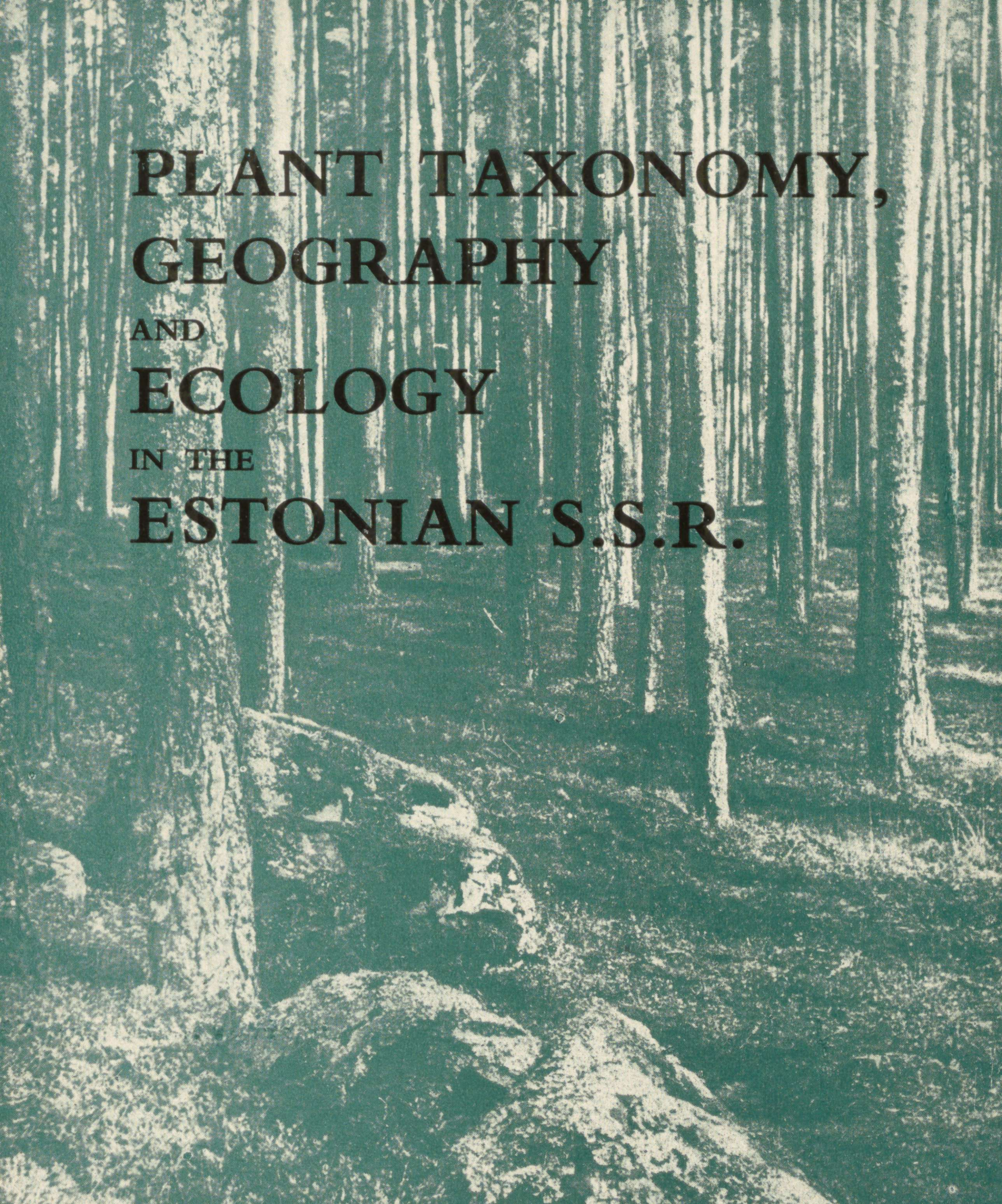

PLANT TAXONOMY, GEOGRAPHY AND ECOLOGY IN THE ESTONIAN S.S.R.

ACADEMY OF SCIENCES OF THE ESTONIAN S.S.R.
INSTITUTE OF ZOOLOGY AND BOTANY

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PREFACE

This publication represents an attempt to introduce the main branches of the botanical research work in Estonia, especially on taxonomy, phytocoenology, ecology, both theoretical and practical, and on nature conservation. These problems are dealt with mainly in the Tartu State University Department of Plant Taxonomy and Ecology (headed by Dr. H. Trass) and in the Botanical Department of the Institute of Zoology and Botany of the Academy of Sciences of the Estonian S.S.R. (headed by Prof. Dr. L. Laasimer), in the following articles signed «TU» and «IZB» correspondingly, and by the scientific staff of national reserves.

Scientific research on plant physiology, genetics, agrobotany, forestry and phytopathology have been left out of the present survey as well as the works on dendroflora and decorative plants issued by the Tallinn Botanical Gardens of the Academy of Sciences of the Estonian S.S.R. The scientists of the Forestry Scientific Research Laboratory of the Ministry of Forestry and Nature Conservation of the Estonian S.S.R are likewise engaged in the research of somewhat botanical inclination. They are mainly occupied with the problems of forest melioration, forest typology and selection work. Plant physiology and genetics are developed, mainly on the agricultural plants, in the Institute of Experimental Biology of the Academy of Sciences of the Estonian S.S.R., at the Department of Plant Physiology and Biochemistry as well as at the Department of Darwinism and Genetics of the Tartu State University.

The following articles do not embrace all the questions being solved in IZB and TU; that is especially true for some groups of Estonian cryptogamic flora. Besides TU, algological research is also being carried on in the Department of Hydrobiology of the IZB. In the latter, the main attention has been paid to the practical problems of growing algae for fish husbandry. Some extensive taxonomical *and ecological research has been made, mainly in the groups of Bacillariophyta, Conjugatophytina, Cyanophyta and Chlorophyta (M. Pork, V. Kõvask, E. Kukk). The algal flora of some lakes, e. g. the Peipsi Lake, has been studied thoroughly by R. Laugaste. The moss flora of Estonia has been comparatively less studied.*

The subjects dealt with in the present paper may be divided into two groups: those, in which a short survey of the development of the discipline in Estonia is given (V. Masing, L. Laasimer, T. Frey, H. Rebassoo, M. Kask, H. Trass); and others, in which there are only the results of more narrowly limited questions investigated (e. g. E. Parmasto, K. Kalamees, J. Eilart, K. Pork, H. Krall).

It should be emphasized that even the research of the two above-mentioned scientific institutions has not been reflected entirely in the following articles. The comparative importance of mycological investigations in both of the institutions should be pointed out. The mycological investigations of IZB have provoked much attention in the other Soviet republics. Remarkable results have been obtained in the study of intraspecies taxa of the microfungi and in the research of mycophilous microfungi with the further purpose of using them in biological control (P. Põldmaa). Interesting results have been obtained in the systematics of Ascomycetes of the U.S.S.R. by using biomathematical methods (A. Raitviir). In the bryological investigations much attention has been paid to the moss communities of alvars, alvar-forests and meadows (L. Kannukene, A. Kalda). It should be regretted that the flora of some cryptogamous groups, e. g. Musci, Hepaticae etc. has not yet been explained in detail regardless of the rather small territory of the republic.

Taxonomic studies of the flowering plants are in progress and new methods are being used in the study of taxa below the level of species. Works on use of the gel-chromatographic method have been started in the genera Triticum, Agropyron, Elymus and others (V. and V. Jaaska). In the field of phytogeography investigations of the development of the floristic composition of the Estonian little western islands (with the help of comparative-statistical methods) are in progress. A detailed survey of the genesis of the Estonian flora on the basis of ample data, gathered during decades with the help of statistical methods and computers, is in project (T. Frey in this publication).

References to the literature quoted in all the articles are presented in a list at the end of the booklet. The references embracing the most important botanical literature of the subjects dealt with here, published *in Estonia since 1960, are marked with an asterisk (*) before the author's name in the bibliography list. Some other works of Estonian botanists, published since 1960 and not cited in the articles of this booklet have also been put on the bibliography list and are also marked with an asterisk.*

At the end of the present publication a list of botanists, mainly working in TU and IZB, their specialities and addresses are given.

The first survey of this kind, "Botanical Researches in the Estonian S.S.R.", was published in 1959 and was dedicated to the International Botanical Congress in Montreal.

The authors of this booklet do hope that it helps the botanists all over the world to establish a productive international contact with Estonian botanists.

The authors

Tartu, February 1969

"FLORA OF THE ESTONIAN S.S.R."

By M. Kask

In 1968 Estonian botanists completed the "Flora of the Estonian S.S.R.". There are eleven volumes with a total extent about 5630 pp.; 2100 species, belonging to 671 genera, 140 families and 45 orders have been described. The work is illustrated by 2760, mostly original, figures. About two thirds of them depict plants; the others are maps of distribution, mainly on the Estonian territory.

Certain preparations for the work began in 1947. The research workers of the IZB and TU of those times were appointed some larger and economically more important families, like *Ranunculaceae*, *Rosaceae*, *Cruciferae*, *Caryophyllaceae*. The preparatory works began with the foundation of the herbaria of the IZB, assembling and studying the literature and learning of research methods, because the scientific staff had had no immediate experience for such a large work. In 1948 the principles for compiling the "Flora" and definite instructions were worked out and discussed by Prof. A. Vaga, the supervisor of the project. The fundamentals in general outlines were to have been the same as those used in the "Flora of the U.S.S.R.", issued by the Botanical Institute of the Academy of Sciences of the U.S.S.R. It was decided to present the material by the phylogenetic system of acad. A. Grossheim published in 1945 with some alterations. This system was founded on the recognition of the monophyletic origin of the phanerogams. By building up the system, six categories of the process of evolution were followed. The most important of these categories are the stages of the evolution — three progressive and one regressive. The stages are characterized by the development of the flower — from the flowers with a non-fixed number of the floral parts till completely established structure. For example, the family *Ranunculaceae* belongs to the primary stage *Protanthophyta*. The biggest amount

Sedum acre on the Vaika alvars. (Photo H. Rebassoo)

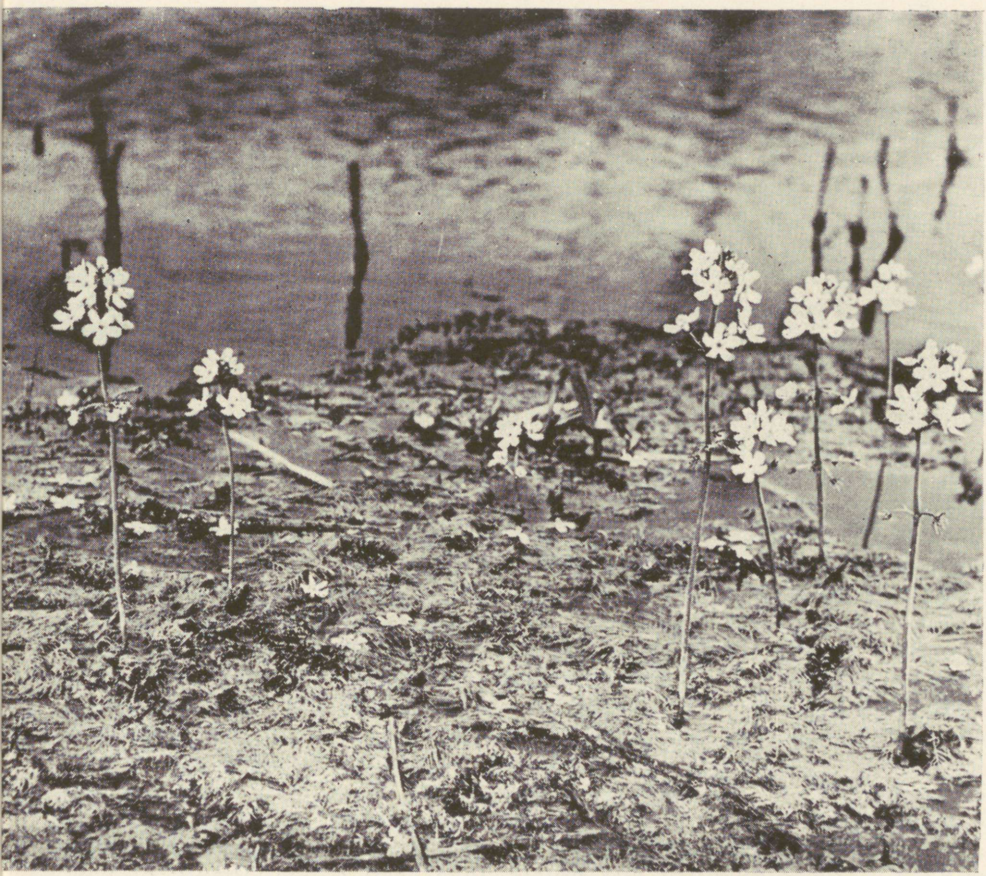
of orders and families, e. g. *Rosaceae*, *Leguminosae*, *Cruciferae*, *Umbelliferae*, belong to the second stage — *Mesanthophyta*. The families *Compositae*, *Euphorbiaceae*, *Gramineae*, *Orchidaceae*, etc., belonging to the third stage *Hypsanthophyta*, have the flower and all its parts highly specialized. A. Grossheim considered the simplified structure in some families (*Lemnaceae*, *Callitrichaceae*, etc.) a secondary phenomenon and did not regard putting them into the beginning of a system correct. That stage of secondary simplified structure was named *Opistanthophyta*. He did not take the families (*Betulaceae*, *Salicaceae*, *Urticaceae*), where the perianth has been simplified as a result of entomophily for a united group; therefore, they are farther apart in his system. As the classes of monocotyledons and dicotyledons are not recognized in the Grossheim system, the orders are grouped in lines of development or trunks. All in all, Grossheim's system of phanerogams has 11 stems with 67 orders and over 300 families belonging to them. The system was appreciated by Prof. Vaga because of its fresh standpoints, revolutionary trend, clear formulation of the basics and their consistent application, as well as the graphic representation of the system in circles, which is a convenient way of illustrating the evolution of the phanerogams by visual aids. In linear representation the Grossheim system begins, like most of the widely used variations of the Engler system, with the order *Ranales* (and *Annonales*) that is followed by *Rosales* and *Leguminosales*, but then the differences come. Instead of *Rhoeadales* and *Parietales*, the orders *Malvales*, *Geraniales*, etc. until *Juglandales* follow immediately. *Salicales* has remained at the very end of the system; but it has not held on in the issues published in the Estonian S.S.R. The order *Juglandales* is followed by the group from *Ligustrales* to *Rubiales* and only then *Rhoeadales* with allied orders. Then *Campanulales* (*Synandrae*) succeeded by *Proteales* up to *Ebenales* follow. Further the monocotyledons come, although A. Grossheim had not named them that way. The placement of the orders among the monocotyledonous group does not differ essentially from that of the Engler system. The Grossheim system finishes with the orders *Piperales*, *Salicales* and *Casuarinales*. In describing the Estonian flora, *Salicales* has been moved in front of the monocotyledons.

In the "Flora" material is presented by a generally recognized scheme. In addition to the characterization of the orders, families, genera and their intermediate units, and the keys of identification in them, the most important part are the descriptions of the species. Species in general have been understood according to acad. Komarov's conception quite strictly. Therefore their division into subspecies is usually missing. Mainly *varietas* and *forma* appear as intraspecific categories. After the plant designation in Estonian and Latin the most important synonymy and the works they come from follow; at the same time the more important monographs are noted. Next comes the morphological description of the species. The latter is succeeded by data showing the time of flowering and fruiting, distribution and sites in Estonia, general distribution, separately in the U.S.S.R. and outside, economical importance mainly according to literature. At the end of the description intraspecific taxa, hybrids and other taxonomic notes have been placed. Characterization of the higher taxa have been composed in accordance with literary data; but the descriptions of the species have been composed mainly on local specimens. For almost every plant an illustration has been added, in most cases wholly or partially original; for many species maps of their distribution in Estonia have been given; maps of the general distribution are in the minority. At the beginning of every book there is a systematic index down to species discussed in that volume. At the end of the volumes summaries in Russian have been placed and from 1962 summaries in German or English have been added. Indexes of the plant names in Latin, Estonian and Russian follow. Explanations of the Latin names are given in footnotes. Specific names derived from personal names have been spelled in capital letters.

The "Flora of the Estonian S.S.R." is being compiled for over twenty years. The first half of that period was not very productive because the composers were still gathering material and experience for their work and had to take part in research work planned somewhat earlier.

Still in the first twelve years the team managed to produce three first volumes. At the beginning of the other half of the period, the body of "Flora" lost its supervisor and fellow-worker, Prof. A. Vaga. Instead of him, K. Eichwald became the new supervisor, and afterwards L. Laasimer. When the "Flora" acquired the central place in the plans of research work, it became possible to employ several junior workers, amateur botanists and collaborators from other institutions. Planned floristic expeditions for gathering materials continued; many families were worked on at the same time. During that time the completed reprints of the 1st and 2nd volumes came out, and the 4th, 7th and 10th volume. Other volumes are still in manuscript and they will be published in the nearest future. By that time it will probably become necessary to publish at least one supplementary volume.

It is interesting to mention that the number of collaborators of the "Flora" generally increases with the increase of the number of volumes. The total number of the authors is 25. The most productive author is Cand. Sc. (Biol.) S. Talts, whose share is 422 species and ca 1120 pp.; her name is placed on the title-page of 8 volumes. Her bigger parts are the family *Papilionaceae* (in the 3rd volume), the order *Araliales* (in the 4th volume), 33 species of the family *Compositae* (in the 6th volume) and the family *Caryophyllaceae* (in the 8th volume). One of the initiators of the "Flora", Prof. K. Eichwald, is the next. He has also taken part in compiling 8 volumes whereas the 10th volume was composed entirely by him; he also wrote the class *Coniferae* (in the 1st volume) and the family *Rosaceae* (in the



Hottonia palustris near river bank. (Photo Ü. Tamm)

2nd volume). All in all his share is 314 species with a total of 784 pp. Research worker L. Viljasoo has taken part in compiling 4 volumes whereas to her account the 11th volume prevailingly comes with the family *Gramineae*. The number of the species worked up by her is 218, with a total of 500 pp. A. Üksip, V. Kuusk and M. Kask contributed over 150 species, the genus *Hieracium*, *Cruciferae* and *Polygonaceae*, etc., and *Scrophulariaceae*, *Labiatae*, etc., respectively.

The number of the species treated in "Flora" is somewhat greater than in identification books. That kind of difference is caused, first of all, by the choice of the included species. "Flora" deals mainly with all native species of which herbarium specimens or very authentic literary information have been preserved, including species which do not exist in Estonia anymore. Such species are for instance *Hypericum humifusum* and *Orchis sambucina*. The adventive plants (e. g. *Turgenia latifolia*, *Trigonella coerulea*) have been included on the same bases. The amount of the adventives is, no doubt, greater than presented in "Flora"; but not all the material has been identified yet or is not available to the compilers of the "Flora". Of the cultivated plants (*Aruncus vulgaris*, *Lilium martagon*, *Narcissus pseudonarcissus* etc.) those that are able to naturalize or can occur as casual plants (*Trifolium incarnatum*, *Coriandrum sativum*) have been taken into account in the first place. In addition to these "Flora" includes the most important and widespread food and fodder crops and decorative plants. The most spread and perspective trees and shrubs have been taken in as well. In the greater part of the volumes, the adventives and the species, occurring only in cultivation, have been marked by special signs. The 59 plants that have been placed under protection, have also got their special sign.

At the time the "Flora" was in progress many new species for Estonia were added. Of the species belonging to the indigenous flora were found during the expeditions or identified from the herbarium specimens gathered previously: *Ranunculus Stevenii*, *Scrophularia auriculata*, *Veronica Dillenii*, *Solanum litorale*, *Hippuris lanceolata*, *Salix rossica*, *S. dasyclados*, *Poa bulbosa*, *P. angustifolia*, *Festuca trachyphylla* and others; of the naturalized species *Veronica filiformis*, *Nepeta sibirica*, *Polygonum cuspidatum*, *Telekia speciosa*, *Erigeron annuus*, *Zizania aquatica* and others have been added. Plenty of new species have been added because of a critical study of the herbaria on the basis of a stricter species concept. The amount of species has especially increased in the genera *Carex* (by 13) and *Hieracium* (by 127). Several taxa, treated before as intraspecific ones, have been elevated to the species rank, e. g. *Potentilla impolita*, *Hyoscyamus bohemicus*, *Rhinanthus apterus*, *Salix arenaria*, *Cuscuta trifolii*, *Alisma lanceolata*, *Festuca arenaria*, etc. After the second World-War new adventives which have been added by tens constitute a special group. *Brassica elongata*, *Sisymbrium volgense*, *S. orientale*, *Erysimum repandum*, *Salsola collina*, *Atriplex tatarica*, *Suaeda salsa*, *Corisper-*

mum sibiricum are the most distributed of them. In this respect, the families *Cruciferae* and *Chenopodiaceae* have been presented most numerously.

The vegetation of the Estonian S.S.R. is very mosaic. Woods, mires and grassland alternate with cultivated land. Therefore, the flora contains mostly mesophytes (55%), then hygrophytes (20%) and xerophytes (17%) follow. Families with a great number of species are: *Rosaceae*, *Papilionaceae*, *Cruciferae*, *Compositae*, *Caryophyllaceae*, *Gramineae* and *Cyperaceae*. They make up almost half of the total number of species.

As for floristic elements, the circumpolar, Eurasiatic, Eurasiatic-Siberian and European ones are the prevailing ones (altogether about 80%). The indigenous species make up about 90% of the whole Estonian flora. They have immigrated to our territory mainly from southern and eastern quarters. Therefore, many of the species are found on their north-western, northern or north-eastern boundaries in our country. For example, such species as *Laserpitium pruthenicum*, *Alyssum Gmelinii*, *Swertia perennis*, *Thesium ebracteatum*, *Carex Davalliana*, *Betula humilis* and many others have their north-western boundary in Estonia; *Thelycrania sanguinea*, *Phleum phleoides*, *Berula erecta*, *Oxytropis pilosa* etc. have their northern boundary; *Anacamptis pyramidalis*, *Hypericum montanum*, *Hedera helix*, *Gymnadenia conopsea* and many others — the north-eastern boundary in Estonia. Species, having their western boundary here, are in the minority. Among these, we can find for instance *Silene tatarica*, *Achillea cartilaginea*, *Dianthus superbus*, *Chaemaedaphne calyculata*, *Veronica teucrium* and few others. There are not many plants with southern or south-eastern boundaries in Estonia. For example, *Rubus arcticus*, *Cerastium alpinum*, *Lathyrus maritimus*, *Chamaepericlymenum suecicum*, *Cochlearia danica*, *Mulgedium sibiricum* belong to them. All in all, Estonia is embraced by area boundaries of about 200 species. A part of them (*Carex Davalliana*, *Asarum europaeum*, *Betula humilis*, *Anemone sylvestris* etc.) are fairly common on the territory of Estonia, but the others (e. g. *Alyssum Gmelinii*, *Astragalus arenarius*, *Cerastium alpinum*) are very rare. A certain part of them is scattered throughout the country, whereas the distribution of the others is limited to particular areas. The most prominent floristic boundary on the territory of Estonia itself is the phytogeographical boundary, established by Prof. T. Lippmaa (1935) and confirmed or corrected by later authors. It divides our republic almost in halves with the main direction NNO-SSW. That boundary continues southward along the costal area of the Latvian S.S.R.; northward it stretches along the northern coast of Estonia to the Leningrad district.

A number of books and papers introducing Estonian flora and vegetation has been completed parallel to compiling the "Flora" and partially on the same basis. These are works of quite different extent and tendency: there are critical discussions on different species or entire families (Eichwald, 1960, 1960[a], 1966; Eilart, 1965, 1965[a]; Kuusk, 1962, 1968; Lellep, 1960, 1963), articles mainly treating the distribution of species (Eilart, 1962, Hein and Puusepp, 1963, "Seltene geschützte Pflanzenarten" 1965; Kalda, 1960, Krall, 1963, Pork, 1963, Rebassoo, 1960, 1962, 1963; Viljasoo and Karu, 1960), surveys about the plant cover of some vegetation units or territories (Akkel, 1967, Kalda, 1960, Karu and Kask, 1960, Laasimer, 1959, Lellep, 1964, Marvet, 1967, Rebassoo, 1961) up to monographs (Laasimer, 1965, Rebassoo, 1968), papers on the history of the flora (Eichwald, 1964, Eilart, 1966, Laasimer, 1962[c]), works on the floristic elements (see p. 17) and some manuals ("A Key to the Estonian Plants", 1966, Krall and Viljasoo, 1965, Pork, 1964[a]). The most outstanding are Prof. Laasimer's profound monograph "Estonian Plant Cover", a big identification book (contains over 1700 species and is abundantly illustrated), and H. Rebassoo's monograph on the vegetation of the Hiiumaa Island.

In the future it will be possible to map all the Estonian plants, to push ahead phytogeographical trend and carry out analysis of flora. At the same time, it is planned to deepen the study of some critical taxa by using biometrical, cytotaxonomical and biochemical methods.

THE DEVELOPMENT OF VEGETATION FROM THE ASPECT OF ANALYSIS OF FLORAL ELEMENTS

By J. Eilart

The vegetation of each country is, when more or less already formed, a zonal phenomenon. However, when we observe the specific composition of plant communities, their great diversity and difference in origin becomes manifest. Besides the species typical for certain communities and through them also for the whole zone others are encountered whose nature throws some light on the route which the community has passed. There is nothing astonishing about the recent plant communities containing ever more "alien" species, whose immigration was unleashed by Man's activities. The formation of the composition of the migratory flora in a given country is a continuous process of enrichment or impoverishment that depends on different factors. During this migration process of various species and fluctuation in their relative importance a more-or-less typical floristic composition of the community is formed. However, the formation of the plant cover in the areas without any vegetation in a comparatively short period (according to A. Raukas, Estonia got rid of the Continental ice-sheet only 11.200—11.000 years ago) did not progress through the immigration of the communities in one front according to the prevailing climate and their former zonality. It was a long lasting immigration and stabilizing process in the communities of plant species with different distribution efficiency, competition ability, ecological requirements and with different distances of their refugia. Unexpected and non-typical places of occurrence of plants, which are often regarded as even "botanical oddities", help understand the complicated ways of the formation of the zonal vegetation. The facts which seem abnormal in contemporary conditions may be highly typical if we take into consideration several palaeogeographical, climatical, edaphical and expansion peculiarities. The palaeobotanical records of the representatives of the semi-desert genus *Ephedra* together with the plants from the *Dryas*-flora of the pre-Boreal period in the present Estonian territory, localities of *Euonymus verrucosa* on the banks of the rivers Narva and Emajõgi, recorded in the previous century (distant from the present day area of distribution of these species); the occurrence of *Hedera helix* and *Taxus baccata* in swampy woods on the island of Saaremaa present evidence of superb value to the history of the formation of plant communities.

An examination of the members of flora and groups of species (floral elements) on the basis of their distribution, ecology, origin, immigration routes and times makes it possible to analyze the formation of the vegetation of a certain physico-geographically integral district.

The theory of floral elements has been thoroughly discussed by J. Eilart (1960, 1963).

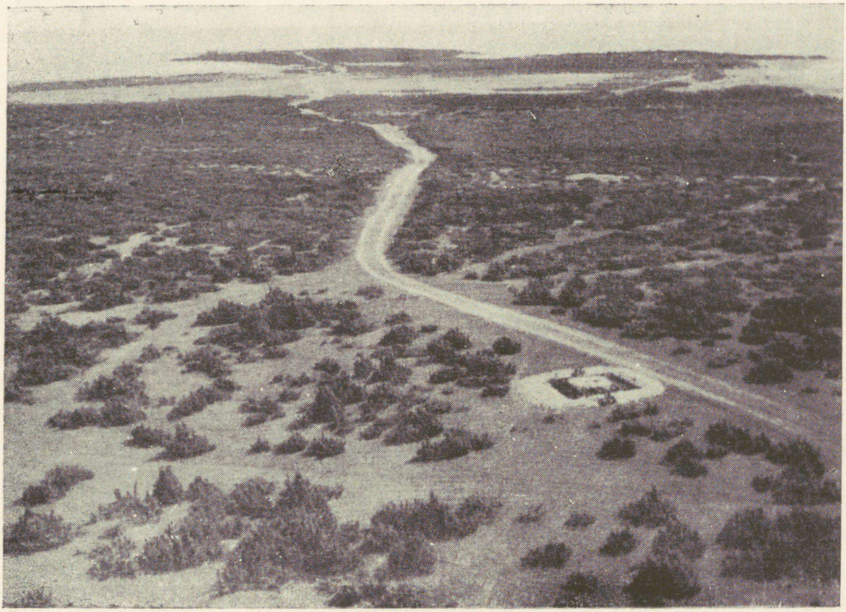
Attempts to classify plants on the basis of the peculiarities of their distribution were already made by F. J. Wiedemann and E. Weber (1852), and by Fr. Schmidt (1855). These naturalists took special interest in the contacts of the areas of various species. On the same principle, K. Eichwald (1935, 1953, 1960, etc.) also analyzed the distribution of several rare species in the Estonian flora. Immigration routes of microfungi were already studied by E. Lepik in 1941. In more recent times H. Rebassoo, in a monograph on the vegetation of the Hiiumaa Island (1967), paid special attention to directional or migratory elements.

Chronological elements on the Estonian territory have been determined casually. The treatise of K. Kupffer (1925), which specifies seven plant groups as having immigrated into the Baltic States at one and the same time, is of great importance. A more detailed survey in this field requires the presence of an extensive catalogue of palaeobotanical records.

The distinction of genoelements is connected with even greater difficulties. The determination of the centre of origin or the centre of dispersal (refuge) requires a profound knowledge of the systematical differentiation of all plant genera. In the Estonian flora, such an analysis was carried out of the genus *Rubus*, subgenus *Cylactis Rafin*. by Eichwald (1959), which enabled him to ascertain the origin of *R. arcticus*, a relic plant in our flora.

There are few results in distinguishing ecological elements (Kleopov, 1941; Walter, 1954; Popov, 1947, etc.) and the so-called

Juniper-alvar near Valjala on Saaremaa Island. (Photo H. Trass)



A view of the Kassari Island shingle-alvar with juniper shrubs. (Photo H. Rebassoo)

compound elements (Meusel, 1955, etc.) in Estonia worth mentioning. More attention has been paid to the classification of Estonian plants in relation to their attitude towards cultivation (Eklund, 1929; Vilberg, 1933; Lippmaa, 1933; Enari, 1944; Rebassoo, 1967, etc.). Such a division may conventionally be considered as a classification of ecological elements too.

The floral elements, i. e., groups of species, the distribution areas of which to a greater or lesser extent coincide, have frequently been understood in a geographical meaning. The first complete classification of elements from this aspect for the Estonian area was given by T. Lippmaa (1935). Geographical elements were further dealt with by J. Eilart (1958, 1963), A. Raitviir (1964, microfungi), L. Laasimer (1965), H. Rebassoo (1967), H. Trass (1968, lichens) and others. In this respect, J. Eilart (1963) particularly emphasized the ascertainment of the

Juniper shrubs on limestone shingle on the Sarve Peninsula Hiiumaa.
(Photo H. Rebassoo)

mass occurrence (ecological) centre (geographisches Massenzentrum einer Art) in order to identify to which element a given species belongs (Steffen, 1930; Walter, 1927; Szafer, 1956; Kleopov, 1941, etc.).

In view of this, we attempt to give a few examples of the peculiarities of the formation of the Estonian flora with the help of the analysis of floral elements. The members of those floral elements, which are more selective in respect to environmental conditions and have, therefore, a more restricted distribution on the territory under investigation, give more allusions to a floristic analysis than species with a wide ecological range. Of the geographical floral elements recorded on the territory of Estonia, the members of the Subatlantic, together with the so-called Pontic and Ponto-Sarmatian elements (Lippmaa, 1935; Eilart, 1958, 1963) belong to this group, the last element of the two being in its distribution principally confined to the steppes and the regions lying somewhat northwards.

The above-mentioned two floral elements have a very characteristic distribution, occurring on the territory of Estonia in habitats ecologically quite different from each other. The distribution of the subatlantic element is overwhelmingly restricted to the West of the so-called "Intermediate Estonian geobotanical district" of swampy woods and bogs ("Vahe-Eesti"). This "Intermediate Estonian district" forms a distribution barrier; but it is also an important historical factor since it separates the eastern territory of the uplands from so-called Lowland-Estonia ("Madal-Eesti"), the latter being subjected to several recent marine transgressions. The Pontic and the Ponto-Sarmatian elements are absent in "Intermediate Estonia" or are represented by the records of single inconsiderable species there. In the western part of Estonia, especially on its western islands, the ranges of a number of subatlantic and steppe plants overlap each other (subatlantic *Taxus baccata*, *Hedera helix*, *Myrica gale*, *Littorella uniflora*, etc., Ponto-Sarmatian *Phleum phleoides*, *Ononis arvensis*, *Koeleria glauca*, *Vincetoxicum hirundinaria*, *Libanotis intermedia*, etc.). This circumstance can be explained, on the one hand, by previous directions of dispersal, and on the other hand, by the presence of analogical conditions in the steppes and on the largest Estonian island Saaremaa (Ösel). There is no doubt that several species, however, although they extend to the southeast of Estonia, immigrated here from the west, or more precisely, from the southwest (*Vicia cassubica*, *Scutellaria hastifolia*, *Oxytropis pilosa*, *Helichrysum arenarium*, *Koeleria glauca*, etc.). This was determined by the places of the refuge of these species, by the postglacial palaeogeography in the Baltic Region, by the presence of analogical conditions in southeastern Sweden, and by the distribution biology of the above-mentioned species. Only during recent periods some of these species, in their long-continued expansion, also arrived in Estonia from the southeast (*Oxytropis pilosa*). As regards other species (*Helichrysum arenarium*, *Jovibarba sobolifera*), their westernmost places of occurrence disappeared gradually, which can be explained by a change in their ecological conditions during the period of the following immigration.

The occurrence of a number of Pontic and Ponto-Sarmatian plants in western Estonian Silurian or Ordovician limestone areas is ecologically determined by the analogy of conditions of such areas, as alvars, with steppes. As the Hungarian "puszta" could develop mainly where forests could not grow (according to R. Sóo), so also are the alvars of Saaremaa, partly at least, primary "alvar-steppes". They were called so, on the basis of the domination of *Juniperus communis*, already in 1906 by H. Witte; of the Estonian authors, T. Lippmaa (1940) presented much evidence of the similarity of this unit with steppes. In any case, the Pontic and Ponto-Sarmatian geoelement, together with the study of immigration directions and periods, enables one to draw important conclusions for the whole formation of alvar complexes. We can say that alvars are unique for Estonia and have been historically formed under the joint action of various factors. An alvar is a primary or secondary vegetation unit of limestone areas with a thin soil layer which is permanently subjected to human actions and characterized by the presence of xerophilous herb-like plants, peculiar to steppes.

The phytogeographical division of Estonia, drawn by T. Lippmaa (1935, completed by J. Eilart, 1958) is founded entirely on the analysis of the distribution of floral elements. The boundaries of these phytogeographical districts reflect contemporary occurrence of characteristic plant-groups, and take into consideration historical factors of the formation of the flora.

Rivers, or more precisely valleys of the rivers, have played the most important role in the immigration of southern elements to the Estonian flora, connecting the territory with distant refuges. River valleys (Velikaya, Daugava, Gauja, etc.) with their specific conditions, which conducted invading plants through ecologically unsuitable conditions of the environment and through climatic conditions which generally were unsuitable, were for thousands of years like corridors. This circumstance has, incidentally, found corroboration in the distribution of various insect species, connected with special plants, in the Baltic States.

Local immigration has generally been influenced by eskers (long narrow glacial ridges, once formed in fissures of the Continental ice-sheet), and, in most recent times, successful expansion of some species can be observed along railway embankments. The invasion of species is a continuous process also temporally. Several relatively xerophilous species (*Libanotis intermedia*, *Veronica spicata*, *Phleum phleoides*, etc.) arrived already before the development of forests.

New palaeobotanical data will give the elemental floral analysis a still more contemporary character.

PROBLEMS OF PHYCOGEOGRAPHY

By E. Kukk

The distribution of hydrophytes is primarily determined by bedrock qualities and by ensuing the chemism of water. Water as an environment, however, is considerably more stable in its composition and physical properties than any other biotic environment of plants. In the discussion of the distribution of algae, it is impossible to proceed only from floristic geography. One should delimit similar or different habitats and in each particular case also take into consideration definite environmental conditions. Ignorance of the relations between an organism and its environment may lead to the generalization of the cosmopolitan distribution of algae.

An algologic investigation of average profundity has been continued on the territory of the Estonian S.S.R. (Mölder, 1938, 1943, 1944, 1945, 1946). A more detailed study has been made of the floristic composition of the blue-green algae (Kukk, 1965, 1969), diatoms (M. Pork, 1967), desmids (Kõvask, 1965) and euglenophytes (I. Tenson, 1967). As the research has been of floristic character, lacking detailed ecological observation, it has not always been possible to analyse the material very deeply from the plant geographical point of view.

As blue-green algae are of a relatively broad ecological amplitude and, therefore, apt to adapt themselves to different environmental conditions, the study of their distribution is especially difficult. From north to south, respectively from higher altitudes to lower ones, algae grow in ecologically different environments. In the north, or in the mountains, a species may be a hydrophyte, to the south, or at lower altitudes, it can be found in aerophytic or subaerophytic conditions, e. g. *Gloeocapsa alpina*. On the contrary, situations may occur in which Arctic-alpine species can be found in aerophytic conditions in the north, whereas they are met as hydrophytes in the south (Cedercreutz, 1955). In Estonia the most interesting finds of blue-green algae from the point of view of plant geography are species of predominantly Arctic-alpine distribution, such as *Gloeocapsa alpina* and *Eucapsis alpina*, the latter occurring in Estonia in three water bodies. *Anabaena lapponica* and *Calothrix ramenskii* are likely to belong to the Atlantic floristic element.

In diatom flora the Arctic element is represented in Estonia by two species, *Tabellaria binalis* (Pork, 1958) and *Achmanthes fragilarioides*. The alpine and subalpine floristic element includes 2.5% of the taxa of Estonian fresh water diatom flora: *Synedra cycloporum*, *Eunotia microcephala*, *E. monodon*, *Achnanthes clevei*, *A. conspicua*, *A. linearis*, *Mastogloia smithii*, *Diploneis mauleri*, *D. oculta*, *Navicula diluviana*, *N. jantzschii*, *N. hustedtii*, *N. subrotunda*, *Pinnularia esox*, *Cymbella thumensis*, *Gomphonema helveticum* and *Denticula elegans* (Pork, 1961, 1967).

The representatives of the Arctic, alpine and Boreal floristic elements (*Eucocconeis flexella*, *Cymbella delicatula*, *C. angustata*, *C. cesatii*, *C. hybrida*, *C. laevis*) are spread in the northeastern and southeastern regions of Estonia and on western islands (Saaremaa, Hiiumaa). Numerous representatives of the Boreal floral element can also be found in Lake Peipsi, where in spring and in autumn *Melosira islandica* ssp. *helvetica* may develop in masses.

Navicula platystoma, which can be found in two of our biggest lakes, Lake Peipsi and Võrtsjärv, belongs to the Pontic element.

The find of *Melosira undulata*, a species of mainly tropical distribution, together with a few Arctic-montane and Boreal species in an *Isoëtes*-lake in eastern Estonia is also of great interest.

In Estonia the finds of the desmid flora are predominantly of Arctic and Subarctic distribution, e. g. *Staurastrum capitulum*; of Arctic flora *Euastrum pectinatum* var. *acuticus* can be mentioned. Of the Arctic-alpine species one can find *Cosmarium coelatum* var. *hexagonum*, *C. cyclicum* var. *arcticum*, *C. holmiense* var. *holmiense*, *C. holmiense* var. *integrum* and *C. nasutum* f. *granulata* in Estonia; some of these species are found in as many as four to five localities (Kõvask, 1965).

The Atlantic element is represented by *Docidium undulatum*, *Staurastrum brasiliense*, *St. cerastes* and *St. longispinum*.

The main area of distribution of *Micrasterias tropica*, *Cosmarium binum* and *C. birene* lies more to the south of our territory.

The finds of *Euastrum wigrense* and *E. crassum* var. *michiganense* should be mentioned among the finds of rare taxa.

A more intense investigation of peat bogs will doubtlessly increase the number of species of the Arctic as well as montane elements in all groups of algae.

The apparently limited distribution of some species is, evidently, the result of an insufficient algological study of various territories. Until 1960, *Anabaena sedovii*, a species described in 1933, had been found only in two localities (Franz Josef Land and in the islands of New Siberia). During the past eight years, however, this species has also been found on the Kola Peninsula, in the Polar Urals and in the Caucasus. In general blue-green algae, being phylogenetically the oldest group, possessing ecologically large adaptability, seem to have occupied all possible ecological recesses. On wide territories, there are almost always different places where the environmental conditions are favourable for the existence of one and the same species for at least a short period. In such cases a formal record of the points of localities leaves the impression as if it were a widely distributed species. The above-mentioned approach is likely to cause the belief that all blue-green algae belong to cosmopolites of universal distribution. The comparison of environmental conditions and the information on the distribution of blue-green algae (Kukk, 1969) have shown that there are certain regularities of the taxa of blue-green algae, possessing a wide area, even in the distribution. In temperate climate, where the environmental conditions display greatest variety, these regularities cannot be very easily observed. In arctic, subtropic and tropic climate, however, they are considerably more distinct. Extreme temperature conditions (permanent high temperature in tropics and low temperature in Arctic regions) and oligotrophy also appear to belong to the essential components among the environmental conditions which determine the distribution of algae. Phycogeographic problems can therefore be solved only by proceeding from ecological geography.

FRUIT BODY DEVELOPMENT AND SPORULATION OF POLYPORACEOUS FUNGI

By E. Parmasto

Regardless of the great importance of the Polyporaceous fungi as destroyers of trees, especially in forestry, very little is known about their spreading biology. This fact is very strange, especially as they have been studied comparatively well.

Several authors have paid attention to the curious situation that there are no spores in fruit bodies even of a number of common Polyporaceous fungi, e. g. *Fomes fomentarius* (Fr.) Fr., *Fomitopsis rosea* (Fr.) Karst., *Trametes suaveolens* (Fr.) Fr., *Daedalea quercina* Fr. etc., in the herbarium collections. This leads us to think that Polyporaceous fungi sporulate only at certain periods and/or times of the day when the mycologists do not happen to be collecting material.

Beginning with A. H. R. Buller's classical, although methodically a bit too simple research of 1909—1924, some 15 scientists have studied the sporulation of the Polyporaceous fungi of a little more than 30 species. However, most of this research was performed in conditions of the laboratory or in conditions disturbing the natural existence of the fruit bodies, so that these results are not quite reliable. Some of the best of these studies may herewith be mentioned: W. C. Percival's (1933) studies about *Phellinus abietis* (Karst.) Jahn ("*Fomes pini*"), works of C. G. Riley (1952) on *Ph. tremulae* (Bond.) Bond. et Boriss. ("*Fomes igniarius*"), H. Orlos' (1958, 1967) and especially studies of K. Bjørnekaer (1938) on the sporulation of many species. Some works published in the Soviet Union should also be mentioned.

Among them are A. S. Bondarzew's work of 1936, in which *Ganoderma applanatum* (Wallr.) Pat. spore production has been discussed quantitatively; P. N. Borisov's research of the sporulation fluctuations of *Phellinus tremulae* and *Ph. igniarius* (Fr.) Quél.,

V. Mikalaikevičius's works of 1962 and 1965 on the same species; studies of A. Vassiliauskas (1964) and A. M. Solovyev (1965) about *Fomitopsis annosa* (Fr.) Karst. spore discharge.

The author of this paper (Parmasto, 1956, 1958, 1959, 1969) studied the development and sporulation of the fruit bodies of 56 Polyporaceous fungi on 220 specimens (1953—1955) in the IZB and since 1965 he has been studying the 12 most important harmful for living trees species. Recently special attention has been paid to the research of the *Phellinus igniarius* complex, *Fomes fomentarius* and *Polyporus squamosus* Fr. The author's collaborators are studying the sporulation of *Phellinus pini* complex and of Polyporaceous fungi that harm fruit-trees.

Methods

The analysis of the results of the research on sporulation shows that the only reliable results can be obtained from studies of fruit bodies made in natural environment. The research in laboratories which has been used by several authors can only be used as additional material in special studies. When the fruit bodies are placed in nature under any kind of shelter (e. g. W. C. Percival, P. N. Borisov), the results of the research are influenced considerably.

The author of this paper has given some reliable methods for research (Parmasto, 1969). We shall review them in short.

The fruit body's life span is determined by marking them with a number just after their appearance and by checking their condition periodically in stationary observation areas.

In order to study the phenology and relative intensity of sporulation, an easily replaceable capsule, with a disk of dark glazed paper at its bottom, is placed under the hymenophore of the fruit body with the help of an elastic strip of sheet-metal fixed to the substrate, i. e. the trunk of the tree, but not to the fruit body. Even the slightest amount of spores is noticeable on the surface of the dark glazed paper by the bare eye. The amount of spores is estimated visually in a 3-stage scale (also compare Bjørnekaer, 1938 and Parmasto, 1956). As in the other studies of sporulation, where the climatic conditions are taken into consideration, a weekly hygrotermograph is set in the vicinity of the fruit bodies and the precipitation is measured.

In order to measure the approximate daily fluctuation of sporulation, a glass slide is fixed about 0.5 cm below the hymenophore always in the same position. The amount of spores falling on the glass slide in a certain interval of time (5, 10, 15, 30 or 60 minutes) is determined by a microscope. The results are expressed in a number which shows the precipitation of spores on one square millimeter per hour. The obtained results only seem exact; the glass slide receives only a small fraction of the discharged spores.

In order to determine the daily spore production, the hymenophore is surrounded by a piece of loosely hanging waterproof wax paper attached to the margins of the fruit body by pieces of adhesive tape. By placing the hymenophore into moist conditions, somewhat different from those in nature, influences sporulation, but not very greatly. 24 hours later, or during a research of diurnal sporulation dynamics in half or a full hour, the paper with the fallen spores should be removed and taken to a laboratory in a hermetically closed bag. The total amount of spores is determined haemocytometrically. The amount of spores is calculated per cm^2 of the hymenophore and hymenium per hour or per 24 hours, and also for the whole fruit body.

In order to study the diurnal fluctuation of sporulation the spores are gathered with the help of the above described method at suitable intervals in the course of half or a full hour.

Biological Groups of the Polyporaceous Fruit Bodies

Besides the generally known Polyporaceous fungi with annual and perennial fruit bodies, a large group of Polyporaceous fungi with annual wintering fruit bodies apparently occurs in the conditions of the whole northern temperate zone. *Amyloporia xantha* (Fr.) Bond. et Sing., *Antrodia serialis* (Fr.) Donk, *A. sinuosa* (Fr.) Karst., *Bjerkandera adusta* (Fr.) Karst., *B. fumosa* (Fr.) Karst., *Ceriporiopsis aneirina* (Sommerf.) Dom., *C. resinascens* (Rom.) Dom., *Chaetoporus nitidus* (Fr.) Donk, *Coriolellus flavescens* (Bres.) Bond. et Sing., *Coriolus zonatus* (Fr.) Quél., *Datronia mollis* (Sommerf.) Donk, *Hirschioporus abietinus* (Fr.) Donk, *Tyromyces semipileatus* (Peck) Murr., etc. At any rate, some of these species may live, either singly or in majority, several years in favourable conditions (*Antrodia sinuosa*, *Datronia mollis*, *Amyloporia xantha*, etc.). In this group of the Polyporaceous fungi the fruit bodies appear in summer; they hibernate and perish only the next summer. In winter they can endure at least —25° C.

Annual Sporulation Fluctuation

The Polyporaceous fungi with annual fruit bodies usually appear in July and August in Estonian conditions, some of them already in May and June; they mature rapidly: in the course of 1 or 2, rarely 4 weeks. Then the tube layer develops; when the tubes are about 0.5—1 mm in length sporulation begins; it takes place simultaneously with the lengthening of the tubes and continues, without intervals after cessation of their growth, 2 or more weeks.

The majority of the species, with annual wintering and perennial fruit bodies, have two sporulation periods: autumnal, which lasts until the fall of the average daily temperature below 2—3° C; and vernal, which begins at the time the average daily temperature rises above 2—3° C. In the summer period of inactivity, a new layer of hymenophore of the Polyporaceous fungi with perennial fruit bodies begins to grow. The period of inactivity may be short or long depending on the species; some do not have it at all. The period of inactivitv usually coincides with the hottest and driest time of summer. The author has given the sporulation periods of species in Estonia in a work of 1959.

The Length of the Sporulation Period During the Year

In the author's work of 1958, in Table no. 3, a general review has been given for many species. The sporulation period of some species is limited to 1—3 weeks (*Gloeoporus Bourdotii* (Pil.) Bond. et Sing., *Oxyporus corticola* (Fr.) Parm.). In the species with perennial fruit bodies it, apparently, depends on the length of the vegetation period and in Estonia it may last 6—7 months (*Fomitopsis annosa*, *Phellinus igniarius*, *Ph. tremulae*, *Ph. laevigatus* (Fr.) Bourd. et Galz., etc.). The usual period of sporulation for the annual wintering fruit bodies is 1—4 months.

Only in case of comparatively long intervals of observations (5—10 or even 20 days) does the sporulation appear to be a lasting process. By checking the observations every few days or even every day do we see that the sporulation of certain species (e. g. *Phellinus tremulae*) is intermittent. The occurrence of sporulation and its intensity besides depending on internal factors is also influenced by climatic conditions.

The Dependence of Sporulation on the Atmospheric Temperature and Relative Humidity

Many Polyporaceous fungi, especially those with perennial fruit bodies, begin sporulation at 2—5° C; short night frosts interrupt the process only temporarily. With the rise of temperature, sporulation becomes more intensive if this is not influenced by the substrate or the air becoming too dry.

The sporulation of fruit bodies growing on living trunks and having a woody consistency and a thick cortex does not generally depend on atmospheric relative humidity fluctuation; but the diurnal periodicity of sporulation certainly does, at least in some species. However, in the cases of annual fleshy fruit bodies, growing on substrates with unstable moisture, they decrease or discontinue their sporulation when the humidity decreases.

One Fruit Body's Total Spore Production

Most of the textbooks and handbooks of forest phytopathology refer to A. H. R. Buller's data obtained through not quite correct methods. We may here mention the results of A. S. Bondarzew's little known research of 1936: the fruit body of *Ganoderma applanatum* produced, as an average of 6 observations in August 1932 in the Leningrad region, for every 1 cm^2 of hymenophore $3.28 \cdot 10^7$ spores (the total fruit body spore number was $2.13 \cdot 10^{10}$).

Numerous observation data of the spore production of the fruit bodies of Polyporaceous fungi are treated in the IZB. For instance, in 1968 in Tartu *Polyporus squamosus* produced $5.6 \cdot 10^6$ to $60.7 \cdot 10^6$ spores per 1 cm^2/24 hrs of the hymenophore ($0.54 \cdot 10^6$ to $5.2 \cdot 10^6$ spores per 1 cm^2 of the hymenium). The total production of a multipliate fruit body was $5 \cdot 10^9$ to $140 \cdot 10^9$ spores.

Since the continuance and intensity of the daily spore production is different for each day, it is incorrect to estimate the total annual amount of spores produced by one fruit body by multiplying the length of the sporulation period by the production of some accidently selected spore production day, as some authors have done.

Diurnal Fluctuation of Sporulation

It has become apparent that the Polyporaceous fungi can be divided into two groups with different sporulation rhythm.

The majority of the species (*Laetiporus sulphureus* (Fr.) Bond. et Sing., *Phellinus tremulae, Fomes fomentarius*, etc.) have two sporulation peaks a day: in the evening and in the morning. During the day a pause in sporulation takes place, or rather a sort of depression, at the time of the lowest atmospheric relative humidity of the day; at night a pause is noticed during the lowest temperature period. On warm nights sporulation can take place and can even be intensive (*Fomes fomentarius*).

Polyporus squamosus sporulates all day, with only rare intervals and for a short period during the middle of the day, at which times the curve of the mean hour intensity of sporulation coincides with the curve of the relative atmospheric humidity almost exactly.

The Compound Character of the Spore Discharge

On the basis of the above-described peculiarity of sporulation, and the comparison of the data of changes of the atmospheric humidity and the data of sporulation intensity, it appears that we have to differentiate two processes in the sporulation: 1) the development of basidia and spores. How long does it take for Aphyllophoraceous fungi is hard to say because of complete absence of data. According to Buller's research of Agaricaceous species, which are conducted in conditions very different from the natural ones, we may say that the proper time is at least one hour. Obviously, this process is mainly influenced by general conditions of the weather, especially temperature, immediately before and during the sporulation.

The second process is the final maturing of the spores and their discharge. The increase of relative humidity of only 3—5% causes an immediate and abrupt increase in the intensity of sporulation of *Polyporus squamosus*, whose hymenium in the vicinity of the wide pores is exposed to the change of external factors.

During a 24-hour period, only one basidium of *Polyporus squamosus* gives spores on every 300—1200μ^2 hymenium. Since the diameter of a basidium is 7—9μ, it is obvious that the fungus uses only a little part of its sporulation potentiality. In favourable climatic condition the fungus is able to increase the production of spores very quickly, without wasting great amounts of substances or energy.

Tasks of Further Research

One of the most interesting tasks of research is further investigation of the diurnal fluctuation of the sporulation of the Polyporaceous fungi: to what extent it depends on diurnal fluctuation of air temperature, relative humidity, atmospheric pressure and intensity of light. It is not excluded that we may find the phenomenon of biological clocks in this case, too. We may assume that the diurnal fluctuation of the sporulation is of an adaptive character (spore discharge in a time most favourable for their spread); but this must be verified. The mechanism of reaction of the fruit body on fluctuations of external factors (temperature, relative humidity) requires further investigation; most likely the ostiola of tubes, the basidia, basidiola or hyphidia situated in the tubes serve as receptors in this complicated process.

We know too little about the development of basidia and the mechanism of spore discharge, especially about its rate and dependence on climatic conditions.

We have only insufficient data on the viability of spores in natural conditions and must disclose a most paradoxal behaviour: the occurrence of a rich sporulation by many species at a time when the temperature conditions are quite unfavourable for spore germination.

The aim of this brief report was not only to introduce the results of research obtained at the IZB, but also to provoke the interest of mycologists and forest phytopathologists in the problems which are worth much more attention than is being paid to them at present.

MYCOCOENOLOGICAL RESEARCH IN ESTONIA

By K. Kalamees

Mycocoenological research was conducted by the Department of Plant Taxonomy and Ecology of the Tartu State University in 1954—1964. Stationary investigations and route analyses were made on 15 site types of the East Estonian forests, beginning with the driest, lichen and *Calluna* type, and finishing with the wettest, bog and mesotrophic mire type, to explain mycocoenological field methods and connections between different fungal groupings and various forest site types. Theoretical problems of mycocoenology were also discussed. The following five types were under close observation: the *Vaccinium*, *Myrtillus*, swampy *Myrtillus*, *Oxalis* and *Aegopodium-Mercurialis* types.

Stationary investigations were carried out on 900 and 1000 sq. metre quadrate sample areas. All the plant cover layers and relief character were described on each sample area. Soil variety and humidity regime were determined. All the fungal species were registered and their fruit bodies were counted. Substrata and sociability were denoted with each species. Observations were made only in autumn in 8—10-day intervals. Sample areas were mainly undivided. Only in one case the sample area was divided into 30 observation belts of 2 metres each. A passage of 0.5 metres was left between each belt not included in the area under investigation and fungal fruit bodies growing there were not taken into account. This method was a result of our experience: in the case of the absence of such passages many young fruit bodies would have been smashed in the moss, changing the results.

Route analyses were made on 100—5000 sq. metre sample areas of various shape, depending on the fungal cover and the character of site type. In each case all the same indicators as in stationary observations were registered; only in determining the abundance of fruit bodies the Haas 6-stage somewhat complemented scale was used. Sociability was indicated in both route and stationary analyses according to the Haas 5-stage scale.

The following conclusions were drawn:

1. It is not correct to treat fungal groupings in biocoenoses as independent communities or to call them associations. Fungal groupings represent such structural elements of phytocoenoses which do not correspond to the concept of synusia. Fungal groupings constitute spatially considerably more restricted and temporally quite different morphological elements subject to a different rhythm (e. g. that of the decomposition of humus) than synusia. It is necessary to devise a new term for such structural elements.

2. The role of fungal groupings in biocoenoses can best be characterized by consortia, i. e. functional structural elements of biocoenosis, since the relationship of fungi on vascular plants first reveals itself in trophic relations.

3. Connections between fungal groupings and forest site types and their role in the structure of plant communities can be thoroughly explained only in different plant communities as a result of stationary observations during the whole vegetation period lasting at least 2 years. The average period for observation is 10 days. The above-mentioned problems cannot be solved by using route investigations. Only preliminary data on the composition of fungal cover in a site type can be collected by using route investigations.

4. The abundance of fruit bodies and sociability are essential mycocoenological indicators in analysing fungal cover. Counting should be preferred while estimating abundance. A six-stage scale, where abundance is combined with sociability, is advisable for subjective estimation.

5. In applying the method of large quadrats, sample areas for fungal cover analyses must exceed 900 sq. metres. Even such a large sample area cannot give quite satisfactory results because it comprises a considerably small part of the actual body of forest community and numerous fungal species remain out of view. Research in forest communities with natural boundaries by the methods of small sample areas or transection seems to be most successful in giving a survey of the actual fungal cover of the given forest community. Such methods have not yet been introduced in Estonia by the mycocoenologists.

6. The richest in species of the studied site types are the *Oxalis*

type with 175 species, then the *Aegopodium-Mercurialis* (142) and *Myrtillus* types (131).

7. The distribution of fungal species (fungi on wood incl.) depends largely on site type peculiarities. These peculiarities are more clearly felt in coniferous stands than in deciduous ones. Common fungal species were not found for all the 15 site types. *Amanita vaginata* var. *badia* and *Cortinarius cinnamomeus* were the most unpretentious species as to differences in site types. There were two common species in five site types studied in detail: *Lactarius vietus* and *Paxillus involutus*. Most species were characteristic in only one site type.

The rich swampy forest type differs in fungal cover from other site types occurring on undrained peat soils, notably because of the differences in stand composition and ecological medium.

Swampy *Myrtillus* and drained mire forest site type fungal covers are conspicuously similar to the fungal cover of site types with optimal humidity conditions. It is, probably, caused by similarity in the above-mentioned site type vegetation to certain site type vegetations with optimal humidity conditions. Phyto-medium, not soil and humidity conditions are primarily decisive factors of fungal cover character in the given site types.

Of the 5 site types studied in detail as to its fungal cover, the *Aegopodium-Mercurialis* site type (21 characteristic species) is the best characterized, the *Myrtillus* type being the worst (4 characteristic species).

8. In studying fungal cover in forest site types we can have satisfactory achievements if the fungal cover only in forest stand groups is analysed, not in forest types. A forest type is determined according to the prevailing tree species, the composition of a stand being essential in studying fungal cover.

A spruce mixed stand is richest in the fungal species of forest stand groups of site types. The vast majority of species, occurring on pure spruce stands can also be found in spruce mixed stands.

Most fungal species growing in coniferous stands also occur in mixed stands; the species growing in the latter occur in coniferous stands in the minority. This depends on the considerably wider ecological range in the mixed stands as compared with coniferous stands.

9. The annual rhythm of fungi is subjected to regular seasonal changes like that of higher plants. Seasonal changes in the fungal cover can be termed as aspects. It would not be correct to regard

those changes in the fungal cover which are connected with an extremely rapid interchange of fungal dominants as aspective. The aspects which have been established on the basis of such fungal species do not reflect correctly the actually existing seasonal stages of development in the fungal cover. Only such seasonal changes may be regarded as aspects of the fungal cover which are regularly repeated at the same place over a number of years. On the basis of general seasonal changes, it is possible to distinguish seven aspects of fungal cover in East-Estonia. These are: early-spring, spring, early-summer, summer, autumn, late-autumn and winter aspects.

FLORISTICAL AND PHYTOGEOGRAPHICAL STUDY OF THE ESTONIAN LICHEN-FLORA

By H. Trass

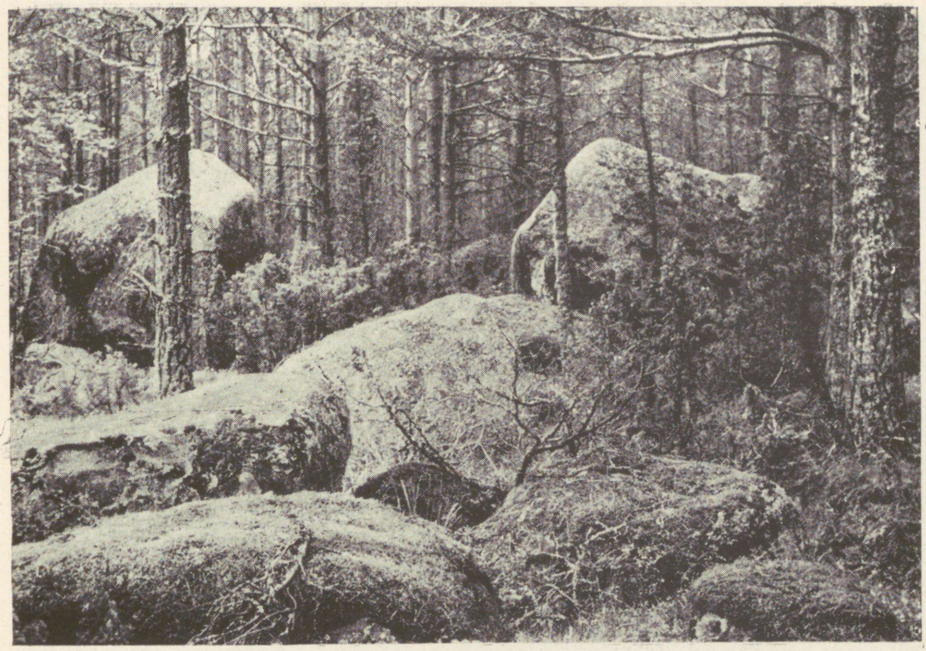
Intensive study of the lichen-flora of the territory of Estonia has continued for over a century (H. Trass, 1962). During this period, particularly, thanks to the investigations carried out by A. Bruttan (1870), K. Mereschkowsky (1909, 1913, 1913[a]), P. Wasmuth (1907), V. Räsänen (1931) and others, the basic floristical composition of the lichen-flora of our territory has been established. A new upsurge in the development of Estonian lichenology began two decades ago when the local Estonian lichenologists started an intensive supplement of the lichenological herbarium of the Department of the Plant Taxonomy and Ecology of the Tartu State University (TU) and studies began to appear on the composition, genesis, geography, ecology and coenology of the Estonian lichen-flora (Trass, 1956, 1957, 1958, 1958[a], 1958[b], 1959, 1962, 1965, 1965[a], 1966, 1966[a], 1968, 1968[a], 1968[b], 1968[c]; Piin, 1967[b]; Sõmermaa, 1965, 1968, etc.). At present, the herbarium of the lichenological laboratory of the TU contains 45 000 specimens. This collection has been increased by original materials from other parts of the Soviet Union (the Kola, Taimyr and Kamchatka Peninsulas, the Far East, East Siberia, Central Asia, Kazakhstan, the Caucasus, etc.) and has been added to by materials obtained through exchange. In addition to the research carried out in the lichen-flora of Estonia, studies have been published on the lichens of some other regions of the Soviet Union (Trass, 1963; Trass et al., 1963; Piin, 1967, 1967[a]; Martin, 1968, etc.). At present the staff of the lichenological laboratory of the TU consists of four lichenologists (see International Lichenological Newsletter, **2**, 2, 1968, p. 9).

A rather considerable amount of floristical and ecological data enabled the author of this paper to compile a monograph on the

Table 1.

Elements, subelements and varieties of elements	Number of species and their % (in brackets)	Average number of localities per species	Species with one locality and their % (in brackets)
1	2	3	4
I. Arctic-alpine	41 (6.1)	4.2	17 (41.5)
1. Euarctic-alpine	21		
1) Pan-Holarctic	19		
2) Eurasiatic	2		
2. Omni-Arctic-alpine	20		
II. Hypo-Arctic-montane	45 (6.7)	9.2	17 (37.8)
1. Euhypo-Arctic-montane	37		
1) Circumpolar-montane	33		
2) European	1		
3) Eurasiatic	3		
2. Omnihypo-Arctic-montane	8		
III. Boreal	149 (22.0)	10.9	39 (26.2)
1. Euboreal			
1) European			
2) Eurasiatic			
3) European-American			
4) Panboreal			
2. Notoboreal			
IV. Nemoral	94 (13.9)	14.9	30 (31.3)
1. Eunemoral	59		
1) European	21		
2) Eurasiatic	5		
3) European-American	18		
4) Pannemoral	15		
2. Omninemoral	35		
V. Mediterranean	11 (1.6)	2.7	6 (54.5)
1. Sub-mediterranean	6		
2. Pseudo-mediterranean	5		
1) European-American	2		
2) Eurasiatic-Boreal-American	1		
3) Multiregional	2		

1	2	3	4
VI. Xerocontinental	19(28)	12.5	5(26.3)
1. Euxerocontinental	14		
1) European	4		
2) Eurasiatic	5		
3) European-American	1		
4) Eurasiatic-Boreal-American	4		
2. Omnixerocontinental	5		
VII. Montane	46(6.7)	4.3	23(50)
1. Eumontane	13		
1) European	10		
2) Eurasiatic	1		
3) European-American	22		
2. Submontane	24		
1) European	10		
2) Eurasiatic	2		
3) European-American	9		
4) Eurasiatic-Boreal-American	3		
3. Omnimontane	9		
VIII. Oceanic	33(4.5)	2.5	12(27.5)
1. Holarctic suboceanic	26		
1) European	12		
2) Eurasiatic	2		
3) European-American	10		
4) Eurasiatic-Boreal-American	2		
2. Multiregional suboceanic	7		
IX. Holarctic	76(11.2)	10.7	19(25)
1) European	3		
2) Eurasiatic	6		
3) European-American	30		
4) Eurasiatic-Boreal-American	37		
X. Multiregional	122(18.0)	27.4	16(13.1)
Endemics	1(0.2)		
Species with undetermined type of areas	40(5.8)		



Siliceous boulders in the pine forest near Variku (north-western Estonia) as a refuge of many Arctic-alpine lichens. (Photo H. Trass)

composition, genesis, development and phytogeographical elements of Estonian lichen-flora as well as on a provisional classification of lichen synysiae (Trass, 1968).

By the time the above-mentioned monograph had been completed, the lichen-flora of Estonia embraced 677 species. In the past two years over 20 new species have been discovered on our territory, raising the species composition of Estonian lichen-flora to 700 species by 1969.

The largest genera of our lichen-flora embrace: *Cladonia* (64), *Lecanora* (46), *Lecidea* (46), *Parmelia* (32), *Caloplaca* (25), *Physcia* (24), *Usnea* (22), *Bacidia* (21), *Calicium* (17), *Peltigera* (15), *Aspicilia* (14), *Collema* (14), *Ramalina* (14), *Verrucaria* (14), *Pertusaria* (13), *Buellia* (12), *Opegrapha* (12), *Rhizocarpon* (12),

Cetraria nivalis and *C. islandica* on the alvar near Üügu, Muhu Island. (Photo H. Trass)

Catillaria (11), *Cetraria* (11), *Acarospora* (16), *Stereocaulon* (10). Among the remaining genera each contains fewer than ten species while 34 genera are represented by only one species. The coefficient of lichens on the territory of Estonia is 0.45.

On the basis of the contemporary distribution areas of the species, their immigration routes and time as well as the ecological relations between the individual species, the following phytogeographical categories of Estonian lichen-flora are distinguished:

(1) elements — determined on the basis of the contemporary distribution of the species, configuration and size of the areas, regularities of zonal and regional distribution as well as centres of abundance;

Psora decipiens on the Võrsna-alvar, Saaremaa Island. (Photo H. Trass)

(2) components — established on the basis of the regularities of the distribution of species within the limits of a given area;

(3) cronants — determined on the basis of the time of immigration of species into a given territory (Holub and Jirásek, 1967);

(4) migrants — ascertained on the basis of the tracks of immigration of species into a given territory;

(5) ecants — established on the basis of the ecological groups of species making up various elements.

The adherence of the species of Estonian lichen-flora to various geographical elements, subelements and varieties of elements is given in Table 1.

Arctic-alpine species (*Cetraria cucullata*, *C. nivalis*, *Ful-*

Solorina saccata on the limestone rocks near Tupenurme, Muhu Island. (Photo H. Trass)

gensia bracteata, *Parmelia incurva*, *P. stugia*, *P. omphalodes*, *Cladonia elongata*, *Ochrolechia frigida*, *Umbilicaria cylindrica*, etc.) are distributed chiefly in the Arctic and the Subarctic regions, having their abundance centres there. After the meridional disjunction they appear again in high-mountain subalpine and alpine high-altitude belts. The distribution of Euarctic-alpine species is confined to the Holarctic region whereas the species of the Omni-Arctic-alpine subelement occur also outside this region in high mountains.

Hypo-Arctic-montane species (*Caloplaca stillicidiorum*, *Cladonia alpicola*, *Lecanora cenisia*, *Ochrolechia androgyna*, *Peltigera venosa*, etc.) are distributed chiefly in the Subarctic regions, in the Boreal zone and in the middle conifer belts of high mountains.

Cladonia subrangiformis on the Võrsna-alvar, Saaremaa Island. (Photo H. Trass)

Euhypo-Arctic-montane species are distributed only in the Holarctic, whereas Omnihypo-Arctic-montane species occur also outside the limits of the Holarctic, including the high mountains of the Southern Hemisphere.

The Boreal element (*Stereocaulon tomentosum*, *Parmelia olivacea*, *P. exasperatula*, *Alectoria implexa*, *Parmeliopsis ambigua*, *Hypogymnia tubulosa*, *Lecanora coilocarpa*, *Cladonia alpestris*, etc.) embraces species which are mainly distributed in the Boreal conifer-forest zone of the Holarctic region. Notoboreal species may occur in the Holarctic region as well as outside it where similar conditions obtain.

Nemoral species (*Anaptychia speciosa*, *Calicium alboatrum*,

Table 2

Elements	Ecological Groups: Epilithic Species — Calcareous	Siliceous
Arctic-alpine	4	20
Hypo-Arctic-montane	2	17
Montane	12	13
Boreal	17	30
Mediterranean	8	1
Xerocontinental	4	3
Oceanic	1	20
Nemoral	—	10
Holarctic	21	20
Multiregional	23	28
Endemic	—	—
	92	262
Species with undetermined type of area	7	10
Total	99	272

Candelariella reflexa, *Coniocybe pallida*, *Parmelia acetabulum*, *P. tiliacea*, *Pertusaria hemisphaerica*, *P. leptospora*, *Phlyctis erythrosora*, etc.) are confined to the deciduous forest zone of the Holarctic region. Species of the omninemoral subelement occur in the Holarctic region, as well as outside it, under the conditions resembling those of the deciduous forest zone of the Holarctic.

Of the subdivisions of the Mediterranean element only a few species of the Submediterranean and the Pseudomediterranean subelement (*Aspicilia farinosa*, *Caloplaca aurantia*, *C. lallavei*, *Cladonia convulata*, etc.) occur in Estonia.

The Xerocontinental element embraces species occurring in the relatively warm and arid regions of the Holarctic (the euxerocontinental element) as well as outside the regions of the Holarctic (*Parmelia pulla*, *Cladonia hungarica*, *Cl. rangiformis*, *Cl. subrangiformis*, *Cl. foliacea*, *Fulgensia fulgens*, *Psora decipiens*, *Squamarina lentigera*, *Toninia coeruleonigricans*, etc.).

The Montane element is represented by the species occurring in the forest belts of the high mountains of the Holarctic region and seldom in the plain regions (*Calicium gracile*, *C. viridireagans*,

Epiphytic Species		Epixylic Species	Epigeic Species			On Devon rocks
Epidendric	Epibryophytic		Calcareous	Psammocolous	On peat	
4	3	—	7	3	—	—
8	7	5	4	9	2	—
12	6	3	1	2	2	2
81	7	42	5	20	10	4
—	—	—	1	—	—	—
1	—	—	11	3	—	—
11	3	1	3	8	5	1
77	4	29	—	2	—	6
27	14	14	8	12	4	3
44	34	54	21	40	18	14
—	—	—	1	—	—	—
265	78	148	62	99	41	30
12	1	6	—	3	—	2
277	79	154	62	102	41	32

Thelotrema lepadinum, *Umbilicaria cinerascens*, *Menegazzia pertusa*, etc.). In addition, the species of the Omnimontane subelement occur in mountains outside the Holarctic.

The Oceanic element in Estonian lichen-flora is represented by species of two subelements, the Holarctic suboceanic and Multiregional suboceanic (*Cladonia tenuis*, *Cl. impexa*, *Verrucaria maura*, *Physcia subobscura, Anaptychia melanosticta*[1], *Ramalina siliquosa*, *Alectoria bicolor*, *Leptogium cyanescens*, *Nephroma lusitanicum*, *Parmelia mougeotti*, *Xanthoria isidioides*[2], etc.).

Species of the Holarctic element (*Cladonia sylvatica*, *Cl. cenotea*, *Stereocaulon paschale*, *Lecidea glomerulosa*, etc.) are widespread in different climatic-vegetational zones of the whole Holarctic.

The Multiregional element embraces species growing in the Holarctic as well as in other floristic regions and in extremely different zones and macro-ecotopes, thus differing from the omni-

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[1] *Anaptychia melanosticta* (Ach.) Trass = *A. ciliaris* var. *melanosticta* (Ach.) Boist.

[2] *Xanthoria isidioides* (Beltr.) Trass = *X. parietina* var. *isidioidea* Beltr.

Arctic-alpine, Omnihypo-Arctic-montane, Omninemoral and other species which can also be found outside the Holarctic.

Strictly local endemics are not found in Estonian lichen-flora. The only species occurring in a limited area of Estonia on the western islands and on the islands of Öland and Gotland is *Cetraria alvarensis*.

On the basis of the regularities of distribution on the local territory of Estonia one differentiates the following components: the northwestern-western, northwestern, northern, western-island, western, eastern and penetrating components. The lichen-flora of the eastern parts of Estonia is considerably poorer than that of the western islands. The eastern component embraces only 40 species, i. e. 40 species which have spread only in the eastern part of Estonia, whereas the western component comprises over 200 species. The penetrating component, which unites the species that are more or less uniformly distributed all over the territory of Estonia, embraces 220 species.

The approximate time of immigration of species into the territory of Estonia has served as a basis for the differentiation of cronants. There are Subarctic, Preboreal, Boreal, Atlantic, Subboreal and Subatlantic cronants.

Among the different elements various migrants, i. e. groups of species that have migrated into a given territory from more or less the same directions, predominate. Thus northern and western migrants predominate among the Arctic-alpine species while eastern migrants predominate among the Boreal species.

Each element is characterized by the occurrence of dominant ecological groups, i. e. ecants. Thus epilithic species predominate among the Arctic-alpine species on siliceous stones, boulders and rocks while epigeic species predominate among the xerocontinental species on calcareous soils (Table 2).

From Table 2 it appears that in Estonia epiphytic species predominate among lichens (227 species); next come epilithic species (272 species, living on siliceous stones, boulders and rocks); then come epixylic species (152 species).

STRUCTURAL ANALYSIS OF PLANT COVER AND CLASSIFICATION PROBLEMS

By V. Masing

The science of plant cover or, as it is called in the U.S.S.R., geobotany, has during its development, repeatedly changed its name and become a subject of more exact research. For quite a long time the term phytocoenology (the science of plant communities) has been used and it is considered a synonym to geobotany. Although the leading Soviet scientist in this field V. N. Sukachew favors "phytocoenology" as a more exact name, in practice and textbooks "geobotany" is more widely used, the latter having in western Europe a wider meaning.

In the course of time, especially during the past decades the concept of plant cover itself has changed. Previously, plant cover was often compared to a mosaic, which consisted of equal well-bordered small "stones" — plant communities. Such an analogy was quite expressive and useful in the initial period of geobotany. At present, especially in connection with expansive vegetation mapping, which covers entire countries, it has become clear that the above conception is too simplified. Depending on the scale, on the aim of the study and, of course, on the nature of the plant cover itself, we may distinguish various parts in the plant cover mosaic and each of them can often be rather conventionally defined. Furthermore, in temporal variability the parts of the plant cover are of very different stability and cannot always be defined without difficulty. All this has lead scientists to a rather opposite conception: the communities are looked upon as forming continuous rows, i. e. continuum, and the necessity of their sharp limitation has been rejected. As Dr. H. Trass indicates (1966) it is necessary to use both the first and second approach; and neither of them should be looked upon as absolute concepts. In the plant cover both sharp boundaries and gradual transitions exist. The geobotanist must be able to analyze both phenomena.

In comparison with the pre-war level of Estonian geobotany, which was mainly presented by the widely known T. Lippmaa school (Laasimer, 1961; Trass, 1961) and even in comparison with the situation of 10 years ago, present day Estonian geobotany has made considerable progress.

In the plant cover we distinguish both in space and time various details and phases, each of which is in its turn divisible. The plant cover has, as it is now usually said, a complicated structure and the first task of the vegetation investigator is to analyze this.

Table 1.

Research Objects of Geobotany and their Classification Units

Objects	Classification Units of the Objects	
	Typological	Regional
Populations	Types of populations	—
Ecological-Phytocoenological Groups of Species	Coenotypes Types of Dominants Life Forms	—
Parts of Morphological Structure of Phytocoenoses (Strata, Synusiae, Microgroupings)	Societies Unions	Regional Facies of Union
Parts of Functional Structure of Biocoenoses (Consortia etc.)	Types of Consortia	—
Phytocoenoses and Stages of their Development	Associations Association-Groups etc.	Regional Units Basing on Distribution of Associations etc.
Phytocoenoses Groups, Complexes etc.	Succession Types Site Types Complex Types	Regional Units Basing on Distribution of Complexes
Vegetation Zones	Zonation Types	Vegetation Zones
Phytogeosphere	—	Regional Division of Vegetation of the World

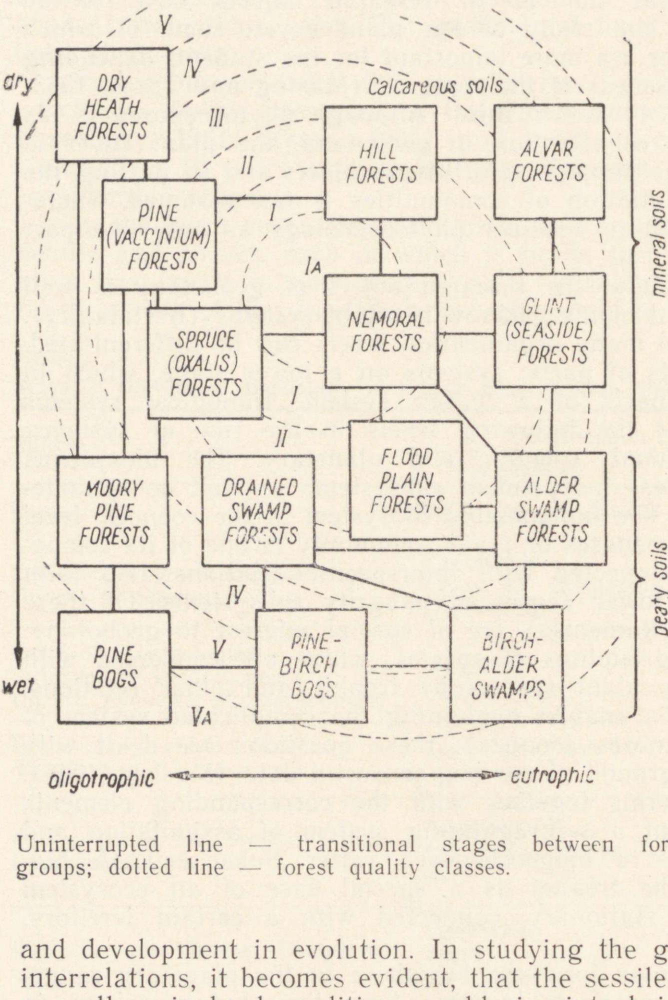
Evidently a great number of research objects have to be distinguished during the study of the plant cover, some of which at one time or another are more important for the student, depending on the aim and preciseness of the research (Masing and Trass, 1963; Trass, 1966). Table 1 shows this. Although phytocoenoses is, as before, in the center of attention in geobotany, the plant cover is often studied from the standpoint of other objects and in putting the question so a differentiation of communities is not assumed. Therefore it is quite logical to consider phytocoenology as only one part of plant cover study.

The differentiation of the research object of geobotany is well understood in the light of the general theory of systems (Bertalanffy). In nature, systems on many organization levels can be differentiated, each of which consists of parts: systems on a lower stage, which in their turn are the parts of a higher system. Biological systems (biosystems) embrace the following levels in the row of systems: organismal, populational, coenotic and planetary. The biosystems have some more or less independent subsystems as well as nonindependent components. The fundamental biosystem of the coenotic level is biocoenoses; phytocoenoses or plant community is one of its components. Populations connected with interspecific relations also form some others with a lower degree of integrity subsystems. Of these consortia (a term of Ramenski) are of special interest to geobotany: they are functional groupings of species, which are connected with a certain autotrophic plant species by trophic and other relations. The study of consortia enables explaining the complicated system of relations in a biocoenoses (connex); these questions are dealt with more closely on the ground of our bog-consortia data (Masing, 1966).

A biocoenoses forms together with the corresponding elements of abiotic environment a self-regulating system of assimilation and energy circulation — a biogeocoenoses (after Sukachew). A biogeocoenoses should be treated as a special case of an ecosystem (by Tansley), as a stationary, connected with a certain territory, ecosystem.

Like the biocoenoses form the biosphere in the planetary range, so also do the phytocoenoses together form the phytogeosphere (a Lavrenko term). The biogeocoenoses taken together form the biogeosphere of the Earth.

Several of the author's latest papers (Masing, 1968, 1969) attempt to specify the conception about biocoenoses as biosystems and about biogeocoenoses as the landscape elements, their structure



Uninterrupted line — transitional stages between forest groups; dotted line — forest quality classes.

and development in evolution. In studying the genesis of biocoenotic interrelations, it becomes evident, that the sessile biosystems in water as well as in land conditions could rise into being only at a certain stage of development.

As can be seen in the study of plant cover, we have to deal with a number of objects; therefore, of course, the necessity of explaining the relations between the objects lying in different levels, arises, and, on the other hand, of comparing the objects within the limits of one and the same level. The relations between the vegetation categories belonging to different levels and being, therefore, also of different size and of different degree of complication also develope differently in various physiographic conditions. This problem has been dealt with in Estonia in the physiographic and ecological research of bogs (Kurm, 1962; Masing, 1958, 1960, 1962, 1964) and forests (Masing, 1965, 1966).

As mentioned above, on the other hand, it is necessary to compare the vegetation categories of the same level between each other. As a result of this comparison, on the basis of certain recurrent characters a classification, i. e. their typology, is built up. Whereas the earlier phytocoenologists were engaged mainly in problems of classifying phytocoenoses (joining them into associations, formations, etc.), today's student of vegetation should elaborate various special classifications in connection with the different level of the objects and the different purposes of research. T. Lippmaa (1933) already elaborated the classification of synusiae (then they were called unistratal communities) for Estonia and, of course, sketchily, for the whole world's phytogeosphere (Laasimer, 1961). The general and special problems of classification of synusiae, especially lichenosynusiae, were dealt with by H. Trass (1955, 1964, 1965).

The old school of classification of plant communities has been developed by K. Pork (1964) and H. Karu (1957) on grasslands and by V. Masing (1958) and H. Trass (1958) on mires.

A classification embracing the plant cover of the whole republican territory and a fundamental description of vegetation morphology based on this, was given by L. Laasimer in 1965. In addition to this a simpler schematic division of plant communities together with identification keys is being used in vegetation mapping and in the university classes ("Field Botany" 1966, A. Marvet, 1968). All the above-mentioned classifications are principally phytotopological, i. e. as the elements for differentiating plant communities, the characters of their composition (floristic characters) and structure (phytocoenotic characters) are used as well as the features of the site or ecotope (ecologic characters). Higher taxa, as association groups and series, are to a large extent ecological and join the communities following each other in a succession. Association is defined as a type of community having a similar stratal structure and a close floristic composition which has been formed in similar site conditions. In a floristic comparison the dominants (the species dominating in the layers) as well as the determinants (indicator species of environmental conditions) are taken into consideration. The size of this basic unit of various authors is rather different because there are no objective quantitative criteria for distinguishing associations. Since we are looking for a more objective criteria of classification, the correlation method, recommended by Tuomikoski, has been used (Masing, 1958) and the criteria of mathematical statistics (Frey, Võhandu, 1966).

Table 2.

Sociations Described in Estonian Pine Bogs
(V. Masing and U. Valk, 1958)

Dominant of tree layer and density	Dominants of field layer	Dominants of moss layer			
		Sphagna (*Sphagnum angustifolium* etc., excl. *S. fuscum*)	Forest mosses (*Pleurozium Schreberi* etc.)	Lichens (*Cladonia* species, *subgenus Cladonia*)	Absent (Very thin layer)
dense ↑ Pine (as a raised bog form) *Pinus sylvestris* ↓ sparse	*Ledum palustre*	II	III	—	III
	Chamaedaphne calyculata	II	III	—	III
	Vaccinium uliginosum	II	III	—	III
	Vaccinium myrtillus	—	III	—	III
	Vaccinium vitis-idaea	—	III	V	—
	Calluna vulgaris	I	IV	V	IV
	Empetrum nigrum	I	IV	—	—
	Rubus chamaemorus	I	—	—	—
	A very thin layer	II	—	V	—

Sociations presented in the columns of the table belong to following associations: I *Pinus sylvestris — Calluna vulgaris — Sphagnum* Ass. II *Pinus sylvestris — Ledum palustre — Sphagnum* Ass. III *Pinus sylvestris — Ledum palustre — Pleurozium Schreberi* Ass. IV *Pinus sylvestris — Calluna vulgaris* Ass. V *Pinus sylvestris — Cladonia* Ass.

Pine-bog near Tōstamaa (south-western Estonia). (Photo H. Trass)

Grass layer of the spruce forest in Venevere. (Photo T. Frey)

In a collation phase, it has proved practical to distinguish sociations (i. e. communities differing from each other by only one dominant); but the difference in dominants is apparently of a too unstable character for the differentiation of fundamental units (Trass, 1963). The relation of sociations to the associations is shown in Table 2.

A characteristic feature of the Estonian geobotanical school, already beginning with T. Lippmaa's period, has been the connection of associations with site types. Hence it is quite obvious that vegetation mapping has played an important role as an illustrative method and in the educational process of our country as far back as 30 years ago.

Large-scale mapping of the republican vegetation, which was finished in 1958 (Laasimer, 1961), enabled us to start solving the problems of making regions, of which more details are given by L. Laasimer in this publication.

Further development of vegetation mapping led to the compilation of maps on still larger scales with the aim of a detailed mapping of nature reserves (Eilart and Masing, 1961 and 1966). In connection with this the problem of how to reflect successional stages and transitional communities on the map had to be solved (Marvet, 1968). Representation of the plant community complexes and other problems of vegetation mapping were also analyzed (Masing, 1962, 1963).

For applied purposes, simpler units than the associations, based on economical criteria are required, e. g. g r a s s l a n d, m i r e and f o r e s t t y p e s. Typology also has its unit hierarchy: subtype, type, type group, type class. Applied typology deals with the republican grasslands (Lillema, Laasimer, Toomre, 1957), mires (Masing and Trass, 1955; Trass 1963[a]) and forests (Karu and Muiste, 1958; Katus and Tappo, 1965; Masing, 1966).

Units used in forest typology are represented in the table 3 for the part of forests on mineral soils. Works on applied typology, especially on forest typology called forth by the practical needs, revealed various theoretical problems in the differentiation of types. Either the conception of biogeocoenoses or the theory of ecosystems have been recommended as a basis for typifying plant communities (Frey, 1969). The need to go over from the hitherto used double-dimensional tableschemes to the multidimensional models becomes evident ever more (Lõhmus, 1969; Masing, 1969). The mass data gathered in the course of the inventory of forests, enables the use of computer technique and mathematical methods.

Vegetational associations, or bog and forest types, are situated in the landscape as spatial series and in a temporal sequence. Therefore, regular combinations of plant communities, which as a whole are objects of geobotanical study have been formed in natural as well as in anthropogenic vegetation. The study of such complexes brings the botanist in contact with the landscape science. Only the first steps have been made in the field of typology of macrocomplexes. An attempt in this line is, for instance, distinguishing the types of bog complexes (Masing, 1960, 1968). Raised bogs are interesting because of their being excellent examples of biosystems on the coenotic level, or biogeosystems on the ecosystem level, which develop an extraordinary autonomy in regard to environmental conditions and a self-regulation during their formation, and are therefore able to stand thousands of years.

The larger the area of the vegetation complex under study, the more are the regularities of its structure influenced by regional geographic factors, the more apparent does its individuality or uniqueness become; the number of its parameters enabling a comparison with the other complexes of its kind, i. e. typifying, decreases. Classifying on typological principles, which was the main generalization method on the lower stages of geobotanical objects, is therefore on the higher stages even more substituted by regioning, i. e. by emphasizing the individual (regional) features of territories. Typifying and regioning as logical generalization methods are antagonistic in case of a big number of parameters. This antagonism disappears as soon as there is only one parameter as a basis for comparing territories, i. e. in arealization (Masing, 1968).

Table 3.

A Part of the Forest Typological Classification
(abbreviated from the "Field Botany" 1966)

Type classes	Type groups	Site types
A. **Mineral Soil Forests** Eutrophic	I Alvar Forests on limestone (Halbhainwälder)	1. Lichen-alvar type 2. **Arctostaphylos*-alvar type 3. *Corylus*-alvar type 4. **Hepatica*-alvar type 5. *Sesleria*-alvar type
	II Hill Forests on shallow calcareous soil (Osrücken-wälder)	6. *Antennaria* type 7. **Fragaria* type (*Hepatica* t.) 8. *Corylus* type
	III Nemoral Forests on deep rich soil (Hainwälder)	9. *Hepatica-Anemone* type 10. **Mercurialis-Aegopodium* type 11. **Dryopteris* type
	IV Flood Plain Forests (Auwälder)	12. *Mercurialis* type 13. *Filipendula* type
	V Glint (Seaside) Forests	
Oligotrophic	VI Heath Forests (Heidewälder)	14. *Lichen type 15. **Calluna* type
	VII Boreal Pine Forests (Boreale Kieferwälder)	16. **Vaccinium* type 17. *Dry *Myrtillus* type
Mesotrophic	VIII Boreal Spruce Forests (Boreale Fichtenwälder)	18. *Moist *Myrtillus* type 19. **Majanthemum* type 20. **Oxalis* type

* The types are differentiated in state forestation (Katus and Tappo, 1965).

Existence of integral logical classification principles does not only connect typological geobotany with regional, but makes it possible to connect them also with various biogeographical disciplines (arealogy) and fundamentals of theoretic geography.

In recent geobotany a differentiation according to the aims and objects of the study, can be recognized and, on the other hand, it tends to an integration and approach to the related sciences.

REVIEW OF ESTONIAN QUANTITATIVE PLANT ECOLOGY

By T. Frey

Historic Background

The early years of quantitative plant ecology were devoted to the problems of sampling, fidelity and homogeneity of plant communities. It is not surprising that the Estonian pioneer work on quantitative ecology by Prof. K. Regel (1921) was concerned mainly with these problems.

The generally unknown works of Dr. E. Markus (1925, 1929) were carried out on the transition zones between bogs and forests. His considerations on the ordination and dynamics of the communities may be termed as a pioneer ecosystem approach in world ecology, which led him to the definition of his "Naturkomplex" (1930).

Dr. G. Vilberg (1929) was the first ardent worker in the field of large-scale determination of plant population age distributions in alvar vegetation; Dr. A. Rühl may be acknowledged as one of the earliest investigators in studying the pH value frequency distribution for several communities, societies (1929, 1936) and single species (1936[a]).

Prof. T. Lippmaa concentrated his efforts on the quantitative description of spatial structure of the communities and discussed the minimal area and classification problems (1931, 1933). His associates and he expanded the structural and ecological approaches to a variety of communities.

After World War II the large-scale vegetation mapping of Prof. Lippmaa had to be continued. Therefore nobody found it possible to devote himself to the statistical aspects of vegetation study. However, some investigations related to the topics were carried out by our foresters.

Beginning with the methodical outline by Dr. V. Masing (1953), Estonian quantitative ecology was developed in depth and in width. He considered two ordination methods: the Ramensky (1938) one and an original procedure. His simple method of weighting the species composition according to the cover proportions of the ecological groups of bog and forest plants allowed him to get results very similar to the ordination obtained by the usage of the Ramensky method.

The next work, "A Guide to the Geobotanical Study of Swamps" by Dr. V. Masing and Dr. H. Trass (1955) was compiled to include as fully as possible a choice of quantitative methods accompanied by some theoretical considerations. This handbook is frequently referred to even now when the first four chapters of the Greig-Smith Manual are available in Estonian.

In 1958 Masing analysed his raised bog data once more in order to compare the properties of the three different approaches:

1) the structural analysis suggested by Lippmaa and Du Rietz (1930);

2) the Braun-Blanquet system;

3) the statistical approach on the basis of ideas of Tuomikoski (1942) and Ramensky (1938).

He concluded that the first was useful in giving a network of the smallest structural elements of the communities to be established; the Braun-Blanquet system turned out to be inappropriate, probably, due to relatively poor species composition of the examined bogs. By using the ecological groups of species, extracted from the interspecific correlation analysis, it was possible to ordinate the quadrats according to the succession due for melioration. The results were highly similar to the ordination of the data obtained earlier (Masing, 1953). He pointed out, however, that the taxonomical value of the communities identified this way must be questioned unless the information related to some other areas is available.

Among the works of ecological interest of Estonian foresters the following results should be mentioned. L. Muiste (1959) analysed the correlation of the stand mean age with stand density, mean d. b. h., mean height and standing crop in different Scotch pine types. T. Krigul (1959, 1961) used a variety of statistical methods in studying the structure of the tree layer in spruce and pine forests. Finally, Dr. U. Valk (1959) and his associates began a complex ecological study of peatlands (see also Valk, 1968).

It should be mentioned, however, that the role of the quantitative and statistical investigations in Estonian botany prior to 1959 was not very important, as one may conclude from the booklet (Botanical Researches in the Estonian S.S.R., 1959, Tartu), published in connection with the Montreal Congress, in which no special attention was paid to this topic. This booklet, meant for the Seattle Congress, already includes a special paper reviewing the recent trends and problems in Estonian quantitative ecology. Below the most interesting results obtained during the last decade will be mentioned.

Sampling Methods

Some reports, considering the sampling methods and their efficiency, were published by Dr. T. Frey (1965, 1966). He has also tried to develop a simple measure of spatial distribution patterns in frequency data (Frey, 1964) and to define a simplified concept, the pattern field, related to the pattern analysis. The pattern field is based on two variants, density and variance, both expressed as a proportion of the possible maximum (Frey, 1967, 1968). For the maximum possible variance a special formula was given.

Ordination Indices

The ordination of fertilized grassland successions according to the weighting proposed by Ellenberg (1954) was elaborated for local conditions (Krall, Liiv, 1965; Krall, Pork, 1966).

Trass (1968[d]) developed a similar system for lichen communities and demonstrated their ordination along the SO_2 concentration gradient from forests towards town centres.

J. Martin (1967) derived an index of competition effectiveness for the same purpose and used it in reflecting the interrelations of several lichen species in moraine successions of the Polar Urals.

Interspecific Correlation

In 1960 Masing continued the correlation analysis of his bog data by using the measure of interspecific association proposed by Katz (1948): $K = CS/AB$, where A and B are the numbers of occurrence of species a and b respectively, in the total number of quadrats (S), and C stands for the number of their joint presence. He got results that were in accordance with the ideas based on analysis of the *Sphagnum* cover dry mass productivity and stem growth.

However, it can easily be demonstrated that in the Katz K the actual C is expressed as a proportion of the $C_0 = AB/S$, the theoretical number of joint occurrence, provided the distributional patterns of the two species are statistically independent. Therefore, this ratio varies from zero up to S (e. g. if $A = B = C = 1$) and it is difficult to show the probability points for a given K value. With this in view, Frey (1966[b]), by considering the usage of Czekanowski's or Sorensen's $K = 2C/(A + B)$ in plant communities similarity analysis, found that, instead of ratio C/C_0, ratio C/C_p should be used. Here C_p equals the number of joint occurrence, corresponding to a P-quantile in χ^2 distribution with one degree of freedom.

In an earlier report Frey, by using the 2×2 contingency table approach as modified by de Vries (1953), found the ecological groups of species for some nemoral spruce forests (Frey, 1963). His objective was to determine the sociological centres of the *Oxalis* and *Pulmonaria* forest types; but he was forced to ignore the *Oxalis* type as such because no corresponding correlations appeared. The *Oxalis* type was considered as a residue of some neighbouring types under the circumstances of closed canopies.

Martin has been continuing the correlation approach by using Cole's coefficient in lichen communities (Martin, 1967).

On the other hand, Frey (1966) re-examined the data by van Groenewoud (1965) by using the C/C_p and $U = C(A + B)/AB$ ratios. On the basis of van Groenewoud's quadrats similarities, it was possible to compare the two ratios with the Mahalonobis D^2 and the Braun-Blanquet method. He concluded that, for the prupose of the Braun-Blanquet' system, the U coefficient is useful; but the C/C_p ratio is preferable in reflecting the quantitative relations.

Cluster Analysis

The search for suitable methods in establishing classification units was started in 1964 at the Tartu State University Computer Centre. The first program written by A. Laumets was essentially similar to the method of Sokal and Sneath (1963). The classification units based on 117 quadrats of nemoral spruce forests were extracted by Frey (1966) by using this program. These units were in accordance with the more subjective results obtained by the foresters (Ilves, 1966). In 1966 Frey and Dr. L. Võhandu published a new method, which differed from the above version by adding a criterion for completing a cluster. The corresponding program was written by S. Veldre and A. Laumets for matrices up to 256 objects.

A third program (Frey, 1969[a]) accounts for the phenogram bonds of the whole matrix. The program written by E. Vuurmann in MALGOL language for the Minsk-22 type of computer provides a straightforward pattern recognition solution of the matrices containing 500 objects. This program has been used for a variety of purposes including sociology, medicine, etc. In order to indicate the sensitivity of the method, Frey has attempted to use a continuously varying quadrat series already analysed by van Groenewoud (1965). The results were offered for interpretation by the author of the original data (Frey, van Groenewoud, in press.)

The methods of organizing large matrices (up to 2000 objects) are now under consideration by Võhandu.

Some results of analysing the plant ecological data were presented by Frey (1966[b]). The numerical taxonomy approach was demonstrated in a report by A. Raitviir (in press).

Mathematical Modelling

Dr. J. Ross and his associates have published a series of reports on the theoretical aspects of the photosynthesis in crops and communities (Ross, 1964, 1965; Ross, Nilson, 1963), on their geometrical structure (Ross, Nilson, 1963, 1965; Tooming, Ross, 1964; Tooming, 1966), on the radiation regime of crops (Ross, 1964; Tooming, Ross, 1964; Ross, Nilson, 1965; Tooming, 1966), on light adaptation of communities (Tooming, 1967[a], Tooming, Nilson, 1967), and on other related problems.

Community Theory

A review of the theoretical and methodical problems as understood by Estonian plant ecologists was given by Masing and Trass (1963). The development of Lippmaa's ideas was given by Trass (1955, 1961, 1964). He has also published some critical papers concerning the principles of vegetation classification (Trass, 1963[a], [b], 1965; Masing, Trass, 1968).

The continuum problems and the possibilities to ascertain the level of community integratedness have frequently been studied (Masing, Trass, 1963, 1968; Masing, 1965, 1968, 1969; Trass, 1965[c], 1966[b]; Laasimer, 1965; Frey, 1966[b], 1967).

The ecosystem as a self-regulating entity is dealt with only in reviews (Frey, 1966[c; d, e], 1969[a]; Masing, 1969).

Summary

The last decade was most favourable for Estonian quantitative plant ecology. Its progress is mostly due to Dr. L. Võhandu, the mathematician who lead the biologists to understanding a variety of mathematical procedures. His enthusiasm in organizing the biometrical investigations and in providing the computer facilities should be acknowledged.

As a result, the degradation if compared with the results obtained in World level of quantitative ecology has somewhat decreased. In some topics this level has been reached already, e. g. the mathematical modelling of photosynthesis, the cluster analysis etc.

The results of the decade were recently summarized on the Second All-Union Symposium of Quantitative Plant Ecology held in Tartu, Estonian S.S.R., April 8—11, 1969.

VEGETATION MAPPING AND DIVISION APPLIED IN PLANNING

By L. Laasimer

In the Estonian S.S.R. one of the most time-consuming works in the series of botanical researches has been the detailed study of plant communities and a large-scale vegetation mapping of the whole territory of the republic. The source maps have also been used in compiling a vegetation map of the Soviet Baltics in the scale of 1 : 600,000 and for several other small-scale maps.

The large-scale mapping of the Estonian territory was begun under the initiative of T. Lippmaa (Laasimer, 1961) and was continued and implemented by the Institute of Zoology and Botany of the Estonian Academy of Sciences. A number of specialists and students took part in the field works. A full vegetation analysis, the study of soil characteristics and of water regime was performed, and simultaneously the depth of the subsoil water level was measured specially in every vegetational unit with an area at least 0.25 km^2. In cases of more homogeneous vegetation the transects were done at 1-kilometre intervals; in cases of mosaic distribution of the plant community stands, the transects were taken at intervals less than one kilometre. As a basis for mapping, topographical maps were used and every different vegetation unit was studied separately.

Quite a number of vegetation types have been investigated with more detailed methods and on some places stationarily, e. g. the eutrophic mires of West Estonia, raised bogs, flood plain meadows etc., the results of which have been published in various papers (Masing, 1958, 1959, 1960, 1964; Kask, 1963, 1965; Karu, 1957; Pork, 1960, 1968; Valk, 1968 etc.).

The purpose of the vegetation mapping of Estonia was to show the actual recent vegetation as well as the potential natural one. The classification of the mapping units is based on the ecological features of the plant communities and is shown also in the name of the corresponding unit. For example, the units of the pine forests (*Pinus sylvestris*) group are: heath pine forests (or: pine forests on sandy soil), pine forests on peaty soil, alvar pine forests, hardwood pine forests, etc. The meadows consist of units as: dry and fresh meadows on calcareous soil, dry and fresh meadows on noncalcareous soil, peatland meadows on calcareous subsoil, etc. Every unit or plant community respectively occurs in connection with certain moisture conditions and fertility of soil, which is reflected in the floristical compound of their structural units (synusia). Knowing the indicative value of the plant communities, their potential degree of quality (fertility) for one or another purpose may be estimated. In the course of the field work the distribution of some protected or phytogeographically interesting species was, likewise, exactly registered and shown by off-scale symbols on the map. In elaborating the principles of mapping, the possibility of a many-sided application of the map was held in view. The possible use of the vegetation maps in various fields, especially in managing and planning the utilization of lands has been repeatedly dealt with in Estonian and Soviet botanical literature (Laasimer, 1960[a], 1962[a, b], 1964, 1966, 1967).

The vegetation of a few small regions of the Estonian territory has been mapped in detail (1 : 10 000 and larger), e. g. the plant communities of nature conservation areas. The theory of large-scale mapping, especially the problem of illustrating vegetation dynamics on maps has been dealt with in some papers of Masing, Eilart, Trass and Marvet (Masing, 1962, 1963; Eilart and Masing, 1961; Marvet, 1968).

T. Lippmaa's phytogeographical division of Estonia (Lippmaa, 1935) shows a distinct floristic boundary crossing Estonian territory from N-NE to SW-S. This line, or actually the long and narrow phytogeographical district (*Estonia interior*), extending from the vicinity of the northern coastal line to the southern frontier of our republic, and reaching even outwards to the Latvian territory, is a western boundary of many eastern species, and an eastern one of even more plants with a western area of distribution. This served T. Lippmaa as a boundary, distinguishing the two major phytogeographical subdivisions (provinces) on the Estonian territory, the eastern subdivision belonging to the Central Russian Province and the western one to the Central European Province, according to Braun-Blanquet, 1932. The boundary, mentioned above, was stated also by the author of this paper and was corrected with the help of the vegetation map (Laasimer, 1958, 1965). The interpretation of this line as a boundary between the western and eastern part (subprovinces) of the Baltic Geobotanical Province and the continuation of this line beyond the frontiers of the Estonian S.S.R. have been discussed in several papers (Laasimer, 1964[a], 1965). According to the author of this paper, the Baltic Geobotanical Province constitutes the deciduous-coniferous (mixed) forest zone in accordance with the views of Lavrenko and Sochawa (1950) or the western section of the boreo-nemoral zone in the sense of Sjörs (1963). The deciduous-coniferous forests of this zone differ from those of the southern taiga by their more "nemoral" character. The question about the phytogeographical divisions and the fixation of the limits between different districts were also raised in connection with compiling the vegetation map of the Soviet Baltics and were discussed by Sochawa, Isachenko and Karpenko (1960). A controversy arose around the question as to where to draw the boundary line between the zone of the deciduous-coniferous forests and the southern taiga forests. Sochawa, Isachenko and Karpenko solved it by drawing the limit through the Estonian territory around the western shore of the Peipsi Lake. Ahti, Hämet-Ahti and Jalas, in their paper (1968), base their vegetation zonation of North Europe in the eastern part of their map on the division of Sochawa and others (s. above). They equalize the southern taiga zone as well as the hardwood-coniferous forests zone with their hemiboreal zone, dividing it into meridional sections, while the author's Western Baltic Subprovince is equal to their slightly oceanic to indifferent section, with the Eastern Baltic Subprovince belonging to the indifferent to slightly continental section. The limit of the southern taiga zone has the character of a sectional boundary towards the West. This boundary line should be drawn along the depression of the Peipsi Lake basin which forms, with its wide belt of wet mires, raised bogs and glacial sands like a natural barrier to the extending taiga forests westwards.

The boundaries of some phytogeographical districts have been corrected in some floristic and phytogeographical researches of which, for example, the floristic monograph about the flora of the Hiiumaa Island by Rebassoo (Rebassoo, 1967) and Eilart's work about the distribution of the continental (the Pontic and Ponto-Sarmatian) floristic element in the Estonian flora (Eilart, 1963) may be mentioned here.

Taking into account the application of vegetation maps, especially in planning optimum land use, as in forestry and agriculture, the distinction of nature conservation areas, regions of recreation and of popular resort, in landscape designing, etc., Estonian territory has been divided into 8 districts and 87 microdistricts. The areas, characterized by the recurrence of certain vegetation types or their combinations (complexes), were connected into one district. Insofar as the vegetation types (plant communities) are restricted to certain sites, they also embrace different topographically characterized places in the landscape or, in other words, the plant communities (in the broad sense of the word) are typical parts of a landscape or of an ecosystem. Therefore, when a territory is divided on the basis of its vegetation, especially into smaller regional units, the division should be directed by the character of the plant communities, but should be limited by the landscape elements. A large-scale vegetation map is at the same time a map of the location of the landscape elements. This is also true for the Estonian vegetation map, which reveals the physiographical features of the moraine landscape. Thus, it is not by accident that the units of vegetational and landscape divisions of one and the same territory may be of similar configurations (compare Varep, 1961). A vegetation district or region, unique in its recurrance of landscape elements, climatic conditions and soils has also its typical economical aspect. Every unit (district) has its special character of management, depending on what role agriculture, forestry or other economic spheres of land useage play in it. The productivity of the cultivated lands can be valued by their yield and can be marked "bad", "satisfactory", "good" or "very good". Likewise the natural or actual vegetation, more or less influenced by man, can be evaluated by the fertility of its sites, which is expressed by the indicative qualities of the plant cover, thus allowing to draw a scale of potential productivity for every unit of division (district, microdistrict), which may be taken into account in planning.

A bonitation of the various districts and microdistricts of Estonia was carried out as follows. Every mapped vegetation unit was estimated according to its agricultural value (productivity) in a five-point scale, number I marking the best, V the poorest lands for agricultural purposes (Laasimer, 1962[b]). The same evaluation was also made according to the purposes of silviculture. The average of these estimates gives the mean value of the district in question.

The lands having a maximal potential fertility for agricultural purposes also mostly possess the best quality for silviculture. Agriculturally bad and poor lands, on the contrary, may be used in most cases with good results for afforestation with certain tree species, which are able to give a higher economical effect than in agricultural land usage. Thus, for example, some lands of southern Estonia having been used for a very long time for tilled crops, have a very low agricultural value, i. e. low fertility of the sandy moraines, which are very often suffering from erosion, but afforestated with pine (*Pinus sylvestris*) give stands at least of second class bonity. Some of them are suitable for grassland cultivation.

Some parts of the Estonian S.S.R. have already obtained the typical character of an industrial landscape (e. g. in the regions of the oil-shale industry), where the natural vegetation has almost entirely been destroyed. In the reconstruction work of these areas and designing greeneries, maps of the potential natural vegetation are of great value. Vegetation maps also help to reconstruct the plant cover of the areas, where under the intensive influence of Man, irreversible changes have taken place. In reconstructing the plant cover of intensively destroyed areas, the botanists work in collaboration with foresters and pedologists, especially in afforestating the opencast pits of oil-shale areas. The scientists of the Tallinn Botanical Gardens of the Academy of Sciences are engaged in solving problems of landscape architecture and planning greeneries and have published a series of papers on the subject (Niine, 1959, 1965; Mägi, 1968).

Lastly, the use of vegetation maps in nature conservation should be mentioned. Some rare and vanishing plant communities of specific character, which have been discovered during the field works and contoured on large scale maps should be taken under protection: e. g. a few typical stands of alvars, rich-in-species wooded meadows of western Estonia, relics of broadleaf deciduous forests.

Division of territories according to their vegetation is of great importance in determining the extent of the phytogeographical regions and districts, especially in the climatically transitional zones. The divisions serving these aims depend more or less also on the classification of the vegetational units (plant communities). The Estonian phytocoenologists, who neither support the opinion of the extremists of the continuum theory nor the opposite idea about the clearly distinguishable hierarchically classified plant communities, have begun research in obtaining objective criteria for the classification of the plant communities by using quantitative methods (see Frey in this booklet). On the other hand, Estonian phytocoenologists are continuing the traditions of Prof. T. Lippmaa in the research of vegetation with detailed synusial methods (Trass, 1955, 1958[b], 1963[a], 1964, 1965[b]; Masing, 1958, 1965).

EXPERIMENTAL RESEARCH IN DYNAMICS OF GRASSLAND PLANT COMMUNITIES

By K. Pork

Experimental researches in the transformations and permanence of grassland plant communities were begun in 1959 in the IZB. The main problem was to investigate the influence of fertilization on the successions of the grassland communities in relation to changes in soil conditions. Five of all fifteen experiments in fertilizing natural meadows lasted 8—14 years. The ecological amplitudes of the grassland plants and their allelopathic influences were studied simultaneously.

At the beginning of the research, it was taken for granted that the grassland phytocoenoses form relatively balanced (permanent) ecosystems providing the environmental conditions remain unchanged. Every grassland ecosystem consists of a number of species with different ecological valencies. The size of their populations is regulated by the interspecies competition in the plant community. As a result of this competition the relations between different species and ecological groups are regulated in such a way that the individual groups or individual species complement each other exploiting the environment to the utmost and the production of the phytocoenoses is close to the feasible maximum under the given conditions.

The reaction of the species to the environmental conditions is determined by their autecological amplitude which is in most of the plants comparatively wide. The experiments in growing grassland species in conditions of different nitrogen store (N — O — 160 g/m^2) show great differences in their autecological optima. Species (e. g. *Festuca ovina*) able of supplying themselves satisfactorily with nitrogen even at a low concentration in the soil have also a low saturation degree (optimum), whereas the yield does not increase on increasing the soil nitrogen consistency. Species (*Festuca rubra*, *F. arundinaceae*, *Poa pratensis*, *Alopecurus pratensis*, etc.) with a higher autecological optimum are also able to use a greater amount of nitrogen.

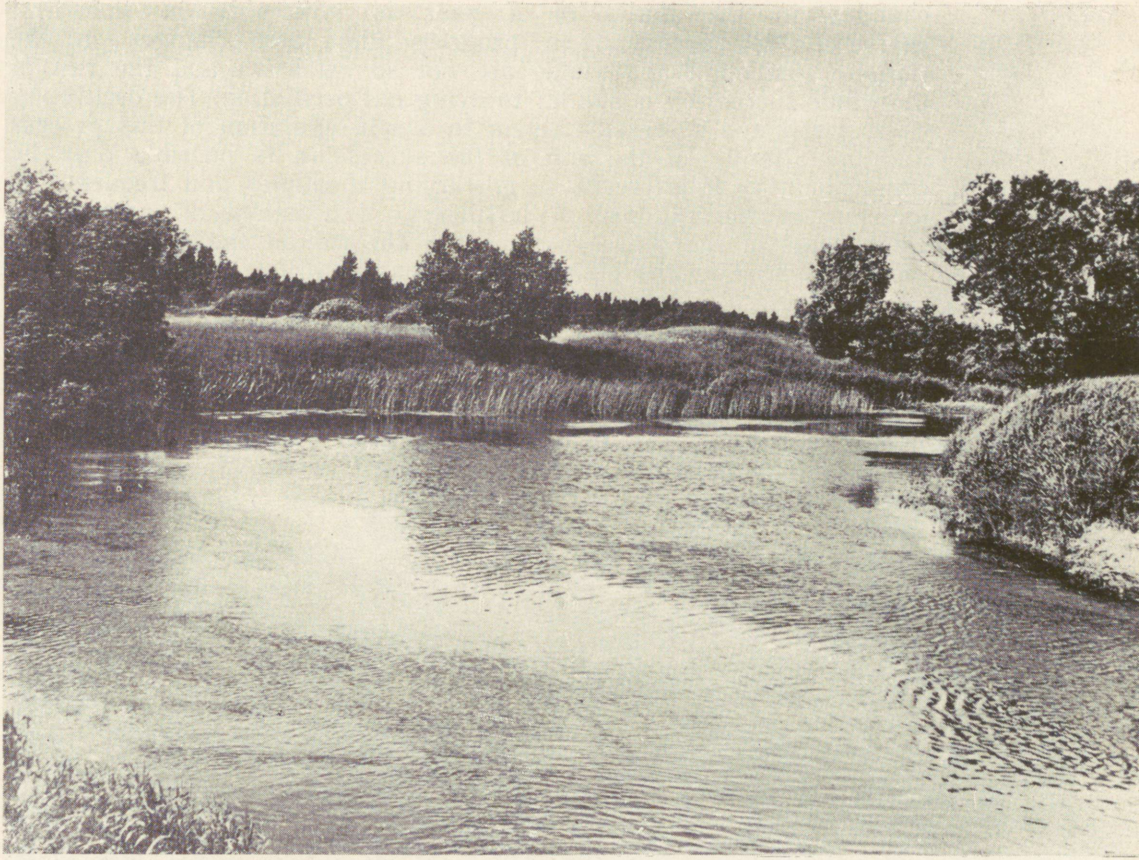
Experiments with mixtures of grassland plants, with one and the same amount of nitrogenous fertilizers, show that a certain species is able to grow and compete in a seed mixture successfully only in definite limited interval of its autecological amplitude; thereby its synecological optimum may differ from its autecological one considerably. The synecological range of a species and the position of its optimum depends on the competition capacity of the other plants growing in the same place (habitat). Hence, a plant may have different synecological ranges and optima while growing together with different attendant species.

The presence of different species and the size of populations in a phytocoenosis are regulated to a most considerable extent by limiting factors. The most important limiting factor in the Estonian natural meadows is the insufficiency of mineral nutrient elements in the soil; therefore the dominating species in these meadows have adapted themselves to a low level of nutrient element storage. As a result of a series of successive manuring during a protracted period, a new ecosystem is formed, corresponding to the higher level of the mineral nutrient elements supply. The approach of the succession to a state of balance requires a few decades.

With the purpose of explaining the run of the successions after manuring, annual counts were made of shoots on permanent plots in size of 0.04 m^2, of which there were 3—6 in each variant. At the same time the projective coverage of the species and the botanical composition of the grass cover was determined.

The changes in the plant cover during the experiments and the transformations in the environmental conditions (moisture, actual evapotranspiration, aeration and respiration of the soil and light, atmospheric moisture and temperature of the plant cover) and the action of some animal components of the biocoenosis were also studied. The most frequent variants of the fertilizers in the experiments were: $P_{60}K_{60}$, $N_{35}P_{60}K_{60}$, $N_{100}P_{60}K_{60}$ adding $P_{60}K_{60}$ every year and 20 tons of peat and dung compost every fourth year. In a few experiments higher amounts of phosphoric, potassic and nitrate fertilizers were also used.

The process of transformations in the floristic compound of the plant communities as a result of fertilizing is not linear. If some new factor, which heretofore was sufficient for storage level, becomes



The Põltsamaa River and its flood plain meadow. (Photo Ü. Tamm)

limiting (e. g. light), comparatively considerable changes take place in the quantitative relations of the species and the morphological structure of the sward. Such an important rearrangement in the plant community is followed by abrupt pauperization in the floristic composition and a decrease of the productivity. In the following process of stabilization the yield again increases until new and more considerable changes take place in the plant community. The range of the changes in the limits of a year is noticeable in the first years of the succession in progress; the later changes in the floristic compound and yields are not so extensive and the run of the whole succession is similar to dying out oscillation. The oscillating character of the succession refers to a self-regulation of this process and the altering of the run of the succession is possible only by complementary interference (e. g. varying the times and frequence of mowing, or the rations of fertilizers, destruction of undesirable components of the grass cover, etc.). The run of the successions is also influenced by the climatic conditions of different years.

In western Estonian natural meadows on calcareous soil in a grass cover, comparatively rich in species, where *Sesleria coerulea*, *Festuca ovina*, *Briza media*, *Brachypodium pinnatum*, *Molinia coerulea*, *Carex montana*, *C. pallescens*, *C. panicea*, *Scorzonera humilis*, *Potentilla erecta*, *Alchemilla vulgaris*, *Crepis paludosa* etc. dominate, many stunted in growth but "pretentious" grasses (e. g. *Festuca rubra*, *Poa angustifolia*, *P. pratensis*, *Festuca arundinacea*, *Dactylis glomerata*, *Phleum pratense*) and legumes (e. g. *Lathyrus pratensis*, *Medicago lupulina*, *Trifolium pratense*, *T. repens*, *Vicia cracca*, *V. sepium*) occur. The natural plant cover of the meadows is usually sparse and low and the degree of coverage is only 50—80%. The moss cover is usually well-developed.

During the first years of manuring, the abundance of the main part of the species of the natural communities increases, because the populations, legumes and the grasses with vegetative shoots (*Festuca rubra*, *Poa pratensis*, *Poa angustifolia*), adapted to a higher level of nutrient supply (fertility) increase most which, thanks to their vegetative propagating are able to occupy the free places more quickly. In a number of experiments the legumes became dominating in all fertilizing variants.

The maximum of the legumes was in the second till of the third fertilizing year; their abundance decreased abruptly in the following years. The action of a pernicious parasite nematode, *Heterodera trifolii*, living on them seemed to be decisive in the drop-out of the legumes from the grass cover. In the natural meadows the parasite occurs in micro-foci and does not spread en masse because of the mosaic distribution of the legumes in the grass cover. As a result of the increasing abundance of the legumes, the infection spread over the whole territory and the plants were destroyed by the nematode. In the experiments without the nematode infection, in the progress of the succession some legumes were replaced by others, and at least

Plant cover of a dry flood plain meadow. (Photo Ü. Tamm)

in the PK variant the legumes kept their dominating state for a protracted period.

Following the disappearance of the legumes from the grass cover the rootstock grasses, mainly *Festuca rubra*, gain a dominating position. A grass cover rich in rootstock grasses formed 3—5 years later. During this period the density of the grass layer increased considerably and expanded to 7000—9000 shoots per 1 sq. m., 2000—

4900 shoots of these belonged to *Festuca rubra*. The degree of coverage reached 92—98% and the height of the grass cover grew to 1.0—1.2 m. Due to the excessive density of the grass cover, competition for light became aggravated. The light was absorbed in the upper layers of the grass cover almost entirely and only 1.2—6.0% of the total light falling on the grass cover reached the soil suface. Furthermore, the transpiration conditions changed sharply: in the dense grass cover the dew remained until noon and the relative moisture in the lower layers of the grass cover did not fall below 90% until afternoon. This phenomenon proved to be unfavourable for a number of low plants, especially for the species with root-leaved rosettes, which were superseded by the grass cover. The moss cover disappeared completely at this stage of the succession.

Festuca rubra dominated in the grass cover for a short time and its abundance decreased abruptly beginning with the 5th to 8th year of fertilizing. The following changes in the floristic compound of the grass cover were not so much connected with domination of only one species; *Poa trivialis*, *P. pratensis*, *Agrostis tenuis*, *Festuca arundinacea*, *F. pratensis*, *Phleum pratense* and a number of legumes and other herbs, which had occurred in the preceding successional stages less abundantly were distributed nearly with equal abundance.

The light factor has the most decisive influence of the environmental factors in the process of the succession in the grass cover. The conditions of soil moisture change less because the actual evapotranspiration of the fertilized variants increases only 10%, whereas the yield rises 2.3—3.7 times. Therefore, the easily assimilable moisture stores are used up quicker in the habitats with insufficient moisture supply and the deficiency in moisture begins earlier than in the unfertilized areas, but the differences are not particularly large. At the same time in the fertilized variants the relative need of water for one yield unit decreases 1.8—3.4 times. This indicates, that the main part of the increase of the yield has been obtained by the more economical utilization of the avilable soil moisture. As a result of fertilation the osmotic pressure in different grassland plants drops to different degrees which might cause the change in the relations of species. Soil respiration increased on the fertilized plots 27—51%, but no special changes in the composition of the soil air were noticed on account of the improvement of the soil aeration conditions. In the laboratory experiments were organized for the study of the allelopathic influences of the grassland community sods, soil and individual species with the purpose to detect the possible factors affecting the run of the succession. The experiments with the seed mixtures revealed only a little allelopathic influence of most of the meadow plants upon other species; but among them there were more strongly affecting plants, e. g. *Anthoxanthum odoratum*, *Poa palustris and Festuca rubra*. The first of the above-mentioned has the strongest influence, in the roots of which the alkaloid coumarin, known as a growth inhibitor, is often accumulated. Experiments with the sods, taken from the grassland communities, showed that the extracts of the soil and sods of almost all of the studied communities influence the germination of the seeds and growth of the acceptor species; but their allelopathic influence is usually only slight. It appears that the allelopathic effects are of minor importance in comparison with the principal ecological factors as e. g. moisture, mineral nutrient elements and light, but they may be essential in single cases because of their selecting effects.

THE PHYTOCOENOSES OF CULTIVATED GRASSLANDS

By H. Krall

The rapid increase of importance of the cultivated grasslands in large-scale socialist agriculture in Estonia has been an object of constant attention of the scientists.

In the Department of Cultivated Grasslands of the Estonian Research Institute of Ariculture and Land Improvement (Prof. R. Toomre and Prof. A. Adoyan et al.) the agrobiological and economical aspects of the cultivated grasslands have been under investigation.

Since 1959, phytocoenological investigations on cultivated grasslands have been carried out in IZB.

Cultivated grassland is considered a biological system, the level of organization of which is a result of agronomic selection pressures having an influence upon the organisms of which it consists.

According to their origin and intensity of cultivation as well as the character of the sward, there is good reason for the division of all plant communities on cultivated grasslands into two major groups in the Estonian S.S.R.

I. Improved Grassland Communities

They include dry meadows and pastures, mostly of natural origin, on which a new plant community (improved grassland) of high productivity has been reclaimed by proper fertilization, utilization and management. In doing so, according to the higher fertility level of the habitats, a successional change of natural plant communities for the cultivated ones occurs.

From 1959—1965 formation of plant communities on improved meadows, dependent on the manuring of natural grasslands, has been investigated in long-term experiments. Investigations of successional changes and general regularities of the vegetation have been developed into an independent research field of experimental geobotany in the IZB (Krall and Pork, 1962, 1963, 1966; Krall and Haak, 1962; Pork and Hein, 1962; Liiv, Krall, Pork, 1965; Krall and Liiv, 1965; Hein, 1966; Kalda and Kannukene, 1966).

II. Cultivated Grassland Communities

A. Intensively Cultivated Grassland Communities

These include cultivated pastures and meadows of high productivity which have been based on arable land after a special mixture of grass seeds had been sown. They are subjected to a regular manner of fertilization and management. According to the duration of use a) cultivated temporary and b) cultivated permanent grassland plant communities may be formed. Among them, cultivated temporary sward development is particularly dynamic and such communities which consist of short-term populations are distinguished by an insufficient self-regulating mechanism. The cultivated permanent grassland plant communities, however, may be characterized by having relatively constant dominants and they possess a well-established self-regulating mechanism, due to which their durability is not dependent on continuous cultivation (plowing). The possibility of introduction of volunteer plant species is inversely proportional to the sward density and continuity of management. Interplant competition in a grassland sward as well as the formation and structure of a community are likewise affected by other components of the ecosystem such as parasitic fungi, bacteria, viruses, insects, nematodes, etc.

B. Semicultural Grassland Communities

The semicultural grassland communities are considered as long-term pastures or meadows based on forage crop rotations (red clover and timothy). Forages used for pasture generally decline in productivity two to four years after their establishment and thereupon the following changes may be observed: a) regressive

Point-method in the study of the floristic composition of the grassland swards. (Photo H. Krall)

successional replacement when less desirable species (*Agrostis tenuis* and forbs) volunteer into a pasture corresponding to the fertility of the habitat and possibilities of such an introduction of plants from natural habitats; in such cases it becomes necessary to plow the grassland; b) re-establishment of a cultivated plant community by sowing the more desirable species and continuous environmental control (fertilization and management) of vegetative growth.

In the early stages of development of cultivated permanent pastures, an original sward consisting of 5—8 or even fewer cultivated grasses and legumes with some arable weeds is formed as early as the end of the first seeding year. Therefore, a characteristic phytocoenotic environment and interrelations between organisms, living together, are established.

The leading group (the "skeleton") of a sward consists of a small number of cultivated dominant species or cultivars, i. e. domi-

Alvar-vegetation on the island of Kõrgelaid (near Hiiumaa). (Photo H. Rebassoo)

nant species accompanied by stabilized (buffer) species. In cases when sown species do not fit the community ecologically and biologically and they are heavily affected by plant pests and/or the pasture is overgazed, years of depression follow due to the insufficiency of the self-regulating mechanism, lability and partially coenotic closeness of the community. According to their phytocoenotic nature, the initial stages of formation of cultivated communities should be regarded as unsaturated cultivated groupings or labile plant communities. Only after a protracted period of time (5 to 10 years) does the specific and coenotic closeness of the community increase; the development of the community passes through several stages and, therefore, a saturated plant community — phytocoenoses with a special composition and structure respective to its habitat and management forms. It is characterized by a dynamic balance and a sufficiently self-regulating mechanism. Rapid changes, resulting in a

Herb layer of the spruce-hardwood forest in Venevere Ecological Stationary (north-eastern Estonia). (Photo T. Frey)

formation of plant communities on intensively cultivated grasslands and especially on pastures (e. g. they occur several times more quickly than in cultivated forest stands), are caused by intensive rotational grazing pressure, which also limits the number of the species and affects the competitive interrelations of a species. The sward of long-term (more than 40 years) cultivated pastures in Estonia (mainly Ass. *Poa pratensis — Trifolium repens*) consists of 15—25 plant species, the tiller density of which in such homogenous communities reaches 5.000—12.000 per 1 sq. m. Some 7—10 mainly antropophytic species belong to the system of the dominants-stabilizers (buffer species) of the community. The rest of the species is mainly apophytic and of volunteer character.

In most cases among the grasses *Poa pratensis* and *Festuca rubra* should be mentioned as compulsory dominants in plant communities of permanent cultivated pastures in Estonia. Both of them endure periodic defoliation well, show an intensive recovery during vegetation and possess a wide range in relation to the environmental

The bank of the island of Kesselaid. (Photo H. Rebassoo)

conditions. As a compulsory dominant among the herbs with the exception of alvars, the dandelion (*Taraxacum officinale*) should be mentioned. *Poa trivialis*, *Dactylis glomerata*, *Agrostis tenuis*, *Trifolium repens*, *Achillea millefolium* are optional dominants on cultivated pastures. A list of adventitious dominants, prevailing in conditions particularly favourable, contains such species as *Agropyron repens*, *Festuca pratensis*, *Medicago falcata* (on alvars), *Alopecurus pratensis*, *Carum carvi*, *Leontodon autumnale*, *Deschampsia caespitosa* and *Festuca ovina* (on alvars).

When a definite successional phase and a dynamic balance has developed in a cultivated community, different associations may be distinguished; but criteria quite different from those used for natural ones are necessary in distinguishing and classifying such communities. The following circumstances should be taken into consideration: 1) the initial composition of seed mixtures and the possibility of the introduction of aggressive species in the first and subsequent years; 2) environmental factors and management system: a) soil fertility, especially nitrogen content from high to the moderate level; b) water supply; c) management (mowing, grazing); d) stability of agricultural measurements; 3) the period required for the successional stages.

In 1966—1968 the author compared some methods in determining the composition and structure of vegetation on several permanent cultivated pastures (Krall, 1968). The point quadrat method proved to be the most suitable one in determining the botanical composition, structure and species frequency of plant communities.

Long-term planning in the IZB foresees researches on regularities of the spatial structure and ecological regulation of grassland plant communities.

THE PRINCIPLES OF BOTANICAL NATURE CONSERVATION

By H. Rebassoo

Estonian botanical nature conservation dates back to the past century, being then casual and limited to certain kinds of regulations in forest parks and to recording rare species (Luce, 1823; Schmidt, 1854, 1855, etc.). Actual nature conservation, including the protection of botanical objects, was begun in the 1920's. The first botanical reserves were: Harilaid Peninsula in the Saaremaa Island established in 1924; the yew (*Taxus baccata*) reservation on Hiiumaa Island established in 1925; the reservation of broad leaved deciduous forest on Abruka Island (in the vicinity of Saaremaa) established in 1930. There were already 47 permanent reserves in Estonia in 1940, 6 of them plant reserves. 26 rare plant species were also taken under protection (Vilberg, 1929[a]; Vilbaste, 1938). In this period Prof. T. Lippmaa and Dr. G. Vilbaste supervised the botanical nature protection in Estonia.

In those years the plant cover of several nature reserves was also studied and the habitats and localities of rare plant species were described (Eichwald, 1932, 1934, 1936, 1937, 1940; Fromhold-Treu, 1939; Lippmaa, 1935[a], 1935[b], 1937, 1939; Lunts, 1937, 1938; Pastak, 1934, 1935; Viirok, 1931; Vilberg, 1929, 1931; Vilbaste 1937, 1939, 1940, etc.).

As a result of the Second World War nature conservation and its organization was interrupted until the 7th of June 1957, when a general Nature Conservation Bill was enacted by the Supreme Soviet of the Estonian S.S.R. With this Bill and a number of resolutions of the Council of Ministers in 1958—1959, a basis was laid to Estonian nature conservation. The reasons for the protection of individual objects and areas were presented in a pamphlet "Nature Conservation Problems in the Estonian S.S.R." (Eichwald, Kumari, Orviku, 1953); the tasks and instructions for botanical research in the national reserves were published in the "Nature Conservation Bulletin" No. 1 (Eilart, Masing, 1959, 1961).

Four national reserves were established in the republic: Viidumäe in the western part of the Saaremaa Island with an area of 593 hectares; Vaika Isles in the vicinity of the western coast of Saaremaa with an area of 35 ha; Nigula, Pärnu district in south-western Estonia, 2730 ha; and Matsalu, around the Matsalu Bay in west Estonia, Haapsalu district, area of 13,900 ha, to which a protective area of 37,000 ha has been added. Beginning with 1962 the Matsalu Reserve was added to the European A-group conservation areas. Of these national reserves 2 are botanical — Viidumäe and Nigula; Vaika Isles and Matsalu Reserve are ornithological ones although some botanical research work there is also carried out.

The most outstanding Estonian botanical reserve which is likewise of All-Union importance, is Viidumäe as a place of occurrance of many rare and relic plant species and communities. The plant communities in the Viidumäe Reserve are manifold: many types of spruce forests, alvar forests, heath pine forests occur there, but also mixed hardwood and pine forests, of which those with oak in the undergrowth are especially rare. These forests are spread mainly on the terraces and plateau of the Saaremaa Central Upland. On the foot of the elevation the rich-in-species plant communities of spring fens, fens, raised bogs and park meadows are encountered.

The Central Upland is the oldest area of Saaremaa, which began to rise above the sea-level about 8000—9000 years ago. Consequently this part of Saaremaa was the first place where many rare and relic species of the subarctic and subatlantic climatic periods found a refuge. At Viidumäe and in western Saaremaa 3 species grow that are not found elsewhere in the Soviet Union: *Juncus subnodulosus*, *Rhinanthus osiliensis* and *Sorbus rupicola*. *Rhinanthus osiliensis* is a neoendemic of Estonia which developed in the west Saaremaa spring fens. Besides the three species mentioned above, some very rare plants for other parts of Estonia, e. g. *Hedera helix*, *Pinguicula alpina*, *Gymnadenia odoratissima*, *Cephalanthera longifolia*, *Vicia lathyroides*, *Cypripedium calceolus*, *Oxytropis pilosa*, *Vicia cassubica*, *Hypericum montanum*, etc., grow in the Viidumäe Reserve. Besides these *Equisetum scirpoides*, *E. trachyodon*, *Anacamptis pyramidalis* and *Iris sibirica* grow in the neighbourhood of the Viidumäe Reserve. More than 500 species which grow on the 593 hectares of the Viidumäe Reserve comprises $^{1}/_{3}$ of Estonian flora.

There is a herbarium at the Viidumäe Reserve consisting of

Forest reserve in north-east Estonia (Heinasaar). (Photo F. Jüssi)

approximately 1000 leaves and continuous phenological and microclimatic observations are made. A large-scale map of Viidumäe plant communities and soil has been drawn; permanent quadrats have been established to follow the successions of plant communities and to study the ecology and biology of the plant rarities. Some concise papers have been published on the plant cover of the Viidumäe Reserve (Eichwald, 1960[a]; M. Reitalu, 1963, 1968[a]).

Nigula Reserve is a forest and raised bog reserve. The relations between forest and raised bog, raised bog vegetation accommodation, peat formation and its properties and the development of "bog islands" are being studied as well as the possibilities of guaranteeing

Vegetation of the broad leaved deciduous forest on the Hanikatsi Island (near Hiiumaa). (Photo J. Vilbaste)

steady and qualitative harvest of wild berries (especially cranberry), hazel nuts and mushrooms (L. Ruus, H. Vilbaste, 1968).

The Vaika and Matsalu reserves have been studied botanically by scientific institutions. In the reed-beds of the Matsalu Reserve, extending over 3000 hectares, the regeneration and biology of the reed is being studied (Margna, 1968). The halophilous and flood plain meadows were investigated by K. Pork (1968), the little islets in Matsalu Bay by U. Sepp (1966, 1968). The problems of preserving the park meadows and the relations between meadows and forests were also dealt with. The changes in flora and vegetation of the Vaika Isles were studied in 1935—1960 (Rebassoo, 1968).

In addition to national reserves, where there are full staff of workers, 28 botanical, botanical-zoological, ornithological, geological and landscape reserves have been established. The latter have no

The Estonian biggest oak in Urvaste (south Estonia). (Photo H. Rebassoo)

permanent personell and nature protection is guaranteed only by enacting respective regime in them, e. g. by prohibiting cutting, mowing, pasture, etc. Three of these are botanical reserves of rare plants, especially orchids and meadow plant communities in Tagamõisa park-meadow in north-western Saaremaa; Halliste park-meadow in western Estonia, a reserve of the rare in recent days in Estonia park-meadow with oaks, flood plains and rare plant species, and the Koiva wooded meadow in south-eastern Estonia, a reserve of an oak-meadow on the flood plain and rare plant species of the steppe origin.

There are 9 botanical-zoological reserves to protect the plants of coastal dunes, broad leaved forests, also oak woods, park-meadows with oak, fens and raised bogs, several forest types and the mineral islands on raised bogs. Several summaries have been published (Hein,

Hydrocotyle vulgaris on Saaremaa Island, a plant under nature protection. (Photo H. Rebassoo)

1965; Kaar, 1964; Kask, 1959; Marvet, 1963, 1967; Rebassoo, 1961, 1967, 1968; Reitalu, 1965) on the flora and vegetation of local reserves.

Legislative resolutions, a list of the national reserves and of objects subject to protection and their descriptions are given in the handbook "Fundamental Materials on Nature Conservation" (1959) and "Nature Conservation in the Estonian S.S.R." (1960).

Estonian flora contains a great number of rare plant species whose area boundaries cross the republic's territory. They belong to various floral elements and their immigration took place at various post-glacial climatic periods. 50 of these species, the so-called natural monuments, have been taken under protection; 9 decorative plant species have been added to them.

These 59 plant species under protection have been divided into 11 groups according to their area boundaries, manner of occurrance, degree of rarity and origin: 1) species with northern boundary in

Estonia (*Oxytropis pilosa*, *Vicia cassubica*, *Radiola linoides*, etc.); 2) species with a relative or absolute north-eastern boundary in Estonia (*Taxus baccata*, *Cephalanthera longifolia*, *Hedera helix*, *Eryngium maritimum*, etc.); 3) species with the north-western boundary of their distribution area in Estonia (*Arenaria stenophylla*, *Alyssum Gmelini*, *Silene chlorantha*, etc.); 4) species having the western boundary of their distribution crossing Estonia (*Silene tatarica*, *Moehringia lateriflora*); 5) species with southern boundary in Estonia (*Cerastium alpinum*, *Rubus arcticus*, *Pinguicula alpina*, etc.); 6) species with eastern boundary in Estonia (*Hypericum montanum*,

Estonian endemic, *Rhinanthus osiliensis*, in the Viidumägi Nature Reserve. (Photo H. Rebassoo)

Cephalanthera rubra on the Laelatu Meadow Reserve. (Photo H. Rebassoo)

Rhynchospora fusca, *Ajuga pyramidalis*, etc.); 7) species with an absolute or relative south-eastern border line in Estonia (*Cochlearia danica, Lathyrus maritimus*); 8) rare species having no areal boundaries in Estonia (*Equisetum scirpoides*, *Cephalanthera rubra*, *Malus silvestris*, etc.); 9) rare endemic species in Saaremaa (*Rhinanthus osiliensis*); 10) a rare naturalized tree of Saaremaa (*Sorbus rupicola*); 11) decorative plants not for sale or picking (*Cypripedium calceolus*, *Gentiana pneumonanthe*, *Iris sibirica*, *Gladiolus imbricatus*, *Daphne mezereum*, *Nymphaea alba*, *Nymphaea candida*, *Helichrysum arenarium* and *Jovibarba sobolifera*). The first ten groups consist of species

Anacamptis pyramidalis in the Abruka Nature Reserve. (Photo H. Rebassoo)

that are not found in more than 20 scattered localities; but there are species among them hitherto registered only from 1—2 localities. In addition to the three afore-mentioned species growing in the Viidumäe Reserve, *Cochlearia danica* is of All-Union importance. Much attention has been paid to the research of single protected plants. This was summarized in a booklet "Rare Protected Plant Species in Estonia" (1965). Several works deal with the question of distribution, habitats, ecology and the recent state of localities of the plants under protection (Eilart, 1957, 1963; Muuga, 1964; Rebassoo, 1959, 1967; Vilbaste, 1960). The results of detail research have been published about the following species: *Taxus baccata* (Eilart, 1962); *Rhinanthus osiliensis* (Eichwald, 1960[a]); *Rubus arcticus* (Eichwald, 1959; Eilart, 1965); *Sorbus rupicola* (Eilart, 1965[a]; Reitalu, 1968); *Radiola linoides* (Rebassoo, 1960).

Protection of rare plants can be put into practice in three ways: 1) by nominal protection, 2) by establishing special reserves, e. g. in Viidumäe or 3) by designing little sanctuaries or "micro-reserves" for species with only 1—2 localities in Estonia, or in some part of the republic. Of these principles two have already been used in Estonia and the 3rd has just been started. In addition to the republican national reserves, reserves of local importance have been established in every district, e. g. on the Hiiumaa Island a part of forest for the protection of *Taxus baccata* and *Hedera helix*.

Besides national and local reserves there are rare species growing in intensively exploited places, e. g. in places to be drained or cut over, e. g. forests, places used as popular resorts, sand and gravel pits etc. Today the problem of protecting the natural areas endangered by cutting or melioration is practically solved, because all the respective works and projects must be coordinated beforehand with the authorities of the nature protection organizations. A very important basis for the protection of rare plants in practice is the large-scale mapping of their localities. These maps help the meliorator and designer to avoid the destruction of these species when intensive land shaping is conducted. The plant communities, which should be reserved in their natural aspect constitute a special problem. The establishing of nature reserves for scientific research work, both temporary and permanent, in all characteristic types of Estonian vegetation according to the IBP program is under progress.

The relic and rare species mentioned above are protected as natural monuments. In the contemporary nature conservation the classical rules and tasks of protection are combined with new and definite ones. Of course, this is connected and cannot be conducted without special knowledge about the plant resources and their reasonable usage according to the IBP program. The detailed research of the plant cover is of importance in order to avoid harmful processes which destroy the natural relations of the plant communities to the corresponding environmental factors (Eilart, 1967). This way we can retain and increase the recreative importance of the plant cover even on such a small territory as the Estonian S.S.R.

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Trass, H. 1968. Analysis of the Lichen-Flora of Estonia. Dissert. in Tartu St. Univ. (Russian.)

ADDRESSES

Eichwald, Karl, Professor, D. Sc. — Flora of the Estonian S.S.R. (Taxonomy and phylogeny, especially *Rubus, Cyperaceae*), phytogeography, nature conservation. TU.[1]

Eilart, Jaan — Floristics, phytogeography (especially Pontic and Pontic-Sarmatian elements of flora), nature conservation. The Estonian Society of Nature Conservation. — Tallinn, 15 Tatari St.

Frey, Toomas, D. Sc. — Quantitative plant ecology, ecology of spruce forests, biometrics. IZB.[2]

Kalamees, Kuulo, Cand. Biol. — Mycology (taxonomy, ecology and coenology of *Agaricales*). TU.

Kalda, Aino, Docent, Cand. Biol. — Plant taxonomy, bryology (taxonomy, ecology). TU.

Kannukene, Leiti — Bryology (taxonomy of *Musci*). IZB.

Kask, Maret, Cand. Biol. — Plant taxonomy (especially *Labiatae*, *Scrophulariaceae*). IZB.

Krall, (Karu) Heljo, Cand. Biol. — Grassland ecology, plant taxonomy (*Salicaceae*). IZB.

Kukk, Erich, Docent, Cand. Biol. — Algology (taxonomy, especially *Cyanophyta*, *Chlorophyta*). TU.

Kuusk, Vilma, Cand. Biol. — Plant taxonomy (*Cruciferae*, *Polygonales*). IZB.

Kõvask, Viive, Cand. Biol. — Algology (taxonomy of *Conjugatophytina*). IZB.

Laasimer, Liivia, Professor, D. Sc., Chief of the Department of Botany of IZB — Vegetation mapping, ecology bryology (especially *Hepaticae*), plant taxonomy. IZB.

Lellep, Elli — Flora of the Estonian S.S.R. (especially *Artemisia*). TU.

Masing, Viktor, Docent, D. Sc. — Plant ecology (general theoretical problems, structure of plant communities, especially of forests and raised bogs), biogeography. TU.

Nilson, Eva — Lichenology (chemotaxonomy, phytochemistry). TU.

Paivel, Aleksei, Cand. Biol. — Dendrology. Botanical Gardens of the Academy of Sciences of the Estonian S.S.R., — Tallinn 19, 44 Kloostrimetsa tee.

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Parmasto, Erast, D. Sc. — Mycology (taxonomy and ecology of *Aphyllophorales*). IZB.

Piin, Taimi — Lichenology (taxonomy, especially *Lecidea*, *Pertusaria*, *Ochrolechia*, sterile crustose lichens). TU.

Pork, Kaljo, Cand. Biol. — Grassland ecology. IZB.

Pork, Maia, Cand. Biol. — Algology (taxonomy and ecology of diatoms). TU.

Põldmaa, Peeter, Cand. Biol. — Mycology (especially mycophilous fungi). IZB.

Raitviir, Ain, Cand. Biol. — Mycology (taxonomy of *Discomycetes* and *Tremellales*, phytopatogenous microfungi), biometrics. IZB.

Rebassoo, Haide-Ene, Cand. Biol. — Biogeography (especially the formation of the flora of islands), nature conservation, flora of Estonian S.S.R. (*Liliaceae, Taraxaca* of the section *Palustria*). IZB.

Remmel, Alide — Floristics (adventive flora). TU.

Sõmermaa, Anne-Liis — Lichenology (ecology of lichens, statistical methods). TU.

Talts, Silvia, Cand. Biol. — Plant taxonomy (especially *Araliales*, *Caryophyllaceae, Leguminosae*), bryology (especially *Sphagnales*). IZB.

Toom, Jaan, Cand. Biol. — Algology (selection of algae, algal cultures in organic wastes), biological treatment of waste waters. TU.

Toom, Maie, Cand. Biol. — Algology (cultures of *Chlorella*). TU.

Trass, Hans, Docent, D. Sc., Chief of the Department of Plant Taxonomy and Ecology of the Tartu State University — Plant ecology (general theoretical problems, structure of plant communities), lichenology (taxonomy and ecology of especially *Cladonia*, *Physcia*). TU.

Viljasoo, Linda — Plant taxonomy (especially *Gramineae*, *Salicaceae*). IZB.

ФИТОТАКСОНОМИЯ, — ГЕОГРАФИЯ И — ЭКОЛОГИЯ В ЭСТОНСКОЙ ССР. На английском языке. Издательство «Валгус». Таллин, Пярнуское шоссе, 10.

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