorkshire and Humber. Looking at the range of sites monitored by C&W in 2018 and comparing it with the national pattern it can be seen that our sample is broadly representative of the distribution of sites across the UK, as can be seen in the adjacent pie charts.

Regional distribution of solar sites monitored by Clarkson & Woods in 2018



Operational ground mounted solar sites - UK distribution pre 2018



East Midlands · Eastern · Scotland · South East · Wales · West Midlands · North West · South West · North East · Northern Ireland · Yorkshire & Humber

Grassland Management

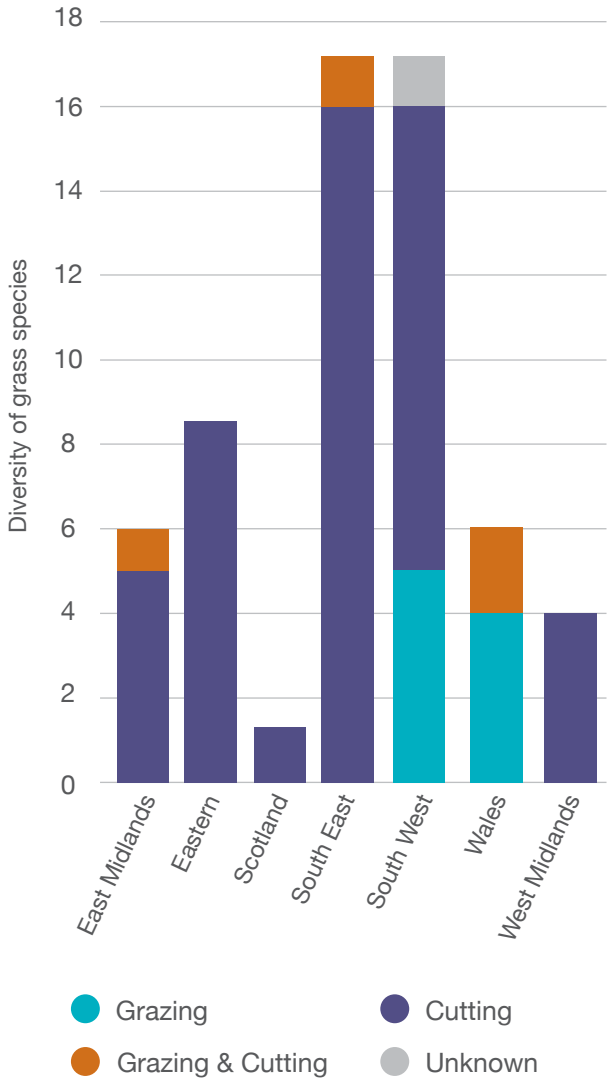
One of the most common questions we are asked is – “are solar farms really sheep grazed?” It turns out that at least a fifth of those we monitored are.

Of the six Welsh solar sites we monitored, all but one had sheep grazing within the array; on the remaining site the field margins were grazed by sheep and Welsh ponies. Over 30% of the sites we monitored in the South West were grazed by sheep, whereas only one of the sites per region in the South East and East Midlands, was sheep grazed, as shown in the adjacent stacked column graph.

It is worth mentioning that most management plans for solar sites include the removal of sheep from the array during May-August to allow the flowers to set seed and reduce disturbance to ground nesting birds; so the absence of sheep from sites may simply reflect adherence to the management plans and significantly more may be sheep grazed at other times of the year than our figures suggest. We intend to, where possible, liaise with local farmers to understand if, and when, arrays may be grazed by sheep. The regional differences in the use of sheep for the grazing of array sites may also reflect the differing farming practices in various parts of the country.

Sheep grazing within an array

Managament by region



Botanical Diversity

For the great majority of sites we used a standardised methodology for the botanical surveys; taking five randomly selected 2m x 2m quadrats directly below panels (Beneath quadrats), five between the strings of the arrays (Between quadrats) and five between the edge of the array and the bounding security fence (Exterior quadrats). In total we have surveyed 778 botanical quadrats.

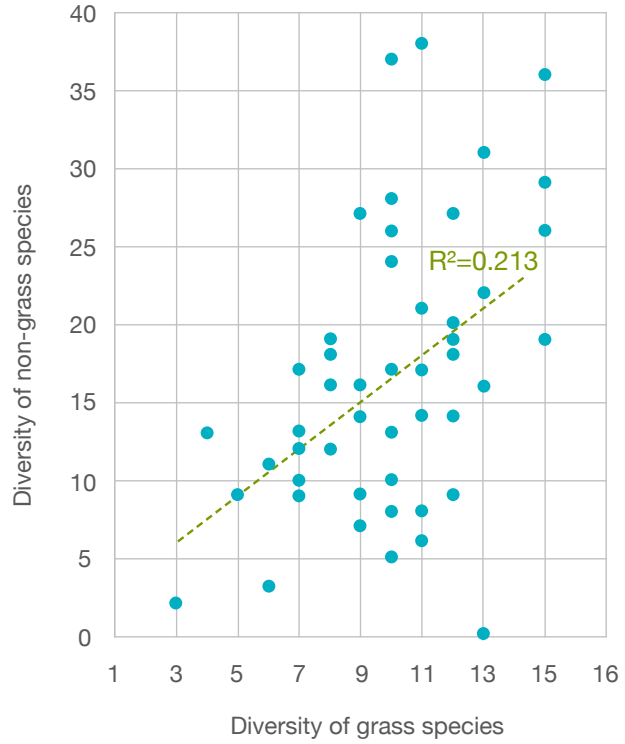
When carrying out impact assessment, we are often challenged by claims that grass fails to grow beneath panels. Of all 778 quadrats we surveyed, only one contained no vegetation at all (and it was taken from a “beneath” quadrat) but it also contained a significant amount of standing water. Only one of the 778 quadrats contained just injurious weeds (broad leaved dock) and no other vegetation.

Fairly unsurprisingly, shading does appear to affect the vigour with which plants grow and the development of grassland vegetation. Of the “beneath” quadrats, 72% contained some extent of bare ground, while bare ground was only recorded in 47% of the “between” quadrats and 43% of the “exterior” quadrats. This variation appears to be less pronounced on former pasture sites compared to arable sites which likely reflects the difficulty in establishing grassland on bare ground within shaded areas. We have not yet examined our data to confirm this and future surveys will give us more information on the establishment of vegetation in these areas.

In total, we recorded 41 different grass species and 195 other plant types. This included five different species of tree saplings, bramble or dewberry growing within the arrays on 40% of sites. This monitoring gave an advance warning of potential problems arisings from woody growth under/around the panels and the need for amending management practices; particularly as these woody species were predominantly recorded under the panels.

The mean number of different species per site was nine grasses with 16 different flowering species, though this ranged greatly. Generally, sites with a high diversity of grass species also had a high diversity of non-grass species, although the adjacent scatter graph shows that this fit is weak. Diversity of non-grass species was the most variable across the sites; with 42 different flowering species on one site but absolutely none on another (which had been treated with herbicide prior to the survey) though had 12 different grass species.

Total diversity of broadleaved plants recorded



A beautifully seeded solar site with an abundance of flowering plants

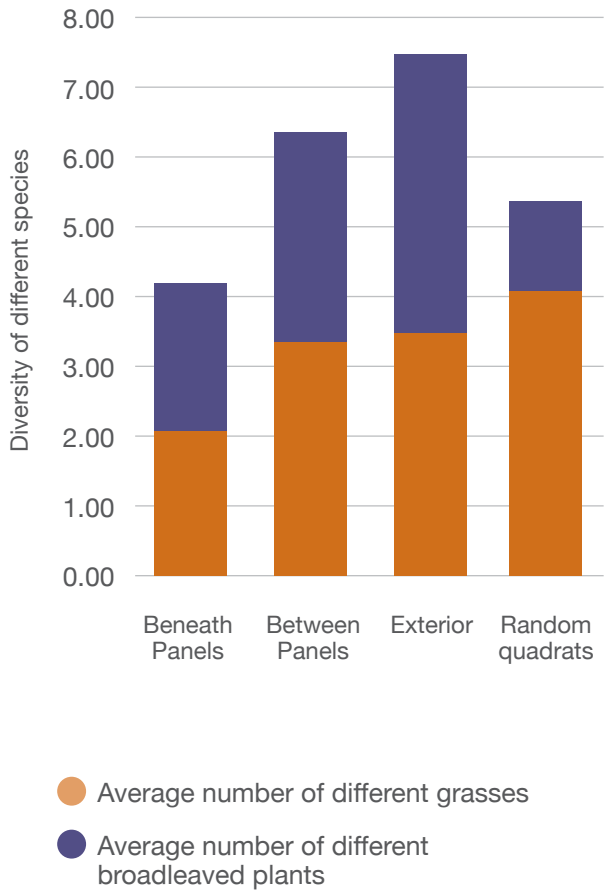
Four sites were found to support 14 different grass species (the maximum diversity recorded in 2018); all of these sites were constructed over three years ago which suggests that diversity within arrays may increase over time.

Yorkshire fog was by far the most commonly recorded grass species, recorded across 92% of sites, with an average cover within quadrats of 11-33%, regardless of quadrat type (“Beneath”, “Between” or “Exterior”). Yorkshire fog was recorded in 40% of all the Beneath quadrats while the next most common grass in these locations (common bent) was only recorded in 20% of quadrats.

In terms of broad-leaved plants, creeping thistle was the most commonly recorded (62% of sites) while white clover was recorded on 60% of sites and creeping buttercup on 56%, this is unsurprising given that they are common species of agricultural land and so were likely to be present prior to the array being constructed.

Across all sites and quadrat types, the quadrats were dominated by grasses. The quadrats beneath panels were the least diverse with an average of four different species per quadrat, compared to the array exterior with an average of seven different species. The abundance and diversity of broadleaved plants is highest in the array exterior as shown in the below graph.

Average number of different species per quadrat




A heavily grass dominated array


Beneath panel quadrat location

Botanical Highlights

Whilst doing the surveys we recorded pyramidal orchids on three different sites; southern marsh orchids, bee orchids as well as common spotted orchids were also recorded on individual sites. Though these are not protected or notable species, they have particular habitat requirements and are indicative of less intensively managed grasslands. They may also indicate ecologically important habitats.

Interestingly, we found species associated with shaded or woodland habitats below panels on some sites, including red campions, white campions, wood avens, cleavers and ferns. Meadow grassland species such as betony, pignut, common centaury, agrimony, cowslip, dyers greenweed, eyebright and ragged robin among others were recorded on several sites.

The monitoring surveys highlighted that two of the sites support a diversity and assemblage of plant species consistent with BAP priority habitat GO6 ‘Lowland Meadows’ in accordance with the Higher Level Stewardship Farm Environment Plan (FEP) Manual (3rd Edition, dated March 2010). Using the same criteria, 17 sites (29%) are considered GO2 ‘semi-improved grasslands’.

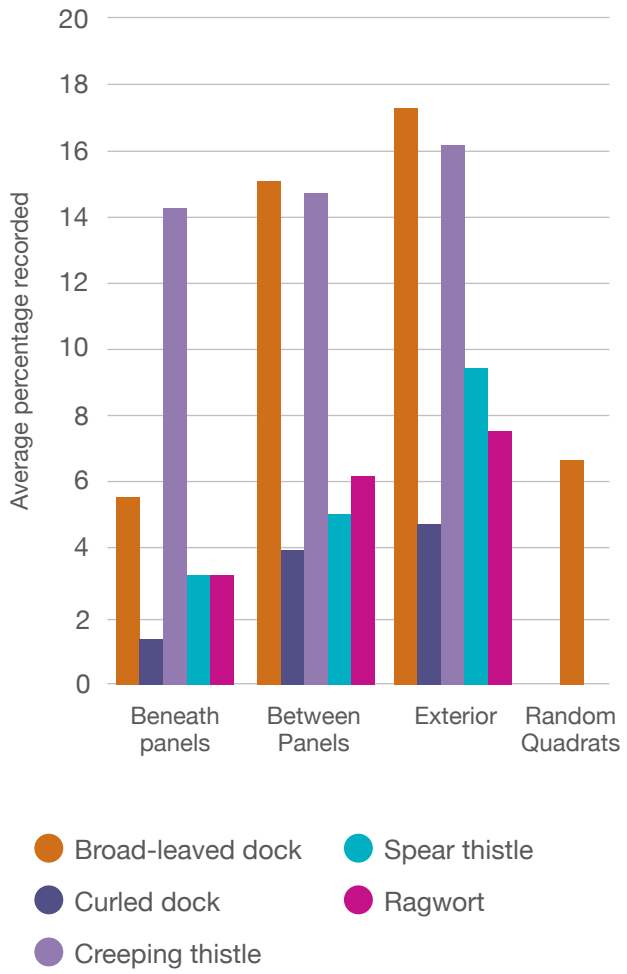
Weeds And Undesirable Species

In the UK there are five different recognised injurious weeds which legally require management to prevent spread onto adjacent land; broadleaved dock, curled dock, creeping thistle, spear thistle and ragwort. At least one of these injurious weed species were recorded within the quadrats on 90% of sites, including sites which had been repeatedly sprayed for such weeds, highlighting difficulties in management. In the remaining 10% of the sites, the surveyor detected injurious weed species elsewhere in the site, which were not picked up by the quadrat survey. In total, at least one injurious weed species was recorded in 34% of all the surveyed quadrats.

Creeping thistle was by far the most common injurious weed, recorded in 15% of all quadrats and on over 62% of the sites. The next most commonly recorded weed was broad-leaved dock, recorded in 13% of all quadrats and on 92% of all the sites. While curled dock was only recorded in a total of 25 quadrats (across 20% of sites). As mentioned previously, creeping thistle was the most often recorded of all vascular plants. Although it occurred within 62% of all sites, it was also noted elsewhere within the sites, outside of the recorded quadrats, and so the occurrence of this species is likely to be higher than 62%.

All five different species were more likely to be recorded within the array exterior; approximately 42% of Exterior and 38% of the Between quadrats featured injurious weeds, while only 24% of quadrats “Beneath” the panels had any injurious weeds. it should be noted that these figures differ from the adjacent clustered column graph which shows the percentage of each different quadrat types which were found to contain the different species of controlled injurious weed whereas 53 quadrats contained multiple injurious weed species. Of these 53 quadrats with multiple weed species, 53% were recorded within the array exterior while 17% were from directly under the panels and 30% between the panels. This is interesting as injurious weeds are generally expected to take hold in the bare areas below panels. Creeping thistle was found to be slightly more dominant in these areas (compared to other areas) but not significantly.

Percentage of different injurious weeds by quadrat type



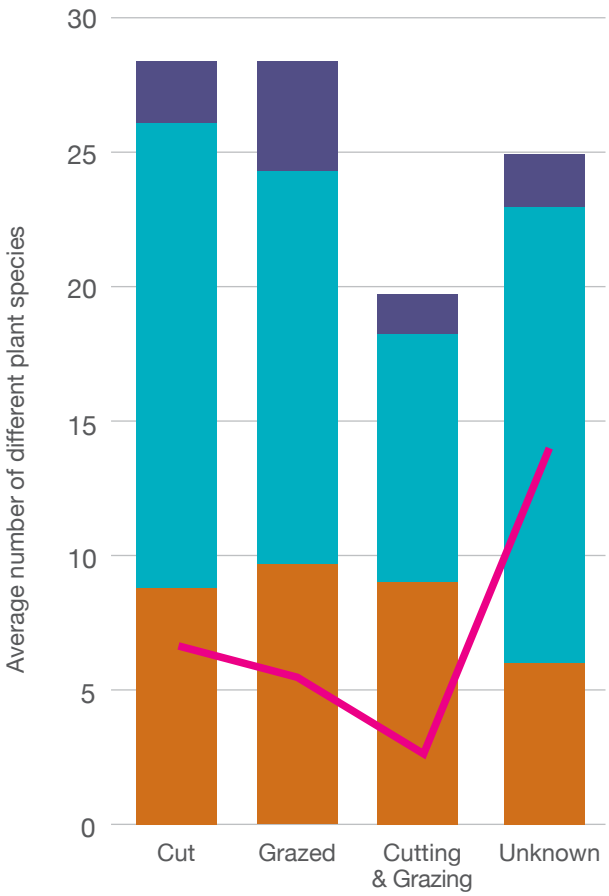
Management of injurious weeds can be a significant challenge and represents a considerable expense for operators. On some occasions where weed species are prolific the use of herbicides may be essential to managing the weed problem and ensuring injurious weeds do not spread to adjacent sites (which would represent a breach of the law). We have observed herbicides being broadcasted non-selectively across sites which had previously been seeded (at significant expense) with a species-rich seed mix. This resulted in not only the injurious weeds being eradicated, but also all other broadleaved plants, including wildflowers. Care should be adopted in selecting appropriate treatments for weed species; even the use of selective herbicides such as Grazon will eliminate many of the species deliberately sown. Where impact assessments and biodiversity enhancement strategies have included the creation of species-rich grasslands, management may need to be modified in order to control the extent of herbicides. This might include topping of the sward at strategic times of the year, more regular cutting or changes in the grazing intensity. As a last resort, spot spraying or weed wiping may be utilised.

[2] Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man. Mark Eaton, Nicholas Aebischer, Andy Brown, Richard Hearn, Leigh Lock, Andy Musgrove, David Noble, David Stroud and Richard Gregory. British Birds 108, page 708–746. Dated December 2015.

A mixed sward within an array

A view between panels showing a well-established grass dominated sward

Management strategy compared with florisitc diversity



Looking at how management affects diversity is difficult and there are a large number of variables making comparisons between management strategies difficult at the current time. Key variables that have been identified include timing of cutting; whether grazing is removed during key parts of the year; whether a site has been seeded with a diverse seed mix; whether a site has been sprayed with a herbicide; whether arisings are removed subsequent to cutting; the nature of the habitat prior to array construction etc. However, as shown in the adjacent combined graph, there is no significant difference in broadleaved or grass species diversity comparing sites managed through cutting and sites managed through grazing; whereas sites managed through both cutting and grazing are typically less diverse, though also less prone to injurious weeds. Sites which are managed through cutting tend to have a higher percentage cover of injurious weeds. Where the management is shown as 'unknown' there was no evidence of any specific management approach (although for the majority of sites management was taking place). Unknown is not synonymous with unmanaged.

It is worth noting that although in some cases there is a legal requirement to control injurious weeds to prevent their spread, they provide a valuable nectar source for invertebrates and are even key food plants for particular butterflies and moths. For instance cinnabar moth caterpillars key food plant is ragwort; cinnabar moths were recorded on seven sites and ragwort was recorded on 19 different sites. Thistles are also primary nectar sources for 10 different species of butterflies and provide a secondary nectar source for a further 26. It is possible to manage operational arrays so as to balance the need to control undesirable species with the biodiversity benefits that such species provide.


A sheep grazed site with a heavily grass dominated sward and sub-optimal invertebrate survey conditions


A common blue butterfly on creeping thistle

Birds And Arrays

Another key concern regarding solar farms and biodiversity are the impacts that the installations have on farmland birds. Across the 62 surveys we recorded 78 different bird species[3].

It is important to note that the bird data is largely from ad-hoc recordings and therefore has numerous limitations including discrepancy in surveyors recording strategies and identification skills, differences in the weather, timings of the surveys etc. Two sites were surveyed using BTO (British Trust for Ornithology) survey methodology with three surveys undertaken during the key breeding bird survey window, this survey requirement reflects concerns raised at the planning stage regarding ground nesting birds.

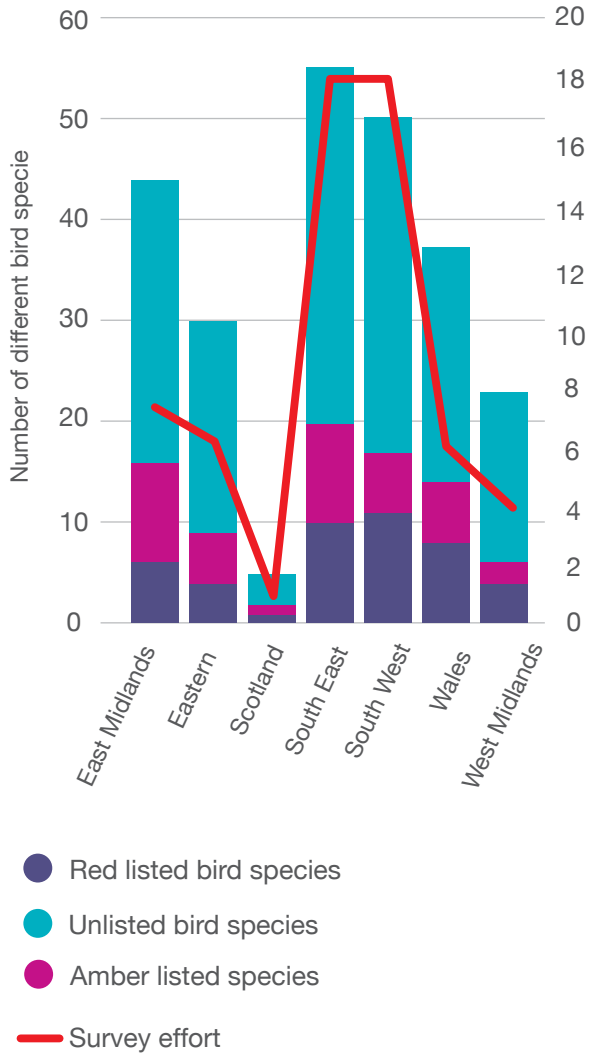
Overall, the species assemblage, shown in the bar chart below, was typical of farmland habitat with a mean of 11 different species per survey. This was, however, very variable with some sites having as little as four different species while others had 28 (recorded during a single survey). As mentioned previously, this large range may be due to differences in surveyors or weather conditions as well as conditions on site/ within the surrounding habitat, for instance water birds such as mallards and moorhens were unsurprisingly absent from arrays without waterbodies on-site or nearby.

Sites with higher numbers of surveys generally had a higher diversity of bird species, ranging from 27-37 different species per site overall. Often this is because those sites are subject to more intensive bird surveys as a requirement of the planning permission. Typically these sites were of high value to birds prior to the installation of the array. It cannot be assumed that the presence of the array is having a positive impact upon bird diversity as no baseline data exists for these sites. However, where bird diversity is high after panel installation this suggests that the impact of the array upon the generalised local bird populations may be neutral though further analysis comparing pre-construction data (where present) with post construction surveys would be required. It is worth considering that impacts may be disproportionate on certain species which might be displaced from array sites, such as those that require long, unbroken sightlines such as breeding skylarks.

[3] N.B. Five of the sites monitored were surveyed more than once in 2018.

A newly planted hedgerow within an array

Number of different bird species recorded by region



Of the 78 different species we recorded, 16 were Red Listed Species of Conservation Concern and 14 were Amber Listed Species of Conservation Concern. The British Trust for Ornithology (BTO) List of Conservation Concern 4 was published in 2015 updating the 2009 version; the document reviews the status of birds in the UK, assessing trends in range and population, localised distribution, historical declines, rarity and international importance. The list separated 244 species into red, amber and green levels of conservation concern, with species on the red list being the most vulnerable or experiencing the greatest decline.

The numbers of red and amber listed birds recorded within each site was highly variable, with no birds of conservation concern at all on five sites while others had as many as five red listed and seven amber listed species.

Regional differences were difficult to identify within the data, due to the differences in sample size within each region, variation in the surrounding habitats and differing levels of survey effort. However, for the South West and the South East, which had the same number of sites and surveys, the South East was found to be slightly more diverse with 55 different species (including 20 Species of Conservation Concern) compared to the South West with 50 different species (including 17 species of Conservation Concern). There were also greater occurances of certain key species such as skylark (a red listed Bird of Conservation Concern, thought to be impacted by solar arrays), which was recorded on nine sites in the South East but only four sites in the South West. Wales and the East also had the same level of survey effort with six sites surveyed each; the Welsh sites were found to be slightly more diverse with 37 different species (14 species of Conservation Concern) compared to 30 species (nine of Conservation Concern) in the East. These differences are shown in the adjacent bar graph.

The most frequently recorded Bird of Conservation Concern was skylark, which was recorded on 47% of the sites. Though no nests were found, skylarks were flushed from sites by surveyors walking between the panels, noted singing while perched on the panels and foraging with the array. On one site a skylark was recorded disappearing into the array while carrying food, indicating the presence of a nest or fledglings. Skylarks are ground nesting birds which typically need long sight-lines to best spot predators, however they are considered loyal to nest sites so may continue to nest in a sub-optimal area which was previously more suitable. The fact that skylark were so frequently recorded is an interesting observation, as the impacts of solar farms on skylarks is a key consideration within ecological impact assessment. Our monitoring shows that skylarks do use solar farms as part of their territory, however, conclusive evidence of breeding within an array is yet be obtained. This would be an interesting area for further research which we intend to pursue.

Skylarks were not the only ground nesting birds recorded using the array interiors; yellowhammers were recorded at 30% of sites. Smaller numbers of lapwing and meadow pipit were also recorded using the sites.

At least one species of ground nesting bird was recorded using 74% of the sites with one site having as many as six different species (blackcap, lapwing, meadow pipit, skylark, stonechat and yellowhammer) recorded during as ad-hoc sighting during a monitoring survey. The “ground nesting” species includes charismatic farmland species and more generalist ground nesting species such as skylark, corn bunting, cuckoo, lapwing, meadow pipit, yellowhammer, stonechat, sand martin, garden warbler, chiffchaff and blackcap.

A grass dominated solar site with mature adjacent habitat

The array exterior of a site seeded as a food source for farmland birds

[4] Birds of Conservation Concern 4: the population status of birds in the UK, Channel Islands and Isle of Man. Mark Eaton, Nicholas Aebischer, Andy Brown, Richard Hearn, Leigh Lock, Andy Musgrove, David Noble, David Stroud and Richard Gregory. British Birds 108, page 708–746. Dated December 2015.

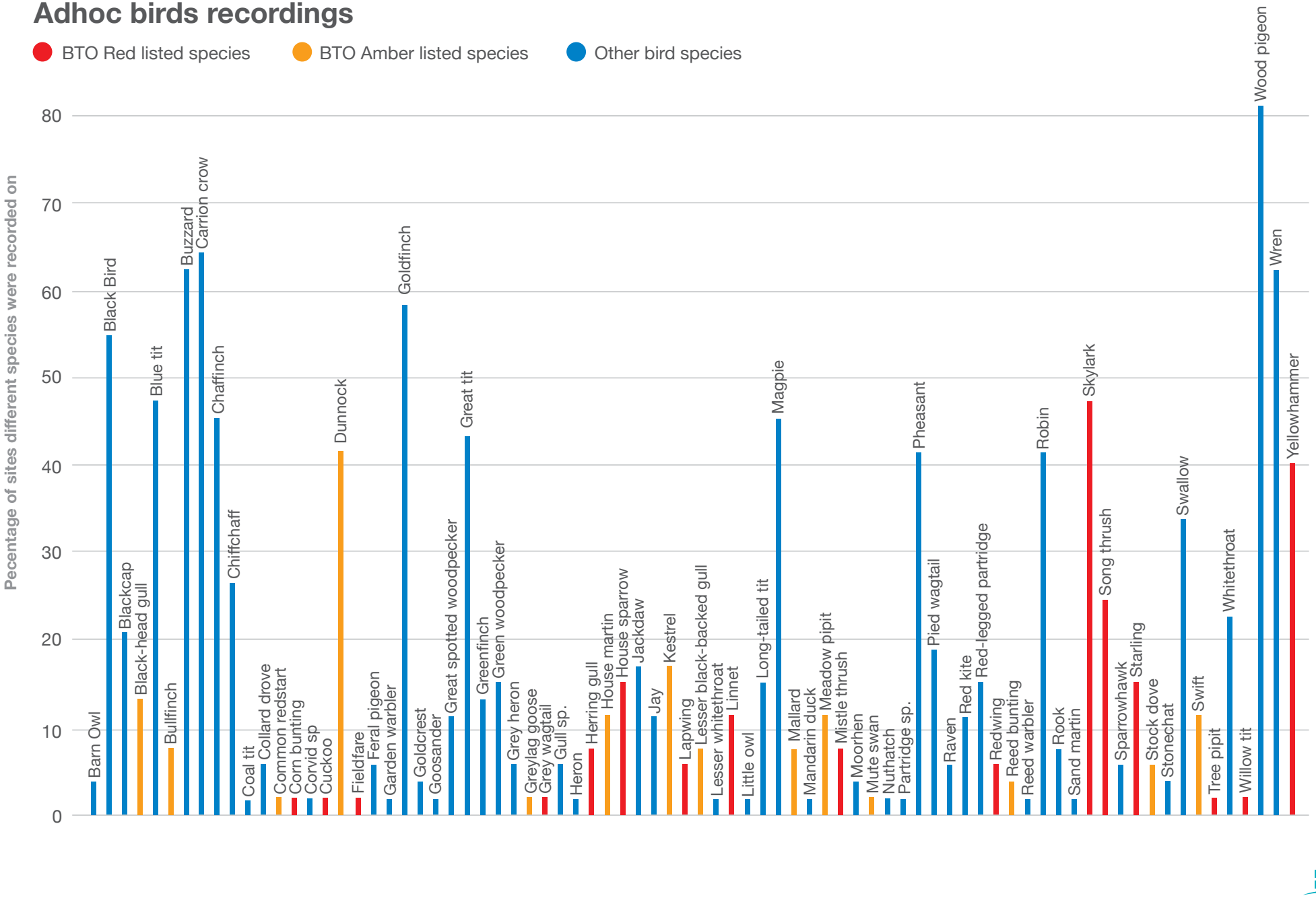
These figures do not include the presence of pheasants, partridges, gulls, mallards or swans, which though ground nesting are mobile or introduced. We should stress that the presence of ground nesting birds within the arrays does not necessarily indicate that the sites are used by these species for nesting. As many of the arrays represent a diverse grassland with low intensity management, the arrays may be used as an important foraging resource by pairs which are nesting within surrounding habitats beyond the arrays. There was a large diversity of species recorded during the monitoring visits, as can be seen in the adjacent graph. The most common bird recorded was wood pigeon (recorded on 81% of all sites). Other common species included buzzards, crows and wrens which were each recorded on 62-64% of all sites. Ad-hoc notes by surveyors include references to yellowhammers utilising the security fencing as a perch from which to sing. Sparrowhawks, buzzards and kestrels were all seen foraging within sites, particularly within the field margins, where the longer grass is likely to offer a good resource for small mammals, invertebrates and reptiles.

It should be noted that results relating to birds are based on ad-hoc observations recorded by experienced surveyors rather than collected through targeted bird surveys. As such this data may not provide a precise representation of the bird assemblage.

Targeted bird surveys are likely to result in identification of more birds and a greater diversity of species. Nevertheless, because of the number of different sites inspected it is possible to use this data to identify general trends and commonalities. There are many further variables which have not been considered in the above analysis such as timing of visits during the day, weather conditions during surveys, month of survey (for instance 10% of the surveys were undertaken over winter November-March due to timings associated with sale of sites / appointment), the surveyors identification skills and time spent on the site. Those more commonly recorded species may have been those which are highly visible or with loud, recognisable song. Additionally, some species may have been recorded flying over the site rather than using the site or boundary habitats. Given that the surveys of the sites were not standardised, it is difficult to draw any robust conclusions.

The long uncut grassland margins providing opportunities for nesting birds, with the front of the panels cut to reduce shading

Adhoc birds recordings



Surveys weren’t always optimal for recording birds or invertebrates, on some occasions there was snow

Ecological Enhancements – Habitat Boxes

Overall we inspected over 400 habitat boxes, across 30 sites, for evidence of use by target species/taxa. Over 40% of these boxes were being used by target species/taxa in 2018.

Where bird and bat boxes were recommended within the management plans or ecological reports for the site, these had been installed on 80% of sites prior to our first monitoring visit. The average number of boxes installed within a single site was six bat boxes and six bird boxes.

In total we found 90 small passerine nests, four barn owl nest sites (including nests with chicks), a wood pigeon nest, and 15 new bat roosts. Given that these boxes were often fairly recently installed, this number is likely to increase with passing time and continued establishment of habitats on site.

Bird boxes were most likely to be used, with an uptake rate of 72%. Of the 90 small passerine nests, we found seven in bat boxes and one in a dormouse box. Of the 90 small bird nests we found in boxes in 2018, 84% looked to be from tit species.

Every site where Schwegler 1B bird boxes had been installed and inspected, at least one box had a bird nest inside - even on sites where as little as two boxes were inspected. five of the nine (55%) sparrow terraces which we inspected were used by birds, though the species within the boxes could not be confirmed. Other specialist bird boxes have been installed on other sites, however, these showed comparatively low levels of uptake; of the 28 specialist boxes checked only three nests were found. The specialist boxes used were Schwegler 3S (starling), Schwegler No. five (tawny owl), Schwegler 2H (robins & similar) or Schwegler 1ZA (wren) nest boxes.

Of the 23 dormouse boxes we internally inspected, none were used by dormice. Three were used by wood mice as well as the one used by a nesting bird.

Clarkson and Woods installing a barn owl box

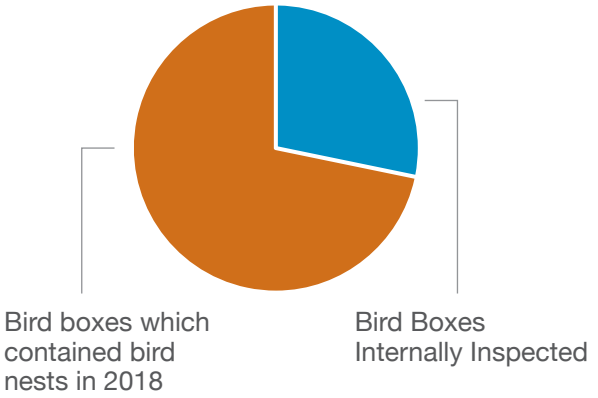
Overall, we inspected 106 bat boxes of six different types. All were Schwegler boxes which tend to be selected for their longevity. Due to supply issues in Europe these boxes can be difficult to obtain and we anticipate that in future years other designs and manufacturers of boxes may be used. Box types consisted of 58 x Schwegler 1FF bat boxes, 23 x Schwegler 2F boxes, 13 x Schwegler 2FN, two x Schwegler 1FN, seven x Schwegler 1FD and two x Schwegler 1FW hibernation boxes. Of the 106 boxes internally inspected during the 2018 survey, 15 were found to be used by roosting bats giving an overall uptake rate of 14.4%.

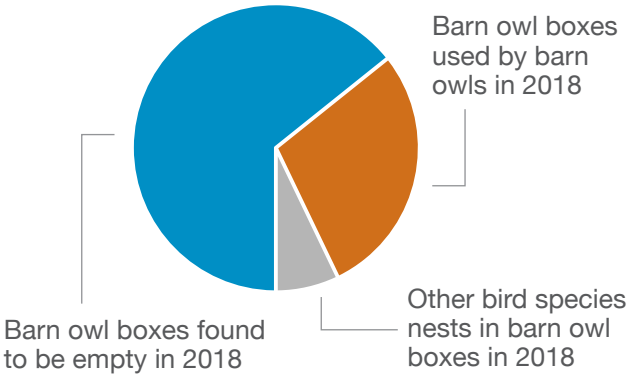
The 15 boxes used by bats included 13 x Schwegler 1FF, (an uptake rate of 22.4%). Notably eight of the successful 1FF's were installed on fence posts which might traditionally have been considered a sub-optimal location for bat boxes. Other successful boxes had been installed in woodland, hedgerows and woodland edge habitat.

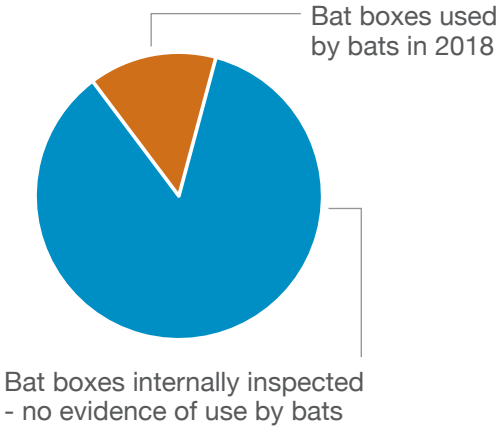
The other two boxes found to be used by bats were both Schwegler 1FD's, giving them an uptake rate of 28.6% which was higher than the 1FF's although there were significantly fewer of these boxes within the sample making these statistics less reliable. It is worth noting that both 1FD's found to be used by bats were on the same site.

Interestingly on the site with the highest uptake of the bat boxes, all boxes were installed on the security fence posts bounding the site. This site is also managed in accordance with the Management Plan with more than double the average number of broadleaved plants and the greatest diversity of grass species recorded of any site monitored. As such the high uptake of bat boxes may be a reflection on the quality of the habitat, and thus foraging opportunity, rather than a commentary on the suitability of the use of fence posts as locations for erecting bat boxes.

Four sites where bat boxes that had previously been found to support roosting bats in 2017, had no evidence of use in 2018. The sites from 2017 included one where droppings were found in 75% of the boxes only two months after installation, on another four sites soprano pipistrelle bats were recorded in two boxes 16 months after installation but no evidence of occupation was recorded in any boxes at either site in 2018. This highlights that boxes may be used on an intermittent basis and that the absence of bats from within a box may not reflect that the box is not used on other occasions by bats. For a true picture of bat box use within solar arrays to be built up, regular inspections over an extended period will be required. There is some anecdotal evidence from box monitoring we have been involved with on other projects that indicate that the hot and dry summer of 2018 may have affected the uptake of bat boxes by bats. Bats require high humidity and relatively stable roosting temperatures which may not be provided within boxes during spells of hot weather. This may highlight the need to ensure boxes are deployed in a variety of exposed and shaded locations to provide a range of different roosting opportunities.



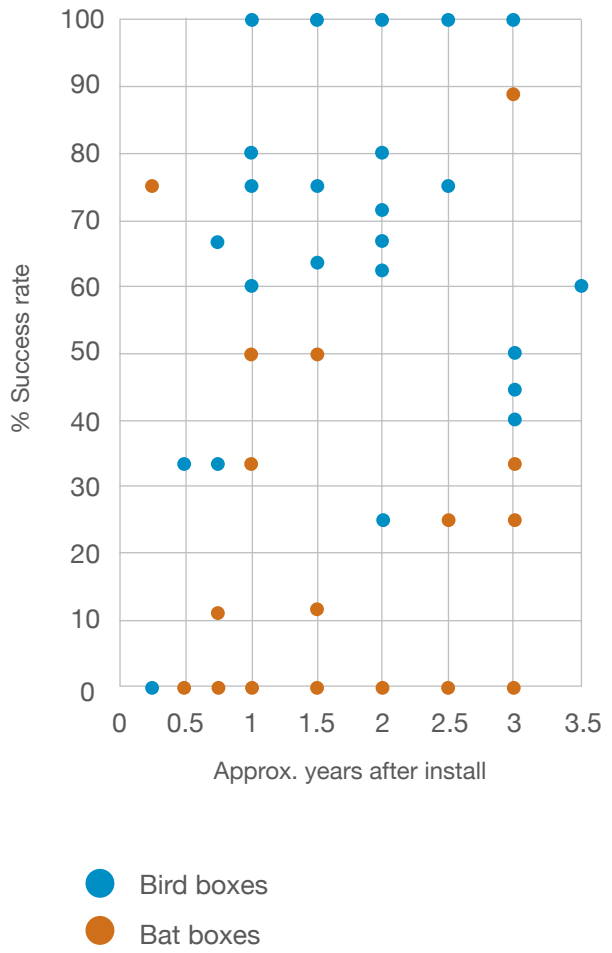




A successful bat box, installed on a post at the edge of a highly diverse grassland

Where we hold the information on the installation dates of the boxes, the success rate (percentage of boxes internally inspected found to be used by target species) of bat and bird boxes is shown as a scatter graph below. This doesn't take into account the number of boxes deployed, availability of other nesting/roosting habitat, the habitats or connectivity of the site and suitability of the boxes, so is over simplified, with a few outliers skewing the data set making it statistically insignificant. However the graph shows a general increase in uptake over time and more ready uptake of bird boxes compared to bat boxes.

Uptake of enhancements by target species over time



Mammals

Mammals were recorded using 91% of sites. We recorded 12 different mammal species using the sites (not including bats found in boxes). Species included deer as well as badger, brown hare, rabbit, fox, mole, common vole, wood mouse, shrew and bank vole.

Across the sites, a third had specific mammal gates, gaps or areas of raised fence to prevent habitat fragmentation, though a quarter of these had become blocked by vegetation. On half of the sites with such features, evidence was recorded of mammals forcing their way under the fence in other locations. Where no such features were deliberately installed mammals maintained access through undulations in the ground, forcing their way beneath the fence or gaps at the bottom of gates or, for deer, by jumping the fence. It has been Clarkson & Woods' opinion that the provision of mammal gates within linear fencing is unnecessary and gates installed were unlikely to be used. This seems to be supported by our findings from these monitoring surveys.

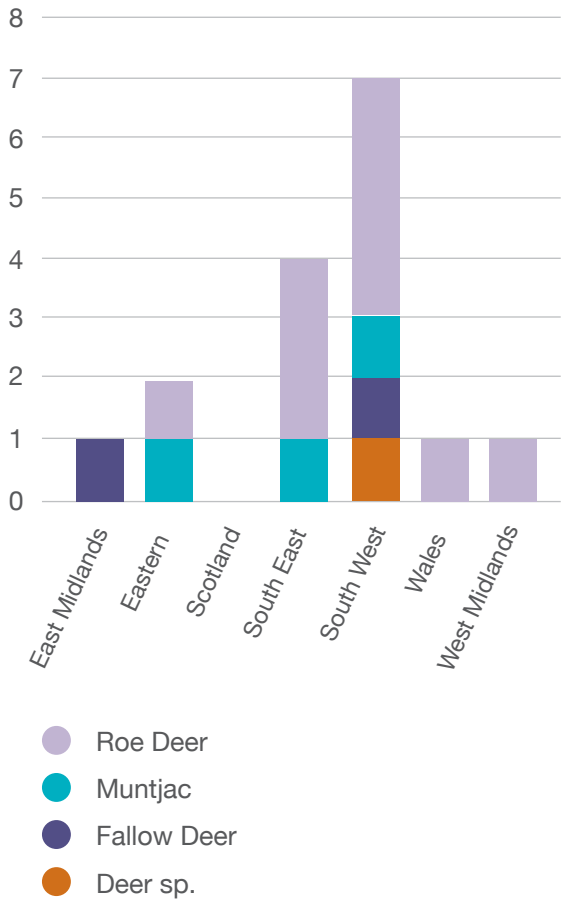
Of all the sites we visited we recorded evidence of use by mammals on all but five sites; interestingly one of which had raised fences to facilitate mammal access. It should be noted that no specific mammal surveys were conducted and data was obtained through ad-hoc recording only; therefore, results are dependent on survey timing, identifications skills of the surveyor, the amount of time spent on the site, weather conditions etc.

Brown hares were the most common mammal, recorded on 53% of sites, while wood mice and bank voles were only recorded on 1.9% of sites each; this is likely a result of under recording more than absence of these fairly common and widespread species. Badgers were found to be actively foraging within 30% of the sites.

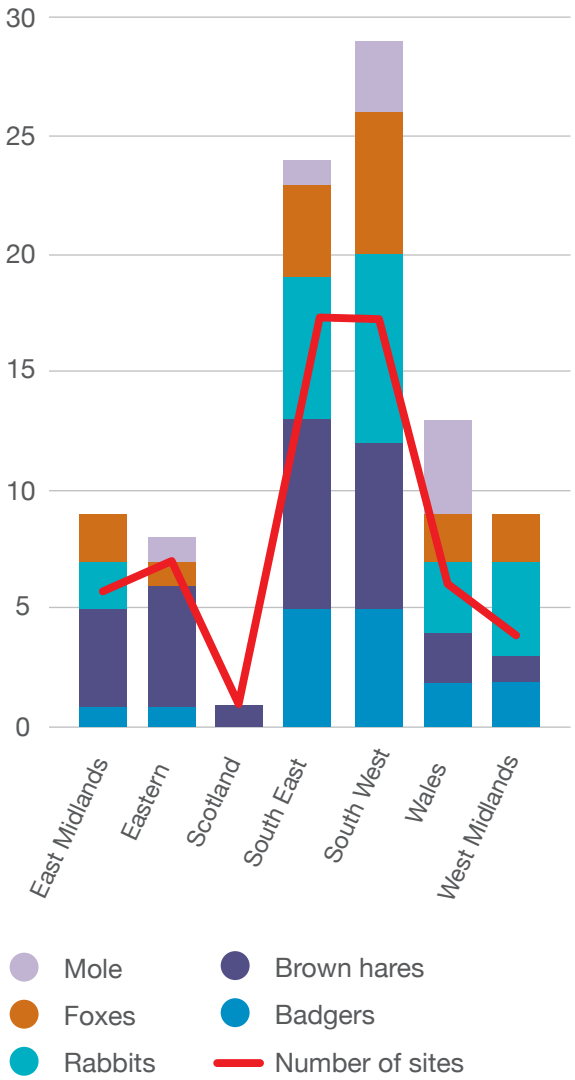
The high numbers of brown hare recorded is interesting as this is a species which has suffered recent declines and is now a Species of Principal Importance under the NERC Act 2006. It may be that solar farms offer an important habitat where this species can forage and shelter with little disturbance or persecution. Where this species was recorded within sites, it was present in fairly high numbers and was seen to be sheltering beneath the panel structures.

Considering solar farms are typically fenced with 6ft high stock proof security fencing, it is interesting that we recorded three different deer species; fallow, roe and muntjac. Deer were recorded within over a quarter of the array interiors. No evidence was found that deer were damaging the panels or related structures. Given that the majority of sites we surveyed were in the South East and the South West it is unsurprising that the highest number of ad-hoc mammal sightings were recorded in these two areas, however the highest number of mammal recordings was clearly within the South West particularly relating to deer species. Wales and the East had equal numbers of sites however more mammal species were clearly recorded in Welsh sites compared with Eastern sites.

Deer species recorded on site by region

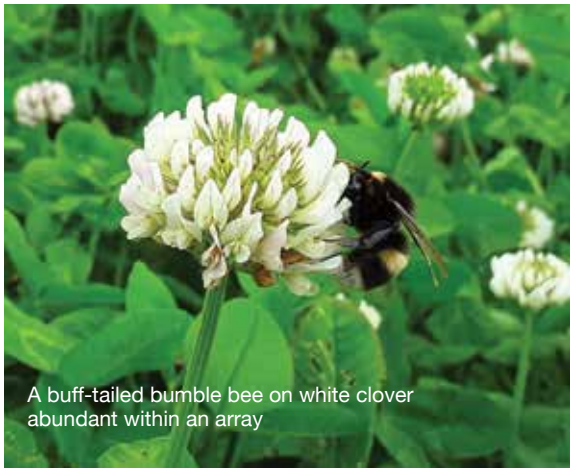


The number of sites different mammal species were recorded by region



Deer grazing within an array

A buff tailed bumblebee on spear thistle



A buff-tailed bumble bee on white clover abundant within an array

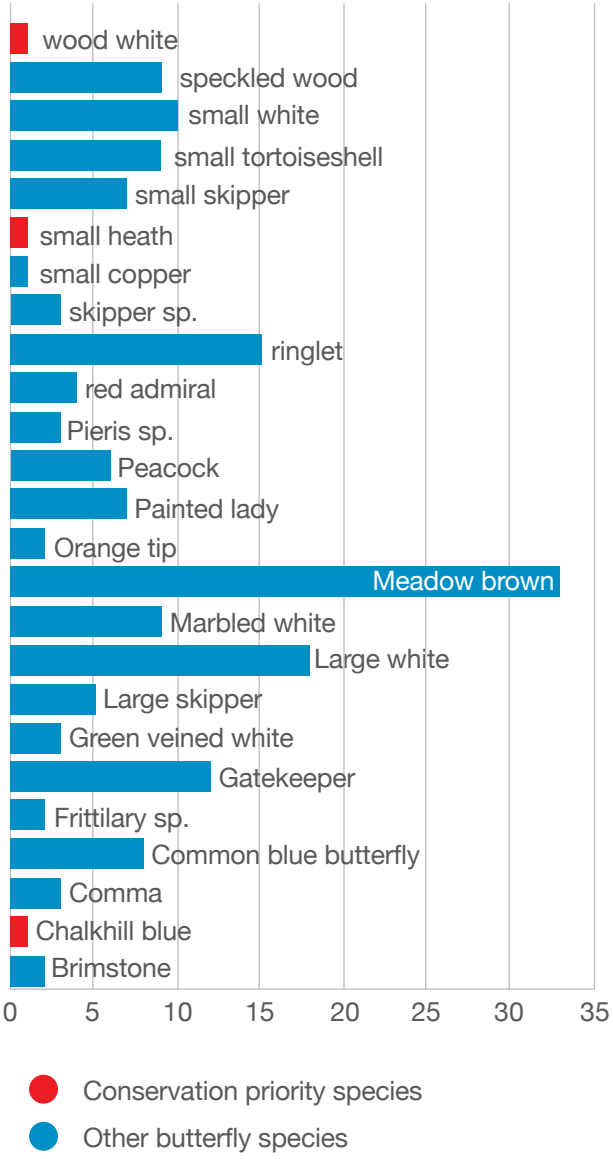
Invertebrates

In total we recorded 86 different invertebrate species across 52 visits (46 sites) in the 2018 summer survey window.

No specific invertebrate surveys were conducted; information on the presence of invertebrate species was obtained through ad-hoc observations noted by surveyors as they were on sites. As such, the invertebrate data is affected by the same limitations as the bird data. Large numbers of invertebrates were likely under-recorded with common families such as earwigs and slugs only recorded on one site each, though presumably present on more.

Almost half of the invertebrates recoded (49%) were butterflies. Butterflies were recorded on 91% of sites we surveyed in summer 2018 with an average of four butterfly species per site. This is likely due to the conspicuous nature of butterflies, making them relatively easy to see and identify during adhoc surveys. Similarly easily distinguishable and common bumblebee species (i.e. red-tailed bumblebee) were the most commonly recorded (on 39% of sites) while buff-tailed bumblebees which are again easily distinguishable were recorded on 15% of sites.

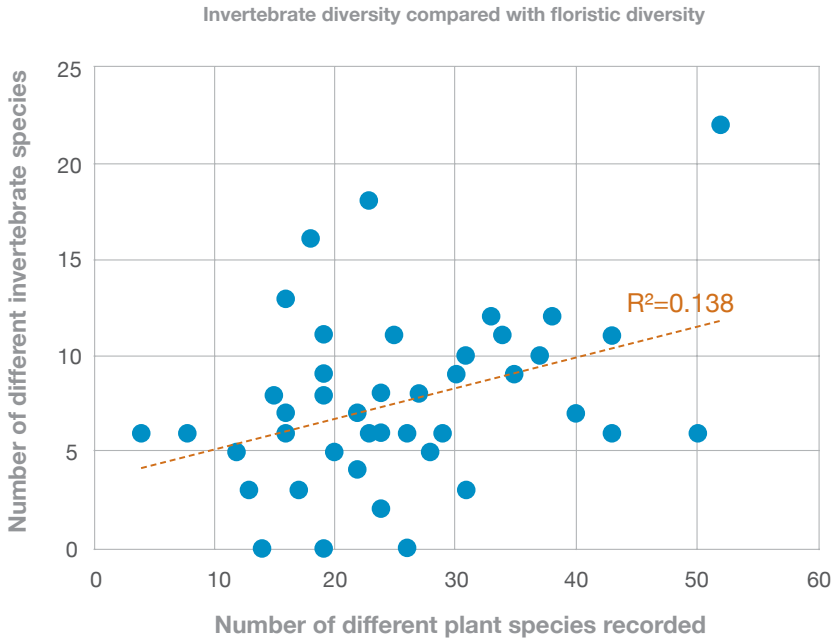
Butterfly species - number of sites



Of the 25 different butterfly species recorded, 22 are Butterfly Conservation Trust 'Low' conservation priority species while the chalkhill blue (recorded on one site in Sussex) is a Butterfly Conservation Trust 'Medium' priority species and Species of Principal Importance under the NERC Act 2006. Wood white and small heath butterflies were each recorded on a different site in the south west; both are 'High' Butterfly Conservation Trust priority species and Species of Principle Importance under the NERC Act 2006. The most commonly recorded butterfly was meadow brown which was noted at over 50% of the sites surveyed.

Sites with higher botanical diversity (recorded during botanical surveys) also had higher recorded diversities of invertebrates (from the ad-hoc recordings only). As shown in the below scatter graph, the recordings were highly variable, presumably due to the high number of variables previously noted, however the upwards trend is clear (though not statistically significant). Sites with higher botanical diversity (recorded during botanical surveys) also had higher recorded diversities of invertebrates (from the ad-hoc recordings only). As shown in the below scatter graph, the recordings were highly variable, presumably due to a high number of variables including the weather, however the upwards trend is clear (though not statistically significant).

Adhoc invertebrate recordings - number of recordings



Butterflies show a similar trend with their diversity being correlated with floristic diverity. The number of butterfly species recorded at a site increases with the number of plant species recorded. This pattern was not however observed in bumblebees. Again, it should be noted that the figures relating to bumblebees and butterflies are from ad-hoc sightings rather than specific surveys.

As can be seen from the graph a notable outlier site was recorded with 52 different plant species and 22 invertebrate species (including 16 different butterfly species), though notably no bee species. This site was seeded and is managed in accordance with a prescriptive management plan and regular ecologist involvement. It is also worth noting that the abundance of different invertebrates (i.e. the number of individuals) has not been assessed, only the presence of different species (the diversity). Some sites may have particular importance for specific species and so may have a low species diversity, but high abundance.

[5] The Butterfly Conservation's UK Conservation Strategy 2025, includes definitions for medium and high threat priority species which have been based on the IUCN international status of the species as well as distribution and population trends since 1976.

With a range of sites surveyed which included various management strategies, in a broad range of locations the surveys highlighted a range of similarities and differences across the sites. Though much of the data recorded was ad-hoc, with large numbers of extraneous variables affecting their comparability, the study has highlighted some interesting findings and emphasises that with proper management, solar farms can become a haven for wildlife. We look forward to continuing these surveys and gathering more ecological data from solar farms.

We will continue with our monitoring work in 2019 and beyond and are currently collaborating with Wychwood Biodiversity as well as Lancaster and York Universities to collate the information we have collected and carry out more robust statistical analysis. This will be submitted to a peer reviewed journal this coming year.

Additionally, we have had input into a tool being created by a group of academics, led by Lancaster University, known as SPIES (Solar Park Impacts on Ecosystem Services). This evidence based tool is aimed at helping solar park developers and operators make management choices which will benefit the environment and people (www.lancaster.ac.uk/spies).

If you would like to know more about the monitoring surveys we conduct, or if you have a solar site which requires upcoming monitoring, please feel free to get in touch with Belinda Howell or Tom Clarkson on 01934 712500 – Hello@clarksonwoods.co.uk.

A six spot burnet moth on spear thistle within an array

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