Vegetational Analysis of Big Run Bog, A Nonglaciated *Sphagnum* Bog in West Virginia

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ABSTRACT

The vegetation of a nonglaciated *Sphagnum* bog in West Virginia was sampled using quadrats, during the summer of 1977. Percent cover was estimated for each moss, herb, and shrub species. A minimum variance cluster analysis of the data distinguished four community types: *Sphagnum-Eriophorum virginicum, Sphagnum*-shrub, *Polytrichum*-shrub and *Polytrichum-Carex canescens.* The vegetation of each community and the spatial pattern of community distribution within the bog is discussed.

INTRODUCTION

The vegetation of *Sphagnum*-dominated bogs and peatlands in glaciated regions of North America, Europe, and Asia has been the object of considerable ecological study (see Vitt and Slack, 1975; Schwintzer, 1978; Damman, 1979). *Sphagnum* bogs also occur in nonglaciated regions of eastern North America. For example, within West Virginia, numerous *Sphagnum*-dominated areas are found at elevations ranging from 780 m to 1,040 m above sea level. Typically, these areas are small in size, ranging from 5 to 50 ha, and are located in frost pockets in the headwaters of small mountain streams. A few areas, however, are quite extensive and have been the subject of previous botanical investigation. These areas include Cranesville Swamp (225 ha) in Preston County (Robinette, 1964), Cranberry Glades (300 ha) in Pocahontas County (Darlington, 1943), and Canaan Valley (2,900 ha) in Randolph County (Fortney, 1975). Surprisingly, the numerous smaller sized bogs have been largely ignored. In this paper, we describe the composition and distribution of the vegetation in a small, relatively undisturbed, nonglaciated *Sphagnum* bog in West Virginia.

SITE DESCRIPTION

Big Run Bog (also known as Olson Bog and Kramer Swamp) is located in the headwaters of Big Run of the Blackwater River (39° 07′ N latitude and 79° 35′ W longitude) at an elevation of 980 m above sea level. The bog is 1.2 km long, reaches a maximum width of 180 m, and occupies 20-25 ha within a watershed of approximately 400 ha in the Monongahela National Forest. The up-

land portion of the watershed has been logged; present day vegetation is second growth mixed oak forest on southwest-facing slopes and beech-birch-maple forest on northeast-facing slopes. The bog itself may also have been logged for red spruce and hemlock (Clovis, pers. comm.) but the absence of cut stumps suggests that it occurred some time ago.

Precipitation at Big Run Bog is estimated from data recorded at Thomas, West Virginia, approximately 10 km northeast of the bog, at a comparable elevation of 935 m above sea level. Mean annual precipitation is 167 cm with a minimum monthly mean of 8.2 cm in October, and a maximum in July of 14.3 cm. At Parsons, West Virginia, 10 km to the southwest of Big Run Bog but at an elevation of only 510 m above sea level, mean annual temperature is 9.8 degrees C and the average length of the frost-free season is 159 days. Certainly the values for both these parameters are lower for Big Run Bog than for Parsons. Lower values at Big Run Bog result from its higher elevation and the bowl-like topography of its watershed, which creates a frost pocket from cold air drainage. For comparison, at Canaan Valley (elevation 990 m above sea level) the mean annual temperature is 8.4 degrees C and the average length of the frost-free season is only 103 days. The above climatological data were compiled from annual summaries for West Virginia obtainable through the U.S. Environmental Data Service (NOAA, U.S. Department of Commerce).

METHODS

Twenty-one line transects were randomly positioned across the bog in a northeast-southwest orientation (Figure 2). Vegetation was sampled from late June through early September, 1977, in a series of nested quadrats centered about contiguous 10 m sections of transect line. Live and dead trees (individuals $>$ 10 cm dbh) and live and dead saplings (individuals 2.5-10 cm dbh) were counted in 5 x 10 m quadrats. Seedlings (individuals $<$ 2.5 cm dbh) were divided into those individuals greater than 50 cm in height and those less than 50 cm in height and were counted in 2 x 10 m quadrats. Percent cover was estimated for upright shrubs in the 2 x 10 m quadrats, for low trailing shrubs and herbs in two 2 x 1 m quadrats randomly located within each 2 x 10 m quadrat, and for mosses in four 0.5 x 1 m quadrats, two of which were lo-

Figure 1. Aerial photograph of Big Run Bog. The area in the bottom portion of the photograph is less distorted than the area in the top because of the oblique angle at which the picture was taken. Stream flow is from bottom to top.

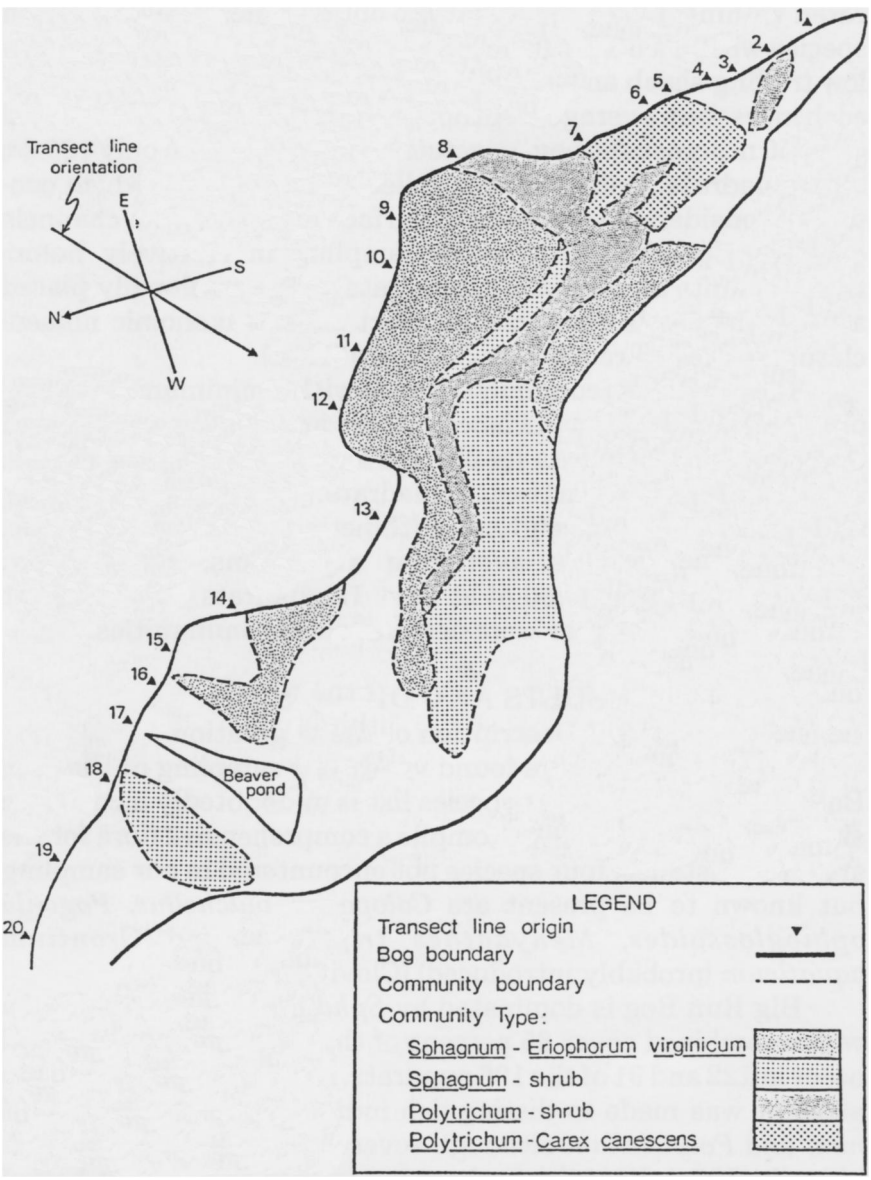

Figure 2. Schematic representation of community distribution in Big Run Bog. The large beaver pond is included; however, the main stream channel is not shown (see Figure 1).

cated within each 2 x 1 quadrat. To obtain a cover value for each species within a 2 x 10 m quadrat, the two cover values for each low trailing shrub and herb species and the four cover values for each moss were averaged. Although the transects covered a total of 1,550 m across the bog, vegetation was sampled in only 126 2 x 10 m quadrats. Data were not collected in quadrats which contained considerable amounts of surface water (stream channels or beaver ponds). Also, when sampling in relatively homogeneous units of vegetation, quadrats were occasionally placed at 20 m intervals along the transect lines. Taxonomic nomenclature follows Strausbaugh and Core (1970).

To distinguish community types with a minimum of subjective bias, a minimum variance cluster analysis was performed using percent cover data for upright shrubs, low trailing shrubs, herbs and mosses from the 126 quadrats. Four separate analyses were done, using unweighted arithmetic, weighted arithmetic, complete, and single averaging algorithms, respectively. Clusters which consisted of at least 10 quadrats which were at least 50 percent similar were designated as communities.

RESULTS AND DISCUSSION

General Description of the Vegetation

Thirty-six taxa were found within our sampling of Big Run Bog (Tables 1 and 2). Our species list is undoubtedly incomplete since our intent was not to compile a comprehensive flora for the area. For instance, four species not encountered in our sampling but known to be present are *Calopogon pulchellus, Pogonia ophioglossoides, Menyanthes trifoliata,* and *Orontium aquaticum* (probably introduced) (Clovis, pers. comm.)

Big Run Bog is dominated by *Sphagnum* and *Polytrichum* which combined cover 85 percent of the surface of the bog, and occur in 122 and 91 of the 126 quadrats, respectively (Table 1). No attempt was made to distinguish individual species of *Sphagnum* and *Polytrichum* although several species may be present (Aurelio, 1974). Vascular herbaceous species cover about half of the surface of the bog; *Eriophorum virginicum,* other sedges and rushes, and *Solidago uliginosa* are the leading dominants. One grass species could not be identified because it was never found flowering or fruiting. Two herbaceous species have limited distributions; *Leersia oryzoides* is found in floodplain areas

along stream channels, and *Polygonum sagittatum* grows primarily on old beaver dams. Of the two insectivorous species encountered, *Sarracenia purpurea* is introduced, while *Drosera rotundifolia* is part of the native flora.

Rubus hispidus is the most frequently encountered vascular species and covers over 30 percent of the surface of the bog (Table 1). Upright shrubs are of relatively minor importance. *Ilex verticellata* and *Pyrus arbutifolia* are typical wetland species and are distributed throughout most of the bog. *Hypericum densiflorum* is also typical of wetland sites but in Big Run Bog it is restricted in its distribution. All other shrub species are more characteristic of upland sites and are found most frequently near the edge of the bog. Several species of blueberry (*Vaccinium*) are present, however, they were not identified to species.

Six tree species are found but they are represented by few individuals (Table 2). Dead trees and saplings are more numerous than live ones. Although tree invasion is occurring, many individuals have died from local rises in the water table level from beaver activity (cf. Schwintzer, 1978). This is evident in Figure 1 where several dead trees are clearly visible around the large beaver pond near the upper end of the bog. A similar situation prevails around the small pond near the outflow end of the bog, although this is not as apparent in Figure 1. Changes in water table level can occur across an entire bog due to long-term natural weather cycles, or more locally due to beaver activity (Schwintzer and Williams, 1974).

Of the species present in Big Run Bog, *Nemopanthus mucronata, Gentiana linearis, Juncus effusus, Carex canescens,* and *Menyanthes trifoliata* have generally boreal distributions but are found at or near the southern limit of their natural ranges in *Sphagnum* bogs in West Virginia. Several other species, although not found in Big Run Bog, also have boreal distributions but are present at or near the southern limit of their natural ranges in bogs in West Virginia. These include *Larix laricina, Abies balsamea, Taxus canadensis, Cornus canadensis, Amelanchier bartramiana, Andromeda glaucophylla, Scirpus atrocintus, Juncus filiformis, Glyceria laxa,* and *Glyceria canadensis* (Rigg and Strausbaugh, 1949; Core, 1955; Strausbaugh and Core, 1970). Presumably, the numerous *Sphagnum* bogs present today contain relict populations of what was once a widespread boreal

Table 1. Species Composition, Dominance, and Distribution in Big Run Bog

			Community Type							
	Entire Bog		*Sphagnum-Eriophorum virginicum*		*Sphagnum*-shrub		*Polytrichum*-shrub		*Polytrichum-Carex canescens*	
Number of quadrats	126		33		27		18		4	
Percent of bog area			25-30		20-25		15-20		5-10	
	Mean % Cover*	Frequency**	Mean % Cover	Frequency	Mean % Cover	Frequency	Mean % Cover	Frequency	Mean % Cover	Frequency
Upright shrubs										
Ilex verticellata	3.7	82	1.5	26	5.3	21	3.3	7	1.6	1
Rhododendron maximum	1.9	58	2.1	20	4.1	16	0.4	5		
Pyrus arbutifolia	1.3	65	1.1	27	0.5	11	4.7	10		
Hypericum densiflorum	1.0	19	0.1	1			1.8	10		
Kalmia latifolia	0.6	36	0.3	13	2.1	10	0.3	2		
Vaccinium spp.	0.3	31	0.6	14	0.1	6	0.3	3		
Viburnum cassinoides	0.2	22	0.1	7	0.1	6	0.5	1		
Nemopanthus mucronata	0.1	17	0.3	9	0.1	6				
Amelanchier sp.	<0.1	5	<0.1	3			<0.1	1		
Total	9.1		6.1		12.3		11.3		1.6	
Low, trailing shrubs										
Rubus hispidus	31.2	119	29.4	33	17.4	26	47.0	17	2.5	1
Vaccinium macrocarpon	2.2	16	5.4	11	<0.1	1				
Gaultheria hispidula	0.1	14	0.4	9	<0.1	4				
Total	33.5		35.2		17.4		47.0		2.5	

Herbs										
Eriophorum virginicum	13.7	75	38.4	32	5.0	19	0.6	7		
Carex canescens	7.6	31	0.2	1	1.0	2	9.8	10	75.6	4
Carex folliculata	4.5	56	1.4	14	1.7	10	3.5	8		
Solidago uliginosa	4.0	66	9.2	30	2.9	15	1.4	7		
Juncus brevicaudatus	3.4	74	4.4	21	4.3	21	0.5	5		
Leersia oryzoides	3.0	20	1.1	1	0.2	3	0.9	3	0.3	1
Scirpus cyperinus	2.8	22	<0.1	1	2.4	8	0.1	1		
Sparganium chlorocarpum	2.7	22	0.5	3	5.7	12				
Polygonum sagittatum	2.7	23	<0.1	1	4.2	10	1.0	1		
Gramineae	2.0	20			6.7	13	0.1	1		
Juncus effusus	1.1	25	0.2	1	1.7	7	1.8	8		
Osmunda cinnamomea	0.5	12	0.6	4	1.5	4	0.1	2		
Sarracenia purpurea	0.2	4	0.1	2						
Gentiana linearis	0.2	14			0.1	2	0.7	6	0.1	1
Dennstaedtia punctilobula	0.1	6			0.1	1	0.1	4		
Drosera rotundifolia	0.1	9	0.2	4	0.1	1				
Total	48.6		56.3		37.6		20.6		76.0	
Mosses										
Sphagnum spp.	58.7	122	93.8	33	64.1	27	25.2	17	33.4	4
Polytrichum spp.	26.6	91	5.5	18	23.7	21	76.6	18	71.0	4
Total	85.3		99.3		87.8		101.8		104.4	

*For each species, mean % cover = $\frac{\Sigma \text{ \% cover for each quadrat in the entire bog or in a particular community}}{\text{number of quadrats in the entire bog or in a particular community}}$

**Frequency = number of quadrats in which a species was found within the entire bog or within a particular community

Table 2. Tree, Sapling, and Seedling Occurrence in Big Run Bog. Data Are the Total Number of Individuals Encountered in 126 Quadrats

	Trees (>10 cm dbh)		*Saplings (2.5-10 cm dbh)*		*Seedlings (<2.5 cm dbh)*	
	Live	*Dead*	*Live*	*Dead*	*>50 cm tall*	*<50 cm tall*
Picea rubens	13	42	26	44	21	77
Betula lenta	2	6	9	27	16	42*
Acer rubrum	1	1			6	26
Tsuga canadensis	2		2	2	7	6
Hamamelis virginiana					1	2
Pyrus americana					3	4

*26 of the 42 birch seedlings were sprouts from one single stump.

Flora in West Virginia. These populations are able to persist in high elevation, cold, moist environments. The origin of this flora is roughly coincident with the most recent North American glaciation, the southernmost extent of which was in central Pennsylvania. Radiocarbon dating of peat cores taken from Cranberry Glades (Arnold and Libby, 1951) and from Buckle's Bog in Garrett County, Maryland (Maxwell and Davis, 1972) indicate that peat accumulation began 10,000 to 12,500 year ago.

Vegetational Communities of Big Run Bog

In our study of Big Run Bog, three major communities were identified by cluster analysis using unweighted arithmetic averaging. A fourth community, although characterized by only four quadrats, was also identified and is discussed because of its unique vegetation and characteristic pattern of distribution (Figures 1 and 2). Mean percent cover and frequency of occurrence by species within each of the four communities is given in Table 1. Similar results were obtained using weighted arithmetic and complete averaging, whereas single averaging was ineffective in distinguishing community types.

Sphagnum-Eriophorum virginicum community

This community is found mainly in the central region of the bog and comprises 25 to 30 percent of the total area of the bog (Figures 1 and 2). The major portion of the community extends

up to 70 m into the bog from the northeast edge. A smaller band runs along the southwest edge, extending up to 30 m into the bog.

Sphagnum forms a nearly complete cover over the entire community (Table 1), while *Polytrichum* is relatively minor and is found on a few hummocks scattered throughout the area. A relatively high herbaceous cover gives the community a meadow-like appearance. *Eriophorum virginicum* and *Solidago uliginosa* occur in more than 90 percent of the quadrats and have their highest cover values within the bog in this community. *Juncus brevicaudatus* is also well distributed, generally occurring in wetter areas.

Rubus hispidus is present throughout the community and covers about 30 percent of the area. Most of the *Vaccinium macrocarpon* in the bog occurs in this community. All species of tall shrubs are encountered, but in terms of percent cover they are of relatively minor importance. Both *Ilex verticellata* and *Pyrus arbutifolia* are well distributed. For all other shrub species, frequency of occurrence decreases with increasing distance from the bog edge, and very few individuals are found greater than 30 m into the bog. *Rhododendron maximum* and *Kalmia latifolia* are often found growing on old tree stumps or other locally raised areas.

Sphagnum-shrub community

This community lies in the central and upper regions of the bog and covers 20 to 25 percent of the total area (Figures 1 and 2). A major portion lies to the southwest of the main stream channel and a smaller section just above the large beaver pond.

Sphagnum dominance occurs throughout this community although not to the extent found in the *Sphagnum-E. virginicum* community (Table 1). Numerous *Polytrichum* hummocks are present. Total herbaceous cover is constant throughout the community, but considerably less than in the *Sphagnum-E. virginicum* community. There are, however, notable patterns in particular species distributions. *Juncus brevicaudatus* is again distributed throughout the community, but generally occurs in wetter areas. In the area above the large beaver pond, an unidentified grass (Gramineae), *Sparganium chlorocarpum, Polygonum sagittatum,* and *Scirpus cyperinus* are the major herbs, whereas else-

where in the community they are of minor importance. Conversely, above the beaver pond, *Eriophorum virginicum* and *Solidago uliginosa* are infrequently encountered but they are the major herbaceous species throughout the rest of the community. Nonetheless, both *E. virginicum* and *S. uliginosa* have considerably lower cover values here than in the *Sphagnum-E. virginicum* community.

Upright shrubs are prominent and have a relatively high cover value (12.3 percent). *Ilex verticellata, Rhododendron maximum* and *Kalmia latifolia* are the most important species. *Pyrus arbutifolia* is sparsely distributed throughout the community. Differences in shrub species distribution within this community are not nearly as pronounced as for herbaceous species, although *R. maximum* and *K. latifolia* are slightly more important above the beaver pond and *I. verticellata* is slightly more important elsewhere.

Polytrichum-shrub community

This community covers 15 to 20 percent of the area of the bog (Figures 1 and 2). The major portion lies in the central region of the bog, appearing as a narrow band, 5 to 15 m wide, in close proximity to the main stream channel, but rather abruptly widening to about 100 m in the vicinity of transect 8. A smaller portion of this community lies near the stream outflow from the bog.

Polytrichum is the dominant moss, with a cover value three times that of *Sphagnum* (Table 1). Numerous well developed *Polytrichum* hummocks rise as much as 40 cm above the hollows which are inhabited by *Sphagnum.* Although 13 of the 16 herbaceous species were found in this community, total herbaceous cover is very low and no particular species are considered as characteristic. *Carex folliculata* and *Juncus effusus* are occasionally encountered, and *Carex canescens* is important only near the stream outflow.

Rubus hispidus is found throughout the community and covers nearly 50 percent of the area. Upright shrub cover is a prominent feature of this community. *Ilex verticellata* is the dominant shrub species along the main stream channel. Except for the narrow band adjacent to the main stream channel, *Hy-*

pericum densiflorum is characteristic throughout. *Pyrus arbutifolia* is most important in the widest part of the community.

Polytrichum-Carex canescens community

This community occurs in the lower region of the bog and comprises only 5 to 10 percent of the total area of the bog (Figures 1 and 2). The ground is covered with mosses, predominantly *Polytrichum.* The vegetation of the community is unique in that the herbaceous cover consists of an almost pure stand of *Carex canescens* (Table 1). Only two other herbaceous species, one upright shrub species, and a small amount of *Rubus hispidus* were found. Although the *Polytrichum* does form hummocks, they are generally hidden by the dense cover of *C. canescens* so that the community has the general appearance of a sedge meadow.

Community Patterning in Big Run Bog

Of the 126 quadrats entered into the cluster analysis, only 82 (65 percent) are accounted for in the four community types identified. Moreover, community development appears to be better defined in the central region of the bog than near either the upper (inflow) or lower (outflow) regions. In the area between transects 7 and 13, inclusive, 83 percent of the 64 quadrats entered into the analysis fall into one of the four communities. In the remainder of the bog, only 29 out of 62 quadrats (47 percent) clustered into one of the four communities.

Alteration of the water table level has been implicated as causing marked changes in the composition of bog vegetation (Schwintzer 1978, 1979; Schwintzer and Williams 1974). We suggest that in the upper and lower regions of the bog, the failure of the vegetation to segregate into distinct communities is a result of the frequent alteration of the water table from intermittent beaver habitation. Although beaver do not inhabit the bog today, they were active as recently as 1974 (Clovis, per. comm.). Several dams are still present near the inflow end of the bog, and some are still functional. There are two small beaver ponds just below the field of view in Figure 1, and one large pond clearly visible in Figure 1. Beaver activity has been less extensive near the outflow end of the bog, although a few dams and one small pond are present. The areas below the beaver ponds are generally quite

wet. This is particularly true in the upper regions of the Bog where numerous stream channels, many of which originate through breaks in the beaver dams, transect the area. Thus, the periodic changes in the water regime may have negatively affected community development in these two regions. In contrast, the relative stability of the water regime in the central region of the bog may have allowed for the development of more well-defined communities. In this region the communities are relatively extensive and distinct; however, the spatial pattern of community distribution is complex.

The processes by which *Sphagnum* bogs in West Virginia have originated have not been fully elucidated (Darlington, 1943; Robinette, 1964), but most and possibly all have developed in association with small mountain streams and not lakes. Thus, a symmetrical marginal zonation of community types from the stream to the bog edge, analogous to the radial zonation characteristic of kettle-hole bogs, might be expected in the bogs in West Virginia. It is clear from Figures 1 and 2 that such a marginal zonation does not exist in Big Run Bog. Rather, the spatial pattern of community distribution is an irregular mosaic. This irregular pattern seems to be typical of *Sphagnum* bogs in West Virginia (Darlington, 1943; Robinette, 1964).

The factors affecting the pattern of community distribution in West Virginia bogs are still open to question. In kettle-hole bogs, community distribution has been shown to be related to cation concentration of surface water, pH of surface water, soil moisture (Vitt and Slack, 1975), and water table fluctuation (Buell, et al., 1968; Schwintzer, 1978). Considering the similarity in vegetational composition between kettle-hole bogs and West Virginia *Sphagnum* bogs, it may be that some of these same factors are operative in the two bog types. Further studies are planned to elucidate the relative influence of biogeochemical and microtopographic-hydrologic factors on vegetation and community distribution in Big Run Bog.

ACKNOWLEDGEMENTS

We thank Dr. Jesse Clovis for sharing with us his historical and botanical knowledge of Big Run Bog; Linda Rader for her help in species identification; and Lon Crow for his help with the

computer analyses. This work was supported, in part, by a West Virginia University Research Grant.

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