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LIFE WADERS FOR REAL

Deliverable D4: Assessment of restoration of ecosystem functions

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- Terrestrial Invertebrates
- Aquatic Ditch Invertebrates
- Dragon Fly Ditch Invertebrates
- Vegetation Communities
- Wintering Wildfowl
- Breeding Birds
- Wetland Ecosystem Services





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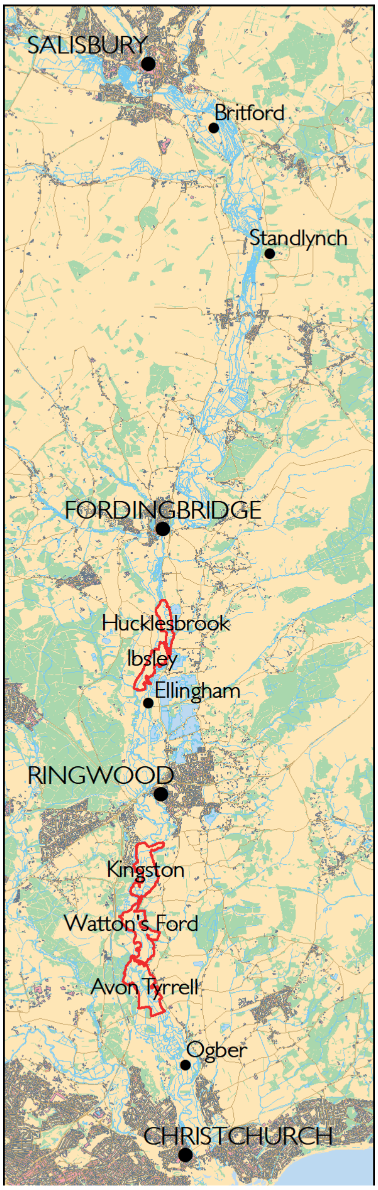
LIFE Waders for Real



Map of the Avon Valley: Salisbury down to Christchurch.

Introduction

The Avon Valley (see map, left) has historically supported nationally important populations of breeding waders. However, in common with other lowland wet grassland sites throughout Britain, numbers of breeding waders in the valley have fallen dramatically since the early 1980s, with declines of 64% in lapwing, 75% in redshank and 97% in snipe. The valley is also designated for its wide range of habitats, an outstanding diversity of plants including several nationally rare species and many invertebrate species including dragonflies, grasshoppers and snails.

Throughout the Waders for Real project, surveys of other species characteristic of floodplain habitats have been carried out to understand any positive or negative impacts of the project's actions. The project aimed to increase breeding wader success in the Avon Valley floodplain through habitat restoration, non-lethal predator control, and stakeholder liaison, providing advice on meadow management, predator control and other general ecological issues where requested.

The implementation of habitat work throughout the project included re-establishment of existing ditches, and the creation of new in field wet features such as scrapes, with the aim of increasing more favourable nest and chick rearing habitat. Temporary electric fences were deployed, in areas of suitable habitat where lapwing pairs were likely to breed or had bred in previous seasons, to exclude ground predators. Liaison with land managers and farmers ensured grazing of vegetation was timed correctly to produce the correct sward conditions when the spring nesting season arrived. Water levels were not managed on sites due to restrictions of the SSSI designations, however one 'hotspot' site which is managed specifically for breeding waders, is authorised to manage water levels and this site was included in our data collection.

Under this part of the project, an assessment of the restoration of ecosystem functions was required, providing data to investigate the abundance of key groups of indicator taxa before and after the habitat improvement work was carried out by the project. This approach should provide greater insight into the impacts of the project in relation to effect on these other taxa, together with a discussion of the various ecosystem services linked to the project's actions.

A wet meadow of the Avon Valley before and after ditch re-profiling habitat works.

Terrestrial Invertebrates

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Introduction

The Invertebrate study, focusing on earthworm and carabid species, explores the relationships between invertebrate communities and environmental variables such as vegetation height, litter cover, bare ground and soil moisture. The study was carried out at 18 pairs of grazed pastures from 14 farms in 2018 and 18 pairs of grazed pastures from 12 farms in 2019 along the Avon Valley catchment area.

Pitfall traps and soil sampling were undertaken between 16th May 2018 and 25th June 2018 and 13th May 2019 and 14th June 2019 around 'wet features' of the fields including scrapes, depressions and ditches as well as 'dry' features in 'dry areas' of the field for comparison.

In all accounts, data analysis was achieved using RStudio (R Core Team, 2017). As seen below, earthworm, ground beetle and overall invertebrate abundances and diversity scores were analysed against a number of indices which represented field composition and structure. To ensure the main objective was achieved and there was a difference in moisture between the wet samples and dry samples the model took year and site into account to test for any yearly and in site differences alongside paired t-tests used for the soil moisture values collected in 2018 and 2019. The Shapiro Wilk normality test was used to test for normality (Dytham, 2011). If data did not show normality, it was log-transformed prior to analysis to obtain the most accurate result.

Soil Sampling

Soil sampling allowed soil moisture values to be obtained for all the soil samples. Soil samples were 2mm sieved and air-dried over two days before 10g of soil was weighed out from each sample and placed in an oven to dry out. The weight of the oven-dried soil was recorded to determine soil moisture content. This data was used to see whether soil moisture levels affected any of the species.

Figure 1: Jess Grimbley, University of Reading setting pit-fall traps to link vegetation with invertebrate abundance.

Vegetation surveys

Vegetation surveys were undertaken along the catchment. Some of the fields fall into MG8 community of the British National Vegetation classification and these species were classed as positive indicator species with species representing lesser quality environment known as negative indicator species. Vegetation surveys were split into 10 sampling point and at each survey point, the percentage of bare ground, litter cover, vegetation height and the percentage cover of positive and negative indicators was measured. The surveys were carried out over wet and dry parts of each field by following a structed 'W Walk' between two pitfall traps. Fields were also classified into grazed or hayed the previous year before the study and their current management.

Percentage vegetation values were recorded for the positive and negative indicator species and converted into mean percentage values for the wet and dry parts of each field. Percentages were also added together to create an abundance value of the species for each field.

Ordination

Canonical constrained ordination (CCA) was used to analyse ordination data and involved analysing species occurring in >5% of the point counts. This method is constrained by the environmental variables of interest and relates the species composition directly to the environmental variables. As a result, a partial CCA was carried out with environmental variables used in the model chosen by forward selection and the ordistep function in R to build a suitable model

As highlighted discussed below, results were interpreted using permutation and revealed there were environmental variables that were influencing the composition of species in fields. These variables were different for earthworms and carabids with the invertebrate groups yielding no significant results. Some variation in the species composition of carabids was attributable to the environmental differences between fields. Forward selection identified wet and dry properties of the soil, litter cover, vegetation height and positive indicator species cover as significant factors explaining the composition of species. Moreover, forward selection identified wet and dry properties of the soil and the type of management on the fields as significantly influencing factors. However, some variation in the species composition of earthworms was attributable to the environmental differences between fields.

The results from ordination, soil sampling and vegetation surveys have been incorporated to form each species accounts, discussed below.

Earthworms

Earthworm sampling was achieved by collecting four soil blocks measuring 185mm x 185mm x 100mm from each field, two from wet features and two from the dry areas of each field. Earthworms were extracted from the soil samples and sorted into two groups 'clitellate' and 'pre-clitellate'. Clitellate individuals were adults and could be identified to species using a key to earthworms of Britain and Ireland by Sherlock (2012) whereas pre-clitellate individuals were juveniles and could not be identified to species level.

Analysis of the data included adding the number of species of earthworm for each of the wet and dry parts of each field. The Simpson Diversity Index was then devised from these values with the pre-clitellate worms removed from this step. Using Simpson's reciprocal index, a diversity score was given for wet and dry parts of the field. A generalised linear model (GLM) compared diversity scores and abundances against the mean percentage of bare ground and litter, the mean vegetation height (cm), the percentage of positive and negative indicator species, wet or dry properties of the fields and whether the fields had been grazed or hayed the year before and during the study. A minimum adequate model was designed using the standard stepwise multiple regression procedure to obtain the most accurate results (Heinze, Wallisch, Dunkler, 2018).

Within soil samples, a total of 1152 earthworms (615 juveniles) were recorded in 2018 and 982 earthworms (268 juveniles) in 2019 demonstrating a significant difference in the number of adults and juveniles over the 2 years. During the two years, there was a higher number of adults in 2019 and the total number of species found was 16, compared to 12 species in 2018. Results show there were more earthworms found in wet areas in 2019, whereas in 2018 more were in dry areas possibly due to flooding in 2018. Furthermore, the model showed statistically significant relationships between earthworm abundance, year, the percentage of positive indicator species, species and the management of the field but no relationships between diversity, year and site as well as no correlations between earthworm abundance or diversity and litter cover. This suggests litter levels within the fields does not make a difference, but fields with a high percentage of positive indicator species can be more valuable in terms of supporting earthworm species and floral biodiversity.

Ground invertebrates

Ground invertebrates and carabid sampling used pitfall traps (77mm depth x 60mm diameter) placed 2 metres adjacent to the soil samples in both wet features and dry areas of the field. Scentless washing up liquid was diluted and poured into the traps, with an additional wire mesh fitted around the trap to prevent small mammals from falling in. Using the Carabidae of Britain and Ireland key by Luff (2007) ground beetles were identified to species with the rest of the invertebrates wet weighed before being counted and identified to order and family levels.

When analysing the invertebrate samples, individuals were sorted into order and family to represent ground-active invertebrates. The abundance of each group was recorded for each of the samples with each of these samples wet weighed to obtain an overall biomass. However, results highlight there were a wide range of surface-active invertebrates, representing a diverse community leading to a statistically significant relationship between invertebrate abundance, year, site, vegetation height and the wet and dry properties of the soil. The model also revealed a statistically significant relationship between invertebrate diversity, year, site, vegetation height and wet and dry properties of the soil as well as a statistically significant relationships between invertebrate biomass, site and vegetation height. These results highlight that humidity is generally a limiting factor for invertebrates as abundance decreased when soil moisture increased past a certain point, indicating a threshold effect. Additionally, invertebrate mass was higher when vegetation height was high. This indicates that denser, higher swards will support larger invertebrates that may be useful for a wader's diet.

When researching carabids, the abundance and number of species of ground beetles were added together for each of the wet and dry parts of each field. A Simpson's reciprocal index was calculated to determine the level of species diversity with diversity scores and abundances compared against the same environmental variables as previously. During the test, 8 pitfall traps were lost or altered by flooding or livestock so the mean abundance per site or per wet and dry area was calculated from the remaining traps on the fields. Carabid abundances and species diversity were recorded for each pitfall trap and soil sample, but the low abundances of carabids extracted in soil samples, lead to exclusion from analysis. However, results show a total of 1080 ground beetles were recorded over 15 sites in 2018 and 908 over 18 sites in 2019. These totals consisted of 47 species found in 2018 and 21 in 2019. The model showed statistically significant relationships between beetle abundance, site and bare ground cover and a statistically significant relationship between beetle diversity and year. Results encourage vegetation removal to increase ground-active invertebrates. However, removal or reduction as a conservation effort for waders will benefit these species but affect other important invertebrates for waders. Furthermore, when considering future management techniques for carabids, reducing emphasis on plant diversity and ensuring other conditions are being met is important due to the species' susceptibility to environmental composition.

Conclusion

Overall, this study has established that various environmental variables and conditions should be considered when planning conservation efforts in relation to waders to support the invertebrate community in the Avon valley. Particularly, vegetation height is important for most invertebrate orders as they prefer a denser, more structural sward. Additionally, this study also revealed that there are species-specific effects on invertebrates when it comes to environmental variables. This study also highlights the issues we face when considering species-specific conservation management techniques and how all species in a community are affected.

Aquatic Ditch Invertebrates

Dr *Clive Bealey, Sophie Brown, Ellie Ness*

Introduction

Aquatic invertebrate monitoring was instigated under the LIFE project target deliverables D2 and D4 Assessment of restoration of ecosystem functions. Under this part of the project, an ecosystem services assessment for the project was seen as beneficial providing data to investigate the abundance of key groups of indicator taxa before and after the habitat improvement work carried out by the project. Specifically, following the creation of more wetland habitat, monitoring of aquatic inverts might reveal how requirements of waders and invertebrates can be balanced with appropriate management.

The aim of this sub-project was to assess the importance of aquatic invertebrate species and populations across selected sites and to analyse the habitat requirements of species present.

Methods

The method was chosen to record aquatic invertebrate numbers at ditches and rivers on four main sites along with vegetation and other physical attributes. These were related to background environment and water body management (e.g. clearance and reprofiling regimes). The monitoring method was based on that developed by BugLife (Palmer *et al*, 2013; **https://cdn.buglife.org.uk/2019/07/2013Manual.pdf**).

26 ditch and 6 river sections were selected for the study across four focal sites: Avon Tyrell North, Hucklesbrook, Kingston and Watton's Ford. Timed sweep net samples were taken from each ditch.

Detailed aquatic invertebrate survey

Sampling was carried out over a 3-minute period along a 20m representative section, using a standard method (taken from the Buglife guidance-Palmer *et al*, 2013).

Each sample is taken by netting the ditch vegetation using short jabbing thrusts in dense emergents and raft-forming plants and occasional longer strokes into submerged plants in deeper water. The surveyor moves along the bank as the netting proceeds, selecting patches of vegetation that exhibit the greatest small-scale mosaic structure, since these patches seems to yield more specimens. An initial sorting of invertebrates and vegetation/debris on the bank was carried out, using a large white tray. A wash bottle containing water was used to release smaller specimens from the net. Large specimens were collected using a small 'tea strainer' and placed directly into a sample tube while the smaller ones were left in the tray while the water was siphoned off until only the invertebrates were left. The invertebrates were then transferred to a labelled sample bottle containing 70% alcohol to be preserved and taken back to the laboratory for identification. Large beetles will pull apart and eat soft animals in the sample unless they die quickly, so were preserved separately.

Two surveys were carried out, in June 2017 and June 2018. Samples were stored in the laboratory and specimens were systematically identified to species, where possible, but at least to Family level. Identification was aided by the Freshwater Biology Association Guide to Freshwater Invertebrates (Dobson *et al*, 2012) and the Aquatic Insects of North Europe (Nilsson, 1996). Numbers of specimens were also counted.

Vegetation

Ditches and surrounding habitat were divided into three sub-habitats: 1. Aquatic (the main, underwater part of the water body); 2. Emergent (the vegetation above the water body but rooted in it), and; 3. Bank (the terrestrial part of the ditch or river bank). Main vascular plant species rooted within the sub-habitats were recorded with an estimate of their cover-abundance using a DAFOR (D-dominant, A-abundant, F-frequent, O-occasional and R-rare) scale. Records were also made of the cover of bare ground and litter (both viewed vertically through the live vegetation), and percentage cover of the following amalgamated groups: bryophytes, grasses.

The vegetation height at the centre of each of the sub-habitats was recorded using a 1m ruler at 10 sample points. This was carried out in August when vegetation was assumed to be at its maximum. The proportion (%) of open water over the entire ditch section was also estimated.

Ditch/river profiles and aquatic chemistry

Detailed recording of physical and aquatic chemistry attributes were undertaken in June.

Water chemistry

Five samples were collected from each of the ditch/river sections at approximately 25m intervals over a representative section. A water sample was collected using either a hand-held bottle or one attached to a pole. Samples were amalgamated for analysis. Sample bottles were marked with a ditch identifier and date. Conductivity and pH were measured on a sub-sample in the field using a portable meter. The following attributes were recorded:

- Water and silt depth, conductivity, pH, turbidity, water colour, flow of main water body

Physical attributes

The following physical attributes were also recorded at each sample point:

- Width of water body, width between bank tops, freeboard (distance from water surface to bank top), bank slope, profile under water, silt depth under water.

Data analysis

Aquatic invertebrate counts at each section were used as uncorrected totals as the length of each sample section was standardised. Several indices were calculated for each ditch or river section using the sample counts, these were a) Species richness (total number of species), b) Simpson's diversity index, c) Biological Monitoring Working Party (BMWP) score and d) Average Score Per Taxon (ASPT) score. The BMWP score is a procedure for measuring water quality using families of macroinvertebrates as biological indicators (Hakes, 1998) and can range from 0 to over 150. A higher BMWP score is considered to reflect a better water quality. The ASPT score equals the average of the tolerance scores of all macroinvertebrate families found, and ranges from 0 to 10. The main difference between both indices is that ASPT does not depend on the family richness. Simpson's diversity index is calculated by the formula:

$$D = 1 - (\Sigma(n/N)^2)$$

Where n = the total number of organisms of a particular species and N = the total number of organisms of all species.

For statistical tests, data were initially tested for normality. Where distributions were non-normal, transformations were applied (logarithmic, square root or arcsine square root for percentages) before applying statistical tests.

In order to determine overall relationships between the indices and water body characteristics, Generalized Linear Models (GLM) were performed using normal models and an identity link.

The 2017 data only were used for this analysis as it was the year when baseline ditch/river water chemistry and physical properties were recorded.

Owing to the large number of environmental variables recorded in the field, groups of variables were allocated to a) baseline ditch/river water chemistry, b) ditch physical properties and c) in-ditch vegetation and reduced to single variables by Principal Components Analysis (PCA) for water chemistry and physical properties and Detrended Correspondence Analysis (DCA) for the in-ditch vegetation. Several variables were excluded from the water chemistry and physical properties groups as the relatively small number samples would otherwise have caused statistical anomalies. For water chemistry, total N (Nitrate) was strongly correlated with both conductivity and pH so combinatory variables were created using the product of the values. Vegetation DAFOR records were re-coded to cover-abundance values (1-5) for this analysis. Only the first PCA/DCA axis values were used as these explained the most variation in the data. These three variables were subsequently used to explain aquatic invertebrate habitat selection. Detrended Correspondence Analysis was perfomed using CANOCO 4.5 (ter Braak & Smilauer, 2002) and Principal Components Analysis was performed using Genstat v19.

Results

A total of 32 transects were surveyed each year over the period 2017-18, although it was not always possible to carry out some individual surveys due either to excessive flooding or dry conditions resulting in no water being present in the ditch. At the time of reporting, only samples from 2017 have been fully identified and quantified.

Aquatic invertebrate populations 2017

A total of 126 species or representatives of unique taxonomic groups were recorded across the four sites. Two ditches were totally dry so sampling of invertebrates and water for chemical analysis was not possible. These ditches have been excluded from the analyses.

For ditches only, Kingston had both the highest mean species richness (21.714) and BWMP score (79). Avon Tyrell North had the lowest mean value for both species richness (12.667) and BWMP score (41.833). Clearly the complete lack of invertebrates in one ditch on Avon Tyrell North and the second lowest count of 9 contributed to this. For the rivers, the species richness tends to be high and Avon Tyrell North had the highest BWMP score of 126 but a number of the ditches showed higher biodiversity indices.

The PCA analysis of water chemistry resulted in axis 1 scores which are strongly negatively related to increasing values for total N, pH and conductivity, while the PCA analysis of physical properties resulted in axis 1 scores positively related to increasing values for size and shape of water body but negatively to silt depth. The DCA analysis of aquatic and emergent vegetation resulted in axis 1 scores relating to species associated with deeper and wider ditches towards the positive score end and shallow, smaller ditches towards the negative end.

The results of the GLMs showed that **species richness** was significantly related to the vegetation DCA score (t-value = -5.94, P <0.001); **BMWP score** was significantly related to Water chemistry PCA score (t-value = -3.53, P <0.001), Physical properties PCA score (t-value = 37.75, P <0.001) and the vegetation DCA score (t-value = -10.45, P <0.001); **ASPT score** was significantly related to to Water chemistry PCA score (t-value = -2.66, P = 0.008) and Physical properties PCA score (t-value = -2.08, P = 0.038).

Owing to the non-normal distribution of the **Simpson's Diversity Index**, Spearman rank correlation coefficients between this and the environmental variables were performed. The results showed that Simpson's Index was significantly related to the water chemistry PCA score only (rs = -0.423, P = 0.005).

Habitat preferences of the aquatic invertebrate fauna

Species richness was only influenced by vegetation score. Primary axis DCA scores for vegetation reflected a trend from high richness for low scores to low richness for high scores. This indicates that invertebrate richness was higher where vegetation of ditches that were shallower and narrower with a smaller water volume were present. Whether this in turn, reflects other factors such as ditch age (since management) and vegetation species diversity might well have influenced the number of aquatic species.

Species diversity seems to be only related to water chemistry, with increasing diversity associated with increasing nitrate levels, pH and conductivity. The more calcareous water bodies carrying a greater nutrient load are probably more productive in a trophic sense with increasing niches available for producers (plants) through consumers (herbivorous invertebrates) to higher level consumers (carnivores). The relative influence of each chemical element on this system is difficult to assess (Shaw et al, 2015).

BMWP scores are strongly related to water chemistry, with increasing scores associated with increasing nitrate levels, pH and conductivity, physical properties, with increasing scores associated with increasing size of water body and vegetation, with increasing scores associated with species of larger water bodies-particularly wider and deeper ditches. This seems to suggest that such water bodies contain higher quality water which is defined as being less polluted, high available oxygen content and elements of naturally occurring vegetation communities.

ASPT scores, although having the same relationship with water chemistry, shows a weak but significant opposite relationship with physical properties, suggesting that once the influence of high-scoring families are reduced, the physical properties of smaller ditches become important.

Discussion

Much of the variation in aquatic invertebrate species and populations across the sites can be explained by changes in the water chemistry. The negative relationships shown by the BMWP, ASPT and diversity indices indicate that these values increase as the total N, pH and conductivity values increase (the PCA is strongly negatively related to increasing values for total N, pH and conductivity). In other words, the more calcareous but productive water bodies appear to carry more of the aquatic invertebrate diversity.

However, water body physical properties, in this case, increasing size of water body as explained by the PCA, also contributes to aquatic invertebrate 'quality' as measured by the BMWP score which is considered to reflect better water quality. The traditional management of both water bodies and aquatic, emergent and bankside vegetation need to be maintained for this and many other species.

Advice on ditch management is available from both Countryside Stewardship and, probably the most applied from Buglife h**ttps://cdn.buglife.org.uk/2019/08/Ditches-management-leaflet-Buglife.pdf**. Advice on frequency of management is difficult to find but a cycle of 5-10 years appears to be optimum. However, it's probably the sensitivity of the management process which is most important and these are laid out in the above advice, summarized in Appendix 3. Management for breeding waders would be totally compatible with good management for aquatic invertebrates if the guidance is followed. For example, producing gently sloping (30-45 degrees) banks with areas of bare sediment that are accessible to grazing stock is a specific recommendation for aquatic invertebrates and aligns well with good management for producing feeding edge habitat for both adult and juvenile waders.

In general, Countryside Stewardship grants are available for management and improvement of water bodies including **WT3:** Management of ditches of high environmental value is available for Mid Tier and Higher Tier on ditches of high environmental value and ditches essential for the management of important aquatic biodiversity. There are also options around these including: **GS9-12** – Several options for the management of wet grassland for wintering and breeding waterfowl, and **WT6-9** – Several options for the management and creation of wet habitats. Well-designed combinations of terrestrial, seasonal wet features and semi- and fully aquatic habitats should be clearly agreed in consultation with experts and, where appropriate, statutory agencies, and set out in site management plans.

Clearly, the aquatic fauna of the Avon Valley is of significant importance and forms part of the invertebrate assemblage for which both the river and wider water meadow system are designated as SSSI and SAC. Continued research and monitoring of this fauna and associated habitats should be considered as high priority.

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Ditch Invertebrates – Dragonflies & damselflies

Dr *Clive Bealey, Ryan Burrell, Dr Andrew Hoodless, Tom Weston*

Introduction

Dragonfly & damselfly (Odonata) monitoring was instigated under the LIFE project target deliverables D.4 Assessment of restoration of ecosystem functions. Under this part of the project, an ecosystem functions assessment for the project was seen as beneficial providing data to investigate the abundance of key groups of indicator taxa before and after the habitat improvement work carried out by the project. Specifically, following the creation of more wetland habitat, monitoring of dragonflies and damselflies might reveal how requirements of waders and invertebrates can be balanced with appropriate management.

The aim of this sub-project was to monitor population changes over the life of the project and to analyse the habitat requirements of species present.

Detailed dragonfly & damselfly monitoring

The method was chosen to record dragonfly & damselfly numbers at ditches and rivers on four main sites plus vegetation and other physical attributes of the ditches and rivers and related to background environment and water body management (e.g. clearance and reprofiling regimes).

The monitoring method was based on that developed by the British Dragonfly Society **https://british-dragonflies.org.uk/recording/monitoring/**

A transect survey method was used which consists of walking along a set route and recording species and numbers. This is the best methodology when recording along linear waterbodies, such as rivers or canals. Standardised sampling was employed, with dragonflies and damselflies recorded up to 2m inland from the transect line and up to 5m metres over the water. The majority of transects followed the edges of ditches, which were typically less than 5m wide and, hence, the whole width was assessed. For river edge sections, animals were counted out to 5m over the water surface.

Four surveys were carried out: Late May-early June, early July, early August and early September over 2016-19.

Vegetation recording

Ditches and surrounding habitat were divided in to three sub-habitats: 1. Aquatic (the main, underwater part of the water body); 2. Emergent (the vegetation above the water body but rooted in it), and; 3. Bank (the terrestrial part of the ditch or river bank). Main vascular plant species rooted within the sub-habitats were recorded with an estimate of their cover-abundance using a DAFOR (D-dominant, A-abundant, F-frequent, O-occasional and R-rare) scale. Records were also made of the cover of bare ground and litter (both viewed vertically through the live vegetation), and percentage cover of the following amalgamated groups: bryophytes, grasses.

The vegetation height at the centre of each of the sub-habitats was recorded using a 1m ruler at 10 sample points. This was only carried out during the third (August) survey when vegetation was assumed to be at its maximum.

The proportion (%) of open water over the entire ditch section was also estimated.

Ditch/river profiles and aquatic chemistry

In 2017 and 2018, detailed recording of physical and aquatic chemistry attributes were also recorded in mid-season.

Water chemistry

Five samples were collected from each of the ditch/river sections at approximately 25m intervals over a representative section. A water sample was collected using either a hand-held bottle or one attached to a pole. Samples were amalgamated for analysis. Sample bottles were marked with a ditch identifier and date.

Conductivity and pH were measured on a sub-sample in the field using a portable meter. The following attributes were recorded:

- Water and silt depth, conductivity, pH, turbidity, water colour, flow of main water body

Physical attributes

The following physical attributes were also recorded at each sample point:

- Width of water body, width between bank tops, freeboard (distance from water surface to bank top), bank slope, profile under water, silt depth under water.

Data analysis

Dragonfly & damselfly counts at each section were combined over the four sample periods to provide a total annual count. Where comparisons between sections were required, these totals were standardised to counts per 100m by correcting for the length of the sample section.

For statistical tests, data were initially tested for normality. Where distributions were non-normal, transformations were applied (logarithmic, square root or arcsine square root for percentages) before applying statistical tests.

The relationships between species composition and environmental variables were explored using Canonical Correspondence Analysis (CCA) CANOCO 4.5 (ter Braak & Smilauer, 2002), in which the environmental variables can be directly correlated with the main axes of the ordination diagram. The 2017 data only were used for this analysis as it was the year when baseline ditch/river water chemistry and physical properties were recorded.

Owing to the large number of variables recorded in the field, groups of variables were allocated to a) baseline ditch/river water chemistry, b) ditch physical properties and c) in-ditch vegetation and reduced to single variables by Principal Components Analysis (PCA) for water chemistry and physical properties and Detrended Correspondence Analysis (DCA) for the in-ditch vegetation. Vegetation DAFOR records were re-coded to cover-abundance values (1-5) for this analysis. Only the first PCA/DCA axis values were used as these explained the most variation in the data. These three variables were subsequently used to explain dragonfly & damselfly habitat selection.

Results

A total of 32 transects were surveyed each year over the period 2016-19, although it was not always possible to carry out some individual surveys due either to excessive flooding or dry conditions resulting in no water being present in the ditch.

Change in dragonfly & damselfly populations 2016-19

A total of 25 species were recorded across the four sites. Three species were excluded from the analyses due to single or very few occurrences. These were Lesser emperor *Anax parthenope*, Downy emerald *Cordulia aenea* and Ruddy darter *Sympetrum sanguineum.*

Of particular note were: the consistent high counts for the banded demoiselle *Calopteryx splendens*, (Figure 1), the sudden decline (between 2018 and 20-19) of the emerald damselfly *Lestes sponsa* and the consistent increase in both the small red damselfly *Ceriagrion tenellum* and the four-spotted chaser *Libellula quadrimaculata* (Figure2). There also seemed to be a contrast in fortunes for the two common blue damselflies, the azure damselfly *Coenagrion puella* (steady decline) and the common blue damselfly *Enellagma cyathigerum* (steady increase). For several species, changes can be at least partly be explained by the differences in background climate within each year. The particularly dry summer of 2018 was preceded by a dry winter and the early summer of 2017 was also unusually dry and this would have affected both the emergence rates of adults from larvae but also the opportunities for successful egg-laying. This and intervening flooding events may explain sudden changes in several of the commoner species including blue-tailed *Ischnura elegans* and large red *Pyrrhosoma nymphula* damselflies.

Some of the changes in other species can be explained by ditch maintenance work (deepening and reprofiling) which is carried out on a regular 5-10 -year cycle and effectively rejuvenates the water body. This creates opportunities for some of the species associated with 'new' habitats and who are good colonisers, including the four-spotted chaser. However, this species and the small red damselfly, are strongly associated with more heathland habitats and their increase in 2019 is almost entirely due to their presence at the heathland edge ditches at Avon Tyrell North.

The emerald damselfly is also strongly biased towards one site, (Kingston), where ditch maintenance in the winter of 2018-19 caused a large release of nutrients resulting in algal blooms which choked the channels of the smaller ditches. This and the possible destruction of over-wintering eggs and larvae clearly caused a sudden decline in adults but will hopefully recover over the next few years.

The contrast in fortunes for the two common blue damselflies, the azure damselfly and the common blue damselfly can also be explained by the rolling out of ditch maintenance work under the LIFE project. This has generally opened up many of the smaller, well-vegetated ditches favoured by the azure damselfly which has resulted in its decline, while providing colonising opportunities for the common blue damselfly which favours a wider range of more open water bodies.

Habitat preferences of the dragonfly & damselfly fauna

Multivariate analysis of species' indices and environmental/vegetation variables showed that species scores were widely spread along both CCA axes. The first axis is mainly one explained by water chemistry (a combination of nitrate concentration, acidity (pH) and conductivity), while the second axis is mainly explained by variations in both physical properties (size and shape of water body) and the type of vegetation present as aquatics and emergent plants. The two axes together explain 87% per cent of the species-environment relationship, which is statistically significant ($F = 2.661$, $P = 0.002$).

The CCA site scores showed a gradient from the slow-flowing (or zero flow), relatively acidic water bodies on the left side of the ordination to the faster-flowing, relatively calcareous (high pH) water bodies on the right side. The highest scoring sites on the right side of the ordination were the most calcareous water bodies (pH >9) and the rivers which were all pH >8.5 and those with low nitrate levels. The sites with the lowest pH values in the range 5.5-6.7, i.e. fairly acidic also had low scores on axis 1 and included Avon Tyrell North ditch 4 which contained an acid mire plant community.

Summary

The monitoring programme established under the LIFE project in the Avon Valley appears to be one that is robust enough to a) Detect population changes across a number of the more common species over time and b) Provide information on habitat requirements of both the common, ubiquitous species but also the rarer habitat specialists. Two species are of particular interest in the latter respect: the small red damselfly *Ceriagrion tenellum* which has a national conservation status of **Notable B** and the scarce chaser *Libellula fulva* which has a national conservation status of **Near Threatened**. While the former species probably owes its presence to the proximity of high-quality lowland heathland habitat, the latter species is entirely dependent on the lowland river valley systems which are its stronghold (Smallshire & Swash, 2014). The traditional management of both water bodies and aquatic, emergent and bankside vegetation are needed to be maintained for this and many other species.

Population changes over the four- year monitoring period can partly be explained by the vagaries of the weather,- particularly flooding and drought events, but ditch and riverbank management programmes will also have had a major influence. Given that the larval development phase is usually two years but ranges from 2-3 months in the case of the emerald damselfly *Lestes sponsa* to more than five years in the golden-ringed dragonfly *Cordulegaster boltonii*, the factors affecting the population of adults are many and complicated and generally poorly known for all but the most common species.

Clearly, the Odonata fauna of the Avon Valley is of significant importance and forms part of the aquatic invertebrate assemblage for which both the river and wider water meadow system are designated as SSSI and SAC. Continued research and monitoring of this fauna and associated habitats should be considered a high priority.

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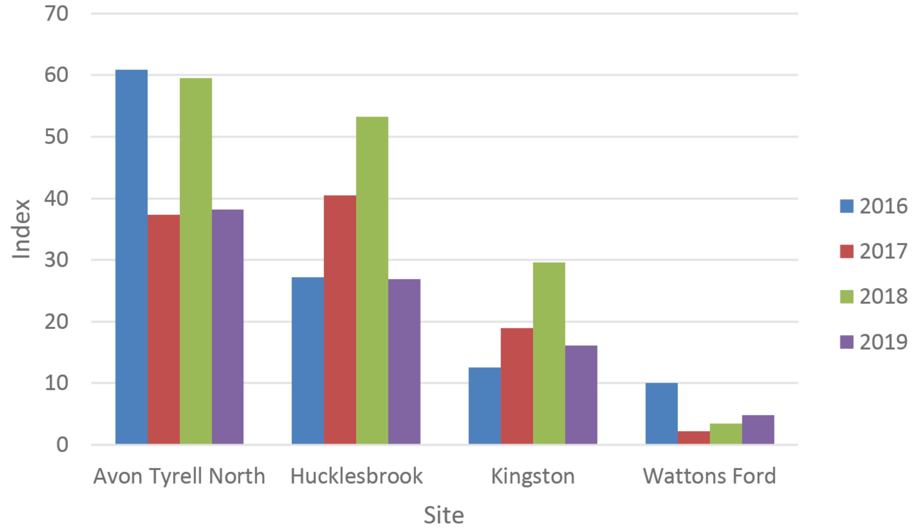

Figure 1: Adjusted counts (total index 100m^{-1}) of Banded damselfly *Calopteryx splendens.*

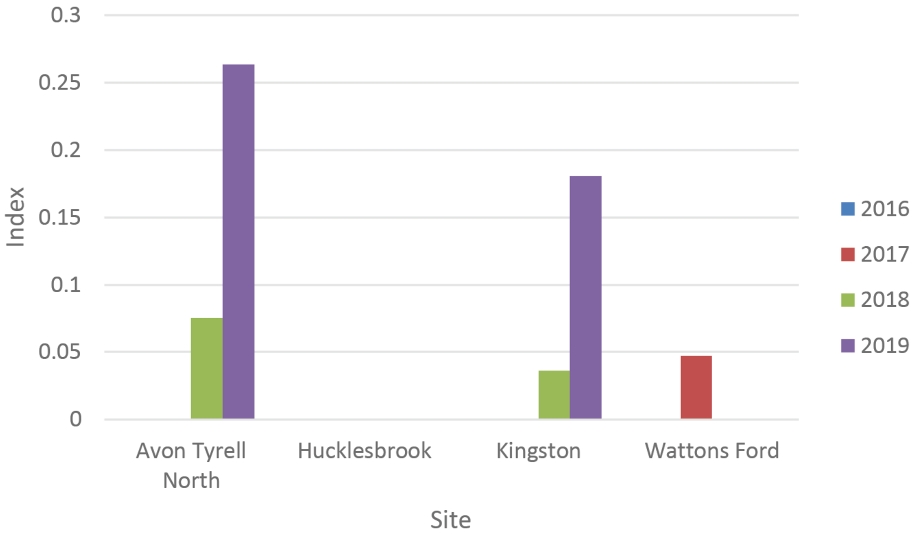

Figure 2: Adjusted counts (total index 100m^{-1}) of Four-spotted chaser *Libellula quadrimaculata*

Vegetation Communities

Dr *Clive Bealey*

Introduction

Vegetation monitoring was instigated under the LIFE project target deliverables D.4 Assessment of restoration of ecosystem functions. Under this part of the project, an ecosystem services function for the project was seen as beneficial providing data to investigate the abundance and quality of key groups of indicator taxa before and after the habitat improvement work carried out by the project. This approach should provide greater insight into the impacts of the project in relation to these other taxa, alongside a discussion of the ecosystem services provided affected by the project's actions. Specifically, following the creation of more wetland habitat, monitoring of vegetation might reveal how requirements of waders and invertebrates can be balanced with appropriate management.

Background

Over the past 25 years, the GWCT has documented a 70% decline in numbers of breeding lapwing and an 83% decline in breeding redshank in the Avon Valley. Our monitoring has provided evidence that the lapwing decline is driven by poor breeding success. The EU LIFE+ Waders for Real project was launched in 2014 with the aim of halting these declines and reversing them. Our approach is to create strategic hotspots of optimum habitat with reduced predation pressure, where the birds are able to fledge sufficient chicks to increase recruitment to the population in subsequent years.

Vegetation monitoring was instigated as one of the LIFE project target deliverables to document changes in habitat stability and restoration of ecosystem functions. Two methods of assessing vegetation composition and change were used:

1. Detailed recording using a fixed quadrat method;
2. Surveys based on the Common Standards Monitoring (CSM) Methodology ("Quality assessment").

Figure 1: Good indicators species: Marsh Marigold, with its bright yellow flowers and dark, kidney shaped shiny leaves.

This two-pronged approach will give us information on gradual change in botanical communities as well as information on the 'quality' of the vegetation, i.e. whether it is of SSSI (high) or sub-SSSI (low) quality. This information is important as we believe that breeding waders need a variety of micro-habitats that provide different elements during their breeding cycle. For example, Lapwing prefer areas of bare ground for nesting but these need to be close to wet depressions (pools or shallow ditches) that remain wet or damp during the chick fledgling stage. There is a link between habitat and nest protection, chick safety (hiding places) and also invertebrate prey availability which is key throughout the entire chick growth phase. Additionally, a key deliverable under the LIFE project is the restoration of ecosystem functions which clearly includes habitat.

Results

Vascular plant species records from the detailed recording were converted to Ellenberg values which assigns a value to the position of their realized ecological niche along an environmental gradient. Ellenberg soil moisture, fertility and acidity (pH) values were used. Competitor, Stress tolerator and Ruderal (C-S-R) characterisation were also calculated (Grime 1979). These are collectively known as ecological indicators.

Project start and end year data were compared, and comparisons were also made between management and conservation 'status'. The most striking differences were between grazed and hayed fields as shown in Figure 1. This difference is statistically highly significant. This can be explained by the management where more intensive cattle grazing throughout the spring to autumn period and a past history of applying fertilizer to some fields to 'improve' them has increased the soil fertility. A reduction in fertility particularly on the grazed fields may be a continuation of a trend detected in the mid-2000s due to agri-environment prescriptions.

Occurrences of positive indicator species, as selected by Natural England for their CSM programme, were converted to a single cover-abundance value-a Quality Score (QS), for each field. Data were available from two pre-LIFE programme surveys and two recent ones. Analysis showed a gradual increase in QS over a 10 year period (Figure 2), with hayed fields showing a consistently higher score compared to grazed ones. This difference is also highly statistically significant. Hayed fields, although more prone to seasonal inundation, are closer to the river and therefore tend to be those containing larger proportions of SSSI quality grassland. These also tend to be more resilient to drastic change when prolonged flooding occurs as they consist of wet-adapted species. In contrast, the grazed fields consist of improved vegetation which can die off or even be scoured out under flooding and therefore take a longer time to recover. This would explain the larger difference in 2017 which was only 4 years after the 2012-13 major flooding event.

This work will feed into analysis of data on wader breeding location, success and habitat use and also with research into the possible link between habitat 'quality' and vital invertebrate food sources, particularly at the chick stage.

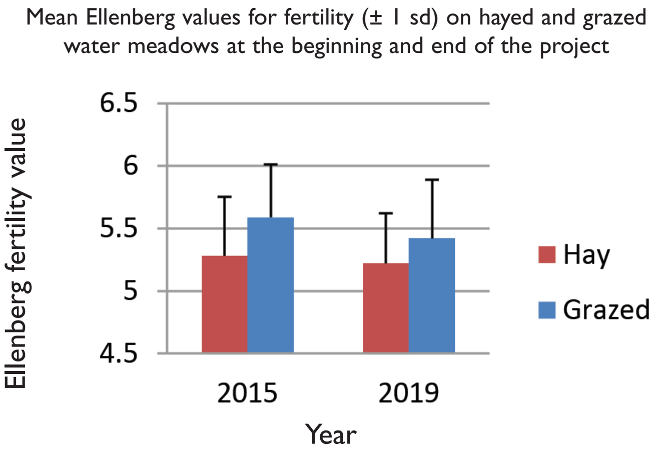

Figure 1: Mean Ellenberg values for fertility (± 1 sd) on hayed and grazed water meadows at the beginning and end of the project

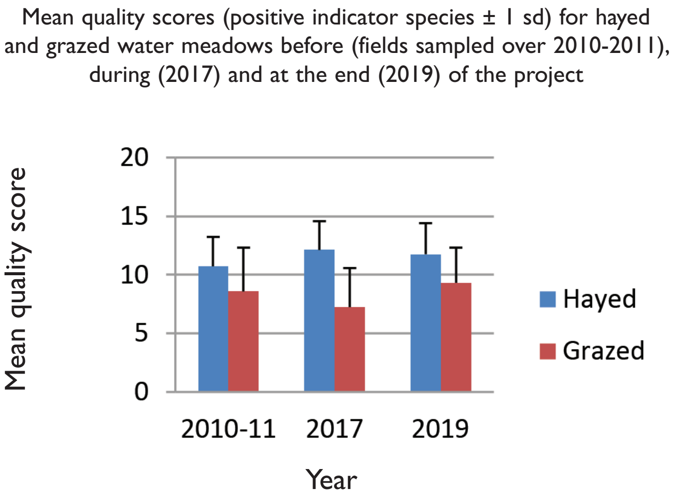

Figure 2: Quality scores (positive indicator species) for hayed and grazed water meadows before, during and at the end of the project

Winter Wildfowl Counts 2015 – 2019

Thomas Weston, Dr Clive Bealey, Lizzie Grayshon, Jodie Case, Ryan Burrell

Introduction

Throughout the Avon Valley, winter wildfowl surveys have been undertaken between 2015-2019 during December, January and February at twenty-one sites, five of which are 'hotspot' sites. The survey involves entering and walking through each field in each site, in a 'W' shape to allow a large area of the field to be covered. This procedure allows more cryptic species such as Snipe *Gallinago gallinago* to be detected, alongside other wildfowl species, and allows the river and riverbanks to be viewed. Birds are recorded on survey sheets using British Trust for Ornithology (BTO) bird codes, recording the number and location of each bird present. Data from survey sheets is inputted into a database soon after the survey. Observers avoid double counting individuals by recording where birds land and which direction they are flying. In the event of flooding, when fields are inaccessible, surveys are done from access points using a scope to get a full view of the fields. If the fields are completely inaccessible, the fields are noted as not surveyed.

During this report, the term 'wildfowl' and 'hotspot sites' will be used. Wildfowl refers to all 28 species of ducks, swans, geese, rails, waders, cormorants, herons and allies noted whilst surveying. Gulls have been omitted from the report due to the mobility of these species and the time of day varying the number of gulls being noted, especially with Blashford Lakes nature reserve hosting a large winter gull roost. Hotspot sites refer to Watton's Ford, Avon Tyrell North, Hucklesbrook, Kingston and Ogber and the other sixteen sites surveyed are referred to as non-hotspot sites.

Rainfall

During the 2015-2019 period, winter (November to March) rainfall was recorded at the Bisterne estate in the Southern section of the Avon Valley. Results show high rainfall was recorded in 2015-2016 (500mm) followed by two winters of lower rainfall (341mm and 443mm).

Figure 1: Mixed flock of Eurasian Wigeon Anas penelope and Common Teal Anas crecca using the Avon Valley's wet meadows. Photo: Andrew Carter

Ducks

In the Avon Valley, ten species of ducks have been recorded in the winter wildfowl surveys between 2015 and 2019. The following sections break up duck species into 'resident' and 'wintering'.

Mallard *Anas platyrhynchos* increased throughout the 2015-2019 period with records in every winter wildfowl season. Peak counts have all occurred in December followed by a decrease into January and February, except for January 2016 and February 2017. In contrast, Gadwall *Anas strepera* sustained a small, increasing wintering population currently totalling twenty-five birds. This species may be susceptible to cold weather as February 2018 was the only month no birds were recorded, coinciding with below freezing temperatures. Another species on the increase, the Goosander *Mergus merganser*, has been recorded on every site within the valley. The highest totals have all occurred in January/February, coinciding with large winter roosts of presumably continental birds that form at Blashford Lakes Nature reserve, in the centre of the study area. On the other hand, Tufted duck *Aythya fuligula*, has been recorded at six sites, one hotspot and five non-hotspots, with the single hotspot site alone hosting 60% of these records. Peak counts have all occurred in February, apart from winter 2015-2016, when widespread flooding and presumably high flow rate within the river channel affected feeding. Lastly, Mandarin duck *Aix galericulata* has been recorded once, whereby five were seen at a non-hotspot site in December 2018 but this species has increased locally.

High rainfall totals in winter 2015-2016 suited winter duck species. Eurasian Wigeon *Anas Penelope* peaked in winter 2015-2016 whereby 1015 were noted in January 2016 and 1230 in February 2016. Since this peak, winter totals have peaked between 200 and 575 birds with totals being higher at Hotspot sites in all surveyed months except January 2017 and February 2019. Similarly, Common Teal *Anas crecca* records peaked in winter 2015-2016 with 836 and 1136 birds seen in January and February 2016 respectively, followed by winter peak totals of 50-210 individuals in subsequent years. Likewise, Shelduck *Tadorna tadorna* peaked in winter 2015-2016 and has been recorded ten times in the surveys with more seen on hotspot sites compared to non-hotspot sites. This is the same for Northern Pintail *Anas acuta* peaking at 157 birds in winter 2015-2016 but seen in single figures in the following winters with more records from hotspot sites than non-hotspot. Northern Shoveler *Anas clypeata* were recorded five times totalling 44 birds. Peak counts were recorded during winter 2015-2016 when 42 birds were observed.

Figure 2: Boggy areas of mud with tussocky grass

Swans

Mute swan *Cygnus olor* are resident in the Avon valley utilising the wet meadows for grazing in the winter. Overall totals show an increase in this species from 2015-2019 with December totals increasing the most dramatically within the valley peaking at 399 in December 2018.

Geese

Canada goose *Branta canadensis* and Egyptian goose *Alopochen aegyptiaca* are resident, self-sustaining non-native species in the Avon Valley with the latter originating from feral populations. *B. canadensis* have increased between 2015-2019 with fluctuations in numbers presumably caused by shooting activities or local movements between feeding sites. In contrast, *A. aegyptiaca* has slightly declined throughout the valley even though numbers within the county increased. Greylag geese *Anser anser* are a resident species with most birds originating from feral/released birds as a result of shooting activities. Numbers fluctuated throughout the winter surveys with maximum flock size varying between 120-170 birds each season.

Figure 3: Snipe probing holes

Waders

Nine species of wader have been recorded on the Avon valley winter wildfowl surveys. Common Snipe *Gallinago gallinago*, have increased from 72 birds in winter 2015-2016 to 536 birds in winter 2018-2019 possibly due to wet, mild winters and lots of suitable habitat available. In contrast, Jack Snipe *Lymnocryptes minimus* have been recorded five times (six birds) at five sites. This is probably an underestimate due to the secretive nature of the species. Green sandpiper *Tringa ochropus* totals fluctuate each winter with birds usually found singly. However, 80% of counts above one have occurred on hotspot sites with presumed site fidelity occurring. Similarly, five records of Common Sandpiper *Actitis hypoleucos* at three sites between 2015-2019 could relate to the same bird arriving in winter 2016/2017 and returning in winter 2017/2018 or three different individuals whereby two return to winter in the valley the subsequent year. Moreover, seventeen records of at least twenty-nine Curlew *Numenius arquata* have occurred at the southern four sites; one of these sites annually records six individuals in February, presumably involving a site faithful flock.

Oystercatchers *Haematopus ostralegus* depend on similar sites to N. arquata, with fourteen records of at least fifty-seven birds being recorded at the three southern sites, plus a hotspot site further north. The 2015-2016 flooding enabled peak counts of Black-tailed godwit *Limosa limosa* (5002) and Northern Lapwing *Vanellus vanellus* (2378) to be recorded in January/February 2016 with nationally important totals of the former recorded throughout that winter. However, drier winters subsequently lead to lower totals of both species overwintering, with numbers peaking at 153 and 712 respectively in subsequent years. In contrast, Common Redshank *Tringa tetanus* winter in low numbers (four birds annually) and were recorded eight times (11 birds) at four sites. Winter 2015-2016 was the only year no Common Redshank were recorded.

Figure 4: Natural in-field wet feature providing Snipe with feeding areas.

Rails

Coot *Fulica atra,* Moorhen *Gallinula chloropus* and Water rails *Rallus aquaticus* are resident within the Avon Valley. The winter of 2015-2016 saw 67 *F. atra* recorded, followed by peaks of 17, 7 and 40 in subsequent winters. In comparison, *G. chloropus* numbers have increased throughout the 2015-2019 winter period peaking 50 birds in December 2018 compared to 10 in January 2016. In contrast, due to the secretive nature of R. *aquaticus,* only three birds have been recorded at two sites, an underestimate of the overall population in the Avon Valley.

Herons and allies plus Cormorant

Little Egret *Egretta garzetta*, Grey heron *Ardea cinereal* and Cormorant *Phalacrocorax carbo* are resident whereas Great-white egret *Ardea alba* were first recorded in winter 2018-2019. E. garzetta peak counts have remained between 28-37 birds with individual site flocks peaking at 10 birds in winter 2017-2018 and 2018-2019. In comparison, *A. cinereal* have increased from 20 birds in December 2015 to 78 birds in December 2018 possibly due to breeding success within the three heronries in the valley. In contrast, *P. carbo* does not breed in the Avon Valley, but wintering birds presumably relate to *P. carbo sinensis*, the migratory subspecies, leading to max monthly counts ranging between 34 and 222 birds within the valley.

Summary

The standardised survey method for winter wildfowl surveys has allowed the surveys to be repeatable between 2015-2019. However, variation between site visits each month and each year may have led to total counts being over or underestimates due to counts based on max counts across the whole valley. This aside, it seems that rainfall and associated flooding largely influences the total numbers of winter wildfowl recorded. The wet, presumably mild winter of 2015/2016, which flooded the Avon Valley, attracted large numbers of ducks especially A. penelope, A. crecca, T. tadorna, A. clypeata, A. acuta as well as waders such as L. limosa and V. vanellus. The subsequent periods of lower rainfall seemed to encourage lower numbers of grazing ducks and waders to winter in the valley. Furthermore, it is assumed temperatures in continental Europe also influence Avon Valley wildfowl totals. If temperatures remain mild, wintering duck species are believed to be short stopping and won't cross the North Sea from areas such as the Netherlands or Germany .Whereas if persistent cold weather occurs winter wildfowl may move to areas with milder climates, like the Avon Valley

The improved habitat management in the valley, throughout this period, has provided pools and more extensive areas for wildfowl to feed and roost. Species such as G. gallinago seem to have increased with management with the wet 'in field' features such as scrapes and pools alongside ditches at different stages of maintenance has provided wildfowl, especially winter duck, safe roosting and feeding areas during the winter.

Figure 5: Camera traps show most of the in-field wet features created by the project have also been used by wintering waterfowl, often Teal.

Breeding Birds

Thomas Weston, Dr Clive Bealey, Lizzie Grayshon, Jodie Case, Ryan Burrell

Introduction

Between 2015 and 2019, bird surveys were undertaken at nineteen farms between March and July throughout the Avon Valley. These surveys were primarily undertaken to record Northern Lapwing *Vanellus vanellus* and Common Redshank *Tringa totanus* activity and pair numbers providing high amounts of data for waders within the Avon Valley. As a result, this report will focus on waterfowl and wetland songbirds breeding throughout the Avon Valley between this period.

Where possible 'full' site surveys were completed where waterfowl and songbirds were recorded alongside waders in every field across each site following the same route as the previous survey. If a full survey was unable to be completed, a partial survey was undertaken where certain fields were surveyed. If no survey was undertaken at a specific site in a given month, 'no data' was added to the analysis. As mentioned, survey effort has varied for songbirds and waterfowl monthly due to variations in the timing of surveys, survey type, observer effort and the frequency of visits in a month. This report takes the max counts from all the surveys undertaken at a site in each month and calculates an 'Avon Valley total' by combining all the max counts from other sites surveyed in the same month. Coverage therefore varies throughout the project and direct comparisons should be viewed with caution. Conclusions have been written with this in consideration.

Waterfowl

Geese

Canada geese *Branta canadensis* have been recorded breeding in the Avon Valley with creches of up to thirty-five birds noted. Survey results show numbers have increased in every month with the main peak for this species occurring in May. Moulting takes place in late June and July and begins with the non-breeders followed by breeding individuals. During this period, numbers within the valley decrease as birds depart to the closest known moult site at Blashford Lakes Nature Reserve situated alongside the valley study area.

Egyptian geese *Alopochen aegyptiaca* have been recorded breeding in the Avon Valley with broods emerging in March and April of up to nine goslings. Surveys show the population has remained relatively stable with Hampshire totals showing a county-wide increase in numbers. In the valley, peak totals occur in April and May before this species undertakes their annual moult within the Avon Valley.

Greylag geese *Anser anser* have been recorded breeding in the Avon Valley annually with broods primarily recorded in May. The sightings highlight a relatively stable population especially in April and May when birds are breeding. During the post-breeding period in June and July, when moulting occurs for this species, there is an increase in numbers. However, it is difficult to determine whether the increase is due to moulting adults remaining in the valley or increased breeding success and more juveniles remaining in the valley.

Figure 1: A Canada goose Branta canadensis nest found while surveying waders April 2015.

Ducks

Eurasian Wigeon *Anas penelope* are a wintering duck within the Avon Valley and do not breed in the Avon Valley or along the south coast. Due to the breeding bird surveys starting in March, the remaining wintering flocks are recorded as birds leave to their breeding grounds further north. As a result, April records are scarce with five birds being recorded in 2016 at two sites and four birds seen at a single site in 2017.

Similarly, to A. penelope, Northern Pintail *Anas acuta* are a wintering duck in the Avon Valley. There have been three records between 2015-2019 in the breeding bird season with one bird in April 2015, one bird in March 2016 and two birds in March 2019.

Eurasian Teal *Anas crecca* are primarily a wintering duck species in the Avon Valley with low numbers over summering in the years surveyed. Breeding has occurred in Hampshire in recent years. The highest numbers recorded in the surveys occur in March and April, fluctuating annually due to flooding and weather, as the local wintering population begins migration. Records after April are unusual but are becoming more annual. In 2015, there were no records after April, in 2016 two birds in were seen in June, 2017 recorded no birds after April, 2018 recorded three in May and seven in June but no breeding was confirmed whereas 2019 recorded two in May, a single in June and two in July.

Mandarin duck *Aix galericulata* are a resident species within the Avon Valley originating from feral release populations. Within Hampshire, this species is increasing with areas of wet woodland favoured for breeding. Survey results recorded three birds in April 2015, one in June 2018 and eight in May 2019 (a female with seven ducklings). The observation in May 2019 was the first confirmed breeding. In June 2019, camera traps picked up a female with four young who were presumed to be the same family although they were not observed on by subsequent bird surveys.

Tufted ducks *Aythya fuligula* are resident in the Avon Valley with breeding being recorded annually. Overall Avon Valley totals show varying numbers throughout the breeding season primarily due to coverage, but June totals, when ducklings are present, show an increase throughout the study period.

Goosanders *Mergus merganser* are resident in the Avon Valley and breeding has been confirmed annually. This is the only river valley in the county in which this species breeds with the Hampshire Bird reports 2015-2018 and these bird surveys identifying at least four broods in 2015, one brood in 2016, three broods in 2017, three broods in 2018 and at least four broods in 2019. The results from the bird surveys have shown an increase in numbers in May and June coinciding with large broods recorded.

Mallard *Anas platyrhynchos* are resident in the Avon Valley and breeding has been recorded annually. Due to the large numbers of birds being released in the winter for shooting it is difficult to determine population changes in the study area with survey results showing an overall increase until July when this species is moulting.

Figure 2: Mallard Anas platyrhynchos brood caught on a camera trap May 2015

Common Shelduck *Tadorna tadorna are resident within the Avon Valley with breeding rec*orded within the study area. Survey results show an increase in individuals in every month with records decreasing in June and July when adults depart to moult in Germany leaving juveniles in the Avon Valley.

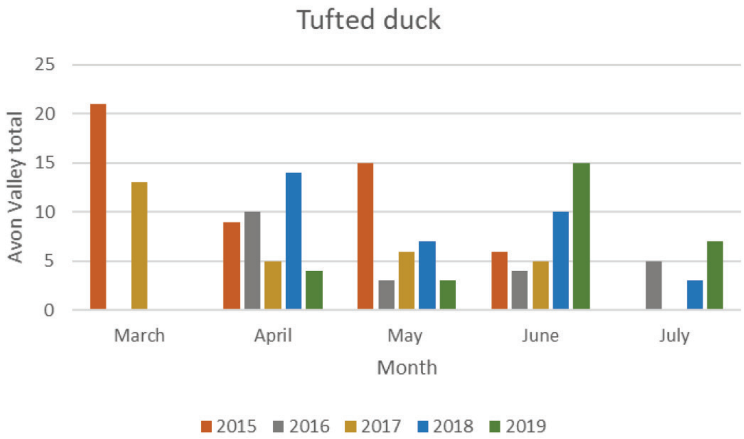

Figure 3: Tufted duck Aythya fuligula Avon Valley monthly totals between 2015 and 2019.

Northern Shoveler *Anas clypeate* are primarily a wintering species in the Avon Valley with low numbers remaining in the summer. At the start of the project, a flock of eighteen were seen in March 2015 decreasing to a single individual in April 2015. The following two years of surveying resulted in no birds observed through the summer. In 2018, twenty-eight were recorded over six sites in April, decreasing to thirteen birds at three sites in May and eight in June. However, a female with ducklings was observed, the first breeding record, but fledging success was unknown. However, in 2019, four birds were observed in March, three in April and two in June. Breeding was suspected and probably occurred in the valley as a juvenile was seen after the main survey period.

Gadwall *Anas strepera* are resident in the Avon Valley and a scarce breeding species within Hampshire. Survey results show numbers using the Avon Valley in the summer have increased but records of breeding have not been confirmed. Overall Avon Valley totals for April, May and June have totalled over 100 birds four times, three in 2018 and one in 2019. In July, birds disperse to moulting sites to complete their moult leading to an overall decrease.

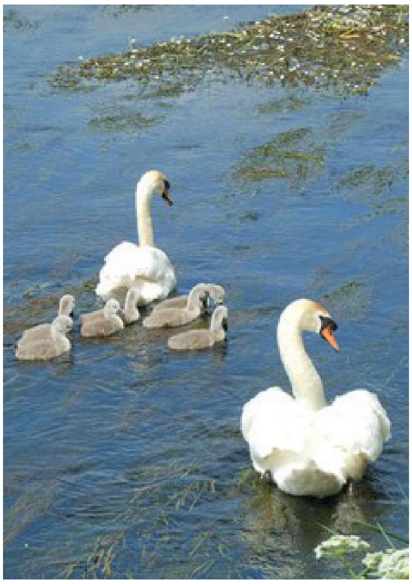

Figure 4: Mute Swan Cygnus olor brood on the River Avon May 2015.

Swans

Mute swans *Cygnus olor* are resident in the Avon Valley and breed annually across all the sites. Results show an increase in the overall Avon Valley total particularly between April and June, the main breeding months when birds are on nests and cygnets are present. July totals highlight the main moulting sites for this species are outside of the main study area due to the decrease in the overall total during the month. Coverage may be an issue too.

Rails

Moorhen *Gallinula chloropus* are resident in the Avon Valley and have bred annually between 2015 and 2019. Due to the fact this species can have three broods in a year, with the first brood caring for the second or third brood while the adults produce more young, total Avon Valley records fluctuate because of breeding attempts and subsequent success of the young.

Coot *Fulica atra* are resident in the Avon Valley and have bred annually within the study area. The main breeding period for this species is between April and June with young present between May and July depending on second broods. Overall Avon Valley totals noticeably fluctuate annually with 2018 and 2019 recording the highest Avon valley totals.

Wetland songbirds

Wetland songbird specialists have been chosen in this section due to the variability of records collected from all songbird species present throughout the Avon Valley.

Cetti's warblers *Cettia cetti* are mostly recorded by song, with a high proportion of records referring to males singing in shrub and reedbed. As a result, Avon Valley totals show consistently low numbers in March with counts during April and May providing a better understanding of the numbers present. Records in April and May show an increase between 2015 and 2017 with the peak counts of at least 105 individuals in April 2017 and 117 in May 2017. A coordinated Avon Valley count in the study area by the Hampshire bird group recorded 105 pairs in 2017 but surveys were not replicated thereafter for comparison. Cold weather in winter 2017/2018 seemed to reduce the population in summer 2018 but a population recovery was already being noted in 2019 in all survey months.

Sedge warblers *Acrocephalus schoenobaenus* breed annually within the Avon Valley with individuals arriving in April, followed by the highest numbers recorded in May, presumably when birds are holding territories. Records decrease into June and July when birds are breeding and become more cryptic in the vegetation.

Reed warblers *Acrocephalus scirpaceus* breed within the Avon Valley annually. Similarly, to A. schoenobaenus, individuals begin to arrive in April with the peak Avon Valley totals occurring in May when birds are singing and setting up territories. Totals decrease into June and July as adults are primarily feeding young.

Reed buntings *Emberiza schoeniclus* are resident within the Avon Valley and breed annually across the study site. Records show an increase in the number of individuals but similarly to C. cetti, there was a drop in records in April and May 2017 possibly due to the cold winter weather in March or survey effort. However, June 2017 records continued the increasing annual trend demonstrated previously showing the weather may not have affected this species too dramatically.

Stonechat *Saxicola rubicola* are resident in the Avon Valley and have been recorded breeding annually. Total Avon Valley counts have shown an increase over the study period with the highest peak count totalling seventy-nine birds in May 2017 including one site hosting seventeen birds. Cold weather in early 2018 seems to have affected numbers present in summer 2018 with 2019 recording an increase after this poor year.

Eurasian Cuckoo *Cuculus canorus* annually visit the Avon Valley but breeding has not been confirmed although suspected due to a range of suitable habitat and host species present. Survey results show the first birds arriving in April, followed by a peak in May and a decline into June with one record in July. Taking into consideration survey coverage, May records show a relatively stable population between twenty and thirty-five birds recorded annually with 2015 the only year when fewer were recorded. Nearby satellite tracking of Cuckoos in the New Forest mirrors the arrival and departure dates of birds in the Avon Valley.

Figure 5: Eurasian Cuckoo Cuculus canorus are normally heard only but this individual was particularly showy in 2016. Photo- Charlotte Pilcher

Conclusion

The summer surveys, undertaken between March and July to record breeding waders within the Avon Valley, has allowed any additional sightings of waterfowl and wetland songbird species to provide an indication of breeding in the Avon Valley study area. Variable coverage and different types of survey effort between 2015 and 2019 has resulted in an issue when comparing data over the five years but general trends have been highlighted from the surveys. The presence of C. canorus in the Avon Valley is positive as a range of habitats in the water meadows alongside farming practices has provided this red listed species with a local stronghold. Similarly, confirmed breeding of amber listed species such as C.olor, A. anser, T. tadorna, A. platyrhynchos , A. clypeate and E. schoeniclus is important for the overall populations of these species, regionally and nationally.

Wetland Ecosystem Services and Restoration of Ecosystem Function

Jodie Case and Dr Lucy Capstick

Wet grassland habitats have certain ecological characteristics which need to be understood in order to maintain the ecological processes present and to support the biodiverse range of species that rely on them. Wetlands provide rich natural resources and services which are vital for sustaining life, and with increasing pressure on these resources, it is becoming more and more important to understand the public benefits, known as ecosystem services, that are provided by wetland habitats.

Globally and within the UK wetland habitats are being lost and degraded. These habitats face numerous threats; they are drained to create land for agricultural production and/or development. Air pollution, water pollution and increased nutrient levels can damage wetland habitats. Management of water flow through canalisation and dams can also significantly alter wetland ecosystems.

In 1982 the Avon Valley constituted as one of the top eight lowland wet grassland sites in England and Wales for breeding waders. Wader species are intrinsically reliant on some of the ecosystem services provided by wetland habitats; services such as water purfication and storage, soil development, and the provision of habitat for diverse vegetation and invertebrate communities. Evidence of breeding wader decline in the Avon Valley since 1982 could indicate a decrease in the natural resources provided by wetlands and an associated decline in habitat quality as well as a level of habitat loss. Consequently, it is likely that the actions taken as part of the Waders for Real project to increase breeding waders could also enhance ecosystem services and alleviate ecosystem function degradation. These actions have included habitat creation, farmer liaison (through expert advisors), predator management and community engagement.

Ecosystem services are broadly categorised as supporting services, regulating services, habitat services, provisioning services and cultural services; wetlands, like the Avon Valley, can provide all of these services (Mitsch WJ et al, 2015).

Supporting services of ecosystems are those services required to maintain ecosystem function and resilience and to produce all other ecosystem services such as cultural or provisioning services (Mitsch WJ et al, 2015). Ecosystem restoration is therefore built on re-establishing these fundamental supporting services of wetlands habitats which many species, including humans, derive benefits. Supporting services include soil formation, efficient nutrient recycling, primary production and habitat provision. The provision of habitat, for waders and other species, is a supporting service which was improved in the Avon Valley through much of the active management carried out as part of the Wader for Real project. However, the wet meadows of the Avon Valley provide other support services; the wetland habitat provides natural flood regulation (see Figure 1) which leads to heterogeneous anaerobic conditions; these conditions support unique soil properties and plant adaptations resulting from flood stress which allow for wetlands to be ecologically diverse and productive. The availability of functional wetland habitat within the Avon Valley could also increase nutrient retention within the catchment (Rhymer CM et al, 2010).

Restoring ecosystem function in wetlands through creating and promoting connectivity of suitable habitat, encourages spatial and temporal heterogeneity within these wetland landscapes, which can be beneficial for all species. Shifting mosaics of habitat provide greater opportunity for colonisation, food availability and protection from predators; this approach can help to increase biodiversity across

Figure 1: Avon Valley meadows show change in water levels within one week – showing that wetland ecosystems are continually in a state of change due to their ability to hold and drain excess water, leading to a constant shifting mosaic of habitats and high levels of biodiversity

taxonomic groups and can stimulate regulating ecosystem services. A number of ecosystem processes can be regulated in wetland habitats including maintenance of air quality, regulation of climate, control of erosion, and protection from extreme climate/weather events.

The Waders for Real approach aimed to restore ecosystem functions by improving habitat conditions for waders and to connect areas of suitable habitat at landscape scale to encourage breeding. This was done by removing predator perching areas such as dead trees and by opening landscapes by clearing areas of willow scrub and old fence lines. Wet features such as ditches were re-dug and existing in field features were maintained and new features created where suitable. This management is likely to have contributed to the provision of regulating ecosystem services. For example, the creation of wet features increases water storage in the landscape and affects flood regulation (Rhymer CM et al, 2010).

Farmer liaison also allowed for sympathetic grazing regimes and stocking levels to be addressed and to manage sward levels to suit breeding wader nesting requirements. This helped to maintain the rich diversity of wet meadow vegetation and support the associated invertebrate communities as an important food resources for wader chicks and other breeding birds. Non-lethal predator management was also carried out, using temporary electric fencing throughout the vulnerable breeding season, which aimed to manipulate mammalian predator behaviour and reduce predation pressure. Management undertaken as part of the Wader's for Real project is therefore likely to have created habitat for a variety of taxa. As mentioned above habitat provision is a vital ecosystem service provided by wetland habitat restoration.

The work carried out by the Waders for Real project would not have been possible without the input, cooperation and hard work by the many farmers, gamekeepers, river keepers and graziers involved. The project understood the need for trusted relationships to be made and to work around farming business so as to not impact on farming practices. As part of restoring ecosystem function, the wetland areas being restored and maintained for breeding waders were also areas which provide many provisioning ecosystem services (material benefits derived from ecosystems) such as food, fuel, genetic resources, natural medicines, building materials, and water. The project aimed to manage a balance between farm production and associated provisioning services, breeding wader conservation and wider ecosystem restoration.

Similarly, wetland areas like the Avon Valley and the species they

Figure 2: Scrape – In-field wet feature dug in an open wet meadow to increase wader chick foraging opportunity and areas of protection from predators

Figure 3: Sparsholt students removing dead trees on wet meadow hotspots to reduce perching opportunity for avian predators

support are an important source of cultural ecosystem services (benefits people obtain from ecosystems) (Mitsch WJ et al, 2015). Wetland habitats can provide opportunities for cognitive development, spiritual enrichment, popular countryside sports, reflection and aesthetic experiences. The management undertaken to improve habitat for breeding waders could have increased the aesthetic values provided by the Avon Valley. In addition, the communication work undertaken as part of the Waders for Real project provided several opportunities for environmental education, another important cultural ecosystem service (Scholte SSK et al, 2016) The Waders for Real project visited schools, country shows and other conservation organisations to share the project with the wider community and to highlight the importance of restoring wetland habitats for public health and wellbeing.

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Figure 4: Stakeholders involved in the Waders for Real project met regularly to receive feedback, share thoughts and plan ahead, providing an important community approach to their involvement in the project.