# Seeds and seed-eating birds: casualties of agricultural change

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**A Linnet feeding on dandelion seeds.**
Richard Chandler

Among the various farmland birds that have declined in Britain over recent decades are the small seed-eaters that feed largely on the seeds of farmland weeds. The widespread use of herbicides, especially on arable land, has by now removed many broadleaved weeds from most of our fields, and has steadily depleted the seed bank in the soil. Over the same period, the transition from spring-sown to autumn-sown cereals and other crops has greatly reduced the numbers of winter stubble fields, which provided both weed seeds and spilt grain. In addition, the loss of traditional flower-rich hay meadows, along with their conversion to intensive silage grass, has further diminished plants the seeds of which are eaten by birds.

Almost all small seed-eating birds in Britain feed to a greater or lesser extent on farmland weeds, taking them either directly from the plants themselves or from the ground below (see Table 1). Some of these birds also eat cereal grain or other crop seeds. Their net population changes over the period 1970–2013 are listed in Table 1, along with some of their major farmland foodplants, mostly in the families Gramineae, Polygonaceae, Amaranthaceae (including Chenopodiaceae), Caryophyllaceae, Brassicaceae and Asteraceae.

## Weed seeds

Weeds are often defined as 'plants out of place', unwanted within the crops of farmland. As such, they have for long been a problem for arable farmers, competing with the crop for water, nutrients and light, and reducing the yield. Like the crop plants themselves, arable weeds have short lifecycles, most progressing from germination to seeding within the growth period of the crop. Species with the shortest lifespans can fit in several generations per year: Shepherd's Purse *Capsella bursa-pastoris* and Groundsel *Senecio vulgaris* can produce seeds in as little as six weeks from germination, and these seeds can, given enough warmth and moisture, grow at almost any time of year. Most arable weeds also produce seeds in prodigious quantities, often in the range 1,000–4,000 seeds per plant (Salisbury 1961). Some of these seeds can lie dormant in the soil for years, until conditions become suitable for their germination and growth. The time over which seeds can remain viable in the soil varies among plant species, but some of the commonest arable

**Table 1. Net population changes of some small seed-eating birds in Britain over the period 1970–2013, as measured by BTO monitoring programmes (Hayhow *et al.* 2016), and their main foodplants on farmland as recorded from diet studies (Newton 1972; Cramp & Perrins 1994; Wilson *et al.* 1999; Holland *et al.* 2006).**

| Species | Population change (%) | Main foodplants |
|---|---|---|
| Chaffinch | +27 | Cereals, *Spergula*, *Polygonum*, *Chenopodium*, *Stellaria*, *Rumex*, *Sinapis* |
| Greenfinch | –39 | *Taraxacum*, *Senecio*, *Sinapis*, *Cirsium*, *Arctium*, *Polygonum*, *Stellaria*, *Chenopodium* |
| Goldfinch | +154 | *Taraxacum*, *Senecio*, *Brassica*, *Hypochoeris*, *Cirsium*, *Arctium*, *Dipsacus*, *Centauria*, *Filipendula* |
| Linnet | –57 | *Taraxacum*, *Stellaria*, *Hypochoeris*, *Sinapis*, *Brassica*, *Polygonum*, *Chenopodium* |
| Twite *Linaria flavirostris* | –21* | *Taraxacum*, *Stellaria*, *Sinapis*, *Brassica*, *Rumex*, *Hypochoeris*, *Chenopodium*, *Polygonum*, *Anthemis* |
| Lesser Redpoll *Acanthis cabaret* | –86 | Grasses, *Taraxacum*, *Hypochoeris*, *Stellaria*, *Filipendula*, *Epilobium*, *Rumex*, *Chenopodium* |
| Bullfinch *Pyrrhula pyrrhula* | –40 | *Taraxacum*, *Stellaria*, *Rumex*, *Sonchus*, *Filipendula*, *Chenopodium*, *Ranunculus*, *Urtica* |
| Yellowhammer | –55 | Cereals, grasses (especially *Festuca*, *Lolium*), *Rumex*, *Polygonum*, *Chenopodium*, *Stellaria*, *Plantago*, *Urtica* |
| Reed Bunting *Emberiza schoeniclus* | –32 | Cereals, grasses, *Chenopodium*, *Polygonum*, *Rumex*, *Atriplex*, *Stellaria*, *Urtica*, *Filipendula* |
| Corn Bunting | –90 | Cereals, grasses, *Polygonum* |
| House Sparrow | –66 | Cereals, grasses, *Chenopodium*, *Polygonum*, *Atriplex*, *Plantago*, *Stellaria* |
| Tree Sparrow | –90 | Cereals, grasses (especially *Poa*), *Chenopodium*, *Polygonum*, *Plantago* |
| Skylark | –60 | Cereals, grasses, *Polygonum*, *Chenopodium*, *Galeopsis*, *Urtica*, *Rumex*, *Stellaria*, *Ranunculus* |

*The Twite, unlike the other species listed, was not regularly monitored, but it was estimated to have declined in numbers by 21% over the 15 years between 1999 and 2013, and underwent a one-fifth shrinkage of breeding range since 1970 (Balmer *et al.* 2013).

weeds have shown seed-dormancy periods of up to several decades or more (Salisbury 1961). During the First World War, 1914–18, the association of the Common Poppy *Papaver rhoeas* with the disturbed soil of the trenches and shell-holes of Flanders arose from the longevity of its seeds, able to survive for decades under grass and yet spring into life when conditions became suitable. The old adage 'one year's seeding means seven years' weeding' is clearly a big understatement for many arable weeds.

The natural attributes of short lifecycles, abundant seed production and seed longevity preadapted such plants to grow among arable crops. Before agriculture, many were presumably restricted to areas of unstable soil, such as landslips and scree slopes, places where wild pigs had rooted up the ground, or any other areas subject to frequent disturbance. With the advent of farming, however, such weeds could spread more widely, providing an abundant food source for the small seed-eaters that became some of the commonest farmland birds. Some of the weeds themselves have been formally classed as 'archaeophytes', brought in and spread through arable farming in ancient times.

The importance of the buried seed bank for birds is not only that it enables their major foodplants to persist through periods of adversity but also that seeds are turned to the surface with each ploughing, becoming suddenly available again. In the past, when weeds were more abundant than they are now, it was common to see mixed flocks of finches, sparrows, buntings and larks, sometimes thousands strong, feeding on newly turned soil. This freshly exhumed food source was especially important because it became available mainly in late winter or spring, when fields were traditionally ploughed for planting, a time of year when most other accessible seeds had been eaten. In recent decades, with the decline in broadleaved weeds, such flocks are seen much less often, but they can still occur when land that has been under grass for decades is ploughed, exposing once again its buried treasure.

## Weed control

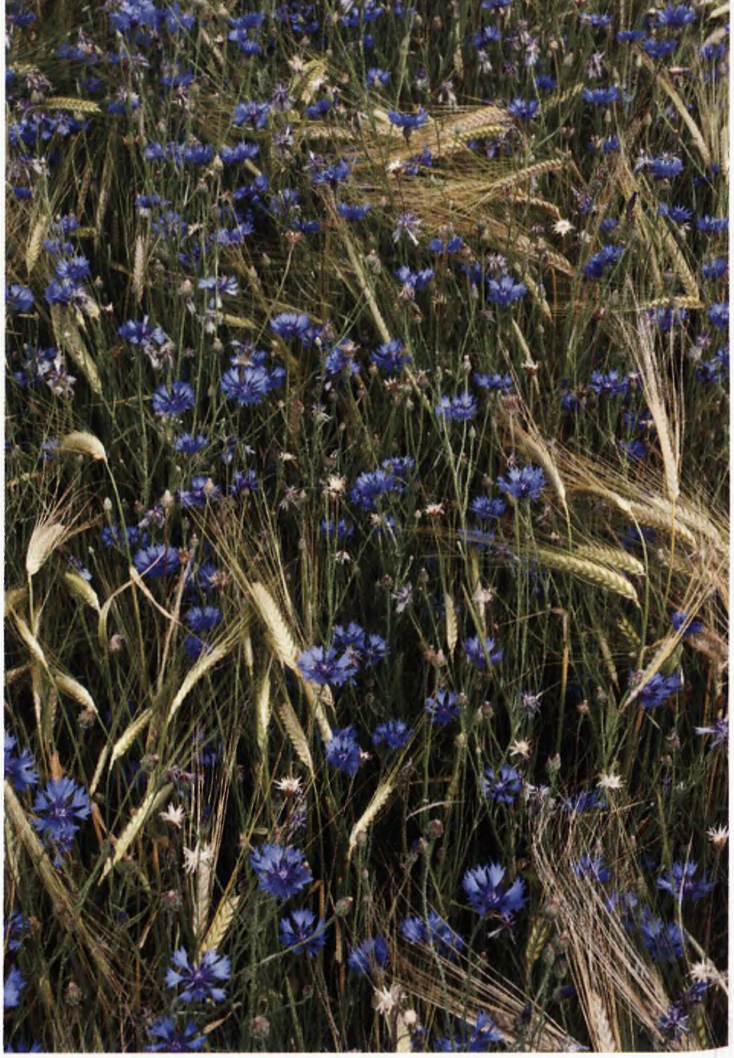
Apart from crop rotation, the first major step in weed control came in the early 18th century, with the development of a seed drill that buried crop seed in rows. This made it easier to hoe out the

weeds between the rows of plants. Before this, when seed was scattered by hand, hoeing among the growing plants was practically impossible. The second development came with improved methods of screening harvested grain to remove weed seeds, preventing them from being resown with the next crop. From the late 19th century, sieves were fitted to threshing machines and subsequently to combine harvesters. All small weed seeds and other impurities were thereby removed from the grain and could be destroyed.

The third main development in weed control came in the 1940s with selective herbicides – chemicals that could be sprayed on a cereal crop to kill only the broadleaved weeds, leaving the monocotyledonous crop unharmed. Crop-spraying was at first on a small scale, but it became widespread from the 1970s as new chemicals became available. Repeated annually, it led to a gradual decline of many weed species, and to progressive depletion of the seed bank in the soil, as each year's growing plants were killed before they could seed. Some species with short-lived seeds declined rapidly, examples including Corncockle *Agrostemma githago* in the early 20th century (mainly through seed-screening) and Cornflower *Centaurea cyanus* and Corn Buttercup *Ranunculus arvensis* in the 1950s and 1960s (mainly through herbicide use). Other arable weeds, with longer dormancy periods, persist to this day, relying on the seed bank and occasional chance seeding. Nevertheless, almost all broadleaved weed species have declined greatly over recent decades, thus removing a major food source for seed-eating birds (Smart *et al.* 2000; Firbank & Smart 2002; Carey *et al.* 2008; Potts *et al.* 2010). The impact of herbicides could increase further in the years ahead if more herbicide-resistant crop varieties come into use, encouraging chemical weed control in even more situations than at present.

The densities of weed seeds in arable soil were calculated in various 20th-century studies. Estimates could range up to several thousand seeds/m$^2$, as measured on the surface and in the top centimetre of soil, but with big variations between fields (Robinson & Sutherland 1999; Moorcroft *et al.* 2002; Larkman *et al.* 2015). During the 20th

**A flock of Bramblings *Fringilla montifringilla*, Chaffinches and Goldfinches, flying over a game cover crop. Large mixed winter flocks of seed-eating birds have become an increasingly rare sight.** Desmond Dugan/FLPA

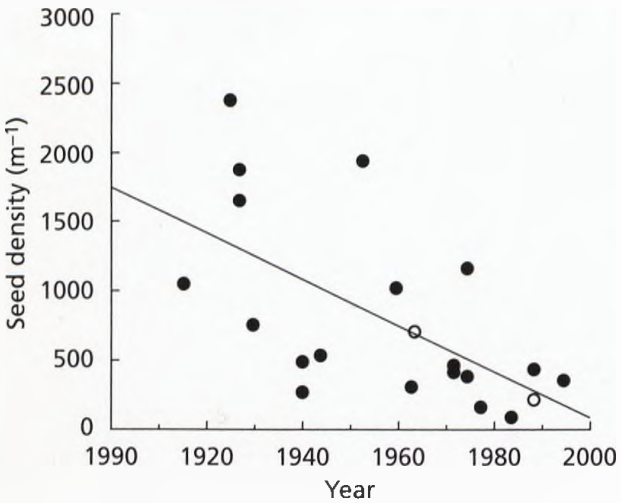


**Changes in farming practices have led to massive declines in arable weeds such as Corncockle (left) and Cornflower (right).** Bob Gibbons

century, however, a massive reduction in average seed densities occurred in arable land, from around 1,400 seeds/m² in 1920 to around 170 seeds/m² in 1995 (Figure 1). This represents an 88% reduction in soil weed seeds over this 75-year period. The most readily available source of these seeds for birds in winter was stubble fields, and, accepting that about two-thirds of all stubble fields are now ploughed in late summer, the total reduction in weed seeds on winter stubble could be around 96%. It is not surprising that those small seed-eating birds that fed mainly in winter stubbles have declined so markedly in Britain since 1970. They include the Corn Bunting *Emberiza calandra* (declined by 90%), Linnet *Linaria cannabina* (57%), Skylark *Alauda arvensis* (60%), Tree Sparrow *Passer montanus* (90%) and Yellowhammer *Emberiza citrinella* (55%) (Table 1).

Weed seeds are not, of course, the only seeds available on stubble fields, and many species eat the grain spilt on the ground during harvest. With the switch, on most cereal fields, from spring to autumn ploughing, any grain or other seeds on

**Figure 1 Published estimates of seed densities in arable soils.** Points represent densities of dicotyledonous seeds in the top 1cm of soil in arable fields in Britain and Denmark (open symbols). Studies were included only if they sampled the entire seed bank between September and November and the fields had been part of a cereal-based rotation for at least five years; results from adjacent fields and years were averaged. Slope of regression through the British data: $-17$ seeds $m^{-2}$ $year^{-1}$, $R^2 = 0.35$.
From Robinson & Sutherland 2002



the surface are buried soon after harvest, and are no longer available for birds over the winter. Moreover, any stubble fields that now remain over winter contain much less spilt grain than did stubbles of the past. This is partly because selective plant-breeding has produced cereal varieties that hold on to their seeds more firmly than those of the past did, and also because harvesting has become less wasteful. In the days before combine harvesters, the cut seed-bearing stems were bound into sheaves which were then arranged as upright stooks to dry, before they were loaded and carted to stack-yards. With such repeated handling, many seeds were shed on the field surface, where they remained to provide food for birds into the ensuing winter. Combine harvesters cut and thrash the grain in one operation, greatly reducing spillage. They came to be used on almost every cereal-growing farm, and over the years have become progressively more efficient. During the period 1970–2000, the average grain spillage from combines declined from 250 to 20 grains/m$^2$, a 92% reduction (Robinson 1997; Robinson & Sutherland 2002; Larkman *et al.* 2015). Now, if two-thirds of cereal fields were ploughed soon after harvest, this would reduce the 8% of fallen grains remaining to less than 3% of their former abundance. Allowing for the slight increase in the area of cereals grown over this period, these figures still imply a roughly 97% reduction in the amount of grain available to birds from unploughed autumn stubbles.

## Grassland weeds, hay and silage

In contrast to arable weeds, most broadleaved weeds (or 'wild flowers') of grassland are biennials, seeding in the second year (such as Spear Thistle *Cirsium vulgare*), or perennials, growing and seeding from the same root stock year after year (such as Meadowsweet *Filipendula ulmaria* and Broad-leaved Dock *Rumex obtusifolius*). Their abundant seeds are normally available to birds only from the plant. Once they are shed, they fall into the herbage below and become inaccessible. Traditional hay fields hosted a variety of broadleaved plants that flowered at different dates through the spring and early summer, providing a succession of seed crops for birds (Newton 2017). Hay fields were usually mown in July, when many of the grasses and broadleaved plants held seeds but while their stems and leaves were still green. So, whenever stored hay

**Goldfinch feeding on Creeping Thistle *Cirsium arvense*.** Richard Chandler

was fed to livestock in the fields in winter, seeds were spilt, attracting small flocks of seed-eaters, especially buntings.

From the mid-20th century, many wild flowers of grassland were eliminated simply through the use of inorganic fertilisers. These compounds can be readily taken up by modern grass varieties, which then grow so vigorously that they outcompete most broadleaved plants, while the remaining, resistant ones such as thistles can be eliminated by spot treatment with herbicides. Even the wild grasses of lowland pastures have greatly declined since the 1960s, as most areas were 'improved' by ploughing and reseeding with modern grass strains. Despite these changes, the much-diminished numbers of wild flowers are still important to seed-eating birds, first in the fields as they are produced, and secondly in any resulting hay that may be fed to outwintered livestock. Over most of the country, however, old-style meadows have given way to intensive silage production. This process entails cutting the grass at an earlier stage of its growth, allowing few plants of any kind to seed, with the

result that grassland seed sources have also greatly declined in recent decades.

## Impacts on birds

Taken together, the declines in arable and grassland weeds and spilt cereal grains amount to a massive loss of food for small seed-eating birds in Britain. The importance of these different seed sources varies among species, depending on their dietary needs, buntings and sparrows concentrating on cereals and grasses while finches concentrate on other seeds. The House Sparrow *Passer domesticus* has also suffered from the increased bird-proofing of farm stores for grain and other animal feed. Moreover, farmland weeds are important to birds not only because of the seeds that they produce but also because they sustain a multitude of insects which, in larval or adult form, feed on the leaves, flowers or seed heads, and comprise another important food source. Particular weed species often support specific kinds of insect which cannot persist without their own foodplants. Furthermore, it is not just strict 'insectivorous birds' that suffer from shortage of insects but some seed-eaters too that require insects to feed their young – examples include the Grey Partridge *Perdix perdix*, various buntings and sparrows. Through detailed research, the decline of the Grey Partridge in Britain has been attributed primarily to the use of herbicides which destroyed the foodplants of insects that were crucial food for the chicks (Potts 2012).

## New seed sources

Whether on arable or grassland, the massive loss of seeds suitable for birds has been offset to some extent by the introduction of new seed sources. One is the increasing growth of palatable forms of oilseed rape. The area under rape in Britain grew rapidly from 0.5% of all tilled land in 1970 to 18% (some 756,000ha in total) in 2012 (Defra 2016). From the time when the seeds form, in late May, until the crop is harvested, usually in July, it represents a major food source for several small seed-eaters, notably Linnets, Goldfinches *Carduelis carduelis* and Greenfinches *Chloris chloris*. Over most of Britain, almost all rape fields are ploughed soon after harvest, but any that are left unploughed provide fallen seeds which feed finches into winter. Their importance is greatest in summer, however, as a substitute for all the lost arable and grassland weeds on which finches formerly fed at this time of year (Newton 1972).

**A flock of Goldfinches in autumn.** Erica Olsen/FLPA

A second new food source is the wheat and other cereal grains put out, mainly in hoppers, for the growing numbers of released gamebirds, which in recent times have numbered more than 50 million individuals per year (Larkman *et al.* 2015). Besides Pheasants *Phasianus colchicus* and partridges, it is mainly larger seed-eaters, such as corvids, that exploit this source, but in their absence smaller species, such as Chaffinches *Fringilla coelebs* and Yellowhammers, can be seen at the hoppers. The third new food source comes from seed-bearing plants grown especially for birds. These include 'game cover crops' intended for Pheasants and partridges. There are also 'wild-bird seed crops' aimed at feeding a variety of seed-eating species, including finches and buntings. These crops usually contain fewer cereals than game crops and more broadleaved plants such as quinoa. Funded largely under agri-environment schemes, such crops are of obvious benefit to seed-eating birds, and their growth has led to local increases in bird numbers, both in winter, when the seeds are available, and in the subsequent breeding season, when birds that have benefited over winter settle to nest locally (Hinsley *et al.* 2010; Newton 2017).

The fourth source of seeds is those provided by householders for 'garden birds'. Widespread provision of such seeds dates back to the 1960s, when peanuts were widely marketed as bird food. In later years, as demand grew, other smaller seeds were promoted, attracting a wider range of species. Some of the earliest beneficiaries were the Chaffinch and Greenfinch, which since the 1960s have continued to increase nationally; they have declined only recently, probably in response to disease (Robinson *et al.* 2010). The Goldfinch was declining until the mid-1980s, when it began to take peanuts and then exploited nyjer seeds and sunflower hearts from garden feeders. Since it developed this habit, the Goldfinch has shown a sustained increase, and it has now become one of the commonest of British finches. These events, both the decline of farmland species and the rise in garden species, indicate the importance of food supply in influencing their long-term population trends. Despite the benefits of new seed sources to some species, however, overall they do not come near compensating for the reductions in weed seeds and spilt cereal grains that have been associated with big net declines of small seed-eating birds.

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