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Protecting Farmland Pollinators: Whole Farm Scorecard - Experiences and Recommendations

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Abstract—Protecting Farmland Pollinators is about identifying small actions that farmers can take that will allow biodiversity to coexist within a productive farming system. Farmers in Ireland recognise the importance of pollinators, but farmland has experienced wide-scale loss of wild pollinators over the last fifty years.
By working closely with 40 farmers, management practices that benefit bees and hoverflies on Irish farmland were identified, and a whole farm pollinator scoring system was developed. Using a whole farm pollinator scorecard, farmers receive 'pollinator points' each year based on the amount and quality of pollinator friendly habitat maintained and/or created and, each year, farmers receive a results-based payment that relates to the points.
Irish farms have great potential to improve both the quantity and quality of biodiversity friendly habitats without negatively impacting on farm productivity. Thirty-one farmers increased their score between year one and year three of the results-based payment and four farms more than tripled their score. The median whole farm pollinator score for the 40 farms increased from 25,696 in year one to 33,572 in year two (31% increase), to, 40,211 pollinator points in year three (56% increase). Each farm type (beef, dairy, mixed and arable) increased their median score over the three years and dairy and arable farms showed the largest increase. This project has helped farmers better understand and engage with nature on their land and has created a measurable system for improving habitats for biodiversity on farms that is accessible to all and has the potential to be rolled out on a wider scale.

Keywords—Bees, Biodiversity, Farmland Pollinators, Results Based Payments

Introduction: Context for the Project

Global biodiversity loss has far-reaching consequences for future generations. Insect pollinators are just one group of organisms that have shown declines in recent years. It has been widely agreed that pollinator decline is due to a combination of factors, including but not limited to, habitat loss, pests and diseases, and pesticide exposure (Goulson et al. 2015; Cole et al. 2020). Farmland is the dominant land use in Europe and the way it is managed is important for pollinator conservation. By providing food, safety, and shelter for pollinators on the farm, halting and reversing their decline is possible. The National Biodiversity Date Centre's research project 'Protecting Farmland Pollinators' is a five-year European Innovative Partnership (EIP) project that has identified actions farmers can take that will allow biodiversity to coexist within a productive farming system. EIPs are about bringing different actors together at EU, national and international levels with a focus on challenges that can benefit society, modernise sectors and markets, for example coming up with solutions to environmental challenges to ensure agricultural productivity and sustainability (European Union 2023). In this project, farmers, researchers, food authorities, farm advisors and commercial companies are working together to come up with a method that will support all farms across Ireland to be more pollinator friendly. Ultimately, these actions could benefit wider biodiversity on farmland.

Locally led multi-actor partnerships such as the Burren Programme in Ireland and various European Innovation Partnership Projects (EIPs) have successfully used results-orientated solutions to protect and manage farmland biodiversity (Dunford & Parr 2020; Moran et al. 2021). The results based agri-environment payment schemes (RBAPS) are different to the prescription-based agri-environment schemes (AES). Payments are based on positive environmental results delivered by the farmers and not based on compliance with measures irrespective of outcome (Keenleyside et al. 2014). Successful RPAPS have been piloted in several European nations, including England (Chaplin et al. 2021), Ireland (McLoughlin 2018; Larkin & Stanley 2021), Romania (Page et al. 2019), and Spain (McLoughlin 2018).

Many methods and land management techniques have been implemented, and shown to have positive impacts on bees and the floral resources on which they rely for food (Hopwood 2008). As part of the 'Protecting Farmland Pollinators' project, we developed a 'Pollinator Scorecard' incorporating evidence from the literature and farmers' perspectives on what can be achieved in terms of managing the farm to help pollinators. Numerous strategies that can improve forage resources for pollinators have been proposed. For example, planting flowers with accessible and high quantity and quality rewards (Nichols et al. 2022). Extending field margins and other uncultivated areas on farmland could encourage bees by increasing wild floral resources and nesting habitats (Rands & Whitney 2011). An alternative management of roadside verges may enhance the availability of habitats for bees by increasing floral resources (Noordijk et al. 2009). By supplying or maintaining the substrates that provide nest sites and by providing specific forage plants, native pollinator populations will be given a chance to increase in number (Wilmer 2011). Incorporating organic crop fields into conventionally managed agricultural landscapes can also provide food resources to encourage greater pollinator species richness (Holzschuh et al. 2008).

The Irish landscape is dominated by agriculture, which comprises approximately 64 % (45,092km^2) of the total land area (Central Statistics Office 2021). Of this, 92% is grassland for livestock grazing and fodder production, although there is regular conversion between grass and arable land (Zimmermann et al. 2016). From 1990 to 2000, arable land and permanent crops increased in area by 35%, followed closely by artificial surfaces which increased by 31% (O'Neill et al. 2013). These changes were largely at the expense of permanent pasture and mixed farmland (Environmental Protection Agency 2006). Since 2000 there has been a further expansion of artificial surfaces and agricultural land (Central Statistics Office 2016, 2021) which has resulted in a decrease in the proportion of semi–natural habitats (SNH). The agricultural industry and the area of agricultural land in Ireland are growing, and the potential for this sector to help protect pollinators and biodiversity on farmland has the capacity to make a big difference in halting biodiversity loss. Currently over €201 million per annum is spent on AES in Ireland (Department of Agriculture Food and the Marine 2022) and there is still evidence of pollinator decline (National Biodiversity Data Centre 2021a, 2021b). In Ireland, the past eight years have shown significant advances in relation to the sustainable management of land use for the provision of flowers and bees, including initiatives such as the All-Ireland Pollinator Plan, the Irish National Action Plan for the Sustainable Use of Pesticides (plant protection products) and the European Innovation Partnership RBAPS. The protecting Farmland Pollinators EIP is another positive example of how land can be managed to help pollinators using RBAPS. Bees are considered the dominant pollinators in many habitats across the world, (Wilmer 2011) although non-bee pollinators (flies, beetles, moths, butterflies, birds and bats, among others) also play an important role (Rader et al. 2016). In temperate regions, most animal pollination is provided by honey bees (*Apis mellifera*), bumble bees (*Bombus* spp.), solitary bees, wasps and hover flies (Klein et al. 2007; Winfree et al. 2008; Stanley & Stout 2013) and as such the Protecting Farmland Pollinators Scorecard was targeted at protecting bees and hoverflies.

With the current concerns about pollinator decline comes a crucial need to improve pollinator habitats. Pollinators provide a vital service to both natural ecosystems and farming, and therefore should be offered a high level of protection given the potentially far-reaching effects of their decline. The European Biodiversity Strategy for 2030 and the EU Pollinator Initiative aim to protect nature and reverse the degradation of ecosystems and set the commitment to reverse the decline in wild pollinators by 2030. The Protecting Farmland Pollinators project aims to test pollinator conservation actions in the Irish context, and to demonstrate a workable and cost-effective model by which farmers can be encouraged to take actions in a pilot area, using a mechanism that is readily scalable to European level. We hope to trial a novel mechanism by which all farms can become more pollinator-friendly in their own individual way under a system that allows clear tracking towards this goal and that is farmer-led. Here we present the proposed pollinator scorecard and a simple results-based payment method that encourages and assists farmers in attempts to help pollinators on the farm.

Materials and methods: Description of the project

Implementation

This five-year project is working with a group of 40 farmers, across farm types (beef, dairy, mixed, and arable) and management intensities (high, medium, and low) in eastern Ireland (Fig. 1). Within each farm type are farms that are intensively managed with very little space for biodiversity, and farms that are already managed in a way that benefits biodiversity. Some farms have higher inputs than others, and three of the farms are certified organic. Initially, there were four organic farmers participating but, an organic dairy farmer converted back to conventional farming during the project. The farm household income also varies within each farm type although farm income was not included in the selection criteria.

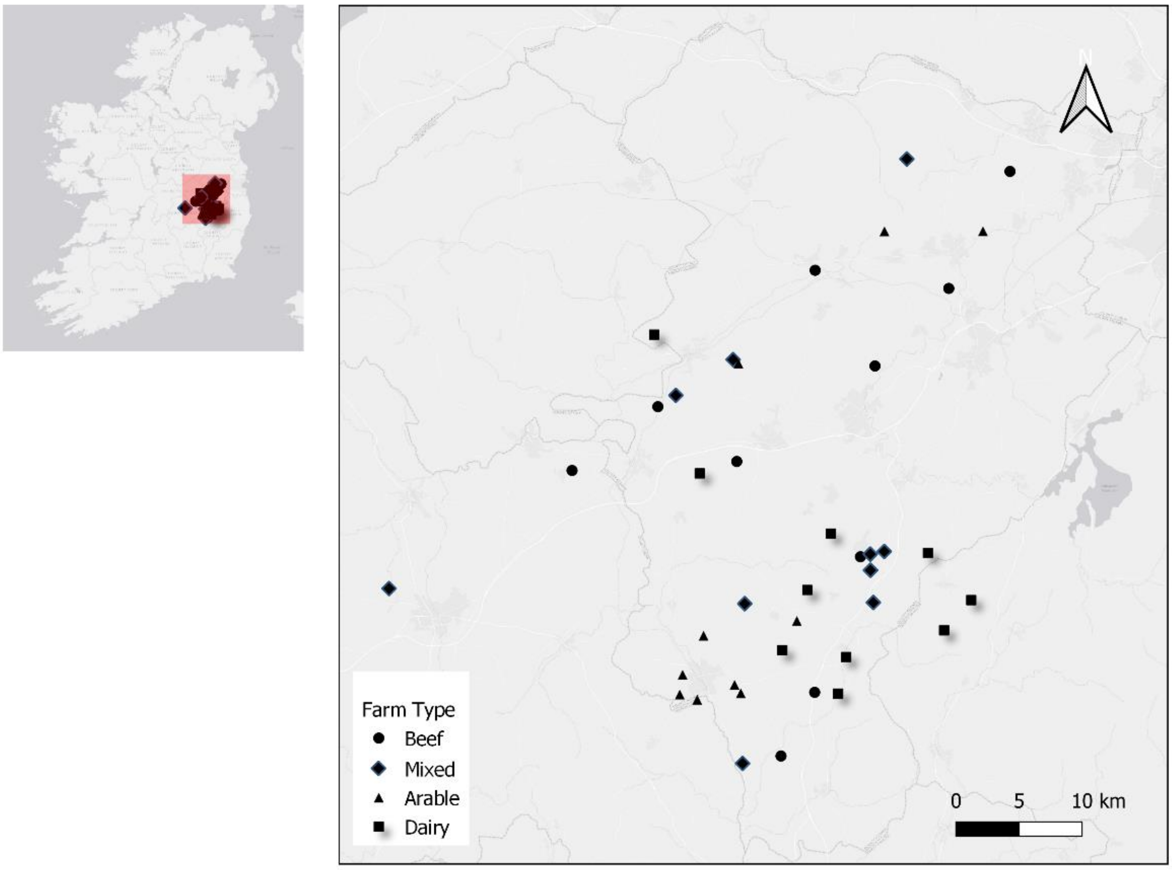

Figure 1 Farm locations and their associated farming practices (beef, mixed, arable, and dairy).

By working closely with farmers, management practices that benefit bees and hoverflies on Irish farmland were identified, and a whole farm pollinator scoring system was developed. This score helps farmers to understand how pollinator friendly their farm is, and identify what simple, low-cost actions they can take to work towards improving their score in a way that does not negatively affect productivity. The scorecard is built on evidence-based actions and a results-based payment model. Within the project, farmers receive an annual payment based on their overall farm pollinator score, which is calculated based on the quantity and quality of pollinator friendly habitat on the farm - the higher the pollinator score of the farm, the more the farmer will be paid annually. Through knowledge transfer, farmers were encouraged and incentivised to provide small wildlife habitats for pollinators on their farms from 2019 onwards.

Site selection

A closed call recruitment was initiated in September 2019 for farmers to express their interest in joining the project. The desired outcome for farm selection was to ensure a diversity of farming systems, within different farm types was captured. To ensure this, farmers were required to fill in an Expression of Interest Form, and based on the data submitted, farms were ranked according to intensity levels; low (score = >5), medium (score = 2.6-5), and high (score = <2.6). From sixty-one expression of interest forms received, 40 farms were selected. Emphasis was placed on making sure all farm types were represented over a range of intensity levels. Farms were also selected to minimise the logistical costs of travel. The minimum distance between farms was 0.2 km.

In the selection phase, applicants were scored according to the following four categories:

1. Average field size hectares (large = 1, ≥ 8.5 ha; medium = 2, 4.5-8.5 ha; small = 3, ≤ 4.5 ha).
2. Frequency of hedgerow cutting (cutting hedgerows annually = 1; cutting hedgerows every two years = 2; cutting hedgerows every three years at least = 3).
3. Farms containing a native wildflower / hay meadow (absent = 0; present = 1).
4. Farms containing clover within the grass pasture (absent = 0; present = 0.5).

Prior to contracts being signed, the Project Manager met with each farmer and walked the farm. During this farm walk, existing pollinator friendly habitats were identified and examples of management practices that benefit pollinators were discussed. Using the data from the Expression of Interest form and the data gathered from the farm walk, a draft baseline pollinator score was created for each of the farms based on the quantity of pollinator friendly habitat. The following criteria were used to generate the baseline pollinator score:

- Total length of flowering hedgerow
- Total area of hedgerow margin when present
- Frequency of hedgerow cutting per hedge
- Quantity of pollinator friendly farm features (wildflower meadow, mixed species sward, clover pasture, bird cover, catch/cover crops, and unfarmed land)
- The number of pollinator friendly trees
- Frequency of pesticide use over the whole farm

This score was generated to further ensure that a wide range of farm intensities were included in the project.

Farmer requirements: Creating bee nesting habitats

Before a farmer could score his or her farm, they were required to create and maintain solitary bee nesting habitat for below ground mining and above ground cavity nesting solitary bees. Of the 102 bee species in Ireland, 80 are solitary bees. Solitary bees nest in two main ways; mining bees burrow into the ground, while cavity nesting bees use existing holes in hollow stems, wood, or stone walls above ground. It was decided not to include provision of nesting habitat within the scorecard itself but to have it as an initial mandatory requirement for two reasons:

1. Nesting habitats can be created at little or no cost.
2. Lack of nesting opportunities is a known limiting factor (Tscharntke et al. 1998; Gathmann & Tscharntke 2002; Murray et al. 2012) and is therefore very important. Farms that are flower rich will not have wild

pollinators unless they also have safe areas where pollinators can nest. The availability of nesting resources is related to high species diversity of solitary bees (Murray et al. 2012).

Based on best expert judgement, each farmer was required to satisfy the following requirements for wild bee nesting habitat per 35 hectares, scaled up on a total farm area basis. Farmers followed the All-Ireland Pollinator Plan's guidelines on how to create solitary bee nesting habitat (National Biodiversity Data Centre 2016). All sites met the minimum requirements and were not identical.

Must have nesting habitat:	Per 35Ha (average farm size)
Bare soil for mining solitary bees	8 separate locations at least*
Bee boxes or equivalent for cavity-nesting solitary bees	3

*For larger farms it is possible to use area equivalents for the bare soil habitats. However, a minimum of eight locations per farm is required. It is preferred if the bare soil sites are spaced across the whole farm. Each bare soil site must be a minimum of 30x30 cm in area. The vegetation around these sites can grow back quickly and will need to be maintained on a regular basis, at least twice a year.

In many cases, solitary bee nesting habitat will already be on the farm unnoticed (e.g., bare soil or natural cavities). If bare soil habitat was already present on the farm it was included in the total count, however, each farmer was required to create a minimum of three bare soil areas.

To test the impact of solitary bee nesting habitat that was created on the farms, 81 bare soil sites from 40 farms, and 29 nest boxes from 18 farms, were surveyed from May-June 2020 (convenience sample: sites that were easy to access and not far from the farm survey locations[1]). Field surveys were conducted between 10am and 6pm, in line with the most active time for most solitary mining bee species (Potts & Wilmer 1997), on days with partial or full sun and wind conditions not exceeding F2 (Beaufort scale). Each site was assessed for solitary bee occupancy. If the site was occupied, the area, aspect, general context (location and whether the nest was manmade), number of nests, and shade for each site was recorded. Each site was monitored for ten minutes.

Scorecard actions and supporting evidence

In consultation with farmers, we created a more sophisticated pollinator scorecard that allows any farm no matter the intensity, size, or type to receive pollinator points each year and, each year, participant farmers receive a results-based payment that relates to the points. The monetary reward associated with each action on the scorecard is in line with existing agri-environment schemes in Ireland. There are nineteen actions on the scorecard (Table 1) and these actions are associated with maintaining habitats that provide food, shelter, and safety for pollinators on the farm, in line with the All-Ireland Pollinator Plan (National Biodiversity Data Centre 2015, 2021a). The nineteen actions can be split into four categories: field margins, trees, fields, and pesticides. Four actions are associated with field boundaries, eight actions are associated with fields and flowers and seven safety actions associated with pesticide use (Table 1, example given in Appendix I). Farmers receive pollinator points when they do not use pesticides (herbicides, fungicides and/or insecticides).

Each of the actions are evidence-based. Field boundaries provide important habitats for wildlife in agricultural landscapes and in Ireland, field boundaries consist mainly of hedgerows which provide essential resources for bees (Hannon & Sisk 2009) (however dry stone walls dominate in some areas in Ireland). Field boundaries offer food, safety and shelter for pollinators on the farm (Svensson et al. 2000; Hopwood 2008). Thus, Action one: *Hedgerow cut every 3-5 years with a 1.5-2 metre margin*, has one of the highest weightings and farmers can easily achieve a high score if they decrease the frequency of hedgerow cutting on the farm.

[1]Additional plant and pollinator surveys were conducted in 2020. Data is not presented here.

Table 1. Whole Farm Pollinator Scorecard – left blank for farmers entry.

	No.	Action	Units of measurement	Approximate amount	Range 1-5	Final Score
Food and Shelter	1	Flowering hedgerow max. cut once every 3-5 years with a 1.5-2m margin or understory fenced from grazing or untilled	metres			
	2	Flowering hedgerow cut once every 2-5 years with at least 0.5m margin fenced from grazing or untilled	metres			
	3	Flowering hedgerow cut once every two years (no margin)	metres			
	4	Other pollinator-friendly field boundary	metres			
	5	Pollinator-friendly flowering trees at least 10 years established (up to max. 500)	number of trees			
	6	Pollinator-friendly flowering trees planted in the last 10 years must be established for 1 year or more (up to max. 500)	number of trees			
	7	Native hay/wildlife meadow (maximum cut or grazed once a year)	ha			
	8	Herbal ley allowed to flower / sown wildflower area	ha			
	9	Clover pasture / mixed species sward allowed to flower	ha			
	10	Bird cover / Poly-crop	ha			
	11	Non-farmed areas (e.g., around farmyard, lanes, roads) unmanaged to allow grass and wildflowers to grow naturally	m^2			
	12	Flowering pollinator-friendly catch, companion or cover crop allowed to flower	ha			
Safety	13	Eliminated herbicides, fungicides, and insecticides from whole farm	Yes or No			
	14	Eliminated herbicides, fungicides, and insecticides from whole farm excluding livestock	Yes or No			
	15	Eliminated insecticides and fungicides from arable crops	ha			
	16	Eliminated insecticides from arable crops	ha			
	17	Eliminated herbicides from whole farm	Yes or No			
	18	Herbicides – spot spray only noxious and invasive plants (Chickweed, Ragwort, Giant Hogweed, and other invasive plants)	Yes or No			
	19	Herbicides - only used on crops and not used to "tidy-up" the farm	Yes or No			

*The number of points awarded for each action is subject to change and will depend on the quality of habitat

Pollinator-friendly flowering trees can also provide food, safety, and shelter for pollinators. This action is measured by simply counting the number of trees on the farm. A maximum score of 500 trees is permitted for each of the two tree actions on the scorecard (Table 1). Only trees that are considered pollinator friendly (e.g., Bird Cherry, Blackthorn, Crab apple, Elder, Fruit, Hawthorn, Hazel, Horse chestnut, Lime, Rowan, Willow, Whitethorn, Wild Cherry) can be included in the count.

Native plant species often provide better food sources for native pollinators and so habitats that support native plants are considered preferable. Native hay meadow is a particularly high scoring feature on the scorecard. Grasslands rich in flowers and riparian areas offer suitable forage sites for bumble, honey and solitary bees (Krewenka et al. 2011) and provide nesting habitats for bumble bees and feral honey bees (Kells & Goulson 2003).

Intensive grasslands support fewer plant (Socher et al. 2013) and bee (Santorum & Breen 2005) species compared to plant and bee communities found in semi-natural grassland (which only comprise less than 1% of the total land area in Ireland (O'Neill et al., 2013). Land management practices such as fertilisation, grazing and cutting of fields can have negative effects on biodiversity in farmland (Pärtel et al. 2005). By incorporating clover into a grass-based pasture system, more floral resources can be made available, and there will be a reduction in the amount of synthetic fertiliser applied. Once it is allowed to flower, clover is an excellent floral resource for bumblebees (Goulson et al. 2005; Power & Stout 2011). Mixed species swards (species diverse permanent pastures) have the potential to be even more beneficial to pollinators as they have a higher diversity of plant species which can support a higher diversity of pollinator species (Ebeling et al. 2008). Herbal leys, also known as multi species herbal leys, are a mix of grass, legume, and herb seeds. They can increase forage production, sheep and cattle growth rates, (Jordon et al. 2022) milk production, (McCarthy et al. 2020) and have the potential to bring a range of benefits to livestock health. Herbal leys can also benefit soil fertility and provide food for pollinators as well as offer protection against drought (Grange et al. 2021). Herbal leys usually contain a mixture of native and non-native plant species. Cover, companion and catch crops, bird cover and polycrops, will also increase the plant diversity on the farm and in turn can increase the floral resources available to pollinators. Cover crops contain many nectar and pollen rich species including Buckwheat, Phacelia, and various Brassicas, and can provide food to pollinators late in the season when there are few flowers available in the landscape. Incorporating a flowering companion crop like clover, into a cash crop, like beans, is another way farmers can receive pollinator points. Catch crops usually contain the same species mix as cover crops but they are grown for a shorter period of time. If allowed to flower they can also be an important food resource for pollinators. Farmers are rewarded for each of these habitats on the farm. Both bird cover and poly crop are a mixture of grain and flower seeds (usually non-native). Apart from providing a food source for pollinators and birds, it can also provide winter cover on the land which reduces soil erosion and leaching.

Making floral resources available to pollinators within a productive field is a win for both biodiversity and the farmer. In addition, every farm has an area of land that is non-cultivated land. This can be a field corner, areas around farm gates, lanes or a farm roads. Such areas of land can be excluded from a farmer's basic payment. These sites can be rich in floral diversity and can provide both floral resources and nesting habitats for bees and hoverflies. The management of roadside vegetation via the planting of native species can increase the abundance and richness of wild bees (Hopwood 2008). If these areas are unmanaged to allow grass and wildflowers to grow naturally, not sprayed with herbicides and allowed to produce flowers, it is included in the scorecard, no matter how small the area.

Bees can be exposed to pesticides in both rural and urban landscapes (Kavanagh et al. 2021). An extensive body of evidence exists that shows the harmful effects of pesticides (herbicides, fungicides, and insecticides) on bees (Henry et al. 2012; Goulson et al. 2015; Cullen et al. 2023). Despite incomplete knowledge regarding the impacts of pesticides on other organisms, there is sufficient toxicity data for a wide range of invertebrate taxa, both aquatic and terrestrial, to warrant caution (Pisa et al. 2015; Sohn et al. 2018; Basley & Goulson 2018; Gibbons et al. 2015). Farmers can use pesticides within a crop for pest and weed control to ensure maximum yield. Sometimes pesticides can be used unnecessarily, either as a precautionary measure or to 'tidy-up' the farm. In the pollinator scorecard farmers receive points for not using pesticides. These points can be scaled from within a field or within the whole farm.

The scoring system and associated weighting is under constant development and will slightly change as the project progresses. The aim is to ultimately create a scoring system that is fully evidence-based. Farmers complete the scorecard by inputting the amount of each action they are taking (quantity of pollinator friendly habitat) and the associated range (quality). If the farmer does not have an amount to fill in i.e., if they are not managing a specific action, they can leave the amount blank or enter a null value. The Project Manager then calculates the score based on the amount submitted by the farmer. Actions are weighted, so that those actions that are more beneficial to pollinators score more. Scores are also further adjusted for quality using a range of 1-5, 5 being the highest quality or most diverse (high number of flowering plant species in flower) and 1 being the lowest, least diverse (low number of flowering plant species in flower). The range is calculated by the farmer, and the project manager is available to assist if help is required. Further details on how the range is calculated can be found in Appendix II.

RESULTS

WHOLE FARM POLLINATOR SCORE

There has been an annual increase in the median pollinator points across the 40 farms in the three years since the project started (year one, year two, year three $\chi2$ (2, N = 40) = 36.6, P < .001). Inspection of the median values showed an increase from year one (Md = 25,696) to year two (Md = 33,572) and a further increase at year three (Md = 40,211). The whole farm pollinator scores for the 2021-2022 farming year (year three of the results-based payments), ranged from 4,512 pollinator points to 471,189 pollinator points. Post-hoc comparisons using Mann-Whitney U tests between pairs of groups to compare year one to year two, and year one to year three, showed that the increases were statistically significant (P = .001 and P < .001 respectively). Increases from year two to year three were not statistically significant. Twenty-five farmers increased their pollinator scores between year one of the results-based payment and year two, and four farmers more than tripled their score. Between year one and year three, thirty-one farms increased their pollinator scores.

The median whole farm pollinator score for each farm type (beef, dairy, mixed and arable) increased each year (Fig. 2). Arable farms showed the greatest increase in pollinator points over the three years, and dairy showed the second greatest increase (Fig. 2). Initially, mixed farms had the highest average pollinator score, and arable farms had the lowest. Through managing their farm in a more pollinator friendly way, arable farmers have surpassed beef, dairy, and mixed farms. The spread of scores within each farm type has also

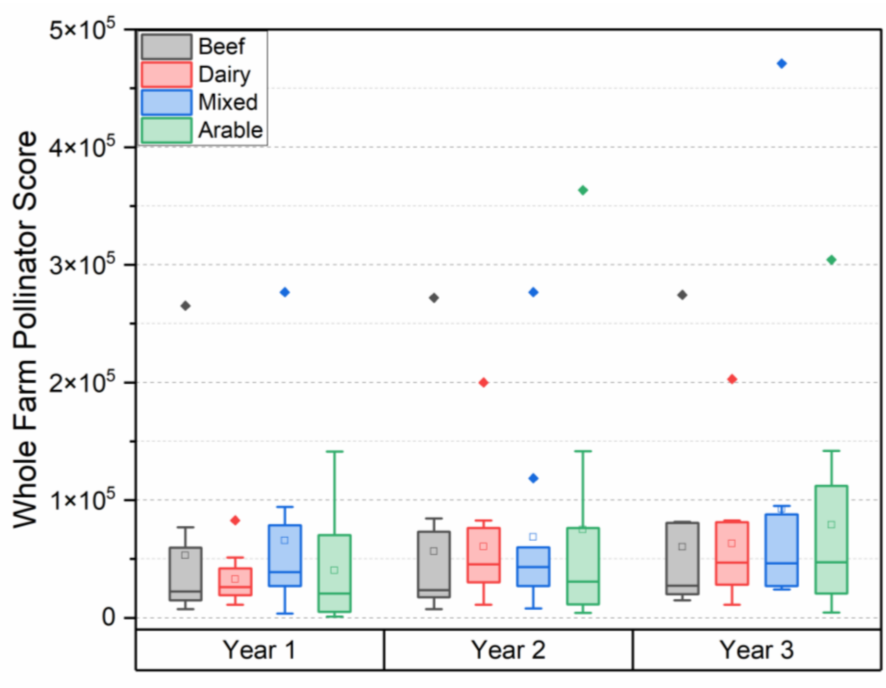

Figure 2. Farm scores within each farm type, beef (black), dairy (red), mixed (blue) and arable (green) for year one (2019/2020), year two (2020/2021) and year three (2021/2022). The maximum (top line outside the box) excluding outliers, minimum (bottom line outside of the box), median (line inside the box) and mean (small square inside the box) whole farm pollinator score for the four farm types are represented. The diamonds outside the box are outliers.

changed over the three years (Fig. 2). Each farm increased the average (mean and median) scores over the three years. Arable farms have maintained the largest spread of pollinator points over the three years. There was a significant increase in pollinator points for arable farms and separately dairy farms, from year one to two and year one to three. There was no statistically significant difference in the pollinator points between farm types for any farming year.

Annually, farmers across Europe receive a basic payment for the area of farmed land they hold (own or rent). Using the whole farm pollinator scorecard, the farm basic payment for each of the 40 farms did not change over the three years. The results-based payment (monetary reward), the associated area of pollinator friendly habitat, the diversity of pollinator friendly habitats, and the total area of productive land eligible under the basic payment scheme (BPS) for a 27-hectare beef farm can be seen in Appendix I. The full pollinator scorecard for the same farm can also be found in Appendix I. The percentage of pollinator friendly habitat increased over the three-year period, which coincides with an increase in the farmers monetary reward (Appendix I; Table 7, and Fig. 8). Year four uses theoretical data (based on a scenario of developing a native meadow rather than a mixed species sward) to show that the area of pollinator friendly habitat on the farm does not have to change for the monetary reward to increase. This is to highlight the importance of diversity of habitats and to highlight that some habitats score higher than others. This difference in monetary reward between year three and year four is due to the quality of the pollinator friendly habitat and is reflected in the weighting of the scorecard actions. Despite an increase in the percentage of pollinator friendly land, the area of land eligible for the basic payment scheme does not change (Appendix I, Fig. 8).

Some actions on the scorecard were more frequently taken than others. All farmers have pollinator friendly trees on their farms, and over the years, the number of trees on the participating farms has increased (Table 2). The number of trees on an individual farm ranged from 12 to >500. Other popular actions on the scorecard are flowering mixed species sward / clover pasture (32 of the 40 farms) and non-farmed area (36 of the 40 farms) (Fig. 3, Table 2). Some of the five additional farmers that recorded the non-farmed area action in year two decided to, 'allow a space for nature on the farm' and some of the farmers did not have the time to keep the area "tidy". Flowering hedgerow is now the third most popular action on the scorecard with 31 of the 40 participant farmers managing some of their hedges for pollinators (Fig. 3).

SOLITARY BEE NESTING HABITATS

The results from the solitary bee survey in 2020 (81 bare soil sites surveyed from 40 farms and 29 nest boxes surveyed from 18 farms), showed that some sites were occupied within the first 4 months of creation. Exposed areas of bare soil created by the farmers were colonised by mining bees on 19 farms, and one-third of nest sites surveyed were

Table 2. ***The quantity of each of the food and shelter actions across the 40 farms. The actions are in order of frequency of use according to the data from year one. The total number of trees and area of each action are shown for year one, two and three. * The number of trees is an underestimate as the cut off for number of trees was 500. Trees (actions 5 and 6), clover pasture/mixed species sward (action 9) non-farmed area (action 11), flowering hedgerows (actions 1-4), native hay/wildlife meadow (action 7), bird cover/poly-crop (action 10), herbal ley/sown wildlife meadow (action 8), and cover/companion/catch crop (action 12).***

Action	Quantity Year 1	Quantity Year 2	Quantity Year 3
Trees	9078 trees*	9078 trees*	9133 trees*
Clover pasture/mixed species sward	640.18 ha	666.24 ha	716.54 ha
Non-farmed area	30.33 ha	31.78 ha	34.50 ha
Other Field Boundary	40699.70 m	35970.70 m	34556.40 m
Flowering hedgerow	37740.40 m	69742.50 m	60698.70 m
Herbal ley/sown wildflower area	28.04 ha	37.56 ha	26.38 ha
Native hay/wildlife meadow	18.9178 ha	26.14 ha	27.88 ha
Bird cover/Poly-crop	19.17 ha	24.24 ha	21.96 ha
Cover/Companion/Catch Crop	127.10 ha	143.64 ha	153.44 ha

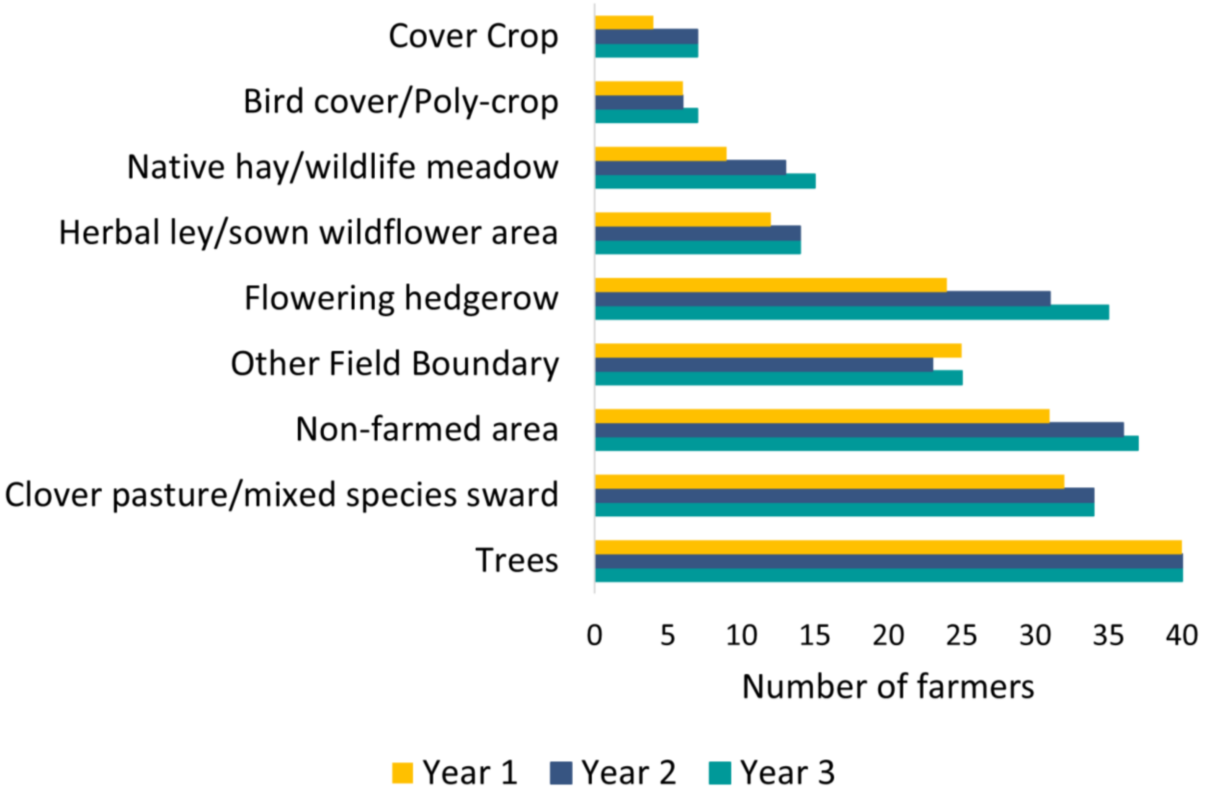

Figure 3. The number of farmers that are associated with each of the food and shelter actions on the scorecard for years one to three. Cover crop (action 12), bird cover/poly-crop (action 10), native hay/wildlife meadow (action 7), herbal ley/sown wildlife meadow (action 8), flowering hedgerows (actions 1-4), non-farmed area (action 11), clover pasture/mixed species sward (action 9) and trees (actions 5 and 6).

occupied (27 out of 81 sites). Across 19 farms, a total of nine different bees were observed. Three species of *Andrena*; *Andrena bicolor* (Gwynne's Mining Bee), *Andrena nigroaenea* (Buff Mining Bee), and *Andrena scotica* (Chocolate Mining Bee), two species of *Nomada*; *Nomada goodeniana* (Gooden's Nomad bee), *Nomada marshamella* (Marsham's Nomad Bee), two species of *Halictus*; *Halictus tumulorum*, *Halictus rubicundus*, and a species of *Lassioglossum* and *Sphecodes*). Nest sites were occupied on all farm types (5 beef, 6 dairy, 3 mixed and 5 arable). The most common bee to nest was *Halictus rubicundus* (found on 9 farms) and *Nomada goodeniana* came in a close second (8 farms). All results reported here include data on active occupied nest sites only. Dairy farms had the highest species diversity of ground nesting mining bees. There was no significant difference in the diversity of mining bees across each of the farm types (beef = 7 species, dairy = 8 species, mixed = 5 species, and arable = 5 species). (Appendix III, Table 8).

The area of the bare soil where occupied nests were found ranged from 150 cm^2 to 12 m^2. The highest number of species were found within areas less than one meter squared (7 species). Occupied nests were in both open locations (no shade; 13 sites) or sheltered (some shade; 14 sites). The number of nests per site ranged from 1 to 150. Across the nineteen farms, ground-nesting solitary bees were found occupying banks of different aspects. South facing banks had the highest nest occupancy and the highest number of bee species. Bees were found nesting on NE banks (2 sites), S (6 sites), SE (4 sites), SSW (2 sites), SW (5 sites), W (3 sites), WSW (1 site) WNW (1 site), NNW (2 sites) and NW (1 site). Although the Northeast aspect had two occupied nest sites, five different species were found nesting within these two sites. Out of the twenty-five occupied nests, fourteen were made by livestock and ten were made by the farmer. All occupied nests were located within a hedgerow.

Eleven of the 29 bee boxes from eight farms were occupied. *Megachile sp.* was the only species observed flying into a nest box. Other bees had not emerged from their nests at the time of surveying. *Megachile centuricularis*, *M. versicolor* and *Hylaeus confusus* were observed flying close to nest boxes. Cavity bees were found nesting on several different aspects: E (1 site), ESE (1 site), S (1 site) SE (1 site), SSW (3 sites), W (2 sites), WSW (1 site) and NNW (1 site). All active nests had floral resources close by. They were placed in areas where the farmer had taken action to protect pollinators, either within a field boundary (hedge or stone wall) or close to a farm garden. All active nest boxes were placed at least 1.5 meters above ground.

Discussion

The whole farm pollinator scorecard has been successfully used by 40 farmers for three consecutive years. It has enabled farmers to identify management practices that can help pollinators on the farm that will not negatively affect farm productivity. This simple results-based payment approach encourages and assists farmers in their attempts to improve their whole farm pollinator score providing further evidence for the usefulness of RBAPS (Dunford & Parr 2020; Larkin & Stanley 2021; Moran et al. 2021).

Farmers are taking action to help biodiversity for various reasons. Some farmers are concerned for the welfare of future generations, some want the financial reward, and some are in competition with their neighbours to have the higher number of pollinator points (opinions collected from farmers during informal conversations). For others however, they were unaware of how easy it was to help pollinators and biodiversity and for most of the 40 farmers they did not realise how they were already helping biodiversity on their farm. Farmers were presented with nineteen actions they could take to help pollinators and over 75% of farmers used this knowledge to support pollinators on the farm. This suggests that to help farmland biodiversity, more resources are needed to help facilitate the transfer of biodiversity knowledge within the farming community. Farmers receive little direction and training relating to biodiversity, so understandably biodiversity is a concept unfamiliar to many. But even when there is high engagement and knowledge transfer, some farmers still do not wish to change. Eight of the 40 participant farms have not taken action for pollinators on the farm i.e. have not implemented any changes in how the farm is managed. There is a combination of reasons for this. Some of these farmers have significant time commitments outside of farming and were unfortunately not able to engage with the project as much as they would have liked. Some of these farmers are not farming full time, some are managing very large farming enterprises, and some of these farms already had high pollinator scores. One farmer did not want to change how they manage their farm. He was happy to create the solitary bee nest sites but not willing to reduce the frequency of hedgerow cutting, as it would be 'too messy'. There can be a perception that environmental schemes are for part time farmers. Larger farmers can see AES as not for them, and some farmers see AES actions as box ticking exercises. Many studies suggest that there is a need to increase farmer understanding of biodiversity friendly management practices and their benefits as well as the removal and dissolution of barriers and constraints preventing more biodiversity friendly management on the farm (Lomba et al. 2020; Moran et al. 2021). This study has reinforced that better engagement with farmers is required to ensure they understand why they should help protect biodiversity, what exactly they are being asked to do and what benefit any actions will have.

Arable farms were initially the lowest scoring farms overall with some farmers offering little to no protection for biodiversity. However, once these farmers were shown examples of simple actions that could be taken to help biodiversity on the farm, they began to manage their farm in a more biodiversity friendly way. Arable farmers had the greatest increase in pollinator points over the last three years and dairy farms had the second greatest increase. There are many possible reasons for this. Perhaps there was a larger scope for change for arable farmers to improve their farm for biodiversity as very little area had previously been managed for biodiversity compared to the other farm types. Eight out of ten arable farmers increased their score between year one and year three and seven of these farmers increased the amount of flowering hedgerow and hedgerow margins on the farm. Arable farmers do not need to move fences to increase hedgerow margins and do not have the same concerns regarding hedgerows encroaching on electric fences, compared with farmers managing livestock. Household income or financial security may also play an important role in changing farm management practices. In Ireland, arable farmers receive the highest direct payment compared to any other farm type and have the second highest family farm income (dairy farmers have the highest family farm income) (Department of Agriculture Food and the Marine 2022). Some farmers do perceive changing management practices as a risk to productivity and if you are in a more secure financial situation, you may be more likely to take that risk. Beef farmers showed the lowest increase in pollinator points over the three years and in Ireland beef farmers have the lowest family farm income (Department of Agriculture Food and the Marine 2022). However, taking action to help pollinators on the farm does not affect the farm basic payment and it can be a source of income to the farmer.

Farmer engagement with the project has been very positive. Farmers have provided positive feedback on the locally led approach to the project, the results-based payment mechanism, and the simplicity of the scorecard. There is no perceived bureaucratic burden which has previously been suggested as the largest barrier to farm participation in AES (Massfeller et al. 2022). The whole farm pollinator scorecard has taken the complexity of the science, policy and administration and distilled them into a simple mechanism that does not add to the administrative or practical workload of the farm business. Biodiversity comprises all life on earth and can be considered a complex term. It is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (The Convention on Biological Diversity 2006). Like climate change, it can be difficult to conceptualise on a personal level, and, in this case, to understand how a farmer can help biodiversity at the individual farm level. Despite this, most farmers have a deep knowledge of nature, and their love of the land is tied to the birds, insects, mammals, and plants that coexist there. They have an instinctive awareness that wildlife is declining from their farms, and when they are incentivised to take action to protect wildlife, they want to see that these actions work. Pollinators provide a unique vehicle to carry a more complex message and most people have an affinity for bees and understand the free services they provide (National Biodiversity Data Centre 2020). The creation and occupancy of the solitary bee nests is a clear example of where farmers can instantly see the results of their labour and is perceived to be a positive easy action that can be taken to help pollinators on the farm. Since the onset of this project over 300 nest sites for mining solitary bees and 130 sites for cavity nesting solitary bees were created. Within the first 4 months, the exposed areas of bare soil were already successfully colonised by mining bees, and one-third of nest sites were occupied. The evidence suggests that hedgerows are the location most likely to be used by ground nesting mining bees on Irish farms. Creating nesting habitat along hedgerows minimises the distance between nesting habitat and potential foraging habitat. This can provide solitary bees with a food source within their short foraging distances (Gathmann & Tscharntke 2002). If managed correctly, hedgerows not only benefit pollinators but can have many other benefits for biodiversity (Graham et al. 2018; Froidevaux et al. 2019), such as, providing berries and nesting habitat for birds (Heath et al. 2017). Hedgerows can help with flood mitigation (Wallace et al. 2021), they provide shade for livestock on hot days and provide shelter on wet and windy days. Hedgerows can also help with pest control (Bishop et al. 2023; Rodríguez et al. 2023) and have carbon sequestration potential (Biffi et al. 2023).

This project has resulted in an increase in the quality and quantity of pollinator friendly habitats on the farms. Farmers were willing to engage with all actions on the scorecard. Hedgerows have been retained and are being managed in a more pollinator friendly way. Farmers are allowing more wild plants to naturally grow in areas that will not impact production (either within productive fields or within non-farmed areas). Farmers are choosing to not cut hedgerows so often (the third most popular action on the scorecard). Farmers are more conscious about spraying pesticides unnecessarily (eight farmers are reducing pesticide inputs on the farm). Some farmers are trying to enhance biological control on the farm though increasing potential habitats for natural pest predators, for example, hoverflies and aphids. Other farmers are trying to reduce input costs and are more reluctant to use pesticides if they can be avoided. Some farmers now realise that the "tidy up" attitude and elimination of "weeds" can be an unnecessary cost and that using herbicides can be harmful to biodiversity. Farmers are now conducting aphid counts in their crops and only treating with aphicides if necessary, in the past, treatment with aphicide would have been used as a precaution. Communication and knowledge transfer is key to achieving this positive outcome. The easiest way for a farmer to increase pollinator points is to change how hedgerows are managed on the farm. This action had the highest uptake by the participant farmers. The quantity of hedgerows managed for pollinators from the 40 farms nearly doubled within three years. Less intensively managed hedgerows will have more flowers and have been shown to provide a more suitable habitat for bumblebees compared to intensively managed hedgerows (Byrne & DelBarco-Trillo 2019). Managing hedgerows less intensively can also offer good nesting and floral resources (especially early in the year) and can have a strong effect on pollination services to crops and non-crop areas (Image et al. 2022). Farmers are also increasing their pollinator points by increasing the number of flowers within their productive fields. Clover pasture, herbal leys, and mixed species sward have higher plant diversity compared to intensively managed monoculture grasslands and if they are allowed to flower, they have the potential to benefit pollinators. They can also help mitigate against the negative effects of drought (Grange et al. 2021) and can also have additional environmental benefits (Cummins et al. 2021). Flowering mixed species swards support improved livestock productive efficiency, and reduce dependence on expensive chemical nitrogen. Clover is a natural substitute for nitrogen fertilizer and its use can help keep farm input costs down. There has been growing interest in clover and mixed species swards with Irish farmers for a number of years (Department of Agriculture Food and the Marine 2022).

Farmers want to know they are doing the right thing and they want to see the impact of their actions. They also want there to be continuity in what they are being asked to do. Using the whole farm pollinator scorecard farmers have the flexibility to bring biodiversity back into their farm in a way that works with their production system and that suits them. This scorecard can also be used to help all farmers understand how pollinator-friendly their farm is, and what simple, low-cost actions they can take to work towards improving their whole farm for pollinators and other biodiversity in a measurable way that does not impact on productivity. Using a 'pollinator-friendly farm' label is an alternative approach that can incentivise farmers to protect biodiversity and can also be used to acknowledge farmers engagement and effort. For example, the apples produced by farmers in Switzerland participating in the Obstgarten Farnsberg Bird Life Project (Bird Life Schweiz 2021) were branded with a, *Hochstamm Suisse* logo. This logo allowed farmers to market their apples at a higher retail value and indicated that a contribution to the diversity and ecology of the cultural landscape was made on the farm where the apples were grown.

The management and enhancement of both the quality and quantity of biodiversity friendly habitats on farmland can be achieved using a results-based payment mechanism. The pollinator scorecard can be used to promote the actions famers take within a wider context so that society better values the contribution they are making. Rewarding farmers for the wide range of values delivered to society like protecting pollinators has the potential to stimulate farmer action in managing farmlands for biodiversity (Lomba et al. 2020) and is an efficient use of public funding. Every farm has some value for biodiversity, but some farms offer more value than others. Is there a baseline score that all farms can meet to ensure biodiversity can be protected on the farm? Can we provide of a novel mechanism that will allow threshold scoring levels to be set, offering an evidence-based and measurable target for biodiversity sustainability accreditation schemes (e.g., Origin Green in Ireland). This is a new and innovative approach to nature conservation on farmland with a low administrative burden. This pollinator scorecard is very readily scalable to all farm types, is easily communicable and could be directly linked to sustainability accreditation schemes in a way that is transparent and measurable. It could also be used in other European countries with minor changes to the weightings of some of the actions. For example, increasing the weightings for trees and other pollinator friendly field boundaries in countries where hedgerows are uncommon or absent. By carefully selecting areas on the farm where flowers could be allowed to bloom without causing a fire risk to cash crops, a balance between biodiversity and farm profitability can be achieved. Using a bottom-up approach and working directly with farmers to identify achievable and practical evidence-based actions to protect pollinators, we can start a chain reaction that has positive benefits for the general health of our environment, our mental health, and the wellbeing of future generations. To maintain pollinator friendly habitats across all farms into the future, long term planning and in some cases, investment is required. Farmers need to be credited, rewarded, and incentivised to protect and enhance biodiversity on their farms.

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AUTHOR CONTRIBUTION

Concept and design, SK, JCS, UF, data collection, SK, NP, NRG, SOB, writing, SK, JCS UF and edits and approval for publication SK.

DISCLOSURE STATEMENT

There is no potential conflict of interest.

DATA AVAILABILITY STATEMENT

Please contact the corresponding author for data requests.

APPENDICES

Additional supporting information may be found in the online version of this article:

Appendix I. Example Farm

Appendix II. Scorecard range

Appendix III. Solitary bee nest data

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