# Assessing the vegetation response to differing establishment methods of 'Skylark Plots' in winter wheat at Grange Farm, Cambridgeshire, England

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**SUMMARY**

Skylarks *Alauda arvensis* have declined by 53% across Britain since 1970, primarily in regions dominated by lowland farmland. To improve breeding opportunities in arable farmland, 'Skylark Plots' i.e. small (16-24 $m^2$) unsown areas within winter cereal crops, were developed by the RSPB and tested in the Sustainable Arable Farming For an Improved Environment (SAFFIE) project. These plots increased the number of late summer breeding attempts and the number of chicks fledged per nest, compared to conventional crops. Skylark Plots are now included as a prescription in the Entry Level Stewardship (ELS) agri-environment scheme in England. The plots are usually created by turning off the seed drill during sowing. However, take up of this prescription has been very low; pernicious weed control and technical difficulties with sowing machinery have been cited as reasons for this. To broaden the appeal to farmers, the option to create the plots through herbicide spraying to remove the germinating crop, was introduced in 2008. Data on the optimum period for spraying and differences in vegetation architecture between undrilled and sprayed skylark plots was lacking however. As evidence from the SAFFIE project showed that plots with greater vegetation cover had higher invertebrate abundance and that skylarks use plots primarily when foraging for invertebrate chick food, the present study was conducted to compare the vegetation cover in undrilled plots with plots sprayed either in December, January or February (during crop germination).

The study showed that undrilled plots consistently had greater vegetation cover than sprayed plots, with the cover increasing in all plots from May to July (whilst remaining suitable for skylark use), the peak period of the skylark breeding season. Vegetation cover within sprayed plots was generally very low, particularly in February-sprayed plots. These differences in vegetation cover are likely to subsequently impact the abundance and accessibility of invertebrate prey available to skylarks during the breeding season with February-sprayed plots in particular being unsuitable for skylark foraging even in July. Our recommendation is that where possible, plots should be created at the time of sowing (turning off the seed drill) in autumn; if spraying is the favoured method of creation then this should take place no later than the end of December.

## BACKGROUND

The skylark is one of the most widespread British birds. In 1997, it was estimated that there were 1 million pairs of skylarks in Britain, with over 50% of these nesting on arable land (Browne *et al*. 2000). However, skylarks are estimated to have declined by 53% between 1970 and 2007 (Eaton *et al*. 2009), equivalent to the loss of approximately 3 million breeding birds on all farmland habitats between 1975 and 1994 (Wilson *et al*. 1997). As such, skylark is now included on the Red list of Birds of Conservation Concern in the United Kingdom (Eaton *et al*. 2009). Consequently, there have been many recent ecological studies to determine the causes of this decline (Robinson 2001, Wilson 2001, Donald *et al*. 2002). In particular, the study by Donald *et al*. (2002) highlighted poor productivity in winter sown cereals. As a ground nesting species, skylark is likely to have a naturally high nest failure rate due to predation. However, being multi-brooded, they can lay up to three, rarely four, clutches during a single breeding season. This appears not to be possible in winter sown cereal crops. As the cereals mature, from mid May onwards, through the booting stage (Zadock scale 40-49 [Zadock *et al*. 1974]), the height increases rapidly from initially around 30 cm to over 50 cm, at which stage the crop structure becomes unattractive to skylarks seeking to make subsequent nesting attempts (Donald & Vickery 2000). They thus turn towards more open areas, which in winter sown cereal fields are often the tramlines used by agricultural vehicles during fertilising or spraying operations, where nest survival rates are low due to predation by animals using the tramlines to traverse the dense crop, and destruction during agricultural activities, although the latter is at a very low level (Donald *et al*. 2002).

During 2002-2006 a research project (SAFFIE 2007), investigated measures which could potentially deliver a mechanism to provide suitable nesting sites once cereal crops begin to mature (Morris 2007). The undrilled patches (skylark plots) were established at the time of sowing by temporarily switching off the seed drill creating bare patches of 16-24 $m^2$ at a density of 2/ha. To reduce access to mammalian predators, patches were not connected to tramlines. They subsequently received all the agrichemical inputs conventionally applied to cereal fields (fertiliser and biocides) but despite applications of herbicides, the lack of competition from the crop permits limited growth of broad-leaved plants and grasses. Skylark plots were successful in increasing the number of late summer breeding attempts and enabled skylarks to raise 0.5 more chicks per nest, than in conventional crops (Morris *et al*. 2004, 2007).

Skylark plots have now been incorporated as an option (EF8) in Entry Level of Environmental Stewardship (ELS) agri-environment scheme in England (Natural England 2008), although uptake of this option has been particularly low with only 1.3% of agreements having skylark plots by June 2009 (Natural England unpublished data). Initially, ELS management guidelines required that plots were created by not drilling at the time of sowing, the management technique tested in the SAFFIE experiment. The option of spraying out areas of germinated cereals was subsequently introduced into ELS to enable those farmers who had technical difficulties with creating them with sowing machinery to take up this option by spraying out the plots by 31 December with an appropriate herbicide. However, the timing of spraying may be critical in terms of achieving the balance between providing sufficient vegetative cover to encourage high abundance of invertebrates, without impeding access to foraging birds, and pernicious weed control. A trial to investigate the vegetative response of four establishment techniques was therefore carried out to further inform conservationists, farmers and decision makers as to the appropriateness, and timing, of using herbicides as a method for establishing skylark plots that provide sufficient herbaceous growth to be potentially attractive to invertebrate food and skylarks.

## ACTION

**Study site:** The trial took place at Grange Farm, Cambridgeshire (OS grid ref: TL3362) in eastern England. Grange Farm is an arable farm (181ha) managed by the Royal Society for the Protection of Birds (RSPB), with a cropping rotation of winter wheat: winter oil-seed rape: winter wheat: spring beans. The soil at the trial site is Hanslope calcareous clay loam (Anon. 1985).

**Methodology:** The trial was conducted in 2008-2009 on two winter wheat fields (total areas 39.74 ha in 2008 and 32.42 ha in 2009). In both years, one of the fields followed winter oil-seed rape and the other followed spring field beans in the cropping rotation. Four methods of plot establishment were trialled:

One quarter of the plots (Table 1) in each field were established during the drilling of the wheat in September (26 September 2008 and 19 September 2009), with the location of the undrilled plots decided independently by the farming contractors in accordance with ELS guidelines. The remaining plots were sprayed out (with glyphosate herbicide) in December, January or February, until the density of plots was at least 2/ha, in line with ELS requirements (Table 1).

**Table 1.** Location and number of skylark plots in the study fields during 2008 and 2009 at Grange Farm.

| | 2008 | | 2009 | |
|---|---|---|---|---|
| | Field A | Field B | Field C | Field D |
| Field size (ha) | 23.96 | 13.21 | 21.00 | 9.39 |
| Total number of plots | 41 | 24 | 40 | 16 |
| Number of undrilled plots | 11 (3) | 6 (2) | 10 (3) | 4 (2) |
| Number of plots sprayed out in December | 10 (3) | 6 (2) | 10 (3) | 4 (2) |
| Number of plots sprayed out in January | 10 (3) | 6 (2) | 10 (3) | 4 (2) |
| Number of plots sprayed out in February | 10 (3) | 6 (2) | 10 (3) | 4 (2) |

**Note:** Number of plots of each establishment type that were assessed in parenthesis.

The location of the sprayed out plots was selected randomly within the study fields using a 25 x 25 m grid. If any plot fell within 50 m of the boundary of each field it was not created and a new plot was selected. This buffer zone around each field was maintained to minimize the possible increased predation risk caused by the presence of 6 m-wide grass margins around the boundaries of all fields (Morris & Gilroy 2008). All subsequent applications of fertilisers, herbicides, insecticides and other agri-chemicals were applied to the whole of each field without regard for presence of skylark plots.

Samples of each establishment type were assessed in each field, with the proportion of plots from each establishment type being equal (Table 1). Vegetation assessments were made in May, June and July of each year. A 0.25 $m^2$ quadrat was placed 10 times along a diagonal running between the opposite corners of each plot being assessed. Each quadrat was subdivided into 25, 10 x 10 cm compartments. The presence of the following was scored for each compartment in each quadrat (giving a maximum score of 25 for each category): bare ground; crop, blackgrass *Alopecurus myosuroides*; and charlock *Sinapis arvensis* (the two prevalent, and pernicious, weed species). Maximum vegetation height was measured in each of the 10 quadrats in each plot. Due to resource limitations, no monitoring of invertebrates or skylark use of each plot was undertaken.

**Statistical analysis**: Vegetation data analyses were performed using Binomial Trials Modelling in SAS (SAS Institute Inc.), using procedure GLIMMIX. All GLIMMIX models were constructed with 'plot' identity included as a random factor. Analysis for vegetation height was performed using Generalised Linear Modelling, using procedure MIXED, with the data being transformed, ln (x+1). Other terms included in all models were establishment type, year, previous crop and all two- and three-way interactions. The model was run for each of the three assessment months individually. Overdispersion in the datasets was automatically corrected by SAS procedures. All results presented are from the full models, although minimum adequate models (MAM) were produced by the stepwise removal of non-significant variables to check the robustness of the results from the full models. Terms that were significant ($P$<0.05) in the full models did not differ from those in the MAMs.

## CONSEQUENCES

Method of establishment was the main factor in explaining the variation in vegetation cover between plots with the exception of charlock in all months and the proportion of bare ground in July (Table 2). The significance and direction of year and previous crop effects were inconsistent. In general, plots following spring beans had a lower proportion of bare ground and higher vegetation cover than plots that followed oil-seed rape. The only significant predictors of charlock cover were year in May and previous crop in July. Charlock occurred above the threshold for herbicide control in all fields in both years. Consequently, herbicide was applied in late May in each year, with a rapid decline in abundance of charlock thereafter. None of the interaction terms that it was possible to test were significant.

**Table 2.** Vegetation cover in skylark plots during May, June and July showing significance of treatment effects. Interaction terms not included, as in all cases they were insignificant. Establishment: 1 = undrilled, 2 = December, 3 = January, 4 = February. SB = spring barley, OSR = oilseed rape. Note: 1. Factor-level contrasts (significance level, *P*<0.05): << = significantly less, < = less but not significant, >> = significantly more, > = more but not significant, = treatments equal

| **May** | Bare Ground | | Wheat Crop | | Blackgrass | | Charlock | |
|---|---|---|---|---|---|---|---|---|
| | Effect | P | Effect | P | Effect | P | Effect | P |
| Establishment | 1<<3<2<4 | $F_{3,398}$ = 4.88 ** | 1>>3>2>4 | $F_{3,398}$ = 8.5 *** | 1>>3>4>2 | $F_{3,398}$ = 10.17 *** | 3<1<2<4 | $F_{3,39\,8}$= 0.1 ns |
| Year | 2008<< 2009 | $F_{1,398}$ = 4.44 * | 2008< 2009 | $F_{1,398}$ = 2.14 ns | 2009>> 2008 | $F_{1,398}$ = 20.61 *** | 2008>> 2009 | $F_{1,398}$ = 6.05 * |
| Previous crop | SB < OSR | $F_{1,398}$ = 9.92 ** | SB > OSR | $F_{1,398}$ = 0.76 ns | SB > OSR | $F_{1,398}$ = 8.71 ** | SB > OSR | $F_{1,398}$ = 3.61 ns |

| **June** | Bare Ground | | Wheat Crop | | Blackgrass | | Charlock | | Height | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Effect | P | Effect | P | Effect | P | Effect | P | Effect | P |
| Establishment | 1<<3< 2<4 | $F_{3,39\,8}$= 5.74 ** | 1>>2> 3>4 | $F_{3,398}$ = 7.08 ** | 1>>2> 3>4 | $F_{3,398}$ = 7.52 *** | 2<4<1 <3 | $F_{3,398}$ = 0.19 ns | 1>>3>2> 4 | $F_{3,398}$ = 3.81 * |
| Year | 2008>> 2009 | $F_{1,398}$ = 30.67 *** | 2008< 2009 | $F_{1,398}$ = 0.22 ns | 2008 << 2009 | $F_{1,398}$ = 5.35 * | 2008 = 2009 | $F_{1,398}$ = 0.0 ns | 2008 << 2009 | $F_{1,398}$ = 8.57 ** |
| Previous crop | SB > OSR | $F_{1,398}$ = 1.22 ns | SB > OSR | $F_{1,398}$ = 0.26 ns | SB > OSR | $F_{1,398}$ = 3.72 ns | SB < OSR | $F_{1,398}$ = 0.77 ns | SB = OSR | $F_{1,398}$ = 0.01 ns |

| **July** | Bare Ground | | Wheat Crop | | Blackgrass | | Charlock | | Height | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Effect | P | Effect | P | Effect | P | Effect | P | Effect | P |
| Establishment | 1<3<2 <4 | $F_{3,398}$ = 2.33 ns | 1>>2> 3>4 | $F_{3,39\,8}$= 7.84 *** | 1>>2> 3>4 | $F_{3,398}$ = 9.30 *** | 1<3<4 <2 | $F_{3,398}$ = 0.3 ns | 1>>3> 2>4 | $F_{3,398}$ = 3.25 * |
| Year | 2008<< 2009 | $F_{1,39\,8}$= 29.92 *** | 2008> 2009 | $F_{1,398}$ = 0.11 ns | 2008< 2009 | $F_{1,398}$ = 1.73 ns | 2008> 2009 | $F_{1,398}$ = 0.27 ns | 2008 << 2009 | $F_{1,398}$ = 5.61 * |
| Previous crop | SB > OSR | $F_{1,398}$ = 5.68 * | SB < OSR | $F_{1,398}$ = 0.12 ns | SB < OSR | $F_{1,398}$ = 3.67 ** | SB < OSR | $F_{1,398}$ = 5.55 * | SB < OSR | $F_{1,398}$ = 2.26 ns |

The proportion of bare ground decreased consistently between months as the season progressed, particularly in undrilled plots (May mean 0.81, 95% CI 0.5-0.95; July mean 0.46, 95% CI 0.15-0.79). Plots which had been created through spraying saw less of a decrease, in all cases retaining >70% (>90% in the case of plots sprayed in February) bare ground into July (Fig, 1). This decline in the level of bare ground was in line with greater abundance of crop and blackgrass, particularly in undrilled plots (blackgrass: May mean 0.1, 95% CI 0.04-0.25; July mean 0.4, 95% CI 0.16-0.76). Crop, (Fig. 2) and blackgrass cover in sprayed plots remained low in all treatments (February sprayed: May mean 0.002, 95% CI 0.0006-0.01; July mean 0.006, 95% CI 0.001-0.026, Fig. 3).

As expected, the mean maximum height recorded in quadrats increased between June and July (Fig. 4), with undrilled plots having significantly taller vegetation (June mean 17.3cm, 95% CI 6.5cm – 44.9cm; July mean 29.3cm, 95% CI 10.8cm – 76.6cm) than sprayed off plots February sprayed: June mean 1.8cm, 95% CI 0.6 cm – 5.0 cm; July mean 4.0 cm, 95% CI 1.5 cm – 10.4 cm, Table 2). There was little difference between mean maximum height in plots sprayed in different months.

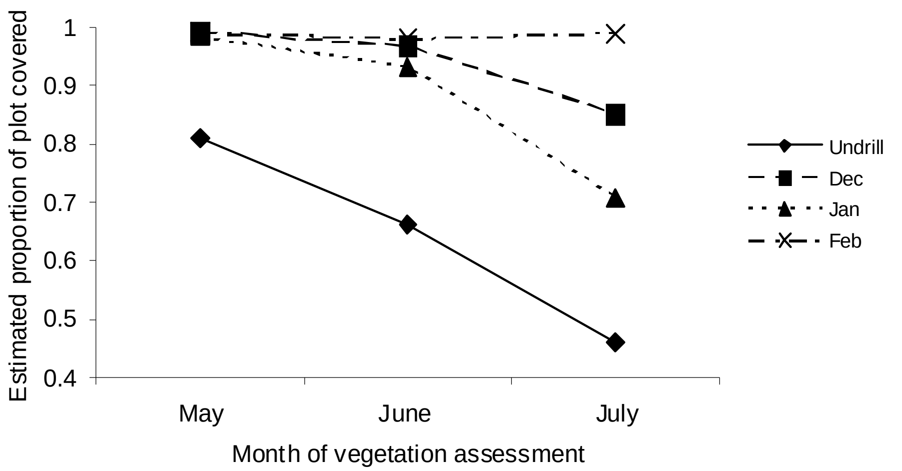


**Figure 1**. Estimated proportion of bare ground during May, June and July in skylark plots established by four treatments.

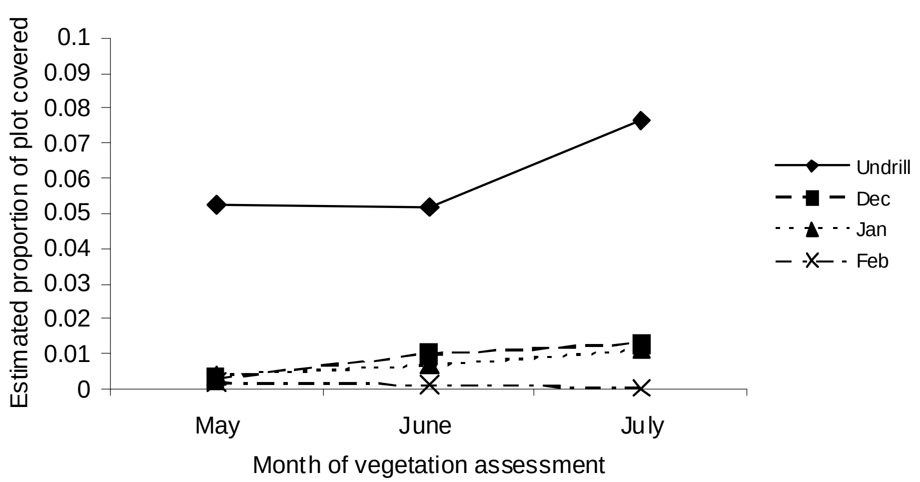


**Figure 2.** Estimated proportion of crop during May, June and July in skylark plots established by four treatments.

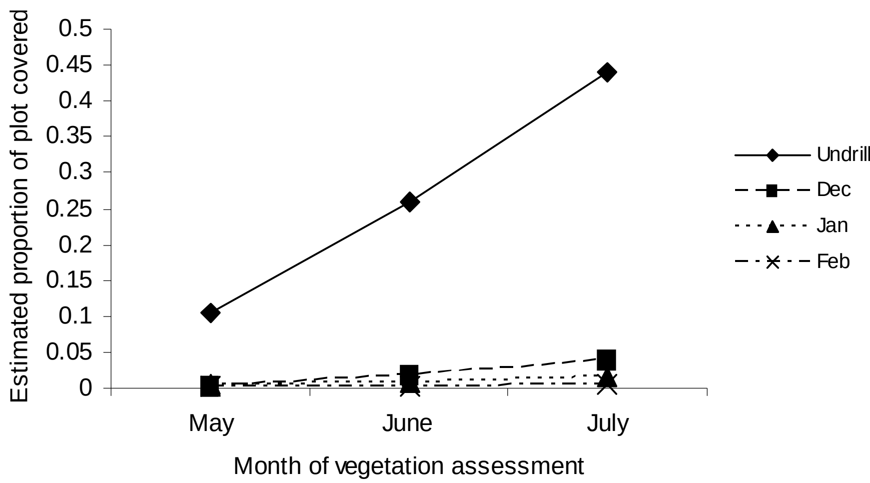


**Figure 3.** Estimated proportion of blackgrass during May, June and July in skylark plots established by four treatments.

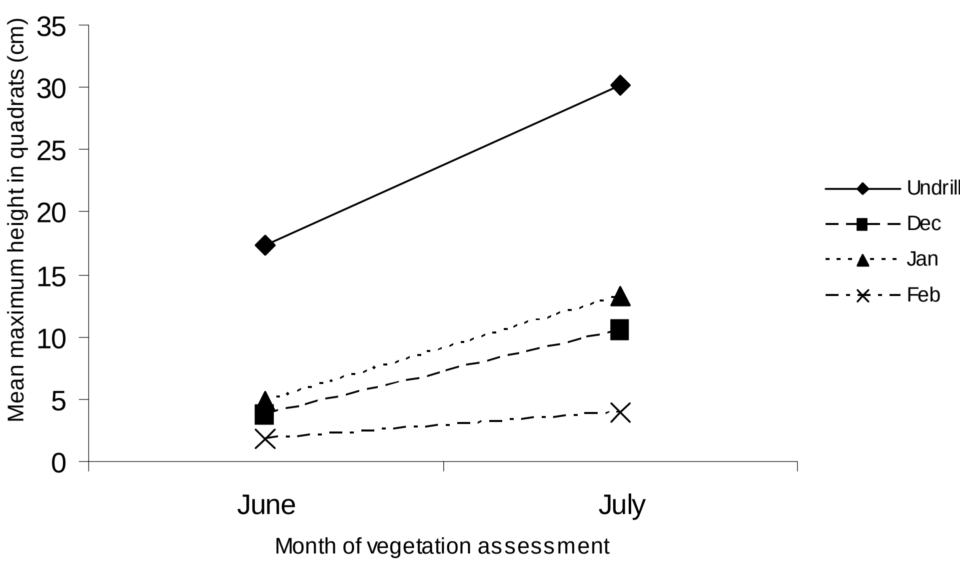


**Figure 4.** Estimated mean maximum height during June and July in skylark plots established by four treatments.

**Discussion:** Skylark plots in cereal fields have been clearly demonstrated as a low-cost practical tool to help reverse the considerable and long-term decline observed in the UK skylark population since 1970 (Harris *et al*. 2007). The greatest benefit of skylark plots appears to be providing additional foraging locations within the crop after the first breeding attempt (Morris *et al.* 2004, 2007). To fulfil this function, it is essential that the vegetation structure in the plots continue to remain sufficiently open to allow skylarks ready access to invertebrate chick food such as Carabidae, Staphylinidae, Araneae and Homoptera. A series of studies have shown that a mosaic of bare ground and vegetation may be beneficial in ensuring a balanced trade-off between ensuring an abundant food supply, access to that food supply and an ability to maintain adequate vigilance against predators (Moorcroft *et al*. 2002, Morris *et al.* 2002, Butler *et al*. 2005).

Smith *et al.* (2009) demonstrated that the number of invertebrates colonising skylark plots is very closely linked to grass cover and, particularly, broadleaved plant cover. It has been found that significant changes in invertebrate abundance are only likely to occur when a threshold of plant cover is reached (Speight & Lawton 1976, Sotherton 1982), with Smith *et al.* (2009) suggesting that this may be higher than most farmers would tolerate (as this cover comprises mostly pernicious weeds). It was clear in this study that there was great variation in the cover of blackgrass and charlock in undrilled plots, and that blackgrass cover increased from May to July. Visual observations suggest plots that had a high cover of blackgrass and charlock, also had greater cover of other broadleaved plants beneficial to invertebrates such as black bindweed *Fallopia convolvulus*, although this was not quantified in this study (Fig. 5). Whilst this may have provided a suitable environment for invertebrates, and thus foraging for skylarks, some farmers may view such ingress of weeds unacceptable, even though the plots cover a very small proportion of a cereal field, typically 0.003 - 0.01%. The sprayed plots had consistently significantly less vegetation cover than the undrilled plots, although those sprayed in December had slightly higher cover than those sprayed in January and February. The plots sprayed in February had particularly low vegetation cover, being almost completely bare (Fig. 6). Considering the findings of Smith *et al*. (2009), it is likely that the abundance of invertebrates in the sprayed plots, especially those created in January and February, will be low especially compared to undrilled plots.

**Figure 5.** Skylark Plot in June 2009 created by leaving an undrilled patch in September 2008 (Graham Uney©).

**Figure 6.** Skylark Plot in June 2009 created by spraying off in February 2008 (Graham Uney©).

Donald *et al.* (2002) found the height of the cereal crop to be one of the main causal factors in skylarks moving nest locations within cereal crops. Generally, once the crop had reached greater than 30 cm high, skylarks moved towards tramlines and other bare areas for foraging and nesting, perhaps due to limited ability to maintain adequate vigilance for predators whilst foraging and increasingly difficult access to the nest (Donald 2004). In this study, even the plots with greatest weed (broadleaves and blackgrass) cover would have still been sparse (c.50% bare) and short (c.30 cm) enough for use by skylarks in July, especially in comparison with the surrounding crop. Although none of the plots in this study were affected, a small number of skylark plots at Grange Farm have had a high ingress of wild oats *Avena fatua* and *A.ludoviciana*, which effectively rendered those plots unusable by late June (pers. obs.).

It is acknowledged that for skylark plots to have any influence on skylark populations they must be adopted on a wide scale and that to encourage use, this may involve compromises in the extent to which the vegetation (weeds) within plots is permitted to develop; hence the acceptance of spraying of plots with herbicides (as used on the surrounding crop). While plots sprayed in December may not have the diverse mosaic of vegetation that develops in undrilled plots, and will therefore probably support fewer invertebrates, a compromise of permitting plots to be established through spraying off emerging vegetation until this time may provide acceptable levels of food, access and shelter for skylarks. However, plots that are almost completely bare, such as those sprayed in January or February, are unlikely to deliver the necessary requirements of invertebrates or cover, and so will contribute little to skylark conservation.

**Conclusions:** For skylark plots to be effective in delivering invertebrate food, this study shows that they are best created at the time of drilling the crop in the autumn. In most cases, the agronomics also favours establishment at the time of drilling rather than spraying later during crop germination (Appendix 1). If implemented no later than the end of December, creation of plots using herbicide can provide added control of pernicious weeds (and thus plot establishment be more amenable to the farmer) whilst successfully creating areas more open than the surrounding crop but not bereft of vegetation. These results suggest that the current ELS guidelines should deliver benefits for skylarks but there is unlikely to be any gain if the spraying off period is extended beyond December, as resultant swards were too sparse to deliver suitable nesting or foraging habitat.

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**Appendix 1.** Economic analysis

The analysis (undertaken by Smiths Gore's farm management; www.smithsgore.co.uk/publications) compares 100 plots (a total of 0.16 ha), established at drilling or by spraying out, with an equivalent area of winter wheat.

| Variables | Winter wheat on 0.16 ha | Skylark plot undrilled | Skylark plot sprayed |
|---|---|---|---|
| Income | £163 | £500 (ELS payment) | £500 (ELS payment) |
| Variable costs | -£67 | -£59 | -£217 |
| Gross margin | £96 | £441 | £283 |
| Change in gross margin | | £345 | £187 |

**Assumptions:**

Wheat yield - 8.5 tonnes per ha
Wheat value - £120 per tonne
Income from plots - £5 per plot (ELS)

**Variable costs:**

- £ 50/ha seed
- £200/ha fertiliser
- £170/ha sprays
- knapsack spraying plots after drilling: 6 plots/hr @ £9/hr labour