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Recording bias in botanical surveys

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ABSTRACT

Recording bias in botanical surveys arises primarily from the recording behaviour of individual botanists, sometimes coupled with the survey techniques and the types of plants being recorded. Recording bias is probably widespread in botanical surveys; it does not invalidate the records, but requires that care is taken with interpretation. Some generalizations are made to help assess recording bias, and are illustrated using examples found during the B.S.B.I. Monitoring Scheme.

INTRODUCTION

In any botanical survey, there is an inevitable degree of recording bias (Hope-Simpson 1940; Sykes *et al.* 1983; Nilsson & Nilsson 1983; Kirby *et al.* 1986; West & Hatton 1990, etc.). Efforts are therefore usually made to minimise bias by adopting a controlled, systematic, repeatable method (Greig-Smith 1964).

In the recording techniques adopted for most national or county plant atlases (e.g. Perring & Walters 1962; Hall 1980), recorders individually select the areas within squares to visit, and then record the species present to fill the time available, or until the list is felt to be comprehensive. Such an unstructured recording technique might be expected to introduce considerable local bias to the data collected, and especially if the surveys are to be repeated. For instance, only 52% of the records collected by two independent parties of botanists six weeks apart in the same tetrads (2-km squares) were common to both surveys (Rich & Woodruff 1990, 1992). Efforts are often made to achieve even coverage (e.g. Dony 1963), but failure to achieve this is only one of many sources from which bias can arise. Documentation of what was done and where and when and by whom can help with interpretation of the data, but such details are rarely collected.

Bias originates primarily from differences in the recording behaviour and the ability of individual botanists, but may also arise from the survey techniques or the types of plants being recorded. The extent of bias in the data collected is rarely known, and few cases are described in detail. Perring & Walters (1962) presented provisional distribution maps of about 40 taxa and explained why the data were thought to be inadequate. Nilsson & Nilsson (1983) found that sampling error accounted for two-thirds of the apparent species turnover rates on islands in Sweden. Preston & Eversham (1992) describe selected examples of botanical and zoological recording bias.

The purpose of this paper is to draw attention to the problems of recording bias by using some examples encountered during the B.S.B.I. Monitoring Scheme (Rich & Woodruff 1990, 1992). The B.S.B.I. Monitoring Scheme was a 10-km square sample survey of Britain and Ireland during 1987 and 1988 to assess the current status of the flora. Over 1600 botanists collected 985,000 records in 425 out of the 429 sample 10-km squares, representing 2660 taxa. Many of the examples are drawn from a comparison of these data with those collected for the *Atlas of the British flora*† (Perring & Walters 1962).

Nomenclature follows Clapham *et al.* (1987).

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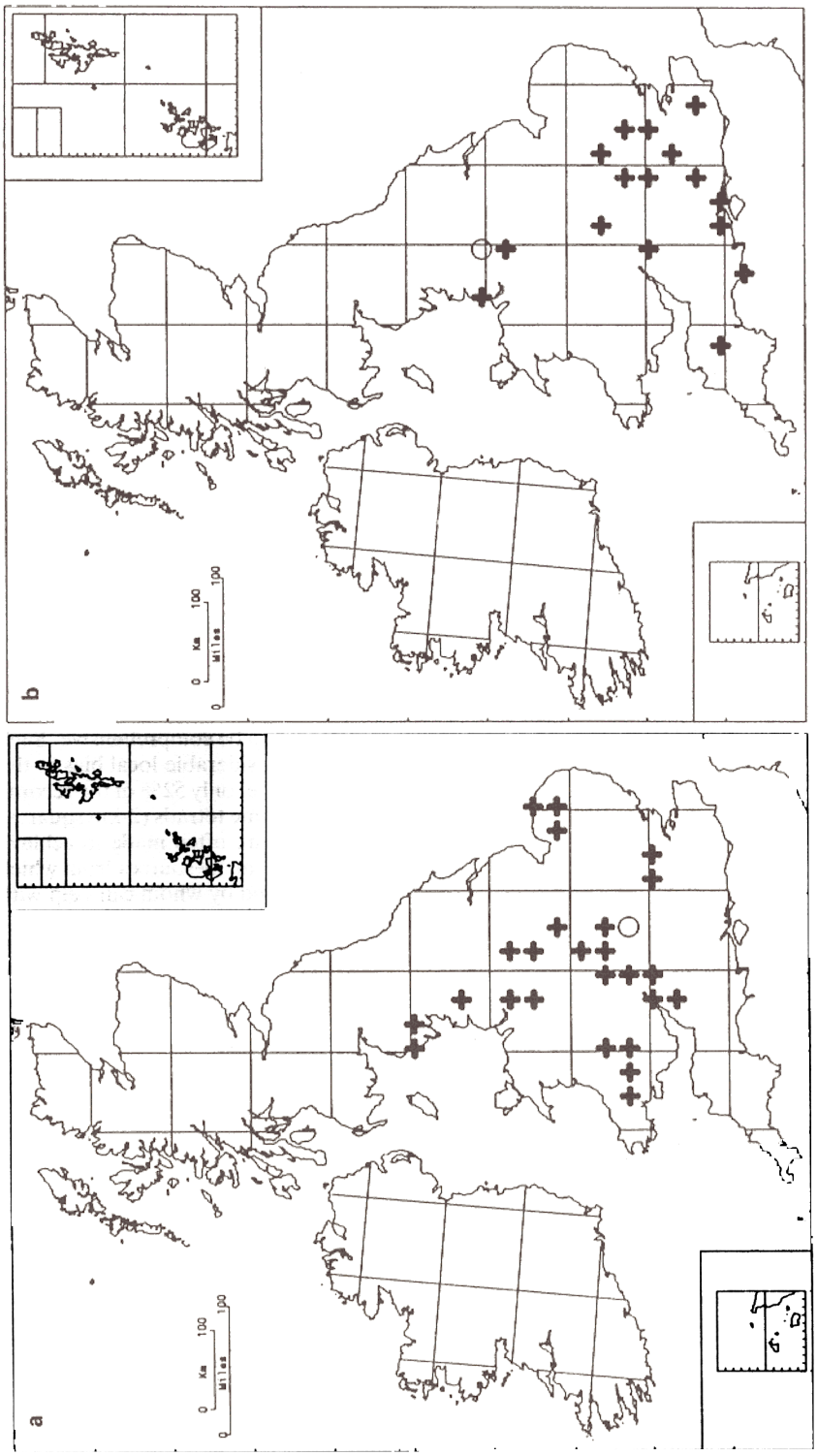
† hereafter referred to as the *Atlas*.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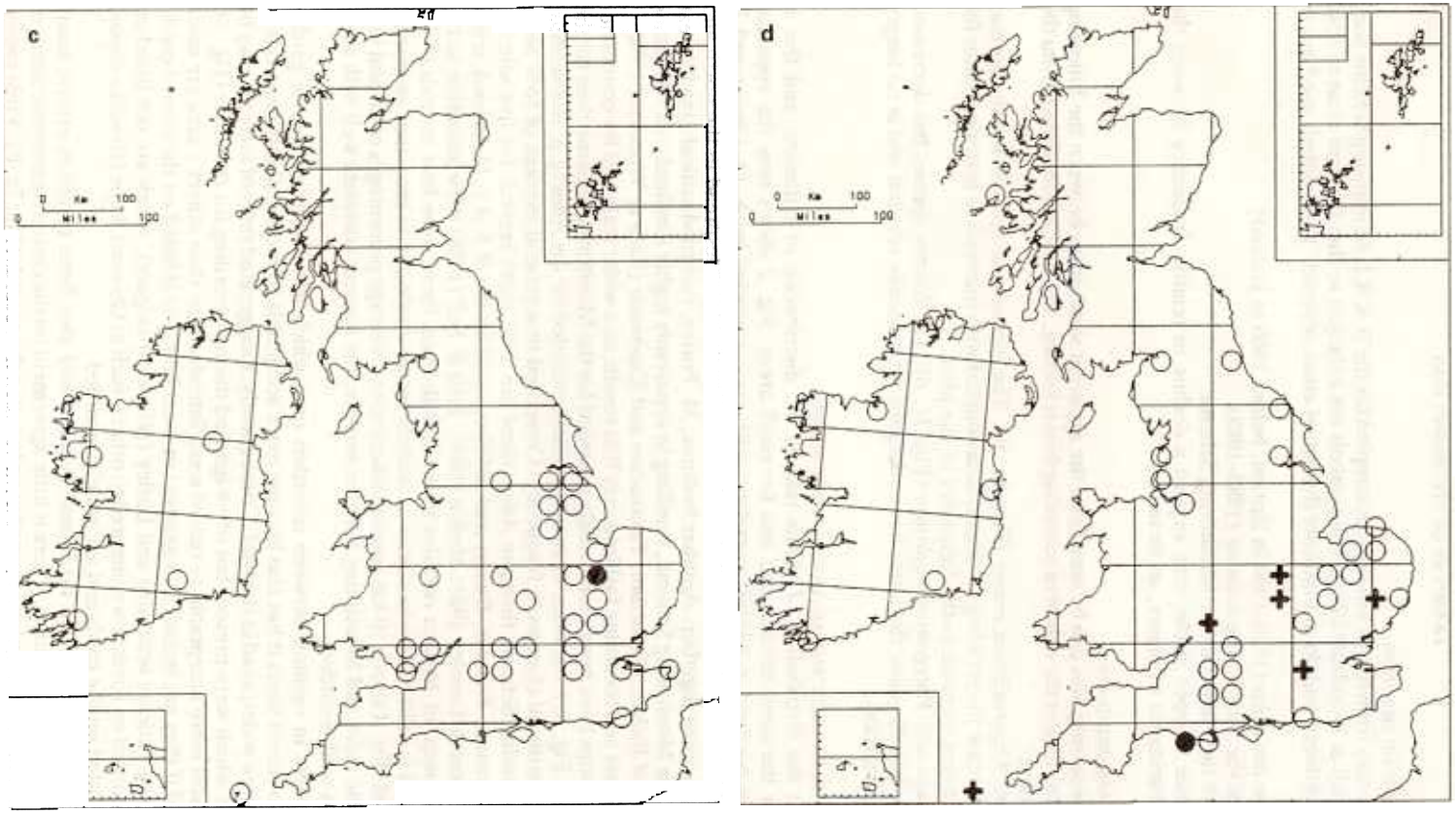


FIGURE 1. Selected pairs of taxa showing apparently similar patterns of change: (a, b) *Rubus vestitus* and *Lagarosiphon major*; (c, d) *Polygonum nodosum* and *Agrostemma githago*.

EXAMPLES OF RECORDING BIAS

NOTE ON PRESENTATION OF THE MAPS

The maps show only data from the 10-km squares sampled for the B.S.B.I. Monitoring Scheme (one in every nine; see Rich & Woodruff 1992). The symbols are enlarged so that they are clear to read when the maps are reduced and do not indicate the actual areas covered. The symbols used are as follows:

○ Recorded only for the *Atlas* (1930–1960 in Britain, before 1960 in Ireland).
✚ Recorded only for the Monitoring Scheme (1987–1988).
● Recorded for both the *Atlas* and the Monitoring Scheme.

Thus, a predominance of open circles may suggest a decline in relative frequency between the surveys, and a predominance of pluses, an increase.

THE IMPORTANCE OF ASSESSING BIAS

The importance of assessing bias can be seen from the apparent similarities between the following selected pairs of maps. Unless the extent of recording bias is known, any conclusions drawn from the data may be misleading.

Rubus vestitus and *Lagarosiphon major* (Figs 1a, b): The increase in records for the former species reflects an increase in recording of critical taxa coupled with incomplete historical data; for the latter it reflects a real increase in the frequency of the plant.

Agrostemma githago and *Polygonum nodosum* (Figs 1c, d): The former species has decreased markedly during the last 30 years; the latter has undergone a taxonomic revision and is no longer recognised by most recorders.

BIASES RELATED TO THE QUALITY AND QUANTITY OF RECORDING

It is often said that the distribution of plants reflects the distribution of botanists, and this is particularly true for the more critical taxa and for small areas. Fig. 2 shows how the apparent distribution of *Carex hostiana* × *viridula* correlates with areas recorded by A. O. Chater and J. Harron who know this obscure hybrid well. It is, however, probably widespread in the north and west where its parents grow together. Another botanist, M. Porter, recorded critical taxa in great detail in Brecon for the Monitoring Scheme, resulting in apparently highly localised concentrations of records of species of *Rubus*, *Hieracium*, *Taraxacum* and *Euphrasia* (Rich & Woodruff 1990).

Taxonomic awareness and recording fashions may bias results on a wider scale and for commoner taxa. Many critical groups have been more widely recorded for the Monitoring Scheme than for the *Atlas* (e.g. *Hieracium*, Fig. 3a), but some were more widely recorded for the *Atlas* (e.g. *Rhinanthus*, Fig. 3b), resulting in artificial changes in frequency. Compared to a general average of 16% more records for the Monitoring Scheme than the *Atlas*, there are 24% more records for five selected genera (*Carex*, *Polygonum*, *Populus*, *Rumex* and *Salix*) covered by the *B.S.B.I. Handbook* series (Jermy *et al.* 1982; Kent & Lousley 1981; Meikle 1984). Trist & Sell (1988) drew attention to the occurrence of two subspp. of *Molinia caerulea* in the British Isles; there were four records of the subspp. in 1987 and 33 in 1988. These increases in records are no doubt due to increased awareness of the taxa concerned. Fig. 4 shows 10-km squares where above average percentages of critical taxa were recorded for the *Atlas* and Monitoring Scheme surveys; the squares correlate well with areas known to have been well-recorded.

There are differences in opinion between recorders over which introduced species or garden escapes to record. In recent years it has also become more acceptable to record all introductions as they have become more widespread in the wild. Consequently, exaggerated rates of increase may be observed for species which were present but often ignored during recording for the *Atlas* (Fig. 5). However, it is also still more acceptable to record some introductions than others – taxa are more likely to be recorded if they are included in national or local Floras or if listed on the record cards. Crops such as Wheat (*Triticum aestivum*) and Barley (*Hordeum vulgare*), which are not listed on cards, are poorly recorded on roadsides compared to others, such as Oil-seed Rape (*Brassica napus*) (Fig. 6), which are listed on the cards and are widely recorded.

Bias also arises from differences in taxonomic opinion and also from common errors; many recorders simply follow the major floras. There is little agreement on the current taxonomic status of the subspp. of *Juncus bulbosus*, resulting in confusion between the records (Fig. 7a, b). *Viola canina*

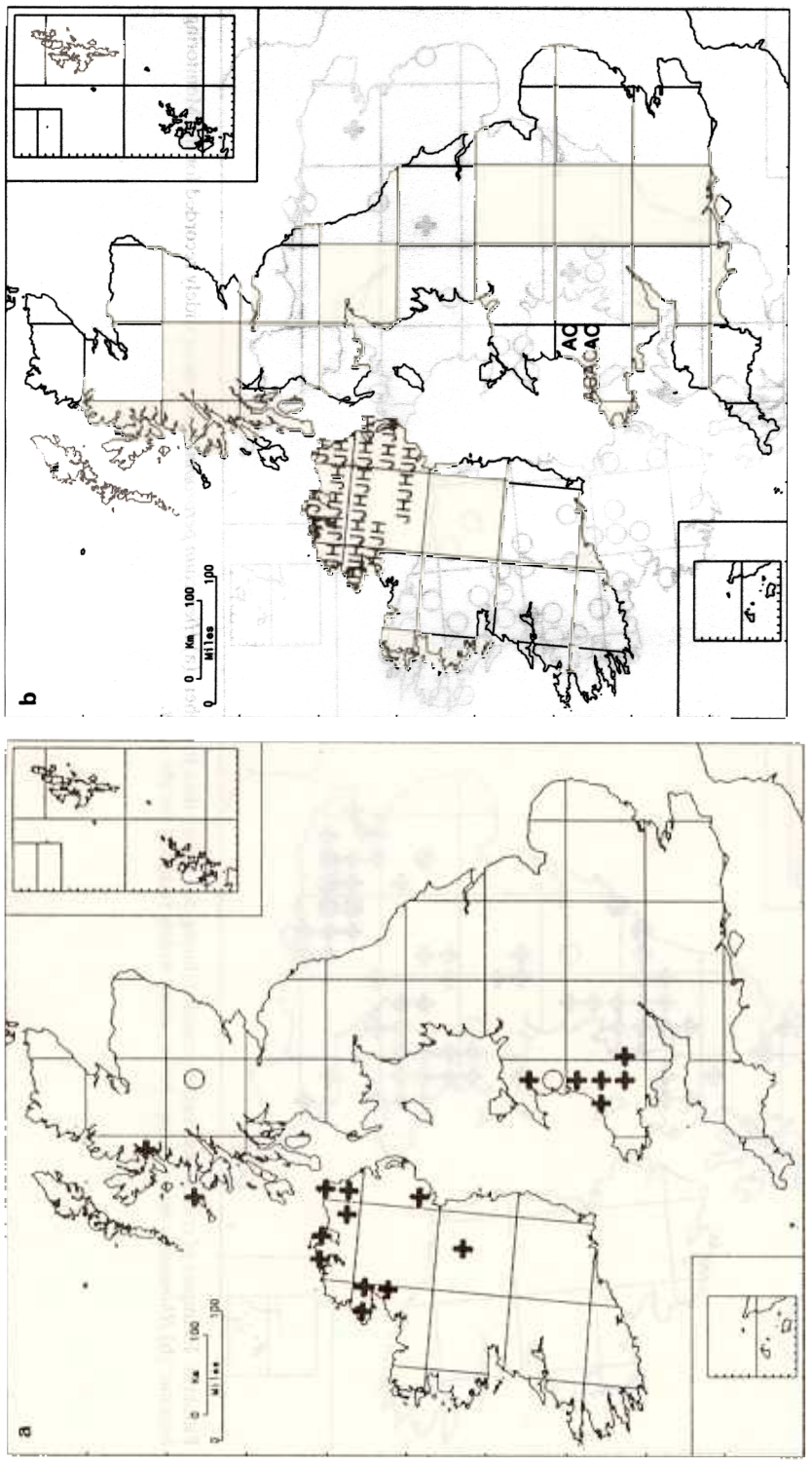


FIGURE 2. Correlation between (a) the distribution of *Carex hostiana* × *viridula* and (b) the areas recorded by two botanists (AC = A. O. Chater, JH = J. Harron).

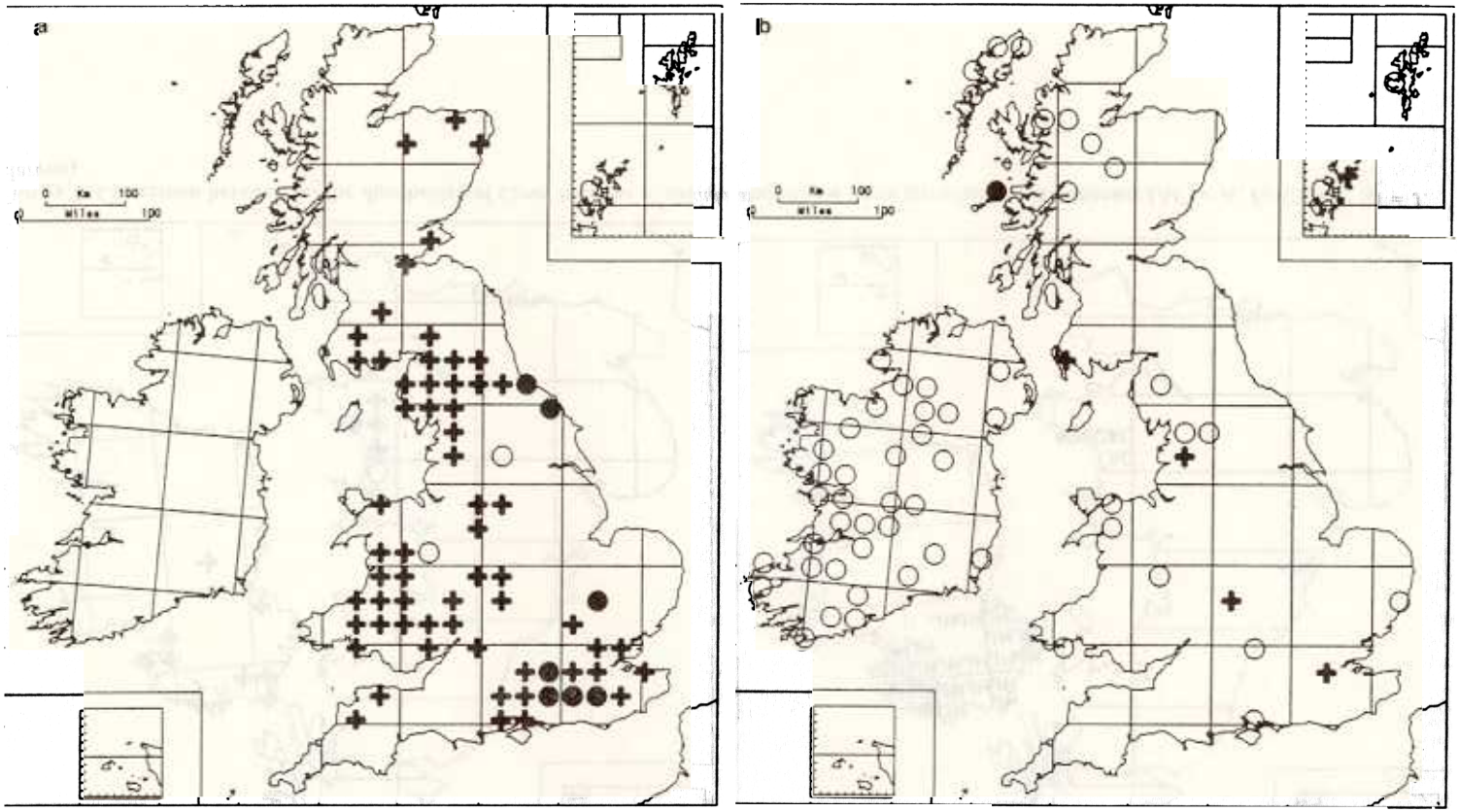


FIGURE 3. Examples of critical taxa better recorded during one survey than the other: (a) *Hieracium perpropinquum*, more widely recorded for the Monitoring Scheme; (b) *Rhinanthus minor* subsp. *minor*, more widely recorded for the *Atlas*.

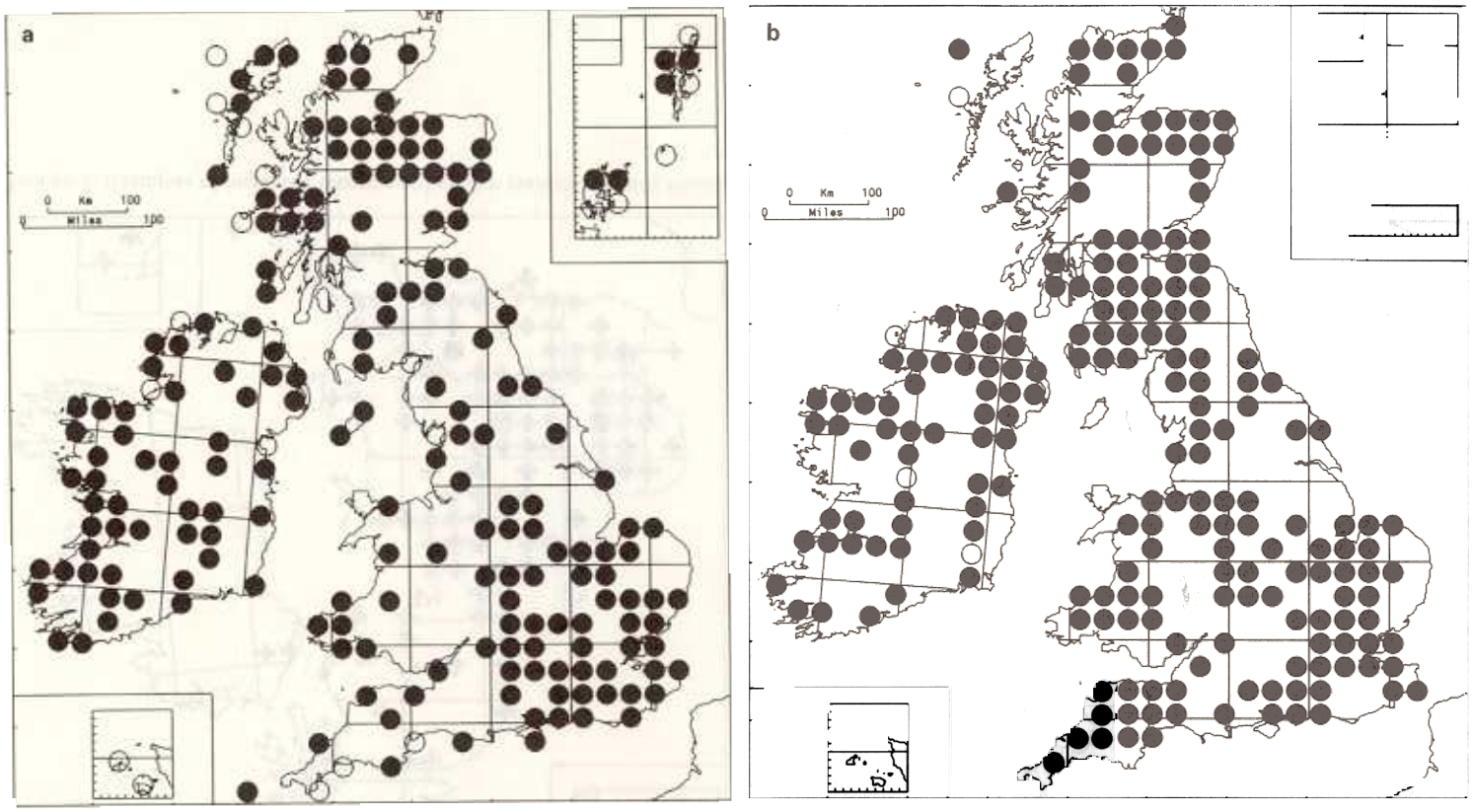


FIGURE 4. 10-km squares with an above average % of critical taxa recorded (number of critical taxa/total number of taxa recorded per square): (a) *Atlas* survey; (b) Monitoring Scheme survey. Britain and Ireland have been assessed separately due to inherent differences in the flora. Open circles show 10-km squares not recorded for both surveys.

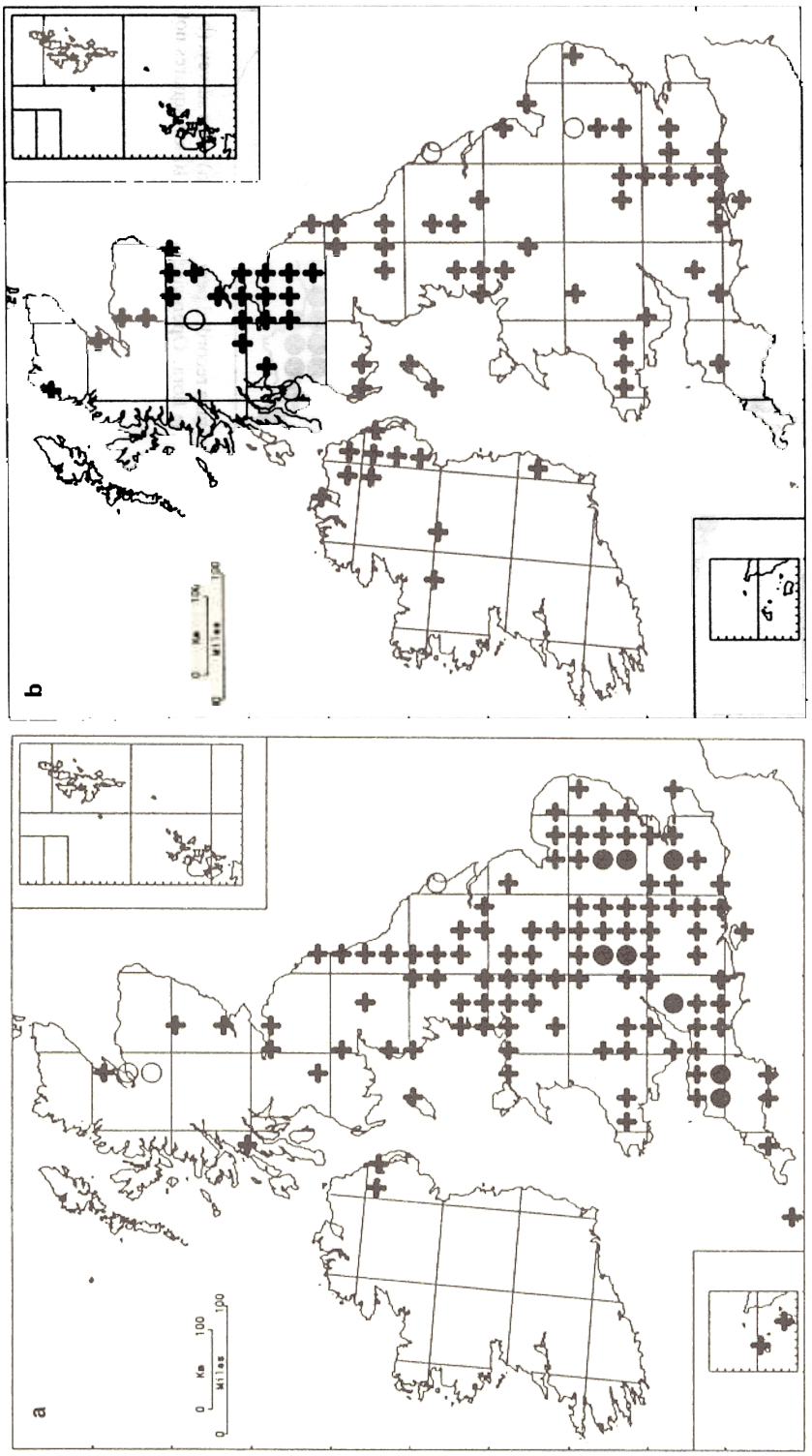


FIGURE 5. Examples of increased recording of garden escapes resulting in exaggerated rates of increase: (a) *Lunaria annua*; (b) *Ribes sanguineum*.

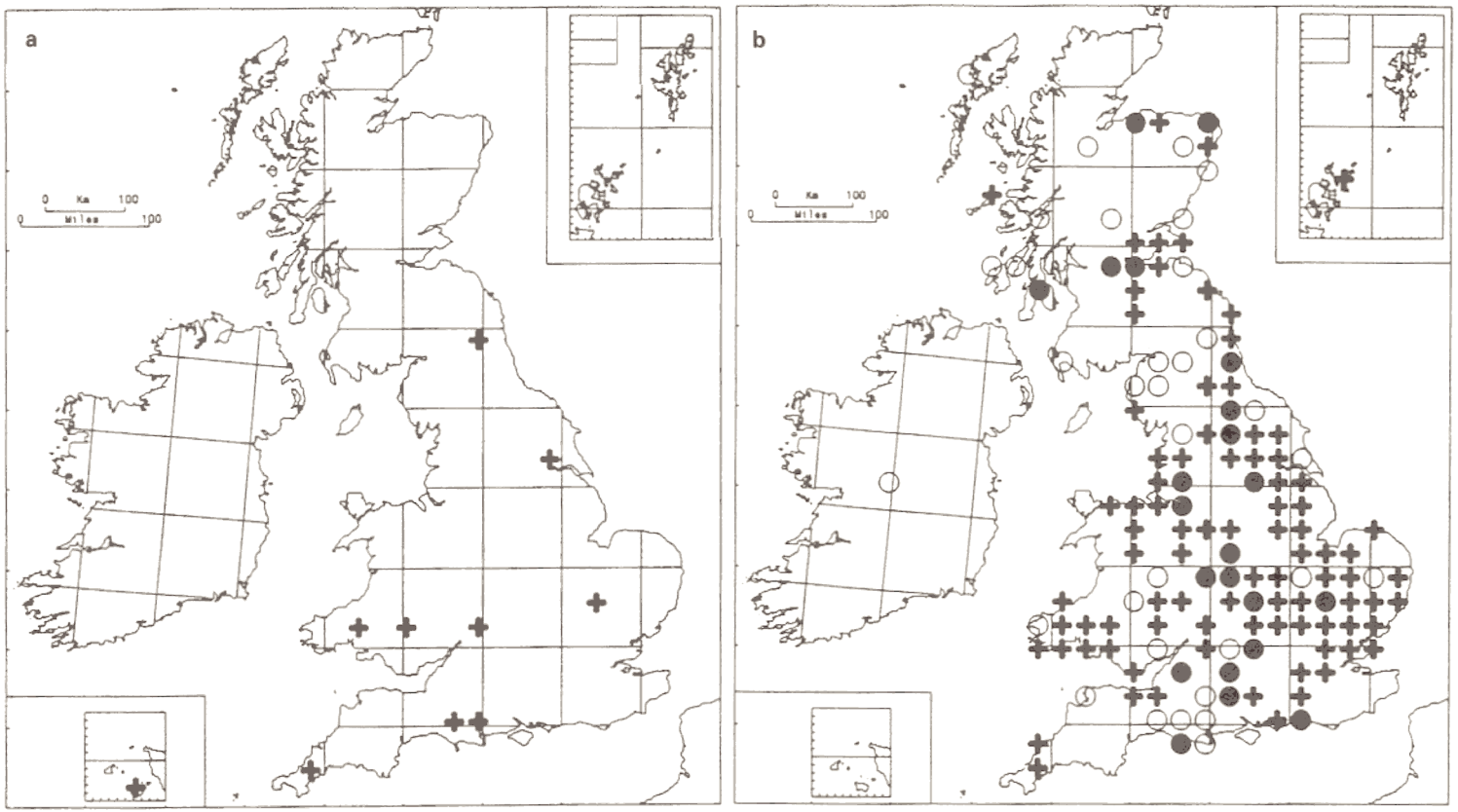
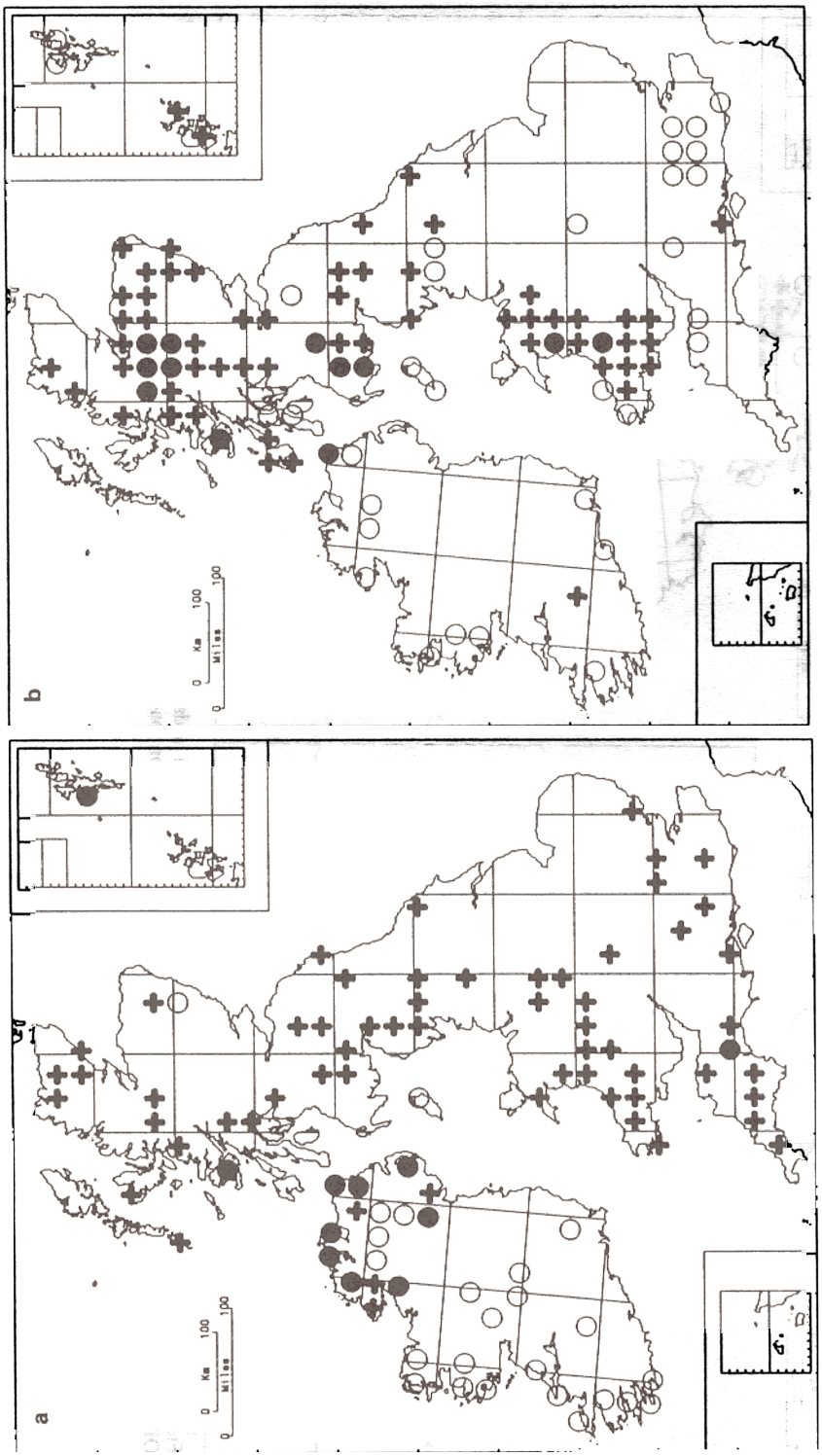


FIGURE 6. Differences in recording of crop plants occurring outside cultivated fields. It is much less acceptable to record (a) Barley (*Hordeum vulgare*) than (b) Oil-seed Rape (*Brassica napus*) despite the widespread occurrence of both on roadsides.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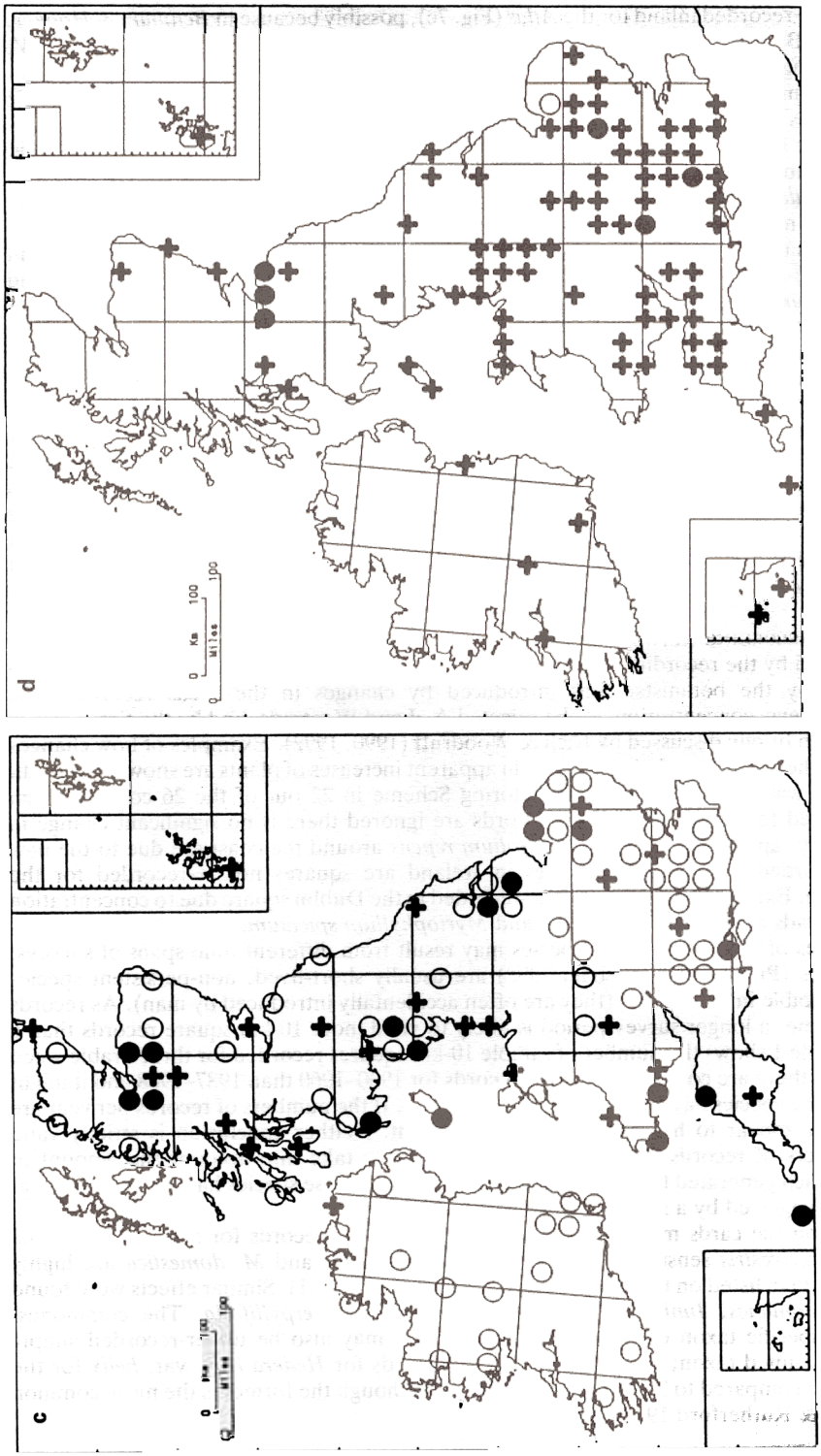


FIGURE 7. Examples of taxa recorded with differences of opinion or recorded erroneously (see text for details): (a) *Juncus bulbosus* subsp. *bulbosus*; (b) *J. bulbosus* subsp. *kochii*; (c) *Viola canina*; (d) *Hyacinthoides hispanica*.

may have been over-recorded inland for the *Atlas* (Fig. 7c), possibly because in *Bentham & Hooker*, the Flora that most British botanists at that time had been raised on, *V. riviniana* was included in *V. canina* (F. H. Perring, pers. comm.). *Hyacinthoides hispanica* has been over-recorded in error for the much more common but less well known *Hyacinthoides hispanica* × *H. non-scripta* (Page 1987; Fig. 7d); the latter is not included in Clapham *et al.* (1987).

Other plants may simply be overlooked if recorders are unaware of their presence in an area. *Festuca altissima* is an uncommon plant of rocky woods and ravines and was almost certainly under-recorded for the *Atlas* (Fig. 8a). *Chenopodium ficifolium*, a weed similar in appearance to the common *C. album*, may also have been overlooked in some areas (Fig. 8b).

Some habitats may be recorded better or more poorly than others due to differences in accessibility. Arctic-alpines such as *Luzula arcuata* and *Juncus castaneus* in Scotland, and *Polygonum viviparum* in Ireland, were under-recorded for the Monitoring Scheme partly due to the remoteness of the localities and partly due to inclement weather. Conversely, car-parks and churchyards have been well-recorded as they are easily accessible.

Increases in numbers of records may result simply from increased recording effort for the Monitoring Scheme (Rich & Woodruff 1992). Numerous examples could be cited, but a clearer demonstration is probably from outside the Scheme itself where the effects can be seen in a wider context. The spread of *Cardaria draba* has been documented by Scurfield (1962). Fig. 9 shows the cumulative number of 10-km squares from which *C. draba* has been recorded. The enormous increase in the 1950s coincides with the *Atlas* field work and reflects a simple increase in recording effort rather than a dramatic spread of the plant. Similar patterns can also be seen in *Epilobium ciliatum*, *Veronica filiformis* and *Impatiens glandulifera*. The Monitoring Scheme results suggest little increase in *C. draba* since 1960.

BIASES RELATED TO RECORDING METHODS

Constraints imposed by the recording methods may result in some systematic biases in addition to those introduced by the botanists. Bias introduced by changes in the areas recorded, the repeatability of surveys, concentration on the selected A, J and W tetrads, and by the time span of recording have been briefly discussed by Rich & Woodruff (1990, 1992). Examples of how changes in coverage and in the areas recorded may result in apparent increases of plants are shown in Fig. 10. *Plantago maritima* was recorded for the Monitoring Scheme in 22 out of the 26 coastal 10-km squares not recorded for the *Atlas*; if these records are ignored there is no significant change in frequency. Similarly, apparent increases in *Trifolium repens* around the coast are due to the new squares being recorded, and apparent losses in Ireland are squares not re-recorded for the Monitoring Scheme. Examples of species under-recorded in the Dublin square due to concentration on the selected tetrads are *Oenanthe aquatica* and *Myriophyllum spicatum*.

Exaggerated rates of decline of casual species may result from different time spans of surveys. Casuals or fugitives (Preston & Eversham 1992) are usually short-lived, non-persistent species which are unpredictable in occurrence (they are often accidentally introduced by man). As records accumulate with time, a longer survey period is likely to yield more 10-km square records than a shorter period. Table 1 shows the number of sample 10-km squares recorded for three arable weed species; in all cases there are considerably more records for 1930–1960 than 1987–1988 and it might be concluded that the species have declined by 75% or more. If the numbers of records per year are calculated, all taxa appear to have become *more* frequent. Neither conclusion is strictly valid because the numbers of records also need to be corrected to take into account the amount of recording effort which generated them. There is little doubt that these species have declined, but at a lower rate than suggested by a simple comparison of numbers.

The taxa listed on the cards may introduce bias by prompting records for selected taxa. The records for *Malus sylvestris* sensu lato, *M. sylvestris* sensu stricto and *M. domestica* are highly correlated with the taxa listed on the five regional record cards (Fig. 11). Similar effects were found in *Asplenium trichomanes*, *Juniperus communis* and *Veronica serpyllifolia*. The commonest segregate or infraspecific taxon of an aggregate or species may also be under-recorded simply because it is the assumed taxon; there were only two records for *Hedera helix* var. *helix* for the Monitoring Scheme compared to 34 for var. *hibernica* even though the former is the more common taxon (McAllister & Rutherford 1990).

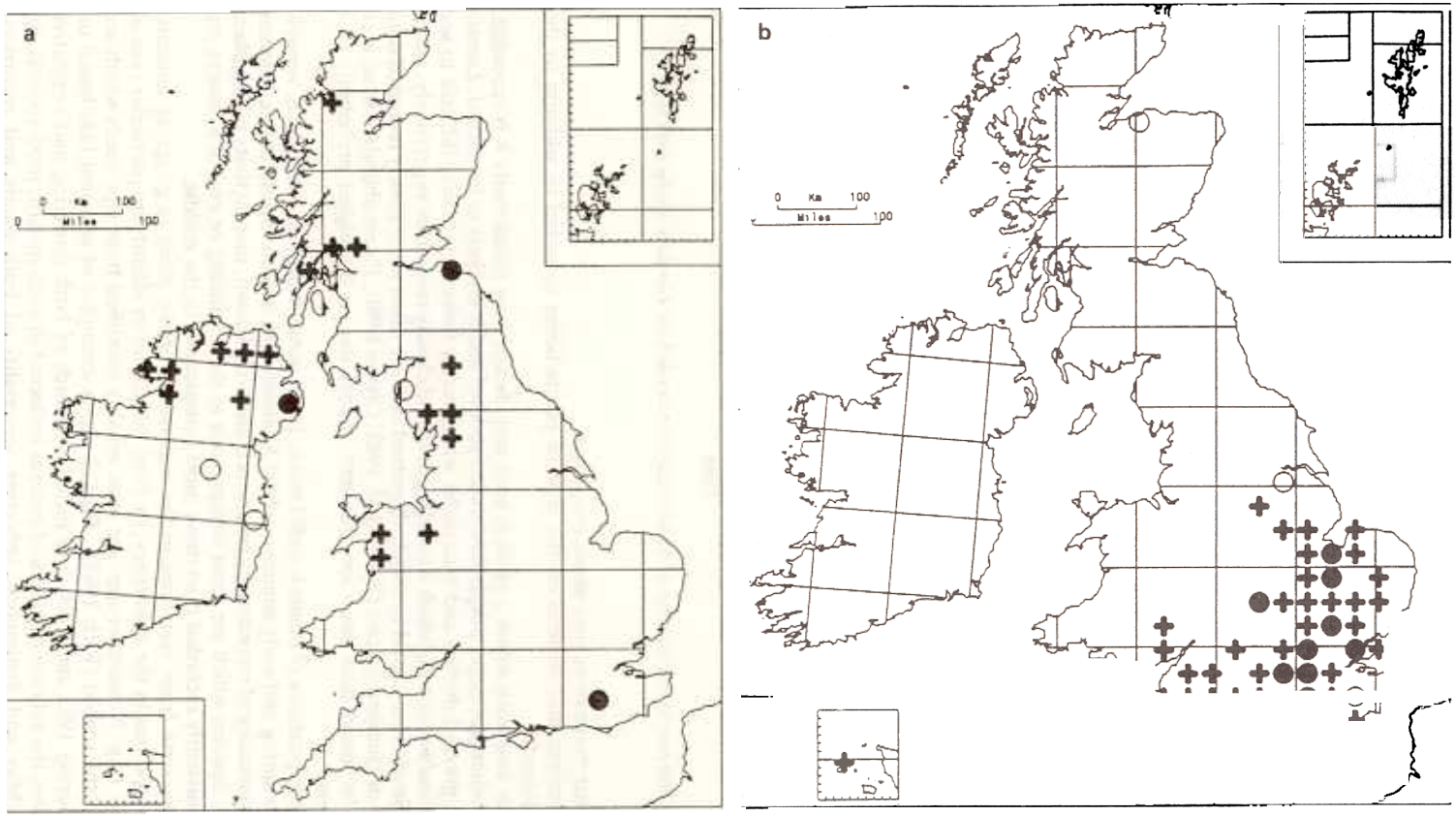


FIGURE 8. Examples of species which may have been overlooked for the *Atlas*: (a) *Festuca altissima*; (b) *Chenopodium ficifolium*.

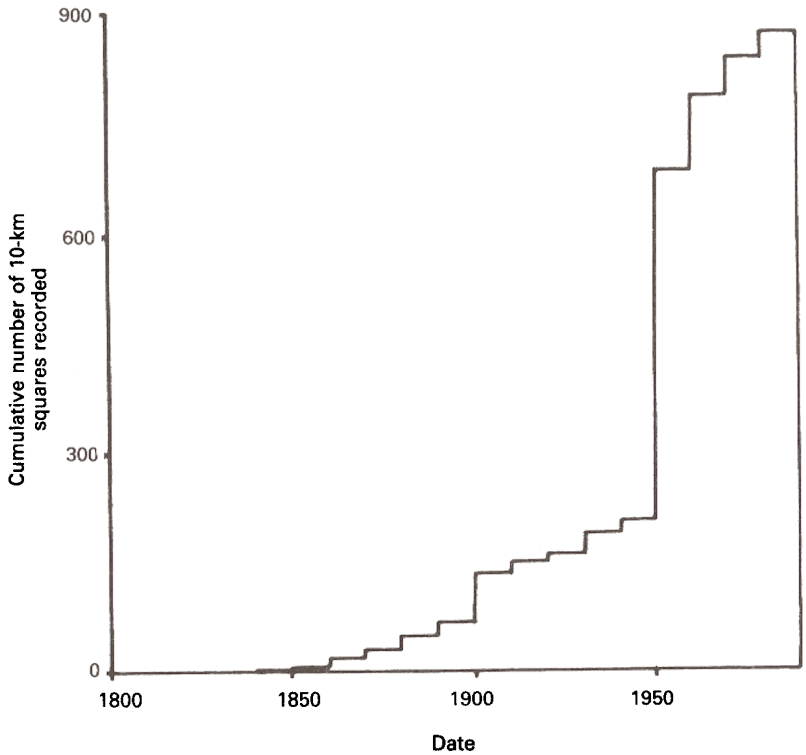


FIGURE 9. Cumulative increase in the number of 10-km squares recorded for *Cardaria draba* with time.

BIASES RELATED TO THE TYPES OF PLANTS BEING RECORDED

Some biases in recording may depend on the type of plants being recorded in addition to the behaviour of the botanists.

The apparency, or ease with which a plant is seen may dictate how consistently it is recorded. *Chamerion angustifolium* has large, purple flowers at eye-level and is unlikely to be missed. *Leersia oryzoides* is a large grass of ditches and watersides which rarely flowers; it is very difficult to see amongst *Phalaris arundinacea* with which it usually grows and closely resembles vegetatively, and is easily overlooked. Small, fine-leaved or widely dispersed taxa are often more poorly recorded than large, broad-leaved or clumped species (Sykes *et al.* 1983; Clymo 1980). Plants abundant in an area are more likely to be found than those less frequent, simply due to the higher probability of a recorder finding them.

The seasonality of appearance of plants is well-known. In the genus *Scilla*, for example, *S. verna* is most conspicuous in spring and early summer, whilst *S. autumnalis* is seen mainly in late summer and autumn. The seasonality of recording by botanists is also well-known, most activity taking place during the summer. Species which are most conspicuous at the beginning or end of a season are likely to be less consistently recorded than those most conspicuous in the middle.

Seasonal bias may arise from variations in the occurrence of the plant (e.g. spring annuals, woodland herbs), variations in the apparency, or from difficulties in identifying particular taxa at certain times of year (e.g. *Nasturtium* spp. are most reliably identified from ripe seeds which are unavailable early in the season (Rich 1987)). Fig. 12 shows examples of seasonal bias based on records collected during 1987 and 1988, and includes records of both flowering and vegetative plants. Fig. 12a shows the relative numbers of records collected in each month; most records are collected between May and September, reflecting seasonality of both plants and recorders.

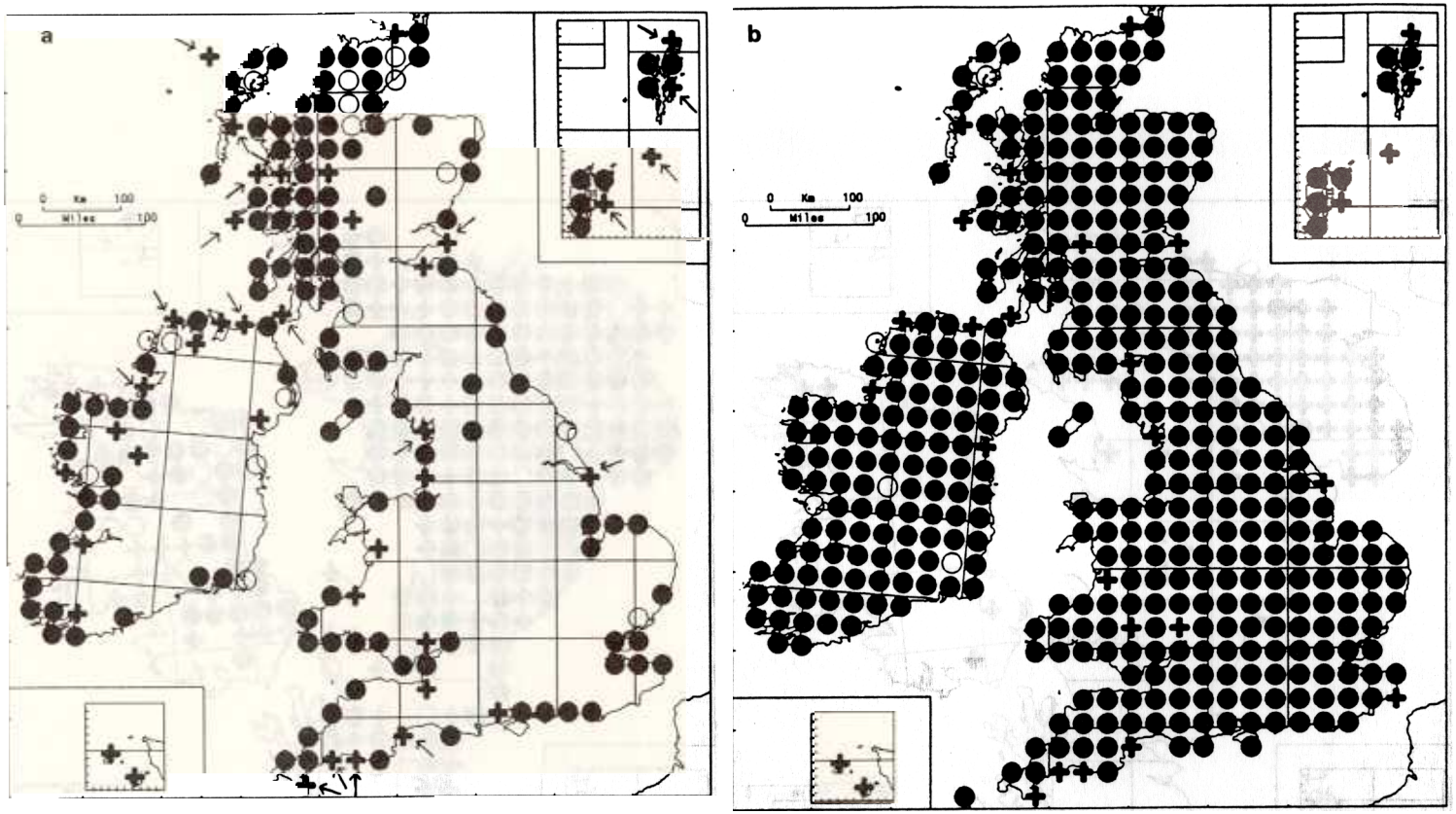
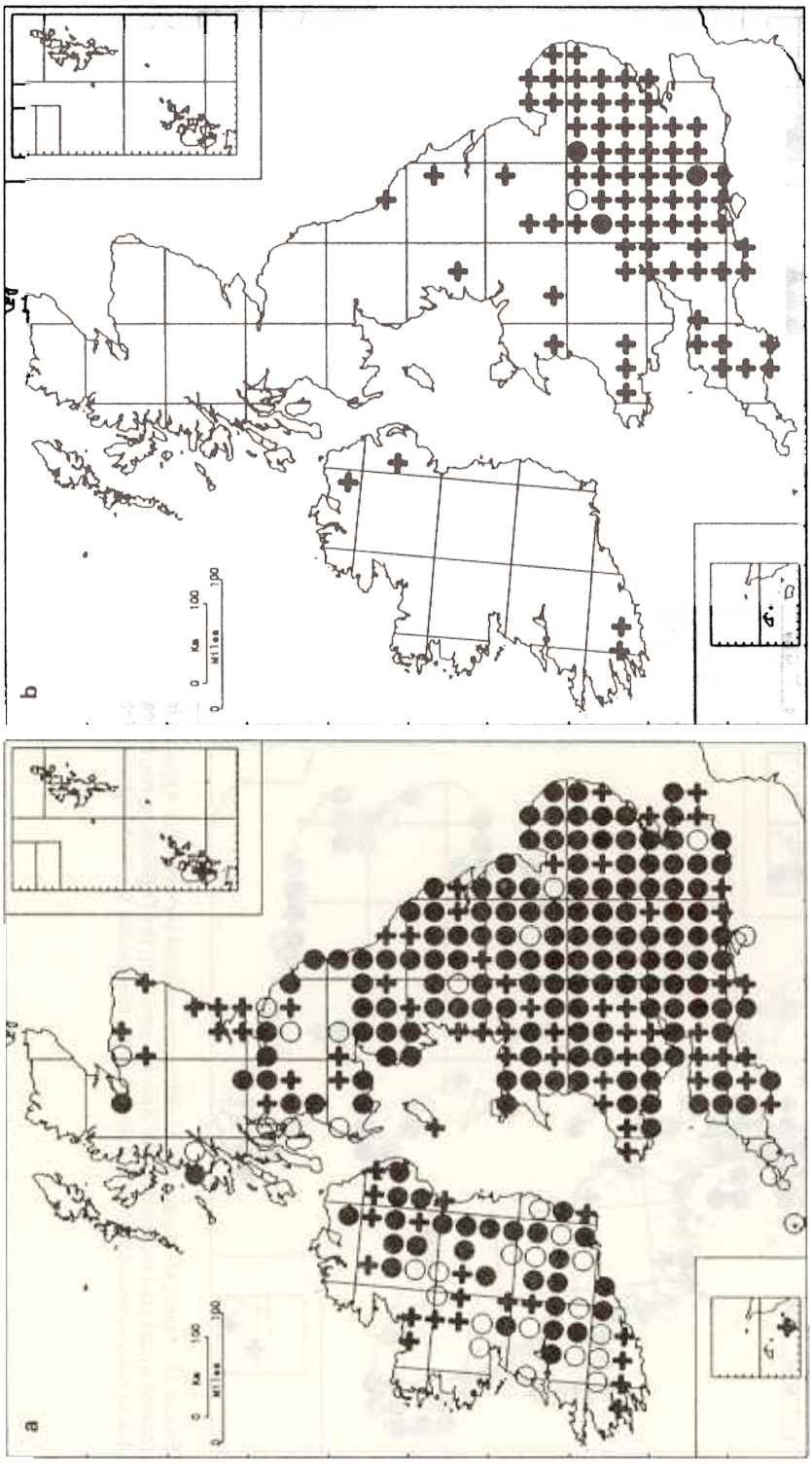


FIGURE 10. Apparent changes due to differences in areas surveyed: (a) Apparent increases in *Plantago maritima* due to increased recording of coastal squares (coastal squares not recorded for the *Atlas* are arrowed); (b) *Trifolium repens*, increases in coastal squares are again visible, and the apparent losses in Ireland are due to squares recorded for the *Atlas* not being re-recorded for the Monitoring Scheme.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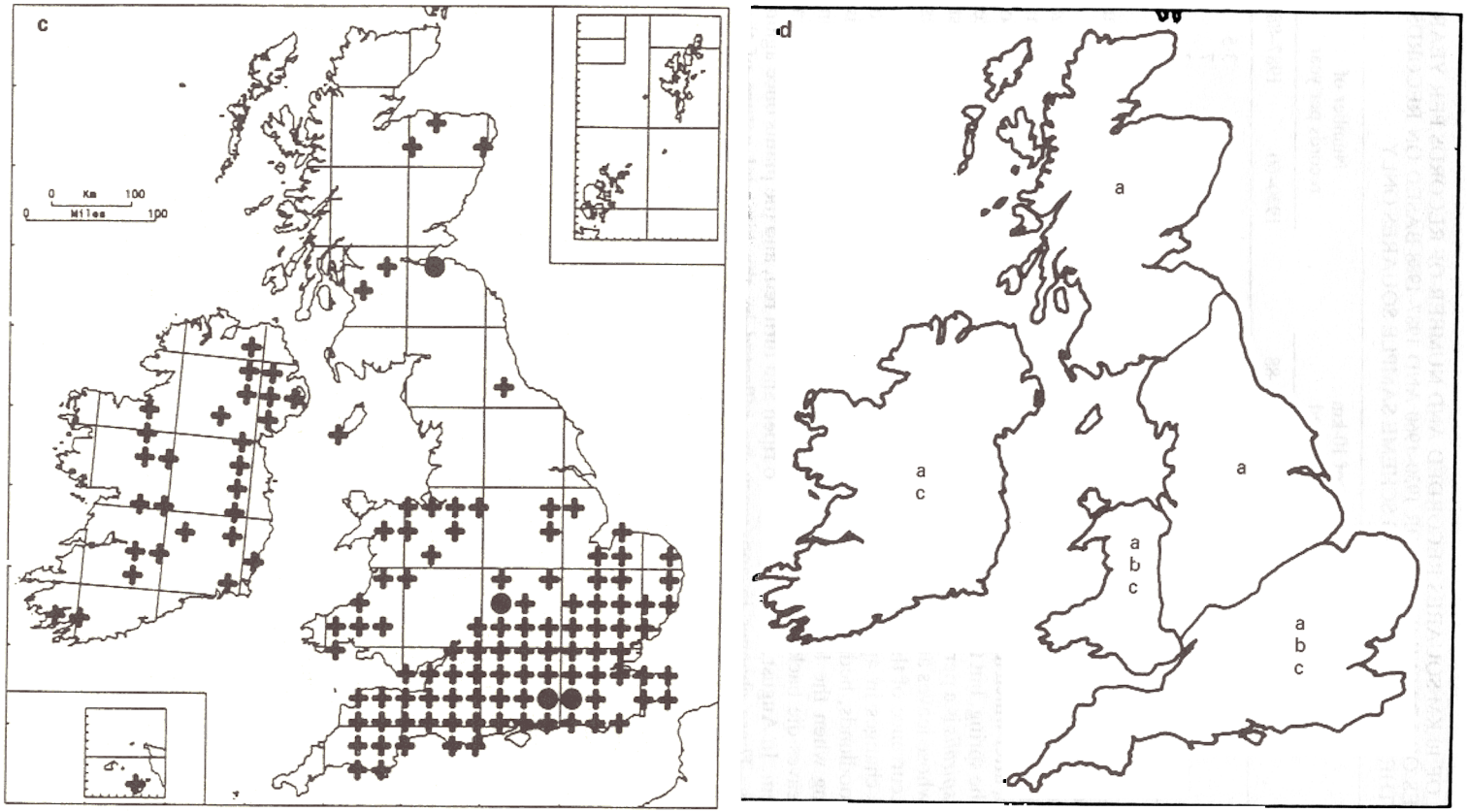

FIGURE 11. Correlations between taxa listed on the record cards and records of the taxa: (a) *Malus sylvestris* sensu lato; (b) *Malus sylvestris* sensu stricto; (c) *Malus domestica*; and (d) taxa listed on the cards (a, b and c as above).

TABLE 1. NUMBER OF 10-KM SQUARES RECORDED AND NUMBER OF RECORDS PER YEAR FOR THREE SPECIES OF ARABLE WEED FOR 1930–1960 AND 1987–1988 BASED ON RECORDS FROM THE B.S.B.I. MONITORING SCHEME SAMPLE SQUARES ONLY

	Number of 10-km squares recorded		Number of records per year	
Species	1930–60	1987–88	1930–60	1987–88
Agrostemma githago	29	7	0·94	3·5
Ranunculus arvensis	55	14	1·77	7
Scandix pecten-veneris	71	6	2·3	3

Trifolium repens is a virtually ubiquitous species present all year, and its seasonal recording pattern would therefore be expected to be similar to that of all records; Fig. 12b shows that it is.

Histograms for species showing seasonal variations in occurrence are shown in Figs 12c–e. *Adoxa moschatellina* is a perennial herb of woodlands and waysides with a very short period of growth from about March to June, after which it withers rapidly and disappears. *Hyacinthoides non-scripta* is also primarily a plant of the spring, but the fruiting stalks persist and it is consequently recorded until late summer. *Spiranthes spiralis* is a perennial herb of calcareous grasslands which flowers in late August and September but whose leaves are usually absent during the summer (Wells 1967). In these cases the seasonality of occurrence of the plants is matched by the records.

Two examples of changes in apparency are shown in Figs 12f & 12g. *Arum maculatum* is a perennial herb of woodlands, hedgerows and waysides, etc. throughout Britain and Ireland. It is conspicuous in spring when the leaves and inflorescences appear, but becomes less obvious in summer when the leaves die back, the fruiting heads are small and green, and other vegetation grows up around them. In August, the fruits begin to ripen and turn red, and the plants once again become conspicuous. These changes in apparency are reflected by the bimodal nature of the records; note that the plant is present in the summer but relatively under-recorded. The seasonality of records of *Viscum album*, an evergreen parasitic herb usually of deciduous trees and shrubs, is not quite as might be predicted. Records increase to May and then decrease, presumably related to the appearance of leaves on the trees. A rise in records might be predicted again in October when leaves are shed, but there is a surprising peak in August instead; the cause of this peak is not known. The small increase at Christmas may not be coincidence.

Fig. 12h shows the seasonality of records of *Salicornia europaea* sensu stricto. *Salicornia* is a critical genus (e.g. Rich & Rich 1988) whose species can only be reliably distinguished in autumn when in fruit, and Fig. 12h reflects this. *Salicornia* records not determined to species show a much broader spread of records as expected. Other similar examples of taxa which can only be identified at certain times of year include *Ruppia*, *Taraxacum* and *Hieracium*.

Such seasonal biases may influence assessments of change with time and might be reflected in the distribution maps. Fig. 13 shows 10-km squares which were not recorded before July or after June for the Monitoring Scheme in 1987 and 1988. Autumn and spring species might be expected to be under-recorded in these squares.

Perring & Walters (1962) noted that some species had died down before observers had arrived to record them for the *Atlas*, and thus appear to be rarer on the maps than they actually are. This effect was particularly marked in S.W. Ireland due to the early flowering season and the remoteness of the south west from the main centres of botanical activity. This is shown by the Monitoring Scheme results for one vernal species, *Anemone nemorosa* (Fig. 14a). The six new records for the Monitoring Scheme in S.W. Ireland are a direct result of more work earlier in the season; five of these new records are for squares visited early in the year (compare Fig. 14a with Fig. 13). No doubt the species also occurs in some of the squares only visited later. Similar results are shown for other vernal taxa such as *Ranunculus ficaria*. An increase in *Chrysosplenium oppositifolium* in Ireland (Fig. 14b), another species most conspicuous early in the year but present all season, may also be explained by this phenomenon.

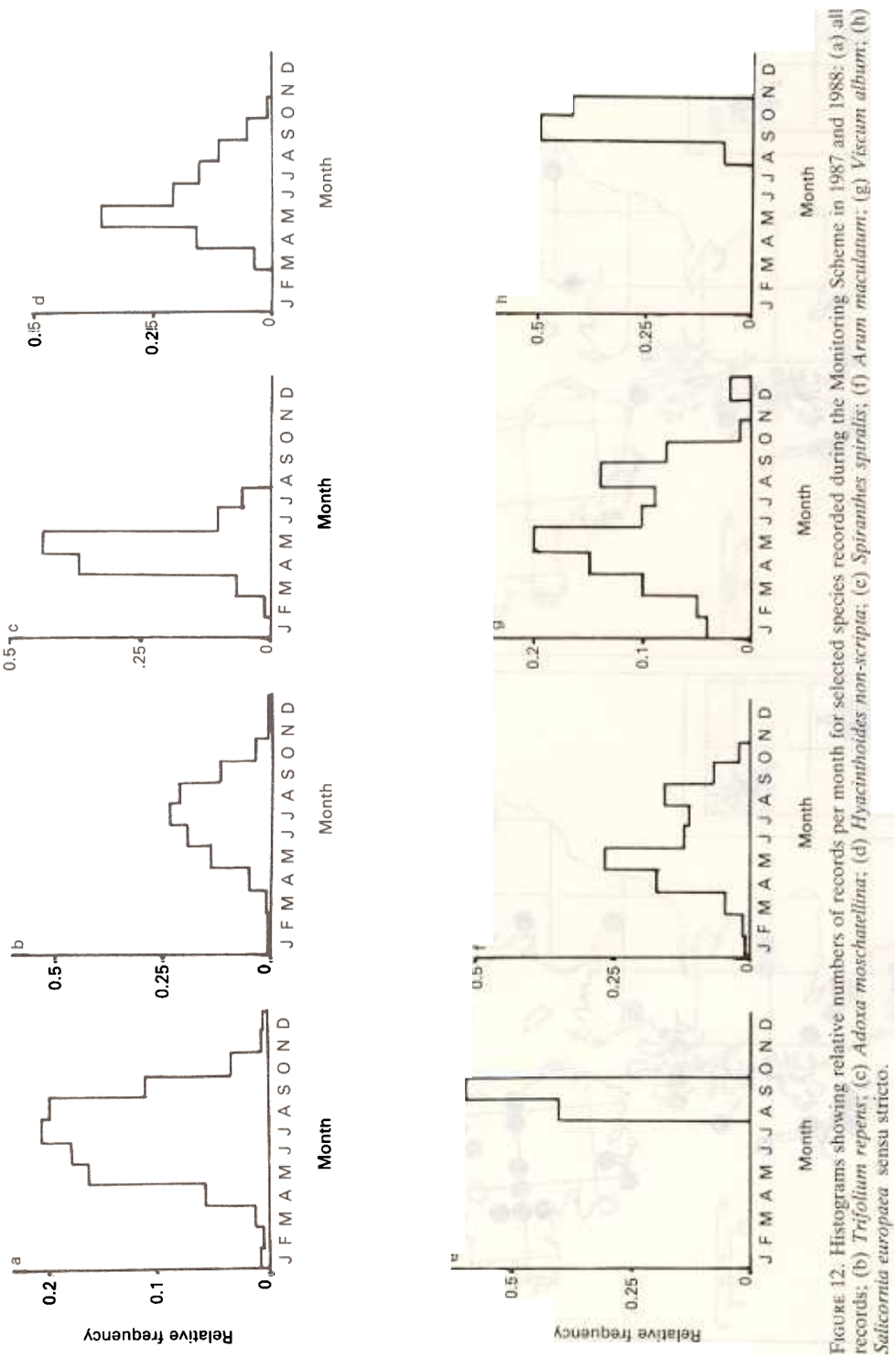

FIGURE 12. Histograms showing relative numbers of records per month for selected species recorded during the Monitoring Scheme in 1987 and 1988: (a) all records; (b) *Trifolium repens*; (c) *Adoxa moschatellina*; (d) *Hyacinthoides non-scripta*; (e) *Spiranthes spiralis*; (f) *Arum maculatum*; (g) *Viscum album*; (h) *Salicornia europaea* sensu stricto.

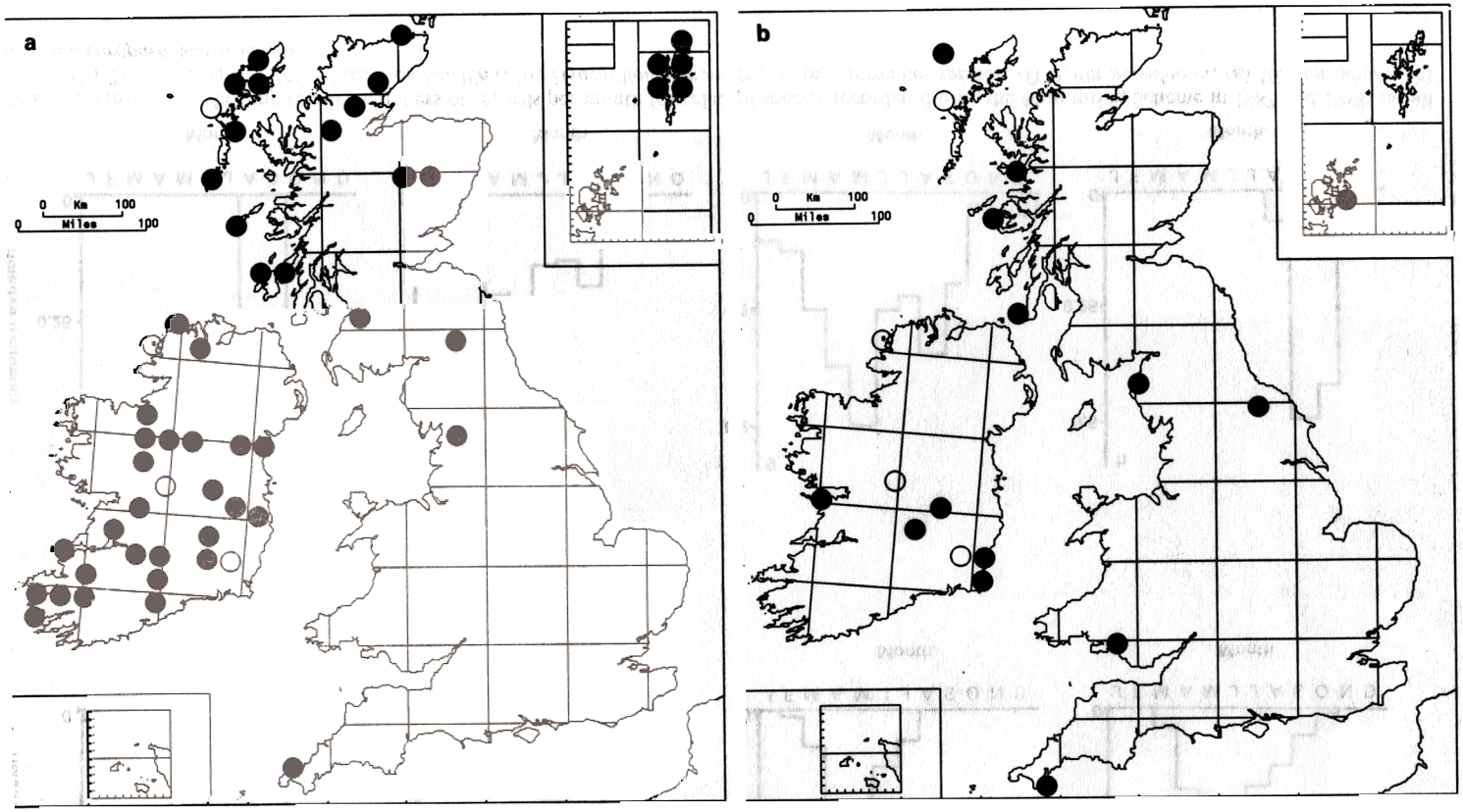

FIGURE 13. 10-km squares with a seasonal bias to the records for the Monitoring Scheme in 1987 and 1988: (a) squares not recorded before July; (b) squares not recorded after June. 10-km squares not recorded for either survey are shown as open circles.

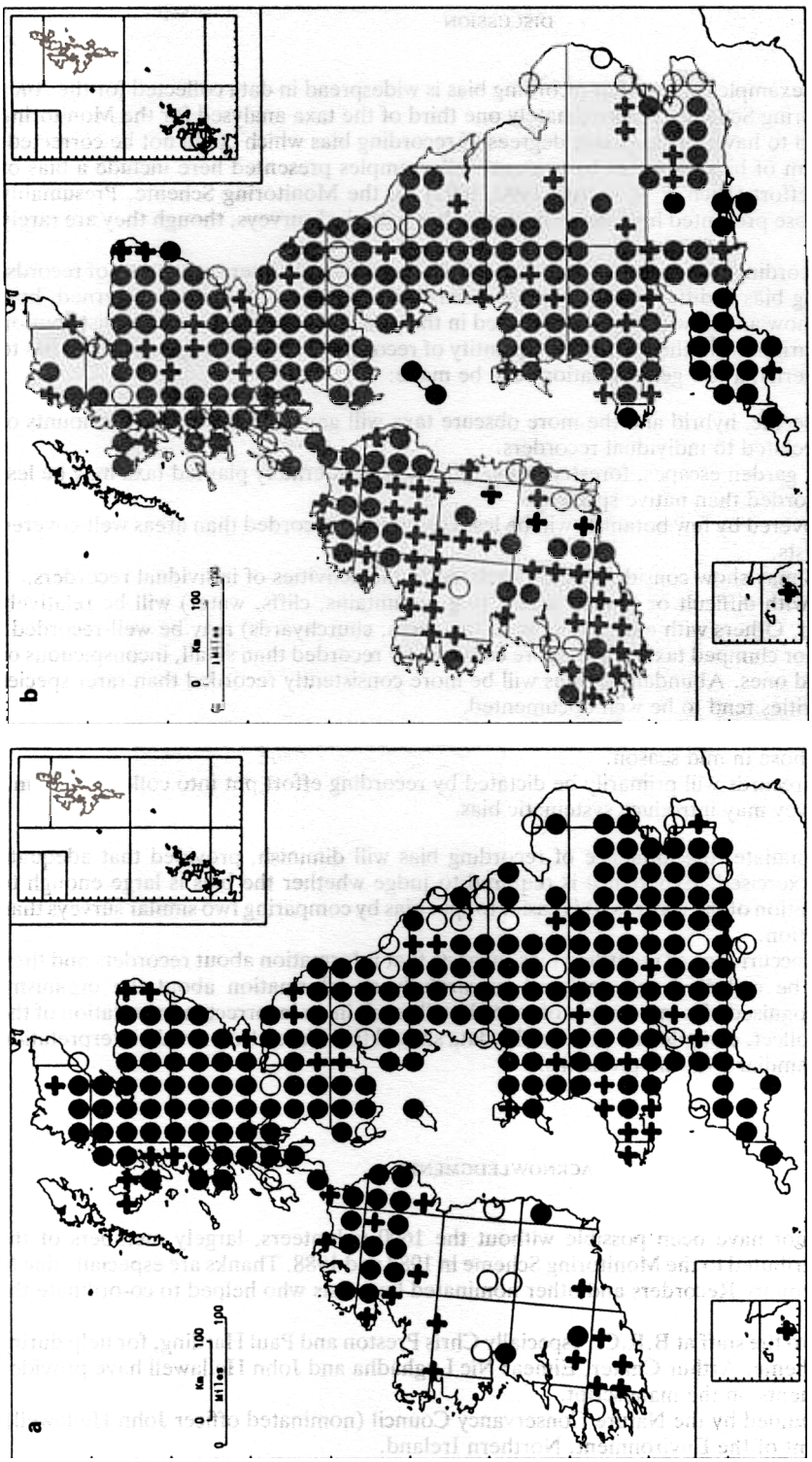

FIGURE 14. Taxa probably under-recorded in S.W. Ireland due to seasonal bias: (a) *Anemone nemorosa*; (b) *Chrysosplenium oppositifolium*.

DISCUSSION

It is clear from the examples above that recording bias is widespread in data collected for the *Atlas* and for the Monitoring Scheme. Approximately one third of the taxa analysed for the Monitoring Scheme were found to have unacceptable degrees of recording bias which could not be corrected. More than one form of bias may also be present – all examples presented here include a bias of greater recording effort (Rich & Woodruff 1990, 1992) for the Monitoring Scheme. Presumably biases similar to those presented here occur in most other botanical surveys, though they are rarely pointed out.

The extent of recording bias indicates that care should be taken with interpreting sets of records. Assessing recording bias is difficult and requires intimate knowledge of the taxa concerned, how they are recorded now and how they were recorded in the past, their habitats, general distribution and frequencies, variations in the quality and quantity of recording, etc. Although each case has to be judged on its merits, a few generalizations can be made:

1. Critical, infraspecific, hybrid and the more obscure taxa will generally show larger amounts of recording bias related to individual recorders.
2. Aliens, casuals, garden escapes, forestry trees, crops and deliberately planted taxa may be less consistently recorded than native species.
3. Areas briefly covered by few botanists will be less consistently recorded than areas well-covered by many botanists.
4. Localized areas may show considerable bias related to the activities of individual recorders.
5. Some habitats with difficult or limited access (e.g. mountains, cliffs, water) will be relatively poorly recorded. Others with easy access (e.g. car-parks, churchyards) may be well-recorded.
6. Large, obvious or clumped taxa will be more consistently recorded than small, inconspicuous or widely dispersed ones. Abundant species will be more consistently recorded than rarer species but national rarities tend to be well documented.
7. Species characteristic of the beginning and end of the field season will be less consistently recorded than those in mid season.
8. The number of records will primarily be dictated by recording effort put into collecting them.
9. Methods of survey may introduce systematic bias.

As records accumulate, the influence of recording bias will diminish, provided that adequate quality control is exercised. Experience is required to judge whether the bias is large enough to affect the interpretation of the records. It is easier to spot bias by comparing two similar surveys than to assess it in isolation.

The widespread occurrence of recording bias suggests that information about recorders and their behaviour should be collected and analysed as carefully as information about the organisms themselves. Unrecognised bias in a sample of records will result in an incorrect interpretation of the data. Those who collect, compile and present the data should therefore also provide interpretation to guide those unfamiliar with the problems.

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