Choice of surveyor is vital to the reliability of floristic change studies

A. OREDSSON*

Department of Systematic Botany, Lund University, Ö. Vallgatan 14–20, S-223 61 Lund, Sweden

ABSTRACT

The flora of an area of 46 km^2 of farmland and wooded hills surrounding the lake of Striern, Sweden was surveyed. Fifty-six different habitats were selected from topographical and geological maps, within which 214 plots were chosen by random sampling. The plots, mostly 10 m × 10 m, were investigated in 1972 and 1998. Each plot was recorded by walking through on parallel lines 1 m apart. Six of the best botanists from the region carried out the field work and their recording capacity was estimated; apart from one individual, variation between surveyors was negligible. Over the 26 years, the mean number of species recorded per plot fell from 32·5 to 30·2; the downward trend probably reflects a true decline in the frequency of species.

KEYWORDS: Change in flora, different surveyors, Sweden.

INTRODUCTION

Ever since the times of Linnaeus, Swedish botanists have maintained a high level of knowledge of the native vascular plants in Sweden. The tradition of writing Floras of provinces is flourishing, often with many amateurs taking part in the field work.

Floras change. Since World War II, a marked increase in the standard of living in Sweden has taken place which has had a massive impact on the natural environment, through air pollution and indirectly by changes in life style, including migration from the countryside (Oredsson 1990).

Unfortunately there are few historical studies which have quantified the abundance of vascular plants sufficiently accurately to allow a statistically reliable assessment of change. Consequently, Red Lists of threatened species are rather more subjective than objective comparisons with the past. One Swedish opportunity to assess change against quantitative historic data was by repeating studies carried out by Hans Göransson as part of his quantitative survey of the flora related to pollen rain in Östergötland in 1972 in which I took part. As I had already demonstrated considerable changes in northern Scania (the southern-most province of Sweden) after 25 years (Oredsson 1990), it was assumed that any changes which had taken place in Östergötland would also be detectable. In this connection, a problem hitherto little discussed in Sweden has arisen, namely the influence of individual botanists on the results of the field work.

This paper deals with a case in which six botanists were involved in recording the same habitats 26 years apart. The field work area covers 46 km^2 of farmland and wooded hills surrounding the lake of Striern, in southern Östergötland, about 200 km S.W. of Stockholm.

METHODS

The 1972 survey was carried out by quaternary biologist Hans Göransson (HG) and the author (AO), while the 1998 survey was carried out by me and four assiduous, proficient, amateur botanists from Östergötland (proof that Sweden is still teeming with Linnean pupils!) - Janne Andersson (JA), Johan Bergstedt (JB), Dan Lindmark (DL) and Rolf Wedding (RW).

Before the 1972 survey, the study area was stratified using 1:50,000 topographical and geological maps. 56 habitats were established, 44 of which combined information from both maps

*Address for correspondence: e-mail: Alf.Oredsson@sysbot.lu.se

(e.g. forest on Växjö granite, or open terrain on clay), and the remaining twelve from the topographical map (e.g. church, or public roads in open terrain). Within each habitat, 1–10 plots were chosen by random sampling depending on the size of the habitat. In 144 cases the general position of the plot was located using 100 m co-ordinates, in 70 cases using 50 m co-ordinates. In the field, the final position was then determined using further random sampling by assistants without specialist botanical knowledge, and thus the final positions differed slightly between the years, although the map co-ordinates were identical.

157 of the plots were 10 m × 10 m. On shorelines (22 plots) a 10 m × 20 m rectangle was surveyed, half in water, half on land. Along roads and water courses (22 plots) the length was 10 m, whilst the breadth varied. These 201 plots were marked out with a cord, and at least the terrestrial part of the plot was walked through along parallel lines 1 m apart. In the remaining 13 plots which included urban areas, the boundary of the garden, grounds or churchyard provided the outer edge of the plot.

In each plot, all identifiable vascular plant species were recorded, no matter what stage in the life cycle (e.g. seedling or withered) or number of individuals. Combining both years, 543 species were found excluding cultivated species.

RESULTS

If all six botanists had a similar capacity to find almost every species in the plots, it would be possible to make a reliable comparison in the flora between 1972 and 1998. The results for the botanists were therefore investigated in detail.

1972 SURVEY

Hans Göransson surveyed 131 plots once between the end of June and early August and 22 plots twice, the first time in May and the second in July or August (Table 1). He found an overall average of 33·1 species per plot, but plots surveyed once had an average of 32·6 species and plots surveyed twice an average of 36·0 species, though this was not statistically significant (The Mann-Whitney U-test; $p=0{\cdot}14$).

I surveyed 61 plots in early August, and found an average of 31·0 species per plot. To make allowances for the different habitats surveyed, which affect the number of species, only habitats investigated by both HG and AO were compared (viz. 107 plots in 21 habitats). For each habitat, the median number of species was calculated, and then the number of plots which fell above, equalling or below these medians summed (Table 2). Using these medians, the differences in number of species recorded between HG and AO are not statistically different (Table 3). It is concluded that HG and AO would have found approximately the same number of species if they had investigated the same plot independently in 1972.

TABLE 1. TOTAL NUMBER OF RECORDS, NUMBER OF PLOTS AND AVERAGE NUMBER OF SPECIES PER PLOT IN THE STRIERN AREA SURVEYED IN 1972 AND 1998.

	1972					1998					
Surveyors	HGa	HGb	HGΣ	AO1	total	AO2	DL	JA	JB	RW	total
No of records	792	4265	5057	1892	6949	1991	453	2188	1290	537	6459
No of plots	22	131	153	61	214	63	18	68	50	15	214
Average no species/plot	36·0	32·6	33·1	31·0	32·5	31·6	25·2	32·2	25·8	35·8	30·2

Surveyors in 1972: Hans Göransson (HGa), twice (12–28 May, 6 July to 5 August) or (HGb), once (29 June to 11 August); and Alf Oredsson (AO1) (5–11 August).
Surveyors in 1998, 6–17 July: Alf Oredsson (AO2); Dan Lindmark (DL); Janne Andersson (JA); Johan Bergstedt (JB); and Rolf Wedding (RW).

TABLE 2. NUMBER OF PLOTS RECORDED BY DIFFERENT BOTANISTS IN 1972 AND 1998 WITH ABOVE, EQUALLING OR BELOW MEDIAN NUMBER OF SPECIES PER PLOT FOR THE SAME HABITATS. SURVEYORS AS IN TABLE 1.

	1972				1998				
	HGa	HGb	HGΣ	AO1	AO2	DL	JA	JB	RW
Above median	1	23	24	22	24	2	27	17	8
Median	0	12	12	4	1	1	6	7	1
Below median	1	28	29	16	15	15	29	16	5

1998 SURVEY

In 1998, the 214 plots were surveyed between 6–17 July by myself (AO2), Dan Lindmark (DL), Janne Andersson (JA), Johan Bergstedt (JB) and Rolf Wedding (RW). The average number of species recorded per plot varied considerably; DL and JB recorded the least, AO and JA the middle numbers and RW the largest numbers per plot (Table 1).

Again, comparisons between surveyors need to take into account the different habitats which each surveyed (Table 2). Median species counts in 174 plots in 35 habitats were again investigated. JA and JB recorded almost as many plots above as below the median, AO2 and RW recorded slightly more plots above the median, and DL more below the median.

The Fisher Exact Probability Test indicated no significant differences in efficiency between the surveyors, except for DL (Table 3). AO and RW had previous experience of field work of this kind, and in a given plot might have observed one or two species more than the other botanists, whereas DL came in late and so was less prepared for the task.

COMPARISON OF 1972 SURVEY WITH 1998 SURVEY

If HG recorded in 1972 with the same degree of accuracy as did jointly DL, JA, JB and RW in 1998, and if my capacity for recording species had not changed, my results from the habitat comparisons in both surveys should have been alike, and they were. The number of plots which fell above, equalling or below the medians in 1972 were 22–4–16; and in 1998 were 24–1–15 (Table 2). Equalling values excluded, The Fisher Exact Probability Test gives p=0·17 (Table 3) which is not statistically significant. Overall I came closer to the ultimate goal of finding all species present in a plot than did the average colleague. As I recorded almost the same number of plots in each year, this should not have affected the comparison between years species by species.

Between 1972 and 1998, the average number of species recorded fell from 32·5 to 30·2 species per plot, a reduction of 7%. Despite the fact that six different botanists were involved in the field work, the downward trend probably represents a true decline in diversity. Details of which species changed will be published in another paper (Oredsson, in prep.).

TABLE 3. ESTIMATES OF DIFFERENT SURVEYORS' RECORDING CAPACITY IN 1972, 1998 AND ONE SURVEYOR BOTH YEARS. DATA FROM TABLE 2 (EXCLUSIVE OF MEDIAN) TESTED BY THE FISHER EXACT PROBABILITY TEST (SIEGEL 1956). SURVEYORS AS IN TABLE 1.

1972		1998					1972 & 1998	
	AO1		AO2	DL	JA	JB		AO2
HG	0·08	DL	0·0005				AO1	0·17
		JA	0·07	0·005				
		JB	0·13	0·005	0·17			
		RW	0·26	0·006	0·17	0·22		

All figures are probability values

DISCUSSION

DIFFERENCES BETWEEN SURVEYORS

In 1987–1988, the B.S.B.I. Monitoring Scheme engaged over 1600 botanists in a sample survey of 10 km squares in Britain and Ireland, during which time 2660 taxa were recorded (Rich & Woodruff 1990). The problems encountered during a comparison with data from the *Atlas of the British flora* prompted the harsh conclusion that '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' (Rich & Woodruff 1992)

Four tetrads (2 km × 2 km each) in West Sussex were investigated by 29 volunteers with a range of botanical abilities representative of many national and county Flora projects in July 1992 (Rich & Smith 1996). They worked in pairs recording vascular plant species for 2·5 hours in each square. Individuals were then rotated to different squares and paired with a different botanist. In all, 634 species were recorded. From this experiment with different surveyors, Rich & Smith learnt that different botanists were the key factor causing variation between the surveys.

In light of these two examples, it was obviously important to recruit the very best botanists available for the 1998 survey of the Striern area, or the differences between surveyors might have masked any floristic change. The results demonstrate it is possible to even out the differences between surveyors provided they are of sufficient quality. This proved to be the case for everybody involved in this project.

SIGNIFICANCE OF INTENSITY

From April to October 1982, six competent field botanists independently recorded the vascular plants in three British woods, each about 30 ha (Kirby *et al.* 1986). Two different methods were used; a walk along 3–3·5 km long routes and quadrat survey in squares of 200 m^2. It was found that differences between surveyors or seasons were much smaller than differences in methods or intensities of survey.

In the Striern surveys, the standard plot was walked through along ten parallel lines only 1 m apart so few, if any, vascular plant species should have eluded a skilled botanist's observation. However, Göransson found on an average 3·4 more species in plots investigated twice than in plots investigated once, and although this is not statistically significant it may indicate there is still some variation due to the season.

ADVANTAGE OF STRATIFIED RANDOM SAMPLING

In August 1964, two professional botanists investigated the flora of the large peninsula of Lake Toisvesi in central Finland, which was divided into 50 1 km squares. Each botanist tried to find as many species as possible in every square. Altogether 362 species were recognised, eleven of which were only found by one surveyor, and 14 only by the other. Moreover, the two surveyors were shown to preferentially select different habitats to record which accounted for some differences between lists for the same squares (Kytövuori & Suominen 1967). In the Striern area, the stratified random sampling technique prevented the surveyors being drawn towards any favourite habitats.

Stratified random sampling is also relatively efficient. In a survey of mountain forest types in the Swiss Alps, it was found that stratified random sampling provided an accurate picture of the small scale vegetation pattern at low sampling effort in areas sized 10–50 km^2 (Gödickemeier *et al.* 1997). It is also used successfully for the British Institute of Terrestrial Ecology Countryside Survey (Barr *et al.* 1993).

A quarter of a century ago, I pointed out the advantages of stratified random sampling for regional mapping of the vegetation (Oredsson 1974). Unfortunately, this method is still far from being generally accepted. Sticking to vague 'walk-about' strategies is a horrible waste of human capital, humiliating a large number of amateur botanists willing to spend so much of their spare time on botanical research.

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