Introduction

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A preliminary ordination study of forest vegetation in the Kirchleerau area of the Swiss Midland

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I. Introduction

At a meeting in 1959 of the working group on forest typology of the International Union of Forest Research Organizations (IUFRO), it was decided to make a comparative study using several different forest vegetation

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research and mapping methods. An area in Switzerland was then studied in the early 1960's using four methods, and the results were published as "Vegetations- und bodenkundliche Methoden der forstlichen Standortskartierung (Ecological and pedological methods of forest site mapping)", Veröff.Geobot. Inst.ETH, Stiftung Rübel, Vol. *39* (1967), H. Ellenberg, editor.

The four methods may be briefly described as follows (see references for titles of the individual papers):

1. The method of the Braun-Blanquet school as an example of a phytosociological method which considers combinations of species and leads to the naming and mapping of plant associations. This paper and the accompanying map will be cited as Frehner (1967).
2. The method of Aichinger which stresses the dynamics of plant associations and leads to the mapping of forest development types. Prof. Aichinger emphasized that he would have mapped this area by the Braun-Blanquet method if he had not been asked to apply his own method. The paper and map are cited as Aichinger (1967).
3. The combined method in which site and vegetational factors are equally considered, based on methods developed for forest site-mapping in the DDR. The paper is cited as Eberhardt et al. (1967) and accompanying maps are cited as Eberhardt.
4. The plant geographical method of Schmid in which regional and local phytocoenoses of the mapped area are related to the vegetation zones of Switzerland. The paper and map are cited as Saxer (1967).

The area studied was selected for its ecological diversity as will be described in more detail in the next section. Briefly, however, there are numerous combinations of exposures, soil parent materials and soil types. In addition, the area has a long history of forest management by man. Cutting and thinning of trees and saplings and planting of trees, primarily conifers exotic to the area, greatly enhance the complexity. Several areas within the forest were formerly used for agricultural purposes and have since been reforested which further modifies the sites. In short, the combinations of sites plus vegetation types approach the maximum possible diversity.

A. Purpose of study

The author of this paper was invited to study the area using methods of the so-called "Wisconsin school" which are summarized in a book (1959) by the late Prof. J. T. Curtis. The methods used in studying the forests of Wisconsin were developed for use in relatively large, homogeneous, natural forests (the antithesis of the Kirchleerau forests), and are not really applicable for mapping purposes. Actually, there is no "Wisconsin method". It is more a philosophy based on the individualistic interpretation of species behavior (GLEASON, 1926, 1939; RAMENSKY 1926, 1930) and the continuum concept of vegetation (McINTOSH, 1967).

It considers that there are no "typical examples", and that vegetation should be studied objectively, quantitatively, and comparatively for a relatively large number of stands within one community type or several closely related communities.

The purpose of my study then may be posed as a question: can a person having no previous knowledge of European ecological conditions (*i.e.*, not knowing which soil and geological conditions are important, not knowing the species, and not having any pre-knowledge of which understory species are associated with which trees and which environmental conditions) use quantitative methods and gain any understanding concerning Swiss forest vegetation in areas long and heavily modified by man?

Within this framework, the vegetation was sampled in May and June, 1968, using my modifications of "Wisconsin" field methods. Since FREHNER (1963) studied the vegetation in this region of the Midland in more detail than the other workers, his results may be more authoritative. I therefore placed my 25 study areas or stands in the associations as mapped by FREHNER (1967). Trees and understory species were studied quantitatively, an ordination of stands was made, and the results of my study were compared with the results of the other four methods.

In order to make these comparisons, the stands which I studied were located on the maps of the other workers and were assigned to the vegetation types as they had mapped them. It was sometimes necessary to group their stands in various ways using my interpretation of their data in order to determine what trends were represented. It is possible that errors have been made through misinterpretation of their data or through slight errors in the boundaries of vegetation types as drawn on their maps. I regret any errors, if such occur.

B. The study area

The following description of the area which was studied by the four methods plus mine is summarized in part from EBERHARDT et al. (1967). The study area is located in the Swiss Midland in Canton Aargau, approximately 35 km northwest of Luzern and 10 to 15 km south of Aarau on the east side of the Suhr Valley.

The forests are located on the western slopes of a ridge or plateau, the long axis of which runs in a north-northwest by south-southeast direction. The top of this ridge is mostly cultivated land. The drainage pattern toward the Suhr has dissected the western side of this ridge into many hilly areas. The forests consequently are on slopes which face north, west, and south, but seldom have an eastern exposure.

The village of Schöftland is at the northern end, Moosleerau is toward the southern end, and Kirchleerau is just south of the central part. The forests of the research area are owned by the above-mentioned communities, and extend about 5 km from north to south. The total forest area mapped by the various methods is approximately 415 to 420 hectares (*c.* 1030 acres).

Since the time available for field reconnaissance was limited, and also to minimize geographical differences, 23 of the 25 stands were placed in the southern half of the area in the Kirchleerau-Moosleerau vicinity. Stands 22 and 23 in the *Aceri-Fraxinetum* were at the northern end near Schöftland.

Elevations of forests in the total mapped area range from 460 to 713 meters above sea level. The macroclimate, averaged from a number of stations surrounding the research area, may be considered as relatively moist (1200 mm average annual precipitation) and relatively mild (8–9 °C. average annual temperature).

It would have been desirable to select my stands for study to include a variety of slopes and aspects, elevations, moisture conditions, etc. However, since I was unfamiliar with the area, several days were spent in exploring the area and selecting from FREHNER's mapped associations stands which were relatively as undisturbed as possible (*i.e.*, had not had recent cutting and planting), and that were large and homogeneous enough to be studied by my field methods. At that time plants were collected, and were identified with the help of Prof. E. LANDOLT and Mr. A. GIGON.

For analysis of stands by the ordination technique, it is desirable to have a minimum of perhaps 20 stands. Ultimately, 25 stands were studied belonging to seven different associations according to FREHNER. No stands were studied in FREHNER's association nine, *Carici remotae-Fraxinetum chrysosplenietosum* (he mapped only one tiny example of this association) or association four, *Querco-Abietetum* prov. (the areas mapped as such have received several diverse forestry treatments and from my standpoint were too small and heterogeneous). The listing of my 25 stands according to FREHNER's associations is shown in Table 1. As seen in Table 1, some of the associations have several subassociations, and the seven associations may be placed in three larger groups.

Table 1, Footnote 1.—Description of geological layers (soil parent material) from MÜHLBERG (1908) and SAXER (1967, p. 156). Numbers 1 to 6 indicate the relative geological age from oldest to youngest. The elevations listed are those for my stands in the various layers.

6. Würm moraine. 510–590 meters. Kalk-containing. Most of the "mixed deciduous forest" species of this region are on Würm moraine.
5. Riss gravel. 510 meters. "Kalk-reich" (rich in $CaCO_3$), often penetrated by sand and clay layers. At the boundary of the gravel on top of molasse, water seeps out in places which can lead to the formation of an *Aceri-Fraxinetum.*
4. Upper sweetwater molasse. 700 meters. Sandstone with marl and clay constituents which give a preference for *Abies.*
3. Upper marine molasse (Helvetien), Wienerstufe. 610–670 meters. Soft sandstone. A strong layer of "nagelfluh" (conglomerate), usually less than 1 m thick is in the lower part of this layer, normally at about 600 meters.
2. Upper marine molasse (Helvetien), musselsandstone. 540–610 meters. Somewhat softer sandstone. Water is conducted in the upper part of this layer just below a band of conglomerate, and trickles or seeps out in some places on the slope.
1. Lower marine molasse (Burdigalien) (upper marine molasse according to Saxer). 500 meters. Relatively hard sandstone makes possible steep slopes which make possible the entry of "Laubmischwald" (mixed deciduous forest) species into the beech forest.

Footnote 2.—Key to symbols for soil types and site factors from "Standortsformenkarte nach D. KOPP" by EBERHARDT.

Bodenformen – (soil types)

Mo Moosleerauer Schotter- und Moränen-Rendzina
Br Brönner – Lehm – Fahlerde
Gä Gänserain – Lehm – Fahlerde
Hi Hirschacker – Lehm – Braunerde
Rr Rossrücken – Lehm – Braunerde
Rö Rötler – Lehm – Braunerde
St Stolten – Lehm – Braunerde
Sö Schöftlander – Lehm – Hanggley

Kleinflächige Besonderheiten (small-surface peculiarities)

⇌ Kleinflächiger Wechsel von Bodenformen
V Kleinflächig nährstoffärmer

Reliefbedingte Wasserhaushaltsstufen (relief-caused moisture gradients)

1 Reliefbedingt frischer
2 Mittlere Stufe
3 Reliefbedingt trockener

Windausgesetzte und -geschützte Lagen (wind-exposed and -protected locations)

v Reliefbedingt windverhagert (relief-caused wind degradation)
| Reliefbedingt windgeschützt (relief-caused wind protection)
s Reliefbedingt warmbegünstigt (relief-caused warmth protection)

Hang- und Plateaulagen (slope and plateau locations)

p in Plateaulage

Weitere Besonderheiten (further peculiarities)

↓ Wuchsleistung ungewöhnlich gering (growth productivity especially small)

Table 1. Location and physical features of stands

Stand number	Forest communities (after Frehner, 1967): Group	Association	Sub-association	Location and elevation (Landeskarte, 1964): Location of stands Coordinates	Elevation in meters	Measured in field: Slope	Aspect	Estimated relative moisture	Geology and soils from maps: Soil parent material[1]	Soil types and site factors[2]
	A. Beech forests (Calcium-poor)									
1		Melico-Fagetum	asperuletosum	648550 - 235800	610	15°	NW	mesic	3	St 1
2		Melico-Fagetum	asperuletosum	648125 - 235400	640	5°	W	mesic	3	Rr 2
3		Melico-Fagetum	luzuletosum	647925 - 235500	620	5°	SW	dry	3	St 2p ⇌ Rr 2p
4		Melico-Fagetum	luzuletosum	648600 - 235850	620	20°	W	dry	3	St 2
5		Melico-Fagetum	cornetosum	648425 - 237050	600	25°	S	dry-mesic	2	Br 2s
6		Milio-Fagetum(prov.)	dryopteridosum	647900 - 235725	570	20°	NE	mesic	2	St 1
7		Milio-Fagetum(prov.)	dryopteridosum	648475 - 235450	670	15°	NW	mesic	3	Rr 2 ⇌ Hi 2
8		Milio-Fagetum(prov.)	dryopteridosum	648275 - 235425	640	25°	NW	dry-mesic	3	Rr 2
9		Milio-Fagetum(prov.)	luzuletosum	647925 - 235625	600	25°	N	dry	2	St 2v
10		Milio-Fagetum(prov.)	luzuletosum	648400 - 234875	610	20°	N	dry	2	St 1 ⇌ St 2
11		Melampyro-Fagetum	typicum	648075 - 235225	630	20°	NW	dry	3	St 3v ⇌ Rö 3v
12		Melampyro-Fagetum	typicum	648075 - 235175	630	15°	S	dry	3	St 3v ⇌ Rö 3v
13		Melampyro-Fagetum	typicum	648100 - 236250	540	25°	SW	dry	2	St 2v
14		Melampyro-Fagetum	leucobryetosum	647875 - 235075	570	25°	W	dry	2	St 3v ⇌ Rö 3v
15		Melampyro-Fagetum	leucobryetosum	647900 - 234625	600	15°	SW	dry	2	Br 3v
	B. Beech forests (Calcium-rich)									
16		Pulmonario-Fagetum(prov.)		648300 - 235175	640	20°	S	dry-mesic	3	Br 2s ⇌ Gä 2s
17		Pulmonario-Fagetum(prov.)		647450 - 234625	530	10°	W	dry-mesic	6	Mo 2 ⇌ Hi 2
18		Carici-Fagetum		648525 - 235350	700	25°	S	dry-mesic	4 → 6	Mo 3
19		Carici-Fagetum		648075 - 234350	590	10°	NE	dry-mesic	6	Mo 3
20		Carici-Fagetum		647675 - 234075	550	20°	W	dry-mesic	6	Mo 3
	C. Ash forests (Calcium-poor)									
21		Aceri-Fraxinetum		648275 - 235525	610	20°	NW	dry-mesic	3	Rö 1 | ✓
22		Aceri-Fraxinetum		646950 - 239025	510	15°	NE	moist	5 → 1	Rö 1 | ⇌ Sö
23		Aceri-Fraxinetum		646725 - 239200	500	20°	N	moist	1	Mo 2 ⇌ Sö
24		Pruno-Fraxinetum		648275 - 236550	580	5°	NW	dry-mesic	2	Rö 1 | ⇌ Hi 1
25		Pruno-Fraxinetum		647400 - 234500	510	10°	W	moist	6	Sö ⇌ Hi 1

Also shown in Table 1 are the locations of the stands and their approximate elevations as determined from maps. The precise location of my stands is not important for the purpose of this study, so no map of the forests is included. However, a map showing the location of the stands which were studied is on file at the Geobot. Institut in Zürich.

The degree and direction of slope were measured in the field. The moisture regime was estimated in the field, being reevaluated in the several visits to each stand. The listing in Table 1 is on no absolute scale, but is relative for the 25 stands studied. Note that there are five relative moisture classes: dry, *dry*-mesic, dry-*mesic*, mesic, and moist.

Underlying geology or soil parent material was determined from a map by Mühlberg (1908), and is correlated with a description of the various layers by Saxer (1967) in a footnote to Table 1. About 80% of the stands are on differing ages of Tertiary molasse deposits, primarily sandstone of various sorts. About 20% of the stands are on glacial deposits, mostly Würm moraine.

Soil types and site factors were determined from the site type map of Eberhardt. A key to the symbols is given in footnote 2 to Table 1. Since Eberhardt expresses many subtle differences, the descriptions are given in his German terms (with only the major categories also in English) to avoid mistranslations.

II. Field Methods

A. Selection of stands

As mentioned above, stands were selected from associations as mapped by Frehner (1967) with the ultimate aim of including several stands from each of his associations. The first criterion in choosing which stands to study was topographic homogeneity—approximately the same slope and aspect was required for the whole stand. The second criterion was "visual" vegetational homogeneity—approximately the same size classes and species were to be represented throughout the stand, *i.e.*, two halves of the stand could not have markedly different ages or composition. Stands which had had recent cutting were avoided, as were areas of pure conifers, in order to study vegetation as close to "natural" as possible. No two stands of the same association were placed adjacent to one another except for stands 11 and 12 which were located on opposite sides of a ridge.

The size of the stands had to be large enough to accommodate the plots used in sampling trees. The actual size of the stands sampled ranged from