Habitat restoration for curlew *Numenius arquata* at the Lake Vyrnwy reserve, Wales

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SUMMARY

Changes were made to the management of moorland and adjacent in-bye land at the Royal Society for the Protection of Birds' Lake Vyrnwy reserve in Wales with the aim of improving breeding habitat for Eurasian curlew *Numenius arquata*. Areas of tall, rank, moorland vegetation were cut to provide a mosaic of short areas for foraging and taller areas for nesting habitat. Some new moorland pools were also created, and enclosed improved grassland was managed with the aim of reducing compaction and improving invertebrate levels. The initial response of the breeding curlew population was encouraging but short-lived, although the population has remained at a slightly higher level than before the management was carried out.

BACKGROUND

Eurasian curlew *Numenius arquata* are ground nesting wading birds that breed on various open upland habitats, such as bogs, moorland, and hay meadows, as well as on coastal marshes and lowland farmland. Curlew are usually associated with damp habitats, and prefer a heterogeneous mosaic of short and longer vegetation (Pearce-Higgins & Grant 2006). Nests are often located in or next to taller vegetation but curlews tend not to nest in very dense vegetation, as they are highly mobile and need to be able to move freely whilst using cover to evade predators. Curlews feed on a wide range of invertebrates both in the soil, and on the ground surface and plants. Their characteristic bill can be used for probing into soft ground and also tussocky vegetation.

Curlew have undergone extensive declines across the whole UK including Wales. The long term UK trend (1970-2010) shows a 61% decline (Eaton *et al.* 2012), whilst the Breeding Bird Survey trend shows a 45% decline between 1995 and 2011 (Risely *et al.* 2013). As a result the curlew is amber listed in the UK (Eaton *et al.* 2009). In Wales, curlew are red listed, and a repeat sample survey in 2006 showed that there were only 1,099 pairs of breeding curlews, representing an 81% decline since 1993 (Johnstone *et al.* 2007). Until the turn of the millennium, the Welsh wintering population was about 25% above the baseline level of 1974, but since 2000 has dropped back (Johnstone *et al.* 2010). Similar declines have also been seen in Northern Ireland, and this has been attributed to low breeding productivity due to a reduction in habitat quality and/or increased predation (Grant *et al.* 1999, Henderson *et al.* 2002).

At the Royal Society for the Protection of Birds (RSPB)'s Lake Vyrnwy reserve, Powys, a mixture of Repeat Upland Bird Surveys (Sim *et al.* 2005) and other ad hoc monitoring show a declining curlew population over the 28 years up to 2006. Between 1978 and 1986 the curlew population ranged between 12 and 32 pairs with a mean of 24 pairs each year. In a 1983-1990 management plan curlew were described as breeding throughout the reserve in all suitable habitats. However, during the 1990s the number of pairs only reached double figures in one year and the mean number of pairs was 6.6. Between 2000 and 2006 the mean declined to two pairs. Furthermore, between 1996 and 2006 productivity only reached or exceeded the target (0.48 chicks per pair) needed to maintain the population in two years.

Given this trend combined with visual assessment of habitat characteristics in relation to curlew habitat preferences (Pearce-Higgins & Grant 2006) we hypothesized that the habitat may have become too uniform with rank moorland vegetation and very short adjacent improved grassland. We therefore concluded that habitat management should aim to create a more heterogeneous sward that would feature taller vegetation suitable for nesting in close proximity to, and intermixed with, short mown "lawns" and pathways for foraging that could also be more easily traversed by chicks. Wet features would also be created as additional potential foraging sites, and adjacent in-bye land (enclosed upland farmland used as in this case for improved grassland, or for either arable cultivation or unimproved grassland) would be managed to improve invertebrate populations and their availability to curlew.

ACTION

The project area for curlew management at the Lake Vyrnwy reserve was comprised of six compartments covering 441.4 ha, and containing 370.8 ha of moorland and 70.6 ha of adjacent in-bye land. Between 2007 and 2011 habitat management was carried out on five of these compartments. Targeted management was conducted on at least part of each compartment, and each parcel of land was also grazed by sheep, cattle, ponies, or a combination of these animals. The sixth compartment comprising 2.7 ha of in-bye land was grazed only.

Moorland management included cutting rank moorland vegetation such as grass and rush, and creating new small moorland pools through the construction of dams, and was carried out before the breeding season in March and early April. A total of 52.6 ha of lawns and pathways were cut into rank vegetation with 23 ha cut in 2007, 19.9 ha cut in 2008 and 9.7 ha cut in 2009. The lawns varied in size and shape but were in the region of 2 to 5 ha. In addition lawns were re-cut prior to each breeding season if the vegetation was growing back rapidly. A total of 13-14 pools were created using either a 360° Hymac digger (2007 and 2008) or a rotary ditcher (2009). Some of these pools became closed over

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ISSN 1758-2067

Table 1. Curlew breeding records at Lake Vyrnwy from 2003-2006 (prior to the curlew project), 2007-2011 (during the project), and 2012-2015 (after the project). Note more intensive monitoring of the project area 2008-2011.

Year	Total pairs	Pairs on the project area	Nesting attempts on project area	Known nesting attempts on rest of reserve	Fledged	Productivity on reserve (chicks fledged/pair)
2003	3					
2004	2					
2005	1					
2006	2					
2007	8-9	5	Unknown	Unknown	Unknown	Unknown
2008	5	5	3	0	4	0.8
2009	4	3	4	0	1	0.25
2010	3	2	3	1	1	0.33
2011	2	1	1	1	1*	0.5
2012	4					
2013	4					
2014	3					
2015	3					

*from pair off project area

with vegetation and were opened up again in 2011. In late June and early July 2011 extensive areas of soft rush *Juncus effusus* were weed wiped to break them up, and weed wiping was also used to manage heath rush *Juncus squarrosus* which began to spread in response to the cutting. Weed wiping brushes herbicide onto plants and allows a more targeted application than spraying.

In-bye management was targeted at reducing compaction, and increasing the pH and organic component of the soil. Three different treatments were applied in September 2007: (i) 10.2 tons of lime ('Calcipril' granulated lime) were applied to 9 ha of land in two compartments; (ii) some areas received scarification using a surface slitter, and (iii) some land was treated with a vibrating sub-soiler called a shakaerator (McConnel two legged shakaerator fitted with grassland kit), operated at a depth of about 25 cm. In order to improve soil fertility of in-bye land in 2008 50 tons of plant material that had been cut from the project area and composted was spread on one area of land, and 150 tons of similar material that had been mixed with farm yard manure was spread on two other areas of land. In 2009 and 2010 farm yard manure was spread over some of the in-bye land at a rate of 10 tons/ha.

Land involved in the trial was under the management control of three different parties, with two separate farming tenancies, and the remaining land managed by the RSPB. The type and location of management on the project area was discussed between RSPB staff and the farmers, taking account of farming operations and the local terrain. Management and progress of the project was reviewed after each breeding season.

Targeted monitoring of the curlew project area from 2008 allowed the location and success of nesting attempts to be recorded. A modified Brown and Shepherd (1993) survey, involving transect surveys over five visits, was used to establish the number of pairs and an estimate of productivity. Where possible, nests were located and monitored, including the use of motion triggered nest cameras. Additional observations gathered information on habitat use and brood movements. Prior to this work, the curlew population was monitored as part of the general reserve monitoring.

To assess the soil invertebrate food resources available to curlew, in 2009 and 2010 soil cores were taken using a soil corer 10.5 cm in diameter by 10 cm in depth. In each year eight samples were taken from each in-bye treatment area (shakaerated, slitted, limed, control), from moorland lawns first cut in 2007, 2008 and 2009, and from around the moorland pools. Each core was carefully sorted through by hand and the invertebrates present identified and counted. The total mass of all invertebrates in a sample was measured using a digital balance to the nearest 0.01 g. At each sample location, as well as the soil core, three soil penetrometer readings were taken.

CONSEQUENCES

Curlew response to management: The initial response to the moorland management carried out was encouraging with five pairs of breeding curlew on the project area and three or four additional pairs elsewhere on the reserve in 2007 (Table 1). The same number of pairs were found on the project area in 2008 but with no others identified on the reserve. However, in following years the number of pairs gradually reduced (Table 1), although since the project finished numbers have remained at a slightly higher average level than in the years immediately before it started.

Weather data from the Cwmystwyth weather station were obtained to consider if conditions in spring in 2009-2011 differed

Table 2. Mean weather data from the Cwmystwyth weather station comparing years 2009-10/11 (2011 data only available for March) with the previous 23 years.

Month	Years	Mean maximum temp (°C)	Mean minimum temp (°C)	Mean rainfall (mm)
March	2009-11	9.2	1.4	82.8
March	1986-2008	8.4	2.2	154.9
April	2009-10	12.8	3.7	67.7
April	1986-2008	10.8	3.2	116.8
May	2009-10	14.2	5.4	98.8
May	1986-2008	14.5	6.1	104.8

ISSN 1758-2067

Table 3. Outcomes of individual curlew nesting attempts on the project area at Lake Vyrnwy 2008-2011

Year	Nesting attempt	Hatched	Predated	Trampled	Abandoned	Notes
2008	1		Yes			Culprit unknown, believed to be fox or badger, but could have been sheep
2008	2	Yes				Fledged 3 or 4 chicks
2008	3		Yes			By sheep
2009	1		Yes			Unknown species
2009	2		Yes			Culprit unknown but possibly corvid, partial brood loss suspected prior to nest was found
2009	3	Yes				Clutch of three eggs, one chick fledged
2009	4				Yes	Following disturbance by sheep
2010	1	Yes				Fledged one chick
2010	2		Yes			By fox
2010	3			Yes		By cattle
2011	1	Yes				Not believed to have fledged any chicks
Total % of nests		**36**	**46**	**9**	**9**	

from the longer term averages (Table 2). March and April in these three years appear to have warmer maximum temperatures and lower rainfall.

Nest location: The general location of nest sites was quite variable through the project. Some nests were situated on cut areas, others were just off the edge of cuts, and some were 100-300 m away from the nearest cut area. The exact nest sites also varied considerably, with nests located in tall rank grass and rush, on tall mossy tussocks in very wet sphagnum dominated areas, on the ground amongst shorter tussocks of cottongrass *Eriophorum sp.*, and on the ground in dry, cut grassy areas.

Nest success and productivity: A total of 11 curlew nests were located on the project area between 2008 and 2011. Four of these nests hatched some chicks (Table 3). Four nests were predated by wild animals and whilst nest cameras were used on some of the nests, the only definitively identified predation by a wild animal was attributable to a red fox *Vulpes vulpes*. Of the remaining three, using signs at the nest, one was believed to have been by red fox or European badger *Meles meles*, one by a corvid, and the other predator was unidentified. The three remaining nests were affected by livestock. In 2008 the eggs from one nest were predated by sheep, whilst in 2009 a nest was repeatedly disturbed by sheep and the female abandoned the nest. After this attempts were made to keep sheep away from known nests by removing them from compartments or using temporary fencing. In 2010 cattle broke through a temporary fence erected to reduce disturbance and trampled a nest.

Calculation of daily nest survival rates (Mayfield 1975) for the egg stage only, showed a daily survival rate of 0.97, which, assuming a 28 day incubation period, gives a probability of a nest surviving to hatching of 0.41. These figures are towards the higher end of the range of survival rates found in a study of curlew breeding success and causes of breeding failure in Northern Ireland (Grant et al. 1999). It is believed that three of the four nests that hatched fledged chicks, but that partial brood loss occurred in at least three broods. The causes of brood loss is not known.

Breeding productivity on the reserve was quite variable between years ranging from 0.25-0.8 chicks per pair, with fledged chicks coming from the project area in every year with targeted monitoring apart from 2011.

Use of the project area by curlew: Curlew were seen across most of the project area. Broods ranged over a number of kilometres through the breeding season as the chicks grew to fledging. Adult birds were seen using the in-bye land for foraging in the early years of the project, but this activity was much reduced in subsequent years. In 2008, these fields were wet and earthworm casts were prevalent, whereas in 2009-2011 the fields were drier, and the availability of earthworms may have been lower. In 2011, adults and chicks were seen feeding on in-bye which presumably was wetter in the later part of the season.

Pools were used for foraging in 2007 and 2008, but as they became increasingly vegetated and less open their suitability apparently declined. Other wet flush areas on the moorland were used with adults foraging around them. Adult curlew ranged widely and regularly fed over open tussocky areas of blanket bog and dry heath. The majority of foraging involved picking invertebrates off the vegetation, but occasional probing was also witnessed. The use of lawns was witnessed in 2008, but in subsequent years the use of large open areas of low uniform vegetation that had been repeatedly cut was limited, with most activity targeted at the edges of cuts. In 2011 when no areas had been re-cut, the sward on the lawns was still more open and uniform than the uncut moorland, but they did show varying degrees of reversion and became commonly-used foraging areas for adults and chicks.

Soil invertebrates: The results suggested that the in-bye land held more soil fauna biomass than the moorland. Beetle larvae were the most frequently recorded invertebrate group in 2010, and second most frequently recorded in 2009. Earthworms were the most frequently recorded group in 2009 but were scarce in 2010. In both years earthworms and then tipulid larvae constituted the majority of the biomass in the samples. Shakaerated land appeared to hold the greatest biomass, but was the only in-bye treatment to have a

ISSN 1758-2067

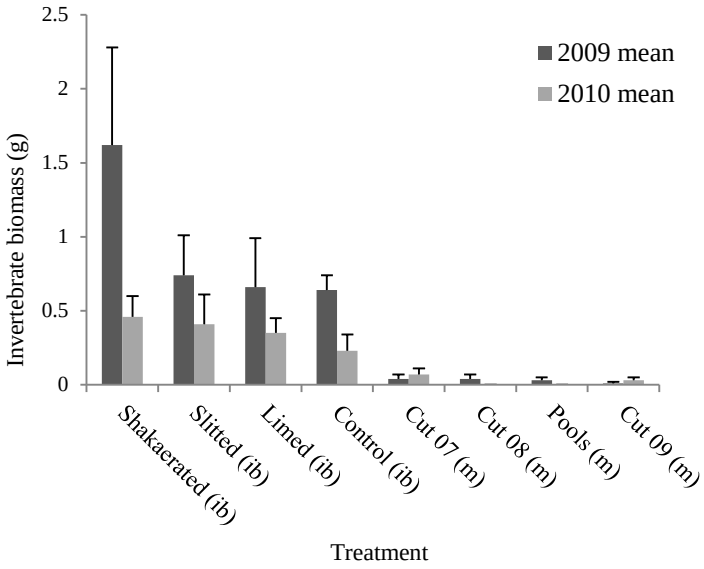

Figure 1. Mean soil invertebrate biomass in each treatment type in 2009 and 2010. Error bars show one standard error above the mean. Treatments marked (ib) are on in-bye land, those marked (m) are on moorland.

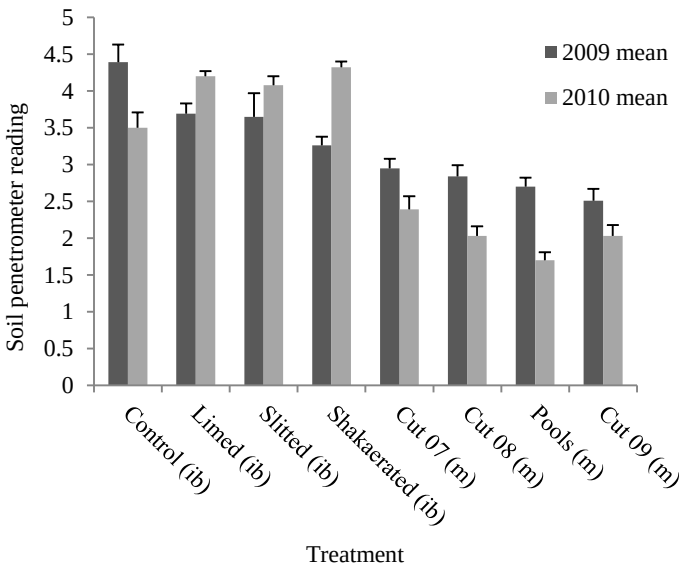

Figure 2. Mean (+ S.E.) soil penetrometer reading in each treatment type in 2009 and 2010. The penetrometer scale goes from 0-4.5. Lower numbers indicate more penetrable soils. Any reading greater than 4.5 was recorded as 4.5 for calculation of the mean; this occurred if the penetrometer had reached the top of the scale but had not actually penetrated the soil. Treatments marked (ib) are on in-bye land, those marked (m) are on moorland.

notable effect compared to non-treated in-bye (Figure 1). However, the in-bye was less penetrable than the moorland, and de-compaction measures did not significantly affect this (Figure 2).

DISCUSSION

The habitat management targeted for curlew at Lake Vyrnwy appears to have yielded a short term increase in the breeding population of curlew on the reserve. It is possible that the sudden increase in the population merely coincided with the instigation of new management. However, whilst the initial extent of the increase was not sustained, the number of pairs on the reserve remained and has continued to remain higher than the mean between 1996 and 2006. This suggests that the habitat management has yielded some benefit to the birds.

The reasons why the increase in numbers was not sustained is not clear, and various factors may have been involved. Observations suggested that in April there were often more birds present than stayed to set up territory. A series of dry springs between 2009 and 2011 may have affected the habitat condition at the time when birds would be prospecting for territories. Weather data suggest that March, April, and May in these three years were drier and warmer than the 25 year mean.

Soil fauna assessments showed that there was greater biomass of soil invertebrates in the in-bye land than in the moorland, but also that in-bye land was less penetrable. The in-bye land was used at times for foraging by curlews, mainly in the first two years of the project. It therefore seems likely that although soil invertebrates were more prevalent on the in-bye land they were less available to curlews if the soil was dry and hard. In these conditions, the birds must rely more on gleaning food from the surface of vegetation and probing into tussocks.

The project has indicated a number of factors that need to be considered further such as the scale of habitat mosaic best suited for curlew and how best to achieve it with a combination of vegetation cutting and grazing. It appears that a finer mosaic of short and long vegetation is preferable, and rather than re-cutting existing short areas, a rotational cutting approach may help to alleviate the issues related to re-cuts.

The results of the curlew monitoring from the project have shown that nesting success was variable between years. Productivity across the whole reserve was at a level sufficient to maintain the population in two of the four years of full monitoring, but in 2011 this was reliant on a chick fledging off the project area.

The productivity target for curlew on the reserve is 0.48 chicks per pair, derived from the range of productivity figures that Grant *et al*. (1999) suggested was required to maintain a stable population. This target was achieved in two of the four years, albeit with birds nesting off the project area in 2011. In their study Grant *et al*. (1999) found productivity levels ranging between 0.14 and 0.47 fledglings per pair, and note that the figures are lower than most estimates of curlew productivity from other studies.

Curlew nesting success is known to be a key driver of population trends (Douglas *et al.* 2014). Unfortunately due to some issues with the nest cameras not all of the nest predators could be identified, but some interesting results were obtained. As well as expected predators such as fox and possibly crow, the involvement of sheep with nest failure was more of a surprise. Although chick loss to herbivores including sheep has been documented previously in ground nesting birds (Furness 1988), the pattern of behaviour with predation of eggs and repeated disturbance of the nest was not expected. These findings highlight the potential issues for nesting curlew with the presence of livestock and the need to consider excluding grazing animals from areas with nests until the chicks have hatched.

ISSN 1758-2067

ACKNOWLEDGEMENTS

We would like to thank Roy Bamford and Fiona Walker for their work on the project.

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ISSN 1758-2067