Bothalia 15, 1 & 2: 131–138 (1984)

Intensity of plant collecting in southern Africa

G. E. GIBBS RUSSELL*, E. RETIEF* and L. SMOOK*

Keywords: check-lists, distribution maps, gamma diversity, herbarium, phytogeography, species diversity

ABSTRACT

The intensity of plant collecting in southern Africa is mapped using records from the Pretoria National Herbarium Computerized Information System (PRECIS). For the entire area, over 85% of the quarter degree grid squares have fewer than 100 specimens recorded. Collecting intensities are compared for different countries, biomes and climatic zones. Future field work from the National Herbarium will be concentrated in areas most seriously under-collected.

INTRODUCTION

Until now there has been no source of precise information about the intensity of plant collecting in southern Africa. Previous indications of collecting intensity, such as the AETFAT maps showing the extent of floristic exploration of sub-Saharan Africa (Leonard, 1965; Brenan, 1965; Hepper, 1979 and Leonard, 1979), were compiled from literature and from the personal knowledge of experienced botanists. Now, PRECIS (Pretoria National Herbarium Computerized Information System) can provide quantitative information about collecting intensity based on the number of specimens from each quarter degree grid square (Edwards & Leistner, 1971) in the entire Flora of Southern Africa region.

Why is it important to know the collecting intensity of a region?

1. Knowledge of areas that are under-collected is necessary when planning collecting trips, so that additional localities as well as additional specimens and taxa may be added to the Herbarium. In this way, each taxon in the Herbarium will be more completely represented both for distribution records and for morphological characters over its range. The time and money spent on collecting trips will thus be used to the greatest possible effect.

2. Knowledge of areas that are well-collected is a guide to using PRECIS to provide additional information. For instance, the list of species for a well-collected quarter degree square can be used as a preliminary check-list for under-collected areas nearby or in the same veld type.

3. Knowledge of collecting intensities is required for phytogeographical studies because of the interrelation between collecting intensity and species diversity (gamma diversity, Whittaker, 1972). Knowledge of collecting intensity will also help in assessing the completeness of species lists.

METHODS

The PRECIS data base is explained in detail by Magill *et al.* (1983) and Gibbs Russell & Gonsalves (in press). The system contains label information for about 600 000 plant specimens in the National Herbarium (PRE), of which about 55% (±325 000 specimens) have their locality expressed as a quarter degree grid reference. In this form, the localities are easily sorted by the computer to produce either distribution maps of the specimens in any species, or check-lists of the species in any quarter degree square. The program that produces the check-lists also reports the number of specimens held in each quarter degree square. These numbers were mapped as given by PRECIS, then broken into size classes as shown in Fig. 1, for easier interpretation. The numbers of quarter degree squares in different regions were counted so that the percentages of different size classes in each region could be compared.

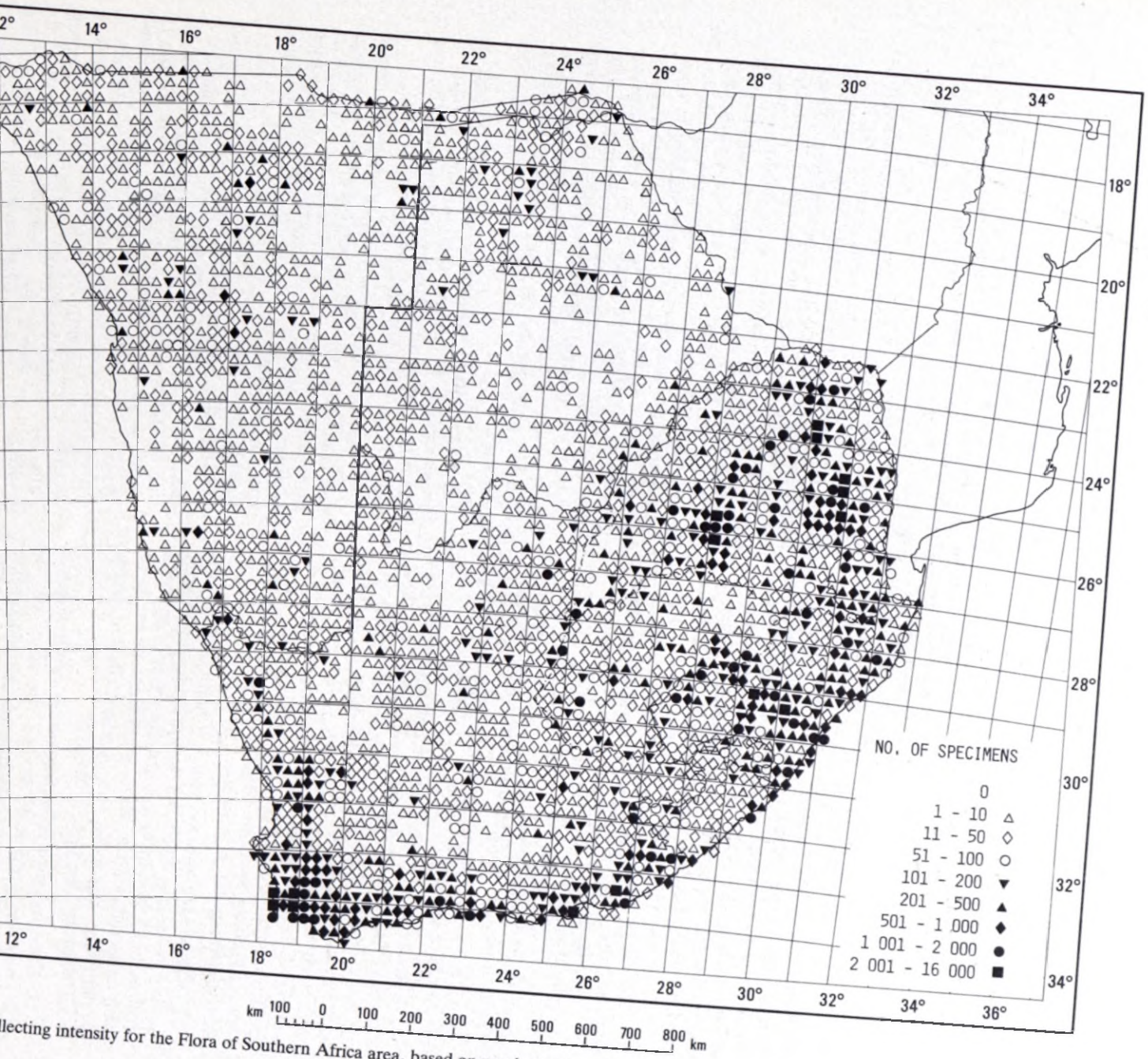
The data shown here, although based on part of the specimens in one Herbarium, are thought to reflect accurately the intensity of collecting for the entire Flora area for the following reasons:

1. The National Herbarium, although located in the Transvaal, has a high percentage of specimens from other regions of the Flora area. Morris & Manders (1981) report that 71,7% of the PRE specimens from the Flora area were collected outside the Transvaal.

2. When a portion of the data for Fig. 1, for which all possible grids were known, is plotted separately, the resulting map is extremely similar to Fig. 1. Grids were determined for about 40 000 of the ± 50 000 specimens of Poaceae in PRE (the other 10 000 had poor locality records that could not be expressed as a grid). Although based on only 12% of the specimens represented in Fig. 1, the collecting intensities shown for Poaceae are similar for countries, biomes and rainfall regions to the intensities shown by all specimens in Fig. 1.

3. When a sample of specimens from other herbaria is plotted for collecting intensity, the results agree with Fig. 1 for well collected and under collected quarter degree squares. Collecting intensities for about 3 500 specimens of *Ruschia* and Ruschiinae (Mesembryanthemaceae) from B, BM, BOL, G, K, L, M, PRE, S and Z were plotted by Dr H. F. Glen. This is important independent confirmation of Fig. 1, because ± 90% of these

* Botanical Research Institute, Department of Agriculture, Private Bag X101, Pretoria 0001.



llecting intensity for the Flora of Southern Africa area, based on numbers of specimens per quarter degree square, as reported by PRECIS.

specimens were from herbaria other than PRE, and the total sample size was only 1% of the number of specimens represented in Fig. 1.

4. The ± 325 000 specimens represented in Fig. 1 constitute more than 16% of the total number of specimens housed in herbaria in the Flora area. *Index Herbariorum* edn 7 (Stafleu, 1981) reports 2 028 400 specimens held in Flora area Herbaria (Gibbs Russell, 1983). This percentage is higher than that of Poaceae or Ruschiinae in Fig. 1, discussed above. Furthermore, if the specimens which are duplicates held in different herbaria, specimens which were collected outside the Flora area, and specimens for which it is impossible to determine a grid reference were subtracted from the total number of specimens, the true percentage cover of the specimens reported in Fig. 1 would be much higher.

In order to test the value of collecting in grid squares shown by PRECIS to be under-collected, a trip was made in January 1983 to the grid square 2728 in the eastern Orange Free State. The numbers of specimens and taxa collected were compared with the previous holdings of the Herbarium to determine whether the trip had added materially to the distribution records both for the taxa and for the area.

RESULTS AND DISCUSSION

Information about collecting intensity can be drawn from the map (Fig. 1) in several different ways, either for the whole Flora area (Fig. 4.C), or for divisions such as countries (Figs 3 & 4), biomes (Fig. 5) and climatic zones (Fig. 6). Regions compared in this paper are shown in Fig. 2.

The first visual impression of the map (Fig. 1) is that plant collecting, as reflected at PRE, has been most concentrated in the central and eastern Transvaal and the south-western and southern Cape, with lesser centres in Natal, Swaziland, Lesotho and the eastern Cape. South Africa, together with Swaziland and Lesotho, is better collected than Botswana or South West Africa/Namibia. However, within South Africa, the central and northern Cape is poorly collected. Closer examination shows that even in reasonably well-collected areas there are quarter degree squares with no specimens recorded, and conversely, in under-collected areas particular quarter degree squares with higher numbers of specimens show the location of towns, roads or research centres. Every whole degree square shows at least a few specimens recorded.

Precise information about collecting intensities in the different countries and in the entire Flora area is given in Figs 3 & 4. Considered as a whole (Fig. 4C), the Flora area is critically undercollected. Over 85% of the area has fewer than 100 specimens recorded per quarter degree square, over 25% of the quarter degree squares have never been sampled at all, and a further 33% has fewer than 10 specimens. The individual countries, however, vary greatly in their coverage. Best collected is Swaziland (Fig. 3A), with no uncollected quarter degree squares, and with the largest class having 201–500 specimens per square. Lesotho (Fig. 3B) is also reasonably well-collected, with a low percentage of uncollected squares, but the largest class has only 11–50 specimens per quarter degree square. Botswana (Fig. 3C) is the most under-collected country, with nearly half the quarter degree squares lacking specimens entirely, and nearly 98% of the squares showing fewer than 100 specimens. It is the only country in which the size class of 0 specimens per quarter degree square is the largest.

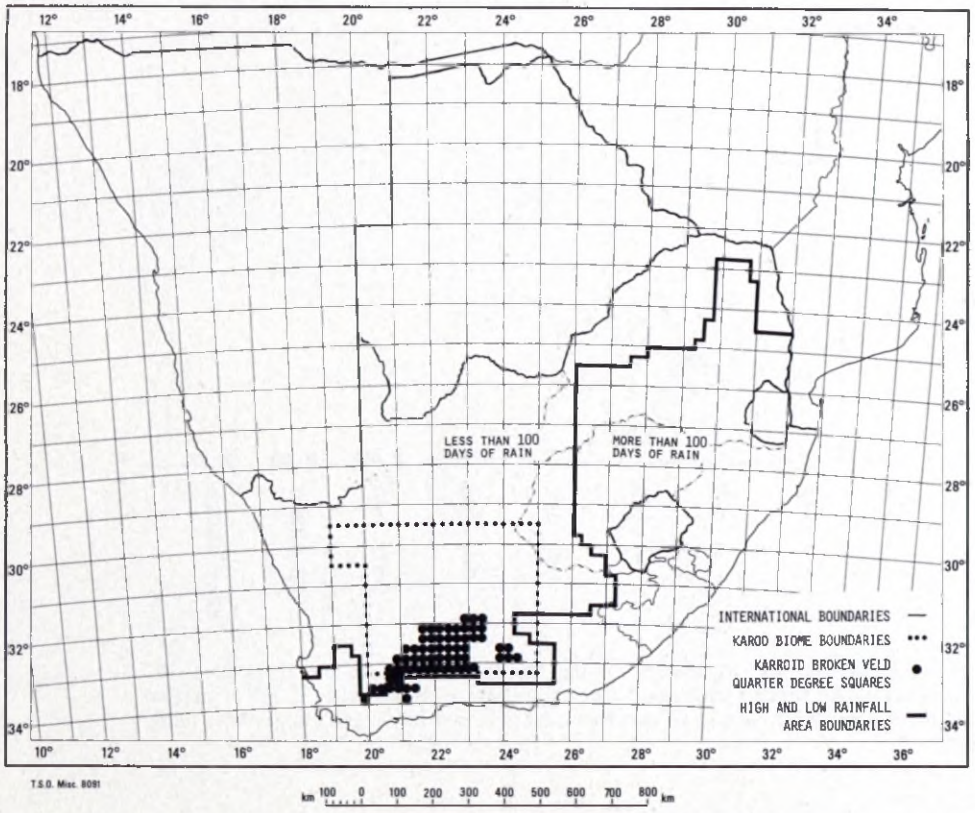


FIG. 2.—Areas compared in Figs 3 (countries), 4 (countries), 5 (Karroid vegetation type) and 6 (rainfall regions).

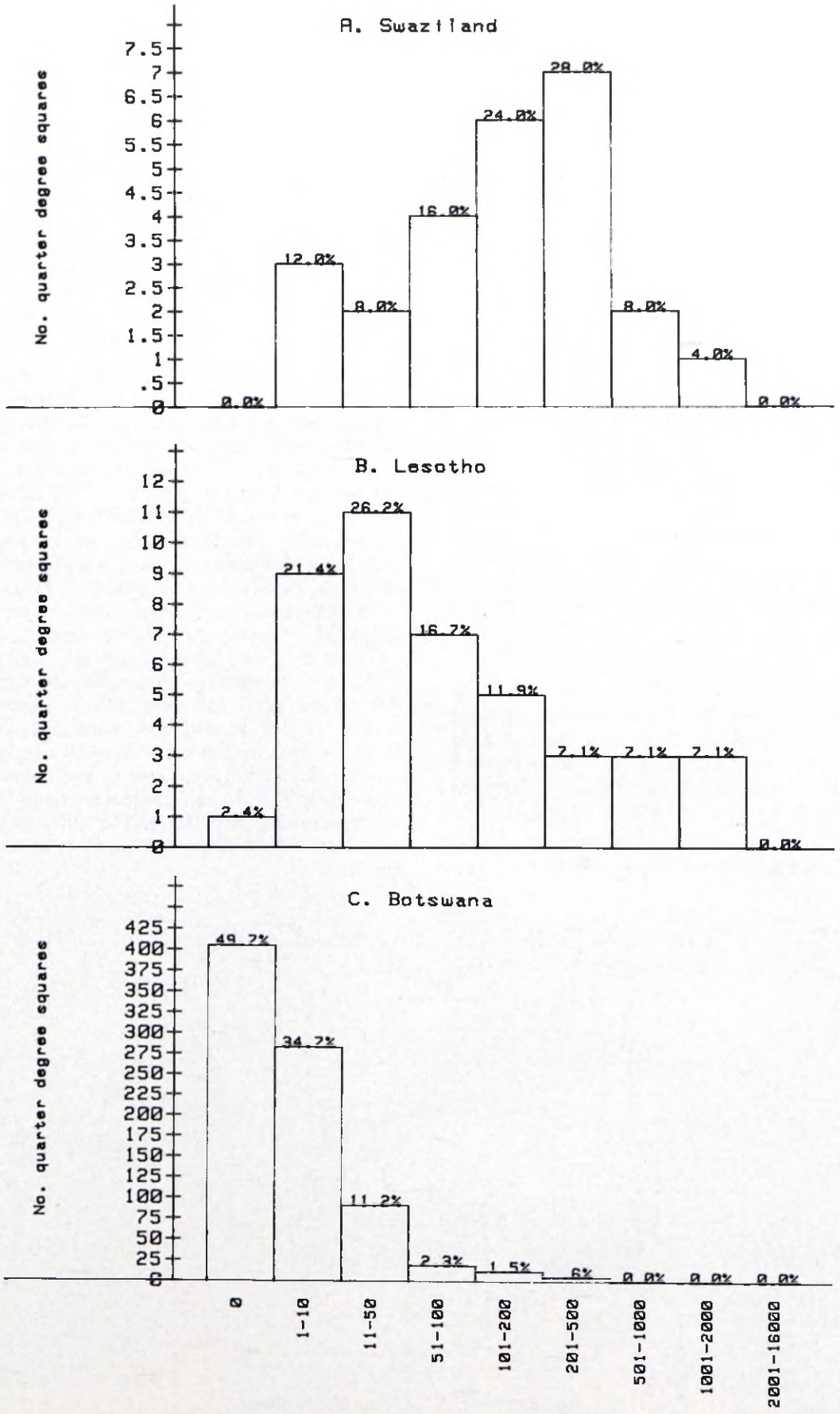


FIG. 3.—Percentages of collecting intensity size classes for the smaller countries in the Flora area. A, Swaziland; 64% of quarter degree squares have more than 100 specimens. B, Lesotho; 33,2% of quarter degree squares have more than 100 specimens. C, Botswana; 2,1% of quarter degree squares have more than 100 specimens.

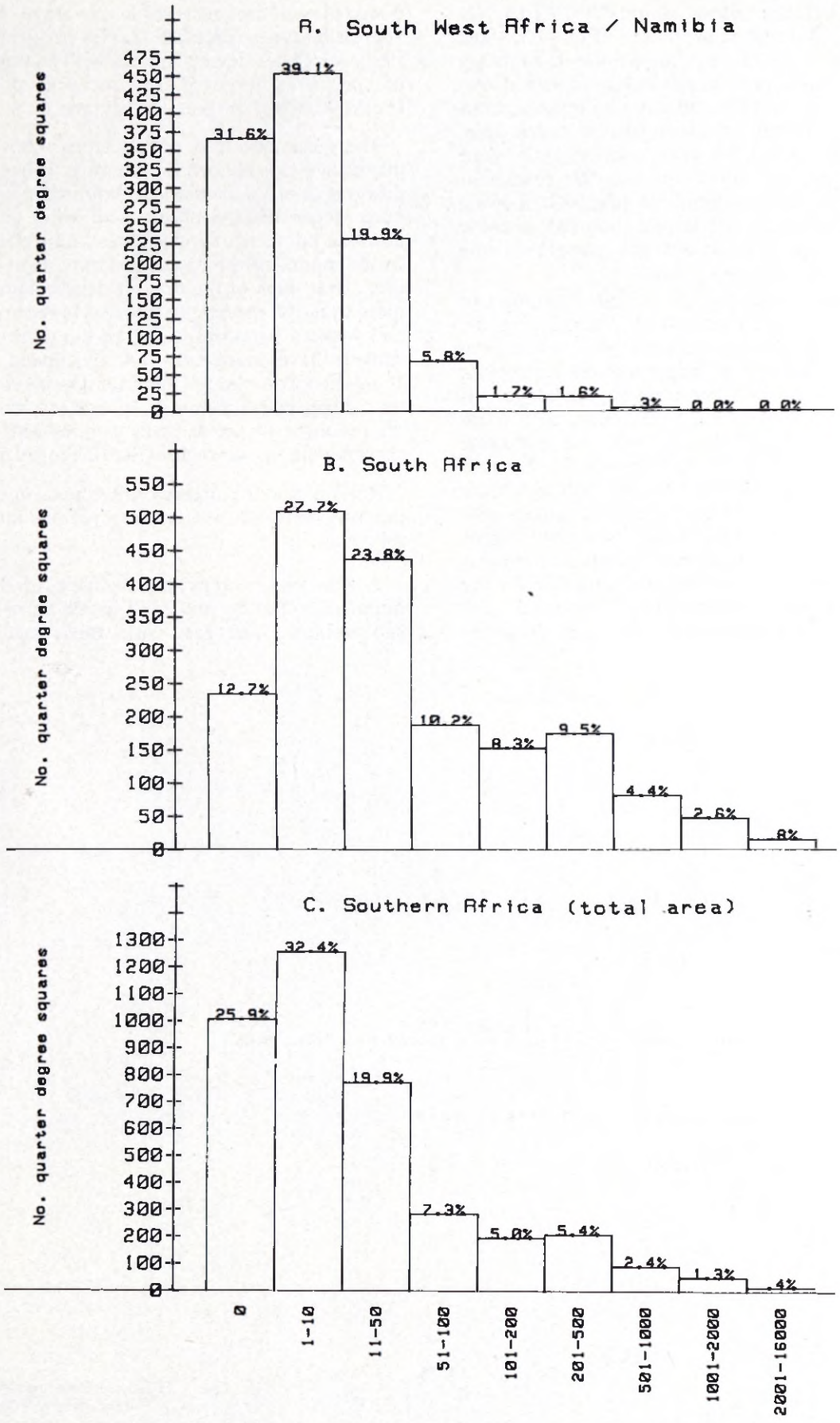


FIG. 4.—Percentages of collecting intensity size classes for the larger countries and total of the Flora area. A, South West Africa/Namibia; 3,6% of quarter degree squares have more than 100 specimens. B, South Africa; 25,6% of quarter degree squares have more than 100 specimens. C, total Flora area; 14,5% of quarter degree squares have more than 100 specimens.

The two larger countries, South West Africa/Namibia (Fig. 4A), and South Africa (Fig. 4B), show similar patterns, with the largest size class being 1 – 10 specimens per quarter degree square. However, South Africa has more quarter degree squares with high numbers of specimens recorded than South West Africa/Namibia, where only four quarter degree squares have over 500 specimens recorded. The entire Flora area (Fig. 4C) shows a similar pattern to the two largest countries, because their greater area overrides the pattern of the smaller, better collected countries.

The Karoo was chosen as an example of determining collecting intensity in a biome (Fig. 5). The outlines of the Karoo biome were taken from the map of Edwards & Scheepers (in Scheepers, 1983) and Fig. 5A shows the percentages of specimens reported in each size class. In a more restricted sample of the Karoo, the collecting intensity in Acocks's (1975) veld type 26, Karroid Broken Veld, are shown in Fig. 5B. Although there is a higher percentage of quarter degree squares with no specimens reported, there are also higher percentages of quarter degree squares with greater numbers of specimens for the veld type than for the biome. Both are obviously under-collected, and reference to Fig. 1 shows where collecting should be done to achieve reasonable coverage for these vegetation types. PRECIS species-per-grid lists, for the few quarter degree squares with a large number of specimens reported, can serve as preliminary checklists while further studies are in progress.

The mesic and arid climatic zones show striking differences in collecting intensity (Fig. 6). The differences are demonstrated both when comparing percentages of size classes and when comparing absolute numbers of grid squares within each region. In the mesic eastern and southern parts of the Flora area, over 44% of the quarter degree squares have more than 100 specimens, whereas in the arid central and western parts only 5,9% of the quarter degree squares have more than 100 specimens. Table 1 shows that even though the drier regions cover more than three times the area of the wetter regions, there are more than twice as many squares with over 100 specimens in the wet regions than in the dry regions.

Reasons for the marked differences in collecting intensity between wet and dry regions include the following:

1. The mesic areas include most of the major population centres, and 33 of the 38 herbaria in the subcontinent. The ease with which roads can be

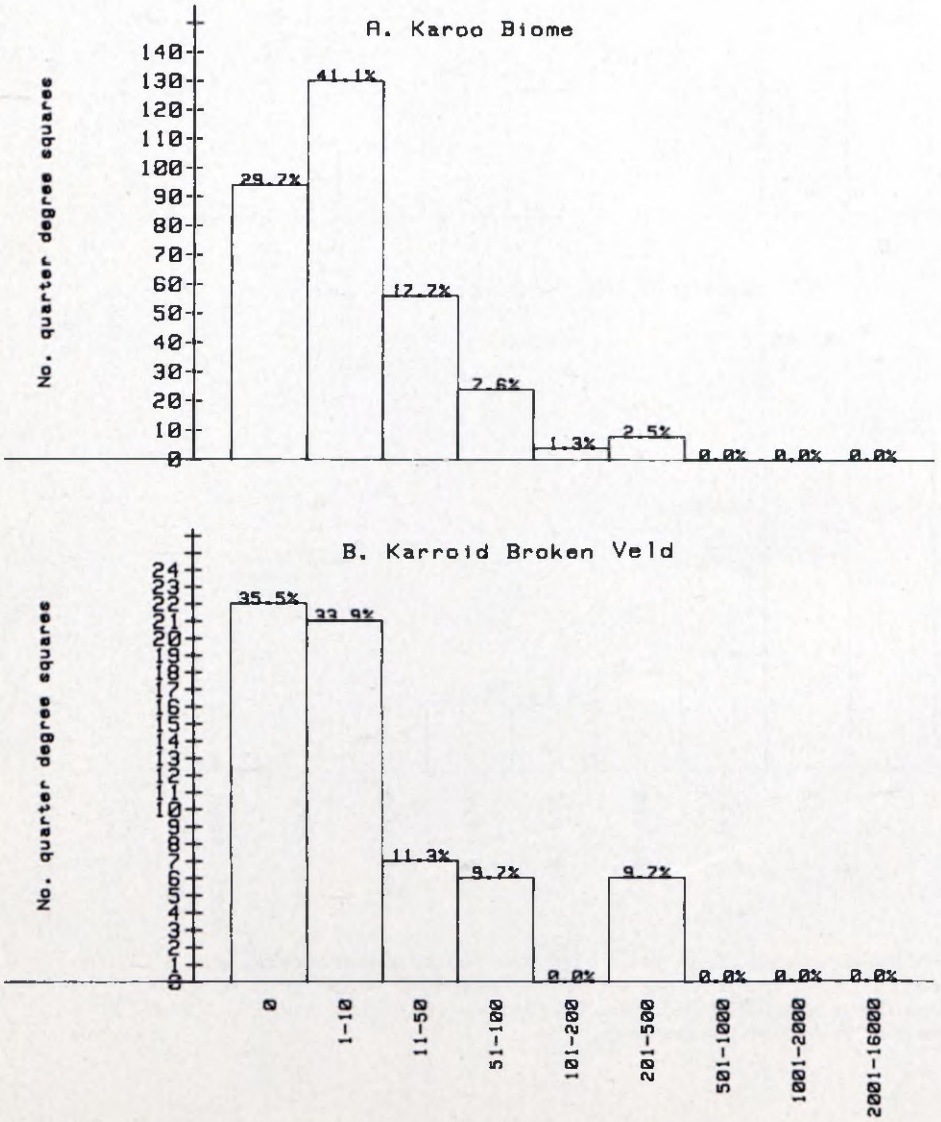


FIG. 5.—Percentages of collecting intensity size classes for the karroid vegetation type. A, Karoo Biome; 3,8% of quarter degree squares have more than 100 specimens. B, Karroid Broken Veld Type 26; 9,7% of quarter degree squares have more than 100 specimens.

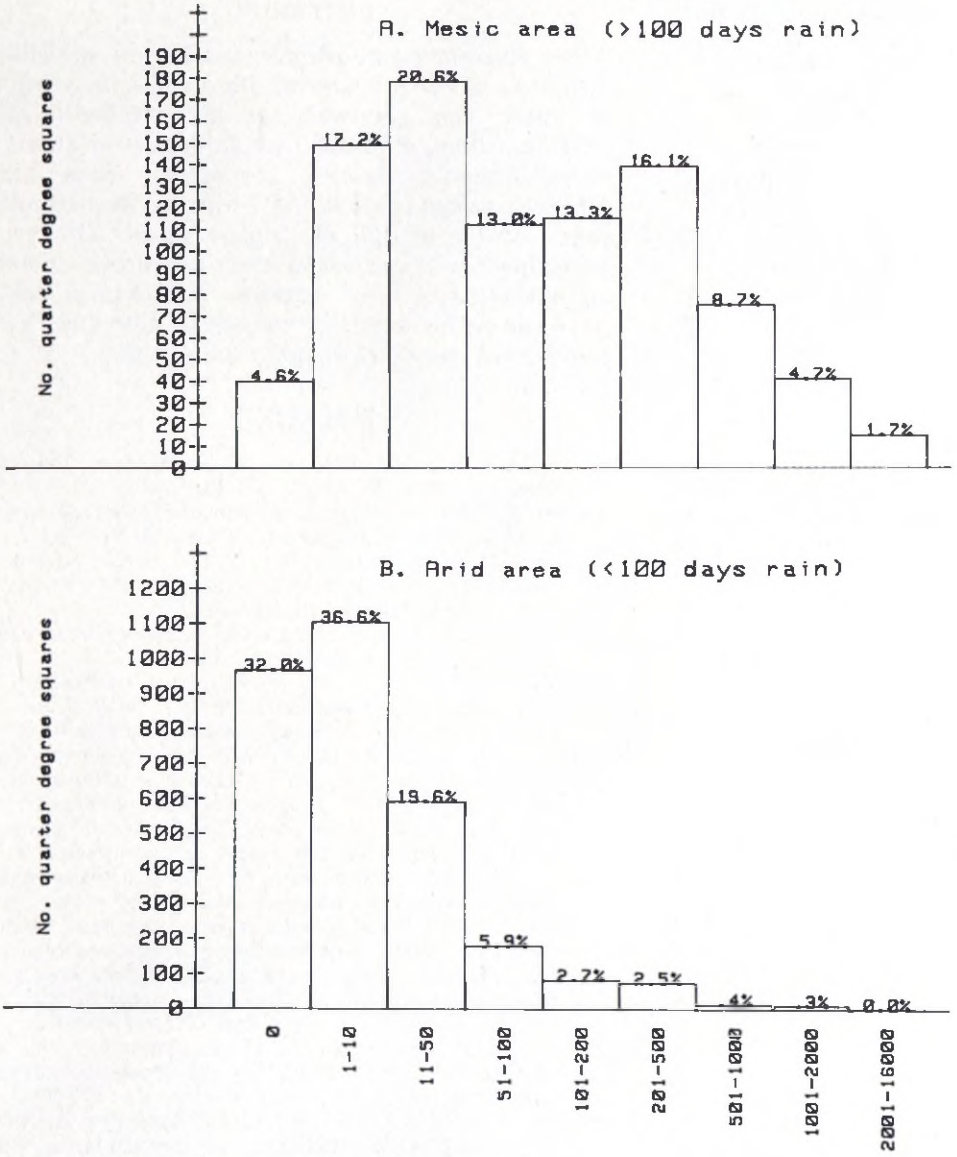


FIG. 6.—Percentages of collecting intensity size classes for the mesic region (more than 100 days with over 0,25 mm rainfall) and the arid region (less than 100 days with over 0,25 mm rainfall). A, mesic region; 44,5% of quarter degree squares have more than 100 specimens. B, arid region; 5,9% of quarter degree squares have more than 100 specimens.

traced in dry areas (for instance from the Reef to Kimberley and from the south-western Cape to the Orange River) and urban centres can be located in mesic areas (for instance Pretoria–Johannesburg and Cape Town) shows that accessible places have a higher collecting intensity than places difficult to reach. Van Dijk (1971) has shown similar effects in distribution maps for frog species.

2. Arid areas not only have lower rainfall, but the rainfall is also more unpredictable (Weather Bureau, 1965). The longer dry season and more frequent droughts in dry areas allow fewer occasions when plants are in a condition to make good Herbarium specimens, in comparison to wetter areas.

3. Differences in species diversity could also make the recorded differences in collecting intensity more apparent than they really are, in terms of true coverage of species present. Species diversities are reliably known for few localities, but if there is a higher species diversity in mesic than in arid areas, then a lower collecting intensity for arid areas, as shown by fewer specimens reported, may be partly a result of there being fewer species there available for collection.

The trip made to grid square 2728, to test the value of collecting in grids shown by PRECIS to have low numbers of specimens recorded, yielded the results shown in Table 2. In total, the trip added about eight times the original number of specimens and six times the original number of species to the Herbarium for the degree grid square. This large increase shows that excellent use can be made of PRECIS to indicate areas in which field work would be especially profitable.

TABLE 1.—Comparison between numbers of quarter degree grid squares in areas with more than 100 days of rain and with less than 100 days of rain

	a. More than 100 days rain	b. Less than 100 days rain	% (a/b)
Number of quarter degree grid squares	864	3 019	28,6
Number of grids with more than 100 specimens	385	179	215

TABLE 2.—Specimens and species in PRE herbarium as a result of collecting trip to degree grid square 2728, previously shown by PRECIS to be under-collected

Specimens	
No. in PRECIS before trip	43
No. collected on trip	292
Total now in Herbarium	334
Species	
No. in PRECIS before trip	37
No. collected on trip	
Re-collections	18
Additional species	185
Total now in Herbarium	222

CONCLUSIONS

Records of specimens collected in quarter degree grid squares in the Flora area show that some areas are relatively well-collected, but that the greater part of the sub-continent is seriously under-collected. Future collecting trips should be planned in a co-ordinated way, using the information presented here, so that new locality records as well as additional specimens and taxa are added to the Herbarium. As a result, each species will be better represented, showing its morphological variation throughout its range.

Quarter degree squares shown to be well-collected can be a valuable source of information for future studies in nearby areas, because PRECIS can provide preliminary check-lists through the species-per-grid listings. PRECIS thus makes the link between previous collectors and Herbarium workers and the present field worker, so that new studies can begin on the basis of work done in the past.

ACKNOWLEDGEMENTS

Dr B. de Winter, the Director of the Botanical Research Institute, has supported PRECIS throughout the course of its development, and he has also given advice during the preparation of this paper. Dr O. A. Leistner provided helpful criticism of the manuscript. Mr S. Makgakga plotted the collecting intensities from the PRECIS printout, and Mrs W. Roux prepared the map for publication.

UITTREKSEL

Die intensiteit van plantversameling in suidelike Afrika word op 'n landkaart afgebeeld deur gebruik te maak van gegewens uit die gerekaniseerde inligtingsisteem, PRECIS, van die Nasionale Herbarium, Pretoria. Daar is gevind dat, binne die betrokke gebied, meer as 85% van die kwartgraadruite minder as 100 eksemplare bevat. Die versamelintensiteite van verskillende landstreke, biome en klimaatsones word vergelyk. Toekomstige veldwerk van die Nasionale Herbarium sal op gebiede wat uiters swak versamel is, toegespits word.

REFERENCES

ACOCKS, J. P. H., 1975. Veld types of South Africa. 2nd edn *Mem. bot. Surv. S. Afr.* 40: 1–128.

BRENAN, J. P. M., 1965. Map of the extent of floristic exploration in Africa south of the Sahara. *Webbia* 19: 911–914.

EDWARDS, D. & LEISTNER, O. A., 1971. A degree reference system for citing biological records in southern Africa. *Mitt. bot. StSamml., Munch.* 10: 501–509.

GIBBS RUSSELL, G. E., 1983. Book review of *Index Herbariorum* edn 7, ed. F. A. Stafleu. *Bothalia* 14: 322–323.

GIBBS RUSSELL, G. E. & GONSALVES, P., (in press). PRECIS – a curatorial and biogeographic system. In F. Bisby, *Symposium on databases in systematics*. London: Academic Press.

HEPPER, F. N., 1979. Second edition of the map showing the extent of floristic exploration in Africa south of the Sahara, published by AETFAT. In J. Kunkel, *Taxonomic aspects of African economic botany*, Proceedings of the IX Plenary Meeting of AETFAT, Las Palmas de Gran Canaria.

LEONARD, J., 1965. Carte du degre d'exploration floristique de l'Afrique au sud du Sahara. *Webbia* 19: 907–910.

LEONARD, J., 1979. Statistiques des progres accomplis en 24 ans dans la connaisance de la flore phanerogamique africaine et Malgache (1953 a 1976). In J. Kunkel, *Taxonomic aspects of African economic botany*, Proceedings of the IX Plenary Meeting of AETFAT, Las Palmas de Gran Canaria.

MAGILL, R. E., GIBBS RUSSELL, G. E., MORRIS, J. W. & GONSALVES, P., 1983. PRECIS — the Botanical Research Institute Herbarium data bank. *Bothalia* 14: 481–495.

MORRIS, J. W. & MANDERS, R., 1981. Information available within the PRECIS data bank of the National Herbarium, Pretoria. *Bothalia* 13: 473–485.

SCHEEPERS, J. C., 1983. The present status of vegetation conservation in South Africa. *Bothalia* 14: 991–995.

WEATHER BUREAU, 1957. *Climate of South Africa, part 4, rainfall maps*. Weather Bureau WB 22.

WEATHER BUREAU, 1965. *Climate of South Africa, part 8, general survey*. Weather Bureau WB 28.

WHITTAKER, R., 1972. Evolution and measurement of species diversity. *Taxon* 21: 213–251.