Acta Bot. Neerl. 37(2), June 1988, p. 187–192

Digital picture processing: a new method to analyse vegetation structure

H. ROEBERTSEN, G. W. HEIL* and R. BOBBINK

Department of Plant Ecology, University of Utrecht, Lange Nieuwstraat 106, 3512 PN Utrecht, The Netherlands

SUMMARY

In this paper a new method for analysis of vegetation structure with a digital picture processing technique is compared with two well-known methods: the point-frequency method and the harvest method. The investigation was carried out in heathland and chalk grassland. Data on vertical distribution measured by the digital picture processing technique were significantly correlated with the data of the point-frequency method and that of dry weight distribution (harvest method). It is concluded that digital picture processing has several advantages with respect to time investment and repetition, and is a good alternative to vegetation structure quantification.

Key-words: digital picture processing, vegetation structure.

INTRODUCTION

Vegetation ecologists are interested in quantifying vegetation structure (Werger *et al.* 1986). Fliervoet (1984) showed a direct relationship between different grassland structural types and nutrient and moisture availability in the soil. Furthermore, the structure of vegetation is important for plant/plant interactions, plant/atmosphere interactions and plant/animal interactions (Fliervoet 1984; Brown, 1984; Fliervoet & Werger 1984; Heil *et al.* 1987).

Vegetation structure has been defined in several ways (Barkman 1979). We consider vegetation structure as: 'The spatial arrangements of different morphological elements, including the temporal changes in these spatial arrangements' (cf. Barkman 1979). Different methods can be used to analyse vegetation structure (Mueller-Dombois & Ellenberg 1974), but most well-known methods compromise time investment and accuracy.

In this paper the results of a new method by digital picture processing (IPAS = interactive picture analysing system) are compared with results of the point-frequency method and those of the harvest method (Mueller-Dombois & Ellenberg 1974).

Until recently, IPAS has been used exclusively in land-evaluation techniques, i.e. remote sensing (Schanda 1976). The IPAS method, however, can be used on a larger scale, and has advantages over other structure analysis methods because of its relative simplicity of data-gathering and its extensive possibilities for data analysis. We used data from two different structured vegetation types in order to test the applicability of IPAS for the analysis of vegetation structure.

---

*Correspondence: G. W. Heil, Department of Plant Ecology, University of Utrecht, Lange Nieuwstraat 106, 3512 PN Utrecht, The Netherlands.

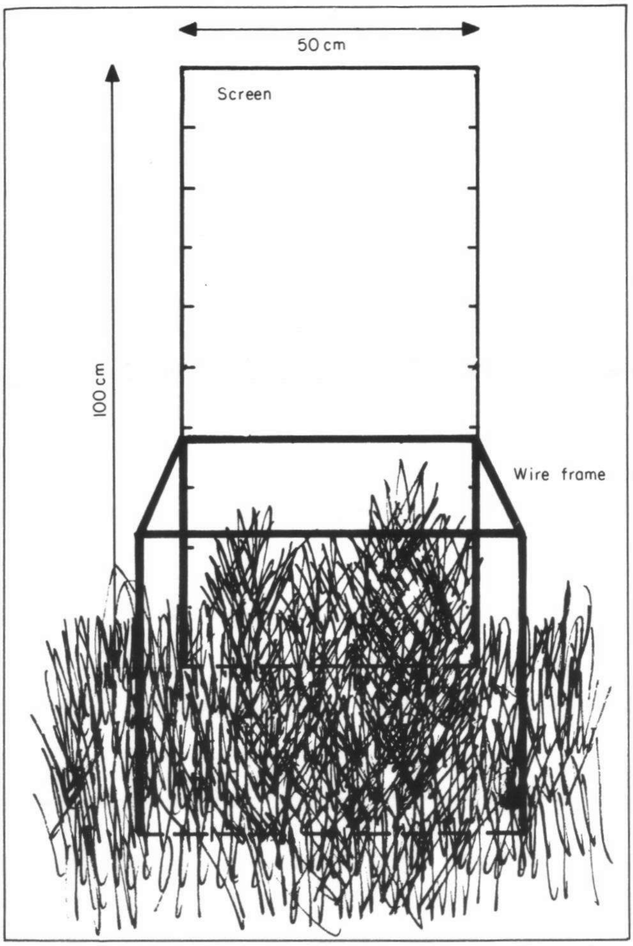

Fig. 1. Position of the wire frame and background screen in the vegetation.

METHODS

The study was carried out in two low vegetation types: heathland dominated by *Calluna vulgaris* (Uddelerbuurtveld, Veluwe) and species-rich chalk grassland (Wrakelberg, South Limburg). Samples of vegetation for the different methods used were collected once a month during the growing season, from May until September. Each sample was replicated five times.

First point-frequency data were collected, then colour slides were taken for IPAS, and finally the plots were harvested to determine the biomass. In addition, the biomass of the chalk grassland vegetation was cut into 10-cm height layers in the laboratory (for details see Fliervoet 1984). All data were collected separately for all plant parts (total), green plant parts (young), dead and senescent plant parts (old), and inflorescences (flowers).

Point-frequency method

The structure of the different vegetation types was analysed by the point-frequency method (Mueller-Dombois & Ellenberg 1974). A metal pin was placed horizontally in the

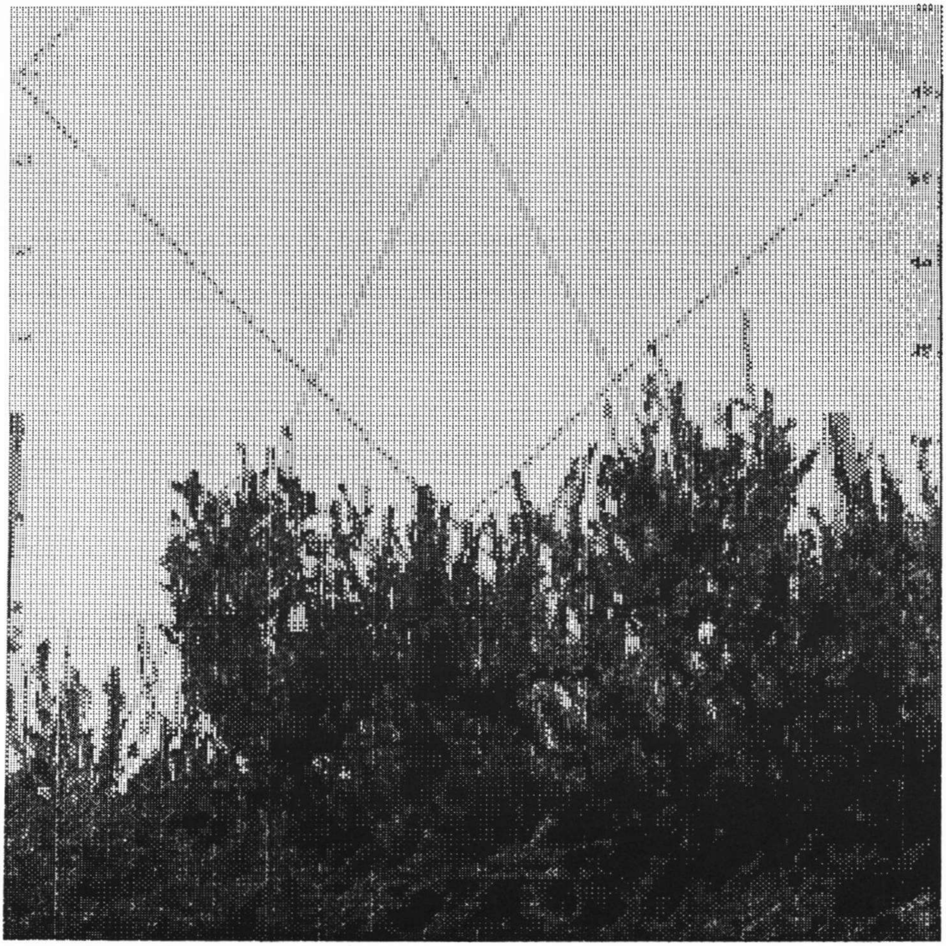

Fig. 2. An example of a digitalized picture of the *Calluna* vegetation.

vegetation, and the touches between the pin and the vegetation were counted. This procedure was repeated at different height levels: every 10 cm from the soil surface to the top of the vegetation.

Interactive picture analysing system (IPAS)

In order to take slides for IPAS, a wire frame of 15 × 50 cm was installed in the vegetation. The vegetation outside the frame was flattened, and a light grey screen (50 × 100 cm) was placed as a background (Fig. 1). Colour slides were taken of the vegetation inside the frame.

Image data could be taken from colour or black-and-white photographs, or from slides, and were transformed by means of a video-camera. In IPAS the data became a two-dimensional area of picture elements (pixels) and each pixel was characterized by a grey tone (300–700 nm) (Fig. 2). A selected area of the picture was measured on the basis of grey tone (pixel by pixel or combination of pixels). The data acquired were stored in a historical file, which is part of a data-storage and data-retrieval subsystem. The stored data could be used as many times as needed.

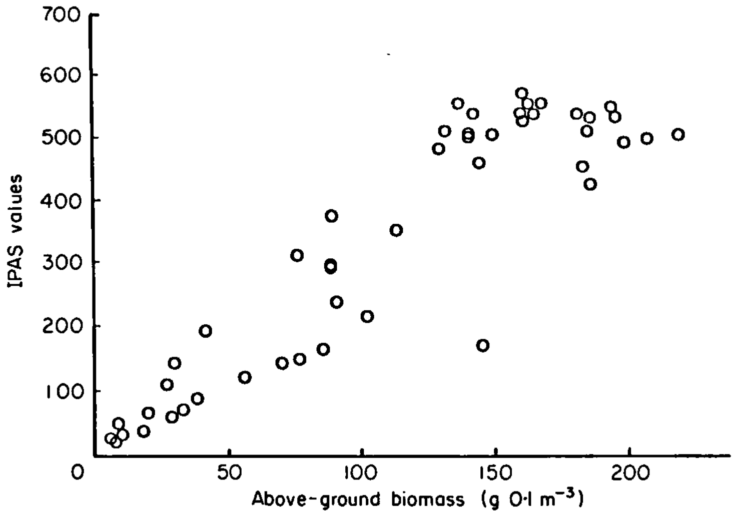

Fig. 3. Scatter diagram of dry weight of the chalk grassland vegetation per 10 cm layer (g × 0·1 m^3) and vegetation density (cm^2) measured with digital picture analysis (IPAS) of the same layer ($r = 0{\cdot}915$; $P < 0{\cdot}001$).

Table 1. Correlation matrix of different vegetation structure analysis methods: IPAS (interactive picture analysing system), Point-frequency (point-frequency method), and Biomass (harvest method)

	Sampling method	Total	Old	Young	Flowers
Calluna vulgaris heathland					
IPAS vs. Point-frequency	Stratified	+++	++	++	+++
IPAS vs. Point-frequency	Unstratified	+	++	–	*
IPAS vs. Biomass	Unstratified	++	+	–	*
Chalk grassland					
IPAS vs. Point-frequency	Stratified	+++	+++	+++	–
IPAS vs. Point-frequency	Unstratified	+++	+	++	–
IPAS vs. Biomass	Stratified	+++	*	*	*

+, Significant ($P < 0{\cdot}05$); ++, significant ($P < 0{\cdot}01$); +++, significant ($P < 0{\cdot}001$); –, not significant. *, no data collected.

We measured the pictures in two ways: stratified in height layers and as total (unstratified). The measurements were executed with a Zeiss computer system (Kontram, FRG).

Biomass

The vegetation inside the IPAS picture frame was harvested after the point-frequency data were collected and slides taken. The above-ground plant parts were separated into young and old plant parts and flowers, and dried for 48 h at 70°C before weighing. In addition the dry weight of the chalk grassland vegetation (above ground) was quantified in layers of 10 cm. Correlation between the data of the three methods were statistically determined using the BMDP2R program (Dixon *et al.* 1981).

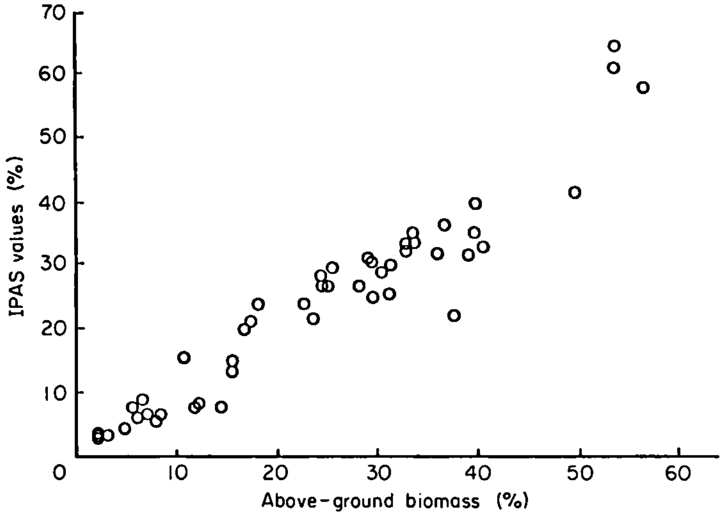

Fig. 4. Scatter diagram of dry weight of the chalk grassland vegetation as percentage of total dry weight per layer of 10 cm and relative vegetation density as percentage of total density measured with digital picture analysis ($r = 0{\cdot}958$; $P < 0{\cdot}001$).

RESULTS

Figure 3 shows a strong correlation ($r = 0{\cdot}915$, $P < 0{\cdot}001$) between the IPAS values per height layer and the biomass of the same layer of the grassland vegetation (Table 1). There was some saturation of IPAS values in the most dense layer; this always occurred in the lowest vegetation layer (0–10 cm). The IPAS and biomass expressed as percentages were better correlated, and showed no saturation ($r = 0{\cdot}958$, $P < 0{\cdot}001$) (Fig. 4).

Table 1 is a synopsis of all correlation tests between the different methods. For all plant parts of *C. vulgaris*, there was a significant correlation between IPAS values and those of the two other methods (Table 1). However, when the data were sampled unstratified, i.e. not in height layers of 10 cm, the IPAS values of young plant parts of *C. vulgaris* were not correlated with both methods. Differences in significance level between the correlation IPAS/point-frequency of the stratified data and the same correlation of the unstratified data are striking (Table 1). Similar results came from the grassland data. However, the data of the inflorescences (flowers) of the grassland vegetation were not significantly correlated between IPAS and the point-frequency method (Table 1).

DISCUSSION

The results show that the applicability of IPAS for analysis of the vegetation structure is good. Although data were collected from two distinctly different vegetation structure types, the results of IPAS were in good agreement with those of the point-frequency and the harvest method.

Either stratified or unstratified sampling may be conducted. Comparison of both sampling methods shows that the best results are obtained with stratified sampling. In general, the investigated vegetation has relatively few plant parts in the highest layers. This probably presents a complication for IPAS with unstratified data because of the relatively strong gradation between grey tones of the pixels in the highest and lowest layers. With stratified data this problem does not occur. The IPAS method can also be used for other short vegetation because of the similarity in structure of most of these vegetation types (Fliervoet 1984). Dependent on vegetation type, however, it will be necessary to calibrate IPAS values with structure parameters such as biomass and leaf area index. After calibration, only pictures are needed to quantify the vegetation structure, e.g. to measure changes in biomass or leaf area index during a growing season. The IPAS method is not suitable to quantify the structure per species in a species-rich vegetation.

We conclude that IPAS has several advantages to other methods with respect to time investment and measurement repetition, and it is a good alternative for quantifying vegetation structure, since the method is non-destructive and may be performed relatively quickly.

REFERENCES

Barkman, J.J. (1979): The investigation of vegetation texture and structure. In: M.J.A. Werger (ed.). *The Study of Vegetation:* 123–160. Junk, Den Haag.

Brown, (1984) Secondary succession: insects–plant relationships. *Bio Science* **34:** 710–716.

Dixon, W.J., Brown, M.B., Engelman, L., Frane, J.W., Hill, M.A., Jennrich, R.J. & Toporek, J.O. (1981): *BMDP Statistical Software.* University of California Press, Los Angeles.

Fliervoet, L.M. (1984): *Canopy Structure of Dutch Grasslands.* Ph.D. Thesis. University of Utrecht.

Fliervoet, L.M. & Werger, M.J.A. (1984): Canopy structure and microclimate of two wet grasslands communities. *New Phytol.* **96:** 115–130.

Heil, G.W., van Dam, D. & Heijne, B. (1987): Catch of atmospheric deposition in relation to vegetation structures of heathland. In: W.A.H. Asman and H.S.M.A. Diederen (eds). *Ammonia and Acidification.* Proceedings EARASAP Symposium 13–15 April 1987: 107–123. National Institute of Public Health and Environmental Hygiene, Bilthoven, The Netherlands.

Mueller-Dombois, D.T. & Ellenberg, H. (1974): *Aims and Methods of Vegetation Ecology.* John Wiley & Sons, New York.

Schanda, E. (1976): *Remote Sensing for Environmental Science.* Springer-Verlag, Berlin.

Werger, M.J.A., Dusink, E.M. & Fliervoet, L.M. (1986): Types of phytomass and leaf area index profiles in grassland vegetation. *Vegetatio* **65:** 39–45.