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By comparing the estimated costs and benefits of each option, the option which appears to deliver the greatest benefit at the lowest costs emerges as the preferred solution. If a costly option emerges as the one likely to deliver the greatest benefit, its acceptance can be argued more convincingly, particularly if sensitivity analysis of the preferred solution has been carried out. This analysis will test the robustness of the proposal compared to other discarded options. These test consists of asking "what if.....?" questions, to see whether any change of circumstances might produce a change of the preferred option.

Conclusion

A cost/benefit appraisal method has a number of advantages:

- It can convince others of the need for appropriate levels of investment
- It involves others who may be more involved with collection use than collection care
- It involves those making decisions on how resources are allocated
- It involves others who may not deal with collections on a day to day basis but whose decisions may affect the survival of a collection.

Using Botanical Records to Interpret Changes in Frequency of British Plants

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Introduction

Change in frequencies of botanical records can help us to understand what is happening to the British flora. This has applications in monitoring for conservation and environmental change. There are three main types of botanical records which can be used:

1. *Herbarium records.* These are the most important source of high-quality information as identification can be verified and there are often useful details annotated onto the sheets. There are a few problems with incorrect or inconsistent labelling, and there are relatively few recent specimens due to changes in attitude to collecting.
2. *Literature records in floras and journals.* These tend to be well-known and widely available, but the identification cannot be verified without voucher material and the records are often copied uncritically.
3. *Field records.* These are unpublished notes or records made on standard Biological Records Centre record cards. They tend to be poorly documented, cannot be verified and the original details are relatively inaccessible, though the summary details are often available on computer. Since the 1960s these have been the main source of records.

Original sources should always be checked. Overall, botanical records tend to be incomplete, biased towards well-known sites, ambiguous, a small sample of the whole picture, and a fascinating challenge to put together. Analysis of the changes in number of records is further complicated by variations in recording effort, and in most cases it is only possible to assess the general trends from the data. The following four examples have been selected to illustrate how the data can be used and some of the problems.

Cotswold Pennycress *(Thlaspi perfoliatum)*

Records of this rare native species of the Cotswolds were compiled from a wide range of sources (Rich, Kitchen & Kitchen, 1989). After a careful conservative assessment of the records it has occurred in a total of 45 native and 37 introduced sites in Britain, but is now only known in nine native sites (80% decline).

Changes in the status of Cotswold Pennycress with time is difficult to interpret due to the inconsistency of botanical recording. When the total number of individual records per decade are plotted there are large fluctuations (Figure 1), which are probably explained better in terms of the recording behaviour of botanists rather than changes in frequency of Cotswold Pennycress. With the rise in activity of the Botanical Society of London in the 1830s and 1840s, there is an increase in the number of records, followed by a trough in the 1850s when the Society collapsed. Collecting by its successor, the Botanical Exchange Club, in the 1860s and 1870s again results in many records with a peak in 1880. The trough in the 1890s is less easy to explain, but the troughs in the 1920s and 1940s may be due to the depression and Second World War respectively. A further rise in the 1950s and 1960s can be attributed to recording enthusiasm resulting from the Botanical Society of the British Isles Maps Scheme, and the rises in 1980s and 1990s to the conservation work carried out on this plant. The number of records per se is thus a poor measure of the status of the plant.

This type of variation can be simplified by summarising the records by 10-km square and/or decade, and extrapolating between the first and last dates of records. Figure 2 shows the number of native 10-km squares from which the plant would be expected to be recorded per decade assuming continuous presence in the 10-km square from the date of the first record to the last. The rise to a peak in the 1860s reflects the increasing knowledge of the distribution of the plant at a 10-km square level, with two main periods of decline, between 1900 and 1920, and in the 1950s and 1960s. The latter is due to the agricultural revolution. Figure 2 gives a better picture of changes in the frequency of the plant than Figure 1.

Red-tipped Cudweed *(Filago lutescens)*

This rare species is difficult to identify and has been poorly researched in Britain. A detailed study was therefore undertaken using mainly verified herbarium material from 20 herbaria, resulting in over 400 records.

Figure 1. Total number of Cotswold Pennycress (*Thlaspi perfoliatum*) records per decade.

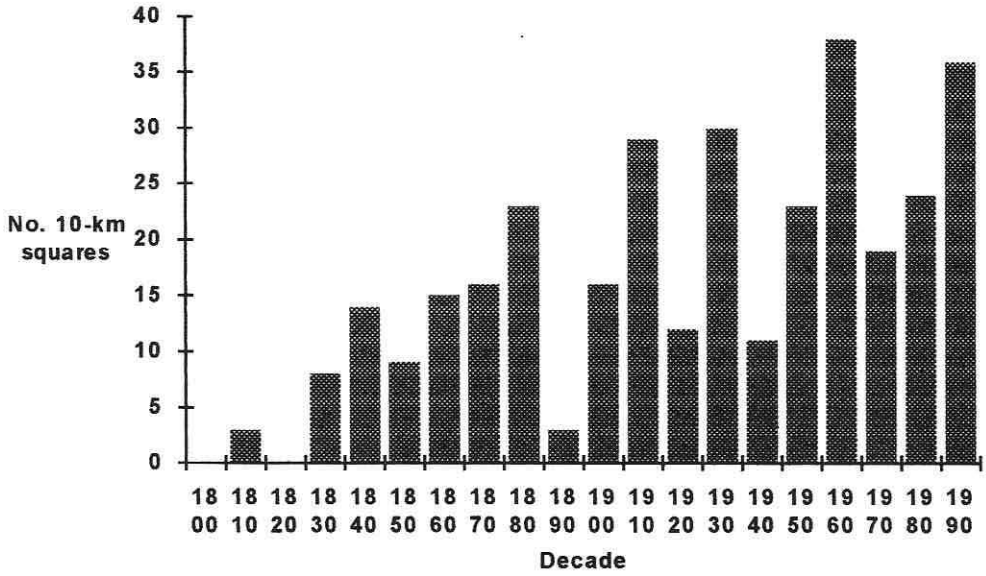


Figure 2. Extrapolated number of native 10-km squares for Cotswold Pennycress (*Thlaspi perfoliatum*) per decade.

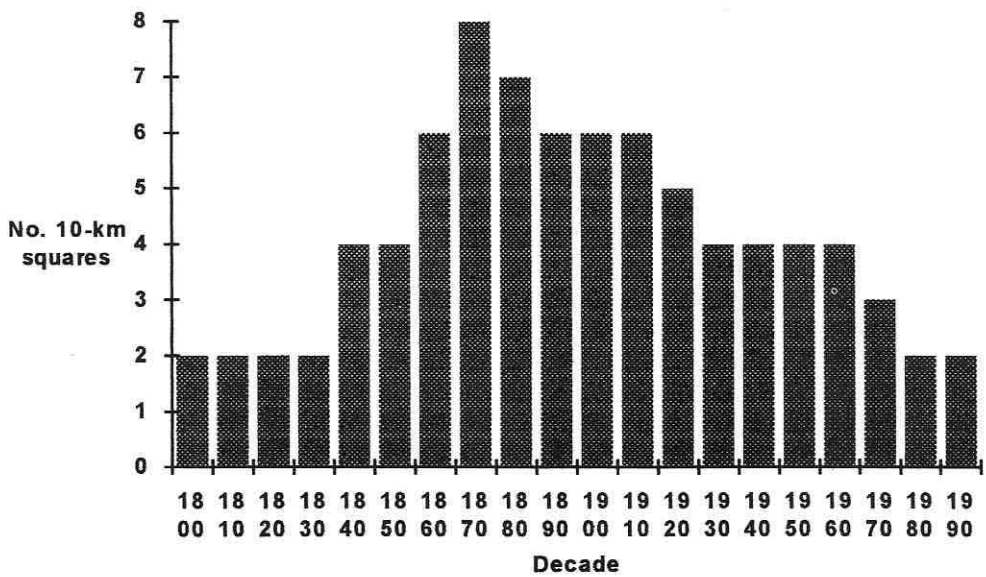


Figure 3. Distrobution of Red-tipped Cudweed (*Filago lutescens*) in South-east England. ■ 1990 onwards. ● 1950-1989. O Pre-1950 and undated records.

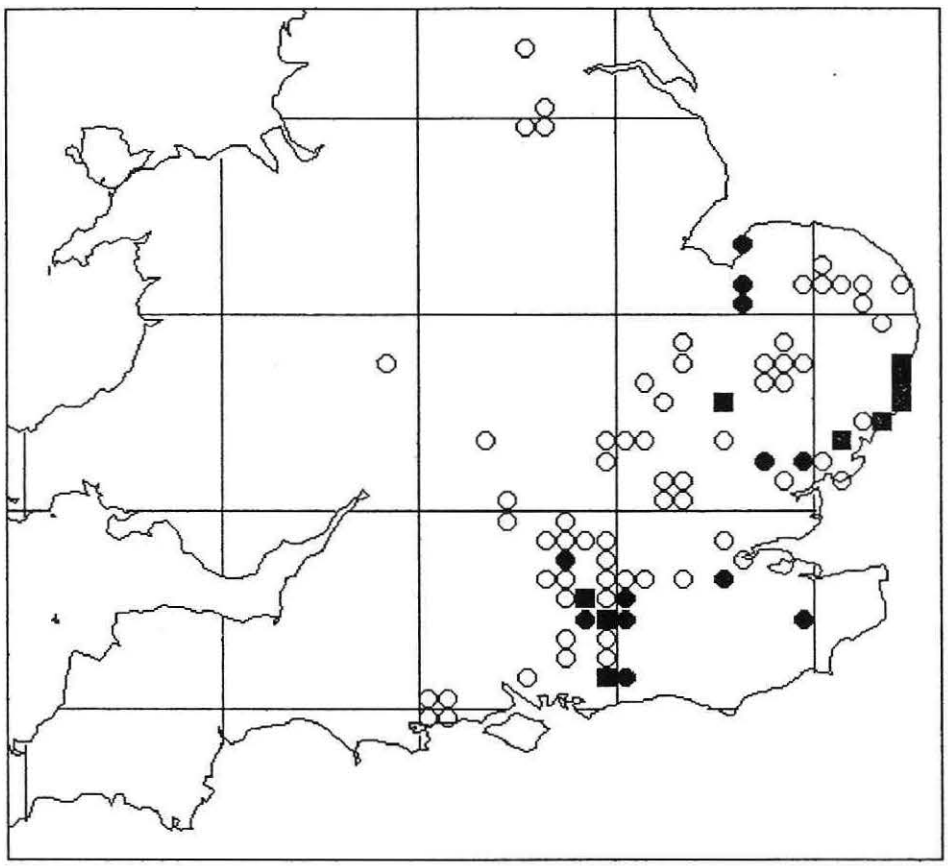
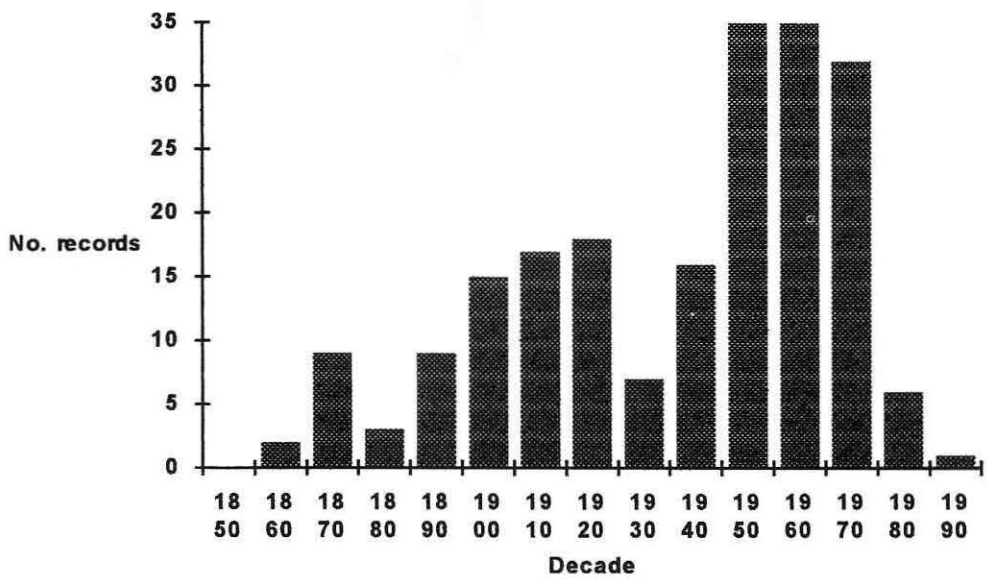


Figure 4. Total number of Ragweed (*Ambrosia artemisiifolia*) records per decade. Data for 1980 and 1990 are incomplete.



It has been recorded reliably in 86 10-km squares in south-east England and records for 11 squares have been rejected (Figure 3). The map in the Atlas of the British Flora (Perring & Walters, 1962) has only 53 correct 10-km square records (61% of Figure 3) and 6 errors (11%). Virtually all the records in Figure 3 available at the time the Atlas of the British Flora was compiled but were not researched. The more complete historical data has also resulted in it being categorised as 'vulnerable' in the forthcoming Vascular Plant Red Data Book rather than merely 'lower risk' (M. J. Wigginton, pers. comm. 1995).

It has been recorded in only 14 sites in ten 10-km squares since 1990. An analysis of the habitat information on the herbarium sheets shows that it has declined in arable field habitats, tracks and heathland (Table 1). These are due to changes in agricultural practices and reduced disturbance respectively. The dates of records show that much of the decline had taken place by the 1960s (data not presented).

Ragweed *(Ambrosia artemisiifolia)*

Ragweed pollen is the worst cause of hay fever in the world (Rich, 1994). In Britain, Ragweed is currently a rare introduction which does not persist as the climate is too cold for it to set viable seed. However, with global warming it could become established when the summer temperature is about 2°C warmer, with the potential to cause misery to millions of hay fever sufferers.

Ragweed has been regularly introduced to the British Isles from North America since the 1860s, often associated with rubbish tips, docks, farmland and bird seed. There was a large increase in records from the 1950s to 1970s (Figure 4), resulting in a Sunday Times report that Britain is about to suffer an imminent plague of Ragweed (Connor 1997). A detailed and sober investigation of the records had already suggested that this increase is a function of increased interest in alien plants and visits by botanists to rubbish tips rather than an imminent plague (Rich, 1994). Indeed, following the waste disposal regulations in the 1970s, rubbish tips have been covered with topsoil and no longer provide a habitat for the plant. At the current rate of climate warming of 0.2°C, Ragweed is unlikely to be a problem for a century.

Small Cow-wheat (*Melampyrum* sylvaticum) and Pyramidal Bugle (Ajuga *pyramidalis*)

These 'Nationally Scarce' plants of northern Britain have shown significant declines according to the maps presented by Stewart, Pearman & Preston (1994). Concern about the quality of the information on which they were based led Scottish Natural Heritage to commission a review of the ecology and distribution of each species, including the information on which the maps were based (Rich, FitzGerald & Kay, 1996).

A comparison of the number of herbarium records for each species in the Nationally Scarce Plants database with the detailed review is shown in Table 2; herbaria have clearly been under-utilised as a source of information. For Small Cow-wheat especially, this has resulted in many valid records being over-looked and some incorrect ones being included in the database (Rich, 1997).

Conclusions

Botanical records can be used to show changes in the British flora. The actual numbers of records vary depending on botanical activity throughout the country, and this recording effort also varies with species, locality and the method of recording. The resulting complex patterns of records require careful interpretation.

Herbaria provide a very important source of high-quality historical information. They provide dates, localities, sometimes other information such as habitats and, most importantly, reference material which can be verified. Surprisingly few botanists utilise herbaria, perhaps due to the effort involved in visiting or borrowing material. Computerised registers of specimens would probably help advertise that the information is available.

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