THE POTENTIAL FOR USING AERIAL PHOTOGRAPHS FOR CLASSIFYING THE SITE QUALITY OF PEATLANDS

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When this article was translated from Finnish to English it was considered that the information contained therein would be of considerable interest to forest managers in Canada, and especially in Ontario. Permission was therefore obtained from the author to make the English version available in the form of a Great Lakes Forest Research Centre Information Report. We wish, at this time, to thank the author, Mr. S. Kellomäki, for his cooperation.

L. A. Smithers, Director,
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ABSTRACT

This is a translation of a Finnish study designed to test the potential for using aerial photographs to differentiate between various peatland and mineral-soil site types, and to interpret their site quality and necessity for forest drainage and fertilization.

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THE POTENTIAL FOR USING AERIAL PHOTOGRAPHS FOR CLASSIFYING THE SITE QUALITY OF PEATLANDS

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1. THE THEORY OF AERIAL PHOTOINTERPRETATION OF PEATLANDS

Aerial photographs are one of the more important aids to forest management planning. For a long time, aerial photographs have been used in mapping forest lands and in classifying lands for taxation purposes. In forest improvement work aerial photographs are primarily used as maps when the appropriate maps are not available. In addition, where forest drainage has been proposed on state lands, aerial photographs are used for more detailed planning; in fact, 75% of the drainage systems are designed from aerial photographs (Lehtimäki 1968, personal communication).

1.1 *On the Fundamentals of Site-quality Classification of Forest Land*

The use made of structure and species composition of ground vegetation in assessing site quality of forest land is based on the premise that surface vegetation readily reflects the interaction of the various site characteristics (Kalela 1961). On mineral soils the surface vegetation indirectly reflects the nutrient status of the soil. In peatlands the surface vegetation similarly reveals its trophic level, since the peat has developed primarily from the remains of peatland vegetation (Heikurainen 1960).

The nutrient levels of mineral soils are difficult to interpret from aerial photographs since tree cover usually screens the lower vegetation. In these cases the tree species are used to indicate the quality of the site. However, site-quality classes based only on the dominant tree species are quite broad in our area [Finland] because the site amplitudes of our few main tree species (pine, spruce, birch) are broad. Therefore, classifications based on tree species are most useful in areas where there occur many tree species whose individual site requirements are very different. In addition, the tree species on a site can be changed through harvesting and reforesting, in which case the species can no longer be used to indicate site characteristics. Along with the lower vegetation and the stand composition, classification of mineral-soil sites from aerial photographs is also based on topography, elevation, stoniness, moisture, forest management, the general use made of the area, knowledge of the locality, etc.

On peatlands the surface vegetation attains a higher degree of importance in site classification than on mineral soils, since the tree cover is often sparse enough to allow visibility of the ground vegetation. The site requirements of the different tree species on peatland are also somewhat more specific than on mineral soil. For example, the presence of deciduous species on peatlands indicates a medium-to-high nutrient status (Heikurainen 1960). Other features, *e.g.*, tree size, are also useful in classifying the quality of peatlands from aerial photographs.

1.2 *The Requirements for Interpretive Elements*

Recognition of a feature and estimation of its significance are based on several details perceptible on aerial photographs. These are called photo-interpretation elements and include such things as shape, tone, size, character, sharpness, composition and patterning, site or location, and overall appearance of the object (Kuusela 1959).

In the interpretation of peatlands, the requirements for patterning and character of the interpretive units (by patterning and character we mean as interpreted from aerial photographs) have been set by Radforth (1963) as follows: (1) The character or patterning that is to be used as the interpretive element must represent a physical feature of the site that can be readily perceived in nature. (By the physical feature we mean, for example, a specific vegetation association, rimpi[1], or other such unit.) (2) The character or patterning that is used for the interpretive element must be a recurring feature. If not, then the physical feature of the soil that it represents is or can be unique, and for this reason is useless in the general classification of the soil. Occasional uses of patterning and character are, however, important as photointerpretation aids.

A simple recognition of ground features is not sufficient, however, since the character and patterning of the interpretive element must be classed according to the essential purpose of the study. From this we arrive at our third principal requirement: (3) The patterning or character used as an interpretive element and representing a physical feature of the soil must be classified according to the essential requirements of the study so as to contain useful information.

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[1] Translators' note: "Rimpi ... indicates an exposed mire surface with no or rather scanty moss vegetation (*Scorpidium scorpioides* is practically the only species possible here), covered for the greatest part of the growing season by stagnant subsoil water" (Huikari 1952).

The ground features used in the classification and the patterning and character that they represent must be recognized and specified before one embarks on the study of aerial photointerpretation of an area. From this we obtain a fourth requirement for peatland photointerpretation.
(4) The photointerpretation is initiated with a ground reconnaissance, during which time one studies and decides the components of patterning and character that are visible on the photograph. By extrapolation from the aerial photographs, the perceptible patterns and characters that are known from ground studies to be of secondary importance and that cannot be used in the general classification of the ground can be eliminated.

If the latter requirement is neglected and randomly selected elements are used, numerous elements will not correspond to distinctly different soil classes, and interpretation will therefore be ineffective.

1.3 *Useful Interpretive Elements in Peatland Interpretation*

The elements used for the interpretation will depend on the intended use for the classification. For example, completely different elements would be considered when interpreting for trafficability on peatlands than for nutrient status.

Interpretive elements useful in classifying peatland site quality are those that portray the surface vegetation and its variability reasonably well. Also, some features that are independent of the soil nutrient status are useful in interpreting nutrient status of peatlands.

The elements for classifying peatland site quality can be outlined as follows.

I Direct Interpretive Elements

1. *Tone*. In black and white aerial photographs the different colors in vegetation are portrayed as various shades of grey. Tonal differences indicate the variation in surface vegetation which, in turn, reflects differences in nutrient status. Differences in soil moisture content can also cause differences in tone; the wetter the peatland the darker it appears, even though the surface vegetation may remain unchanged (Kommitten ... 1955). Color photographs make interpretation easier and more precise, as the human eye is capable of distinguishing many more variations in color than in tones of grey.

2. *Surface patterning*. Many details of the soil can be grouped to form a specific patterning when placed against a certain background. Examples of this are "rimpi" conditions or delta formations. The patterning of the soil depicts, independently

of the nutrient status, the quality differences of the growing medium (Kuusela 1959). Patterning is generally used for the classification of trafficability of peatlands for Armed Forces purposes (Radforth 1958).

3. *Granularity of the ground surface.* Granularity refers to the regular, small-scale tonal differences in the ground surface. This is a result of the spottiness of peatland vegetation; *e.g.*, *Sphagnum* hummocks may appear granular on aerial photographs.

II Indirect Interpretive Elements

1. *Location.* The position of the object in relation to its surroundings is often an important factor, as many plant species and associations appear only on known soil types or in recognizable communities (Kuusela 1959).

2. *General appearance.* Most objects have a characteristic appearance on aerial photographs which can at times be difficult to identify positively (Kuusela 1959). Peatlands are generally distinguishable by their general appearance.

III Other Considerations for Site-quality Classification of Peatlands (other than interpretive elements)

1. *Tree species.* Different tree species generally give some indication of nutrient status. Pine-dominated peatlands are usually poorer than spruce-dominated peatlands. Vigorously growing deciduous trees indicate that the growing medium of a peatland has a medium-high or high nutrient status (Heikurainen 1960). Separation into the principal sites is based on the recognition of different tree species and on estimates of their abundance.

2. *Knowledge of the components of the peatland complex.* A peatland complex consists of the peatland in its entirety within a locale made up of various site types and peatland vegetation communities. The specific vegetation communities (peatland types) can be recognized as individual units. However, little consideration should be given to individual features. A peatland complex is comprised of recognizable peatland types and their substitutes. For example, the central parts of raised bogs are generally very sparsely treed *Sphagnum fuscum* pine peatland or treeless *S. fuscum* peatland. On the edges of this are tall shrub pine peatlands and the bordering areas are usually comprised of either wet spruce (birch) peatlands or very wet treeless peatlands, both of which have a slightly-better-than-medium

nutrient status. Knowledge of the substitute types for the different components of peatland complexes will aid the interpreter (Küchler 1968).

1.4 *The Interpretation*

Interpretation of nutrient status of peatlands is conducted by proceeding to an individual object via a stepwise process of identification and elimination. The interpretation begins with differentiation of treed, shallow peat areas from treeless peatlands. Next, the main broad types are identified and, finally, attempts are made to distinguish among peatland types or the most closely related interpretive groups.

2. A CASE STUDY TO ASSESS THE POTENTIAL FOR USING AERIAL PHOTOGRAPHS FOR CLASSIFYING PEATLAND SITE QUALITY

2.1 *Study Area*

The author sought last summer to ascertain the potential for using aerial photographs in classifying site quality in peatlands. The study was conducted in the area of Suonenjoki. Used in the study were 1:22,000 black and white panchromatic and 1:10,000 infrared aerofilm aerial photographs.

The study area was comprised of two government forest inventory tracts (1.4 x 1.2 km). An east-west-oriented system of lines was superimposed onto the black and white photographs of the tracts. The line system consisted of 20 lines spaced 80 m apart. At 40-m intervals along each of these lines single relascope assessments were made. This produced a grid of point samples. In all, 1600 point samples were taken of which 1200 were usable. The interpretation was conducted by systematically visiting all sampling points. In addition to the author's interpretation, Unit Forester Jussi Akkanen did the interpretation on his own inventory tract. As a result of the sampling design the interpretations for the tracts are not completely parallel, as can be seen from the following tables (see p. 7 and 9).

2.2 *The Interpretive Elements Used*

The different tones used in characterizing site types on black and white photos were divided into four classes: not recognized (tree cover interfered with visibility of the ground), light, medium, and dark. In the interpretation of the infrared photographs, the following six colors were used: no recognition (tree cover interfered with visibility of the ground), grey, brown, green, yellow, and red. A two-number system, of which the first number represented the primary color and the second a secondary color or tinge of another color, was used to assess the color for each study plot.

Each sampling plot was assigned to one of the main type groups from aerial photographic interpretation, and these typings were later compared with those derived from ground information.

Field work entailed identifying the peatland type by ocular assessment for each sample location. In addition, the following stand information was obtained: tree species composition, basal area, mean height, mean volume, and stage of development. This information was obtained from the measurements taken in the study areas by graduate students Sipi Jaakkola and Simo Poso. They were assessing the value for forest management planning of sampling at different intensities with the aid of aerial photographs.

2.3 *Results*

2.3.1 *Differentiation of Peatland from Mineral Soil*[2]

Table 1 shows the percentage success in distinguishing peatland from mineral-soil sites using aerial photographs.

For more than 80% of the interpretations it was possible to differentiate peatland from mineral-soil sites. Better results were obtained when taking all sampling locations into account instead of just the sampling sites on peatlands; interpretation errors were made in calling some peatlands mineral-soil sites, but not vice versa.

Not all sampling points were interpreted since the tree cover hindered ground visibility. The interrelationships among tree species were most useful in interpretation. With an increase in spruce and deciduous trees interpretation became more difficult, and the most common errors were made in recognizing spruce (birch)- or birch (spruce)-dominated peatlands. However, these types were only small areas within other cover types, and this may account for difficulties in interpretation. Pine-dominated and open peatlands were readily separated from mineral-soil sites. The few errors that were made could not be explained by differences in the basal area, mean volume, mean height, or stage of tree development between the two types.

2.3.2 *Differentiation of the Main Type Groups*

In the development of a site-quality classification, peatlands are first divided on the basis of tree cover into three main type groups: spruce peatlands, pine peatlands, and open peatlands. This is very easy to accomplish in the field and difficulties did not arise in differentiating these three groups.

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[2] Translators' note: Kellomäki translates "kangas" as "mineral soil", but more explicit definitions are: i) firm forest land with cover of raw humus; ii) healthy woodland [Metsäsanakirja (Forest Dictionary), 1944. Otava, Helsinki].

Table 1. Differentiating between peatland and wooded heath on mineral-soil sites

Area	Film	Sample plots		Interpreted		Identification success (%)	
x)	xx)					of total number of sample plots	of total number of peatland sample plots
1	1	Total	Peatland	Correctly	Incorrectly		
1	1	800	201	666	134	83.3	53.2
1	2	800	201	659	141	82.4	39.8
2	1	400	121	337	63	84.3	52.9
2	2	400	121	326	74	81.5	57.0

x) Inventory tract.

xx) Photographic material: 1 = black and white, 2 = infrared aerofilm.

Recognition of main type groups from aerial photographs is based on identification of tree species and on estimates of their relative abundance. Table 2 shows the success with which the main type groups were identified.

The open peatlands were always distinguishable from the spruce and pine peatlands. Pine peatlands were usually recognized correctly. Pine peatlands incorrectly interpreted as spruce peatlands were primarily those having both spruce and pine. A few of the pine peatland sampling sites were interpreted as open peatlands; these areas had been clearfelled or were young plantations, neither condition being recognizable from aerial photographs. In compartment 1, the spruce peatland type group was interpreted incorrectly with both types of photography. The spruce peatlands that were interpreted as pine peatlands are primarily *Vaccinium myrtillus* or *V. vitis-idaea* spruce peatlands on which pine is a naturally occurring species (Heikurainen 1960). Surprisingly, the interpreter overemphasized pine dominance and therefore made incorrect assessments.

2.3.3 *The Photo-sensitivity of Aerial Photographs to Peatland Surface Vegetation*

A study of the photographs revealed that vegetation in spruce peatlands was darker than in pine peatlands, and lightest on very wet, treeless peatlands. There were no noticeable differences in vegetation color on the different spruce peatland types, which were more or less similar in tone [shade]. The vegetation of the sedge-rich pine peatlands and the very wet, treeless peatlands was lighter than the shrub-dominated pine and wet treeless peatlands. Vegetation characterized by *Sphagnum fuscum* communities was as dark as or darker than the areas that were shrub dominated. Areas of low sedge dominance were as light as or lighter than areas of tall sedge dominance.

According to the Swedish explanations, the *Carex-* and herb-rich types of sedge peatlands are definitely lighter on photographs than the vegetation of shrubby peatlands. The distinctly delineated, darker, shrubby center in raised bogs is readily recognized; the sedge-rich borders are lighter (Kommitten ... 1955).

On infrared photographs, the brown or brownish-colored peatlands were primarily shrub dominated; green or greenish ones were sedge peatlands or peatlands that have a significant herb component in the surface vegetation. Yellowish-green or yellowish-brown represents primarily sedgy or low shrub peatland types, on which the peat moss areas can definitely be separated from the other surface vegetation.

2.4 *Using Aerial Photographs in Classifying Site Quality in Peatlands*

Separation of the different peatland types that have similar surface vegetation cannot be made using aerial photographs when these

Table 2. Success in identifying main type groups

Area	Film	Number interpreted: Total	Number interpreted: Correctly	Identification success (%)	Numbers in main type groups studied: Spruce swamp[1]	Numbers in main type groups studied: Pine swamp[1]	Numbers in main type groups studied: Open peat-land	Identification success (%): Spruce swamp[1]	Identification success (%): Pine swamp[1]	Identification success (%): Open peat-land
1	1	92	77	83.7	18	72	2	33.3	95.8	100.0
1	2	74	67	90.5	7	65	2	28.5	96.9	100.0
2	1	55	51	92.7	6	45	4	100.0	93.3	100.0
2	2	54	50	92.6	7	43	4	100.0	88.3	100.0

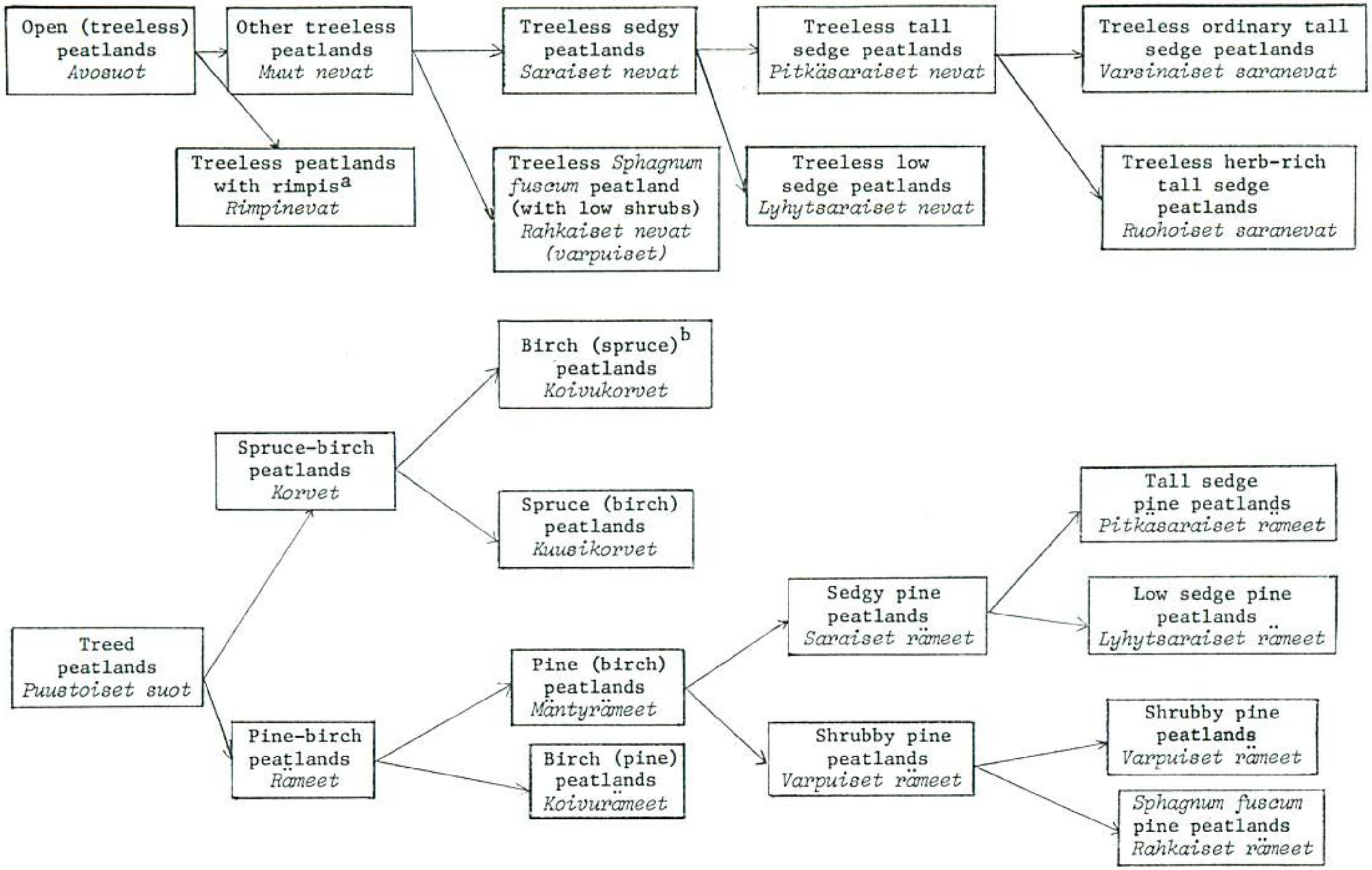
[1] Translators' note: These are the original author's translations. In North America swamps are usually regarded as wooded, minerotrophic types, *i.e.*, wooded fens (Heinselman 1963); hence, it would be preferable to substitute the term "peatland" for "swamp" in the above table.

types together form part of a larger entity. Since the different spruce-dominated types could not be distinguished on the basis of their surface vegetation, related differences in nutrient status could not be distinguished from the photographs. The surface vegetation on pine peatlands and treeless peatlands could be divided into three groups on the basis of differences in tone [and color]: light (yellowish), which depicts very poor low sedge (small sedge) peatland types; medium-dark (greenish tinged), which depicts the sedgy or herb-rich, relatively nutrient-rich peatlands; dark (brownish tinged), which depicts the poor, shrubby or peat-moss-dominated peatland types. If, in addition to noting the various groupings of the surface vegetation, the shade tolerance and nutrient requirements of the tree species are considered, then the stand criteria (such as density and mean height) and, independent of the nutrient status, the site-quality differences in peatlands that indicate various ground surface conditions (rimpi conditions, *Sphagnum* hummocks), can be shown as in Figure 1.

The potential for using the scheme shown in Figure 1 for classifying the site quality of peatlands has not been investigated. According to the author the peatland entities (interpretive groups) as depicted in the scheme can be differentiated with relative ease.

Unlike Mäkelä and Ranta (1961), the author found that open peatlands could not be subdivided into the nutrient-related types of herb-rich and ordinary treeless peatlands. In considering the following groupings, this shortcoming is not important. These groups are given below as in Figure 1, along with classes of forest-drainage quality for climatic region I [of Finland].

	Interpretive Group	Forest-drainage Quality Class
1.	>>Rimpi>> treeless peatlands *(Rimpinevat)*	1
2.	*Sphagnum fuscum* treeless peatlands *(Rahkanevat)*	1
3.	Low sedge treeless peatlands *(Lyhytsaraiset nevat)*	2
4.	Tall sedge treeless peatlands *(Pitkäsaraiset nevat)*	5-7
5.	Birch (spruce) peatlands *(Koivukorvet)*	7-10
6.	Spruce (birch) peatlands *(Kuusikorvet)*	5-8
7.	Birch (pine) peatlands *(Koivurämeet)*	5-7
8.	Tall sedge pine peatlands *(Pitkäsaraiset rämeet)*	5-7
9.	Low sedge pine peatlands *(Lyhytsaraiset rämeet)*	3-5
10.	Shrubby pine peatlands *(Varpuiset rämeet)*	3-5
11.	*Sphagnum fuscum* pine peatlands *(Rahkaiset rämeet)*	1-2



[a] Translators' note: "Rimpi ... indicates an exposed mire surface with no or rather scanty moss vegetation (*Scorpidium scorpioides* is practically the only species possible here), covered for the greatest part of the growing season by stagnant subsoil water" (Huikari 1952).

[b] Translators' note: A species in parentheses is secondary in importance to the main dominant.

Figure 1. A flow chart for identifying site quality in peatlands (Mäkelä and Ranta 1961, and Kellomäki 1969).

The forest-drainage quality classes of the interpretive groups fall into three groups. The interpretive groups can be used successfully in planning for peatland drainage. For example, those peatlands that are worth draining can be differentiated, at least under southern Finland's conditions, from those that are not worth draining[3]. In addition, the interpretive groups are useful in planning for fertilization.

The use made of aerial photographs in our program of forest land amelioration is not very extensive since the peatland areas are quite accessible, the property boundaries are not easily recognized, and the ameliorative treatment generally does not extend over several photographs. For these reasons, extensive use of aerial photographs has not been necessary, or in some cases even possible.

With the completion of primary drainage work in the near future an enormous task lies ahead in managing drained areas so that these can be made to produce wood satisfactorily. In planning for this, aerial photographs may prove to be essential.

3. SUMMARY

The paper discusses the qualitative requirements of the elements for interpretation of aerial photographs. Direct interpretation elements include tone, ground patterns and granularity of the soil surface, to the extent that these can be detected on the aerial photographs. Location and general appearance of the area are indirect elements of interpretation. The tree species composition and the structure of peatland continuum types do not fall into the "element" category, although they may be of help in interpretation work.

Interpreting the nutritional class of the peatland is done by elimination, starting with broad categories and ending with specific ones. Interpretation begins with differentiating between mineral-soil and peatland sites. The main type groups are then identified, and finally an attempt is made to distinguish the individual peatland types.

The second part of the paper describes an experiment in which peatland was distinguished from mineral-soil sites in 80% of the cases. Table 2 shows the success with which the main type groups were interpreted. For identifying the individual types the author recommends the use of the interpretive type groups. The forest-drainage bonities of the interpretive type groups fall into three classes which are adequate for practical forest-drainage work, *e.g.*, in distinguishing peatlands worthy and unworthy of draining, and in identifying fertilizing needs.

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[3] Translators' note: Kellomäki does not suggest which quality classes are worth draining, but we assume they must be the higher ones, possibly 5 and above.

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