Strategy Framework to identify and evaluate methods of reducing damage to brassica crops by woodpigeons, *Columba palumbus*

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The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

Contents

Grower Summary

Headlines

- There is no single, effective control measure for consistently reducing woodpigeon damage to brassica crops.

- When used in combination the following control options ordered by effectiveness show some promise;
  - Nets/Covers (over small areas since this may not be cost effective)
  - Human Disturbance
  - Shooting
  - Gas Canons
  - Flags
  - Decoys
  - Habitat Modification

- A number of future options are discussed in the review including chemical, behavioural and taste repellents, sacrificial crops and improving the understanding of woodpigeon behaviour and movement in order to better target controls.

1.0 Introduction

Woodpigeons, *Columba palumbus*, are considered a serious pest of brassica crops in the UK, causing severe damage, especially to young plants. Several methods of protection have been identified in the past but despite recommendations, effective solutions appear to be elusive. This study aims to determine to what extent quantifiable information exists on the geographic and economic damage caused by woodpigeons to brassica crops. It also reviews and assesses practical control and scaring options for growers in order to construct a strategy framework for identifying gaps in our knowledge and suggests potential future investigations to test and recommend practical options for control by growers.

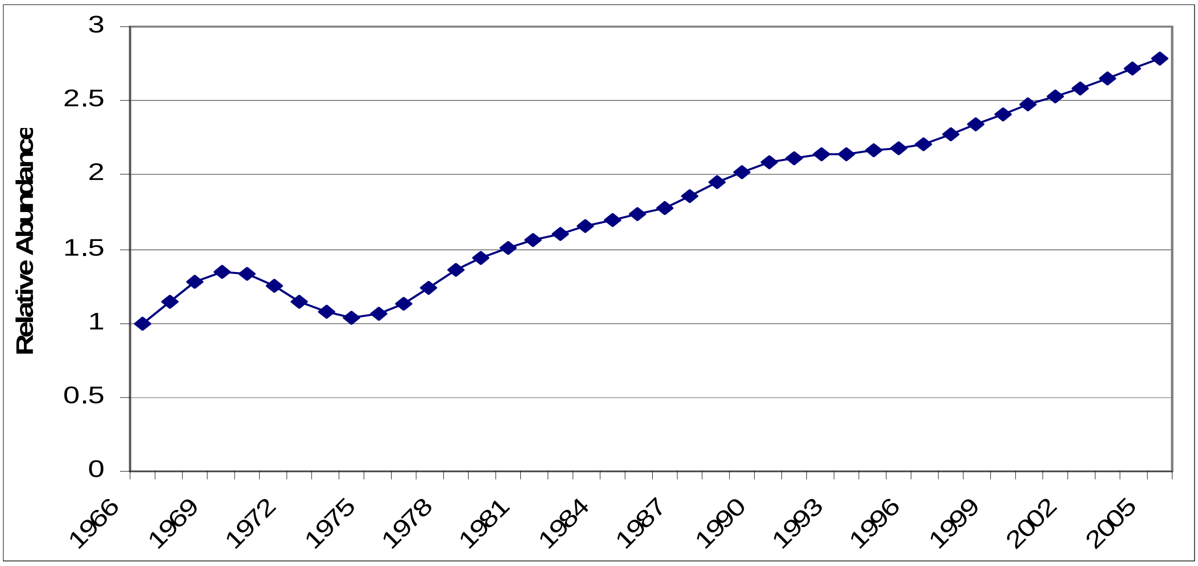
One key component of this study is to consider the practicalities of employing recognised methods of deterrent or potential combinations of methods that would result in deterring and ultimately controlling woodpigeons. Additionally, there is an effort to evaluate the level of financial and practical 'effort' required by the grower to reduce crop damage to an acceptable level. However, it has proven difficult to obtain relevant good quality data on levels of damage and the effectiveness of control measures. This report also discusses prescriptions that could operate within current administrative agricultural schemes that may be available to growers, such as the Single Payment scheme, set-aside and Environmental Stewardship. This includes identifying multi-functional benefits of prescriptions; for example, where sacrificial crops designed to attract woodpigeons away from brassicas may also operate as a buffer zone to protect watercourses from nutrients and pesticides.

2.0 Woodpigeons

2.1 Woodpigeon Population Size and Change

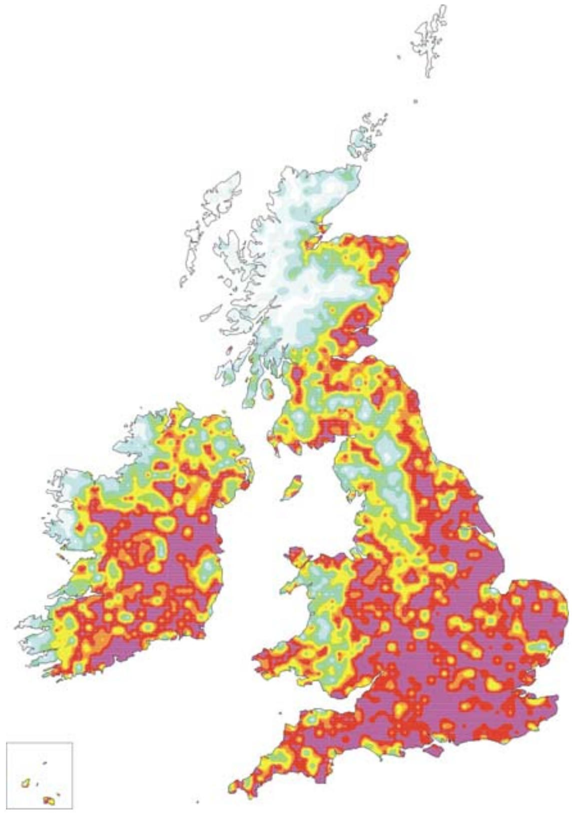
The most recent estimate of woodpigeon breeding population size in the UK has been produced by Newson *et al* (in preparation). Using data from the joint BTO/JNCC/RSPB Breeding Bird Survey (BBS), the figure was placed at 8.2 million birds whereas a previous estimate published in 1997 (Stone *et al*, 1997) placed the figure at 5.7 million adults. Although the density of woodpigeons is reported to be highest in broadleaved woodland (79.2 birds/km^2 compared to 46.1 birds/km^2 in tilled farmland, which includes brassicas) the number of birds in tilled farmland (2.27 million compared to 0.45 million in broadleaved woodland) exceeds any other habitat class (Newson *et al*, 2005). Figure One shows a graph of the relative abundance on woodpigeons since 1966, which is produced using the BTO Common Birds Census (CBC) and BBS data. Figure Two shows a map of relative abundance using data from the last BTO Breeding Bird Atlas (Gibbons *et al*, 1993).

Figure 1. Relative Abundance of Woodpigeons, produced using BTO CBC/BBS data.



Woodpigeons breeding range extends from western Siberia and Iraq in the east to the Faeroes in the west. They are migratory in northern and eastern Europe, but in Britain and Ireland are predominantly sedentary. However, there are some coastal movements, especially in autumn and spring (Wernham *et al*, 2002). Birds ringed and recaptured as juveniles had moved an average of 11km, birds ringed as juveniles and recaptured as adults had moved an average of 5km, and birds ringed and recaptured as adults had moved an average of only 2km. This sedentary nature, as well as their tendency to form large flocks to roost or feed increases the agricultural problems woodpigeons cause. Woodpigeons are widespread and numerous across the British Isles, but are particularly common in much of England, eastern Scotland and parts of Ireland.

Figure 2. Relative Abundance of Woodpigeons in Britain and Ireland (Gibbons *et al*, 1993). Dark colours indicate high densities of woodpigeons.



Locally, woodpigeons will travel a significant distance between feeding sites and roosting sites (Inglis *et al*, 1997). Birds residing in poor arable areas (as defined by MAFF Agricultural Census Surveys) travelled a mean of 20.5km, whereas birds residing in good arable areas travelled a mean of 10.2km. No such data exist for brassica crops. This wide foraging strategy means that when birds are scared from one field, they will in practise move to any number of fields within several kilometres.

2.2 Agricultural Practice and Woodpigeon Population Changes

Woodpigeons numbers supported by any given area will depend on the availability of a suitable food source. It was ~8,000 years ago that agriculture began to permeate into European economic and social behaviour (Jaeger, 2002), and since then a succession of radical changes in the way that agriculture is practised will have had profound effects on woodpigeon numbers. Since it is over-winter food shortages that appear to limit the woodpigeon population size (Murton *et al*, 1974), and clover, which is favoured by woodpigeons, was becoming increasingly uncommon as a result of changing agricultural practice in the 1960s, it had been predicted that woodpigeon numbers would fall (Wright, 1982). Indeed, this is what was observed (see Figure One) until the introduction of new cold-resistant oilseed rape, which could be sown in the autumn, and provided over-winter food for woodpigeons. Large scale production of oilseed rape began in Britain in 1973 (Inglis *et al*, 1997). One study recorded woodpigeon numbers in relation to crops grown over a 25 year period between 1961 and 1986, split into two periods of 1961-1971 and 1975 to 1985. It was observed that although population size in November/December was limited by the area of cereals sown in both periods, the population in January/February was limited by the area of clover ley in the period 1961 to 1972, and by oilseed rape in the period 1975 to 1986 (Inglis *et al*, 1990). Relatively recent changes in the use of novel brassica varieties and in the timing of drilling and harvesting patterns may also have had profound effects on woodpigeon populations, since it provides a food source in the hardest winter months.

2.3 Woodpigeon Feeding Ecology

Woodpigeon diet can be varied, and includes seeds, leaves, fruit, buds and root crops. It is likely that as grazers and seed foragers they were historically limited to feeding on forest floors and glades (Murton, 1965). The introduction of agriculture has enabled the woodpigeon to become very abundant, so that it is now considered a pest by many growers. The woodpigeon is a social bird and often feeds in flocks. During winter months, woodpigeons may spend the entire day feeding in order to sustain themselves, although their feeding bouts tend to concentrate at dawn and dusk (Banham, H., pers. comm. 2007). Woodpigeons have a large crop, which can be used to store food, thereby allowing them to take food to the roost (Murton, 1965). Unfortunately, this may also make it harder to prevent them from damaging brassica crops, since they can go for relatively long periods of the day without feeding and still not reduce their overall consumption (Kenward, 1978a).

Woodpigeons would preferentially feed on stubble grain until it becomes depleted, at which point they switch to clover leys, pastures and brassica crops (Kenward and Sibly, 1977), and it is thought that woodpigeons prefer younger brassica plants (MacDonald, 2005). Indeed, Crocker *et al* (2002) reported that woodpigeons feeding on cereal seed would, on average, require 53.1 grams of food intake, whereas woodpigeons feeding on Dicotolydenous crop leaves, such as brassicas, would, on average, require 999.8 grams of food intake. In addition, it takes 10 to 15 days for a woodpigeon to acclimatise to a brassica diet, in which time feeding behaviour, consumption and anatomy of the digestive tract change (Kenward and Sibly, 1978). Woodpigeons feeding at brassica sites were reported to have lower body weights than those at lodged barley sites, and yet they spend a considerable amount of time resting at brassica sites (Kenward and Sibly, 1977). It is thought that woodpigeons are limited by the rate at which they can digest brassica leaves, and that they simply cannot collect and digest enough in one day to sustain themselves. This means that they must supplement their diet if it is predominantly brassica leaves, and they do so with crops such as clover, which contains greater concentrations of both protein and fat (MAFF, 1960, cited in Kenward and Sibly, 1977).

3.0 Brassicas

3.1 Crops

The Brassicaceae Family includes about 350 genera with approximately 3,200 species of pungent or acrid herbs. Within the Brassica genus, only six species are the source of the edible crops. These are cruciferous plants with tap roots and erect branching stems. Vegetables of the species *B. oleracea* include the cabbages, cauliflower, broccoli, brussel sprouts and kales; *B. rapa* includes Chinese cabbage, turnip and mustards; and *B. napus* includes oilseed rape, canola and greens. All crops have an abundance of fibre and vitamin C, and most are also high in folate, potassium, and calcium. Brassica crops, which are also sometimes known as “coles”, are hardy cool season plants native to western Europe, the Mediterranean and temperate regions of Asia. Brassica crops are similar in cultural requirements, morphology, disease and pest susceptibilities.

In the UK brassica crops are grown largely in East Anglia, as well as in Cornwall, Kent, Lancashire and Scotland. Cauliflowers can essentially be grown and harvested the year round, although peak harvesting times tend to be in March and July; broccoli is grown and harvested between June and November; cabbages grow at different times of year dependent on the variety; and fresh greens are grown and harvested the year round. In order to maintain continuity of supply, several different varieties of crop are used, planting dates are staged, and when crops cannot be harvest in the UK, they are often imported from France, Germany, Netherlands and Spain. The TASCO Brassica Guide lists 14 general quality issues pertaining to brassica crops, and woodpigeon damage is one of those named.

3.2 Economics of Damage

Woodpigeons are considered one of the top two most economically important vertebrate pests at brassica sites (MacDonald, 2005), rabbits, *Oryctolagus cuniculus*, being the other. Despite this fact, there has been relatively little quantified research into the economic damage that woodpigeon do cause. However, in 1973, MAFF undertook a detailed study to measure the damage to brassicas in the Vale of Eversham (Murton and Jones, 1973). Every two weeks from November to mid-May one hundred plants were examined and scored on a four point scale, from no damage to leaves stripped. Both cabbages and Brussel-sprouts were tested. It was reported that woodpigeons rarely attack brassica plants before the end of December, and that damage peaks in March, perhaps when there is little alternative food available. Although woodpigeons preferred Brussel-sprouts to cabbages, damage to Brussel-sprouts was limited to the tops of plants, and buttons were unaffected. This damage might result in slower growth, later harvest and therefore problems with respect to supplying the client. At the time of publication it was concluded that some estimates of damage to crops warranted full-time employment of a person to scare woodpigeons.

It is certain that growers feel there is an issue with respect to economic damage that woodpigeons cause to brassica crops (Banham, pers comm. 2007). Indeed, one grower suggested that crops would be ruined unless some measures were taken to either control the woodpigeon population, or to remove them from fields. This might particularly apply in March and April, when brassica plants are young, and there is little alternative forage available. Furthermore, the issue of developing a universal control strategy is complicated by the range of crops and varieties of crops grown, as well as the staggered timing of both drilling and harvesting. The scientific evidence is not definitive, and further studies in this area might aid the decision-making process that growers undertake when considering investing in bird deterrents.

4.0 Control Methods

4.1 Auditory Deterrents

<u>4.1.1 Gas Cannons</u>

Gas cannons are automated scaring devices that fire either single of multiple bangs in order to startle birds and cause them to flee the site. There are a small number of scientific studies into the effectiveness of gas cannons that generally indicate they can successfully reduce damage to crops (Cardinall and Hayne, 1944; De Grazio, 1961 both cited in Bishop *et al*, 2006). However, Potvin and Bergeron (1981, cited in Bishop *et al*, 2006) further compared single gas cannons with dual pivoting cannons and found that static single cannons provided no protection, whereas synchronised dual pivoting cannons reduced losses on maize fields by 73%. The main weakness of gas cannons and other auditory scarers is that birds become rapidly habituated, and so in order to maintain their effectiveness they need to be moved around every few days, and reprogrammed. They are therefore labour intensive. There is also an issue with respect to noise nuisance, which must be carefully considered before employing gas cannons near private housing. Newer models of gas cannon incorporate visual scaring techniques, and are said to be more effective, although very limited scientific evidence exists on their efficacy (Bishop *et al*, 2006).

4.1.2 Bio-acoustics
Bio-acoustic deterrents operate by broadcasting either distress calls of the target species or the calls of natural predators. As such they are biologically meaningful sounds and the instance of habituation by the target species seems to be reduced. Such devices have been shown to be effective repellents for gulls and corvids (Bremond *et al*, 1968). Baxter (2002, cited in Bishop *et al*, 2006) reported almost complete clearance from landfill sites was reported, although birds returned fairly rapidly once the equipment broke down. Harris and Davis (1998) suggested that raptor calls might be useful to deter birds since they might indicate that predators are close-by. However, there is no properly controlled evidence to suggest this might work in practise, and since raptors tend to hunt in silence, its biological relevance may be limited. Woodpigeons communicate distress largely through visual means (see Decoys below), and so bio-acoustics using woodpigeon calls is not a recommended deterrent option.

4.2 Visual Deterrents

4.2.1 Falconry
Since falcons and hawks can be natural predators of pest species such as woodpigeons, they can be used to deter birds from fields. Kenward (1978b) reported that when a trained goshawk, *Accipiter gentilis*, was used to attack flocks of pigeons, they were more successful on brassica sites than on grasslands and stubbles. Further, attacks were more successful in the last hour before sunset, than in the previous four hours. In another study, Kenward (1978a) showed that pigeons immediately resettled on brassica sites after goshawk attacks 23% of the time, and after nearly half the attacks, birds were seen feeding on the field later the same day. The use of hawks to control woodpigeon numbers at brassica sites could be successful, although it is labour intensive and expensive. Indeed, Kenward (1978a) concluded that bird scaring techniques involving humans might be more successful than the use of hawks. Falconry might be used in combination with bio-accoustics and balloons or kites (see below) to improve the efficacy of all three methods.

4.2.2 Decoys
Decoys have been shown in several studies to have a significant deterrent effect on woodpigeons (Hunter, 1974; Inglis & Isaacson, 1984). Inglis and Isaacson (1984) confirmed that real woodpigeon decoys with open wings, displaying the white wing marks, had a significant effect on whether arriving woodpigeons would land or not. Indeed, the wings alone, so long as they have the white marks, deterred woodpigeons from landing. Hunter (1974) compared painted metal models of woodpigeons with real woodpigeon decoys, and reported a reduction in damage to cabbages for a four week period whichever was used. In some cases this might be long enough for the crops to grow past their most vulnerable stage. In order to be effective, decoys must be in good condition, so that the visual cues are clearly visible (Inglis & Isaacson, 1987).

4.2.3 Lasers
Lasers have been tested in a number of studies, with mixed results. Blackwell *et al* (2002) reported that no effect was observed on starlings, *Sturnus vulgaris*, limited effect on rock doves, *Columba livia*, and some success on geese and mallards, *Anas platyrhynchos*. However, the geese and mallards habituated within 20mins. McKay *et al* (1999a) used a laser on two cormorant roosting sites, both of which were disturbed, but some birds remained at the second site. Lasers are expensive, require specialised knowledge for

operation and are most effective in low light conditions or at night. As such they may not be a favoured method of scaring woodpigeons from crops.

4.2.4 Kites and Balloons

Balloons appear to be effective for relatively short periods of time, although their effectiveness is increased if eyes are printed on them (Inglis, 1980, cited in Bishop *et al*, 2006). McLennan (1995) found that beach balls with printed eyespots significantly reduced landings by song thrushes, *Turdus philomelos*, for 2 weeks, and landings by blackbirds, *Turdus merula*, house sparrows, *Passer domesticus*, and starlings for 3 weeks in a vineyard. Habituation seems to be relatively rapid when this deterrent method is used, and as a long term solution, balloons are not recommended.

Kites are largely reported to be ineffective at deterring birds (Bishop *et al*, 2006). Hothem and Dehaven (1982) tested raptor-mimicking kites suspended from helium balloons in a vineyard. They concluded that there was only a slight decrease in damage in a small area, but that damage elsewhere in the vineyard increased. As with balloons, birds appear to habituate rapidly to kites, and they are not a recommended option for deterring woodpigeons from brassicas.

4.2.5 Flags

Flags and streamers are caught in the wind, and the resulting movement startles birds, often causing them to flee the site. A number of studies have shown that their use can be effective, although again it may not be a long-term solution since habituation does occur (Bishop *et al*, 2006). Central Science Laboratory (Anon, 2005b) tested tape deterrents using several types of tape arranged in different configurations. Using high-visibility tape in a herringbone configuration was deemed the most effective, and markedly reduced or prevented grazing on oilseed rape fields. This method was considered to be cost effective. Flags are relatively cheap and easy to employ, and are considered to be an option worth considering with respect to woodpigeons on brassica sites.

4.2.6 Mirrors

The principle behind mirror use is that they startle birds by producing a bright flash of light. There is relatively little evidence regarding their application as bird deterrents, although Bishop *et al* (2006) reports that there are devices available in the UK that manufacturers claim are effective against pigeons.

4.2.7 Human Disturbance and Scarecrows

The presence of humans is one of the most effective bird deterrents available, as well as being one of the simplest. The Civil Aviation Authority (2002) states that it is particularly effective if straightened arms are raised and lowered to mimic the wing beats of a large raptor. Vickery and Summers (1992) reported that brent geese, *Branta bernicla*, rarely attempted to visit sites where intensive human disturbance had been applied for one month. There were no signs of habituation to the human scarer and damage to the crop was reduced by an order of magnitude. Although highly effective, this is an expensive and labour intensive deterrent, and a judgement must be made regarding the losses incurred through crop damage compared to the cost of using a human scarer.

Scarecrows work by mimicking natural predators, often humans, thereby causing birds to flee the site (Harris and Davis 1998). Scarecrows need to be highly visible, life-like and moved on a regular basis in order to retain their effectiveness (Vaundry, 1979 cited in Marsh *et al*, 1992). Although relatively recent developments have seen the introduction of automated inflatable human scarecrows, their effectiveness has similarly been seen to reduce rapidly as birds become habituated (Andelt *et al*, 1997, cited in Bishop *et al*, 2006). Although scarecrows can be effective at deterring birds, they may be labour intensive to move on a regular basis. Their effectiveness can be increased when used alongside auditory deterrents, and human presence could also reinforce their effect (Bishop *et al*, 2006).

4.3 Exclusion

4.3.1 Nets

This is considered to be one of the most effective measures used to prevent bird damage to commercial crops (Bishop *et al*, 2006). However, the cost of completely covering a field with nets is likely to be prohibitive unless the crop is of very high value, and bird damage is high. Littauer *et al* (1997, cited in Bishop *et al*, 2006) reported that the cost of covering 100 acres with netting and a supporting structure was in excess of $1million. There may also be problems experienced in removal of the netting prior to harvesting. However, there is potential for netting to be used experimentally to study the damaging effect of woodpigeons on brassica crops.

4.3.2 Fleece & Plastic Covers

These may be used as a normal part of growing a commercial crop to bring forward the growing season (Banham, pers. comm.), in which case their role as a damage prevention measure is supplementary and a bonus. As with nets, the use of fleece or plastic coverings may provide near complete protection of a crop from birds, thereby reducing damage to almost zero. However, since they are generally only used early on in the growing cycle when the plants are most susceptible, alternative measures are required once the covers have been removed.

4.4 Habitat Modification

4.4.1 Sacrificial Crops and Alternative Feeding Areas

Alternative feeding areas (AFAs) are areas managed to provide preferred feeding that is more attractive to the pest species than the commercial crop. Although AFAs may simply involve managing a set-aside area, sacrificial crops can be purposely sown in order to lure birds away from the commercial crop (Bishop *et al*, 2006). AFAs have been employed in the UK where damage by geese is a problem, and to a certain extent have been successful (Owen, 1977), although Vickery *et al* (1994), showed that their establishment may not be economically viable for cereal growers. Their success generally relies on being able to scare pests from the commercial crop onto the sacrificial crop, ensuring that the sacrificial crop is at an attractive growth stage at the correct time, and that the sacrificial crop persists (Smith *et al*, 1999). It is possible that sacrificial crops may simply provide woodpigeons with the food they require to supplement their unsatisfactory diet of brassicas. Additionally, if the areas that are sown or managed are small enough, it may be feasible to use those areas to trap large numbers of woodpigeons at once.

4.4.2 Potential for reducing the costs of sacrificial crops using (GAEC)

Currently in England, there is considerable concern over resource protection, such as the threat posed to water-courses from diffuse pollution from agricultural run-off (Defra Diffuse Pollution Review, 2002). Through the Water Frameworks Directive EU member countries will have to attend to water quality and reach pre-defined standards from 2009. Methods to counteract diffuse pollution include the use of a buffer strip along water-courses, normally in the form of 2 m grassy field margins, as an objective under Good Agricultural and Environmental Conditions (GAEC). For fenland farms, with high quality and highly productive soils, and high value crop rotations, the cost of buffer implementation might be higher than average, especially where many boundaries are ditches and dykes. Mitigation against some of the highest costs of this requirement could include a set-aside requirement under GAEC and Local Environment Risk Assessment for Pesticides (LERAPs). Both margin and LERAP requirements can be combined to meet both obligations. Generally, multifunctional benefits are viewed as additional value for money, especially where schemes are supported via subsidized payments. It may therefore be that greater financial scope would allow buffer strips and crop-edge zones to be managed for dual or multi-functional purposes, particularly since 2005, when almost all arable land, including for potatoes and vegetables, became eligible for the Single Farm Payment. One potential application might be where fast growing and nutrient absorbing crops such as mustard or oilseed rape could be used as a buffer zone for spray drift, and would simultaneously operate as a sacrificial crop, to draw pest species, such as woodpigeons away from commercial crops at crucial times.

Probably the most appropriate sacrificial crops for woodpigeons would be young oilseed rape or clover, timed to be at its most attractive to woodpigeons in spring, when damage to young brassicas is most acute. By incorporating sacrificial crops into field boundaries, which then act as buffer strips under cross-compliance or as set-aside margin if managed correctly, the net costs required for woodpigeon damage control might be reduced relative to the damage woodpigeons cause.

4.4.3 Modification of Roost Sites

Should roost sites be identified, it might be possible to encourage birds to leave an area by either removing or modifying the roost site. Good and Johnson (1976, cited in Bishop *et al*, 2006) reported that blackbirds completely abandoned roost trees that had one third of the canopy removed. However, in order for this to be effective, it may be necessary to use other techniques such as bio-acoustics in conjunction, and distance to alternative roosting sites needs to be considered. It would be incredibly useful for farmers to have some idea of how far woodpigeons are travelling to get to roosting or nesting sites, since this might allow them to target control measures more effectively.

4.5 Lethal Techniques

4.5.1 Shooting

Shooting has a dual purpose, in that some birds are killed, but also those birds that live are generally scared away. Woodpigeon shooting is covered by a General Licence and woodpigeons have been extensively shot both for crop protection and for sport. Murton *et al* (1974) suggested that shooting might not have an effect on local woodpigeon population size, since it largely substitutes for naturally occurring over-winter mortality. Indeed, Murton (1964) reported that despite being given essentially unlimited resources for the purpose of exterminating a local population of woodpigeons, it proved impossible to do so. However, Central Science Laboratory (Anon, 2005a) developed a model to predict national woodpigeon population numbers, which suggested that should shooting shift from winter to summer, woodpigeon numbers would gradually decline. Although it may be highly resource intensive to reduce woodpigeon numbers by shooting, it is an effective scaring technique, and it has been suggested the human disturbance involved may reinforce the scaring effect (Townshend & O'Connor 1993).

4.6 Chemical Repellents

There are three categories of chemicals used as bird deterrents, namely taste repellents, behavioural repellents and tactile repellents. Although some testing has been done, predominantly in the US, many of the chemicals are not registered for use in the UK. Bishop *et al* (2006) analysed the literature available, and found that out of 27 studies, 20 showed chemical repellents to be very or partially effective, and seven showed they were ineffective.

4.6.1 Behavioural Repellents

Behavioural repellents such as 4-aminopyridine (Avitrol), are essentially toxicants, and operate because in low doses they cause disorientation, which often results in distress calling, startling other birds and causing them to fly away (Bishop *et al*, 2006). Although habituation can still occur, studies indicate that Avitrol is effective at reducing bird damage to field maize (Stickley *et al*, 1976) and ripening sunflowers (Besser and Guarino 1976). Avitrol is not registered for use as a bird repellent in the UK.

Tactile repellents work by either coating plants in a sticky substance, or using chemicals that upon contact cause an uncomfortable feeling for the bird. Clay-based coatings that become sticky when they are damp have been shown to be effective both in the field, reducing loss of rice seed (Decker *et al*, 1990) and in the laboratory, repelling captive red-winged blackbirds (Daneke & Decker, 1988).

4.6.2 Taste Repellents

The use of taste repellents is generally expensive, in terms of cost of the chemicals and potentially the hardware to apply them, and the man hours required for their application. Currently only Zinc dimethyldithiocarbamate (Ziram) and Aluminium ammonium sulphate are registered for use as bird repellents in the UK. McKay and Parrott (2002) reported that Ziram failed to protect oilseed rape after one application, although they concluded that repeat spraying could be more effective. No evidence appears to exist relating to the use of aluminium ammonium sulphate. Cinnamamide is a novel repellent that has been shown to significantly reduce the damage to the inner leaves of treated brassicas (Gill *et al*, 1998). It does, however, face the common problem of poor persistence, which is being addressed, and to some extent remedied (Cotterill *et al*, 2004). Gill *et al* (1998) treated late in the growing season (late February) and suggested that treatment early in the growing season would be more effective.

4.6.3 Pesticide Treatments

Some research has also been undertaken into whether woodpigeons avoid pesticide-treated seeds (McKay *et al*, 1999b). Fewer fields with fonofos-treated cereal seed were used by woodpigeons than fields with untreated seed. This effect was observed for the first week after drilling only, and it was concluded that the observed reaction was related to concentrations of fonofos remaining on the fields. Avery (1989) shows that it is not necessary to implement 100% treatment, since birds will learn to avoid a food source even when a small proportion of it is unpalatable.

5.0 Discussion

This study has involved extensive literature research using sources including the British Trust for Ornithology, the University of East Anglia and the John Innes Centre libraries, databases such as Web of Science, Ingenta and JSTOR, personal communication with brassica growers at T.A. Smith & Co. (Farm Produce) Ltd. (TASCO) and the world wide web. Control methods have been categorised into auditory deterrents, visual deterrents, exclusion, habitat modification and lethal techniques and chemical techniques. Although some of the literature is not directly relevant to woodpigeons and brassica crops, every document cited relates to damage that birds do to commercial crops. In some cases there is very little scientific evidence to either support or refute the use of bird control methods, and it is recommended that further work is done where appropriate.

Auditory deterrents seem to be effective to some degree. With respect to woodpigeons, it is recommended that gas cannons are used rather than bio-acoustics. This is because alarm and distress signalling in woodpigeons is generally more visual than auditory. It is clear that birds become habituated to auditory devices if they are used in a simple and repetitive fashion. However, when there is some investment, either in more technologically advanced devices or in man-hours to manage the devices, then damage to crops can be significantly reduced. It is worth noting that when using gas cannons, neighbouring housing needs to be accommodated with respect to noise nuisance. In addition, auditory deterrents are a method of scaring birds from a specific site, and the birds will inevitably land elsewhere. As such the problem is moved on but may not be reduced overall. The use of a combination of methods might prove particularly effect with gas cannons, in that shooting will reinforce their effect and kill some birds.

The success of visual deterrents is highly variable. Whereas most kites, balloons, falcons, lasers, mirrors and scarecrows had a very limited effect, human disturbance and to a lesser extent decoys and flags appear to offer some protection to crops. Again, these techniques will not affect the woodpigeon population level, but they may ensure birds are present on target sites significantly less than they would have otherwise been. It would be useful to better understand how to use decoys and flags, and to what extent human disturbance removes woodpigeons from sites, and for how long.

Exclusion is clearly the most successful method of reducing crop damage. However, it also tends to be the most expensive, and as such may not be an economically viable option for brassica growers. Fleece and plastic covers are already used by brassica growers, although the primary purpose is to speed up development of early season crops. They are considered expensive and although can be used twice, are becoming more expensive. Exclusion nets may be useful to experimentally determine the damage that woodpigeons do to brassica crops.

Habitat modification has been reported to be an effective method of reducing damage to crops and is considered to be environmentally friendly. Since woodpigeons cannot sustain themselves on brassica crops alone due to their dietary requirements, the option of sacrificial crops is one worthy of further investigation. This is particularly the case since it may be possible to derive some subsidy from managing areas to comply with one or more agri-environmental and agricultural schemes. There is no scientific evidence that roost site modification is effective against woodpigeons, although little research has been carried out. However, it is likely to be useful for growers to understand more about the movements of woodpigeons during the day in order to target control measures more effectively.

Lethal techniques have been shown to be ineffective at reducing woodpigeon population levels. This could be because immigration and breeding rates exceed mortality inflicted on the local population, and that shooting substitutes for natural over-winter mortality. From a wider perspective, lethal techniques do seem to be consistently more effective than auditory, visual or chemical techniques at reducing damage on particular fields. It is not clear whether this is because of the mortality inflicted or because shooting may reinforce other techniques, such as human disturbance and gas cannons. As such shooting could be a highly valued complimentary technique in woodpigeon control.

Chemical deterrents can be very effective in reducing crop damage, but many of the chemicals are not registered in the UK. The taste repellent Cinnamamide does appear to offer some protection in trials so far completed, although its persistence needs to be improved, without allowing residues to remain on the plant.

Many of the techniques described in this report may be completely ineffectual in reducing brassica crop damage by woodpigeons. There is an issue with respect to moving on the population of woodpigeons rather than reducing the population level. Indeed, it would appear to be impossible to reduce the woodpigeon population size with current agricultural practice. In the past, agricultural land was owned and farmed in smaller plots, and the owner tended to do the farming as well. Farmers therefore had an incentive to carry out scaring and shooting on their own land. Currently, there are larger companies growing crops, and renting land from smallholders. This means that often the land managed by one company is dispersed, making it harder to develop a holistic strategy for deterring birds.

The best strategy is a combination of options. Human disturbance seems to be consistently successful at removing woodpigeons, particularly when complimented by regular shooting. Should gas cannons be used, but not intensively, they will be successful since their effect will be reinforced by regular shooting. Since the land is often dispersed, another option might be to cooperate with other local growers to employ one person full-time to move around the fields dispersing woodpigeons, moving gas cannons etc.

6.0 Further Work

Although some studies already exist that pertain directly to woodpigeons and brassica crops, they are limited, and in some cases dated. Although studies that involve neither brassica crops nor woodpigeons may still be relevant, it is likely that specific field studies would reveal more relevant and appropriate recommendations. The further work that could be undertaken to lead on from this report can be categorised into three points:

- Observational work in order to determine greater detailed knowledge about the movements of woodpigeons throughout the day. Understanding where woodpigeons supplement their diet of brassica leaves could be vitally important, and knowing where they are roosting and breeding would be similarly so. Furthermore, observing woodpigeons after deployment of scaring techniques might reveal more efficient ways of keeping them away.
- Understanding and costing the true level of damage that woodpigeons can inflict on a brassica crop. By measuring damage inflicted on brassiacas, and calculating a cost, the grower is equipped with the knowledge to make a judgement themselves whether it is worth paying for control measures. This could be looked at in several ways, for example feeding trials to see how much brassica crop a woodpigeon eats in a day; assessing crop damage and woodpigeon numbers in the field; field trials using exclusion techniques to assess damage.
- Testing specific control techniques experimentally. This report has identified several control measures that seem most able to deter woodpigeons from brassica sites. However, all of these techniques can be fairly labour intensive, and therefore expensive. Experimental work into how best to use these measures, either alone, or in combination, could reveal the most cost effective way of doing this.

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