LIFE 13 BIO/UK/000315

LIFE Waders for Real

Deliverable D2. Document outlining the effect of habitat actions at hotspots on habitat suitability for waders

Lizzie Grayshon
Lucy Capstick
Andrew Hoodless

Abstract

Through the LIFE Waders for Real project we have added new or restored existing wet features in 217 ha of fields across the Avon Valley. This has created wet grassland habitat better suited to lapwing and redshank nesting/brood rearing due to the increase in accessible wet features (ditches/scrapes). These techniques have an effect on the vegetation structure and community within the water meadows, these effects are explored here.

Contents

Introduction

The numbers of breeding waders, such as northern lapwing, redshank, black-tailed godwit and common snipe, have been declining on farmland across Europe for at least the last 40 years (Newton, 2004). Poor productivity, rather than reduced adult survival, is now recognised as the main demographic driver of this decline (Roodbergen, van der Werf and Hoetker, 2012). This reduced breeding success is primarily due to agricultural improvement of their favoured wet grassland habitats through field drainage, increased fertilization of the grass swards and increased livestock densities (Wilson, Ausden and Milsom, 2004). These changes have resulted in a drier habitat with reduced botanical and invertebrate diversity, lower food availability and increased disturbance (Newton, 2004). Agri-environment schemes in several countries have attempted to mitigate these management changes by compensating farmers for maintaining higher field water levels and practicing lower intensity farming (Wilson, Ausden and Milsom, 2004). However, in many cases this has not been effective in halting the decline of breeding waders at a local scale (Leigh, Smart and Gill, 2017). There are several reasons why the management implemented under these schemes may have been ineffective; it may be because the habitat management is not implemented as prescribed (Burgess, Clark and Harrison, 2000), because the financial compensation for some measures has been insufficient (Batáry *et al.*, 2015), or because the prescriptions themselves do not create suitable habitat (Kentie *et al.*, 2013). It may also be that the length of such schemes is insufficient to achieve benefits or allow follow-up maintenance of habitat works (Kleijn *et al.*, 2006).

In addition, even where there is suitable wet grassland habitat, wader productivity can be limited by non-habitat factors (MacDonald and Bolton, 2008; Teunissen *et al.*, 2008; Leigh, Smart and Gill, 2017). There is an increasing body of evidence, from scientific studies conducted on breeding waders across Europe, that predation of nests and chicks by generalist predators is limiting wader population recovery in many situations (Bolton *et al.*, 2007). In several countries the numbers of these generalist predators, such as foxes and corvids, have increased over the period of wader decline (Newton, 2004; Bolton *et al.*, 2007). Furthermore, the effect of poor habitat quality and the impact of predation are likely to be linked (Whittingham and Evans, 2004). Waders nesting or feeding in sub-optimal habitats may be more vulnerable to predation, for example the increased vegetation density seen in improved grassland can reduce lapwing's ability to detect predators (Evans, 2004). Additionally changes in habitat may facilitate predator activity, for example increased availability of man-made perching structures can increase avian predator activity (Wallander, Isaksson and Lenberg, 2006)

Restoring breeding wader numbers is therefore likely to depend on a combination of habitat management and reduced predation. Reduced levels of predation will not be enough to reverse declines if there is insufficient food for adult birds or a lack of brood rearing areas. Providing appropriate habitat is the crucial first step towards stabilising wader numbers; a mosaic of conditions is necessary to satisfy all their requirements. Some habitat measures may in themselves serve to reduce predation; the removal of dead trees on field boundaries may make fields more attractive to breeding waders and reduce perching opportunities for avian predators. Similarly, RSPB research has shown that fields with high foot-drain flood densities attracted significantly higher densities of nesting lapwings and there is evidence that breeding lapwings' ability to deter predators is higher when they nest colonially (Berg, Lindberg and Källebrink, 1992; Eglington *et al.*, 2008).

Rationale for habitat works in the Avon Valley

The implementation of agri-environment schemes can be targeted by government agencies, based on the occurrence of particular species or habitats (Natural England, 2015). However, at a local level this can still result in disparate patches of managed habitat which may not operate as effectively in conserving a species as a smaller number of larger patches. In the Avon Valley we used previous survey data to identify target groups of fields where waders were still present in reasonable numbers, habitat and predator manipulation were feasible and the landowners were sufficiently motivated, to stand a good chance of success at creating 'hotspots' of high lapwing and redshank productivity. This approach has not been tried before, certainly in a non-reserve situation. However, the improved anti-predator defence of nests by lapwings in groups suggests that it is a logical approach to more quickly establishing self-sustaining meta-populations. Anecdotal evidence suggests that redshank nest survival is also higher in fields with increased densities of lapwings. Focusing all effort on sites where there is the maximum chance of success is likely to be the best strategy in situations where resources are limited. Habitat improvements comprised three main components: creation of new in-field wet features, opening up of field boundaries and grazing to ensure appropriate swards in spring.

At the start of the Waders for Real (W4R) project in 2014 inappropriate water levels, and an increasing polarization of sward conditions towards intensively grazed short swards or rank areas with scrub encroachment were identified, as important issues throughout the Avon Valley. Over the previous ten years, these have led to a decline in the floristic interest of the meadows and a reduction in their suitability as breeding habitat for waders. Limited water control structures throughout the Avon Valley make it difficult to regulate water levels of some key fields in spring. During the last 15 years there has been a large reduction in the number of livestock within the valley, with a shift from dairy herds to beef cattle. On many units within the Avon Valley SSSI the reason for unfavourable conservation status in 2014 was under-grazing rather than stocking levels that were too high. Appropriate grazing management by farmers is essential to maintain the suitability of swards for breeding waders and wintering wildfowl. The ability to graze fields appropriately is closely allied to control over water levels so that livestock can gain access at certain times of year. Working with Natural England, we identified fields at each hotspot site that would benefit from a change in grazing regime and talked to farmers about changes to numbers of livestock, timing of grazing and desired sward height and structure in spring. This has involved identifying fields where conditions could be improved for redshank and snipe and those where swards are most suitable for lapwings. By modifying the grassland management in these fields, we hoped to create a sward with a more varied botanical community and a diverse structure which is likely to be preferred by breeding waders.

Examination of our lapwing productivity data for 2007-2014 in relation to winter rainfall (a proxy for field wetness in spring) indicated a positive relationship, suggesting that lapwing breeding success was dependent on field conditions in spring (see Annex 1). Given that there were very few in-field features that remained damp throughout the spring in 2014, this suggested a need for scrapes and foot drains to improve foraging conditions for chicks. There is good evidence from RSPB research that increasing wet feature density (in their case these were foot drains) attracted significantly higher densities of nesting lapwing and these lapwing nested near such features. Later in the season, chick field use increased significantly with foot drain density and chicks were more likely to forage nearer foot drain floods in areas of wet mud created by receding water levels. We therefore made the implementation of more wet features within or adjacent to the main lapwing nesting fields a

priority in the Avon Valley. We hoped these wet features would create more areas of bare ground and increased soil penetrability which provide ideal brood rearing areas.

Discussion with farmers and study of historic aerial photographs indicated growth of willow scrub along field boundaries at several fields which have supported breeding waders in the last ten years. Using photographs and ground surveys, we were also able to identify dead trees near regular wader nesting fields; these were known or likely to be used as perches by avian predators. Much of the recent literature on wader nest predation suggests that the red fox is the main predator, but most of the studies have been conducted on nature reserves where there are few trees and low densities of breeding corvids. Our data from the Avon Valley, using temperature loggers in lapwing nests, indicated that corvids were responsible for about 40% of nest predation. Corvids, herons and raptors are all implicated as important predators of wader chicks in studies in the Netherlands. Consequently, we believed that by opening up field boundaries we would be able to increase the nesting density of lapwings in key fields and, through selective removal of certain trees, help to reduce avian predation on eggs and chicks.

Proposed habitat work

In our original proposal we intended to:

-Double the area of in-field wet features (carriers/footdrains and scrapes) over at least 120 ha of fields (over approximately 30 ha per 'hotspot') to provide more attractive nesting areas for lapwings and redshank and better quality and more accessible brood rearing areas.

-Increase the area of habitat suitable for nesting redshank in the Avon Valley by 20 ha and at least halt the decline in the number of breeding pairs.

- Create at least four patches of optimal habitat for breeding snipe, totalling approximately 20 ha, situated close (within c. 500 m of the edge) to our 'hotspots'. If successful, a prescription describing the management required will be documented for promotion at other sites across the country.

Work commenced February 2015 with the production of management plans for each hotspot site which contained specific habitat management and creation targets.

Types of habitat work carried out

Practical habitat management began in autumn 2015 on our hotspot sites and continued until autumn 2018/2019. This included a variety of different works aimed at increasing lapwing and redshank productivity.

Creating wet features

Wet features, such as ditches and scrapes are extremely important for lapwing and redshank when raising chicks, as these habitats are rich in invertebrate food, and the soft ground facilitates feeding.

Scrapes

Scrapes (which are shallow depressions designed to retain water) were added within fields to create more chick foraging habitat away from linear wet features and the main river channel. Predation risk may be higher near linear features, such as ditches or fence lines, as these features can be used by mammalian predators to move through the landscape. In addition, deep drainage ditches and large river channels may be too steep sided to provide accessible wet ground for chick foraging.

Creating a mosaic of wet features within fields also produces a more complex habitat structure, which in turn creates areas of cover for protection from avian predators and open areas for foraging.

Before (left) and after (right) the creation of a shallow gutter and scrape to improve chick foraging habitat.

Creation of these large in-field pools also benefitted other species outside of the breeding season. The pools are utilised throughout the winter months by wintering waders, including snipe and jack snipe, and wintering waterfowl, such as wigeon and teal. The Avon Valley is nationally protected for its wintering wildfowl and waders. It is an extremely important area for large flocks of wigeon, teal, pintail, black-tailed godwit and many other species. The production of habitat that benefits these

species is therefore of conservation importance.

Ditches and foot drains

In many areas, we aimed to increase the quality of the lapwing foraging habitat provided by restoring existing ditches and drains. This involved removing vegetation that was blocking ditches, joining side ditches that had been separated back to the main carrier channel and re-digging ditches that had dried out completely.

Maps of before (left) and after (right) ditch reinstatement and creation, using both existing and relict ditch lines to create more in-field wet feature.

Opening field boundaries

We aimed to reduce lapwing predation risk in the Avon Valley by increasing the ability of lapwing to detect predators and reduce the availability of habitats used by predators.

Tree and willow removal

The growth of trees and scrub in the wet meadows in the Avon Valley had reduced the suitability of the fields for breeding waders. Dead trees and scrub provided perching posts for avian predators. We therefore aimed to reduce the amount of standing dead trees and scrub at hotspot sites.

However, when removing this vegetation other species which utilise the Avon Valley needed to be considered. The Avon is an important habitat for several fish species including barbel, roach, lamprey and salmon. Salmon enter the river in March on spring migration and there is a second wave of migration in the autumn when the salmon move up the river to spawn. In places on the river

Avon water temperatures currently reach sub-lethal levels for salmonids, consequently shady cover at the river edge is important for regulating water temperature.

Retaining some trees and low shady cover at the river edge was therefore necessary for the fish population. Trees and shrubby cover on south-facing banks and at the lower confluence points at each site afford the greatest shading value for fish. Before removing trees and shrubs from ditch edges, work was discussed with the Avon Roach Project and the Barbel Society in order to reduce conflict between management for waders and management for fish. Shrub was only removed where it was appropriate for both groups; for example, only relatively new scrub growth (not well-established cover) was removed from ditch lines and only where it was unlikely to benefit fish.

Trees and low shady cover are important. We need to consider the balance of requirements of the waders with those of other species. Trees and shrubby cover on south-facing banks afford the greatest shading value for fish. There might be scope for mitigation planting on the south banks of the river if trees are taken out elsewhere. We were advised to talk to the Avon Roach Project and the Barbel Society when planning works to discuss synergies and possible conflicts. The method of scrub removal was considered carefully. In general, it was possible to cut the willow scrub back along carrier ditches, but herbicide was not be used to kill stumps owing to the proximity to water. As herbicide was not used there was some re-growth and where possible this was controlled by flail mowing in August and September each year.

The removal of material resulting from tree-felling and scrub removal was considered on a case-by-case basis. Natural England and the Environment Agency were in favour of creating woodpiles for invertebrates, but in most cases Natural England would prefer these off the floodplain on to higher ground nearby owing to the risk of material being washed away during high winter floods. A compromise solution was to remove all willow scrub from the wet meadow habitat but to leave some larger material, resulting from the felling of dead tree, on site in wood piles.

Field boundary removal

Lapwing prefer to nest in sites with a wide field of view to enable earlier detection of predators. We removed old disused fence lines in reduce field enclosure. This increased the suitability and appeal of the wet meadows in the Avon Valley for breeding lapwing.

Changing grazing regimes

Lapwing prefer shorter swards for nesting, approaching predators are more visible, and prey is more accessible. In the Avon Valley, where under grazing was the main problem, we aimed to create sward conditions more suitable for breeding waders by working with farmers and statutory agencies to moderate the grazing regime.

Natural England has promoted more grazing in the valley. Throughout the project liaison with land managers and farmers ensured that the grazing levels and timing were appropriate to recover and maintain suitable sward structures for breeding waders. In particular, areas of rush, sedge and meadowsweet encroachment were identified, and advice was given on cutting and/or grazing to curtail this and get the sward back to grasses. Fields were identified at all hotspots for management specifically for redshank and snipe. These were grazed to create patchy swards with vegetation heights varying between 10-20 cm, with about 10-15% rush cover.

We encouraged farmers to use suitable livestock for grazing. Older, docile cattle were preferable to younger cattle and both were preferable to horses. The older livestock are less likely to cause disturbance to breeding wader or to trample nests or chicks.

Other aspects of the biological community were considered when the grazing regimes were altered. However, grazed fields are generally better for biodiversity than hay fields except where flora are the conservation priority.

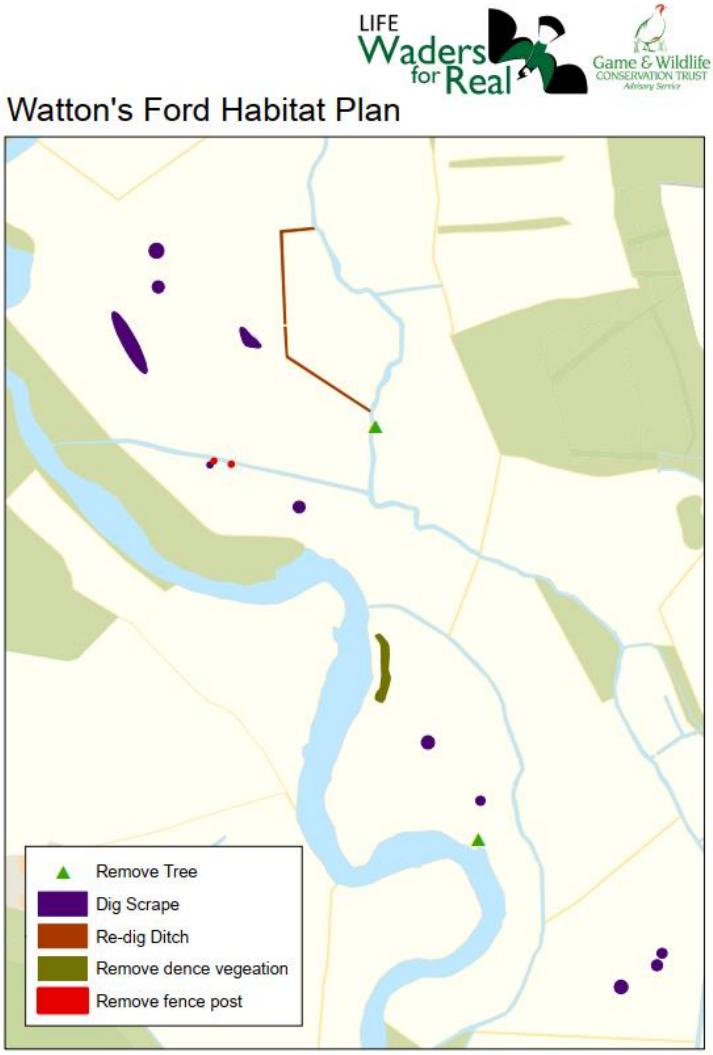
Trampling of riverbanks near salmon redds is a potential issue, but temporary electric fencing can solve the problem or at least reduce the impact.

How we planned the habitat work – management plans

As part of the initial habitat management planning process the Senior Officer and Project Officer made a visit to a wet meadow grassland site which supports a high number of breeding waders. They visited Elmley NNR, Kent in May 2016 to discuss the management of the habitat for waders with the site manager. In particular they discussed sward management (for lapwing and redshank), the creation of infield wet features and the interaction between managing wet features and managing grazing cattle.

Field visits when the water levels were high were used to gain good insight into the locations of low points within the fields. These low points naturally retain water longest so are obvious targets for the siting of in-field wet features. Visiting sites when the water levels were higher also allowed us to accurately map the locations of pre-existing ditches, which could then be reinstated. By targeting pre-existing features for restoration, the project aimed to restore some of the sites to a more naturally functioning state. Following this exploratory research management plans for each hotspot site were produced, in collaboration with landowners and farmers as well as relevant statutory agencies (Natural England and the Environment Agency). Natural England provided formal consent for all the management plans for each hotspot. In addition, any work on the main river required formal Environment Agency consent. Work on other floodplain channels could be approved by the council ecologist, but the Environment Agency were copied in on all correspondence. Flood defence consents were required for all our sites and these were successfully obtained.

Example of initial plans



The same location before (left) and after (right) a ditch has been re-dug and vegetation cleared.

Habitat work carried out compared to proposed work

Habitat works commenced in August 2015 and continued until March 2019, with some work being conducted on five hotspot sites. This included work on the four original hotspot sites (Hucklesbrook-Ibsley, Kingston, Avon Tyrell and Watton's Ford) and work on one of the new hotspots identified as part of the project extensions (Standlynch). In the project extension habitat work at an additional new hotspot site (Ogber) was proposed. Unfortunately, there were unforeseen landowner complications at this site; there are several different landowners and exact boundaries are unclear. It was not possible to resolve these complications within the timeframe of the project. Beyond the timeframe of the project we plan to further explore the possibility of carrying out work at the site; the site holds several pairs of lapwing and redshank and has potential for improvement. It may be possible to come to an agreement with the landowners for future work on breeding waders. In addition, we were able to use some of the money designated to habitat work on Ogber to complete habitat work on other site adjacent to hotspots instead.

Total habitat work completed on the hotspot sites

Wet feature creation

We have added new or restored existing wet features in 200 ha of fields across our original four hotspot sites. This has created wet grassland habitat better suited to lapwing and redshank nesting/brood rearing due to the increase in accessible wet features (ditches/scrapes). The amount of suitable wet features has at least doubled compared to what was originally available per field, this exceeds our original proposal of improving 120 ha of habitat for breeding lapwing and redshank (see Table 1).

In addition, we have been able to improve habitat on two sites adjacent to hotspot sites, creating 17 ha of fields with new or restored wet features. On these sites we have again at least doubled the amount of in field wet feature available to breeding waders (see Table 1).

Finally, we carried out additional management on the new hotspot sites (identified as part of the project extension); 12 ha of fields with restored wet features were created at the Standlynch hotspot site (see Table 1).

Table 1: Amount of wet feature added and wet feature restored across sites

Site	Scrape added (m²)	Ditch reprofiled (m)	Ditch added (m)	Fields with wet features added (ha)	Site Area (ha)
Avon Tyrell North – Hotspot site	998	866	83	34	132
Hucklesbrook – Hotspot site	1955	2463	1603	53	53
Ibsley – Hotspot site	1090	0	0	30	68
Kingston – Hotspot site	4937	0	0	45	109
Watton's Ford – Hotspot site	1377	349	0	38	115
Sopley Island – Adjacent site	562	738	0	9	40
Avon Tyrell South – Adjacent site	0	110	0	8	78
Standlynch – New hotspot site	285	2226	0	12	64
Hotspot total	10357	3678	1686	200	477
Hotspot average	1773.7	984	281	35.3	90.2
Total	**11204**	**6752**	**1686**	**229**	**659**

Our original proposal outlined that we would create approximately 1000 m of new boundary ditching and restore 1000 m of in-field carrier/wet feature restoration. Ultimately, it was not feasible to sub-divide the work carried out between in-field and boundary wet features due to fluid nature of field boundaries in our landscape. Instead we have measured our habitat work in the form of ditch creation, ditch restoration and scrape creation. All scrapes were created in the middle of fields whereas ditches were sometimes along field boundaries and sometimes infield. All ditches created or restored were appropriate and accessible for use by wader chicks, for example they were not deep carrier boundary ditches running alongside woodland or another inappropriate habitat.

Each hotspot site has received on average 281 m of new ditching and 984 m of reprofiled ditching. This included 1718m of ditch re-profiling at the new hotspot site Standlynch in the winter of 2018/2019.

In addition, 1773.7 m² of scrapes were created on average on each hotspot (see Table 1). This measurement is not directly comparable with the proposed 1000 m of new of new boundary ditching and 1000 m of in-field carrier/wet feature restoration. However, we are confident that the management we have undertaken has had achieved the same overall outcome, especially when the overall amount habitat now made appropriate for breeding waders is considered. For details on habitat work see Annex 9, Table 3.

Tree, scrub and field boundary removal

Each hotspot had an average of 2.5 large dead trees removed (not including scrub removal). On the new Standlynch hotspot site it was possible to remove two trees during the winter of 2018/2019. However, on this site it was not possible to remove the dead oak as proposed due to its importance for roosting bats. In addition, we were also unable to remove the willows due to access issues. Old disused fence lines were increasing field enclosure specifically on one hotspot site (Ibsley). Consequently over 1 km of fence line was removed from that site (See Table 2).

Table 2: Amount of field boundary opened across sites

Site	Fence Removed (m)	Trees removed	Site Area (ha)
Avon Tyrell North – Hotspot site	0	0	132
Hucklesbrook – Hotspot site	0	0	53
Ibsley – Hotspot site	1012	5	68
Kingston – Hotspot site	0	3	109
Watton's Ford – Hotspot site	0	5	115
Sopley Island – Adjacent site	0	0	40
Avon Tyrell South – Adjacent site	0	0	78
Standlynch – New hotspot site	0	2	64
Hotspot total	1012	13	477
Hotspot average	168.6667	2.5	90.16667
Total	**1012**	**15**	**659**

Grazing and sward management

In collaboration with Natural England, the landowners and the farmers, we modified the grazing and sward management on a site by site basis in order to create suitable conditions for breeding waders

Working alongside Natural England, we have encouraged an increase in livestock numbers on some sites, particularly Hucklesbrook. Hucklesbrook is now grazed by up to 30 horses and 10 cattle between May and July, this has resulted in maintenance of a shorter sward, which is more suitable for lapwing.

Many of the fields at Kingston were improved agriculturally in the 1970s, leading to denser grass swards. These swards therefore require cutting in late summer and aftermath grazing to ensure suitable sward structures for lapwing and redshank in spring. This management is conducted by the landowner, however prior to the project the timing of the grazing was unsuitable for breeding lapwing. A large free ranging herd of approximately 90 young cattle were introduced from late May/early June; these young and energetic cattle were a particular issue for late lapwing clutches and small chicks as they caused disturbance and increased the risk of trampling. Through negotiation with the livestock manager, we ensured that the site was grazed in smaller units, which facilitates more flexibility. In addition, the livestock manager now consults with project ecologists before livestock are introduced so up to date information about breeding waders can be taken into account. This means the introduction of cattle to fields with breeding waders can be postponed until later in the season.

There was a similar issue at another hotspot site (Watton's). As on Kingston, young cattle (in this case young bullocks) were introduced to fields before the waders had finished breeding. This again has largely been resolved through better liaison with the livestock manager. In addition, the landowner has made it a high priority to make sure a hay cut is taken off the key fields on this site and that the fields are heavily aftermath grazed. This has meant an appropriate sward is maintained coming into the following spring.

On the Avon Tyrell sites grazing is mainly carried out by two tenant farmers and the swards were largely appropriate for breeding waders. In this case the tenants were advised by Natural England to lower the stocking density, but we were able to support the tenants in maintaining a higher stocking density. The project provided evidence of good breeding wader success, despite the higher stocking density. We believe this is down to the type of stock; older cattle who do not disturb nests and chicks.

Management for redshank and snipe

We are confident that the wet grassland habitat we have created favours redshank as well as lapwing. This is evidenced by the increase in number of redshank pairs over the course of the project (from 19 pairs in 2015 to 35 pairs in 2019). Redshank require a diverse sward; tussocks and clumps of grass provide nesting habitats, more open areas provide foraging sites and a mosaic of vegetation provides cover from predators. Similar to lapwing, redshank chicks forage around wet features. The addition of new wet features and restoration of existing wet features in 229 ha of fields over the project is therefore likely to have benefited redshank. We suggest that this exceeds the proposed creation of 20 ha of habitat suitable for breeding redshank.

Snipe prefer slightly different conditions to lapwing, they require slightly taller vegetation and damper soil conditions generally, rather than just around wet features. However, over the course of the project, the improved and in some cases lighter, grazing regimes have made some fields more appropriate for snipe. This is evidenced by the observation of drumming snipe in the Avon Valley in two later project years.

Monitoring of benefits of habitat works

By combining detailed monitoring of the breeding wader populations with ongoing assessments of the vegetation and field conditions we were able to document the effect of the habitat work detailed above in the Avon Valley.

We measured vegetation structure, community composition and soil penetrability using several different monitoring methods. This monitoring was used to demonstrate any effect of the changes in vegetation management, and wet feature management, implemented through the project.

We also looked at how the lapwing were using the habitat to directly explore whether the habitat work carried out was achieving benefits for breeding waders. For example, we recorded fine-scale habitat features at brood locations and paired random sites to gain a better understanding of the vegetation structures favoured by chicks. In addition, we radio-tracked lapwing chicks to enable us to relate lapwing site choice to habitat attributes, such as the presence of wet features or specific vegetation conditions.

Changes in vegetation community composition

The vegetation community and field conditions were monitored using several methods over the course of the W4R project (See D4: Assessment of restoration of ecosystem functions).

Firstly, the vegetation community (at a species level) was recorded in detail at fixed quadrat locations across 36 fields at the start of the project (2015) and this survey was repeated at 14 sites in 2019. By repeating this survey changes in vegetation over the course of the project could be identified and related to management (e.g. stocking levels and hay-cutting regimes). As well as providing information about the diversity and quality of the botanical community analysing the composition of the vegetation community can also provide information about the environmental conditions. Specifically changes in abundance or diversity of species that prefer particular conditions (such as wet ground or fertile soils) could indicate the impact of management change on environmental conditions.

The repeated analysis of fixed quadrat locations in 2015 and 2019 indicated that over the course of the project sites did not see an increase in species which prefer wet habitat or species which prefer more or less acidic soils. However, there was evidence that the number of species that prefer high fertility soils decreased between 2015 and 2019, particularly on grazed (rather than hayed) fields (See Figure 1). The elevated fertility of these fields was likely caused by historical mis-management (overstocking and artificial fertiliser input) therefore this decline in fertility could be evidence of the sensitive management of stocking densities implemented through the project.

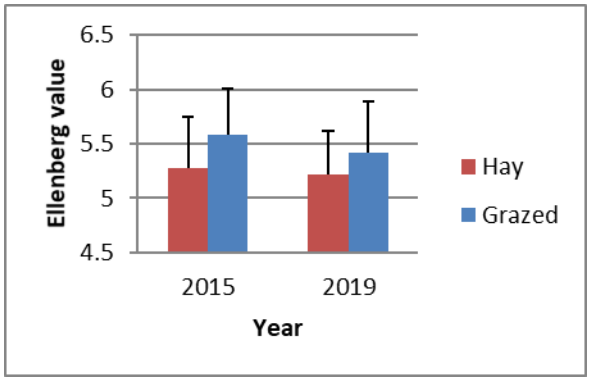


Figure 1: Fertility scores for hayed and grazed water meadows at the beginning and end of the project.

High fertility and vegetation species that prefer high fertility conditions are likely to produce a faster growing denser sward. The decline in these species is therefore likely to benefit breeding lapwing which prefer a shorter more open sward for nesting.

Secondly, wider scale surveys, based on the JNCC/NE Common Standards Methodology, were carried out. This method involved a quality assessment of the sites, based on the presence or absence of positive and negative botanical and management indicators, and resulted in a quality score (QS) being produced for each site (See D4: Assessment of restoration of ecosystem functions). These surveys were carried out for each site over three survey periods: one before the W4R project (2010-11) and two later (2017 and 2019).

Quality assessments suggested that the quality score (based on positive indicator species) of sites in the Avon Valley increased slightly over the 10 year monitoring period, particularly on hayed fields (see Figure 2). The greater increase in QS in hayed field could be because of the higher resilience of these communities to disturbance (their recovery is less likely to be perturbed by exceptional events like flooding (see Deliverable D4 Assessment of restoration of ecosystem functions).

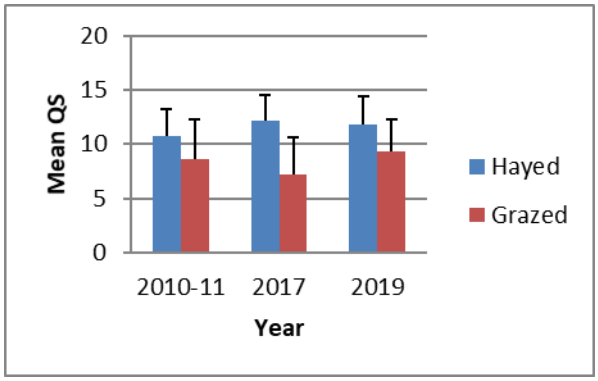


Figure 2: Quality scores (positive indicator species) for hayed and grazed water meadows before, during and at the end of the project

In addition, analysis of more limited data documenting negative indicator species suggested that the there was some decline in fields with high abundance of these negative indicators. The presence of dense stands of these negative indicators (including creeping thistle *Cirsium arvense* and broad-leaved dock *Rumex obtuifolius*) would likely be avoided by nesting lapwing. However, the survey carried out in 2019 (at the end of the project) suggested that there were no sites with a major negative indicator ('weed') problem.

In general, an overall increase in quality of the botanical community of the river meadow habitat is likely to benefit breeding lapwing. A more diverse and robust vegetation community could support increased abundance and diversity of invertebrate prey as well as providing a more varied structure. Consequently, the increase in quality seen over the course of the project is likely to represent an increase in suitability of habitats for breeding waders.

Changes in vegetation sward and soil conditions

In addition to the detailed surveys of botanical communities, described above, additional vegetation surveys took place, in April, May and June, in each field in which waders were present. A W-shaped transect was followed across each field in order to sample all parts of the field in a representative manner. At 30 points on the transect vegetation height and soil penetrability (measured using a penetrometer) were recorded.

These surveys showed that there were differences between years in both vegetation height and soil penetrability, however these differences were generally related to annual variation in external factors (such as overwinter rainfall) rather than indicative of management changes (see Table 3). For example, lower soil penetrability in 2016 is probably due to lower rainfall in this year and taller vegetation in 2018 could be due to overwinter flooding limiting sward management.

However, we might not expect to find evidence of large shifts in these measures due to management changes over the relatively short period of the W4R project. Other factors not mentioned here (such as major flooding events) are likely to have influenced the vegetation and soil conditions. In addition, this field scale examination of vegetation sward and soil conditions could be too broad to identify micro-changes in the habitat which benefit breeding lapwing. For example, the creation of in-field wet features is likely to create a small area of more penetrable soils rather than affecting the whole field. The more detailed examination of specific habitats used by lapwing indicates that the habitat management implemented over the course of the project did create suitable habitats .

Table 3: Table showing difference between years in vegetation heights and soil penetrability in fields used by breeding waders in the Avon Valley (high soil penetration resistance values indicate more penetrable soils). Means ± SE.

Year	Average of soil penetration resistance (kg)	Average of vegetation height (cm)
2015	7.11 ± 0.18	28.95 ± 2.72
2016	4.8 ± 0.11	24.89 ± 1.97
2017	7.35 ± 0.12	22.78 ± 0.86
2018	6.67 ± 0.17	42.25 ± 1.99

Changes in habitat and lapwing breeding success

As well as looking the results of our vegetation surveying, and other habitat monitoring, for evidence of the impact of our habitat works we can also directly relate our measures of vegetation and soil condition to our monitoring of lapwing breeding success. This can provide further indication that the conditions we aimed to create benefited breeding waders.

Chick survival was actively monitored over the course of the project on hotspot sites using a combination of methods. These results of this monitoring can provide insight into the impact of project habitat management on chicks. Lapwing chicks were caught as close as possible to hatching and radio tagged. Chicks were then radio tracked frequently to establish survival to fledging and to

monitor habitat use. In addition, on any occasion where chicks were observed foraging, measures of environmental condition were taken and then compared to paired random sites; this meant we could look at lapwing chick foraging preferences and relate that to our habitat management.

Chicks survived better in fields with shorter vegetation heights. Shorter vegetation is likely to improve lapwing ability to perceive predators and facilitate chick foraging. The reduction in species which prefer fertile soil within the community could contribute to creating a short, less dense sward (See Monitoring of benefits of habitat works – Changes in vegetation community composition). This suggests that the projects' efforts to create a suitable sward by reducing under grazing, and to mitigate the issue of vigorous grass growth on formally improved grassland, was positive (See Total habitat work completed on the hotspot sites – Grazing and sward management, Page 13).

Although, we did not find evidence for a shift in vegetation community (more species which prefer wet conditions), or an overall increase in soil penetrability, that would indicate the benefit of wet feature creation, this is likely because of the scale of the wet features we created relative to the total field area. We did find evidence that lapwing chicks preferred to forage in conditions associated with wet features; chicks favoured sites where there was a greater proportion of bare ground and where the soil was more penetrable. This suggests that the mobile lapwing chicks could utilise the wet features created and restored as part of the W4R project (See Total habitat work completed on the hotspot sites –Creating wet features Page 11).

Finally, our observations of nest failure provide a direct indication of a positive effect of habitat management; we encouraged farmers to use older more docile cattle and to delay the introduction of livestock until after waders had finished breeding (see Total habitat work completed on the hotspot sites – Grazing and sward management, Page 13). This success of this strategy is reflected in the fact that only 8 nest failures (7% of all failures) were lost due to farming practices or livestock throughout the project. As with the observations of nest survival, our monitoring of chick survival indicated that the livestock and grazing management encouraged by the project had positive effects. Of the 85 radio tracked chicks, whose fate was known, only one was trampled. The delay in grazing on some fields and the use of older cattle is likely to have prevented further trampling of chicks.

Continuation of actions after the end of the project

While some of the habitat actions, i.e. tree removal, are permanent, some will need repeating at intervals in the future to ensure continued suitability of sites for breeding waders. The willow scrub will require ongoing management to prevent re-growth. Most of the willow scrub removal occurred along the edges of watercourses, therefore it was not possible been unable to use herbicide on the stumps to prevent regrowth owing to concerns about leaching of chemicals into the water. It may be possible to use 'eco-plugs' (crystalline pesticide which can be embedded in tree stumps without the risk of contamination) at certain locations, but these are expensive. As an alternative we are encouraging farmers to cut the vegetation along the ditch edges that we have managed, using a flail mower every September. In addition, the wet features will require maintenance, some of the ditches and scrapes that have been dug will start to silt up and become more vegetated over time. We anticipate that they will need renewing every 4-6 years to maintain them in optimum condition for waders.

Through this project we have established a much closer working relationship with Natural England and the local officers understand the rationale and can see the benefits of the work undertaken. They are keen to ensure that appropriate maintenance actions, such as periodic ditch and foot drain re-profiling continue in the future. Clearly there is currently some uncertainty following Brexit about the funding mechanism for this, but there is an expectation that breeding waders will remain a high priority within a new agri-environment scheme. Natural England have made it clear that they will ensure that maintenance of scrapes and ditches created under the LIFE Waders for Real project will be written into new agri-environment scheme agreements as farmers in the Avon Valley renew contracts. We have also discussed with landowners the need for on-going maintenance of features and hopefully the response of the waders will provide a good motivation for them to take responsibility for this. Through our socio-economic questionnaires, all farmers surveyed agreed that they plan to continue inputting some of the conservation measures for waders beyond the project.

References

Batáry, P. *et al.* (2015) 'The role of agri-environment schemes in conservation and environmental management', *Conservation Biology*, 29(4), pp. 1006–1016. doi: 10.1111/cobi.12536.

Beintema, A. J. (1994) 'Condition indices for wader chicks derived from body- weight and bill-length', *Bird Study*, 41(1), pp. 68–76. doi: 10.1080/00063659409477199.

Berg, A., Lindberg, T. and Källebrink, K. G. (1992) 'Hatching Success of Lapwings on Farmland: Differences between Habitats and Colonies of Different Sizes', *Journal of Animal Ecology*, 61(2), pp. 469–476. doi: 10.2307/5337.

Bolton, M. *et al.* (2007) 'The impact of predator control on lapwing Vanellus vanellus breeding success on wet grassland nature reserves', *Journal of Applied Ecology*, 44(3), pp. 534–544. doi: 10.1111/j.1365-2664.2007.01288.x.

Burgess, J., Clark, J. and Harrison, C. M. (2000) 'Knowledges in action: An actor network analysis of a wetland agri-environment scheme', *Ecological Economics*, 35(1), pp. 119–132. doi: 10.1016/S0921-8009(00)00172-5.

Eglington, S. M. *et al.* (2008) 'Restoration of wet features for breeding waders on lowland grassland', *Journal of Applied Ecology*, 45(May), pp. 305–314. doi: 10.1111/j.1365-2664.2007.0.

Evans, K. L. (2004) 'The potential for interactions between predation and habitat change to cause population declines of farmland birds', *Ibis*, 146(1), pp. 1–13. doi: 10.1111/j.1474-919X.2004.00231.x.

Kentie, R. *et al.* (2013) 'Intensified agricultural use of grasslands reduces growth and survival of precocial shorebird chicks', *Journal of Applied Ecology*, 50(1), pp. 243–251. doi: 10.1111/1365-2664.12028.

Kleijn, D. *et al.* (2006) 'Mixed biodiversity benefits of agri-environment schemes in five European countries', *Ecology Letters*, 9(3), pp. 243–254. doi: 10.1111/j.1461-0248.2005.00869.x.

Leigh, S. G., Smart, J. and Gill, J. A. (2017) 'Impacts of grassland management on wader nest predation rates in adjacent nature reserves', *Animal Conservation*, 20(1), pp. 61–71. doi: 10.1111/acv.12283.

MacDonald, M. A. and Bolton, M. (2008) 'Predation on wader nests in Europe', *Ibis*, 150, pp. 54–73. doi: 10.1111/j.1474-919X.2008.00869.x.

Natural England (2015) *Countryside Stewardship Manual*. NE608; Natural England. Available at: www.gov.uk/countrysidestewardship.

Newton, I. (2004) 'The recent declines of farmland bird populations in Britain: an appraisal of causal factors and conservation actions', *Ibis*, 146(4), pp. 579–600. doi: 10.1111/j.1474-919X.2004.00375.x.

Roodbergen, M., van der Werf, B. and Hoetker, H. (2012) 'Revealing the contributions of reproduction and survival to the Europe-wide decline in meadow birds: review and meta-analysis', *Journal of Ornithology*, 153(1), pp. 53–74. doi: 10.1007/s10336-011-0733-y.

Teunissen, W. *et al.* (2008) 'Identifying predators of eggs and chicks of Lapwing Vanellus vanellus and Black-tailed Godwit Limosa limosa in the Netherlands and the importance of predation on wader reproductive output', *Ibis*, 150, pp. 74–85. doi: 10.1111/j.1474-919X.2008.00861.x.

Wallander, J., Isaksson, D. and Lenberg, T. (2006) 'Wader nest distribution and predation in relation to man-made structures on coastal pastures', *Biological Conservation*, 132(3), pp. 343–350. doi: 10.1016/j.biocon.2006.04.026.

Whittingham, M. J. and Evans, K. L. (2004) 'The effects of habitat structure on predation risk of birds in agricultural landscapes', *Ibis*, 146(s2), pp. 210–220. doi: 10.1111/j.1474-919X.2004.00370.x.

Wilson, A. M., Ausden, M. and Milsom, T. P. (2004) 'Changes in breeding wader populations on lowland wet grasslands in England and Wales: causes and potential solutions', *Ibis*, 146, pp. 32–40. doi: 10.1111/j.1474-919X.2004.00371.x.

Annexes

Annex 1 Relationship between winter rainfall and lapwing productivity.

Avon Valley winter rainfall, readings from Hurn (November-March) and lapwing productivity (chicks fledged per pair) during 2007-2014.