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SILVA FENNICA

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ON

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ACTA FORESTALIA FENNICA. Sisältää etupäässä Suomen metsätaloutta ja sen perusteita käsitteleviä tieteellisiä tutkimuksia. Ilmestyy epäsäännöllisin väliajoin niteinä, joista kukin yleensä käsittää useampia tutkimuksia.

SILVA FENNICA. Sisältää etupäässä Suomen metsätaloutta käsitteleviä kirjoitelmia ja pienehköjä tutkimuksia. Ilmestyy epäsäännöllisin väliajoin.

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ACTA FORESTALIA FENNICA. Innehåller vetenskapliga undersökningar rörande huvudsakligen skogshushållningen i Finland och dess grunder. Banden, vilka icke utkomma periodiskt, omfatta i allmänhet flere avhandlingar.

SILVA FENNICA. Omfattar uppsatser och mindre undersökningar rörande huvudsakligen skogshushållningen i Finland. Utkommer icke periodiskt.

SILVA FENNICA
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FOREST TYPES AND FOREST ECOSYSTEMS

HELSINKI 1960

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Preface

In connection with the International Botanical Congress in Montreal August 19—29, 1959, a well attended Symposium on Forest Ecosystems was held. As a preparation for this symposium, at which I had the honour to act as Chairman, eighteen mimeographed papers were distributed among the participants. The papers principally dealt with the question of finding a common platform for the different schools of forest types and forest ecosystems. As is well known, we in Finland are very interested in this field of science and many papers on forest types have been published in inter alia Acta Forestalia Fennica during recent decades.

It is now fifty years since A. K. Cajander published his treatise on forest types, a study that to-day is considered one of the classic works on forestry. The Forestry Society of Finland has decided to celebrate this fiftieth anniversary by publishing in this 105th volume of Silva Fennica the above-mentioned preparatory papers together with a summary of the proceedings and discussions of the symposium. For this generosity I wish to thank the Society. In this connection it must be mentioned that the major part of the bibliography has been compiled by Prof. V. J. Krajina (Vancouver) and the bulk of the discussion by the industrious secretary of the Symposium, Dr. J. S. Rowe (Ottawa); the editor of this volume is Prof. L. Heikurainen.

A more detailed account of the background of the Symposium is given in my introductory talk at the Symposium, see p. 105.

We hope that this volume will serve to increase international cooperation in forest botany and lead to a better coordination of the work on forest types and ecosystems.

Helsinki, November 1959.

Ilmari Hustich

Contents:

Können wir eine gemeinsame Plattform für die verschiedenen Schulen in der Waldtypenklassifikation finden?

Erwin Aichinger[1]

Ich befasse mich mit dieser Frage von zwei Richtungen: 1. Als praktisch tätiger Forstmeister vom Gesichtspunkt moderner forstwirtschaftlicher Arbeit und 2. Als Fachbotaniker.

Als Forstmeister musste ich mich mit dieser Frage eingehendst befassen, weil wir die grossen forstwissenschaftlichen Erfahrungen der ganzen Welt nur dann als Erfahrungsgut übernehmen können, wenn es uns gelingt den »Waldtyp» so klar floristisch, ökologisch, syngenetisch und chorologisch zu umschreiben, dass wir in der ganzen Welt unter denselben Namen auch dasselbe Objekt verstehen.

Viele forstwissenschaftliche Erkenntnisse von allergrösster Bedeutung, haben sich nur darum in der Welt nicht durchgesetzt, weil mit Veröffentlichung der Forschungsergebnisse nicht gleichzeitig erklärt wurde, für welchen genau umchriebenen Waldtyp, die gewonnen Erkenntnisse Geltung haben.

So verweise ich auf die vielen Irrtümer in der Beurteilung der finnischen Waldtypen, zu denen es nie gekommen wäre, wenn man unter derselben Typenbezeichnung auch dasselbe Objekt verstanden hätte. Wenn in diesem Zusammenhange Herrn Rubner in den Mund gelegt wurde, dass sich die finnischen Waldtypen in Deutschland nicht anwenden lassen, so liegt der Grund dieser teilweisen Ablehnung wohl nur darin, dass Herr Rubner *seine Untersuchungen* an einem anderen Objekt, also *am untauglichen Objekt durchführte.* In diesem Sinne hat *Cajander* zu recht, wenn er schreibt: »Auch liegt die Gefahr nahe, dass man solange die mitteleuropäichen Waldtypen im allgemeinen nicht näher beschrieben sind, in Mitteleuropa vorkommende Waldtypen ohne weiteres mit den entsprechenden nordeuropäischen identifiziert, was zu schweren Fehlschlüssen führen kann».

Darum sollten wir versuchen die einzelnen Waldtypen so zu umschreiben und benennen, dass wir unter denselben Namen immer auch dasselbe Objekt verstehen und erkennen. Wie kam ich zu meinen Überlegungen!

Nachdem ich zehn Jahre als Forstmeister einen sehr grossen Waldbesitz bewirtschaftete, der im hügeligen und bergigen Gelände, vom klimatisch ozeanisch beeinflussten Alpenrand bis ins klimatisch kontinental beeinflusste Alpeninnere reichte, habilitierte ich mich an beiden botanischen Lehrkanzeln der Wiener Universität das Gesamtgebiet der Pflanzengeographie.

Dabei konnte ich auf Erkenntnisse aufbauen, die ich von meinen verehrten Lehrern und Freunden Scharfetter, Beck von Mannagetta, Schröter und insbesondere von Braun-Blanquet vermittelt erhielt.

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[1] Direktor des Instituts für angewandte Pflanzensoziologie, Klagenfurt, Österreich.

Es wird nicht möglich sein alle Waldtypen nach ein und derselben Methode zu erfassen, weil sich die Untersuchungsmethode dem Objekte anzupassen hat. Daher sind im einen Fall diese und im anderen Fall jene Merkmale zur Unterscheidung der Waldtypen heranzuziehen.

In der Sippensystematik gehen wir ja auch einen ähnlichen Weg, um die einzelnen Pflanzenarten zu erfassen. Hier werden zur Trennung der einzelnen Arten verschiedene Merkmale herangezogen, z.B. morphologische Merkmale der Blüte, der Frucht u.s.w. Immer aber richten sich die artunterscheidenden Merkmale nach dem Objekt.

In Europa wird insbesondere nach 2 Methoden versucht die einzelnen Waldtypen zu erfassen: 1. Die *einen* betrachten die Dominanz in den verschiedenen Schichten im Sinne der fennoskandinavischen Pflanzensoziologen als Grundlage für die Erfassung der Waldgesellschaften. Die *anderen* bauen im Sinne der Zürich-Montpellier-Pflanzensoziologen die Vegetationseinheiten mit Hilfe von Charakter — und Differenzialarten auf, weil sie erkannt haben, dass sehr viele dominierende Arten weit verbreitete Ubiquisten sind — dass es nicht angeht, z.B. alle Calluna vulgaris-Heiden, alle Pinus silvestris-Wälder, alle Picea excelsa-Wälder mit jeweils ähnlicher Dominanz, nach ihrer Dominanz in den verschiedenen Schichten zu einem Waldtyp zu vereinigen — und weil im Laufe der jahreszeitlichen Entwicklung in ein und derselben Pflanzengesellschaft mehrere Arten zur Vorherrschaft gelangen können.

Mit welcher Methode wir auch die verschiedenen Waldtypen erfassen wollen, immer müssen wir uns bemühen, sie so abzugrenzen, dass sie Ausdruck bestimmter Umweltverhältnisse sind.

Überall dort, wo unwirtliche Verhältnisse herrschen, wo z.B. der Wasserhaushalt oder der Nährstoffhaushalt oder die Wärme für anspruchsvollere Arten nicht ausreicht, treten solche Pflanzen zusammen, welche die ungünstigen Verhältnisse besser ertragen können. Damit kommt es zur Dominanz anspruchsloser Arten. In diesen Gebieten spricht vieles dafür, die einzelnen Pflanzengesellschaften nach Dominanten zu erfassen und abzugrenzen.

Je mehr sich aber die Umweltverhältnisse bessern, desto mehr tritt die Individuenballung zurück und ein Reichtum an verschieden gearteten Individuen kommt auf. Immer weniger können wir die Einheiten auf Grund von Dominanten erfassen und immer mehr werden die Charakterarten, die da und dort die feinsten Zeiger der ökologischen Verhältnisse sind, als unterscheidende Merkmale an Bedeutung gewinnen.

Aus dieser Schau ist es verständlich, dass z.B. streugenutzte Wälder ihren Nährstoffhaushalt oberflächlich verlieren und sich daher Pflanzenarten, den Boden beherrschend, in Individuenballung durchsetzen, welche den herabgesetzten Nährstoffhaushalt des Oberbodens ertragen können.

Es ist verständlich, dass es unter den ungünstigen Klimaverhältnissen der oberen Waldgrenze ebenso zu einer Dominanz und Individuenballung kommt und wir daher diese Waldgemeinschaften auf Grund der Dominanz einzelner Pflanzenarten in den verschiedenen Schichten im Sinne der fenno-skadinavischen Pflanzensoziologen fassen können.

Im Gelände der bodenfrischen, nährstoffreichen Auenwälder und der ungestörten nährstoffreichen Laubmischwälder tritt ein Reichtum verschiedener Arten auf und können wir diese Wälder auf Grund von Charakterarten fassen.

Wir können uns daher in den Alpen, wo nährstoffarme Waldgesellschaften neben nährstoffreichen liegen in diesem Fall dieser und in jenem Falle jener Methode bedienen.

Es gibt eben Pflanzengesellschaften, die sich auf Grund der Dominanz in den verschiedenen Schichten ebenso einwandfrei fassen lassen wie mit Hilfe von Charakterarten. Dies gilt besonders für bestimmte fazielle Ausbildungen verschiedener Assoziationen im Sinne der Charakterartenlehre.

Es gibt aber Pflanzengesellschaften, die nur mit Charakterarten und nicht auf Grund der Dominanz in den verschiedenen Schichten unterschieden werden können, weil sie keine dominanten Arten besitzen; z.B. kräuterreiche Fagus silvatica-Abies alba-Picea excelsa-Mischwälder.

Ebenso finden wir auch Wald-Gesellschaften, die sich nur mit dominanten Arten und nicht mit Hilfe der Charakterarten abgrenzen lassen, weil keine Charakterarten zu finden sind, z.B. im Kahlschlag bewirtschaftete, streugenutzte Wälder. So hebt Braun-Blanquet hervor, dass: »künstliche Eingriffe in den Gesellschaftshaushalt die Charakterarten meist rasch vetreiben» und »dass sich bei der in Gang befindlichen natürlichen Wiederbewaldung der Staatsdomänen in den Hochsevennen die Charakterarten des Fagetums ganz allmählich einstellen, und zwar in dem Masse als sich die Assoziationen ihrem ursprünglichen Wesen nähern. Erst im unberührten Hochwald finden wir sie vollzählig und stellenweise reichlich vertreten.»

Braun-Blanquet verweist aber auch auf die umfangreichen Erhebungen Linkolas in Finnland, aus denen hervorgeht, dass Lycopodium annotinum, Listera cordata, Pirola uniflora, Linnaea borealis und andere Charakterarten erst in älteren Waldbeständen sich einstellen.

Schliesslich sind auch Waldgesellschaften anzutreffen, die weder mit Hilfe der dominanten Arten in den verschiedenen Schichten noch mit Hilfe von Charakterarten erfasst werden können. In solchen Fällen müssen wir eben mit anderen Methoden versuchen, die Waldgesellschaften zu erfassen, genau so wie in der Sippensystematik, wenn wir erkennen, dass wir eine Art weder mit Blütenoder Fruchtmerkmalen, noch mit Blattmerkmalen unterscheiden können, aber doch aus ihrem ökologischen Verhalten zur Auffassung einer eigenen Art kommen.

Mit ökologischen Merkmalen allein können wir die Waldgesellschaft nicht fassen. Ich komme mit Braun-Blanquet zur Überzeugung, dass sich Ökologie und floristische Gruppierung der Gesellschaften zueinander Verhalten wie die noch wenig bekannte Ursache zur sichtbaren Wirkung.

Wenn es mir auch gelungen ist da und dort mit beiden Methoden brauchbare Ergebnisse zu erzielen, so bin ich doch zur Erkenntnis gekommen, dass wir weder mit der einen, noch mit der anderen Methode alle Waldgesellschaften einschliesslich der Wirtschaftswälder einwandfrei fassen können. Nicht nur, weil forstwirtschaftliche Eingriffe den Gesellschaftshaushalt stören und die Charakterarten vertreiben, sondern weil entsprechend der Jahreszeit und dem jeweiligen Lichtungsgrad unsere Wälder einen so verschiedenen Aufbau besitzen, dass sie nur sehr schwer rein floristisch erfasst werden können.

Ich habe mich eingehendst bemüht die verschiedenen Waldgesellschaften auf Grund von Charakterarten zu erfassen und habe diese Arbeit da und dort mit grossem Erfolg durchgeführt.

So zeigte es sich immer wieder bei meinen pflanzensoziologischen Lehrwanderungen für Forstmeister, dass die Teilnehmer von dem Erfolg solcher Lehrwanderungen begeistert waren.

Der Erfolg dieser Kurse brachte der Forstwirtschaft aber nicht den erwarteten Erfolg! Warum blieb der Erfolg eigentlich aus?

Heute, nach fast 20 Jahren, ist es mir klar, warum es so kommen musste. Denn die Lehrwanderungen bereitete ich genau vor und suchte die Pflanzenbestände auf, wo sie durch eine Fülle von Charakterarten ausgezeichnet waren. So kam es, dass die Lehrgangsteilnehmer von der Bedeutung der Charakterarten als Zeiger bestimmter Waldgesellschaften begeistert waren.

Als aber die Lehrgangsteilnehmer wieder in ihre heimatlichen Wälder kamen, da konnten diese Zusammenhänge nicht wieder gefunden werden; denn die Wälder waren von der Wirtschaft sehr beeinflusst und die in den mehr oder weniger noch ursprünglichen Wäldern da und dort vorgefundenen und bei der Lehrwanderung aufgezeigten Charakterarten fehlten.

Es musste ja so sein; denn die Wirtschaftswälder wurden durch Kahlschlag, Lichtungshiebe, Aufforstungen, Waldweide, Streunutzung, Anbau standortsfremder Holzarten in ihrem natürlichen Aufbau so gestört, dass sie ihren charakteristischen floristischen Aufbau verloren haben.

Wie will man aber im Sinne der Charakterartenlehre für jeden Waldort etwas aussagen, wenn durch die wirtschaftlichen Eingriffe die Charakterarten, diese feinsten Standortsanzeiger, zum Verschwinden gebracht wurden?

Auf den pflanzensoziologischen Exkursionen ist es möglich, die Örtlichkeiten auszusuchen, die noch den vollständigen charakteristischen Aufbau besitzen.

Der Forstwirtschaft ist damit aber nicht gedient, dass da und dort die Wälder den charakteristischen Aufbau besitzen, denn sie wirtschaftet ja nicht nur dort, wo zufällig der charakteristische Aufbau der Waldgesellschaft nicht gestört wurde, sondern überall und muss daher über jede Örtlichkeit in bezug auf den Waldtyp eine Aussage machen können.

Mit diesen Ausführungen möchte ich aber den Wert der Methode, Waldgesellschaften mit Hilfe von Charakterarten zu erfassen, nicht herabsetzen, schon allein, weil man mit dieser Methode in der Lage ist, sich da und dort zu orientieren.

Ganz ähnlich liegen die Verhältnisse beim Beginnen *Waldgesellschaften auf Grund der Dominanz von Arten in den verschiedenen Schichten zu erfassen.*

Diese Methode bringt sicherlich in den fenno-skandinavischen Ländern mit ihrem kühleren Klima und den jüngeren Böden ebenso gute Resultate wie in den Wäldern der Voralpenstufe, die vielfach ähnliche Verhältnisse aufweisen, wie in den fenno-skandinavischen Ländern. Ebenso werden wir auf herabgewirtschafteten Böden, die ihren guten Wasser- und Nährstoffhaushalt verloren haben gute Resultate erzielen.

Wenn wir aber in den verschiedenen Höhenstufen der Alpen unter verschiedenen geologischen Bedingungen mit dieser Methode arbeiten, so werden wir die verschiedensten Waldgesellschaften mit einer Soziation erfassen und damit Irrtümer hervorrufen.

So untersuchte ich z.B. viele Fichtenwälder der Picea excelsa-Vaccinium myrtillus-Hylocomium splendens Soziation und musste feststellen, dass diese Fichtenwälder in klimatischer, bodenkundlicher, biotischer und syngenetischer Hinsicht, trotz des herrschenden Vorkommens von Picea excelsa in der Baumschicht, Vaccinium myrtillus im Niederwuchs und Hylocomium splendens in der Moosschicht verschieden zu werten sind.

Unter dieser Soziation haben wir Waldbestände auf Kalk und Dolomitböden ebenso, wie auf quarzitischen Böden. Wir haben Bestände die sich über einen Pinus Mugo Bestand entwickelten und solche, die in Beziehung zum Larix decidua Wald stehen; ferner neben primären Beständen auch sekundäre, insbesondere auch Waldverwüstungsstadien des Fagus silvatica -Abies alba -Picea excelsa Waldes u.s.w.

Mögen auch alle diese Bestände ein und derselben Soziation angehören, so sind sie doch als Glieder verschiedener Entwicklung aufzufassen und sollten doch in Abhängigkeit von verschiedenen Umweltbedingungen wirtschaftlich anders behandelt werden.

Daher sollten wir neben dem floristischen Hinweis, dass diese Bestände der Picea excelsa-Vaccinium myrtillus-Hylocomium splendens Soziation angehören, aufzeigen, in welcher Höhenstufe der Bestand jeweils liegt, welcher Entwicklungsserie er angehört und welche Bodenunterlage ihm zur Verfügung steht.

Fassen wir die bisherigen Erkenntnisse zusammen, so kommen wir zur Überzeugung, dass weder mit der Methode der Schule Zürich -Montpellier, welche die Waldbestände auf Grund von Charakterarten zu fassen sucht, noch mit der fennoskandinavischen Methode, welche die Bestände auf Grund der Dominanz in den verschiedenen Schichten zu erfassen sucht, es möglich ist, alle Waldbestände so einwandfrei zu erfassen, dass mit demselben Namen einwandfrei auch dieselbe Einheit erfasst werden kann.

Dazu kommt, dass wir dem Forstmann der Praxis neben seinen vielen technischen und rechnerischen Arbeiten in Ländern mit einem grösseren Pflanzenarten-Reichtum gar nicht zumuten können, mehr als tausend Pflanzen im sterilen und vertilen Zustande zu kennen. Damit bricht selbstverständlich unser Bemühen zusammen, der forstlichen Praxis ein auf die vollständige charakteristische Artenverbindung aufgebautes System zu vermitteln.

Ich habe mich daher bemüht, rein der Fortwirtschaft dienend, einen Waldtyp aufzustellen, der die Möglichkeit bietet alle Wälder so zu erfassen, dass wir mit demselben Namen auch dasselbe Objekt erfassen.

Hiebei müssen wir vom Erscheinungsbild (Physiognomie) ausgehen und dieses floristisch, pflanzengeographisch, ökologisch und syngenetisch, unter besonderer Berücksichtigung der menschlichen Einflüsse untermauern.

Damit komme ich zur Erfassung der Waldtypen als Vegetationsentwicklungstypen, welche vornehmlich der praktischen Auswertung dienen sollten.

Zu demselben Vegetationsentwicklungstyp fasse ich alle diejenigen physiognomisch einheitlichen Pflanzenbestände zusammen, welche sowohl in ihren floristischen und soziologischen Merkmalen als auch in ihrem durch die Standortsverhältnisse bedingten Haushalt übereinstimmen und demselben Stadium einer Entwicklungsreihe angehören.

Damit erfasse ich die Vegetationsentwicklungstypen (Waldentwicklungstypen) folgend:

I. *Floristisch-physiognomisch,* indem ich alle Vegetationseinheiten (Bestände) mit ähnlichem floristischen Erscheinungsbild (Physiognomie) zur selben Obergruppe stelle

II. *Floristisch-ökologisch,* indem ich die Vegetationseinheiten nach ihren Umweltbedingungen zu *ökologischen Gruppen vereinige.* Ich spreche von *floristisch-ökologischen Gruppen,* weil ich mich in der Zuteilung zu den einzelnen Gruppen von ökologischen Differenzialarten leiten lasse.

III. *Floristisch-syngenetisch, indem ich die Waldbestände bzw. Heiden innerhalb der einzelnen Gruppen als Glied einer Vegetations-Entwicklungsreihe betrachte.*

Im Bestreben nur der Sache zu dienen, um zu einer »common platform for the different schools of forest type classification» zu kommen, habe ich die Frage der lateinischen Bezeichnungen mit meinem verehrten Lehrer und Freund Braun-Blanquet besprochen und meinte er wörtlich:

»Ja zweifellos es ist sehr wichtig, dass die reine Wissenschaft mit der Praxis in Verbindung und Übereinstimmung kommt und dazu scheint Deine Forschung, die Du hier entwickelst, richtig. Es ist aber nun ein gewisser Zwiespalt zwischen reiner Wissenschaft und Praxis, indem der Praktiker sich nicht mehr mit der Wissenschaft so eingehend befassen kann, dass er alle Feinheiten erfasst. Wenn man nun die Waldgesellschaften rein wissenschaftlich studiert, so sollte das Ergebnis dieses Studiums dem Praktiker zugänglich gemacht werden, auf eine Weise, die eben keine grossen Schwierigkeiten bietet. Und wenn man nun in der Praxis statt der mehr oder weniger schwer verständlichen lateinischen Namen, die in der Wissenschaft unentbehrlich sind, deutsche Namen wählen würde für gewisse Erscheinungen, sagen wir für Waldgesellschaften, so wäre das zweifellos ein Vorteil. Wenn man also die deutschen Bezeichnungen für festgestellte Waldgesellschaften einführen würde, so erscheint mir das sehr angezeigt.

Es ist ferner zu bedenken, dass die Forstleute ein sehr schweres Studium vor sich haben, sehr belastet sind und infolgedessen mit der Artenkenntnis nicht so vertraut sein können, wie es eigentlich wünschbar wäre und daher scheint es sehr angezeigt, wenn man ihnen die Sache möglichst erleichtert. Wenn also der wissenschaftliche Forstmann, der sich mit den Assoziationen befassen kann, vom wissenschaftlichen Gesichtspunkt aus dem Forstpersonal die wissenschaftlichen Ergebnisse möglichst einfach und möglichst ohne lateinische Namen zugänglich macht. Das scheint mir ein Zukunftsziel, woran gerade ein Professor wie Du arbeiten und Fortschritte bringen kann.

Es ist selbstverständlich, dass man sich nur in deutschsprachigen Gebieten zur Vermittlung der deutschen Sprache bedienen sollte, während man in der Schweiz entweder deutsch, französisch oder italienisch, in Spanien spanisch, in Finnland finnisch, in Italien italienisch, in Jugoslawien slowenisch und serbokroatisch, in Ungarn ungarisch, in Polen polnisch sich für die Benennung der Waldtypen ausdrücken müsste u.s.w.

Es lassen sich natürlich sehr gut Erkenntnisse, die Du in diesem Raum gewonnen hast in das Italienische, Französische oder in welche Sprache man will übersetzen. Andererseits sind die Resultate, von denen Du sprichst, in einem bestimmten Gebiete gewonnen. Sie können auch auf andere Gebiete mit ähnlicher florengeschichtlicher Vergangenheit und ähnlichen geologischen und klimatischen Verhältnissen angewendet werden. Wenn es sich um Gebiete mit anderer florengeschichtlicher Vergangenheit, anderen klimatischen und geologischen Gegebenheiten handelt, dann ist die Übertragung der von Dir gewonnen Resultate weniger möglich. Jedenfalls kann der Forstmann immerhin herauslesen aus den Verhältnissen, was er will und kann versuchen, mit gleichen Anwendungen in seinem Gebiete vorzugeben.»

Bei dem Bestreben im Interesse forstwirtschaftlicher Auswertung die Waldtypen als Vegetationsentwicklungstypen zu fassen, also die syngenetische Stellung zu erfassen, zeigt es sich ,dass viele Waldentwicklungstypen sich leicht zu bestimmten Assoziationen im Sinne der Charakterartenlehre und zu bestimmten Soziationen im Sinne der fenno-skandinavischen Schule stellen lassen; andere können als Soziationen, nicht aber als Assoziationen im Sinne der Charakterartenlehre gefasst werden, und wieder andere Waldentwicklungstypen lassen sich weder als Assoziationen noch als Soziationen erfassen.

Fassen wir die Ergebnisse meiner Überlegungen zusammen:

Ich habe die Tatsache hinausgestellt, dass die forstliche Praxis nicht in der Lage ist, sich eine solche umfangreiche Pflanzenkenntnis zu erwerben, dass sie sich den vollständigen floristischen Aufbau aller Wälder aneignen kann, weil sie zu sehr mit allen möglichen wirtschaftlichen und technischen Aufgaben belastet ist.

Daher muss für die forstliche Praxis ein Weg gesucht werden, auf dem sie die einzelnen Waldtypen doch so erfassen kann, dass unter demselben Namen auch dasselbe Objekt verstanden wird.

Für die forstliche Praxis ist es besonders notwendig den Namen des Waldtyps noch zu ergänzen durch:

1. die besonderen Bodenverhältnisse,
2. die syngenetische Stellung,
3. die Zugehörigkeit zu einer bestimmten klimatisch bestimmten Höhenstufe,
4. die geographische Lage und
5. den Hinweis ob es sich um einen primären oder sekundären Bestand handelt.

Da der Waldtyp vornehmlich praktischen Zwecken dienen soll, insbesondere um zu erfahren für welchen bestimmten Waldtyp diese oder jene wissenschaftlichen Erkenntnisse erworben wurden, sollte man sich vornehmlich der Landessprache bedienen. Trotzdem habe ich aufgezeigt, wie man in lateinischer Bezeichnung diesen oder jenen Waldtyp schematisch als Waldentwicklungstyp darstellen könnte.

Um diese konkreten Bezeichnungen in lateinischer Sprache nicht mit den wissenschaftlich gefassten Assoziationen zu verwechseln wäre es notwendig, dass die wissenschaftlich gefassten Assoziationen immer mit dem Autornamen versehen werden, um zu erkennen mit welcher bestimmt umschriebenen Assoziation wir es zu tun haben.

Im übrigen wäre zu empfehlen, dass auch die Assoziationen und Soziationen in der Namengebung durch den Hinweis ihrer syngenetischen Stellung eine Ergänzung finden.

Schliesslich möchte ich klar hinausstellen, dass nach meiner Überzeugung das wissenschaftliche Endziel in der Erfassung der Biocenosen doch in der Erfassung als Biogeocenosen im Sinne Sukatschew's liegt. Die Erfassung der Wälder als *Forstbiogeocenosen* stellt natürlich an das Können so grosse Ansprüche, dass es kaum möglich sein wird, diese Arbeit in der Forstwirtschaft neben allen übrigen Arbeiten durchzuführen.

Vorliegender Ausführungen stellt nur einen Vorschlag dar, der lediglich einen Beitrag liefern soll, weil mir persönlich die Erfassung der Wälder als Waldenwicklungstypen in meiner praktischen und wissenschaftlichen Arbeit sehr viel gegeben hat.

Can we find a common platform for the different schools of forest type classification?

TORE ARNBORG[1]

In this attempt to answer the question posed in the title it is postulated that forest-type classification is not a matter of classifying the forest-plant communities but of classifying the site types with the aid of the vegetation. To begin with I will give a short review of the forest-type system used in practical forestry in northern Sweden (Eneroth 1936, Arnborg 1945—1958).

The forest types are based on the plant communities. The communities belong to the *field layer* (dwarf-shrubs, herbs, grasses, ferns) and to the *bottom layer* (lichens and mosses). Besides these there are the *shrub layer* and the *tree layer;* the tree seedlings belong to a special *seedling layer.* From the point of view of plant sociology it is important to base the plant-community classification on the elementary one-layer units, or synusiae. The north European oakless conifer region usually has a fully developed field and bottom layer and the division into forest types can for this reason be based on these layers. After clear cutting these become balanced more quickly than the tree layer and they are more differentiated than that layer is. The north Swedish forest-type system is intended to be used within the region mentioned.

The forests belong to three main groups: *heath forest, meadow forest* and *mire forest.* As regards the nutrients in the soil we can distinguish four different vegetation series in northern Sweden: 1. *the dwarf-shrub series,* 2. *the Dryopteris dwarf-shrub series,* 3. *the herb dwarf-shrub series* and 4. *the herb series.* The first three series belong to the heath-forest group with dwarf-shrubs, narrow-leaved grasses and a few herbs and, in series (2) and (3) some ferns and meadow herbs also. The fourth herb series belongs to meadow-forest group with predominating high meadow-herbs and broad-leaved grasses and ferns.

The four series appear on types of ground which can be classified, according to the nutrient supply, as (1) poor, (2) good, (3) rich and (4) very rich.

As far as water supply in the ground is concerned one finds different series with different vegetation series. One can classify the site types as 1. very dry, 2. dry, 3. fresh, 4. moist and 5. wet. The differences in the vegetation are especially marked in the bottom layer of lichens and mosses. On very dry ground the reindeer-lichens (Cladonia) predominate, on fresh ground mosses.

When determining the forest type we in Sweden, as they do in Finland (Cajander), start from the field- and bottom-layer vegetation in a tree stand which is normally closed and middle-aged. In the same forest type the plant

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[1] Institute of Plant Ecology, Uppsala, Sweden; Director, The Swedish Association for Forest Tree Breeding.

synusiae may change according to the density of the stand, and the composition of the vegetation is quite different in a clear-cut area from what it is in a more or less closed stand. There may be various facies of the same site (forest) type: normal facies, open facies, grazing, burned, etc. but it is still the same type. The site or forest type may cover, with various facies, two or more different plant communities. We must learn about all the different succession facies. Before we know more than we do now we must also study the ground with regard to moistness, soil structure, topographic conditions, exposure etc.

Generally speaking, the following recommendation can be made. In every climatic forest region we should analyse the vegetation and decide the various plant communities, starting from the synusiae, and study the succession, the competition between different layers, and the age of the stand; and we should take into consideration the time which has elapsed since the establishment of the stand, natural (Sirén 1955) or artificial, and the past played by the forest management i.e. the past played by man and also the effect of animal life. The forest type is a site type and can be decided only after a close plant- and zoosociological and environment study. The forest types coincide with the ecosystems.

In practice we need forest (or ecosystem) types for designing the site as a site for growing the trees. The following factors must be taken into consideration: climate, including precipitation, temperature and length of the growing season, topography, ground conditions, time, animal life, including insects, grazing and browsing animals etc. and man. When we know these ecosystems and know about the ecology and productive capacity of the trees we also know which tree will be the best from the economic point of view.

The forest types in Scandinavia are plant-community types but are also based on more or less known correlating environment features. The Cajander forest type Myrtillus-type (MT) is called in Sweden frisk ristyp, which means fresh dwarf-scrub (blueberry, Vaccinium myrtillus) type. In the forest-type system of Eneroth (1936) and Arnborg (1945—1958) the type is named according to the moisture in the ground and the vegetation.

Cajander, Morozov, Sukachev and others have given directions for forest-type classification. For practical purposes these types are very useful as forest-regeneration types and also as management types. In Sweden the differences in altitude are very important to the forest growth. We still know too little about the influence of elevation and exposure on the vegetation and we cannot use the forest types to determine the site quality. In Finland the use of the types as real site types is easier.

Even if we do not know about the forest type as ecosystems we can use the vegetation, if we know its different facies, and can determine the forest type as an imperfect site type. The following are examples of forests, where the existing vegetation does not give the real capacity of the ground: (1) The slow-growing spruce (Picea abies) forests on dry to fresh sites in northern Scandinavia, where pine (Pinus silvestris) can produce twice as much as spruce; we know this from the field and bottom layers, i.e. from the forest type in our system, and therefore plant pine. (2) The aspen (Populus tremuloides) on burnt land in Canada, where white spruce (Picea glauca) can give more economic production. (3) The vinemaple (Acer circinatum) scrub with red alder (Alnus rubra) in the Pacific forests, where Douglasfir (Pseudotsuga menziesii) and hemlock (Tsuga heterophylla) are the most economic trees. (4) The Arctostaphylos scrub land on the slopes in the Sierra Nevada, California, where the ponderosa pine is the best tree.

Thus the present stand, even if it is not a productive one, and the field- and bottom-layer vegetation, sometimes the shrub layer, gives an idea of the real site type. According to the present vegetation we can choose the best tree for each district and each site.

The only common platform for different schools of forest-types classification is, as I understand it, a basis founded above all on very carefully performed analyses of the plant communities and of the soil as well as of the influence of climate, time, man and animal life. We must learn from the plant communities and the plants about the ground as a site for trees. The forest type is a unit for practical forestry.

The forest types must be described in such a way that one can identify the type in every facies and determine the site according to forest production. Our intention must be to identify and describe the site types and at least to know the ecosystems. The base for classifying, the methods for analysing, or the types themselves could not be common, but the fundamental rules and the aim can be the common platform for all the different schools of forest-type classification. Inevitably it must be a tremendous task to identify and describe the forest types as ecosystems: the goal toward which all efforts ought to be directed.

It pays to learn more about the forest, to know which trees are giving the highest production and to get the right tree on the right site. — The geneticists can help the foresters to get the best trees. The ecologists can help the foresters to decide the best site for these trees.

A combined structural and floristic approach to the definition of forest ecosystems

PIERRE DANSEREAU [1]

The word »forest» would seem to be one of the terms applying to vegetation which it is least urgent to redefine. The reference, however, in much phytogeographical literature to »forest areas» or »forested areas» is often a very loose one. Not infrequently this applies to geographical regions that are neither desert nor true grassland, in the sense that trees are common within them. I shall not attempt to discuss here the »true» or the »scientific» definition of *tree* as opposed to *shrub*, nor shall I re-enter the discussion about *savana* vs. *forest*. I shall take off from my earlier definitions (1951, 1958) and present a scheme for a structural approach to forest ecosystem classification.

Trees, therefore, are woody plants (branched or unbranched) reaching a height of more than 8 meters. *Forest*, in turn, consists of trees whose canopy, or crown projection (when in leaf), covers more than 60% of the ground area; it usually harbours more than one layer. By contrast, *woodland* covers 25—60%, and *savana* has a woody growth from 2 to 10 m., covering 10—25% and a herbaceous growth up to 2 m. covering 25—100%. Such sharp delimitations are unquestionably arbitrary, although some argument may be made for their empirical value and further argument for the practical usefulness of at least some such categories. (See Dansereau 1958, Table VI.)

I have published many papers on structure of vegetation and I have tried to emphasize the spatial distribution of the biomass is as important as floristic composition and site requirements. It is a likely expression of *environmental potential* for one thing, and it also functions *in a physical capacity* as a controlling agent of light, heat and moisture. I feel bound to add that I have at no time considered the species composition and the ecological conditioning less important than physiognomy for I truly believe that all three criteria must necessarily be applied if any fragment of vegetation is to be described and understood. Thus in referring to the maple forest of the St. Lawrence Valley I am convinced that its true definition lies in the following facts:

1) *Historically* it consists of trees (Acer, Fagus, Fraxinus, Tilia), shrubs (Cornus, Corylus, Sambucus), and herbs (Trillium, Sanicula, Hepatica) derived from a very old Tertiary stock, once widespread across the Northern hemisphere, now virtually disappeared from Western North America but abundantly represented in Eastern Asia and Western Europe, and now somewhat further impoverished by the Pleistocene glaciation.
2) *Ecologically* it occupies well-drained upland sites on soils which are derived either from Precambrian granites and gneisses, Paleozoic limestones, schists or sandstones or Pleistocene and recent gravels, sands and clays; it exists under a strongly rhythmic continental climate with very severed and snowy winters and warm summers with abundant rain. To this can be added the observation that the maple forest enjoys great stability and is not readily displaced by any other community.
3) *Structurally*, it grows to about 100 feet in height, is fairly closed (sometimes nearly 100% coverage), broadleaved in the canopy which is deciduous in the fall and remains barren until late spring; it contains very few evergreens; its stratification changes with the season, for the lowermost layer of herbs is often quite dense in the spring and very scattered in the summer.

Obviously each forest type must be graded according to all three criteria above. This for instance has been done by the Society of American Foresters (1954), who deal (and for practical purposes) with a limited area that has on the whole a common floristic history. If, however, a universal scheme is set up, it must disregard, *in its highest order of magnitude*, all floristic and immediately ecological criteria and resort to structural and climatic ones. Thus, on a world basis, the following subdivisions of the *forest biochore* can be recognized: tropical rainforest, temperate rainforest, tropical deciduous forest, summergreen deciduous forest, needle-leaf evergreen forest, and evergreen hardwoods (Dansereau 1958). A small-scale map of the world will show only these six kinds of forest. Moreover, this generalized regional shading does not mean that the whole of each area is (or even was) occupied by one of these types, inasmuch as they are only assumed to be or to have been the *climax* within the area encompassed by that particular formation-*class*. But there also exist other formation-*types* (scrub), meadow, etc.) and indeed other forests.

How than does the structural approach land itself to the characterization of ecosystems smaller than the formation-type, smaller than the formation-class, but larger than either the individual stand or the plant community?

Referring to my own scheme of plotting vegetation,[1] it is easy to grade any individual *stand* of forest as has been done in Dansereau and Lems (1957), any *association* (generalized from the study of many stands, as in Dansereau 1959 and Dansereau et Arros 1959). Such a sliding scale lends itself to an unending variation of patterns. Because of this it presents a useful device for recording at all times and places and provides a standard of comparison.

The question, however, which is most pertinent to the present topic is more likely the following: what are the most important features of structure? All classification implies a hierarchy. For example, are spacing and layering more significant than deciduousness? Is the latter also to be stressed more than leaf size and texture? In other words, should a universal classification of forests, or

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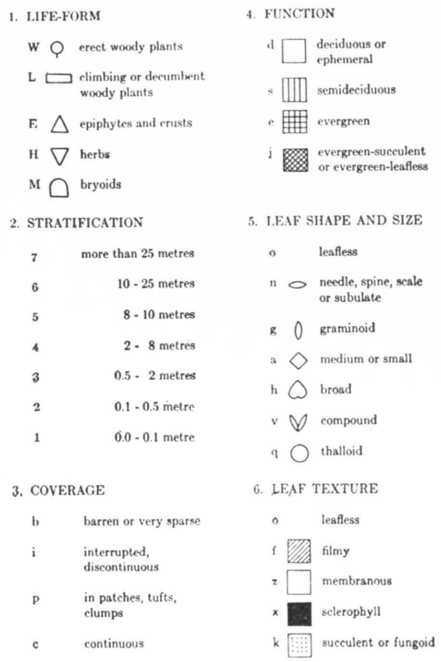
[1] Director, Institut Botanique, Université de Montréal, Canada.

[1] Table I (from Dansereau 1959) is included herewith as a key to this universal system of recording vegetation.



1. LIFE-FORM

W	♀	erect woody plants
L	▭	climbing or decumbent woody plants
E	△	epiphytes and crusts
H	▽	herbs
M	∩	bryoids

2. STRATIFICATION

7	more than 25 metres
6	10 - 25 metres
5	8 - 10 metres
4	2 - 8 metres
3	0.5 - 2 metres
2	0.1 - 0.5 metre
1	0.0 - 0.1 metre

3. COVERAGE

b	barren or very sparse
i	interrupted, discontinuous
p	in patches, tufts, clumps
c	continuous

4. FUNCTION

d	□	deciduous or ephemeral
s	▥	semideciduous
e	▦	evergreen
j	▩	evergreen-succulent or evergreen-leafless

5. LEAF SHAPE AND SIZE

o		leafless
n	⬭	needle, spine, scale or subulate
g	⬯	graminoid
a	◇	medium or small
h	♡	broad
v	V	compound
q	○	thalloid

6. LEAF TEXTURE

o		leafless
f	▨	filmy
z	□	membranous
x	■	sclerophyll
k	⬚	succulent or fungoid

Table I. The six basic criteria and the corresponding symbols for the building-up of structure diagrams

even a classification within a given formation-class first recognize evergreen vs. deciduous forest each of which in turn will subdivide into broad-leaf, small-leaf and needle-leaf types? And shall these in turn be graded as multistratal, paucistratal and unistratal?

If the four coverage classes of each of the three upper layers recognized in my system are plotted, 100 combinations are possible. But some of them, such as W7b, W6b, W5b, are not *forest!* There would remain, nevertheless, an unwieldy number of assemblages, many of which differ very little from one another. It would seem useful therefore to group them as follows: *high forest* for W7 dominant in coverage; *medium forest* for W6 dominant, and *low forest* for W5 dominant. Then, one could recognize single, double and triple-layered canopy — or maybe more simply: layered and unlayered canopy, discounting »b» as a proper layer.

A similar mechanical grading can be applied to the understory which can be referred to in simple terms as woody, herbacecus, bryoid, or any combination of the three with coefficients e, i, p and b. Finally, epiphytes and lianas can be mentioned also as b, p, i, or c when present.

Thus a limited number of structural types will emerge, on the basis of spatial arrangement alone. It would remain to qualify this further by the relative importance of evergreenness.

It must now be emphasized again that structural charactere alone are being invoked and that this cannot lead, of itself, to ecosystematic classification. An application of the above-mentioned grading to the forest associations of the Laurentian area is given herewith in the Table II. Jack pine »barrens», pincherry brush and other plant communities of a *woodland* or *savana* formation-type are, of course, excluded.

It is evident that only a combination of floristic data, structural arrangement, and site correspondence can lead to a satisfactory regional classification. It is at the point of intersection of these various criteria that *types* can be located. The present table is a preliminary listing of forest associations (grosso modo sensu Montpellier[1]) to be found in the St. Lawrence Basin.

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[1] I am afraid that the orthodox adherents of this School will be shocked by the *nomina nuda* which I so freely use in this table, since I have not previously offered regular association-charts for each unit. I have departed in so many ways from Sigmatism that I can hardly present an apology in this one instance.

Table II. Forest associations in the St. Lawrence Valley.

Explanation of symbols:

Dynamic stage: A: pioneer; B: consolidating; C: subclimax; C': serclimax; D: quasiclimax; E: climax; F: proclimax.

Climax area: T: Taiga or Lichen Woodland; C: Boreal Forest; E' Northern Hardwoods; E: Maple Forest.

Layering and function (see Table I): W, L, E, H and M are life-forms; figures are height-classes; d, s and e are deciduous, semi-deciduous and evergreen; b, i, p, c are coverage (Dansereau 1959).

Name	Dynamic stage	Climax area	Layering & function		Site		
			woody	herbaceous	moisture	temperature	soil
Abietetum balsameae	D F	C T	W7,6ec W1,1eb	M1ec	fresh	cool-cold	var.
Acereto-Ulmetum laurentianum	C'	E	W7,6dc W 3db	H3di, H2dp	qmphi-	warm	org. & silt
Aceretum rubri	C	E(C)	W7,6dc(i) W5dp	H3db	wet, amphi-, dry	var.	sand- silt
Aceretum saccharophori laurentianum[1]	E	E	W4di W7dc	H1di	fresh	cool	var.
Aceretum saccharophori quercosum	D	E	W7dc W4di	H2db	fresh	warm	silt
Aceretum saccharophori tsugosum	E D	E' E	W7d(e)c W3di W2ep	H2d(e)b M1ep	fresh- moist	cool- cold	var.
Betuletum abietosum	C	C,E'	W6d(e)c W5ei W2si	H2e(d)i M1ep	moist	cold	var.
Betuletum luteae	F	C,E'	W7,6d(e)c W4dp W2ep	H1dp	moist	cold	var.
Betuletum papyriferae	C	C,E',E	W6dc(b) W5db	H2db	dry	var.	var
Betuletum papyriferae cordifoliosum	C	C,T	W6dc(i) W5d(c)i	H2dp	fresh	cold	var.
Betuletum populifoliae	C	E	W6,5di(b) W2db	H2dp M1ep	var.	cool	var.
Fagetum grandifoliae	D	E	W7dc W4di	H2di	fresh	cool	var.
Fraxinetum riparium	C'	E	W6dc W4db	H2dc(p)	wet	cool	org. & silt
Piceetum glaucae	E	C	W7,6ec W5db	H2,1d(e)p M1ec	fresh	cold	var.
Piceetum marianae	E F,C	C E,E'	W7,6ec W5di	H2,1d(e)p M1ec	fresh- moist	cold	var.
Piceetum rubentis	F	E'	W6ec(p) W5e(d)i	H2,1d(e)p M1ep(e)	fresh- dry	cool cool	var. var.
Pinetum resinosae	E	E,E'(C)	W7ec W3db	H2dp M1ep	dry	cold	sand
Pinetum strobi	C F	E C	W7ec W3dp(b)	H3dp H1ep, M1ep	dry	cool- warm	sand
Populetum tremuloidis	C,D'	E',C,T	W6,5dc W3db	H3dp H2ei	dry- moist	var.	var.
Quercetum albae	F	E	W7dc W3db	H2di	fresh- dry	warm	silt
Quercetum boreale	F	E,E'	W7,6dc W5di W2dp	H2di H1dc(p)	dry	cool	silt- gravel
Quercetum monteregiense	C'	E	W7,6dc W4di	H3db H2dp(c)	wet	cool	silt- sand
Thujetum occidentalis	3	E,E',C	W4ec	H2,1dp	wet, dry	cool-cold	var.
Tsugetum canadensis	C	E,E'	W7,6ec W4di W2ep	H2di M1ep	moist	cool-cold	sand- gravel

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[1] Several other types have been recognized.

Some major problems in vegetation classification

R. DAUBENMIRE[1]

Before we can expect much progress toward achieving a common basis for the classification of forests or other types of vegetation, it will be necessary to settle some highly controversial points, the outcome of which will establish a set of guiding principles and so reduce the divergence in viewpoints of different workers. I propose to enumerate some of these controversial matters, and comment briefly upon them.

1. Some have advocated that we base classification entirely upon plants, whereas others consider as our goal the classification of ecosystems and take environment into account as well as the plants. It can hardly be disputed that we must rely upon vegetation alone to determine which combinations of environmental factors have closely similar biologic potential, yet an idea is but half expressed if mention is made of many Poa pratensis communities without referring at the same time to the cow, or of Artemisia rigida communities without referring to the extreme stoniness and shallowness of the loamy soil. Thus even though vegetation is used as the primary criterion of the limits of an ecosystem-type, environmental characters often become extremely useful in characterizing the significant attributes. Moreover environmental considerations help in establishing the useful limits of refinement in classification, and may serve as a basis for establishing higher categories of classification, rather than placing exclusive emphasis on floristics. While the case seems good for giving environment more emphasis, there is also solid evidence that it cannot be given first place in classification, for man lacks an ability to predict the nature of vegetation from a given set of environmental data, except in such a broad manner as to be of little use.

2. Whether vegetation is used as the sole, or merely as the most important, criterion of classification units, the question still arises as to how much of the phytocoenosis is to be considered significant. Clements, and most foresters in the U.S.A. have based classification entirely on the plants of the tallest layer, ignoring all shrubs, herbs and non-vascular plants. This would seem to imply that the environment under one cover type, e.g., Pinus ponderosa, is everywhere so similar that the differences can be ignored, but the demonstrated facts are precisely the reverse. The pine has a broad ecologic amplitude and is superimposed on many undergrowth types, each of which is dependent on different soil and climatic conditions but not the least dependent on the pine, although their expression is modified by it.

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[1] Professor, Department of Botany, State College of Washington, Pullman, Washington, U.S.A.

At the other extreme, Cajander's classification was based entirely upon the plants that are mostly ignored in the U.S.A., — in his 1926 definition of forest site types he neglected even to mention the trees to be expected on several of the types and, whereas he carefully pointed out the importance of distinguishing seral and climax undergrowth types, there is not hint of the successional status of such trees as are mentioned.

Classification based on one of these systems or the other may work in restricted areas, but any universally acceptable system must give a balanced consideration to all vascular vegetation, if not to all macroscopic vegetation.

3. Much vegetation description and mapping has been done on an objective basis considering only the present vegetation (the cover type) and making no attempt to record its successional status as shown by age-class distribution, relics on contiguous areas, etc. Other workers see an infinite variety of dynamic states, all showing trends toward a common climax (i.e., young Pinus contorta with no other tree, intermediate-aged P.c. with young Picea engelmanni, old P.c. with intermediate-aged Picea, and all possible intergrades), and prefer to consider all such stands as immature stages of a self-perpetuating (Picea) forest. This leads logically to the view that we should not simply aim to classify vegetation but to classify landscapes into units of equivalent vegetative potentialities (i.e., habitat types, homoeces, equivalent environments).

The ecosystem concept, and the succession concept, if they are accepted, would seem to favor this philosophy. In both practical and theoretical science it is important to take cognizance of the fact that in the northern Rocky Mountains, a stand of Abies grandis with an undergrowth of the Pachistima myrsinites type is self-perpetuating on some sites, but is seral to Thuja plicata plus Tsuga heterophylla with the same undergrowth on other sites. Age-class distributions among the trees, geographic location and soil profile are all useful in distinguishing the successional status in situations like this. Floristics alone are inadequate. If the goal is to classify the land surface according to its biotic potentialities, then the focus must be directed toward the climax and each habitat type may appropriately be named after its climax community. In mapping, all areas of equivalent potentiality and which are permanent could have the same color, with the various types of ephemeral communities now occupying parts of the unit indicated by secondary features.

4. Most synecologists have looked upon the landscape as a mosaic of concrete stands, many of which resemble each other sufficiently to warrant grouping into abstract named categories. They recognize that no two stands of one category are alike, and that there are gradients in both community structure and environment which run in all directions. Yet they see local steepening of gradients that make it possible to recognize definable categories. Usually these persons are fully aware that differences of opinion exist as to how finely units are to be split, yet are convinced that there exist real units delimited by the steepening

of the gradients (not wholly arbitrary segments) and these can be verified by others. The numerous association tables that have been published provide factual evidence in support of this view.

In contrast there are some who think vegetation a continuum not lending itself to any but artifical segmentation. Basic data supporting this view are still exceedingly limited. Grossly smoothed curves from which the supporting points have been omitted cannot be considered evidence. Data representing different attributes of only one layer of vegetation that have been summed, then transformed to still a further level of abstraction by mathematic manipulation do not allow a critical reader to determine for himself whether conclusions are warranted or not. Analytic methods that require sampling units of about 10 acres within which it is doubtful if edaphic and microclimatic conditions are uniform evoke suspicion of the ecologic meaning of the data. Failure to record separately the size classes of trees suggests that some objective of sampling has been hold more important than discrimination between apparently stable and clearly temporary communities. Floras are generally recognized as continua, and any method of subdividing the landscape on essentially a floristic basis, ignoring succession and environmental variation, will seem to substantiate the continuum hypothesis. By far the majority of ecologists who have worked with vegetation have described, tabulated and named vegetation categories (associations, sociations, forest types, etc.) from tundra to rainforest. If vegetation is a continuum it must have an undulating type of variation to allow so many investigators to provide data for closely similar stands over wide area. We are faced with a choice of either a continuum or a classification; the two viewpoints are strictly incompatible. Without classification there can be no science of vegetation.

5. Some botanists believe that all vegetation types in a given area are converging toward one climax (Clements' monoclimax hypothesis), whereas others think the vegetation types found on dune, peat and well-drained loam have their own distinctive sequences of seral communities leading toward distinctive climaxes that are equally stable (the polyclimax hypothesis as championed by Tansley 1935).

Factual evidence supporting monoclimax is non-existent, whereas some have shown by population-analysis data that more than one community type in a restricted area can show concrete evidence of self-perpetuation (e.g., Kell 1938). On this basis polyclimax is easily defined and demonstrable. But once the criterion of self-perpetuation is cast aside, there is an infinite regress to speculation, such as led Clements to this »Eoclimax», in which millions of years are considered unimportant, and the improbability of a return to Eocene vegetation patterns is ignored.

6. There is no doubt but that the same vegetation mosaic can be classified differently for different purposes, and with equal validity. For range management purposes forests can be classified as to whether the undergrowth is useful grasses or worthless shrubs, a silviculturist might classify the same land according to its ability to support vigorous growth of a given tree. But is there not one classification that is more fundamental than others, — one that shows a maximum of harmony among vegetation composition and dynamics, soil, and climate? One that allows a maximum of prediction of other characteristics (including range and timber potentialities!) when only a few are given? With the adoption of an ecosystem philosophy this situation becomes a possibility, although it has been frequently doubted.

On the other hand it is entirely possible that double standards for vegetation classification may have to be recognized. One (which has been in mind while writing the above paragraphs) which is useful where the character of natural vegetation has not been entirely effaced, and another for areas so long disturbed that none but artificial vegetation exists.

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Whether or not the time is ripe for advocating a common basis for vegetation classification depends on the amount of disagreement on points such as the above. We are in an uneviable situation in that the vegetation that must be studied to work out principles of classification is rapidly becoming so thoroughly altered as to make the discovery and verification of principles very difficult.

Können wir eine gemeinsame Plattform für die verschiedenen Schulen in der Waldtypenklassifikation finden?

HEINZ ELLENBERG[1]

In vielen Ländern bedient sich heute der Forstmann bei wissenschaftlichen und praktischen Arbeiten bestimmter geobotanischer Typenbegriffe, die eine Ordnung in die Mannigfaltigkeit der Pflanzenkombinationen oder deren Standortsbedingungen bringen sollen. Die Gesichtspunkte der Typisierung und Klassifikation sind aber nicht überall die gleichen, weil die natürlichen Voraussetzungen nicht in allen Gegenden gleich sind und weil die forstliche und die wissenschaftliche Entwicklung in den einzelnen Ländern verschieden verlief. Dies ist so lange kein Mangel, wie es lediglich auf räumlich engbegrenzte Untersuchungen und Planungen ankommt und die angewendete Methode ihren Zweck erfüllt. Sobald man aber überregionale oder gar weltweite Vergleiche anstrebt, lernt man es bedauern, dass man die Typenbegriffe der verschiedenen Schulen so schlecht parallelisieren kann, und dass oft gleichlautende Begriffe ganz verschiedenes bedeuten.

Eine gemeinsame Plattform für die verschiedenen Schulen kann nur durch Zugeständnisse von allen Seiten erreicht werden. Sie wird aber bei gutem Willen gefunden werden können, weil sich die namhaftesten Schulen in den Grundgedanken näher stehen, als man nach manchen Polemiken glauben möchte.

Den grössten praktischen Erfolg und die breiteste Anwendung in der Forstwirtschaft eines Landes hat bisher der *Waldtypenbegriff Cajanders* in Finnland gehabt. Deshalb sei hier dieser als erster betrachtet. Cajanders Begriff bezieht sich lediglich auf den Pflanzenbestand, nicht auf den Standort, und er ist *rein floristisch*, nicht physiognomisch, weil die finnischen Wälder physiognomisch nur wenig verschieden sind.

Auch die *skandinavischen Schulen* arbeiten mit floristisch definierten Grundbegriffen, insbesondere mit der Soziation im Sinne von Du Rietz. Bis heute strebten sie kaum an, der Forstwirtschaft zu dienen, und können hier deshalb ausser Betracht bleiben.

Gleichfalls im wesentlichen floristisch ist das *System von Braun-Blanquet*, dem die meisten Forscher und Praktiker in Mittel-, West-, Südost- und Südeuropa folgen, und das auch teilweise in Ostasien, Indien, Afrika und Südamerika bevorzugt wird. Es geht insofern über die finnischen und skandinavischen Typologien hinaus, als es eine *Hierarchie von Typenbegriffen* schafft und dadurch eine sehr grosse Zahl von Grundeinheiten zu ordnen gestattet. Die Grundeinheit, die *Assoziation*, ist durch das Vorhandensein oder Fehlen bestimmter Artengruppen gekennzeichnet, also im Prinzip ebenso wie der Waldtyp Cajanders. Charakterarten oder treue Arten spielen dabei in den jüngeren Publikationen eine immer geringere Rolle und erhalten erst bei den höheren Einheiten des Systems, den Verbänden, Ordnungen und Klassen, entscheidende Bedeutung.

Wie Nordhagen und andere Skandinavier bewiesen haben, lassen sich die Soziationen im Sinne Du Rietz' unschwer in Verbände im Sinne Braun-Blanquets einordnen. Dasselbe gilt m.E. auch für die finnischen Waldtypen. *Die gemeinsame Plattform der fennoskandischen und der Braun-Blanquet'schen Typeneinteilungen wäre also durch allseitige Anerkennung der höheren Einheiten des Braun-Blanquet'schen Systems erreichbar.*

Unter diesen für eine rasche Verständigung sehr nützlichen Oberbau lassen sich auch die *Waldentwicklungstypen von Aichinger* einfügen, die bei einem Teil der österreichischen Forstpraktiker Anklang gefunden haben. Sie betonen die natürliche und anthropogene Dynamik sowie die Geschichte der Waldgesellschaften, deren Kenntnis für ein volles Verständnis der heutigen Pflanzenbestände unentbehrlich ist. Dies wird übrigens auch von den Anhängern der Braun-Blanquet'schen Schule immer mehr anerkannt, jedoch nicht im System der Vegetationseinheiten zum Ausdruck gebracht. Denn die genetischen Beziehungen der Waldgesellschaften sind sehr heterogen und können nur für wenige Bestände ohne umfangreiche Aktenstudien und pollenanalytische Untersuchungen, und auch durch diese oft nicht sicher, festgestellt werden. Eine Klassifikation von Typen sollte aber immer auf greifbaren und jedermann ohne weiteres sichtbaren Kriterien aufgebaut werden.

Was die *angelsächsische Schule* betrifft, so steht auch deren ganz auf die konkreten Gegebenheiten gerichtete Typologie in keinem unüberbrückbaren Gegensatz zu der Braun-Blanquet'schen. Typisieren heisst immer Abstrahieren, und zwar umso mehr, je umfassender die Einheiten sind. Das einfach beschreibende floristische Prinzip, nach dem man Konsoziationen und Soziationen bzw. Assoziationen im Sinne der Angelsachsen aufstellt, und das Tansley eine so klare Beschreibung der Britischen Inseln ermöglichte, eignet sich nicht dazu, diese Einheiten systematisch zu ordnen. Auch hier bietet sich als Oberbau und als Hilfsmittel für die allgemeine Verständigung der Begriff des Verbandes an, der im Sinne von Braun-Blanquet durch eine bestimmte Gruppe von Arten gekennzeichnet wird.

Der wissenschaftlich arbeitende Geobotaniker muss es sehr bedauern, dass die Angelsachsen und Nordamerikaner unter Assoziation etwas anderes verstehen als die meisten europäischen Forscher. Dieser Umstand braucht aber den praktischen Forstmann weniger zu belasten. Denn für ihn würde es meiner Ansicht nach durchaus genügen, von »*Lokaltypen*» zu sprechen. In artenarmen Gebieten können diese in erster Linie durch konstante oder dominante Arten, in artenreichen dagegen vorwiegend durch Differentialarten gekennzeichnet werden. Wenn man solche Lokaltypen mit Namen in der jeweiligen Landessprache belegt,

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[1] Prof. Dr., Direktor des Geobotanischen Instituts der Eidg. Techn. Hochsch. Stiftung Rübel, Zürich, Schweiz.

ist eine Verwechslung weniger leicht möglich. Nur die exakt im Sinne der Braun-Blanquet'schen Schule als Assoziationen, Verbände, Ordnungen und Klassen beschriebenen Einheiten sollte man mit lateinischen Namen und den entsprechenden Endungen bezeichnen.

Als gemeinsame Plattform für alle floristisch arbeitenden Schulen kommt mithin meiner Ansicht nach ein Oberbau aus floristisch definierten Verbänden sowie höheren Einheiten im Sinne Braun-Blanquets in Frage. Er genügt für die allgemeine Verständigung und lässt ausreichend Spielraum für die örtliche Gliederung in Grundeinheiten, seien es nun Soziationen, Cajander'sche Waldtypen, Assoziationen oder andere mehr oder minder lokal gültige Typen.

Wie aber ist eine Verständigung möglich mit allen den Schulen, die nicht die Artenkombination der Waldbestände, sondern andere oder zusätzliche Kriterien in den Vordergrund der Betrachtung stellen?

In der letzten Zeit hat der Begriff der *Biogeozönose im Sinne von Sukatschew* auch über Russland hinaus immer mehr Anklang gefunden. Er drückt eine Erkenntnis aus, die sich jedem Geobotaniker immer wieder aufdrängt und die von den rein floristisch arbeitenden Schulen keineswegs geleugnet wird, nämlich dass Pflanzenbestand und Umwelt eine Einheit bilden. Jeder Waldbestand ist in diesem Sinne eine Biogeozönose, und zwar eine einmalige und in genau der gleichen Beschaffenheit nirgends wiederkehrende. Will man diese Mannigfaltigkeit ordnend überschauen, so braucht man Typenbegriffe und muss abstrahieren. Dabei erhebt sich die Frage, ob man den Pflanzenbestand oder seinen Standort, d.h. die Gesamtheit der Umweltsfaktoren, oder gar die Tierwelt in den Vordergrund stellen soll.

Da die Tiergemeinschaft in der Biogeozönose von der Pflanzengemeinschaft abhängt, kann man sie bei der Klassifikation von Wäldern in der Regel ausser acht lassen. Schwerer ist die Frage zu lösen, welche Rolle dem Standort bei der Klassifikation von Biogeozönosen zukommt.

Standortskundliche Klassifikationen der Vegetation sind schon von den älteren Pflanzengeographen, z.B. von Warming, Drude und Schimper unternommen worden, und zwar meistens mit dem Ziel, eine weltweite Übersicht zu gewinnen, die ohnehin zunächst von den floristischen Besonderheiten absehen muss. Eine allgemeine Einigung über ein System konnte aber nicht erzielt werden, weil man das Hauptgewicht verschiedenen Standortsfaktoren zumass und weil die zum Zustandekommen bestimmter Formationen (im physiognomisch-ökologischen Sinne) ausschlaggebenden Faktoren nur ungenügend bekannt waren. Diese Kenntnis fehlt uns grossenteils auch heute noch, so dass es *unmöglich ist, ein allgemein befriedigendes rein standortskundliches System von Waldtypen aufzustellen.*

Diese Einwände bleiben bestehen, wenn man nicht die gesamte Erde, sondern nur ein Teilgebiet betrachtet. Die Standorte gestatten zwar ohne weiteres eine grobe Einteilung der Vegetation. Sie bedürfen aber eines sehr gründlichen Studiums im einzelnen, wenn man sie auch für eine feine Einteilung der Waldbestände nutzbar machen will. Deshalb erscheint es einfacher, die Typisierung der Wälder zunächst auf Merkmale zu begründen, die man an den Pflanzenbeständen als solchen feststellen kann.

Ein derartiges Vorgehen ist nur scheinbar einseitig floristisch. Denn da die Artenzusammensetzung von den Umweltsfaktoren mitgeprägt ist, erfasst man diese ebenfalls, auch wenn man sie zunächst gar nicht studiert. *Die Einheiten der Braun-Blanquet'schen Schule sind also mit anderen Worten Typen von Biogeozönosen, deren floristische Kriterien viele wesentliche standörtliche Gegebenheiten mit einschliessen.*

Allerdings erweist es sich bei den untersten Einheiten, den Lokaltypen, oft als zweckmässig, auf standörtliche Besonderheiten entscheidendes Gewicht zu legen, zumal wenn es sich um mehr oder weniger stark vom Menschen beeinflusste oder gar um standortsfremde Bestände handelt. Geologisch mehrschichtige Böden, z.B. sandüberdeckte Lehme, ermöglichen nicht selten besseren Baumwuchs, als er nach der Bodenflora zu erwarten wäre. Auch bei oberflächlich stark durch Viehweide oder Streunutzung degradierten Böden kann dies der Fall sein. Hier wäre es falsch, dem floristischen Prinzip zuliebe waldbauliche Gesichtspunkte zu opfern. In manchen Fällen können bodenkundliche Kriterien sogar ganz in den Vordergrund treten, wie dies z.B. bei der forstlichen Standortskartierung nach Kraus und Schlenker in Württemberg üblich ist.

Waldbauliche Lokaltypen können also nicht immer nur durch Artengruppen gekennzeichnet werden. Man muss und kann sie teilweise durch bodenkundliche oder andere standörtliche Kriterien abgrenzen, wenn diese genau studiert wurden. Ihre Einordnung in floristisch definierte Verbände, wie sie oben empfohlen wurde, wird dadurch nicht in Frage gestellt.

Dem floristischen Prinzip gebührt aber in der Typologie der Biogeozönosen und deren Klassifikation seiner grösseren Einfachheit wegen vor standörtlichen Gesichtspunkten im allgemeinen der Vorrang. Die letzteren sollten nur in besonderen Fällen bei der lokalen Typisierung in den Vordergrund treten.

Einfach ist der Gebrauch des floristischen Prinzips allerdings nur dort, wo alle Arten bekannt und alle wichtigen Arten leicht erkennbar sind. *In floristisch noch ungenügend durchforschten Gebieten,* namentlich in den überaus artenreichen Tropen, ist eine konsequente Anwendung des Systems von Braun-Blanquet *zunächst* ebenso unmöglich wie die der übrigen floristischen Systeme.

Hier sind jedoch in der Regel auch die Standortsverhältnisse nur in sehr groben Zügen bekannt, so dass eine rein standörtliche Einteilung der Waldvegetation ebenfalls wenig geraten erscheint. Als bestes Hilfsmittel haben sich in solchen Gebieten *Lebensformen, also physiognomisch-ökologische Merkmale* der Pflanzenbestände, erwiesen, wenn man sie durch standörtliche ergänzt. Die klaren Einteilungen südamerikanischer Formationstypen durch Beard können als beispielhaft gelten und wurden auch von anderen Tropenforschern übernommen. Sie verfeinern die altbekannten Formationsgruppen im Sinne von Schimper, Brockmann-Jerosch und Rübel, beruhen aber auf der gleichen Grundlage.

Für die erste Übersicht leisten solche Formationstypen Hervorragendes. Eine genauere Einteilung der tropischen Waldvegetation wird aber auch für forstliche Zwecke nicht ohne die Kenntnis der Arten auskommen. Nach den Erfahrungen von Duvigneaud, Lebrun und andern Forschern in Afrika sowie von Hueck, Schmithüsen, Ellenberg und anderen in Südamerika ist es in den Tropen durchaus möglich, Verbände im Sinne Braun-Blanquets aufzustellen und ihnen Assoziationen oder andere Lokaltypen zuzuordnen.

Die Einteilung der Vegetation in physiognomisch-ökologische Formationen ist also nur ein erster Schritt für die Waldtypologie, dem die Gliederung in floristisch definierte Einheiten folgen muss. Für die Typologie in den floristisch besser bekannten Gebieten sind die Formationen kaum noch erforderlich, können aber auch hier als die oberste Stufe der Einteilung gelten.

Einzelne Formationstypen decken sich mit Klassen des Braun-Blanquet'schen Systems. In der Regel sind sie jedoch umfassender, weil dieselbe Formation in verschiedenen Florengebieten auftreten kann. Hartlaubwälder, die den Gesellschaften der mediterranen Quercetea ilicis sehr ähnlich sehen und gleiche Lebensformen aufweisen, gibt es z.B. auch in Chile, an der kalifornischen Westküste, im südafrikanischen Kapland und in Südwest-Australien. Doch würden diese ganz anderen, bisher noch nicht beschriebenen floristischen Klassen angehören.

Die Formationsgruppe ist also umfassender als die Klassen des Braun-Blanquet'schen Systems, wurde aber bisher von diesem nicht herangezogen. Als oberstes Kriterium für die Klassifikation der Vegetationseinheiten benutzt die Braun-Blanquet'sche Schule allerdings nicht die Artenzusammensetzung, sondern die »Organisationshöhe», d.h. die zunehmende Kompliziertheit in der Schichtung und Lebensformen-Kombinztion der Bestände. Diese ist wie der Formationsbegriff ein physiognomisch-ökologisches Prinzip. Es wäre m.E. ein leichtes, dieses Prinzip durch *einen allgemein anerkannten Überbau von Formationstypen* zu ersetzen, die man entsprechend ihrer Organisationshöhe anordnen könnte. Dadurch würde endlich eine Brücke zwischen den physionomisch-ökologischen und den floristischen Systemen geschlagen.

In Nordamerika, insbesondere in den USA, ist die Waldtypologie unter dem Einfluss der *Clements'schen Klimaxlehre* viel längere Zeit theoretische und deduzierende Wege gegangen als in allen anderen Gebieten der Erde. Darunter litt das sorgfältige Studium der Tatsachen, d.h. die genaue floristische und standörtliche Aufnahme zahlreicher in der Natur gegebener Einzelbestände. Infolgedessen ist hier trotz einzelner guter Ansätze noch keine für forstwirtschaftliche Zwecke brauchbare und allgemein anerkannte Typologie und Klassifikation möglich, weil es an Material fehlt.

Manche jüngeren Forscher in den USA neigen allerdings wie Whittaker zu der Ansicht, dass eine Typisierung überhaupt unmöglich sei, weil die *Vegetation ein Kontinuum bilde.* Zweifellos ist diese Ansicht bis zu einem gewissen Grade berechtigt. Denn in einer Naturlandschaft zeigt die Vegetation nur selten scharfe Grenzen. Ohne Abstraktion lassen sich nirgends Typen aufstellen, und diese Abstraktion macht künstliche Abstufungen nötig, wo die Pflanzenbestände sowie ihre Standorte gleitend in einander übergehen. Mit dieser Schwierigkeit haben jedoch nicht nur Geobotaniker, sondern überhaupt alle Forscher zu tun, die sich mit Lebewesen beschäftigen. Trotz mancher unbefriedigender Konsequenzen wird aber niemand dem typisierenden Ordnen seine Berechtigung, ja seine Notwendigkeit absprechen können. Ob eine Typisierung und Klassifikation der Wälder nach ähnlichen Gesichtspunkten wie in Europa oder in Kanada auch in den USA möglich ist oder nicht, wird im übrigen nur der ernsthafte Versuch erweisen können. Denn bei aller Kritik, die die floristischen Systeme erfahren haben, lässt sich nicht leugnen, dass sie in manchen Ländern mit grossen praktischen Erfolgen in der Forstwirtschaft angewendet werden.

Rückblickend ergibt sich, dass die verschiedenen vegetationskundlichen Schulen in den praktischen Fragen der Waldtypologie nicht durch unüberbrückbare Gegensätze von einander getrennt sind. Für alle ist eine gemeinsame Plattform denkbar oder besser gesagt *zwei* voneinander unabhängige und einander ergänzende *Plattformen*, die von verschiedener Ebene aus einen Überblick über die Unzahl der lokalen Typen gestatten.

Auf der *ersten Plattform* steht die Einteilung in *physiognomisch-standörtliche Formationstypen*, die eine erste grobe Orientierung ermöglichen und die in den Tropen vielerorts noch das einzige Mittel zur Verständigung sind. Begriffe wie »tropical rain forest», »evergreen seasonal forest» oder »tree savanna» mögen als Beispiele dienen. Da die Bezeichnungen in englischer Sprache bereits am weitesten eingebürgert sind und zum Teil wörtlich in andere Sprachen übergenommen wurden, schlage ich vor, sich für den internationalen Gebrauch allgemein *auf Bezeichnungen in englischer Sprache zu einigen.*

Auf der *anderen Plattform* stehen die *Verbände und die höheren Einheiten des Braun-Blanquet'schen Systems.* Sie sind durch Gruppen von differenzierenden oder charakteristischen Arten, also floristisch definiert. Ihre Bezeichnung erfolgt am besten in der üblichen Weise mit Hilfe *wissenschaftlicher Pflanzennamen* und bestimmter Endungen, schon um das floristische Prinzip zu betonen (z.B. Fagion silvaticae, Quercion pubescentis, Quercion ilicis). Die Zusammenfassung zu höheren Einheiten, Ordnungen und Klassen, ist nützlich, aber nicht überall erforderlich.

Auf *tieferer Ebene*, derjenigen der *Lokaltypen* verschiedener Prägung, ist eine internationale Einigung bei dem augenblicklichen Stand der Forschung weder möglich noch unbedingt notwendig. Man sollte nur bei der Namengebung klar zum Ausdruck bringen, ob es sich um eine Assoziation oder eine Einheit anderen Ranges im Sinne von Braun-Blanquet, um einen der finnischen Waldtypen, eine

Soziation oder Konsoziation im Sinn der Skandinavier oder Angelsachsen, um eine Biogeozönose im Sinne Sukatschews, einen forstlichen Standortstyp mit Betonung der Bodeneigenschaften, um eine Waldtypengruppe im Sinne Zlatniks, um einen Waldentwicklungstyp im Sinne von Aichinger oder sonst einen anderen Typenbegriff handelt. Deshalb sollte man sich entschliessen, *den Ausdruck »Waldtyp» schlechthin auf keinen Fall mehr zu gebrauchen.* Er führt nur immer wieder zu Missverständnissen, die bei genauerer Bezeichnung der unteren Einheiten der Waldklassifikation durchaus vermeidbar sind.

Es wäre schon viel erreicht, wenn die beiden darüber liegenden Plattformen allgemein benutzt und anerkannt würden.

Comparison of forest ecosystems (vegetation and soil) in different climatic zones

G. A. Hills[1]

A forest ecosystem is a biological productivity system in which the forest as a group of organisms utilizes the energy of its environment to produce matter (Ovington, 1958). A forest ecosystem is an open dynamic system which, for convenience of study, may be subdivided into four subordinate systems, namely (1) ecoclimate (Geiger, 1957), (2) soil, including parent geologic materials (Nikiforoff, 1942; Crocker, 1952), (3) vegetation (Tansley, 1935), and (4) mesofauna (Odum, 1957). Intermeshed with this complex of local systems are extensions of four systems of continental or global extent. The physical environment and systems may be grouped into two (1) macroclimate, and (2) landform. The systems of living organisms may be grouped into (1) the human, socio-economic system, and (2) the biosystem consisting of all other organisms, both plant and animal, ranging from microscopic to macroscopic dimensions.

Landform and macroclimate are the superior physiographic systems. Landform includes not only the surface relief but the entire solid and liquid continental mantle. The purpose of this paper is to show that an integration of landform and macroclimate constitutes the environmental potential which exerts a functional control on the distribution of organisms and their productivity in the local system.

Since environmental potential is relative to the capacity of the organisms to develop it, the human and biotic systems have important functional controls. The biosystem supplies the local forest ecosystem with its central feature, namely a pattern of forest genotypes, having varying productive capacities under varying environmental conditions. The biosystem also provides the local system with other genotypes (plant, animal and micro-organism) which accelerate, decelerate and otherwise modify forest production. The rate and type of forest production is also modified, both consciously and unconsciously through the human socio-economic system. The scope of this paper does not include further discussion of either the biosystem or socio-economic system.

The concept of total productivity system in forestry has been reached from two viewpoints (a) by an enlargement of the concept of forest (Sukachev, 1958), (b) by a broadening of the concept of soil-climatic units (Hills, 1952). Since somewhat similar concepts, for example, ecosystem (Tansley, 1935), holocene (Friedrich, 1930), organic whole (Wohlfarth, 1955), region (Brunhes, 1910), landscape facies (Neustruev, 1930), have developed in different countries and within different disciplines, standardization of definition and nomenclature is required. More important, however, is an understanding of the principles under-

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[1] Chief Research Scientist, Forest Station, Maple, Ontario, Canada.

lying the abstraction and classification of these complex units (Sukachev, 1944, 1958; Hills, 1959). For example, whether the total system is classified in terms of one or more of its parts (climatic, landform, soil or vegetation features), or by the whole (site index or other productivity rating), it is the whole system and not the part which is classified.

Since, sooner or later, the total system will be defined in terms of all of its parts, the main point for discussion should be: Which part should be stressed in the initial basic framework? The dynamic nature of ecosystems necessitates the establishment of a relatively stable base within which to measure the changes in the development of soil and vegetation which are coincident with changes in climate in both time and space.

In the following synoptic discussion of climate-soil-forest relationship in Ontario, it is hoped to demonstrate that the landform features of relief and geologic materials adequately meet this requirement. In this classification of forest sites, the coincidences of forest and environmental features are treated as having mutually dependent relationships. Such a framework of enquiry for studying the development of vegetation and soils and evaluating productivity systems, Dewey and Bentley (1949) have called »transactional» (Whittaker, 1954).

In order to make valid comparisons of vegetation and soil within different climatic zones, it is essential that the climatic cone be relatively homogeneous in regard to the climate which affects vegetation (cf. Daubenmire, 1956). Unfortunately, effective climate changes within short distances due to variations in local landform features such as slope, aspect, relative mass-elevation, geological materials, ground water, and the distribution pattern of bodies of land and water.

It is essential, therefore, to postulate a potential effective climate which lies just beyond the local modifying irregularities of landform and which forms part of that climatic continuum of astronomically derived energy which changes uniformly from equator to pole, being modified only by major terrestrial features such as land and sea masses, mountains and broad plains. Significant changes in this climate will be accompanied by significant changes in the successional development of vegetation on similar landforms. To this climatic realm, lying beyond the tree cover, and unmodified by local irregularities of the earth's surface, the term macroclimate has been applied.

Obviously, this outer continuum of macroclimate cannot be conveniently measured directly. It can, however, be satisfactorily expressed as a mosaic of effective local climates. Since meteorological stations are too sparse and the significance of absolute levels of atmospheric phenomena for vegetative growth has yet to be determined, a »phytometer» method of classifying effective climates has been employed which not only serves to establish suitable regions but is also used in the detailed description and identification of sites (including interpretation from aerial photographs).

The combined climate, relief, geological materials, soil profile and vegetation continua which constitute the site spectrum of Ontario were examined to determine those relationships of vegetation development to landform which appear to be coincident with regional changes in (a) effective temperature, (b) effective humidity.

Although a specific macroclimate can be most fully described in terms of all the modifications associated with every possible landform, it can be more simply expressed with reference to the type of local climate which is the least modified and hence the one which is most representative. The well-drained portion of a gently undulating terrain of moderately permeable loam, neither highly deficient nor toxic in regard to plant nutrients, is assumed to meet this requirement (Hills, 1950; Daubenmire, 1956). Normality of soil as well as that of landform is required since vegetation is the instrument used to measure climatic variations.

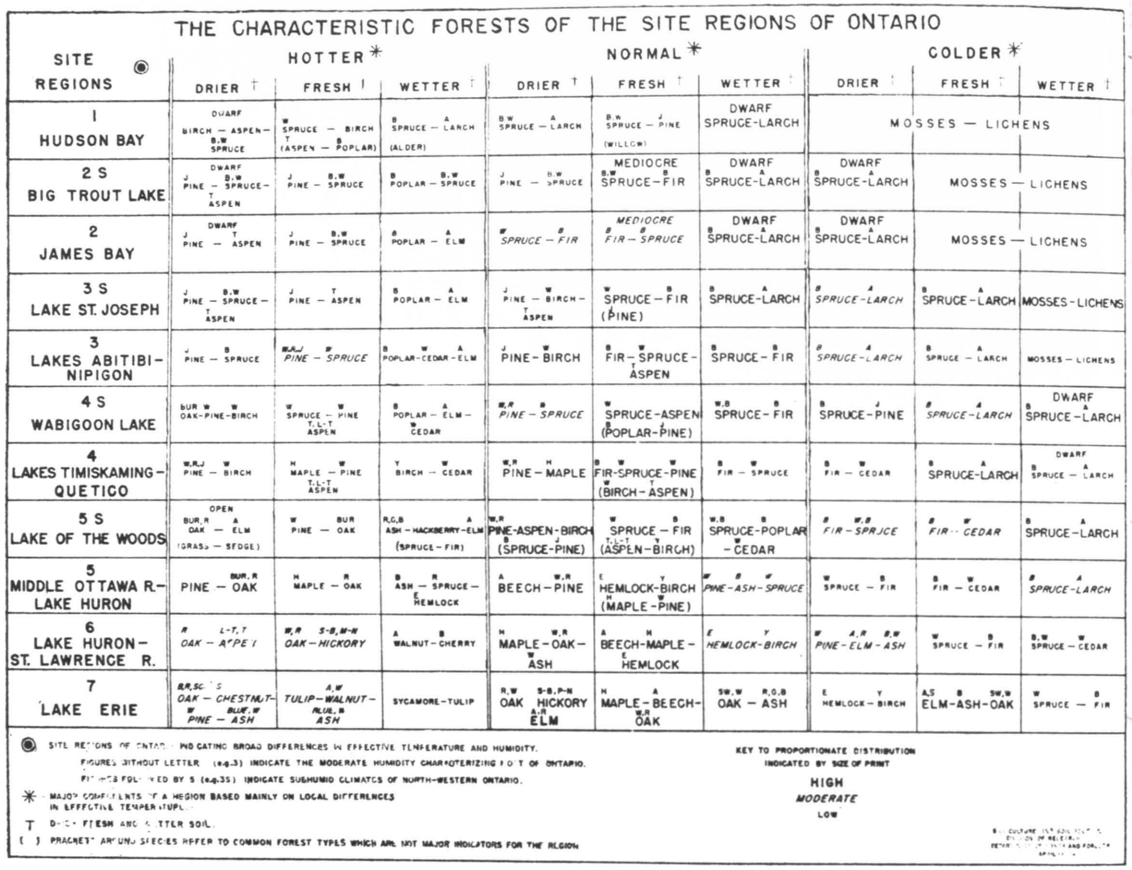
This basic landform reference type, together with eight important deviations from it, constitute the basis for defining the site regions of Ontario (Hills, 1952). These nine classes are derived by combining three soil moisture regime classes: (1) drier than normal, (2) normal (i.e. fresh), and (3) wetter than normal, with three ecoclimatic classes: (1) warmer than normal, (2) normal, and (3) colder than normal.

Site regions are regions of forest types since they are established by noting the succession of forest types on each of the nine major climatic-landform classes. Chart No. 1 presents the distribution pattern of vegetation in Ontario associated with these units. For brevity, the characteristic species of the most stable (climax) forest type upon each specific combination of macroclimate (region) and landform control is shown on the chart.

It is not the mere presence of a species which characterizes a region, rather it is the physiographic site (i.e. the ecological niche) in which it is found. White spruce, for example, is found in all site regions in Ontario, but occupies different niches in each. It moves from the warmest sites in the north to the coldest and wettest in the south. It is found on all ranges of soils, from dry to wet, and on all ranges of local climate, from hot to cold, if all the regions of Ontario are considered, but it never occupies the full range of soil moisture or local climate in any one region.

The shift in successional trends of vegetation development is well illustrated by comparing regions 4 and 5. The tolerant hardwoods on the normal sites (normal ecoclimate and fresh soil moisture) of region 5 are replaced in region 4 by fir, spruce and pine on similar sites. Tolerant hardwoods do occur in region 4 but are confined to the drier sites with a normal ecoclimate and to sites with warmer than normal ecoclimate.

That regions are also characterized by other than »normal» sites may be seen when regions 6 and 7 are compared. In the Lake Erie (No. 7) Site Region a



THE CHARACTERISTIC FORESTS OF THE SITE REGIONS OF ONTARIO

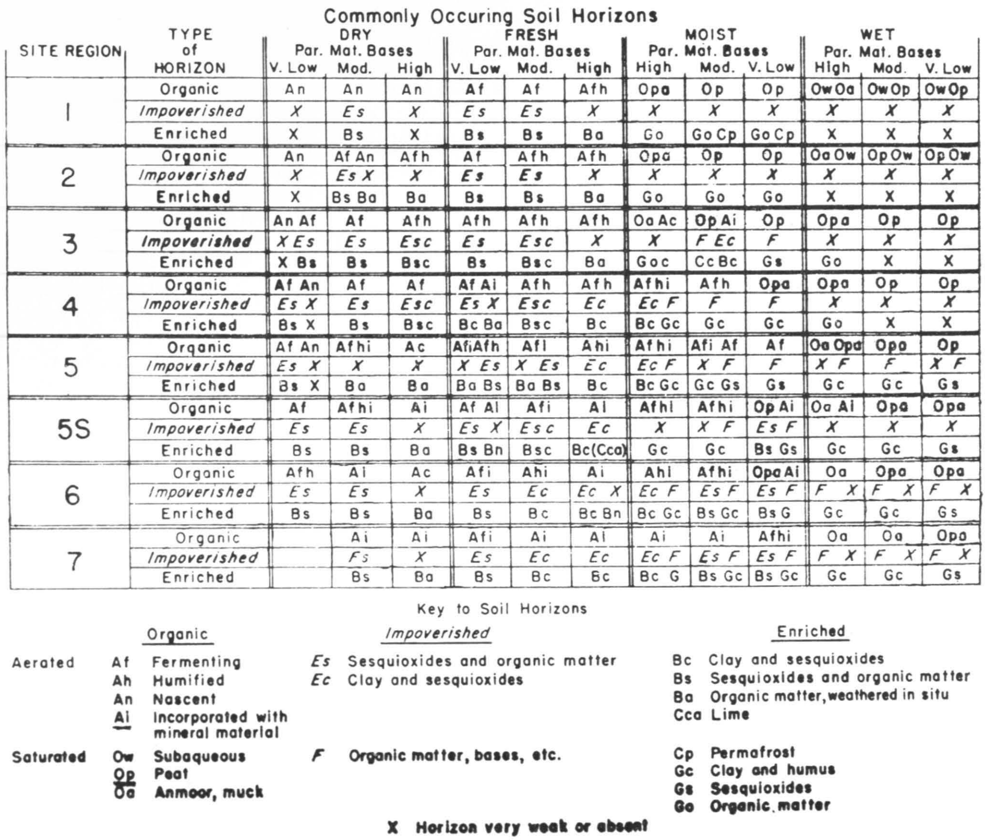
SITE REGIONS ◉	HOTTER ✳			NORMAL ✳			COLDER ✳		
	DRIER †	FRESH †	WETTER †	DRIER †	FRESH †	WETTER †	DRIER †	FRESH †	WETTER †
1 HUDSON BAY	DWARF BIRCH – ASPEN – B.W SPRUCE	W SPRUCE – BIRCH T B (ASPEN – POPLAR)	B A SPRUCE – LARCH (ALDER)	B.W A SPRUCE – LARCH	B.W J SPRUCE – PINE (WILLOW)	DWARF SPRUCE-LARCH	MOSSES — LICHENS		
2 S BIG TROUT LAKE	DWARF J B.W PINE – SPRUCE – T ASPEN	J B.W PINE – SPRUCE	B B.W POPLAR – SPRUCE	J B.W PINE – SPRUCE	MEDIOCRE B.W B SPRUCE – FIR	DWARF B A SPRUCE-LARCH	DWARF B A SPRUCE-LARCH	MOSSES — LICHENS	
2 JAMES BAY	DWARF J T PINE – ASPEN	J B.W PINE – SPRUCE	B A POPLAR – ELM	*W B* *SPRUCE – FIR*	*MEDIOCRE* *B B* *FIR – SPRUCE*	DWARF B A SPRUCE-LARCH	DWARF B A SPRUCE-LARCH	MOSSES — LICHENS	
3 S LAKE ST. JOSEPH	J B.W PINE – SPRUCE – T ASPEN	J T PINE – ASPEN	B A POPLAR – ELM	J W PINE – BIRCH – T ASPEN	W B SPRUCE – FIR J (PINE)	B A SPRUCE-LARCH	*B A* *SPRUCE-LARCH*	B A SPRUCE-LARCH	MOSSES-LICHENS
3 LAKES ABITIBI-NIPIGON	J B PINE – SPRUCE	*W.R.J W* *PINE – SPRUCE*	B W A POPLAR-CEDAR-ELM	J W PINE – BIRCH	B W FIR – SPRUCE – T ASPEN	B B SPRUCE – FIR	*B A* *SPRUCE-LARCH*	B A SPRUCE – LARCH	MOSSES – LICHENS
4 S WABIGOON LAKE	BUR W W OAK-PINE-BIRCH	W W SPRUCE – PINE T.L-T ASPEN	B A POPLAR – ELM – W CEDAR	*W.R B* *PINE – SPRUCE*	W SPRUCE-ASPEN B J (POPLAR-PINE)	W.B B SPRUCE – FIR	B J SPRUCE – PINE	*B A* *SPRUCE – LARCH*	DWARF B A SPRUCE – LARCH
4 LAKES TIMISKAMING-QUETICO	W.R.J W PINE – BIRCH	H W MAPLE – PINE T.L-T ASPEN	Y W BIRCH – CEDAR	W.R H PINE – MAPLE	B W W FIR-SPRUCE-PINE W T (BIRCH – ASPEN)	B W FIR – SPRUCE	B W FIR – CEDAR	B A SPRUCE-LARCH	DWARF B A SPRUCE – LARCH
5 S LAKE OF THE WOODS	OPEN BUR,R A OAK – ELM (GRASS – SEDGE)	W BUR PINE – OAK	R,G,B A ASH – HACKBERRY – ELM (SPRUCE – FIR)	W.R PINE-ASPEN-BIRCH B J (SPRUCE-PINE)	W B SPRUCE – FIR T.L-T Y (ASPEN – BIRCH)	W.B B SPRUCE-POPLAR W – CEDAR	*B W.B* *FIR – SPRUCE*	*B W* *FIR – CEDAR*	B A SPRUCE – LARCH
5 MIDDLE OTTAWA R.-LAKE HURON	BUR, R PINE – OAK	H R MAPLE – OAK	B R ASH – SPRUCE – E HEMLOCK	A W.R BEECH – PINE	E Y HEMLOCK-BIRCH H W (MAPLE – PINE)	*W B W* *PINE – ASH – SPRUCE*	W B SPRUCE – FIR	B W FIR – CEDAR	*B A* *SPRUCE-LARCH*
6 LAKE HURON-ST. LAWRENCE R.	*R L-T, T* *OAK – ASPEN*	*W,R S-B, M-H* *OAK – HICKORY*	A B WALNUT – CHERRY	H W.R MAPLE – OAK – W ASH	A H BEECH-MAPLE – E HEMLOCK	*E Y* *HEMLOCK-BIRCH*	*W A.R B.W* *PINE – ELM – ASH*	W B SPRUCE – FIR	B.W W SPRUCE – CEDAR
7 LAKE ERIE	*B,R,SC. S* *OAK – CHESTNUT –* *W BLUE, W* *PINE – ASH*	*A,W* *TULIP – WALNUT –* *BLUE, B* *ASH*	SYCAMORE – TULIP	R,W S-B, P-N OAK HICKORY A.R ELM	H A MAPLE – BEECH – W.R OAK	SW.W R,G,B OAK – ASH	E Y HEMLOCK – BIRCH	A,S B SW.W ELM-ASH-OAK	W B SPRUCE – FIR

◉ SITE REGIONS OF ONTARIO INDICATING BROAD DIFFERENCES IN EFFECTIVE TEMPERATURE AND HUMIDITY.
FIGURES WITHOUT LETTER (e.g.3) INDICATE THE MODERATE HUMIDITY CHARACTERIZING MOST OF ONTARIO.
FIGURES FOLLOWED BY S (e.g.3S) INDICATE SUBHUMID CLIMATES OF NORTH-WESTERN ONTARIO.
✳ MAJOR COMPONENTS OF A REGION BASED MAINLY ON LOCAL DIFFERENCES IN EFFECTIVE TEMPERATURE.
† DRIER FRESH AND WETTER SOIL.
( ) BRACKETS AROUND SPECIES REFER TO COMMON FOREST TYPES WHICH ARE NOT MAJOR INDICATORS FOR THE REGION

KEY TO PROPORTIONATE DISTRIBUTION INDICATED BY SIZE OF PRINT
HIGH
MODERATE
LOW

Chart No. 1.

maple-beech-oak forest is the climax on the normal sites. However, on the warmer ecoclimates, extensions of the mixed mesophytic (tulip tree, etc.) and oak-hickory forests of the south occur, and on the wet soils with cooler ecoclimates boreal species such as spruce and fir are found. This region is neither Carolinian nor Boreal, but a maple-beech-oak region having extensions of northern and and southern vegetation on specific landforms. Although these deviations do not justify calling the region either Boreal or Carolinian, they are a major factor in differentiating this region from region 6, where a beech-maple-hemlock forest occurs on the normal sites, but where the mixed mesophytic species do not occur.



Commonly Occuring Soil Horizons

SITE REGION	TYPE of HORIZON	DRY Par. Mat. Bases			FRESH Par. Mat. Bases			MOIST Par. Mat. Bases			WET Par. Mat. Bases		
		V. Low	Mod.	High	V. Low	Mod.	High	High	Mod.	V. Low	High	Mod.	V. Low
1	Organic	An	An	An	Af	Af	Afh	Opa	Op	Op	Ow Oa	Ow Op	Ow Op
	Impoverished	X	Es	X	Es	Es	X	X	X	X	X	X	X
	Enriched	X	Bs	X	Bs	Bs	Ba	Go	Go Cp	Go Cp	X	X	X
2	Organic	An	Af An	Afh	Af	Afh	Afh	Opa	Op	Op	Oa Ow	Op Ow	Op Ow
	Impoverished	X	Es X	X	Es	Es	X	X	X	X	X	X	X
	Enriched	X	Bs Ba	Ba	Bs	Bs	Ba	Go	Go	Go	X	X	X
3	Organic	An Af	Af	Afh	Afh	Afh	Afh	Oa Ac	Op Ai	Op	Opa	Op	Op
	Impoverished	X Es	Es	Esc	Es	Esc	X	X	F Ec	F	X	X	X
	Enriched	X Bs	Bs	Bsc	Bs	Bsc	Ba	Goc	Cc Bc	Gs	Go	X	X
4	Organic	Af An	Af	Af	Af Ai	Afh	Afh	Afhi	Afh	Opa	Opa	Op	Op
	Impoverished	Es X	Es	Esc	Es X	Esc	Ec	Ec F	F	F	X	X	X
	Enriched	Bs X	Bs	Bsc	Bc Ba	Bsc	Bc	Bc Gc	Gc	Gc	Go	X	X
5	Organic	Af An	Afhi	Ac	Afi Afh	Afl	Ahi	Afhi	Afi Af	Af	Oa Opa	Opa	Op
	Impoverished	Es X	X	X	X Es	X Es	Ec	Ec F	X F	F	X F	F	X F
	Enriched	Bs X	Ba	Ba	Ba Bs	Ba Bs	Bc	Bc Gc	Gc Gs	Gs	Gc	Gc	Gs
5S	Organic	Af	Afhi	Ai	Af Al	Afi	Al	Afhl	Afhi	Op Ai	Oa Al	Opa	Opa
	Impoverished	Es	Es	X	Es X	Esc	Ec	X	X F	Es F	X	X	X
	Enriched	Bs	Bs	Ba	Bs Bn	Bsc	Bc(Cca)	Gc	Gc	Bs Gs	Gc	Gc	Gs
6	Organic	Afh	Ai	Ac	Afi	Ahi	Ai	Ahl	Afhi	Opa Ai	Oa	Opa	Opa
	Impoverished	Es	Es	X	Es	Ec	Ec X	Ec F	Es F	Es F	F X	F X	F X
	Enriched	Bs	Bs	Ba	Bs	Bc	Bc Bn	Bc Gc	Bs Gc	Bs G	Gc	Gc	Gs
7	Organic		Ai	Ai	Afi	Ai	Al	Ai	Ai	Afhi	Oa	Oa	Opa
	Impoverished		Fs	X	Es	Ec	Ec	Ec F	Es F	Es F	F X	F X	F X
	Enriched		Bs	Ba	Bs	Bc	Bc	Bc G	Bs Gc	Bs Gc	Gc	Gc	Gs

Key to Soil Horizons

	Organic		*Impoverished*		Enriched	
Aerated	Af	Fermenting	*Es*	Sesquioxides and organic matter	Bc	Clay and sesquioxides
	Ah	Humified	*Ec*	Clay and sesquioxides	Bs	Sesquioxides and organic matter
	An	Nascent			Ba	Organic matter, weathered in situ
	Ai	Incorporated with mineral material			Cca	Lime
Saturated	Ow	Subaqueous	*F*	Organic matter, bases, etc.	Cp	Permafrost
	Op	Peat			Gc	Clay and humus
	Oa	Anmoor, muck			Gs	Sesquioxides
					Go	Organic matter

X Horizon very weak or absent

Chart No. 2.

Site regions are likewise patterns of soil types since the features of effective climate, landform (i.e. relief and geologic materials), vegetation and animal life are the soil-forming factors. Therefore different soil development occurs on similar landforms within different site regions. Since landform features occur independently of macroclimate, site regions do not necessarily have a similar landform pattern, although they generally have comparable landform niches. Consequently, the variation in vegetation from one site region to another is coincident both with changes in macroclimate and in regional landform patterns. This means that variations in soil types from one site region to another reflect not only differences in macroclimate but also the patterns resulting from those combinations of relief, geological materials and vegetation which are peculiar to each region.

Chart No. 2 shows the soil profile spectrum for Ontario analysed on the basis of macroclimate (site region) and two significant physiographic features, namely, soil moisture regime and base content of parent material. On this chart only one subhumid region is included (namely 5S) to illustrate the influence of the present subhumid macroclimate and the still drier climate of the xerothermic period of the past.

The chart was designed to show how the dominant soil types coincide with the more significant physiographic controls. A greybrown podsolic (Ai, Ec, Bc) profile is common in the south on tolerant hardwood sites well supplied with lime; on similar materials in the north a grey-wooded (Afh, Ec, Bc) profile supporting boreal conifers is common. The occurrence of both podsol (A, Es, Bs) and brown podsolic (A, X, Ba) profiles on materials with a low base status in all regions is apparently dependent upon local coincidences of all the factors of the ecosystem.

The chart illustrates the reduction in biological activity in going from south to north through (a) a reduction in the number of ecological niches characterized by (i) brown podsolic or greywooded soil profiles, (ii) incorporated Ai horizons, (iii) humified Oa horizons, and (b) an increase in the number of ecological niches characterized by (i) the relatively unproductive peat (Op) horizon, (ii) raw humus (Af) horizon. A very generalized distribution pattern of soil horizons is presented on the chart, owing to the limited number of differentiating features used.

The combination of all the vegetation and environmental factors which characterize site regions determines not only which forest species may be grown but the variations in the rate and type of growth under various cultural and natural treatments. Consequently, a site region is an area in which similar production may be expected from similar forestry practices within similar combinations of forest types, soil types, ecoclimate, and landform.

Since similar soil profiles develop under widely different combinations of environmental features, the significance of a specific profile in the evalution of forest production is dependent upon the total ecosystem of which the soil is but a part. For example, an Ai, Ec, Bc profile may indicate the highest forest production within any single region, but it does not mean that the level of production will remain constant from one region to another on the same profile class, nor will it remain constant within one profile class on different parent materials in the same region.

Likewise, lesser vegetation types, when used as indicators of productivity, must be considered in relation to the combinations of landform, soil and biotic features within which they occur (Tamm, 1950; Whittaker, 1954). Becking (1957) points out that in the Zürich-Montpellier school, geographical-ecological characteristics are being substituted for fidelity of species. Heimburger (1941) and McLean and Bedell (1955) are among those who have demonstrated the integration of lesser vegetation types with the other features of the ecosystem in their evaluations of sites in Canada.

Since biological productivity varies from one site region to another, both in kind and in rate, a regional scale of productivity ratings is needed. Accordingly, the range in forest production for each region, based upon estimates of total annual dry matter production, is divided into seven use-capability classes ranging from A, the highest, to G, the lowest. By comparing these ratings of the productivity of ecosystems within specific contiguous regions, a relative rating between regions may be established. The general use-capability rating of an ecosystem is refined to indicate, in more detail, the relative quantity and quality of a specific product (e.g. black spruce pulpwood) within the regional scale.

Summary

1. The total production possible from any specific locality is limited by the potential energy of the combined macroclimate and landform features of that area. The actual production of the area will depend upon the dynamics of the ecosystem which develop within it. That is, production depends upon (a) the development of a forest vegetation and the degree to which it is able to utilize the productive potential of the physical environment under the soil and ecoclimatic conditions with which it is associated, (b) the development of soil horizons (both mineral and organic layers), (c) the changing ecoclimate systems.
2. Since combinations of macroclimate and landform not only constitute the basic potential productivity but exercise a functional control on the integrated development of vegetation, soil and ecoclimate, combined macroclimate landform units provide the basic classification of ecosystems.
3. General correlations between forest type, lesser vegetation types and soil profile classes are of little value. However, vegetation types and soil profile classes do provide important indications of changes in productivity levels if used within combined units of macroclimate and landform which are well-defined with regard to their potential effectiveness in forest production.
4. The site classification outlined above, in which integrated vegetation-environmental units are organized at local and regional levels, has proven to be a workable scheme for the comparison of soil and vegetation systems in different climatic zones and for the evaluation of forest productivity.

Classification of the vegetation, especially of the forests, with particular reference to regional problems

Aarno Kalela[1]

The ecosystem (Tansley 1935) is a unit which comprises the whole organic population of a given locality, both plants and animals, and further the habitat of these organisms, with its microclimate and its soil. All the components of the ecosystem, both living and inanimate, are in close mutual correlation. Changes in one component are reflected in the entire system and the consequences will continue to be felt until dynamic equilibrium has again been reached.

The different components of the ecosystem can, of course, also be studied and treated as separate units. This fact is especially evident in regard to the vegetation, which in most land ecosystems forms the centre of the whole system (Troll 1950, Daubenmire 1951). It is on the vegetation itself that the classification of plant cover ought to be based. However, the vegetation units should be so defined that they are as uniform as possible, even when the other components of the ecosystem are taken into account (comp. e.g. Cajander 1921, Daubenmire 1952, 1954).

Where man has not interfered with the development of ecosystems or, at least, where his influence is slight, the vegetation is more or less in equilibrium both internally with regard to the plant species composing it, and externally with regard to the other components of the ecosystem. Consequently, the vegetation is generally simply and remarkably uniform and its dynamics are slight. It is therefore undoubtedly advisable to choose the vegetation in such undisturbed areas as the starting point when basic principles for the classification of plant communities are sought.

The regular pattern of the virgin vegetation appears in several ways. Firstly, we can note that in any district it is composed of a great number of homogeneous portions, the stands. They may be wide or small in area and they may change sharply or gradually into each other. Replacing one another somewhat like the squares in a chessboard, they together form the vegetation of the district in question.

Most stands — including all the forest stands — are composed of a varying number of subordinate units, called societies: layer societies, patch societies, aspect societies, societies formed by epiphytes, etc. (e.g. Clements 1916, 1936, Nichols 1923, Kujala 1929b, Kalela 1939, 1954, etc.). Sometimes these societies are sharply distinguished from each other, sometimes there are no distinct limits between them. Each society is as a rule more homogeneous in species composition and in ecological character and structure than the stand as a whole (comp. in addition Gams 1918, Lippmaa 1934, Cain 1936, Daubenmire 1952, etc.). In spite of this, the organic unity of the societies within one and the same stand must be emphasized. The natural basic units for the study of the vegetation are not the societies, but the stands, i.e. the whole vegetation in the locality (e.g. Gleason 1936, Kalela 1939).

Another aspect of the pattern apparent in vegetation which has reached dynamic equilibrium, is that certain stands in the area prove to be more or less similar as far as species composition and ecological structure are concerned. Thus it is possible to talk about stand types.

When classifying stands into stand types the phytosociologists and phytosociological schools have used different methods — as is well known (comp. e.g. Du Rietz 1921, 1930, 1936, Cajander 1922, 1931, Nordhagen 1928, 1936, Alechin 1933, Sukachev 1934, 1954, Clements 1936, Cain 1939, Kalela 1939, Tuomikoski 1942, Braun-Blanquet 1951, Whittaker 1953, Poore 1955, Ellenberg 1956, etc.). The only correct way, in the author's opinion, is to pay attention to all the species found in the stands and to take into consideration all features seen in their occurrence, structure and other characters. There is *a priori* no reason to single out any species or any of their characters as a classificatory basis. Moreover, it is not necessary that each character should occur in every stand of a certain stand type. The classification should be based on all the similar and distinguishing characters of the stands in question (e.g. Tuomikoski op.cit., Kalela 1939, 1954).

As long as we agree about the principles of the classification of stands, it is a question of secondary importance how high a standard we set for their homogeneousness, i.e. how widely or narrowly the stand types are to be limited. Obviously there is no reason to adhere to any rigid system in this matter; the character of the given vegetation, the object of the study, etc., should determine the limits. The goal should be to distinguish units which really have an equivalent in nature.

It is often emphasized that the variation in vegetation is as a rule multidimensional in character, i.e. the stands cannot be placed in any linear series according to their similarity, but they express correlations in several directions forming a net-like system (Ramenski 1930, Tuomikoski op.cit., Goodall 1954, Ehrendorfer 1954, Whittaker 1953, 1956, Poore 1955, etc.). It is evident that this phenomenon causes difficulty in the classification of stands. On the other hand, we have to grant that it is fairly slight in some cases and much more conspicuous in others.

Further, it has been claimed that the variation in several features of the vegetation is completely gradual, the stands forming an uninterrupted series, a »continuum», in which only arbitrarily limited units could be distinguished (Cain 1947, Curtis & McIntosh 1951, Brown & Curtis 1952, Goodall op.cit., Whittaker 1956). The investigated cases are so far very few, however, and they

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[1] Ph. D., Professor, Department of Botany, University of Helsinki, Finland.

hardly allow generalization of the statements. In some cases, at least, the material seems to be somewhat in adequate for a reliable analysis. The result might also look different if all the plant species were taken into account and not, as is usually the case, a small number (e.g. the tree species) only. At all events there are apparently great differences between different kinds of vegetation in this respect also (comp. also Dansereau 1954, Daubenmire 1954).

The great number of stand types even in a restricted area has created the need for higher categories of plant communities. The farthest development of such a hierarchic system has been made by the Central European school under the leadership of J. Braun-Blanquet (e.g. 1955). Within a small area, grouping stand types into a purely floristic system such as this school uses can be done fairly easily. When applied to a larger area however we, meet with great difficulties, because similarities in the species composition of the stands, which form the basis of the system, decrease at the same time as the area is enlarged (e.g. Gleason 1926, Alechin 1927, Kalela 1939, Cain 1947, Ellenberg 1954, 1956). The difficulties are the greater the smaller the categories in question, are. The situation might be helped to some degree by including forms corresponding to or approaching each other ecologically and structurally — besides the identical and taxonomically closely related species — as the basis of the system (e.g. Nordhagen 1936, Kujala 1945, Kalela 1954.)

However, with good reason we could ask how useful this kind of hierarchic system is, even within relatively local bounds where it is possible in reality. Even in such a case it is only one side of the study of plant communities. As we try to extend the system to include wider areas, it will become more and more divorced from reality and will be in still greater danger of becoming a useless end in itself.

Another task of the student of plant communities — and a much more important one in the author's opinion — is the study of vegetation as a topographic-regional phenomenon (e.g. Cajander 1921, 1922, Kalela 1939, 1949, 1954, Daubenmire 1952, 1954, Ehrendorfer 1954). Each stand belongs to a larger topographic unit, the stand complex (e.g. Cajander 1903—09, 1913, 1921, 1922, Nichols 1917, 1923, Du Rietz 1921, 1930, Nordhagen 1928, Kalela op.cit., Sjörs 1948). These stand complexes are parts of the plant cover which are more or less clearly distinguished from the surroundings and composed of numerous stands representing diverse stand types of various sizes and alternating in different ways — being mosaic, belt-like or reticular in shape.

When comparing the stand complexes of a certain district we can observe great regularities in their structure and occurrence. Just as we are able to group similar stands into certain stand types, we can group similar stand complexes into certain complex types (Cajander op.cit., Nichols op.cit., Kalela op.cit.).

A wide area, where the same complex types prevail in localities corresponding to each other with regard to topography, microclimate and soil, is called a vegetation region (Kalela op.cit.). Within each vegetation region the macroclimate is homogeneous in broad features. Between two neighbouring regions there is a transition zone (ecotone, Clements 1916, 1936), where the complex types characteristic of each region and the intermediate complexes occur side by side.

The stand types of a vegetation region can, as a rule, be divided into two groups: regional (climatical, zonal) and local (edaphical, azonal) plant communities (Schimper 1898, Nichols 1917, 1923, Cajander 1916, 1921, Walter 1942, 1954, Daubenmire 1954 etc.). To this division, which is very conspicuous in most vegetation regions of the world (least pronounced in the Arctic and many alpine regions), phytosociologists have not always paid sufficient attention.

In each vegetation region the prevailing climate contributes to the development of definite kinds of soils. The stand types which are the most competitive ones on these »normal» soils, not representing any extreme habitats for the plants, together form the regional plant communities of the region in question. They form a single great stand complex, which, ramifying reticularly, covers most of the area of the vegetation region.

The number of these communities is generally small. They are all »closely related», i.e. they show great similarity in species composition, ecological character and structure and even in physiognomy (e.g. the coniferous forests in the cool boreal regions, the hardwoods in the humid regions and the steppes in the arid ones in the temperate zone, etc.). Certainly it is not a mere chance that most of the investigated cases of vegetation regarded as »continuums» have been regional plant communities. There are apparently also vegetation regions with a hygrically extreme macroclimate, where this group of communities is only represented by a single stand type (e.g. many steppe regions and forested areas bordering them; several temperate, subtropical and tropical »rain forest» regions, etc.).

The local plant communities of a vegetation region are competitive only in certain edaphically and microclimatically peculiar localities, where the soil development also occurs in an exceptional way compared to the predominant one in the region. In such extreme habitats (alluvial river banks, shores of seas and lakes, dune areas, bare rocks, peatlands, salt flats, etc.), the local communities form stand complexes generally small in size but mostly sharply defined, resembling tiny islets in the immense complex of the regional communities.

As a whole the local communities in every vegetation region form a very heterogeneous group. They belong to several different complex types and each of these, as a rule, consists of numerous stand types. Even within one and the same complex type the stand types often clearly differ from each other in species composition, ecological character, structure and physiognomy (comp. treeless and wooded communities in peatland complexes, meadows, bush and forests in alluvial complexes, etc.) and still greater differences exist between the stand types of different complex types. Most of the local communities are, both as stands and as stand types, more sharply defined than the regional communities. With regard to them a thought of »continuums» hardly comes into our minds at all.

Those vegetation regions having — obviously as a result of similarity of macroclimate with all its consequences — ecologically and structurally corresponding and often also floristically related complex types of both regional and local communities can be considered to represent a wider vegetation unit, the plant formation (Cajander 1921, 1922, Kalela 1949, 1954). For example, the boreal forest formation with two large vegetation regions, one in Eurasia, the other in North America, and in addition a number of smaller vegetation areas on nontropical mountains of the northern hemisphere.

The concepts vegetation region and plant formation can, of course, be applied in a wider or narrower sense, according to the degree of resemblance and equivalence of the complex types that we demand. If we understand the boreal forest formation in such a wide sense as mentioned above, both its main areas consist of several belts in the north-south direction, and each of them of still smaller areal units, as we pass inland from the ocean coasts. Consequently, we may divide the formation into smaller units, such as subformations, etc.

The dynamics of the vegetation has, as is well known, especially attracted the Anglo-Saxon ecologists (e.g. Clements 1916, 1936, Nichols 1917, 1923, 1926, Tansley 1920, 1935, Cooper 1926, Gleason 1927, Cain 1939, 1947, Whittaker 1953 etc.). Here these problems can be touched on only briefly and with special reference to the distinction between regional and local plant communities. Even in virgin vegetation regions hardly if at all influenced by man, disturbances in the equilibrium of both categories of plant communities occur. They may be caused by fires started by lightning, by herds of wild animals, avalanches, water and wind erosion and other catastrophic factors. These processes damage and even destroy vegetation and may create barren spots free from competition, where the vegetation has to start its development from the beginning. Such disturbed localities, however, cover only insignificant areas and the vegetation generally regenerates fairly soon. Nevertheless we can here speak of developmental series — successions —, in which plant communities differing in composition and structure gradually follow each other in a definite order. The first of these successional communities are very short-lived, later ones lasting somewhat longer and the final stage, the climax community, is stable.

The last-mentioned statement holds strictly true for the regional plant communities only. In these communities disturbing factors cause successional development, but — presuming an unchanged macroclimate — the succession always finally leads to one and the same climax phase again. In this sense the regional plant communities are really self-maintaining.

In regard to the local plant communities the case is more complicated. Besides the above described development we have to take into account some other kinds of processes, caused by edaphic, topographic or microclimatic changes. On riversides on which alluvial sediments are deposited annually, the ground surface is continuously rising and the bank grows towards the river bed. Then the lowermost of the belt-like communities of the shore spreads to the newly exposed soil, the next lowest one to its former site and so on. A substitution of the same kind among local communities is seen on those seashores where a gradual upheaval of land occurs, in connection with filling-in of lakes and ponds, with drying-up of peat bogs, etc. All these sequences can also be called successions if we understand by this word a change in vegetation having a certain direction and consisting of certain phases. They deviate, however, from the above mentioned successions in the tardiness of the whole process. Most of its phases are therefore fairly long-lived and so approach the climax stage of the regional communities. Furthermore, the course of these successions is of such a nature — progressive — that the habitat conditions continually become less and less extreme; finally they may exceed the limit above which the local communities in question are no longer competitive and consequently are replaced by regional communities. Thus only the latter are really stable, true climax communities. Reverse changes, leading from developmentally advanced communities to lowly ones, also occur (e.g. sequences caused by rising ground water level in peat bogs). These regressive (retrogressive) processes are, however, always incidental and only temporary. Sooner or later development in a progressive direction begins again.

The ideas shortly explained above coincide in essential points with the well-known and much debated climax theory of the North American school, farthest developed by F. E. Clements (e.g. 1916, 1936). According to this theory in every district under the prevailing climate only one plant community, the climatic climax formation — often abbreviated to climatic climax or simply climax — exists. All the other communities are successional or — to use a term proposed by Clements — seral. Sooner or later they reach the climatic climax.

In formulating this concept Clements actually meant — if the author has understood him correctly — the regional communities of a given vegetation region as a whole. As before mentioned, this group is generally composed of a few, closely related and stable stand types — sometimes of only one single stand type — which together form the bulk of the plant cover in the area in question. On the other hand, it should be noted that Clements applied the term climatic climax very broadly and afterwards distinguished smaller units within it (associations, fasciations, locations). Thus it is largely a matter of taste whether to speak of a high ranking community type or of a group of community type.

Clements obviously included the local communities in the category of seral units. And as mentioned before there is no doubt that in them successions in a certain direction often occur, which may finally lead to regional communities, i.e. to the climatic climax. In any case a possibility of this kind exists, at least in theory.

In proposing the term »extrazonal vegetation» Russian phytosociologists have recognized the important fact that the regional (zonal) plant communities of a given vegetation region, as a rule, occur as local (azonal) communities in the neighbouring region (e.g. mixed hardwood forests are regional on Central European lowlands, but local in most part of Fennoscandia). Clements looks upon the phenomenon from a dynamic point of view. In his system the extrazonal plant communities belong to the categories preclimax and postclimax. They are understood as caused by a change in macroclimate, either as outposts of an advanced climatic climax (preclimax) or as relics of a regressing one (postclimax). Successions of this type are obviously always very slow, even slower than successions caused by topographic and edaphic changes. Therefore it may often be difficult to decide to which of the two categories an extrazonal plant community belongs. It is evident that changes in macroclimate also produce successional development in local plant communities. Their interpretation is obviously, however, still more difficult.

In areas affected by human activity the vegetation is much more heterogeneous and less regular than in undisturbed districts. This is chiefly caused by the strong dynamics of the vegetation. Disturbances in the equilibrium of the plant communities are numerous and repeated and thus the actual vegetation is composed of a checkered mosaic of various stands, in which the majority represent all kinds of changing stages of numerous successions. It is natural that this heterogeneity and instability greatly hampers the study of plant communities. Observing patterns in vegetation is much more difficult in all respects, in limiting stands, in classifying stand types and in distinguishing topographic-regional units.

However, even in districts of this sort the vegetation has a developmental tendency towards an equilibrium, the climax stage. Thus there, also, this idea must be the basis and the guiding principle of all phytosociology (comp. Cajander 1926, 1931, etc., Daubenmire 1952). We should try to find climax communities and to make first-hand investigations in them. The successional phases in which development has progressed farthest follow in the second place, and only after them the short-lived initial stages of the successions. In limiting stand types — especially among the unstable successional communities — we are forced to compromise with the demands of homogeneity and to be contented with comparatively broad and collective types, omitting the most temporary and rarely occurring communities. Otherwise the number of stand types will be so great that it would be quite impossible to deal with them or to gain any comprehensive idea of the system as a whole.

Where forests are concerned the question is particularly difficult. This is partly due to the complicated structure of the forest stands, partly to the longevity and great competitive capacity of their dominant plants, the trees. For surmounting these difficulties the Finnish theory of forest types by A. K. Cajander (1909, 1926, 1931, 1949 etc.) offers one and, at least today, perhaps the best way. Although it has been primarily developed for the boreal forests, its ideas evidently have a more general application, too (comp. Linkola 1924, 1929, 1930, Ilvessalo 1929, Kujala 1929a, 1935, 1936, 1945, Heimburger 1933, Kalela 1941, 1954, 1958 etc., Hustich 1949, 1950, 1955, Linteau 1950, Keltikangas 1959, etc.).

In undisturbed areas, where the forests are regional communities, they are characterized by the same regular pattern as plant communities in general. All the forest stands are old. Young and middle-aged forests do not exist or only occur exceptionally. Each tree species grows on such sites and in such abundance as is determined by its ecological requirements and by the strong competition between plants. The same uniformity as in the tree layer also prevails in the lower layers of the forests. Thus distinguishing stand types — always few in number — does not present any great difficulty.

In districts exposed to more or less intensive human influence the situation in forests, and particularly in their tree layers, is quite different. There are forests of all ages — from seedling stands to mature timber forests. Forest fires have changed the composition of the tree layer to a great extent. By various procedures man has cleared forests to make fields and meadows and often later let them revert to forest again. In planted forests man tries to control the composition of the tree layer; in other mature stands he is able to change its composition at will by felling. However, even in the tree layer there appears to be a clear tendency towards the climax stage. If it is not disturbed, competition eliminates weak pioneer tree species one after another. Finally only the strongest competitors survive and then the equilibrium and uniformity of virgin forests has been reached even in this layer. However, before that a new disturbing factor has often upset the balance again. The lower layers of a forest usually reach equilibrium or a stage close to it faster than the tree stand, in South Finland generally in 40—70 years. The tree layer does the same in a century or two, perhaps taking even longer. Therefore the Finnish theory of forest types pays special attention to these lower layers, known as the ground vegetation.

The boreal forest formation is poor in tree species everywhere and this is particularly true of the North European forests. For example, in South Finland the virgin forests would be more or less pure Scotch pine woods on dry and infertile sites, and Norway spruce woods on better sites. Thus in the climax forests of this country two stand types, pine forests and spruce forests, could be distinguished. However, if we take the ground vegetation and the growth of the trees into account, these stand types prove to be rather collective and heterogeneous. It is obviously better to distinguish a couple of pine stand types and a few spruce stand types.

In the dry and poor forest sites of South Finland the pine is usually the first tree to occupy the ground in burnt-over areas and in treeless clearings and it is also the biotically strongest tree up to the climax phase there. On more fertile and moister sites the succession is more complicated. The first tree layer may be composed of any species common in the district: pine, spruce, white birch, grey alder, even aspen, either one of them alone or two or more species mixed in various proportions. Further development leads through different pure or mixed tree stands, if not during the second generation then during the following ones, to pure spruce forests.

Each tree species has a special influence upon the microclimate and upon the soil of its habitat. Thus it is evident that the ground vegetation even on similar sites and in forests of the same age varies somewhat, depending upon the composition of the tree layer. On the other hand these differences should not be exaggerated. Thus on the medium forest sites in South Finland the ground vegetation is essentially uniform, although the tree layer of the equivalent stands are composed ot birch, pine or spruce alone or of mixtures of these. The pine stands on the driest sites of this district diverge much more from this kind of pine stand, just as the spruce stands on the sites differ from this kind of spruce wood. Within certain limits the ground vegetation in many successional forests — at least in the boreal torest zone — appears to indicate primary differences existing in soil and microclimate better than the tree layer.

Even in pure stands the influence of trees upon the habitat may be very different according to age and these differences are, of course, also expressed in the ground vegetation. We can take as an example the ground flora of the spruce forests on the best sites in South Finland during three different stages: sapling stage, middle-aged dense stand and old stand, which is beginning to get thin again. The differences between these three successive communities are so great that we might, perhaps, think of placing them in separate stand types. On the other hand it is clear that they form one solid, indivisible entity. In addition, the differences are not by any means always as great as they are in this case. In general, the poorer the habitat and the thinner the existing tree stand, the smaller they are. Thus for instance, the ground vegetation of the poorest pine woods in South Finland remains essentially unchanged from the beginning of the succession up to the climax stage.

Even in primarily equivalent habitats and presuming the same composition in the tree layer, the ground vegetation in the beginning of its successional development is dissimilar according to the situation, whether the sapling stand originates in a cut-over area or in a new burn, in an old meadow or in a field. In the course of growth of the trees these differences get slighter and slighter, almost entirely disappearing by the timber forest phase. On the other hand, on two primarily different habitats and even under a similar tree layer the ground vegetation is already diverse at the starting point of the succession, irrespective of whether the forest stands in question originated in cut-over or burnt areas, in meadows or in fields, and the differences are preserved up to the climax phase.

Analogously, the changes caused in forest stands by grazing, thinning of the tree layer, wind and snow breaks, etc., are diverse owing to the site. All these factors — as well as forest fires, clear-cuttings and other more severe human measures — have to be regarded as accidental and as more or less temporary phenomena in forest succession. They are able to retard the natural development of the vegetation but they cannot — in any case not commonly and not to any great extent — change the primary character of the habitat or the directions of the successions.

As a brief summary of the above discussed points of view we have to state that in each macroclimatically homogeneous area influenced by human activities, where forests are regional plant communities the following two categories of forests can be distinguished: (1) a small number of stable climax communities occurring on primarily different habitats and characterized by essential differences in composition and structure of both tree layer and ground vegetation; (2) a great number of diverse unstable successional communities, which are developing or tending to develop towards one of the climax communities.

Around each climax community there is firstly a series of communities which actually only represent young stages of the climax tree layer and those of the climax ground vegetation. Another group is made up of those communities which only deviate from the above-mentioned ones by temporary differences in the tree layer and by fairly unessential ones in the ground vegetation caused by the secondary influence of the trees upon the habitat. Lastly a rather insignificant group of successional communities follow, the distinguishing characters of which are caused by such purely accidental and transitory factors as grazing, logging, wind and snow injuries, etc. To sum up: each climax community and all the successional communities developing towards it form, as a whole, one forest type.

We may still quote the definition of Cajander himself (1926, 1949): All those stands are referred to the same forest type the vegetation of which at or near the time of maturity of the stands and provided the stands are normally stocked, is characterized both by largely identical floristic composition and a similar ecologico-biological nature, as well as all those stands the vegetation of which differs from that defined above only in those respects which — resulting from differences in the age of the stand, fellings, chance in tree species of stand, etc. — have to be considered as merely accidental or ephemeral or at any rate not permanent.

In undisturbed districts the climax stages of the forest types are — practically speaking — the only existing forest communities. In reality in such a district we do not need a concept like forest type at all. In districts strongly influenced by man it has, by contrast, a wide bearing. There it makes it possible to discern regularities in the extremely varying plant cover and to combine forest stands closely related as regards site and the most essential properties of the vegetation into natural units.

Can we find a common platform for the different schools of forest type classification

VLADIMIR J. KRAJINA[1]

Forests, due to a wide variety of climatogenic, pedogenic and biogenic processes, are the most diversified and highly evolved entities encountered in the earth's biosphere. The complexity of the task of classifying forest types has been met by an equally complex and varied methodology on the part of research workers in all countries where the problem has been confronted. Yet each in his own way has contributed something to our understanding of the problem, and it is well to remember that the present discussion would be impossible without their efforts.

With this in mind, it is felt that a brief consideration of past efforts at forest classification would not be amiss. Forests may be synecologically classified at the three levels: environmental, biocoenotic, and ecosystematic.

I. Environmental or Ecotopical Classifications. The main interest lies here in the limiting and controlling characteristics of the ecotope of different forest parts. Sometimes such studies are directed only to a consideration of macroclimatic differences (climatopic approach). In North America, environmental studies, based on macroclimatic characteristics of different geographical regions, lead Cowles (1899) and especially Clements (1902—1939) and Tansley (1911—1939) in their concept of plant formations to the application of the same idea, applied previously in soil classification by Dokuchaev (1879, 1899). These same plant formations of Clements became the foundations for »A Forest Classification for Canada» by Halliday (1937), that has useful application in bioclimatic zonation in present days (Rowe, 1959). Clementsian adherents are Nichols (1923—1930) and Braun (1916—1950).

Russian typologists, deriving their ideas from the founder of Russian forest typology, Morozov (1903—1931), are represented by such names as Serebrjannikov (1904, 1913), von Kruedener (1903—1930), Guman (1911), Gutorovicz (1912), Ramenskij (1924—1952), Alekseev (1926, 1928), Pogrebnjak (1927—1955), Vorobjov (1929—1953), Vasiljev (1929—1938), Kozhevnikov (1931—1939) and Efimova (1939), Arkhipov (1932, 1939), and many others. They are mainly environmental ecologists, using some soil characteristics for their forest classification. Their system, artificial as it may be from the point of view of forest biocoenoses, has definitely its practical application.

A similar edaphotopic approach to the classification of forest environment is much used by Franz Hartmann (1948—1952) in Austria and in the physiographic site classification scheme of Hills (1950, 1952) here in Canada.

Even if such classifications, called by Svoboda (1949) as artificial, are holocoenotically incomplete because they do not give due emphasis to the very real effects of ecological action, reaction or coaction, they nevertheless inform us on significant characteristics of the environment. These, in turn, may contribute basic information to more comprehensive ecological studies.

II. Biocoenotic Classifications. At this level, biocoenoses are studied analytically and synthetically in their qualitative and quantitative composition. These studies are usually dominated by either a phytocoenotic approach (phytosociology or phytocoenology), or a zoocoenotic approach (zoosociology or zoocoenology).

Biocoenotic (mostly phytocoenotic) classifications, called by Svoboda (1949) as natural, frequently unaccompanied by environmental information, are represented first by the work of the Finnish typologists, Cajander (1909—1943), Ilvessalo (1920—1929), Lakari (1920), Aaltonen (1923—1948), Linkola (1924, 1929), Lönnroth (1925), Kujala (1926—1945), Svinhufvud (1937), Tuomikoski (1942), Kalliola (1939), Hustich (1949—1955), and Kalela (1954—1958), and their followers in different countries such as Bornebusch (1923—1931) in Denmark, Korstian (1917—1928), Heimburger (1934, 1941), Sisam (1938), and Kabzems (1951) in North America, Mikyška (1928—1951), Klika (1929), Hilitzer (1934), Zlatnik (1935—1954), Zvorykin (1954), and Vincent (1953) in Czechoslovakia, Jedlinski (1928) and Kulezsa (1936) in Poland, Blanckmeister and Merz (1929), Kötz (1929), Wiedemann (1929), and Meusel (1935) in Germany, Aichinger (1949—1954) in Austria, Boyko (1945) in Palestine, and Champion (1936, 1938) in India.

This category includes the phytogeographic-physiognomic school, founded by von Humboldt (1806, 1807), Kerner von Marilaun (1863), Grisebach (1872), Drude (1890, 1896) and Schimper (1898—1935), followed by Domin (1904—1930) and lead by Brockmann-Jerosch (1907—1929), Rübel (1912—1936), Däniker (1939), supported by studies of Raunkiaer (1903—1934) on life forms. Phytogeographic-physiognomic methods are recently still used for mapping as by Küchler (1947—1956) and in tropics as by Richards (1936—1952).

Phytocoenotic classifications include also the studies of the Scandinavian ecologists, represented in Norway by Nordhagen (1923—1954), in Sweden by the Uppsala School, lead by Du Rietz (1918—1936). Here further belongs Gams (1918—1954) in Austria, Lüdi (1919—1948) and Schmid (1922—1942) in Switzerland and Lippmaa (1935, 1939) in Estonia as well as the Polish ecologists Szafer, Pawlowski, Kulczynski, Sokolowski, Motyka, Wallisch, Stecki and Walas (1923—1949).

Here belongs the whole Zürich-Montpellier school, grouped around a great ecologist, Braun-Blanquet (1913—1959). Dansereau (1957) writes (p. 200): »The

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[1] Professor of Forest Ecology, The University of British Columbia, Vancouver, B.C., Canada.

Zürich-Montpellier school invokes the floristic composition first and places almost exclusive emphasis upon it, trusting, as it seems, that association-characteristics embody the very ecological-pedological-climatic factors which determine them. Although there are valid objections to such a sweeping assumption and weakness in the method itself, it does have the merit of grouping communities exclusively upon the basis of plant features instead of causal (climate-soil-habitat) factors.» There is a long series of followers of this ecological school, among them: Allorge (1922), Pavillard (1921—1936), Quinochet (1938, 1954) and Emberger (1954) in France, Beger (1922, 1930), Koch (1926, 1947), Pallmann (1927—1948), Moor (1937, 1938), and Etter (1943, 1947) in Switzerland, Tüxen (1928—1958), Ellenberg (1937—1954), Schwickerath (1940—1954), and Knapp (1949) in Germany, Klika (1928—1955), Krajina (1933—1935), Sillinger (1933—1939) and Hadač (1944—1949) in Czechoslovakia, Horvat (1930—1938) in Yugoslavia, von Soó (1927—1947) in Hungary, Aichinger (1933) in Austria, Bharucha (1933—1954) in India, Conard (1935—1939) and Becking (1957) in U.S.A., de Vries (1939, 1953), Barkman (1950, 1958), and Westhoff (1951, 1954) in the Netherlands, Poore (1955, 1956) in England, Meijer Drees (1949—1954) in Indonesia, Borza (1958) in Roumania, and Tchou (1948, 1949) in China, to name a few.

To the same biocoenotic level could be assigned the earlier studies of Russian phytocoenologists, among them Gobi (1876), Tanfiljev (1892), Krylov (1898), Sukachev (1903—1944), Tkaczenko (1911, 1939, 1952), Alechin (1915—1951), Keller (1916—1938), Lavrenko (1926—1949), Sokolov (1926—1956) Katz (1928—1948), Soczava (1927—1955), Korczagin (1929—1946), Afrorin (1933), Shennikov (1935—1956), Iljinskij (1936, 1945), Tikhomirow (1934—1946), Gorczakovskij (1949, 1954), Leskov (1943), or of the Polish typologist Paczoski (1891—1930). Gobi in St. Petersburg (Leningrad) developed the first community concept in his »types» as the »mutual combination of plants or the grouping of plant forms.» Paczoski (1896) coined »phytosociology» as the study of the genesis, the life, and development and the distribution of vegetation formations. The same designation was independently proposed by Krylov (1898) as »the social relations between the plants.»

Some of the biocoenotic systems as well as bioclimatic classifications could be designated as syngenetic, if they solve and classify the dynamic successional relations of the plant communities.

III. Ecosystematic or Biogeocoenotic Classifications. This approach encompasses both previous levels, ecotopical as well as biocoenotic, is holocoenotic and usually not only »natural» in the sense of Svoboda, but also »syngenetic». Indeed, it is not as new as might be concluded from the fact that it has become more popular in recent times. One may find that some phytocoenologists pay relatively great attention to the environmental causes of studied phytocoenoses. Such a predilection for environmentalism is found especially in studies of some Russian phytocoenologists as well as in some publications of the Z.-M. school (e.g. Braun-Blanquet and Jenny, 1926).

When the author published his study »Die Pflanzengesellschaften des Mlynica-Tales in den Vysoké Tatry» (1933), in which he followed the analytic and synthetic methods described by Braun-Blanquet, he included the significant environmental characteristics of every plant association under study. These environmental characteristics, called frequently in some parts of Europe as »ecological», form the ecological framework for the classification of plant associations and, in this regard, are equally as serviceable as floristic structure. As evidenced by statements in the publication previously mentioned (1. Teil, p. 776), I had formed the conclusion that both characteristics, floristic and environmental, are very necessary for description of any ecologically basic unit. Whilst acknowledging the significance of fidelity among synthetic characteristics in the floristic structure of plant associations, I went on to reject the absolute tenet of its dogmatic prescription in such plant associations. Ecologically well distinguished associations that have marked and measurable differences both environmentally and in some vegetational characteristics cannot surrender their existence to a concept that requires them to possess exclusive, selective, or at least preferential species whose ecological amplitude must be narrow enough to limit them to the boundaries of the association. Such species occasionally do not exist but their absence in no way detracts from the validity of the association determined by other means. Especially in the forest classification such modified criteria are necessary. Nevertheless, the extreme view of Paczoski (1930), proposing an absolute rejection of fidelity, cannot be recommended.

In 1935 Tansley proposed the concept of the ecosystem that was preceded by the holocoen (Friederichs, 1930). Tansley himself did not use his concept in his later publication on »The British Islands and their vegetation» (1949). Sillinger (1939), in his classification of forest communities, adds the environmental characteristics, especially the nitrification capacity of different forest humus horizons, to the floristic structural differentiation. In 1940 Deyl published his »Plants, soil and climate of Pop Ivan» with his phytocoenoses characterized not only floristically, but especially by their ecotopes. Similar ideas were also defended in the studies of F. K. Hartmann (1932—1947) and Schmid (1944).

In recent studies, Sukachev (1945—1958) proposed an interesting and holocoenotically most complete concept of a biogeocoenosis that is composed of an ecotope, divided into a climatope and edaphotope, and a biocoenosis, subdivided into a phytocoenosis, zoocoenosis, and microbiocoenosis. This system seems ideal for the ecosystem classification of any parts of the biosphere.

In reality the plant associations in the sense of the Z.-M. school, liberated from the dogmatic necessity of the exclusive, selective or preferential species, characteristic of the plant association, may very well be retained. And here we might note that there are usually several characteristic species present in every association, distinguishing such higher synecological units as alliances, orders. etc.

Together with this concept of the plant association, modified as indicated, the whole system of floristic analysis and synthesis outlined by the Z.-M. school would be much enhanced if incorporated as the phytocoenotic phase of Sukachev's biogeocoenosis, composed also of its zoocoenotic and microbiocoenotic phases and the whole ecotope.

Here it is necessary to admit that almost the same phytocoenosis may occur on two (or several) different ecotopes, or that the same ecotope may develop two or several different biocoenoses, especially after logging and under forest management. E.g., in the Coastal Douglas-fir Zone (bioclimatic), the Pseudotsuga menziesii — Thuja plicata — Polystichum munitum association occurs on slightly podzolized β-gley soils (Wilde) developed from glacial till with more or less permanent seepage water (pH 6.0), or it may develop on alluvial terraces with rich sandy loams, slightly podzolized, affected during the spring-floods by high water table from the river. On the contrary, the first mentioned edaphotope, after logging, may develop either a pure stand of Alnus rubra, a pure stand of Acer macrophyllum, or a mixed stand of both species, or a stand of Pseudotsuga menziesii — Thuja plicata; the dominant in the herbaceous layer, associated with all the above cases, will remain Polystichum munitum. All these stands will, in time, be converted into an edaphic climax, characterized by Thuja plicata — Polystichum munitum association, but in the case of Douglas-fir stands this may not occur until as many as several hundred years have elapsed.

Curtis and McIntosh (1951) have developed the idea of a continuum involving gradual variation from stand to stand and from one bioclimatic zone to another. Such a continuum can be followed either in climates or in soils. Thus, there is a gradual continuum between such different soils as podzol and chernozem, however, these soils are recognized as readily distinguishable zonal soils. The continuum may be also interpreted as proof of primary succession (in the sense of Braun-Blanquet).

The author agrees with Odum (1953), Woodbury (1954), Oosting (1956) and Dansereau (1957) that the crux of the ecological thinking is the holocoenotic point of view. Therefore, the *successful synecological classification of forests must depend only on the ecosystematic foundations in the sense of Sukachev's biogeocoenoses, the phytocoenosis of which has its counterpart in the plant association as interpreted and studied by the Zürich-Montpellier school.* Such biocoenotical and environmental foundations for the ecological classifications are demonstrated in the recent publications by Daubenmire (1952—1959) in U.S.A., Dahl (1956) in Norway, Dansereau (1957) in Canada, and Ellenberg (1954) in Germany. Sukachev's scheme is followed recently by many Russian ecologists, e.g. Jaroshenko (1946—1953), Bykov (1950—1956), Krylov (1950—1956), Isaczenko (1953, 1956), Ivanenko (1952), Zonn (1955, 1956), Pjavczenko (1956), Povarnicyn (1956), in Hungary by Zólyomi (1954), and in Czechoslovakia by Mezera (1955) and Zlatnik (1956).

As evidence of a widening cognizance of the environmental approach, recent studies, published by Braun-Blanquet in cooperation with Pallmann and Bach (1954) discuss the environmental factors of different plant associations in most commendable detail. Many other European ecologists show evidence of following the same line. In recent years Hills (1955—1959) modifies his physiographic system as much as to become ecosystematic; however his approach is still much more environmental than biocoenotic.

It might be useful at this point to attempt a more complete definition of a fundamental phytocoenosis (plant association), since it is an intrinsic unit of a biogeocoenosis. The author (with his collaborators) uses, in the classification of British Columbia forests (1950—1959), the following definition:

A plant (forest) association is a definite uniform (homogeneous) phytocoenosis that is in dynamic equilibrium with a certain complex of environmental factors (ecotope); its floristic structure — i.e. stratification (layering), species significance (Artmächtigkeit, or abundance and dominance), sociability, constancy, fidelity, and vigour of the component species — lies within limits governed not only by the ecotope (climate, soil, substratum, topography, and biotic environmental factors), but also by the historical factors of the vegetational development (the fourth dimension or space-time factor).

The author will accept any modification of the above definition, if it will lead to scientifically better foundations. Forest ecologists should know their field methods and improve them by any and every worthy innovation. They should never become enslaved by any dogmatic tenets that may prove to be false.

In order that an ecological classification may be used by the forester, silvicultural characteristics might be included, having respect to: productivity and quality of trees; capacity for conservation of soil, water, and other habitat factors; methods of cutting and logging; methods of slash disposal; methods of reforestation; stocking, and methods and time of thinning and pruning; relation to pests; possibility for ranch management; wildlife management.

Only the accurate synecological knowledge of forests, concretely registered and mapped for every forest region, will form the sound foundation for any forest management, silvicultural or genetical.

Can we find a common platform for the different schools of forest type classification?

VILJO KUJALA

As a basis of comparison I have to take the Finnish system of forest types. According to A. K. Cajander: »All those stands are referred to the same forest type the vegetation of which at or near the time of maturity of the stands and provided the stands are normally stocked, is characterised by a more or less identical floristic composition and by an identical ecologico-biological nature, as well as all those stands the vegetation of which differs from that defined above only in those respects which — being expressions of differences due to age, fellings, etc. — have to be regarded as merely accidental and ephemeral or at any rate as only temporary. Permanent differences call forth a new forest type in cases where they are sufficiently well-marked, or a sub-type in cases where they are less essential, but nevertheless, noticable.»

Cajander's concept of forest types is thus rather complicated and therefore it has often been misinterpreted. Of the basic principles of the system I would like to draw attention especially to the following.

A clear distinction has to be made among temporary and permanent types of plant associations. The former are caused by momentary site factors which are repeated only seldom, the latter by permanent or often repeating factors. The changes caused by the momentary factors are sometimes very great, but none the less they will pass. Some of the most notable of these kinds of factors are clear cuttings, forest fires, and (in the past) shifting cultivation. There hardly exists in the southern part of Finland any dry forest land where the mentioned disasters would not have occurred many times. Afterwards, however, the vegetation has always returned to the original form; no change of type has taken place.

That is important because by taking the stable vegetation as a basis, forest lands can be mapped permanently. This has been done in Finland and obviously it is possible elsewhere where the forests are allowed to develop naturally after cuttings and fires. On the other hand, it is probably difficult to do in countries where the effects of culture are so strong that natural permanent flora has no opportunity to form.

The idea of permanent and non-permanent plant associations is by no means unique to Finland. The climax theory of American scientists is built on the same grounds. When developed to its extreme, it has only theoretical value and importance, but when limited to short-period successions and to local sub-climaxes, its usability is great. In their basic form the Finnish forest vegetation types

actually are the same as the American site sub-climax and the associations caused by momentary factors are the successive stages of the types.

To the distinctions of the Finnish classification of forest vegetation and sites belong also the fact that attention is given to the whole plant cover, to all layers of vegetation, and to all plant species.

Some schools of thought seek to use the trees as the main basis for forest. The immediate result of this is that in the same major type there will be included many very different plant associations whose closest correspondents clearly belong to different major type groups. The bases for this kind of classification are more economical than ecological.

In Finnish vegetation type classification the growing stock holds the same position as the other vegetation. A certain forest type has certain species of trees. Momentary factors—cuttings, forest fires, etc.—often have great effect on the trees. The result usually is that the original tree species give way to others. Gradually, however, the growing stock returns to the original form which is characteristic for the forest type, but it generally requires a period of one tree generation. In the successive stages of forest types according to this description there can occur various tree species, even those that do not occur in the climax of the type.

The ground cover returns to its stable condition more quickly than the growing stock for the reason that in cuttings and even in forest fires there remains some seeds, roots, and rhizomes of the original species and that the development of small plants is more rapid than that of trees. The ground cover returns to a form resembling the climax stage sooner than the trees. Therefore, the misconception might have arisen that the Finnish classification of forests does not take into account the trees but only the ground cover.

Special attention has also been given to the development of growing stock in Finnish research of forest types. In the same type the development and growth of the natural normal stands is the same. It should be possible to use the growth of the trees as the indicator of the type. This can indeed be done. However, care is necessary. It has to be taken into consideration that the growth of trees can vary also from temporary causes (different kinds of silvicultural treatments, cuttings, calamities, inherent differences, etc.).

The problem of stratified soils belongs here, too. By that I mean the often repeated statement that if there are layers rich in nutrients deep within the ground where only the roots of trees and not those of the ground cover can penetrate, there arises a contradiction between the tree growth and site classification indicated by the forest cover. Without denying this kind of probability, there is, however, reason to point to factors which perhaps lessen this conflict especially under natural conditions.

The layers of the forest soil are not independent of each other. For the vegetation, most important is the surface layer where those nutrients occurring in

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[1] Professor, Forest Research Institute, Helsinki, Finland.

the minimum amounts, especially nitrogen and phosphorus, are found. They originate from forest litter which is mainly formed by trees. Thus, the plants growing on the forest soil are strongly influenced by the trees. I have the impression that the species belonging in the forest cover are mainly actual humus plants. This is supported by some of my experiments.

In half-meter plots I have separated the humus layer (in the spring when it is still frozen and can be separated) entirely from the underlying mineral soil with bituminous cardboard and plastic membrane.

The result at first has been increased vigor in the forest cover and abundant blooming on the experimental plots. Gradually the vigor has decreased, however, and now after six years the forest cover of the separated plots hardly differs from the surrounding areas. The common ground cover plants of Finland— Deschampsia flexuosa, Maianthemum bifolium, Anemone hepatica, Oxalis acetosella, Trientalis europaea, Linnea borealis, Vaccinium vitis-idaea, etc. — are this kind of humus plants.

Water is also an important factor and perhaps trees obtain it primarily deep underground. But apparently also the transpiration water taken from the depths influences the ground cover by increasing the humidity of the microclimate of the forest.

A clear idea of the effect of the humidity of the air can be obtained by examining the vegetation occurring on the boulders common to our forests which have been moved by the continental glacier. It is mainly formed by lichens on dry woodlands, by mosses, grasses, and herbs on fresh woodlands. The rocks forming the base are alike.

Apparently these facts decrease the controversy between ground cover and growing stock, especially after taking into account the fact that trees also take a great portion of their nutrients from the upper layer of the soil—soil with surface layer poor in nutrients is unfavorable to trees as well. However, I do not want to insist that this mentioned conflict could not occur, for example, when the formation of humus is seriously disturbed, as may be the case particularly in densely populated tracts and countries.

The most difficult problem in the field of forest typology is apparently formed by countries with an old civilization where the original forest vegetation has disappeared in some places entirely. The Braun-Blanquet school has been developed under these conditions. It distinguishes plant associations on the basis of the flora and in addition gives special attention to the characteristic species, whereby the plant association gets an ecologically emphasized character. In that respect the school of Braun-Blanquet is along the same lines as Cajander's, but otherwise the differences are great. It is true that no experiments on the application of the Braun-Blanquet method in Finnish forests have been made, but I have the impression that his method would lead to a more rough division of types than the Finnish one, especially as our species are less numerous. Under this kind of vegetational condition it is hardly possible to make a classification without taking into account all of the plant species. Every one of them is able to express something about the ecologic character of the plant association in which it occurs and all the species together could characterize the type even though there would be no characteristic species in the sense of Braun-Blanquet's school.

Finally, the Russian forest type classification should be considered. It differs from many others in that site factors are used as indicators of the types.

I have nothing to say against the practice in which the site factors are used as guides for finding unknown types, just as the botanists use their knowledge of habitats in locating plants, and in limitations of the types. This has been done in Finland when, for example, the Pyrola type of clay soils is separated from the Myrtillus type of moraine soils. Apparently a series of different type variations can also be distinguished on our sandy soils. Actually, the same kinds of methods have been applied when I have sorted a group of parallel types and type variations from different climatic regions (e.g., in studying the forest types of Canada in 1931). There, climatic factors have been taken as guides in distinguishing types and type variations. Anyway, it is practical to deal in such a way. It can be a matter of discussion, however, if it is necessary to take the factors of the soil and climate as proper characteristics for forest site types. I feel that the forest types should be retained as vegetational types, so that they would be characterized only on the basis of vegetation indices. Because of the lack of sufficient experience, it should be questioned if the application of abiotic characteristics would make the number of types unnecessarily large.

This being the case, I arrive at the conclusion that a common basis for the different schools of forest type classification can be found. The method of the school of Braun-Blanquet perhaps forms an exception, but probably only in that it deals with vegetation which is not natural and cannot develop into natural forms because of such factors as intensive cultural influence.

The tree species cannot be taken as the primary basis for the classification of forest site types. It leads to the separation of plant sociations which distinctly belong together into different major types and furthermore it is more economical than an ecological classification.

The practice of Russian typologists of taking the habitat — soil, climate, and other non-biological factors — as proper characters for the types is unnecessary and questionable even for the reason that in this manner the way is cleared for the harmful increasing of the number of types.

Mapping Tropical Forest Vegetation

A. W. Küchler[1]

In many tropical countries an interest has been awakened in the character and meaning of the vegetation because the increasing populations and the growing demands for tropical raw materials require a more rational land-use. In the past, slowly growing or stagnant population figures permitted an indifference toward vegetation which extended from the various government agencies even into the rank and file of the scientists. The changes we are witnessing today all over the tropical world are dramatic and we scientists from non-tropical countries have a real share of the responsibility for the direction these changes are taking.

It is true, of course, that a considerable number of excellent men have been studying the tropical vegetation for some time and in some detail. We need only think of the members of the colonial forest service of the (once British) Commonwealth; names like Beard, Burtt-Davy, Champion, Chipp, Fanshawe, Richards and a host of others come to mind. The non-British part of the tropics have also had their share of first class scientists, devoted to the study of vegetation. But in spite of all the work accomplished, much remains to be done. Indeed, in many regions little more is known than the barest distinctions between forests and savannas if, in fact, any information is available at all.

It would seem that a concerted effort to study tropical vegetation can now be made, perhaps through some world-wide agency like the Food and Agriculture Organization of the United Nations or one of the various committees of the United Nations Educational, Scientific and Cultural Organization, such as the Committee for the Study of the Humid Tropics. One of the forms such an effort can take is to map the vegetation of the regions concerned in order to establish an inventory of the vegetational resources that are available at present.

Vegetation maps are now obtainable for all parts of the world. This, however, does not mean that the goal, just proposed, has already been reached. Far from it, indeed, for most maps are on a very small scale and therefore imply a degree of generalization which makes them useless for most practical purposes. My proposal is therefore an extensive mapping program of all tropical vegetation, and that such maps be prepared at a scale of 1: 1 000 000 or larger. The sheets of the International Map of the World at 1: 1 000 000 are now available for practically all parts of the world, including the tropics and they form a good basis on which to build up cartographic information on the vegetation of the tropics. I want to state emphatically, however, that the proposal to use the scale of 1: 1 000 000 need not exclude vegetation maps at a larger scale. For instance, various sections of the Congo State have been mapped in considerable

detail and valuable vegetation maps are available at various scales for sections of Peru, Indonesia and others. But the amount to be done remains vast because so much of the tropical vegetation has never been mapped at all and the existing small scale maps are based on travellers' reports rather than on actual mapping; and also, where vegetation maps do exist, their scale is usually too small to reveal the desirable detail. Such maps are therefore useful primarily as guides for future and more accurate mapping. But the fact, that these good maps of small scales exist should not discourage future mapping. On the contrary, their very existence usually points to a real need for vegetation maps in these areas.

Indeed, this need is now very great in most tropical regions. Various national and international governmental and privat agencies are making funds available for socalled underdeveloped areas, and wherever problems of land-use are involved the preparation of vegetation maps should be given a high priority. However, if this were to be done, an important question would arise immediately.

This question deals with the manner of showing the vegetation on the maps. A comparison of existing maps reveals that there is at the present time no uniformity of approach, and yet, this may seem desirable if one international organization were to promote the mapping of appreciable parts of the tropical vegetation. A different question is whether it is feasible to use one classification of vegetation throughout the tropics. For instance, it can be imagined that largely unknown and unpopulated regions covered with tropical rainforests require a different approach than a more densely populated region of which a good portion is cultivated. More densely populated areas often permit mapping at relatively large scales which, in turn, permit a more revealing classification than is possible at smaller scales.

Many people in non-tropical countries picture the tropical vegetation as a bewildering jungle with thousands of species arranged without order or pattern over vast areas. Either it is hopeless to map such an area for lack of distinct vegetation types and it is simpler, though not so useful, to refer to the whole area as tropical rainforest. Or else, one realizes that within the tropical rainforest different types do exist, but that they merge imperceptibly and cannot be identified.

There are indeed cases to exemplify such difficult conditions but it is more than probable that such examples represent the exception rather than the rule. Many of the less dense forests, especially in regions where the rainfall is less extreme, are simpler and can be described and classified without the seemingly insurmountable difficulties presented by some rainforests of the tropical lowlands. Where the forests give way to still more open communities like the Brazilian campo cerrado or some of the savannas of Tanganyika, the possibilities of identifying particular vegetation types improve still further.

One way to overcome some of the obstacles in mapping tropical vegetation is not to think in fixed terms, or in the terms of any one particular classification

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[1] Geographical Dept., University of Kansas, U.S.A.

of vegetation. It happens often that one classification will succeed where another one fails and frequently it is possible to combine certain features of one classification with those of another. Men like Beard (1944), Burtt-Davy (1938), Champion (1936) and others have prepared very useful ways to classify the physiognomy of the vegetation down to the finest detail. This includes the height and density for every individual synusia, the character, amount and location of epiphytes and lianas, and even the size and character of the leaves. It is not necessary to always use all characteristics listed in such classifications, but wherever anyone of them can contribute to a better and more accurate description of vegetation types, it should be used. This is particularly important where such a feature permits a mapper to distinguish one vegetation type from another.

Essentially, all physiognomic analyses rest on the concept of life forms. This was first introduced by Alexander von Humboldt (1807) and later approached from a different direction by Raunkiaer (1918). The latest and perhaps the most satisfactory presentation of life form categories was given by Ellenberg (1956) whose tabular arrangement should always be within reach of all vegetation mappers.

While therefore our resources to analyze the physiognomy and structure of the vegetation permit us to indicate any differences that may set off two types from each other, the use of physiognomic data is not at all our only means to attain our goal. Our description can be greatly enriched and refined by floristic information. Of course, this is the very approach which is so forbidding that it forced the evolution of advanced physiognomic classifications. But even though the number of species may seem overwhelming, there are yet certain floristic groups which differ so much from the rest that they can be treated as separate items useful in identifying vegetation types. Such groups include especially the palms, bamboos, tree ferns and a lot of others. Among these, however, the number of species is often relatively limited in any one vegetation type. This can help materially in refining the details established physiognomically. Aside from this, there are many tropical forests where a few or relatively few dominants distinctly prevail, so that in such cases the mapper can employ floristic data in greater detail than outlined above.

In addition to the physiognomic and structural analysis, possibly refined by floristic data, a third type of information can help even more in establishing individual plant communities. This includes the large variety of environmental features which affect or even control the extent and distribution of certain vegetation types in the landscape. There are several distinguished vegetation mappers who have successfully advanced ideas of combining ecological and vegetational features for the purpose of establishing vegetation types, and indeed, relating them to their sites at the same time. Both the physiognomic and the floristic features of the vegetation react usually to changes in the environment, especially where such changes are relatively abrupt. A few examples will suffice to illustrate this, and one need only think of the extent of river flood plains which are periodically innundated, low terraces which are rarely flooded and higher terraces always out of reach of even the highest floods. Or compare the flood plains of rivers with the steeper sides of the valleys, and possibly the less steep uplands. Each will have its own peculiar type of vegetation. Changes in the substratum are usually reflected in the vegetation with remarkable clarity. The sequence of salt water, brackish water and fresh water displayed between the seashore and areas farther inland reveals a zonation of the vegetation, and, in fine detail, just the beach alone can possess two, three or more strip-like vegetation zones, based on the amount of spray blown by the wind from the waves to the shore. The differences in the soil are often very distinct, and sand, limestone, sandstone, granite, lava and organic accumulations all produce their own plant communities. Many other environmental features can be added to the given examples.

The combination of physiognomy and structure with floristic composition and ecological features permits us to be much more hopeful in our attempts to map tropical vegetation than some of us have been in the past. However, in order to insure the greatest success, a vegetation mapper must be thoroughly acquainted with all possible approaches to the description of the vegetation. He can then use a wide variety of resources and distinguish units of vegetation that others might well have overlooked.

The chief purpose of such a broad approach is above all to permit the actual mapping of vegetation, especially where highly organized systems cannot be readily applied. What is particularly important here is to have the vegetation mapped at all. Once the different types are clearly shown on a map at 1 : 1 000 000 or larger, the more important ones can be singled out for further study. In this manner, our knowledge of the tropical vegetation is gradually deepened, slowly perhaps, but nevertheless surely. The more profound our appreciation of the vegetation and the sites on which it occurs, the more efficient can be our planning for a land-use which promises the highest sustained yields that circumstances can permit.

Y a-t-il un terrain d'entente possible entre les différentes écoles au sujet de la classification des types forestiers?

ANDRÉ LINTEAU [1]

Les botanistes, les géographes, les écologues et les forestiers s'emploient tous à décrire la végétation, mais les buts poursuivis par les uns et les autres diffèrent dans une large mesure. Personne ne reproche, je crois bien, les méthodes suivies par les botanistes pour décrire les espèces, les genres et les familles si ce n'est d'autres botanistes. La taxonomie des végétaux est leur but ultime et les procédés suivis sont depuis assez longtemps crystallisés.

Le phytogéographe vise à connaître la distribution des plantes à travers le monde et à indiquer la coincidence de groupes floristiques avec les zones climatiques, bref à délimiter les régions phytogéographiques.

L'écologue n'est pas intéressé à la flore comme telle mais plutôt à la végétation, c'est-à-dire, à cette entité concrète qui possède une physionomie et une structure particulière au milieu ambiant.

S'il n'a pour but que l'utilisation de l'étage supérieur de la végétation en le rasant pour des fins commerciales et sans se soucier de ce qui adviendra par la suite, le forestier n'a pas besoin de s'appuyer sur l'écologie ni sur la phytogéographie. Mais même dans les pays oú la matière ligneuse abonde, on se préoccupe de plus en plus de l'avenir de la forêt et l'on reconnaît la nécessité de faire appel à l'écologie pour maintenir les conditions de boisement les plus désirables. L'aménagement bien compris de massifs boisés ne saurait s'effectuer sans une connaissance au moins rudimentaire de l'habitat. Comme l'agronome, le sylviculteur doit connaître la fertilité de diverses unités du parcellaire ainsi que les facteurs biologiques qui conditionnent le maintien et l'évolution des espèces et des groupes arborescents particuliers à l'aire géographique oú il déploie ses activités. Si l'objet de l'aménagiste est la forêt dans son ensemble, celui du sylviculteur est le peuplement.

L'aménagiste a besoin d'indices de fertilité pour caractériser les divers niveaux de productivité des massifs boisés. Ces indices sont ordinairement des mesures dendrométriques. En sylviculture expérimentale, il est fort souhaitable de pouvoir disposer de tels indices et classes de fertilité, mais pour connaître les conditions de vie et de nutrition des peuplements, autrement dit la *station* ou le milieu ambiant où ils se développent, il faut aller plus avant. S'il est vrai que qu'extérieurement la présence de certaines communautés végétales croissant en liaison avec les peuplements révèle les conditions de vie et de nutrition de ces derniers, il est non moins nécessaire de faire appel aux données de la pédologie pour apprécier la valeur de la station avec le plus de certitude possible et le sens

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[1] Forestry Branch, Dept. Northern Affairs and National Resources, Quebec, Canada.

de certains stades évolutifs des peuplements aussi bien que des autres strates végétales. L'union de la pédologie et de la phytosociologie permettra ainsi de connaître le potentiel normal des stations, la raison des dépressions de production ligneuse, et l'orientation à donner aux mesures correctives.

Il semble inutile d'entrer ici dans le champ des controverses qui s'élèvent de temps à autre en certains pays oú la sylviculture en est à ses premiers pas, à savoir lequel des deux, du sol ou de la végétation il faut classer en premier lieu, Au sylviculteur européen la question paraît oiseuse car il admet gébéralement que les deux sont inséparables. Il est clair toutefois, si l'on travaille à l'échelle des grandes régions oú le climat, la topographie et la géologie présentent des conditions variées que la possession de cartes réunissant ces éléments offre l'opportunité de situer les communautés végétales dans un cadre bien défini, mais si nécessaire soit-il, le complexe physiographique est un arrière-plan: c'est la vie qui se développe en surface — celle de la végétation et du sol — qui fait l'objet de préoccupations particulières.

Les climats régionaux contrôlent le déploiement des types de forêt, comme le témoignent au Québec notre grande forêt coniférienne au nord et la forêt mixte ou feuillue au sud. Alors que dans la première, topographie et géologie n'ont qu'une influence secondaire sur la nature des essences, l'emprise exercée par le climat plus tempéré des localités méridionales se desserre quelque peu en faveur des variations du relief et de la roche-mère. Dans le premier cas, la qualité des peuplements se reflète de façon très évidente dans le tapis végétal. Dans le second, cette simplicité et cette homogénéite du cortège floristique font place à une organisasion plus compliquée mais incomparablement moins indéchiffrable que le jeu nuancé des facteurs édaphiques et physiographiques. C'est pourquoi, si l'on travaille à l'échelle d'un pays, l'étude systématique des résultantes, celle des associations végétales, nous achemine-t-elle beaucoup rapidement vers la connaissance du milieu qu'en s'aventurant d'abord à définir les multiples facettes de ce dernier et les principes qui régissent la composition et la qualité des peuplements. Mettons ordre en premier lieu à ce qui fait l'objet des préoccupations du sylviculteur et dans la perspective des climats et des paysages les unités stationnelles révéleront leurs caractères essentiels.

C'est ainsi qu'on en arrivera à définir les principaux types de sol, l'influence de leurs caractères sur la communauté végétale et à juger de l'action bonifiante ou dégradante de certains taxa sur la station, action qui se manifeste sur les humus et aussi sur le substratum.

L'intérêt du forestier-sylviculteur étant d'ordre synécologique, la question se pose, à savoir quel système de classification des communautés végétales est le plus en mesure de contribuer à la connaissance du milieu et des stades évolutifs des peuplements.

L'homogénéité et la simplicité reconnues des populations végétales des régions nordiques fatalement ont fait du concept de dominance l'élément essentiel de leur classification. C'est pourquoi aussi la présence caractéristique de quelques plantes s'identifie avec tant de facilité avec la station. La végétation de climats moins rigoureux, par contre, étale une certaine luxuriance et une hétérogénéité relative. Cette situation a eu pour effet de susciter l'élaboration de nouvelles méthodes d'analyse ayant pour but d'établir nettement la structure de ces communautés plus complexes.

Ce n'est pas notre intention de retracer ici l'historique de la phytogéographie et de la phytosociologie. Rappelons simplement que les protagonistes de différentes écoles de pensée modernes se sont inspirés à des dégrés divers des oeuvres des pionniers allemands, russes et scandinaves. Le travail de Cajander en Finlande au début du siècle a sans doute ouvert la voie au traitement statistique des communautés végétales. Celui de Raunkiaer au Danemark a aussi été le point de départ de quantités d'études sur le sujet dont Tansley soulignait l'état de confusion qui régnait encore en 1934.

Au cours des derniers vingt-cinq ans, la connaissance des communautés végétales européennes a fait des progrès énormes. Dire que l'uniformité des concepts et des méthodes d'analyse n'est plus en question serait fausser la vérité et ce n'est pas pour l'annoncer non plus que ce congrès est tenu. Il existe encore des divergences d'opinion quant à la façon dont l'analyse de la structure des groupements devrait se faire. Les vocables employés pour désigner les communautés et toute la hiérarchie des groupes ne sont pas les mêmes partout. Certaines écoles mettent l'emphase sur les relations pédologiques comme l'adaptation à l'habitat. Alors que certaines n'envisagent que l'aspect statique, d'autres soulignent particulièrement le dynamisme de la végétation. L'indépendance ou l'interdépendance des divers étages, strates ou synusies de la communauté et l'espace minimal de l'unité végétale sont encore des concepts discutés. Certaine école identifie le type de forêt au moyen de plantes-indices ou indicatrices; l'autre, sans nier l'existence de telles plantes, reconnaît l'association en mettant en relief certains éléments que l'on désigne pour cela plantes caractéristiques. La plupart n'offrent cependant pas de méthode de synthèse et de hiérarchisation des unités végétales.

L'expérience acquise au Canada depuis trente ans démontre avec force que les diverses phytocénoses d'une région peuvent être définies au moyen de méthodes d'analyse proposées par l'une ou l'autre des écoles de pensée. Les travaux entrepris par Rousseau, Bellefeuille, Ilvessalo, Kujala et Heimburger entre 1930 et 1945 furent les premiers du genre au Canada. Les unités écologiques définies portaient le nom de types forestiers. La méthodologie à laquelle ces chercheurs ont eu recours procédait en tout ou en partie de Cajander, Sukachev, Hult-Sernander, Raunkiaer, Sørensen. Des travaux subséquents couvrant toute la région boréale, la même qu'avaient parcourue les chercheurs précités, n'ont pas infirmé les résultats déjà obtenus bien que les méthodes d'analyse n'aient pas été tout à fait les mêmes. Les concepts d'abondance-couvert et de sociabilité employés ont été introduits et les valeurs estimatives ont été celles de Braun-Blanquet.

Les types forestiers ainsi définis indiquent clairement qu'ils constituent des unités écologiques bien déterminées et que les peuplements possèdent une productivité dont la variation est de faible amplitude. Ce que ne révèlent pas directement les types forestiers de complexe physiographique comparable et de valeur à peu près semblable, c'est qu'ils constituent des stades de succession voisins.

L'emploi des méthodes analytiques de Braun-Blanquet révèle que la sous-association, ses variantes (quelquefois l'association) et le type forestier au sens de Cajander et de ses supporteurs sont une et même chose. Pour obtenir une idée d'ensemble de la végétation d'un pays ou d'une région étendue, il est désirable, cependant, de synthétiser toutes les données relatives aux sous-associations et aux variantes en un tableau qui établisse un ordre hiérarchique complet.

Le système proposé par l'Ecole de Zürich-Montpellier à cet égard semble offrir le plus de promesses. Des critiques plus ou moins fondées à son endroit proviennent souvent de ceux qui n'en ont pas fait un loyal essai. Le concept de fidélité des espèces qui est à la base de tout le système ne saurait être remplacé, à mon sens, par quelque chose de plus strict qui resserrerait de plus près la définition des unités de végétation.

Il nous a été donné récemment d'établir les alliances, associations, sous-associations et variantes d'un large secteur de la Province de Québec et de caractériser écologiquement aussi ces diverses unités de végétation. L'enchaînement de celles-ci aux types de terrain et au niveau de fertilité des sols apparaît clairement. Nous croyons fermement que les résultats obtenus permettent pour la région sous étude, d'asseoir des expériences sylvicoles sur une base écologique solide.

Some Problems of Forest Climaxes in Poland

ANNA MEDWECKA-KORNAŚ[1]

Ever since the classical work of Clements (1916) the climax theory has been the subject of extensive study and discussion both in America and in Europe. The theory has been rejected by some authors for two reasons: 1) it is alleged that the concept of climax communities is not conformable with the continuous changes takin place in nature and 2) in many areas climaxes have not developed.

However, the former reason looses its significance in view of Braun-Blanquet's modifications to Clements' original definition of climaxes. According to Braun-Blanquet the development of soil and vegetation tends to a definite end point determined by the climate. »This relatively permanent final condition we have called a soil and vegetative climax. But climax itself, it must be expressly stated, is only a resting point, a breathing space in the ceaseless change of the composition of vegetation» (Braun-Blanquet 1932). The communities directly preceding the development of a climax are sometimes referred to as subclimaxes, quasiclimaxes, etc. (Dansereau 1954, 1956). Climaxes develop where the relief of the terrain is usually more or less flat, and where the influence of ground water is not direct. Where the soil is mature and, independently of the substratum from which it has developed, analogical conditions for the development of vegetation (Pallmann 1947) are provided. In this approach climaxes are associated with peneplanation of the terrain and with such a development of soil as seems impossible of attainment in most conditions, since probably the processes involved last longer than secular climatic changes (Etter 1947). Consequently the climax concept becomes in most cases hypothetical. To overcome these difficulties such terms as *climax group*, *paraclimax*, *climax swarm* etc. (Tüxen and Diemont 1937) and the concept of *zonal associations* (Alehin 1951, Lavrenko 1950) have been introduced. The last of these terms is in fact synonymous with *climax associations* but is free of any implication of succession (Walter 1954).

Before discussing those plant communities of Poland that can be considered as climaxes it is necessary to make some definitions. The term *plant association* is here used in the sense given it by the Swiss and French phytosociological school (Braun-Blanquet 1932, 1951) and generally accepted in central Europe. However plant communities are not split into such small units as has recently practiced mainly by German workers, especially as these small units are useless for the problems here considered.

In the whole of Poland, with the exception of small areas in the high mountains, all climaxes are forest associations. This is caused by the temperate climate of the country. In Poland the annual rainfall is 500 to 800 (1000) millimetres, with the maximum im summer, the mean temperature of January is —1 to —5°C and of July not more than 19°C, while the mean temperature of the year is 6 to 8°C. The forests are composed of more than 30 native tree species grouped into more than twenty associations (Medwecka-Kornaś 1959). They are deciduous and mixed, belonging to the geobotanical Province of Central Europe, or purely coniferous. In spite of intensive human activity the forests in many regions have retained their natural character.

If a vertical profile is traced from the Carpathian Mtns. to the lowlands of central Poland the highest altitudinal forest zone (1150 to 1600 metres above sea level) consists of forests with Picea excelsa appertaining to the Piceetum tatricum association. The severe climate of the high mountains eliminates almost all species except spruce. In the herb layer acidophilous plants dominate. Owing to the strong influence of spruce on soil processes furthering the accumulation of acid raw humus and the podsolization of the upper soil horizons this association can develop equally on limestones, on granites, and on sandstones of different fertility differentiating into a few sub-associations. Piceetum tatricum is the only dominant forest of the upper altitudinal zone and undoubtedly forms the climax, much like the spruce forests in analogous conditions in other European mountains, e.g. the Alps.

In the lower altitudinal zone (600 to 1150 or 1200 metres) the forests are dominated by Fagus silvatica or Abies alba with admixtures of Picea excelsa. The forests dominated by beech constitute the eutrophic Fagetum carpaticum association. This association has been considered hitherto to be a climax. However, the association grows usually on mountain sides and only on rather rich substrata. It is not found, for instance, on limeless sandstones and conglomerates and is usually associated with brown soils, the formation of which is favoured both by the decomposition of beech litter and of herbaceous plants of the association. The saturated, biologically active humus of these forest inhibits podsolization processes and, though an acid reaction characterizes brown soils in the mountains, the association includes no acidophilous plants (Medwecka-Kornaś 1955). It has been recently reported (Myczkowski 1958) that on flat and dry ground Carpathian beech forests have sometimes a quite different, typically acidophilous character. Beech forests of this kind approach floristically the Luzulo-Fagetum association (Tüxen 1954) which should be classified in the Vaccinio-Piceetalia and not the Fagetalia order. It is impossible to conclude from data now available whether beech forests of the latter kind are connected with soils of more advanced development. If this was so, the acidophilous beech forest might have to be classified as the climax of the lower altitudinal zone of the Carpathians. The small areas it occupies at present are the result of the varied relief of the mountains. The purely coniferous forests with fir or spruce (Piceetum tatricum abietetosum) growing alongside of beech forests in the lower altitudinal

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[1] Botanical Institute, Jagiellonian University, Cracow, Poland.

zone have developed either in connection with the special local conditions (the barrenness of the substratum, the lack of permeability of soil, the unfavourable local climate of valleys etc.) or as a result of recent human activities.

The climate of the Polish lowlands permits the simultaneous development of many forest associations. Some of them are clearly related to strictly local conditions of the habitat (e.g. Saliceto-Populetum, Alnetum glutinosae s.l., relict communities of the Quercetalia pubescentis order etc.). Among the associations spreading over large areas three must be mentioned here: Querceto-Carpinetum medioeuropaeum, Pineto-Quercetum, and Pineto-Vaccinietum myrtilli. The question now arises which of these associations corresponds most accurately to the definitions of the climax theory?

The Querceto-Carpinetum association is common throughout Poland at elevations less than 600 metres above sea level. It is differentiated both geographically, and includes many tree species, as for instance Carpinus betulus, Quercus robur, Q.sessilis, Tilia cordata, and in some regions Fagus silvatica. The shrub layer in these forests is rather rich and the herb layer consists of basi-neutrophilous species. This community is very viable and the typical combination of its species can sometimes be found even in small, badly devastated stretches of forests. Querceto-Carpinetum stands are the result of various succession series and seem to be, at least in some conditions, very permanent. For this reason, similarly as other communities of the Carpinion alliance, it has been frequently defined as a central European climax (Jeswiet, de Leeuw, Tüxen 1933). However, the association is limited by its relatively high edaphic requirements. It occurs on brown, rich, medium moisture, clayey or sandy clayey soils. Where the influence of a fertile substratum is weaker or the habitat is poorer the next community, Pineto-Quercetum, develops.

Pineto-Quercetum is a mixed forest composed most frequently of Quercus sessilis, Q. robur and Pinus silvestris with an admixture of other trees. The dominating species in the herb layer are those of acid soils, though extremely acidophilous species are lacking. Also a few less exacting species of the order Fagetalia growing in decidous forest may be found here. Pineto-Quercetum association develops in the lowlands at elevations less than 600 metres above sea level, mainly in flat country, on deep soils not affected by ground water. The soils are usually light, sandy, sandy-clayey or loess, little or moderately podsolized. Owing to these properties Pineto-Quercetum of the Polish lowlands fits most accurately the typical traits of climax communities. This was pointed out as early as 1932 by Braun-Blanquet. Similarly the communities of the alliance Quercion robris-sessiliflorae, which resemble the Pineto-Quercetum association of Poland, are considered by some authorities (Tüxen 1930, Braun-Blanquet 1932, Quantin 1935) to be the climaxes of western Europe.

On the poorest sandy soils in Poland grow pine forests of the Pineto-Vaccinietum myrtilli association. In the soil profile podsolization is clearly visible and in some instance there may be an iron hard-pan (ortstein) layer under the alluvial layer.

The authors who consider that Querceto-Carpinetum is the climax of central Europe and those who maintain that central European climaxes are formed by the associations of the alliances Quercion robris or Pineto-Quercion are of different opinions on an important question. The former maintain that the improverishment of vegetation and the podsolization of soil are the result of human activities in forests, whereas according to the latter it is caused by natural tendencies in the development of soil and vegetation. A discussion on the problem with regard to other European countries is beyond the scope of this paper. It must be stressed, however, that the conditions prevailing in the forests of Poland very frequently support the latter point of view (Medwecka-Kornaś 1952, Piotrowska 1955, Matuszkiewicz 1956). The Pineto-Quercetum association in Poland is frequently a forest of tall trees and natural density. The distribution of the stands of those forests depends very regularly on local conditions. The stands are also found in Bialowieza Forest, the best preserved forest area of the lowlands of central Europe (Matuszkiewicz 1952, 1954).

What has been said hitherto leads to the following conclusions:

1. The more numerous are the forest associations that can develop in a climatic region the more complicated is the problem of climaxes. For this reason it is easier to define a climax in extreme climatic conditions, as for instance in the highest altitudinal zone of the mountains (Braun-Blanquet 1932).
2. It is also difficult to define a climax forest when the prevailing forest association counteracts the natural tendecies of soil development in existing climatic conditions, e.g. the eutrophic Fagetum carpaticum association in the humid climate of the Carpathian Mtns. In such cases it is necessary to discard all observations made in localities with nonmature soil and non-flattened relief.
3. In the climate of Poland the natural tendency of soil development goes towards podsolization (endopercolative soils, Pallman 1947), and the natural development of vegetation tends towards more oligotrophic and acidophilous communities. For this reason it seems reasonable to assume that the climax associations in the whole area, from the lowlands to the upper altitudinal forest zone, are the acidophilous associations from the class Vaccinio-Piceetea: Pineto-Quercetum, acidophilous beech forests, and Piceetum tatricum.
4. Since in many cases the above mentioned climax associations are not developed or they occupy small areas only it would obviously be more correct to accept the concept of climax groups (Tüxen and Diemont 1937). E.g. in the Polish lowland, the climaxes would be: Querceto-Carpinetum on limestone substrata, Pineto-Quercetum on siliceous soils such as loess, and Pineto-Vaccinietum myrtilli on quartz sands.
5. If, contrarily to the original theory of Tüxen and co-workers, it is assumed that associations of climax groups (excepting the poorest communities defined

as paraclimaxes e.g. Pineto-Vaccinietum in Poland) have the potential possibility of further development and are merely a very stable stage in a long succession series, then the two theories, of climax groups and of monoclimaxes, are not mutually contradictory. This can be seen in the case of the Querceto-Carpinetum association which, though it forms part of a group of climaxes, often shows a tendency to further development. Thus, climax groups, since in a way they constitute a stage preceding a climax, can be regarded as subclimaxes or quasiclimaxes, in the meaning given to these terms in America.

6. The climax theory is undoubtedly of great theoretical and practical significance. Nevertheless, the examples described here clearly show that it would be difficult and of no avail to use it in the classification of plant communities. Such classifications should be based on floristic and ecological differences between units, while the assessment of the degree of development and stability should form part of the characteristics of these units.

The Ecosystem Concept as an Aid to Forest Classification

J. D. OVINGTON [1]

The need to classify forest types becomes of increasing importance as forests are managed more intensively for timber production, water supply and the conservation of natural resources. Governmental agencies, land surveyors, foresters and forest biologists all need to group forest communities into recognisable and easily defined units, but the size of the basic unit of classification is likely to vary with need and geographical location. Some degree of co-ordination in classification is desirable and may be attained by a more general recognition and application of the ecosystem concept.

However, the whole association of site factors and living organisms comprising a forest ecosystem is so complex that it is difficult to comprehend in its entirety. Forest communities by virtue of the longevity and great size of the trees have a multilayered structure and whether planted or natural, are rarely homogeneous. Consequently, attempts have been made to identify forest types by considering variations in one feature of the ecosystem, for example the ground flora, humus layer, frequency of natural regeneration or the nature of the existing tree cover. Such techniques have usually proven to be of limited application and more comprehensive systems of classification have been developed using a combination of site factors (Cajander 1926, Coile 1952 and Hills 1952). Hills, for example integrates physiographical, biological, and cultural features in evaluating the distribution patterns within forest lands and recognises the fundamental unity and balance of the forest community.

Numerous investigators have reported significant correlations between the timber production of well stocked forest stands and site quality classes graded according to some method of synthesising different aspects of the ecosystem (Hill, Arnst and Bond 1948). This is particularly true where an overall assessment of soil properties has been included in the site classification procedure. Knowledge of the relationship between tree growth and site quality is of economic value to the practising forester for forest management can be improved when reasonably accurate forecasts can be made of forest productivity under different types of forest cover and management. Once a satisfactory relationship between forest productivity and site is established, it serves as a guide for future management plans and is particularly useful in helping with the selection of tree species for planting deforested areas from which the tree cover has been cleared for a long time. Periodic reassessments of site productivity ratings must be made since the number of possible forms of land-use can be multiplied by improvements in techniques. In Britain, the advent of deep ploughing and the application of

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[1] The Nature Conservancy, London, and Dept. of Botany, University of Minnesota, U.S.A.

mineral fertilizers, notably phosphorus, has permitted the successful afforestation of difficult upland areas which would have been regarded as unplantable at one time.

Whilst remarkable advances have been made in devising and applying schemes of forest classification, the methods used are largely empirical and we know relatively little of the dynamic processes governing the relationships between site and the living organisms of the forest community. Detailed investigations of as many factors as possible in a few specially selected forest ecosystems would provide basic data essential to an understanding of the limitations and affinities of different classification schemes. Furthermore, they would facilitate a more dynamic approach to forest classification by illustrating the changing nature of the forest ecosystem both on a short and long term basis.

Studies of ecosystem dynamics will be concerned mainly with the role of the forest population and with the various processes affecting the production of organic matter by forests and the subsequent movement of minerals, water and energy through the system. The primary producers of organic matter are the trees and ground flora and their productivity sets a maximum limit to the activity of the other living organisms. When the tree cover is reduced by harvesting or disease, the ground flora generally becomes more luxuriant so that the two can be regarded as complementary, their gross production depending largely upon site factors such as climate, soil, aspect etc. The combination of trees and lesser vegetation constitutes a relatively efficient means of site utilisation since the photosynthetic tissues are well dispersed above the earth's surface and the roots are able to spread throughout a large soil volume. Only part of the organic matter produced by the trees and ground flora is retained within the plant biomass and a large proportion of the plant production is shed over the soil either via the canopy fauna or as litter fall. The comminution of the litter at the soil surface and its incorporation within the soil is brought about by the joint activity of the soil flora and fauna, the weight of organic matter accumulated over the forest soil reflecting the balance attained between litter fall and decomposition. The importance of this exchange between living organisms and the soil has been long recognised yet only scanty information is available of the quantitive aspects and the mechanisms concerned in the diverse processes involved in the exchange. For example, there are abundant data of the productivities of different woodlands in terms of the volume of marketable stem but relatively few data of the weights of bole, branch, leaf and root material produced and the total amounts of nutrients and energy which they contain. Similarly, numerous investigators have recorded the weights of litter accumulated over the mineral soils of woodlands but few have attempted to measure the annual litter fall and to determine whether the amount of surface litter is constant from year to year and if not, at what rate it is being increased or depleted. A well developed organic layer may contain a large proportion of the nutrients within the ecosystem and changes in the humus mass can release or immobilise significant quantities of plant nutrients. So long as the total amount of litter on the forest floor is not changing from year to year the release of nutrients through decomposition will be broadly equivalent to the nutrient content of the annual litter fall.

During the last fifty years there has been extensive afforestation in Britain and since the history of many of the plantations is reasonably well documented it has been possible to record some changes in the ecosystem that follow afforestation. The nature of the forest community is controlled to a considerable extent by site conditions but is also influenced by the species of tree present and in Table 1 comparative data are given for two neighbouring stands of Pseudotsuga taxifolia and Alnus incana planted on open heath (Ovington 1956). The differences from the original heath condition are expressed on an average yearly basis for the first twentytwo years after planting and it is clear that there has been a marked accumulation of organic matter, nutrients, water and energy in the forest communities, largely through the development of the trees and litter. The rate at which the accumulation has taken place is very different for the two forest stands, Douglas fir tending to be more effective than alder. As woodlands mature they pass through progressive stages of development and by investigating age sequences of forests on similar sites, the magnitudes of ecosystem change and of the circulatory systems can be determined at different phases (Ovington 1957, 1959 and 1959 a). Comparable changes occur in natural stands since the species composition and stocking density are liable to vary as the stands mature.

The significance of the internal distribution and movement of nutrients, water and energy within forest ecosystems cannot be evaluated without taking into account external influences for, under natural conditions, ecosystems are not independent units completely isolated from outside factors. Carbon and nitrogen are supplied to the ecosystem from the atmosphere. Minerals contained in the precipitation (Madgwick and Ovington 1959) and in air borne material trapped on the tree crowns make an important contribution to the available mineral nutrients and are further supplemented by biogeochemical weathering of the soil and underlying rock. On the debit side, nutrients are removed from the ecosystem in the water that drains from the soil. The pattern of the input and output of water and energy for forest ecosystems is very different to that for mineral nutrients since only a small proportion (probably less than one per cent) of the incident energy and precipitation is retained within the ecosystem. In the case of water, about fifty per cent of the precipitation falling on British forests is intercepted by the tree canopies and evaporated back into the atmosphere without ever reaching ground level. Most of the ground water is either transpired by the trees or is eventually discharged into the streams.

The tendency to elaborate systems of classification is a direct result of increasing recognition of the complexity of the forest community. No practical system of forest classification could take into account all of the diverse factors characteristic of forest ecosystems so that the art of classification is to be able to arrive at some workable compromise between the complexity of the ecosystem and the practical limitations of field observation. Ecological research of forest ecosystems will assist in assessing the value of selected features of woodlands as a means of synthesising inter-related factors for classification purposes. In the past, forest classification has been primarily concerned with the forest crop as an expression of site factors but site conditions are liable to be changed by the forest organism. It is important to ensure that these changes do not impair the productivity of future forest stands, particularly since the general tendency is for forests to be increasingly restricted to sites which are ingerently poor. Perhaps the most important contribution of ecosystem ecology to forest classification will be in drawing attention to the need to include in the classification procedure some indication of the anticipated long term changes that are likely to occur as forest types mature and are harvested.

Table 1. The average, annual change of three components of the ecosystem in adjacent plantations of Pseudotsuga taxifolia and Alnus incana during the first 22 years after planting heathland.

Pseudotsuga taxifolia:		Trees	Ground flora	Litter layers	Total
Organic matter					
O.D. Weight	Kg/ha.	+ 8,490	— 595	+ 988	+ 8,883
Carbon	Kg/ha.	+ 5,700	— 340	+ 458	+ 5,818
Nitrogen	Kg/ha.	+ 38	— 9.8	+ 8.5	+ 36.7
Sodium	Kg/ha.	+ 2.5	— 0.1	+ 0.3	+ 2.7
Potassium	Kg/ha.	+ 13.5	— 4.0	+ 0.8	+ 10.3
Calcium	Kg/ha.	+ 31.9	— 4.9	+ 10.5	+ 37.5
Magnesium	Kg/ha.	+ 2.3	— 0.6	+ 0.4	+ 2.1
Phosphorus	Kg/ha.	+ 5.0	— 0.7	+ 1.0	+ 5.3
Water	Kg/ha.	+ 8,120	— 325	+ 559	+ 8,354
Energy	Cal/ha.	+38,199	—2,680	+3,811	+39,330

Alnus incana:		Trees	Ground flora	Litter layers	Total
Organic matter					
O.D. Weight	Kg/ha.	+ 5,682	— 497	+ 245	+ 5,430
Carbon	Kg/ha.	+ 3,500	— 297	+ 110	+ 3,313
Nitrogen	Kg/ha.	+ 31	— 7.5	+ 2.1	+ 25.6
Sodium	Kg/ha.	+ 0.3	— 0.1	+ 0.1	+ 0.3
Potassium	Kg/ha.	+ 6.2	— 3.0	+ 0.2	+ 3.4
Calcium	Kg/ha.	+ 28.7	— 2.8	+ 3.3	+ 29.2
Magnesium	Kg/ha.	+ 1.9	— 0.4	+ 0.1	+ 1.6
Phosphorus	Kg/ha.	+ 2.7	— 0.7	+ 0.2	+ 2.2
Water	Kg/ha.	+ 5,786	— 86	+ 127	+ 5,827
Energy	Cal/ha.	+23,713	—2,323	+ 929	+22,319

The Concept of Climax in Forest Botany as applied in India

G. S. Puri[1]

In India, the monoclimax theory of Clements is generally followed. Although, some workers in the past have showed some preferences towards the polyclimax theory and have interpreted the occurance in some areas of Physiographic climax, or Edaphic climax, the trend in most of the studies has, however, been towards the recognition of only one climax, that is the climatic climax. Working in the Sholas of the Nilgiris, Ranganathan (1938) even went to the extent of stating that there are two climatic climaxes, namely, the forest climax and the grassland climax, the former in sheltered slopes and the latter in unprotected areas where the hazard of frost limits the coming in of tree species. This theory was, however, considered untenable by Champion (1938) and Bor (1938), and later by Ranganathan (1955) himself, and the present author (Puri 1959) agrees with the latter and the monoclimax theory, therefore, holds good in Indian Forest Botany.

The classification of the Indian vegetation given by Champion in 1938 has recently been modified by the author (Puri 1959) and the communities have been separated in each vegetation zone into climatic, edaphic and biotic. Thus, the biotic communities even though on account of the persistence in some cases of particular features of the habitat do not seem to progress sufficiently rapidly towards the next higher stage in succession, their status is considered to be only seral. Some of the edaphic communities, which appear to remain in a fixed condition for the time being have been considered embryonic in the sense of Huxley.

The climax vegetation over whole of the Indian region is essentially a forest and in most of the places the forest is composed of evergreen species. This is seen clearly from the presence of relicts, which in almost all the cases comprise of evergreen communities occuring in the midst of degraded scrubs, savanahs, or grasslands. Recently the author (Puri 1958) has described one evergreen relict among the deciduous forests of the Hoshairpur Siwaliks and similar relicts have been described by Bor (1942) from Assam areas and by the author from the Deccan (Puri and Vasavada 1957) and Rajasthan (Puri 1958). The climate in India that gives rise to climax vegetation of the evergreen species is monsoon tropical, with most of the rain falling during the summer months of June, July, August and September. The winter monsoon on the east coast in northern India does not seem to affect very much the vegetation development over most of the Indian territories, as a whole.

The direction of the monsoon winds becomes very important in the develop-

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[1] Botanical Survey of India, Poona, India.

ment of the vegetation. Unlike, Europe, where due to the Pleistocene glaciation soil conditions over most of the areas have become uniform and vegetation development follows distinct latitudinal and altitudinal variations, the Indian vegetation is characterised by homogenity, rather than heterogenity, over large stretches of the country, covering several latitudinal and altitudinal lines. Thus, Prosopis specigera, Acacia arabica, Tephrosia purpurea, Aerva spp., Zizyphus spp., Tamarix spp., Calatropis procera, and many others occur from Rajasthan in the north to Cape Commorin in the south, covering several latitudinal lines (Puri et al. 1959, Wadhwa 1959).

The vegetation development in the Himalayas, the Siwaliks and the Gangetic valley is governed by the South-East and North-West branch of the Monsoon, which bring about a gradual decrease of rainfall and a gradual increase of dryness as one proceeds from the south-east towards the north-west. Thus the evergreen forests are developed in the vicinity of the Bay of Bengal and as one proceeds towards the north-west, the forest vegetation gradually becomes drier, and deciduous communities become prominant towards the extreme north and north-west of India. Thus the vegetational changes in the north Indian territory do not strictly follow latitudinal lines, but changes occur from south-east to north-west, one type of vegetation extending over a wide range of latitudinal and altitudinal lines. Although, in these communities the general nature of the vegetation at present appears to be deciduous and even scrubs and savanahs may seem to predominate, there is ample geographical (Wadia 1937) and historical evidence as shown by Randhawa (1945) for the belief that only a few centuries ago, the vegetation of the Gangetic valley was dominated by evergreen species like Saraca indica and Anthocephalus cadamba. In the Himalayas also the dominant evergreen vegetation, characteristic in the east gets gradually changed to somewhat moist deciduous communities in the west. It may be noted here that all the Indian species of Oak and Conifers are evergreen and the presence in the Himalayas of deciduous species like Aesculus, Populus, Salix, Juglans, Horse chestnut, etc., is considered to be a migration during the Pleistocene from the territories on the west (Puri 1945, 1946, 1949).

The Himalayan vegetation is a distinct sere, in which Oaks constitute distinct climax communities. The presence of conifers and mixed Oak and Conifer communities over large areas in the Himalayas is due to the presence of glacial moraines, flood-plains, scree slopes and differences due to scarp and dip slopes, or biota (Puri 1956, Mohan and Puri 1956); the natural or artificial causes bringing in disturbances in the Oak climax. The Himalayan area has a long history of human disturbances, which resulted in shifting cultivation, fire, grazing and these practices have created many a communities of conifers in place of Oak climaxes. Thus, there are primary as well as secondary seres, which can be easily distinguished. On the monoclimax theory all the communities other than pure Oaks are edaphic or bio-edaphic in nature, which show a distinct tendency towards the Oak climaxes. The author has studied these forest communities on a large scale in the Himalayas and he does not find any place where any plant community other than Oaks could be called a climax, (Puri 1950, Puri and Gupta 1951, Mohan and Puri 1955, 1956, 1957, Puri and Maini 1957, Gupta 1959). These observations differ considerably from those of Trevor (1920), Glover (1930), Gorrie (1933), Dudgeon and Kenoyer (1925), Champion (1938), Kenoyer (1921), and Osmaston (1922) who had not fully accepted Oak communities as climax and have tried to give the status of climax to several other communities. Recently, Gupta (1959) has carefully studied the vegetation of Tehri Garhwal in which Dudgeon, Kenoyer and Osmaston have worked previously and he rightly considers Oaks to be climatic climax over all the areas. He also recognised fixed seral communities of Pinus roxburghii on the quartzite formations but indications of their progress, though slow, to Oak climax are clearly visible. Those so called edaphic climaxes of Osmaston and others could be properly defined in Clement's terminology as sub-climax or pre-climax. These recent studies further confirm Puri's (1957) conclusions of the north-west Himalayan regions.

In the eastern Himalayas which was the least affected by the Pleistocene glaciation, the conifers are less permanent. There are, however, eastern conifers, which are as much part of the vegetation as Oaks and Laurels. The Oak-Laurel community on the east is the climax type of vegetation (Puri 1959).

Most of the Alpine vegetation in the Himalayas is not truly alpine because the climate there too is monsoonic and tropical and the migration from the neighbouring countries of herbaceous alpine species has given these areas mostly an alpine character, but at almost all places, even right to the tip of the glaciers, the vegetation comprises of tree species, although in some remote places stunted shrubs of Junipers, Salix and Rhododendron are present. It is difficult to do more justice to the status of the so called alpine vegetation because the data on its floristic is at present too limited, (Puri 1949, 1959, Gupta 1959).

The climax vegetation in the Siwaliks is also an Oak, Quercus incana, although large areas at present, have extensive communities of Pinus roxburghii and Shorea robusta (Mohan and Puri 1956). The Shorea robusta community does not seem to be the climatic climax in the Siwaliks though it seems to be eminently suited to the Siwalik clay (Puri 1950, 1951), which at some places may have supported in the past Quercus incana community and now bears patches of evergreen forests of Putranjiva, Bischofia a.o. with an undergrowth of canes and tall ferns (Puri 1957).

The vegetation in the Indus and the Gangetic plains has been almost every year destroyed completely, creating water-logged, alkaline or other barren conditions. In the extreme west which is now characterised by desertic conditions with conspicuous sand-dunes, high wind, water erosion and aridity and high temperature, the climax vegetation appears to be of evergreen species comprising of Prosopis specigera, Salvadora oleoides, S. persica and Tecomela. There are, however, some edaphic variants with Acacia senegaelnsis (Puri et al. 1959, Puri and Jain 1959). In the eastern side the conditions are more favourable for the growth of grasslands with stunted and malformed trees of Zizyphys, Capparis, Prosopis etc. The grasslands in the Indo-Gangetic plains, apparently extensive and permanent in character are truly bio-edaphic communities and represent retrogressive stages (Misra 1958, Puri 1959). In almost all cases there are indications of the development of secondary seres (Puri and Misra 1954).

In the Aravallis the climatic climax is likewise an evergreen community of Anogeissus pendula (Puri and Jain 1958). In the Vindhyas and Satpuras the vegetation is mixed, characterised by the species like Teak, Terminalia, Hardwickia, Butea, Stereospermum, Anogeissus, Lagerstroemia etc. This vegetation excluding teak had extended right into the Siwaliks formation in the north where Shorea robusta had formed an important constituent. The status of this vegetation is not clearly understood, although the evergreen species of Eugenia, Terminalia chebula etc., try to get in to give the vegetation an evergreen status (Puri and Mahajan 1957).

In Central India and the Vindhyas, Puri and Wadhwa (1959) have again shown that grasslands are biotic in nature. Mooney (1933) has drawn similar conclusions in his study of forests of Bihar and Orissa. In the Madhya Pradesh, Misra (1958), Bhatia (1954) and others have again demonstrated to the grasslands being biotic and bio-edaphic and a climax community being a moist deciduous forest.

In all these areas, the succession of forest communities has been complicated on account of the peculiar stratification of the hills. The vegetation is clearly recognised as distinct on dip slopes and escarpements and different types of rocks when out-crop on the surface govern the growth, development and succession of plant communities (Puri 1959). To give an example, one finds in the Siwaliks, the strata of ferruginous clay and conglomerate alternating with each other. The clay bears moist deciduous vegetation of Shorea robusta, Eugenia and several Lauraceous species. The conglomerate bears Anogeissus latifolia, Lagerstroemia, Terminalia, Eugenia etc. typically deciduous vegetation. The erosion of the surface exposed one or the other rock bringing on the surface the second type of rock and a more or less sudden change in the vegetation develops sometimes with the presence in newly developing vegetation of one type of old trees which are clearly remnants from the older type that has preceeded in the same localities. This sort of sudden changes has misled several workers in the part to consider one or the other community as climatic climax (Puri 1950). Truly speaking the climax vegetation is an evergeen community with Oaks, the conditions for the growth and establishment of which have unfortunately been destroyed by natural or artificial causes.

Similar examples of the alternation of evergreen communities on red clay and deciduous communities on basalt or amygdaloid have been found in the Deccan trap country (Puri 1957, Puri and Mahajan 1957, Puri and Vasavada 1957). But here too the climax appears to be of more of an evergreen character than a deciduous community.

The vegetation along the Western Ghats which are served by the Arabian Sea branch of the Monsoon, is again characterised by the same two types of communities, i.e. the evergreen and the deciduous (Puri) 1959). The evergreen community occurs on red soils or laterite and are characterised by such species as Hopea parviflora, Cinnamonum zeylanicum, Vitex altissima, Garcinia indica, Elaeocarpus tuberculatus, Callophyllum inophyllum, Holigarna grahamii, Memecylon edule, Dipterocarpus turbinatus, Macranga peltata, Gardinia gummifera, etc. (Arora 1959, Ahuja 1959).

The black soil series have a vegetation mostly of deciduous or moist deciduous species of Terminalia, Tectona, Careya, Buchanania, Lagerstroemia, Diospyros, etc. Teak and Bamboo often come in this sere on black alluvial soils under the humid tropical conditions and vegetation also changes to evergreen communities, which constitute the climax (Puri and Arora 1959, Arora 1959).

Thus, in India, the monoclimax theory of Clements is accepted and only climatic climax communities are recognised. The edaphic, and bio-edaphic communities are seral in nature. The climax vegetation is usually an evergreen community of tall trees if biotic interference is completely removed.

Can we find a common platform for the different schools of forest type classification?

J. S. Rowe[1]

The common platform must be sought in agreement on underlying concepts; that is, in agreement on the nature of the phenomena (forest units) that are to be classified and on the kind of classification appropriate to such phenomena. In this article it is suggested that the significant forest entities are ecosystems rather than plant communities as such, that however conceived they are found, on systematic examination, to be intergrading rather than discrete, that there is therefore, irreducably, a subjective element in their definition, and that the abstract types into which they can be classified are necessarily artificial categories shaped by purpose. All these ideas are related, and it is convenient to begin with a consideration of the nature of the forest.

The forest is not particulate by nature. A prerequisite of classification is, of course, the identification of the things to be classified. These may be self-evident entities, as individual plants or animals, or they may be blending, coalescent, patterned phenomena such as climates or soils, in which latter case there is less likely to be unanimous agreement as to what natural units or »species», if any, exist. The forest, whether conceived in terms of vegetation or ecosystem, belongs in the latter category. To say that it does not consist of self-evident units is not to deny the existence in many places of geographically distinct divisions in its matrix, but it is to assert that such divisions do not occur consistently, and thus in nature no regular demarcation of units of specific composition and form can be found. The fact that students of vegetation, for example, have failed to agree on what basic units exist, suggests that there are no natural ones. Although recurring pattern can often be perceived in the complex tapestry of forest vegetation, apparently providing the prerequisites of classification, the apparent discreteness of the pattern patches has usually dissolved, on analysis, into a continuum (McIntosh 1958). Thus the forest is probably to be thought of most accurately in terms of gradient patterns, its segmented geographic appearance being due to local steepenings in rates of gradient change (at least in the absence of disturbance).

The appropriateness of classifying phenomena that show continuous variation has been questioned in these words: »Discrete entities may be practically self-defining, but continuous variables, in space or in time, resist internal partition» (Womble 1951). Speaking particularly of vegetation, Goodall (1954) suggested that it might be more appropriate to »ordinate» the segments of continua, i.e. to arrange them in a uni- or multi-dimensional order, rather than to force them unnaturally and arbitrarily into discrete classes. However, for purposes of forestry, the classification into »types» does have useful aspects, and this is its sufficient justification. Purposeful selection of useful characteristics allows the development of genetic concepts around which a classification can be built. Thus gradients can be divided and the segments grouped in classes in the same way that discrete objects are categorized. The important point is that the forest is not »self-ordering», and recognition of this fact allows freedom in dealing with specific problems of classification and at the same time promotes a tolerant attitude toward the work of others.

Purpose dictates the kind of forest units recognized. If the subjective basis of the establishment of forest units is acknowledged, then certain controversial issues disappear. Attention is shifted from questions of the »naturalness» of the divisions to more practical aspects, namely to their efficiency and value for defined purposes. The excellence of a classification will likewise be judged not so much by its accordance with the principles of biological taxonomy as by its utility with respect to particular ends. Thus purpose will establish, quantitatively and qualitatively, the appropriate kind of dividions to be made, and a suitable classification will be derived if need be on the basis of important characteristics.

There is a different point of view, a different purpose, between those who study the forest as an academic object of interest and those who study it in relation to the practical field of management; consequently it is to be expected that there will be differences of opinion as to how it shall be conceived and how divided into useful parts or units. The one group may be primarily interested in describing and systematizing the vegetation; the other will be concerned equally with environment or site, for ecological and developmental considerations are of great importance for management. The difference is that between »Pflanzensoziologie» and »Angewandte Pflanzensoziologie» between, for example, »associations» (sensu Braun-Blanquet 1951) and »vegetation development types» (sensu Aichinger 1950). From the standpoint of the forester it seems logical that the significant forest entities should be conceived as ecosystems, and this on philosophical as well as on practical grounds.

Forest units as ecosystems. The ecosystem concept has been steadily gaining recognition in recent years, and the term (or its many equivalents) appears more and more frequently in biological literature. The transactional system biocoenose-ecotope, which may by omission of the zoocoenosis be simplified to forest phytocoenose-site for purposes of the present discussion, is rightly recognized as more meaningful than its components treated separately. In the words of Tansley (1935): »Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them tor their special environment, with which they form one physical system. It is the systems

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[1] Forest Research Division, Dept. of Northern Affairs and National Resources, Ottawa, Canada.

so formed which from the point of view of the ecologist are the basic units of nature on the face of the earth».

Lindeman (1942) defined »ecosystem» inclusively as »any system composed of the physical, chemical and biological processes active within a space-time unit of any magnitude», and Evans (1956) pointed out the need to narrow the definition in order to make it useful for particular purposes. Recently Sjörs (1955) has examined the concept in some detail, speculating on its possible vitalizing effect if injected into vegetation science, hitherto a predominantly analytical field. Among those who have sought a basis for forest science in the central concept of the ecosystem (as »total site» or »biogeocoenosis») may be mentioned Hills (1952) and Sukachev (1954).

Although the concept of the ecosystem has gained wide currency, its implications have not been recognized to the same extent. If forest vegetation and site, phytocoenose and ecotope, are interrelated parts of a greater whole, then neither stands alone as a »natural phenomenon», nor expresses adequately in itself the essential ecosystem. The latter must be studied as a whole and described in all aspects. The phytocoenose has sometimes been accepted uncritically as an adequate indicator of the ecosystem and of its other parts, an idea that needs to be closely examined.

Significance of the phytocoenose. What significance does the phytocoenose have in relation to the rest of the ecosystem? A commonly held viewpoint is outlined in the remainder of this paragraph. The phytocoenose faithfully reflects the integrated impact of total environment, and is itself the only proper measure of this (unknown) impact. The failure of many ecological studies to demonstrate a consistent relationship at any level between vegetation and environment is explained as due to the fact that the »integrated impact» of the latter cannot be measured instrumentally; the usual analytical approach — the search for limiting factors — is a methodology incapable of dealing with integrated environmental effects. Similar phytocoenoses which are observed in what appear to be different habitats indicate that compensating factors are at work; that is, different constellations of environmental factors may so interact as to produce essentially the same biological results. The identification and classification of »biologically equivalent sites» can therefore be based on the identification of similar phytocoenoses, although there is usually the proviso that these must be »mature», »stable» or »climax», terms implying a state of dynamic equilibrium with environment. In short, the idea is that the phytocoenose is the measure of the ecosystem and the key to its essential characteristics.

There is an element of truth in all this, yet there is much that can be misleading. Possibly a more exact and enlightening expression of the relationships between a phytocoenose and its environment would be this, following Mason and Langenheim (1957):— that during the life spans of the organisms presently composing the community, the environmental forces impinging on them have

not exceeded, in any essential respect, their physiological tolerances. The unknown dimensions of tolerances of associated species therefore constitute the »measure» of environment, and the amplitude of mutually shared spans of these tolerances determines the range of environments, actual and potential, within which a specified phytocoenose may occur. The potential range may not be occupied due to lack of opportunity and time for migration, or due to an inability of the member species once there to compete with other species whose tolerances and past histories allow them to be present also. To identify »biologically equivalent sites» or »equivalent ecosystems» on the basis of phytocoenoses alone involves, therefore, a degree of presumption.

Significance of similar phytocoenoses. The problem may be illuminated by a closer examination of the question: What significance can be attached to the identification of similar, geographically separated phytocoenoses? Obviously it is necessary to know in what respect they resemble one another, then what range of conditions the criteria of similarity operate within. Leaving aside for the moment an examination of the basis of »similarity», it is evident that if resemblance is established on the basis of mutual occurrence of one or a few species whose ecological amplitudes are broad due to genetic diversity of population and/or to physiological plasticity of individual biotypes, then a wide range of environments may be lumped together as »biologically equivalent». The range may be further increased in directions of decreasing competition stress. Foresters have long known that tree species grow differently in pure stands than in mixed, and experimental proof using shorter-lived species has been been provided by studies such as those of Ellenberg (1952). Ecological behaviour reflects intrinsic physiological processes modified by competition, and therefore it cannot be said that a given plant indicates some environmental phenomenon unless the competition to which it is subjected is also specified. Recognizing this fact, Vernet (1958) suggested that the part played by competition may be allowed for in practice if, instead of single species, the combination of species found living together in nature is studied as a whole. However, this approach cannot be trusted to solve the problem in all situations, for the subordinate species of a community frequently depend on the microenvironmental conditions created by the dominant trees rather than on the intrinsic characteristics of the habitat. (Here, incidentally, critics of those who classify site by means of vegetation have frequently scored a telling point; if the forest growth potential of a site is to be interpreted from the vegetation, then it must be shown in every area of application that the vegetation, or at least those aspects of it that are being used, is indeed a reflection of site *per se* and not of the forest growth.)

A nice illustration is provided in the northern part of the trans-continental boreal forest zone of Canada, where the black spuce (Picea mariana) with a floristically consistent undergrowth of feather mosses and low herbs (Calliergonella schreberi, Hylocomium splendens, Linnaea borealis var. americana, Cornus canadensis, Pyrola spp. and Lycopodium spp., etc.) occupies a tremendous range of sites apparently by default; the competitors that at the southern edge of the boreal forest limit this community to a narrow range of habitats are not present in the north. Similarly, on islands having a sparse flora due to historical circumstances, certain pre-adapted species may expand into a wide variety of niches (Wace and Holdgate 1958, Heslop-Harrison 1951). It might be argued that the niches are biologically equivalent, a truism in the sense that they do indeed support the same groups of species. In more fundamental ways, such as in the transformation and accumulation of energy and matter (productivity), the niches may be widely different. Thus the »similar» features, on the basis of which the niches are equated, may be of a non-essential kind.

A closer look at the idea of »similarity» of phytocoenoses is instructive. It is evident that the subjective basis of similarity must always relate to what is considered to be significant by the observer. No two patches of vegetation are exactly the same in all respects, and in the judgement as to whether they are sufficiently alike or unlike to be placed together or in separate categories there is indisputably a personal choice. The phytogeographer may be satisfied to establish standards of similarity on the basis of gross structure of the vegetation; the phytosociologist may stress the details of floristics. To both approaches the ecologically-oriented worker may object, arguing that similarities in relation to environment and development must be established at a primary level. Thus Duvigneaud (1946) questioned »Tüxen» identification of two subassociations of the Cariceto-canescentis Agrostidetum on the grounds that they had no ecological validity, and Daubenmire (1952) rejected some of the forest site types identified by Kujala because they did not seem to him to be ecologically or successionally sound. It should be pointed out that whether recognized or not, ecological interpretation usually enters into the observational and descriptive procedures used by every field worker in vegetational studies, hence geographical or sociological indicators may fortunately turn out to be excellent ecological indicators, even though no conscious effort has been made to bring the two together. However, the argument is strong that it is unwise to base the identification of equivalent ecosystems or of »biologically equivalent sites» on phytocoenoses whose synecological and syngenetic relationships are poorly understood and whose similarities are of a highly subjective nature. Clearly, too, the concurrent description of the ecotope is required to put each phytocoenose into correct perspective and add precision to its functional relationships.

Practical classification in »forest ecosystem types». We come finally to a consideration of the purposive delimitation of ecosystem units. In all sciences relating to the earth's surface an areal framework has been found essential to detailed classification. For example, the regionalizing principle is usually invoked early in classifications relating to climatology, pedology and plant sociology. Division of the land mass into parts that are relatively homogenous reduces complexity within these parts and thus facilitates classification of constituent entities. Following Major (1951), the ecosystem may be conceived as a function of the following relatively independent variables: macro-climate, geologic surface material, topography-relief, effective biota and time, this last »factor» representing residual effects from historical interactions of the others. If areas can be defined within which one or more of the first four factors are relatively constant, then the task of classification of ecosystems below this level will be simplified.

Climate has no static features and it cannot be identified as a geographic entity; as its impact can only be inferred at second hand from features of the biota or the land, it is not useful in an empirical zoning of the landscape. The relative size of areas-of-uniformity of the other three components will determine their hierarchical position in a system of zoning. As areas of uniform biota are often relatively large, and furthermore as the biota (principally the plants) constitutes the main use-feature of the land, it provides, compositionally or structurally, the appropriate criteria for initial divisions. Usually the boundaries of biotically-defined regions coincide with those of major geomorphologic units; this strengthens the primary divisions. However, the physiographic features are more useful at lower levels, that is, for zoning in turn the biotically circumscribed areas, if this is desirable. At all levels a strictly empirical approach is enjoined for, paraphrasing Egler (1947), whether or not an extent of land is one zone, several zones or several subzones is a matter of opinion, and the degree of subdivision depends upon its usefulness for purposes of description and classification.

Within the framework of biotic regions (provinces, life zones, etc.) or their physiographic and vegetational subdivisions, the local units recognized will depend on the uses foreseen. As previously emphasized, ecosystem is not a finite concept; it includes everything from the unit organism and its environment to the entire world. Accordingly various boundaries can be set, as two examples will illustrate:— Sukachev's (1958) orientation is to vegetation use, and he recognizes forest community ecosystems or forest (biogeocoenosis) types. The limits in both space and time of each concrete biogeocoenose are set by the phytocoenose, but within these limits the ecosystem is fully described in all aspects. In classification, the biogeocoenoses that are united into one type must be homogeneous dynamically, i.e. the relationship biocoenose-ecotope must be consistent. On the other hand, Hills (1958) recognizes landscape ecosystems (total sites), and his orientation is to all facets of land-use including forestry. Within a regional framework the ecosystem boundaries are made to conform to geomorphologic segments which are relatively homogeneous as to pattern of soil materials and topography. Thus delimited, the ecosystem is described in all essential parts, spatially and developmentally. Classification stresses similarity in the more stable physiographic features.

Conclusions. A common basis for forest typology is found in the central concept of the ecosystem, integrating both biocoenotic and ecotopic aspects of the forest. It must be recognized that there are many different ways to divide the forest into unit ecosystems, depending primarily on purpose which determines methods, sets the scale and brings appropriate criteria to the fore. The ecosystem has not prescribed limits in space or in time; its size and extent, and the period within which it is considered as a functioning entity, are determined by the purpose and methods of a study. It follows that agreement of various systems of typology *in practice* is neither possible nor desirable, as differences in purpose will always exist. Such differences are not important, providing that a common conceptual basis, as outlined above, is accepted.

Können wir eine gemeinsame Grundlage für die verschiedenen Schulen der Waldtypenklassifikation finden?

A. SCAMONI[1]

Bevor man die oben gestellte Frage beantwortet, ist es notwendig, den Begriff des Waldtyps genau zu definieren, denn er ist in sehr verschiedener Weise gebraucht worden.

Es sei an die Waldtypen von Morosow und Kreudener in Russland, an die Waldtypen von Sukatschew in der Sowjet-Union, an Cajanders Waldtypen in Finnland erinnert, und es erhebt sich die Frage, ob es zweckmässig ist, den Begriff des Waldtyps weiter zu verwenden. Um eine gemeinsame Konzeption zu gewinnen, sei empfohlen den Begriff des Waldtyps für den Typ einer Wald-Biochore nach Pallman (1948) oder für einen Typ der Wald-Biogeozönose nach Sukatschew (1957) anzuwenden.

Nach dieser Definition zeigt ein Waldtyp gleiche Umweltsbedingungen, eine gleiche Vegetation und eine gleiche Fauna, er zeigt auch eine gleiche Entwicklungstendenz und erfordert gleiche forstliche Behandlung.

In Wäldern, die durch menschlichen Einfluss kaum oder nicht verändert worden sind, ist eine Kongruenz zwischen den biotischen und abiotischen Faktoren gegeben, so dass die Phytozönose der Ausdruck der gesamten Biochore oder Biogeozönose ist. Temporäre Veränderungen sollten als Entwicklungsphasen zu einem Typ zugeordnet werden. In Wäldern, die vom Menschen stark verändert worden sind, kann eine bemerkenswerte Diskrepanz zwischen den primären Standortsfaktoren und der Vegetation auftreten, so dass die Phytozönose nur den augenblicklichen Zustand widerspiegelt und eine relativ schnelle Entwicklung zu beobachten ist. Auch diese abgewandelten Bestände stellen besondere abgewandelte Biochoren und Biogeozönosen dar, mit denen es die Forstwirtschaft in steigendem Masse zu tun hat.

Wenn in Wäldern, die durch menschlichen Einfluss kaum oder nicht abgewandelt worden sind, ein Waldtyp in jedem Fall einem Typ einer Biochore oder einer Biogeozönose entspricht, so erhebt sich die Frage, ob in abgewandelten Wäldern, die die gleichen Standortsbedingungen aufweisen wie die nicht veränderten Bestände, man besondere Waldtypen ausscheiden muss.

Nach Erfahrungen scheint es notwendig, dass die abgewandelten Wälder, die eine besondere Dynamik zeigen und die besondere forstliche Massnahmen erfordern, als abgewandelte Waldtypen = Biochoren oder Biogeozönosen behandelt werden müssen.

Es ist jedoch notwendig, ihre Beziehungen und ihre Zuordnung zu »natürlichen» Waldtypen zu bestimmen. So können diese beiden Arten der Waldtypen

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[1] Institut für Waldkunde der Forstwirtschaftlichen Fakultät, Eberwalde, DDR, Germany.

in eine Gesellschaftsreihe, einen Gesellschaftsring nach Schwickerath (1954) oder in einen Waldentwicklungstyp nach Aichinger gestellt werden. Man kann auch die abgewandelten Wälder mit den natürlichen Wäldern auf dem gleichen Standort zu einer Einheit vereinigen und die Abwandlungen als temporäre Erscheinungen, Degradationsstufen oder Entwicklungsphasen ansehen.

Wenn eine gemeinsame Grundlage zur Klassifikation der Waldtypen gefunden werden soll, so muss man eine Einigung über die Gesichtspunkte erzielen, die für die Bestimmung der Waldtypen massgebend sind.

In Wäldern, die nicht oder wenig verändert worden sind, erscheint die Lösung nicht so schwer, da, wie schon oben gesagt wurde, die Phytozönose, die die Bäume und Sträucher mit umfasst, den Waldtyp repräsentiert. Jedoch sind weitere Untersuchungen über die Kongruenz zwischen den einzelnen Teilen der Biochore oder Biogeozönose notwendig.

In abgeänderten Wäldern ist die Phytozönose, insbesondere die Bodenvegetation, der Zeiger für den augenblicklichen Zustand, aber sie kann mittels der syngenetischen Arten die Herkunft aus der naturnahen Vegetation angeben und durch bestimmte Arten die Tendenz der Entwicklung anzeigen. In diesen abgeänderten Wäldern wird eine Analyse nach den primären Faktoren in Kombination mit einer Analyse der Phytozönosen von grösserer Bedeutung sein, aus ihr wird auch die Reihe der Typen zu erkennen sein, zu der ein bestimmter abgeänderter Typ gehört.

Eine solche Reihe von Typen besteht aus einem bestimmten Grundtyp der nicht oder kaum gestörten Waldvegetation, zu dem die abgewandelten Typen zugeordnet werden müssen.

In Mitteleuropa treten die Fragen der abgewandelten Waldtypen sehr stark in den Vordergrund, da infolge der jahrhundertelangen Einwirkung des Menschen auf den Wald grosse Veränderungen vorgenommen worden sind, und die Aufgabe wächst, auch diese Bestände zu klassifizieren.

Da eine einheitliche waldtypologische Behandlung der naturnahen und der abgewandelten Wälder aber anzustreben ist, müssen auch die Methoden der Klassifizierung einheitlich sein, wobei je nach Objekt der eine oder andere Komplex der Untersuchung der Biochore oder Biogeozönose mehr in den Vordergrund treten muss. So kann auch kein Primat der vegetationskundlichen Analyse gegeben sein, die, absolut gesehen, eine Klassifizierung *aller* Wälder geben kann, jedoch in abgewandelten Beständen ihre Grenzen hat, da für forstwirtschaftliche Zwecke nicht nur die Erkennung des aktuellen Zustandes wichtig ist, sondern auch die Kenntnis der Potenz des betreffenden Standorts von grosser Bedeutung ist.

Meines Erachtens müssen diese Tatsachen in einer Waldtypologie, die der Praxis der Forstwirtschaft dienen soll, sehr stark beachtet und bei allen Untersuchungen der Beeinflussungsgrad, die Stärke der Veränderungen, die sich in Form einer Degradation kundtut, in Rechnung gesetzt werden.

Wie schon erwähnt wurde, spielt die Phytozönose eine besondere Rolle im Beziehungsgefüge der gesamten Biochore oder Biogeozönose. Von allen Gliedern dieses Komplexes ist sie am leichtesten zu bestimmen. So kann also die Analyse eines Waldtyps mit einer Analyse der Phytozönose beginnen.

Zu diesem Zweck ist es erforderlich, auch eine gemeinsame Grundlage zu einer natürlichen Ordnung der Vegetation zu finden.

Diese Ordnung der Vegetation muss nach Kriterien ausgeführt werden, die in der Materie selbst liegen, d.h. in erster Linie muss die Vegerarion nach soziologischen Gesichtspunkten geordnet werden.

Es wird empfohlen, die Konzeption der natürlichen Waldgesellschaft als eine Grundeinheit für die naturnahen Wälder anzuwenden. Die Grössenordnung einer natürlichen Waldgesellschaft entspricht der einer Assoziation im Sinn von Braun-Blanquet, jedoch ohne die Bedingung des Vorkommens von sog. Charakterarten.

Wir sind der Meinung, dass eine Waldassoziation von einer charakteristischen Kombination der Artengruppen aller Schichten bestimmt wird.

Die soziologischen Artengruppen werden in einem bestimmten floristischen Bereich nach ihrer soziologischen Amplitude induktiv ermittelt. Ergeben sich Charakterarten, so können diese als eine bestimmte soziologische Artengruppe betrachtet werden. Auch das Fehlen von Artengruppen muss als ein soziologisches Merkmal gewertet werden. Es treten hierzu die Merkmale der mittleren Artenzahl, der Homogenität, der Art der Untergliederung und, wenn auch in letzter Linie, die der Artmächtigkeit.

Es ist am besten, die Waldassoziationen als Regionalgesellschaften aufzufassen und in diesem Rahmen das Beziehungsgefüge aufzustellen. Es können nur solche naturnahe vegetationskundliche Einheiten Geltung haben, die der phytologische Ausdruck einer Biochore oder Biogeozönose sind (s. Scamoni und Passarge, 1959).

Auch in abgewandelten Wäldern (Forstgesellschaften im Sinne von Tüxen) kann das Prinzip der charakteristischen Artengruppenkombination sehr erfolgreich angewendet werden.

Wie bei Braun-Blanquet werden die Assoziationen in Subassoziationen, Varianten etc. unterteilt. Wenn eine floristische Unterteilung bei signifikanten Artmächtigkeitsunterschieden nicht mehr durchgeführt werden kann, so kann als »ultima ratio« die Ausscheidung der untersten Einheiten nach der Artmächtigkeit erfolgen.

Auf jeden Fall müssen für die vegetationskundliche Bearbeitung genaue pflanzensoziologische Aufnahmen vorliegen, bei der allgemein anerkannte Prinzipien angewendet werden. Am verbreitetsten sind die von Braun-Blanquet, es können aber auch Prozentschätzungen gebraucht werden. Und auf alle Fälle hat die Klassifikation der Vegetation durch genaue Tabellenarbeit zu erfolgen.

Die kleinste Einheit, die bei ungestörten Verhältnissen ausgeschieden werden kann, muss einen Waldtyp repräsentieren. Vom vegetationskundlichen Standpunkt kann diese Einheit neutral »Ausbildungsform» einer Assoziation genannt werden, die einer Variante oder einer Fazies im Sinn von Braun-Blanquet entsprechen würde. In dieser Vegetationseinheit müssen Standortsuntersuchungen durchgeführt werden, um die Beziehungen zu den abiotischen Faktoren zu klären und ihre Homogenität zu beweisen.

In abgeänderten Phytozönosen muss besondere Aufmerksamkeit auch auf die Untersuchungen gelegt werden, die die Beziehungen zu einem natürlichen Grundtyp herstellen lassen, so auf die syngenetischen Artengruppen und vergleichende Untersuchungen des Standorts.

Manche Autoren scheiden Waldtypen nur nach primären Standortsfaktoren aus, es sind dies die sog. Standortstypen oder Standortsformen. Der Grund hierfür liegt in der Begrenzung der Aussagefähigkeit der Vegetation in abgewandelten Wäldern im Bestreben, eine allgemeingültige Typisierung vorzunehmen und die Potenz der Standorte zu bestimmen.

Von der Konzeption der Biochore oder der Biogeozönose ausgehend, erscheint aber eine solche Typisierung nur nach primären Standortsfaktoren zu einseitig und wird in sehr vielen Fällen durch eine vegetationskundliche Untersuchung ergänzt, so dass es sich meist um kombinierte Methoden handelt.

Diese Fragen tauchen auch bei der Nomenklatur der waldtypologischen Einheiten auf. Soll sie nach der Vegetation, nach den primären Standortsfaktoren oder durch eine Kombination beider durchgeführt werden?

In diesem Punkt gehen die Ansichten weit auseinander. Wenn man die aktuelle Vegetation herausstellt, so kann kein allgemeingültiges Prinzip erreicht werden, da die Schwierigkeiten bei den abgewandelten Phytozönosen, den Forstgesellschaften, gross sind. Bezeichnungen allein nach den primären Standortsfaktoren können oftmals nicht die notwendige Kürze erreichen und regionale oder zonale Unterschiede genügend ausdrücken.

Für naturnahe Bestände, die die Basis für jede Betrachtung abgeben sollten, ist es empfehlenswert, die Nomenklatur auf der Basis der natürlichen Vegetation zu entwickeln, die die zonalen und regionalen Gegebenheiten und auch die des Standorts enthält. Wenn nötig, kann eine kurze Bezeichnung für den Standort hinzugefügt werden.

Wenn in abgewandelten Phytozönosen die Beziehungen zum Grundtyp bestimmt sind, kann die Zuordnung auch im Rahmen ausgedrückt werden und der Abwandlungsgrad kurz bezeichnet werden. Bei allem Bestreben nach einem kurzen Ausdruck werden längere Namen nicht zu umgehen sein.

Als Beispiel für den ersten Fall der naturnahen Vegetation sei »Dentaria-Ausbildung des Melico-Fagetum balticum», genannt, aus der die zonale und standörtliche Gegebenheit gleich zu ersehen ist. Als Beispiel für abgewandelte Bestände sei genannt: »Rubus-Kiefernforst des Melico-Fagetum balticum», vielleicht unter Hinzufügung: »auf lehmnahen Sanden».

Eine zu lange Bezeichnung kann aber vermieden werden, wenn für die Standortsformen und Abwandlungsstufen Abkürzungen gebraucht werden, wie es die Erfahrungen unserer Waldklassifikation gezeigt haben.

Abschliessend kann gesagt werden, dass es möglich erscheint, eine gemeinsame Basis für die Waldtypenklassifikation zu finden, wenn weder die Vegetationskunde noch die Standortskunde das Primat beanspruchen. Die Lösung der Schwierigkeiten ist in der Synthese zu finden, auf der Grundlage der Konzeption der Biochore oder Biogeozönose.

Vor allem muss nochmals darauf hingewiesen werden, dass wir es immer mehr und mehr mit abgewandelten Wäldern zu tun haben werden. Auch bestimmt die Intensität der Forstwirtschaft die Grössenordnung der waldtypologischen Einheiten. Bei einer Intensivierung der Forstwirtschaft rücken die kleinsten Einheiten immer mehr in den Vordergrund, die man bei einer extensiven Wirtschaft nicht zu berücksichtigen glaubt. Auch hierin ist auf eine Einigung hinzustreben.

Zusammenfassend kann man sagen: Bestände mit natürlicher oder naturnaher Vegetation bilden die Grundtypen der Klassifikation. Hier werden die Grundtypen der Biochoren oder Biogeozönosen aufgestellt mit der gesamten Vegetation, also einschliesslich der Baumschicht. Mehr oder minder abgewandelte Biochoren oder Biogeozönosen werden in Beziehung zu den natürlichen Typen in eine Serie gebracht und als besondere Abwandlungen, Entwicklungsphasen oder Degradationsstufen behandelt. Das Beziehungsgefüge wird primär vegetationskundlich, sekundär standörtlich festgestellt.

Die kleinste Einheit, die nach vegetationskundlichen und standortskundlichen Faktoren ausgeschieden wird, stellt einen Waldtyp, d.h. einen Typ der Biochore oder Biogeozönose dar. Seine Bezeichnung soll unter der Eliminierung des Ausdrucks »Waldtyp» nach vegetationskundlichen Gesichtspunkten, gegebenenfalls mit einer akzessorischen Bezeichnung des Standorts erfolgen.

Entsprechend der Hierarchie der Vegetationseinheiten können diese Einheiten zu grösseren vereinigt werden, etwa zu Assoziationen, die aber auch höhere Einheiten der Biochore oder der Biogeozönose sein müssen. Eine höhere Einordnung zu Verbänden, Ordnungen etc. hat für die Praxis der Forstwirtschaft wenig Bedeutung, so dass die kleinste Einheit, die Ausbildungsform, und die mittlere Einheit, die Assoziation oder die Waldgesellschaft die wichtigsten sind.

The Correlation between the Concept »Forest Ecosystem« and »Forest Biogeocoenose« and their Importance for the Classification of Forests

V. N. Sukachev[1]

The idea of the existence of interrelations among all the objects and natural phenomena is quite old and at any rate dates to some of the past centuries. Nevertheless it hasn't yet been sufficiently considered in the studies of biological, physical and geographical problems. On the contrary, in the study of nature there was a tendency to introduce among the sciences certain differentiations or subdivisions narrowly specializing them, that led to the loss of the idea of the interrelations existing among all the natural phenomena. Only during the last few decades the concept that both courses are of the same importance became quite obvious and this stimulated the creation of such new sciences as geophysics, geochemistry, physical chemistry, biochemistry, biophysics and others which eliminate sharp differentiations between certain specialized branches of science by tending to investigate the interrelations among the natural phenomena which are usually studied with the help of different sciences. Such »intermediate« sciences proved to be very useful. At the same time they have let us see the great complexity and variability in the forms of interaction between the natural phenomena and prove the necessity of such sciences which help to investigate the interactions of several (more than two) cathegories of natural phenomena as well as the interconnections among such interactions. One of such sciences may be considered, for instance, biogeochemistry. One can also include among these sciences biogeocoenology, which helps to investigate the biogeocoenoses i.e. the complexes of the biocoenoses existing on the earth's surface and which are composed of phytocoenoses, zoocoenoses, and microcoenoses, together with the interacting corresponding components of atmosphere, lithosphere, hydrosphere, and pedosphere, which form one interconnected unit of the complex.

An obvious necessity for distinguishing such natural complexes arose about 60 years ago, as it was mentioned in the works by Dokuchaev and later by Berg and Morozov. This necessary was especially stressed in the work by Abolin (1913) who suggested to name such a complex as »epigen« and the science investigating these epigens as »epigenology«. The necessity of introducing such a concept in science is show by the fact that this idea arose independently in different countries of the world and it resulted in giving different names to the same concept. The following terms were suggested: *ecosystem* (Tansley, 1935), *biosystem* (Thieneman, 1944), *holocoen* (Friedrichs, 1937), and *ecotope* (Troll, 1950) as well as others.

The most popular term in the Soviet Union is the »*biogeocoenose*«, while abroad during the last few years one can meet more often with the term »*ecosystem*«. Therefore there arises a question whether the above mentioned terms are real synonyms, and if it is true, which of them should be preferably used? The »ecosystem« is an older term. But if the priority of terms is taken into account then »epigen« suggested by Abolin should be preferred. In deciding this question it is desirable to establish which of the given terms expresses better the sense of the concept. Tansley (1935, p. 299) considered that the ecosystem includes the whole complex of organisms (the »biom«, by Clements) together with the complex of physical factors of its environment, i.e. the habitat factors in a broad sense of the word, and regarded the ecosystem as one cathegory of the multitudinous physical systems of the Universe which range from the Universe as a whole down to the atom. But the use of the expression »system« in general speech and in the discussion of scientific problems is quite vague as »system« may be used in different senses of the word, sometimes even excluding the mutual influences of the objects within the system, as for example in the system of taxones. Considering that the best characteristics of the studied complex is the presence of mutual influences and the interactions among the components, we must admit that the term »biogeocoenose« is the best of all for the given case. This term is formed by the word »koinos« (that means »common« or »community«) while the prefixes »bio« and »geo« denote the participation of live organisms and inanimate nature of the earth's surface within the complex. The interconnections among the components forming the biogeocoenose may be shown schematically.

Moreover one must add, that the term biogeocoenose as used in the Soviet Union, contrary to the term »ecosystem« introduced by Tansley, is understood as an empirical unit (according to Major, 1958, p. 354), i.e. as quite a definite object of the study.

The concept »phytocoenose« is understood by the majority of Soviet phytocoenologists not as a general term for all the different taxons of vegetative cover, but as a term, determining an area of vegetation which is characterized by a uniform system of interrelations among the plants. Similarly to the above mentioned the concept »biogeocoenose« cannot be considered as a general term for all the taxonomic subdivisions of the biogeocoenotical cover of the earth and it determines a plot of the earth's surface over which there exist definite and still more complicated interactions of the mentioned components of the live and inanimate nature. Therefore the biogeocoenose should not be considered as an abstract unit, as it was suggested by Major (1958, p. 354). An abstract biogeocoenological unit of a corresponding plant association is the type of the biogeocoenose. The interactions within the biogeocoenose call forth certain forms of transformations in the substance and energy contained and the interchanges of such with the adjacent biogeocoenoses and other natural phenomena. The form and intensity of these interactions as well as the exchange of substances

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[1] Academy of Sciences, Forest Institute, Moscow, USSR.

and energy are determined firstly, by the properties of the components (such as plants, animals, micro-organisms, atmosphere, soil and subsoil, inclusive the hydrological conditions), secondly, by the quantity and distribution of the organisms within the biogeocoenose and its general structure, and thirdly, by the type of environment of the given biogeocoenose, or the medium of its existence. The continuous interactions among all the components of the biogeocoenose and the surrounding natural phenomena make every biogeocoenose a dynamic phenomenon which is constantly found in motion, transformation and development. The climax biogeocoenose is a relatively stable phase reached by successional changes. The biogeocoenoses may be set on every area of the earth's surface covered or uncovered with water, if there exist live organisms.

On the whole, the biogeocoenose may be regarded as a live laboratory accumulating the energy of the sun and transforming the substance and energy. These processes are composed of many chemical, physical and physiological interacting items. One may say that the cosmic and the biogeochemical actions of the live matter are accomplished through the biogeocoenose, i.e. with the help of the biogeocoenotical process. As most of the practices of land management are directed to a more advantageous use of the soil as well as of plant breeding and animal husbandry which in their turn are connected with the control of the biogeocoenotical process and with the direction of the transformation and interexchange of the substance and the energy within the biogeocoenose (which may be natural or artificial created for the benefit of Man) the science of biocoenology acquires not only a great theoretical, but also a practical importance.

The forest may be considered as a natural phenomenon marked by an extremely complicated structure with complicated biogeocoenotical processes which are at the same time quite peculiar.

The practice directed to the most advantageous use of different valuable forest products depends greatly on the biogeocoenotical processes within the forest. Therefore the forest biogeocoenology serves as a most important theoretical basis in forestry. It permits, particularly, to decide quickly the problems of increasing the forest output, of the improvement of organisation and management and of the building up of new forests which would serve for definite purposes. Considering that the scientific knowledge as well as the most advantageous use of the natural phenomena require their classifications, the problems of forest classification (forest typology) are also of great importance. According to the above said it must become comprehensible that the classification of the forests with the help of a system based on the biogeocoenology would prove to be of the greatest scientific importance and the most useful in forest management. From that standpoint the main unit in forest classification should be the »forest type» which would present a unification of forest plots (i.e. separate forest biogeocoenoses) which are homogeneous in the composition of forest tree species, in the other layers if vegetation, in the fauna, in the complex of environmental factors affecting the growth of the forest (such as climate, soil and hydrological conditions), in the interactions among all the components of the biogeocoenose, and consequently they are homogeneous in the processes of the restoration, successions and growth of tree species.

All the forest plots referred to the same forest type which was determined as described above and it should be considered as a type of forest biogeocoenose, will require under similar economic conditions similar forest management.

The better would be known the different transformations of the substance and the energy which undergo in the forest biogeocoenoses, the more precisely would be done the forest classification, becoming still more valuable in forestry. A more detailed description of this subject can be found in the works by the author (Sukachev 1940, 1947, 1958).

These ideas should be kept in mind while performing scientific work and during the itinerary studies of the forest types. But a more thorough investigation of forest types requires still more methods besides the one described above. It is necessary to organize a complex stationary investigation proceeding the whole year round for the study of their behaviour during a period of several years, using the most modern methods of biology as well as of physics, chemistry, pedology and other sciences. Taking into account the above, I consider that by using the biogeocoenology as a basis for the forest typology it would be desirable and still quite possible to unite the different trends in forest classification.

A new attempt to classify Australian Rain forests

L. J. WEBB[1]

General Description. Rain forests are scattered in a strip averaging 20—50 miles wide along the eastern coast of Australia, generally at low to moderate altitudes (generally below 2—3 000 ft.), and spreading through 32 degrees of latitude from Cape York to Tasmania. Four Rain forest formations are now recognized (Webb 1958) roughly corresponding to the major climatic zones near sea-level: Tropical (11°—21°S.), Subtropical (20°—35°S.), Warm Temperate (30°—37°S.) and Cool Temperate (38°—43°S.). At increasing altitudes (to 4—5 000 ft. in North Queensland), outliers of Temperate Rain forest occur on the subtropics and tropics, where they represent a montane series. On high fertility soils, at elevations of up to 2 000 ft. approx., Subtropical Rain forest replaces Warm Temperate Rain forest in the intermediate climatic region where these formations overlap. Typically, Rain forest soils are well-drained latosols (deep or skeletal), derived wholly or partly from basic or sub-basic igneous rocks or calcareous sediments, under present rainfalls averaging 30—160 inches per annum. Rain forest stands not yet cleared vary from riverine strips or isolated fragments a few acres in extent, to pure or nearly pure Rain forests several hundred square miles in area.

In areas where soil fertility or moisture is limiting and fires are frequent, there are transitions and mixtures of Rain forest species with Eucalypts and other members of the sclerophyllous Australian element. However, where true Rain forest is »mature, integrated and apparently stable» (to borrow a useful dictum from Beard 1944), it is sharply separated from adjacent sclerophyll forests with narrow ecotones.

Historical. Previous attempts to classify Australian Rain forests did not go far. Wood (1949), Beadle and Costin (1952) and Williams (1955) proposed several divisions at what was essentially a formation level. A few University ecologists, working mainly in southern New South Wales and Victoria, described small areas of Rain forest of temperate character, and listed some associations based on obvious floristic dominance (e.g. Brough et al. 1924, Patton 1933).

In the best known and most detailed description of an Australian Rain forest (in mid-eastern N. S. Wales), Fraser and Vickery (1938) doubted whether associations actually existed in their »Subtropical» forests, and subdivided only Temperate Rain forest, in which dominance (by Nothofagus) was marked. In one of the few studies in Queensland, Cromer and Pryor (1942), avowedly following the English-American school, separated three associations in a drier type of Subtropical Rain forest. In a more recent and comprehensive study in northern New South Wales, Baur (1957) was able to identify associations in Rain forests obviously dominated by Nothofagus moorei and Ceratopetalum apetalum, but hesitated to go beyond a general alliance (Argyrodendron) and several tentative association examples in Rain forest of tropical character.

These piecemeal studies used with varying success criteria of floristic dominance established in temperate regions elsewhere and redefined in Australia (Crocker and Wood 1947, Beadle and Costin 1952). No attempt has been made to systematise or establish ecological validity for the numerous forest »Types» which foresters, admittedly for practical purposes of timber exploitation, recognize even in complex Tropical and Subtropical Rain forests (e.g. Swain 1928, Haley 1957, and unpublished data in Queensland Forestry Dept. files).

Some problems of classification. The ecological segregation of mature Rain forest has already been noted, but early workers sometimes included transitions and ecotones in their definition. Thus Fraser and Vickery (1938) accepted species of Eucalyptus, Tristania and Syncarpia as integral and stable members of »Subtropical Rain forest» in New South Wales, of which Dansereau (1952) was subsequently led to quote Eucalyptus pilularis as a »characteristic plant».

Ecologists working in restricted areas of Victoria and New South Wales were prone to regard any collection of trees with floristic affinities to Indo-malaysia as »Tropical Rain forest». Following this floristic bias, the term »Subtropical» was applied in New South Wales to Ceratopetalum apetalum and related Rain forests which are essentially Lower Montane or Warm Temperate. This confused use of »Subtropical» was continued recently by Williams (1955) and Baur (1957). It is now considered (Webb 1956, 1958) that Subtropical Rain forest is an ecological entity in its own right, with characteristic ecological features, as well as being related to Tropical and Warm Temperate Rain forests. Subtropical Rain forest is best (asymmetrically) developed in the Southern Hemisphere — in mid-eastern Australia, South Brazil, and South Africa (now fragmentary).

Popular nomenclature has also been confusing, e.g. the use in Queensland of »scrub» for Rain forest. The popular use of habitat terms has led to absurdities such as »Dry Rain forest» and »Wet Sclerophyll forest» now current in the literature.

At the formation level the use of the terms Tropical, Subtropical and Temperate follows Schimper and others who interpret latitudinal climate as a broad controlling factor for vegetation. But the influence of altitude in the different geographical zones is an immediate problem e.g. Warm and Cool Temperate Rain forests are recognizable (with structure and flora somewhat reduced) on certain highlands of tropical Queensland. Such altitudinal changes may be best treated as montane series, as proposed by Beard (1944, 1955): Tropical Lower Montane and Tropical Montane Rain forest, Montane Thicket and Elfin Wood-

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[1] University of Queensland, Brisbane, Australia.

land. This classification has however been confused by recent amendments by Richards (1952, pp. 364—5), who has included Beard's Lower Montane in Tropical Lowland Rain forest, so that Beard's Montane is now Richards' Tropical Submontane, and Beard's Elfin Woodland is now Tropical Montane Rain forest. Richards' abbreviation does not seem suitable in Tropical Queensland, where all of Beard's series are represented on the mountains reaching about 5 000 ft. and where, contrary to Richards' view, a Lower Montane Rain forest is strikingly different in structure and physiognomy from Lowland Rain forest, although some species are shared.

Actually, Lower Montane Rain forest in the Australian tropics is ecologically homologous with Warm Temperate Rain forest at higher latitudes which has a similar structure, similar soils, and which shares many dominant genera and some species. This raises the point whether the use of montane-series terms obscures ecological relations, and it may be preferable to talk about Warm Temperate Rain forest in the tropics, even though this sounds contradictory.

In tropical Queensland, at moderate altitudes, forest types resembling Subtropical Rain forest appear where rainfall drops below about 60 inches annual average. They are often associated with Hoop Pine (Araucaria cunninghamii) which is absent from Tropical Rain forest. In Subtropical Queensland and northern New South Wales, Warm and Cool Temperate Rain forests occur, usually on highlands, and these could be regarded as Subtropical Lower Montane and Montane respectively. Under subtropical conditions, however, soil fertility plays a major part, so that it is common to find »Lowland», »Lower Montane» and »Montane» Rain forests growing side by side, but on soils from different parent materials.

In cool temperate Victoria and Tasmania, Subtropical Rain forest does not occur, and Warm Temperate Rain forest is restricted to east Gippsland, so there is no problem of anomalous climatic terminology in what is essentially a Temperate Rain forest region.

The above discussion suggests that, even at the formation level, the use of climatic terms, based on geography and floristic history, confuses ecological relationships.

At the association level Australian ecologists have generally adopted a floristic-structual approach in their classification and have mainly dealt with categories above the level of association (see e.g. Beadle and Costin 1952, Costin 1958). A notable attempt was made by Wood (1939) in South Australia to group associations on related soils as an »edaphic complex» i.e. a floristic-habitat approach. The construction of an exclusively floristic hierarchy, which would follow Braun-Blanquet, has not been tried.

Extensive ecological surveys in the Tropical and Subtropical Rain forests of eastern Australia, involving floristic spot-listing and counts, have been made in co-operation with the Queensland Herbarium and Queensland Forestry Department (Webb 1956). Characteristic dominants in any one place were found to be many and variable over short distances, so that perhaps a dozen representative species were necessary to designate a stand. On adverse site, there are few tree dominants, and characteristic combinations with understorey (including vine) species develop. Owing to the high proportion of endemic species confined to climax Rain forests in an area, comparison of floristic lists revealed species of high fidelity for different localities. These species are so erratically distributed that they would not be of use in naming associations in the field. Grouping of common and prominent tree species at the generic and family level was also tried, and revealed striking differences in the flora of different stands e.g. Sapindaceae, Celastraceae and Rutaceae are most frequent in the understorey of dry types of Subtropical Rain forest.

The practical difficulties of recognizing valid associations in Tropical and Subtropical Rain forests at or near their optimal conditions might mean that associations, as conventionally defined, do not exist. Some authors (e.g. Richards 1952, p. 338) have indeed suggested that there is only one association in the primary Rain forest of a tropical region. We shall for the present accept this point of view, which avoids much fruitless argument. If, as has been said, a classification is a mirror of existing knowledge, then a rational floristic classification of complex Rain forests seems as present impossible, at least as a first step below the formation level.

An alternative — physiognomic classification. Diagnostic features: It is considered that vegetation should, first of all, be characterized by its own features. This is a frankly empirical approach, and continues the preoccupation of Burtt-Davy (1938), Richards, Tansley and Watt (1940), Beard (1944, 1946, 1955), Dansereau (1951) and others with what the last author has termed »structure as a significant factor in describing vegetation types». Although physiognomic-structural characters are not discontinuous entities like presence or absence of species, they provide a ready means of identifying Rain forest subformations in the field. This method does not rely on elaborate synthesis of floristic data in the herbarium, and avoids the presumption of simple cause and effect relations with one habitat factor (implied, for example, in the arrangement of Beard's Formation-series along a gradient of soil moisture).

The following diagnostic features are used in the physiognomic classification recently proposed for Australian Rain forests (Webb 1956, 1958):—

1. leaf size: commonness of microphyll, notophyll or mesophyll leaf sizes. »Notophyll» is a new small mesophyll leaf size class (2 025—4 500 sq.mm., with leaf-blade approx. 3—5 inches long) which appears consistently as the most common leaf size of trees (mature exposed simple leaves or leaflets) in relatively undisturbed Subtropical Rain forests growing on favourable sites. The size limits were derived empirically after measuring many leaves throughout the range of Subtropical Rain forest, and are supported by statistical data.

2. tree layers and canopy closure: whether upper, middle or lower tree layers are present, and which layer is continuous i.e. height and depth of canopy closure.
3. species dominance: whether simple or complex in upper tree layers.
4. emergents: whether deciduous, semi-evergreen or evergreen.
5. special growth forms e.g. woody lianes (vines), vascular or mossy epiphytes, palms, araucarians, tree ferns, plank buttresses, simple or compound leaves, toothed or entire leaf margins.

Using these features, a dichotomous field key was developed for twelve sub-formations of Australian Rain forests which are named exclusively by physiognomic and structural characters e.g. Tropical wet lowland Rain forest is »Mesophyll Vine forest» and Tropical Lower Montane or Warm Temperate Rain forest is »Simple Mesophyll Vine forest». Under drier and less favourable conditions, there is Tall Monsoon forest (»Semi-evergreen Vine forest») and Low Monsoon forest (»Deciduous Vine thicket»). Further subdivision will be undertaken when this Tropical formation is better known. Similarly, welldeveloped Subtropical Rain forest is »Notophyll Vine forest», grading under certain ecological conditions (which have been defined) — into »Araucarian Vine forest, Araucarian Vine woodland, Microphyll Vine woodland and Semi-evergreen Vine Thicket». Warm Temperate Rain forest is »Simple Notophyll Vine forest», which grades into Cool Temperate Rain forest — »Microphyll Mossy forest or thicket».

Relation of sub-forms to habitat: The formidable theoretical problems in the correlation of species and site (e.g. Goodall 1954, Poore 1955, Bray and Curtis 1957) are bypassed by using the plants themselves as the indirect measures of different environmental complexes, and this in fact justifies the empirical classification of vegetation by its own features. If diagnostic features of ecological significance are chosen, they provide a key to understanding other properties of the forest ecosystem which co-vary (cf. modern methods of soil classification by the United States Department of Agriculture).

Without experimental evidence, we may infer that variations in (say) leaf size of Rain forest dominants throughout eastern Australia are associated with variations in soil moisture, radiation, »exposure», and soil nutrient availability. For practical purposes, we can fix the extremes of a factor which limits the growth (but not necessarily the establishment) of a forest type under otherwise favourable conditions. For example, welldeveloped Subtropical Rain forest (Notophyll Vine forest) in mid-eastern Australia exists where the annual average rainfall is above about 45 inches, with at least 10 inches and 20 rainy days average in the dry spring (August to November), and where the mean temperature of the coldest month does not fall below 49°F. Within these general climatic limits, soil properties such as available phosphorus and calcium, porosity, drainage, aeration and the stage of humification, decide the growth and regeneration of different sub-forms.

Within a particular climatic and soil regime, the forest sub-forms arrange themselves in a series which measures different degrees of ecological fitness in combatting the local environment. The greater the variety and volume of environment integrated within a closed Rain forest, the more advanced is the sub-form in what Braun-Blanquet (1932) has termed sociological progression. Under optimal conditions, trees are tallest, stratification and spacing are dense, and species are most diverse. Away from the optimum or, as Whittaker (1953) put it, the climax with the maximum community mass, structural and floristic characters change, e.g. the upper, middle and finally the lower tree layer becomes discontinuous in the series Notophyll Vine forest to Semi-evergreen Vine thicket. This also reflects differences in site quality (log volumes, density of stocking) for species of value to the forester. It suggests that the most successful artificial regeneration of species would be in sites occupied by sub-forms more advanced than that in which the species occurs naturally e.g. Araucaria cunninghamii from Araucarian Vine woodland planted on Notophyll Vine forest sites.

Comparison of Australian sub-forms with Brazilian Rain forests. A recent phytosociological study of Brazilian Rain forest by Cain et al (1956) provides a convenient, although incomplete, basis for comparison with Australian surveys (Webb 1956, 1958). It is of particular interest to compare the use of leaf-size criteria in both regions, since it is fundamental in the Australian classification, and was claimed as valuable and undeservedly neglected by Cain et al (loc. cit.).

At Mucambo, Brazil (lat. 1°27″ S.), Tropical Rain forest trees above 8 m. high had the following leaf sizes (recalculated to include the new notophyll leaf size established for Australian Rain forests): mesophyll and larger 53% of species, notophyll 31, microphyll and smaller 16, and compound leaves 27% of species.

Tropical Rain forest (Mesophyll Vine forest) in North Queensland (lat. about 17° S.) has the following range: mesophyll and larger 50—70% species, 60—70% individuals, notophyll 30—50; 30—40, microphylls and smaller 0—5; 0—5, and compound leaves 30—50; 20—40, and entire leaf margins 70—90% species, 75—95% individuals.

These data are comparable except for the larger proportion of microphylls at Mucambo, which is most likely due to differences in sampling methods, although different sub-forms may be involved e.g. North Queensland »Simple Mesophyll Vine forest» grows on lower fertility soils at altitudes about 600—3 500 ft., and has 30—50% mesophylls, 40—50% notophylls, and 5—15% microphylls.

Unfortunately, further data in Cain et al (loc. cit.) do not include leaf areas, so that direct comparison with the Australian sub-forms is not possible. Nevertheless a few comments are possible. At Alto do Palmital (lat. 25°30″ S.), »Temperate Rain forest» (sic!) has 34% microphylls. This is rather higher than sub-forms of Subtropical Rain forest as now defined, which occurs at lower montane situations or lower fertility soils than »Subtropical Rain forest in the same region. At Caioba (lat. 25°50″ S.) »Subtropical Rain forest» has only 3% microphylls, but at Pelotas (lat. 32° S.) microphylls number about 60% of species in attenuated coastal Rain forest. The latter percentage is comparable to that in mid-eastern Australian Microphyll Vine Woodland in drier areas. Percentage of individuals, rather than of species, gives a better picture of the actual forest, particularly where groups of tree species tend to be locally abundant owing to increasing site adversity.

It would be of great interest to compare phytosociological data for the forests of Parana Pine (Araucaria angustifolia), which seem ecologically homologous with Australian Subtropical Vine woodlands and Vine forests in which Hoop Pine (Araucaria cunninghamii) is predominant. It is stressed, however, that such comparisons should involve the whole ecosystem, in which soil nutrient status (at least for Australian Subtropical Rain forest) is of great importance.

Using standardised diagnostic features, it should be possible, after preliminary field surveys, to identify physiognomic sub-forms of Rain forest over extensive areas. Since floristic classification seems in most places impracticable as a first step, a physiognomic classification would provide a rational basis for the comparison of forest ecosystems in the tropics and subtropics.

DISCUSSION

The symposium »Definitions and classifications of forest ecosystems» (IX International Botanical Congress in Montreal 1959, Forest Botany Section) was held jointly with Section Ecology in McGill University, Biology Building, on August 24th.

Introductory talk

by the Chairman, Dr. I. Hustich.

Ladies and Gentlemen, Mesdames et Messieurs,

Je vous souhaite les bienvenues.

I have the honour to open this Symposium on Forest Ecosystems. However, before we proceed further it is necessary to outline the background of this meeting.

In July 1958 I was asked by the Program Committee of the IX International Botanical Congress to organize a Symposium on Definitions and Classification of Forest Ecosystems. It was suggested that about twenty scientists from different countries and representing different schools should be invited to take part in this effort. We received surprisingly quick and keen co-operation from nearly everyone who had been approached. Soon something which might suitably be called an international team was formed to discuss this complicated and, as you know, increasingly confused problem. Eighteen ecologists and forest scientists contributed papers to this symposium and these papers were, in some cases already in the early spring, mimeographed and circulated (also partly discussed) among the members of our group.

The following scientists have contributed papers to this Symposium:

Prof. E. Aichinger, Austria
Dr. T. Arnborg, Sweden
Prof. P. Dansereau, Canada
Prof. R. Daubenmire, USA
Prof. H. Ellenberg, Switzerland
Mr. G. A. Hills, Canada
Prof. A. Kalela, Finland
Prof. V. J. Krajina, Canada
Prof. V. Kujala, Finland
Dr. A. W. Küchler, USA
Dr. A. Linteau, Canada
Dr. Anna Medvecka-Kornaś, Poland
Dr. J. D. Ovington, Great Britain
Dr. G. S. Puri, India
Dr. J. S. Rowe, Canada
Prof. A. Scamoni, Germany
Prof. V. N. Sukachev, USSR
Dr. L. J. Webb, Australia

Many of the persons mentioned have, as you know, not been able to join us here in Montreal. I thank them all for their great efforts to make this symposium a little more than a simple discussion.

Very early on, we also decided that every paper could not possibly be read properly during the symposium. It would take at least 6 hours and I do not think that you like ecosystems that much. Instead we decided to give a general survey of the opinions expressed in these papers. This difficult task was allotted to Dr. Krajina who, as you might know, has long been familiar with the European literature, including the Russian, and who now also knows the American and Canadian approach to the problem. To provide a basis for the discussion proper, Dr. Rowe will further provide more concrete suggestions and opinions concerning the question: »Can we find a common platform for the different schools of forest types and forest ecosystems».

Many responsible forest scientists are very interested in this symposium. At the IV World Forestry Congress in India in 1954 the need for clarification and unification of the study of forest types was discussed; it was Professor Sukachev who at that time drew attention to the problem. The matter was referred to a committee of the International Union of Forest Research Institutes which held a meeting in Poland just one month ago to discuss the same problem. I have fresh greetings from the chairman of that meeting, Professor de Philippis from Italy, who hopes that we shall send him details regarding our meeting. The Program Committee of the World Forestry Congress next year in USA is also interested in our Symposium. Thus, the problem that we shall discuss has recently been very much in the foreground and I hope that we can also help to further international co-operation in this field of research, the importance of which should not be underestimated.

Can we really find a common platform for the different schools of classification of forest ecosystems and forest types? For myself I cannot venture any opinion; my research in this field is insignificant. I have acted merely as a technical convener of this symposium. However, it seems to me that we have reached a stage marked by an almost universal need of more cooperation and of useful compromise. Many very simple and fundamental phytogeographical and ecological expressions, like forest, woodland, savannah, etc., still have different meanings in different countries, not to mention the jungle of terminology in this field.

Forest typology, or, to use more modern concepts, forest ecosystem or biogeocoenose classification, is not only a pure science, although there is a certain l'art pour l'art pattern over much of our work. Forest typology was originally also intended to be an important tool for the evaluation of actual and perhaps potential productivity of sites, particularly in virgin forest areas. The vegetation itself should be and to some extent is the simple master key. To-day when the manifold influence of man is rapidly increasing and when the areas of secondary forests are expanding we know, in fact, much more about the productivity of many sites in many regions than before, using as keys not only the present vegetation cover but also our knowledge of the time and method of cutting, the extension of fires and former cultivation and so on. We have also developed more practical instruments to investigate ecological correlations which were earlier often left to more or less fanciful speculation. Thus we can nowadays, to express it too simply perhaps, move from superficial forest types to ecosystems or biogeocoenoses proper. There is also, however, another trend which must not be overlooked. There is among us a tendency to proceed along too narrow lines, to study, for instance, either the soil or the present tree cover or the ground vegetation only. This type of highly specialized work is useful but also tends to give too simple a picture of the dynamic and complex connections which work in an ecosystem. One would often like to have a more holistic view of a forest even in a scientific paper.

And one more point. We must remember that most of the work in phytosociology, in forest typology and vegetation classification has been done in regions with a rather simple vegetation pattern, in the boreal and temperate regions. I sincerely hope that botanists with experience from the tropics will also come forward with their opinions.

I hope that we can discuss our problem to-day with a feeling of mutual goodwill and that we can meet in a spirit of co-operation.[1]

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The Chairman then asked Prof. Krajina to present a summary outlining the areas of agreement of the eighteen papers mentioned above.

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[1] *Acknowledgements.* I would like to thank Prof. J. E. Bier, Dr. D. R. Redmond and all the above mentioned contributors for their help in organizing this Symposium. Dr. Harold A. Senn encouraged us to publish the contributions with the discussion in a single volume. I.H.

Prof. V. J. Krajina:

Ecosystem Classification of Forests

The great biological theories of life evolution by Lamarck (1801—1809) and Darwin (1859), the disclosure of evolutionary mechanisms by Mendel (1866) and his followers, the discoveries of viruses by Iwanowskij (1892) and later by Stanley (1935) coupled more recently with Oparin's theory on the origin of life (1926—1957), formed the basic philosophical environment in which the advent of the ecosystem theory in ecology was imminent.

Tansley (1935) regarded the ecosystem (in the sense of physics) as »including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome — the habitat factors in the widest sense.» Thus we may arrive at a new definition of ecology as a study of ecosystems.

Ecosystems in the sense of Tansley »are of the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom.» As with every new idea, the ecosystem had its precursors (microcosm by Forbes, 1887; epigen by Abolin, 1913; naturkomplex by Markus, 1926; holocoen by Friederichs, 1930), but in its scope, Tansley's ecosystem, which involves the whole universe, is original. Evans (1956) wrote: »In its fundamental aspect, an ecosystem involves the circulation, transformation, and accumulation of energy and matter through the medium of living things and their activities.» The recent publication by Patten (1959) on the trophic-dynamic aspect of the ecosystem is based upon the same assumption.

However, Tansley's ecosystem is too universal to be concrete. Being philosophically sound, it lacks a definite level. Though it is much more suitable for synecological than autecological studies, it needs to be supplemented by a concrete scale of synecological units. In this respect, the holocoen or coen of Friederichs (1930) could serve as a more concrete unit, but it still lacks that schematic clarity as presented by Sukachev's biogeocoenose (1945). We may define the biogeocoenose as the basic synecological ecosystematic unit. Sukachev considers it as an empirical unit which is geographically identified, whereas for an abstract unit he proposes the type of the biogeocoenose. Nevertheless, for naming an individual plant we use a specific name (e.g. Pseudotsuga menziesii), although we know that the concept of species requires an abstraction based upon many similar individuals. Therefore, per analogiam, the distinction between the biogeocoenose and the type of the biogeocoenose is rather unimportant.

Sukachev's biogeocoenose is composed of a biocoenose, including a phytocoenose, a zoocoenose and a microbiocoenose, and an ecotope, divided into a climatope and an edaphotope. Here we may quote Arnborg (1959)[1] that »the only common platform for different schools of forest-type classification is a basis founded above all on very carefully performed analyses of the plant communities and the soil as well as of the influence of climate, time, man and animal life. We must learn from the plant communities and the plants about the ground as a site for trees. The forest type is a unit for practical forestry.» A similar notion can be found in this quotation from Linteau (1959): »L'union de la pédologie et de la phytosociologie permettra ainsi de connaître le potentiel normal des stations, la raison des dépression de production ligneuse, et l'orientation à donner aux mesures correctives.»

The basic phytocoenose, an intrinsic part of the biogeocoenose, should be presented as a plant association in the sense of the Zürich-Montpellier school, liberated from the dogmatic necessity of the exclusive, selective or preferential species characteristic of the plant association. For the support of this correction, which I discussed in my studies (1933, 1959), I quote Ellenberg (1959): ». . . the importance of characteristic species or species of high fidelity is

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[1] The expression »(1959)» here refers only to the authors papers in this volume of Silva Fennica.

going decreasing more and more and they become only important and decisive in the higher units of the system: in the alliances, orders and classes.» Thus Ellenberg and many other European ecologists agree with this necessary correction. It will also make the common platform more readily acceptable to the Russian and Scandinavian (Finnish and Uppsala) schools. Here I quote Kujala (1959): »Every (plant) is able to express something about the plant association in which it occurs, and all the species together could characterize the type even though there would be no characteristic species in the sense of Braun-Blanquet's school.» Similar thoughts were expressed also by Kalela (1959) in his contribution. It is possible that some plant-sociologists will disagree with this idea thinking that such a concept means seemingly the end of Braun-Blanquet's floristic scheme. However, in forest classification this rigid tenet would cause serious objections especially from the viewpoint of the practicing forester. There will always remain many plant associations that are the more readily distinguishable by their characteristic species, in addition to their other analytical and synthetic floristic characteristics and whole ecotope. However, in some plant associations such species of high fidelity will be missing, whereas they will always possess, besides their differential species, species characteristic for alliances, orders, etc. These associations, either with or without characteristic species, are notable for special growth responses (in trees by height and diameter) to their particular ecotope.

At this point, I would like to stress two similar ideas expressed by Rowe and Scamoni. Rowe (1959) claimed: »A common basis for forest typology is found in the central concept of the ecosystem, integrating both biotic and environmental aspects of the forest.» Scamoni (1959) wrote: ». . . it seems possible to find a common basis for classifying forest types, when neither vegetation science nor site science claim the primateship for doing it . . .» These ideas are in consonance with the holocoenotic views of either the ecosystem or biogeocoenose.

Major (1951) pointed out correctly that, just as Jenny (1941) relates any soil property to the factors of soil formation presented by the equation: $s = f\,(cl, p, r, o, t)$[1], it may be assumed that vegetation is the function of the same factors, shown by the equations: $v = f\,(cl, p, r, o, t)$. Indeed these two equations could be considered as mathematical representations of Tansley's ecosystem or Sukachev's biogeocoenose. The five independent variables (cl, p, r, o, t) cannot be reduced in number as some students of site classification are tempted to do. The roles of biota (plants and animals) and time, especially in both soil and vegetation formation, cannot be underrated in forests. Daubenmire wrote (1959): »It can hardly be disputed that we must rely upon vegetation alone to determine which combinations of environmental factors have closely similar biologic potential.» He continued: »Even though vegetation is used as the primary criterion of the limits of an ecosystem type, environmental characters often become extremely useful in characterizing the significant attributes.»

Here I quote Evans (1956) again: »The ecologist is primarily concerned with the quantities of matter and energy that pass through a given ecosystem and with the rates at which they do so. Of almost equal importance, however, are the kinds of organisms that are present in any particular ecosystem and the roles that they occupy in its structure and organization. Thus, both quantitative and qualitative aspects need to be considered in the description and comparison of ecosystems.»

Any universally acceptable system must give a balanced consideration at least to all macroscopic plants. Here I would like to place a quotation from Ovington (1959): »The combination of trees and lesser vegetation constitutes a relatively efficient means of site utilisation since the photosynthetic tissues are well dispersed above the earth's surface and the roots are able to spread throughout a large soil volume.»

In recent proposals by Hills (1959) for the classification of forests we read as follows: »The total production possible from any specific locality is limited by the potential energy of the combined macroclimate and landform features of that area.» Because Hills included in his landform »not only the surface relief but the entire solid and liquid continental mantle», we can come to the conclusion that, from Major's variables of vegetation and soil formation, Hills considered biota and time less important. We may further quote from Hills as follows: »Since combinations of macroclimate and landform not only constitute the basic potential productivity but exercise a functional control on the integrated development of vegetation, soil and ecoclimate, combined macroclimate-landform units provide the basic classification of ecosystems.» Hills continued: »General correlations between specific forest types, lesser vegetation types and soil profile classes are of little value. However, vegetation types and soil profile classes do provide important indications of changes in productivity levels if used within combined units of macroclimate and landform which are well defined with regard to their potential effectiveness in forest production.»

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[1] cl = climate, p = parent material, r = relief, o = organisms (biota), t = time.

But even this rather inflammable stipulation by Hills is in reality not a severe contradiction of the general ecosystem concept, as some biocoenologists might construe. In reality Hills continued Clements' environmental bioclimatic approach when he, as a first step, supported the climatic divisions by combination of macroclimate and landform characteristics, whereas he recommended the vegetational and soil profile subdivisions as the secondary step. Indeed, most European ecologists usually do the same. They study plant associations in different climatic zones which are often distinguished before they start detailed ecological studies of the plant communities. It is true, of course, that most ecologists will still rather prefer to designate the climatic zones by climatic climax plant communities than by their causes, but this is only the second side of the same coin.

It might be useful at this point to attempt a more complete definition of a fundamental phytocoenosis (plant association), since it is an intrinsic unit of a biogeocoenosis. The author (with his collaborators) uses, in the classification of British Columbia forests, the following definitions:

A plant (forest) association is a definite uniform (homogeneous) phytocoenosis that is in dynamic equilibrium with a certain complex of environmental factors (ecotope); its floristic structure — i.e. stratification (layering), species significance (Artmächtigkeit, or abundance and dominance), sociability, constancy, fidelity, and vigour of the component species — lies within limits governed not only by the ecotope (climate, soil, substratum, topography, and biotic environmental factors), but also by the historical factors of the vegetational development (the fourth dimension or space-time factor).

In order that an ecological classification may be used by the forester, silvicultural characteristics might be included, having respect to: productivity and quality of trees; capacity for conservation of soil, water, and other habitat factors; methods of cutting and logging; methods of slash disposal; methods of reforestation; stocking, and methods and time of thinning and pruning; relation to pests; possibility for ranch management, wildlife management.

However, it is generally agreed that, in most tropics, the temporary classification of vegetation will be physiognomic and the biogeocoenoses will be distinguished in the next step. This complies with ideas expressed by Ellenberg (1959), Küchler (1959), and Webb (1959).

In the seemingly contradictory findings on the concept of climax in forest botany as expressed by Medwecka-Kornaś in Poland (1959) and Puri in India (1959), it should be understood that original virgin forests can be more easily studied and judged as far as their climaxes are concerned. Indeed even the polyclimax and monoclimax views are not as distant and contradictory as some interpreters present.

Similarly, Gleason's individualistic concept of plant communities can be understood as a view in which the time and influence of the secondary and primary succession (mainly by plants established first) are phylogenetically stressed with greater emphasis than in certain other views. This space-time factor in phylogeny of plants plays such a great influence upon distribution of plant communities that they are really much more geographically restricted than their potential environments.

As far as the continuum in the sense of Curtis and McIntosh (1951) is concerned, it is not a phenomenon peculiar only to vegetation. It may be found with rocks, soils and climates. In vegetation, the continuum may be studied by an ordination method (Goodall, 1954; Greig-Smith, 1957; Bray and Curtis, 1957) that cannot replace the classification. It was probably an unfortunate misunderstanding that led the existence of a continuum to be used against the justification of a vegetational classification. Every science has a classification of its subjects of research. As Daubenmire (1959) claimed, without classification there can be no science of vegetation. We may modify this statement, saying that without classification there is no science of ecosystems, and no ecology. And, indeed, no science.

I would like to conclude by stating that Tansley's holocoenotic view of the ecosystem, most suitably amended for classification of biosphere by the use of Sukachev's concept of the biogeocoenose, could unify all schools of synecological thought toward one endeavour — that of changing the unknowns into knowns. Each school might find in this scheme its own role and application (Aichinger, 1954; Kalela, 1954; Zlatnik, 1954—1956; Rowe, 1959).

By ecosystematic forest classifications, concretely registered and mapped, we shall arrive at fundamental rules controlling the forests, and sound foundations for any silvicultural treatment in forest management. We may end with the hope expressed by Arnborg (1959): »The geneticists can help the foresters to get the best trees. The ecologists can help the foresters to decide the best site for these trees.» This ecological role can be performed best through the ecosystem classification of forests or biogeocoenology.[1]

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The Chairman expressed gratitude of the audience for Prof. Krajinas detailed and objective presentation. He then asked Dr. Rowe to try to put forward some concrete points to serve as a basis for the discussion.

J. S. Rowe:

Definition and Classification of Forest Ecosystems

Forests can be conceived in many different ways: — as simple assemblages of trees (cover type), as vegetation communities (phytocoenose type), as unified vegetation-site systems (ecosystem type). Each concept has its value for particular purposes. In forestry, where concern is not only with the tree crop but also with the land on which it grows and regenerates, a point of view which integrates the forest-site totality seems most appropriate. The concept »ecosystem» is logical and useful in this context; it is consonant with the viewpoint of the forest as a dynamic productivity system, the locus of reciprocal relationships of biotic community, climate and land.

At the Fourth World Forestry Congress in India, 1954, attention was drawn to the value of forest typology in the practices of silviculture, forest management and forest exploitation. It may be appropriate now to re-emphasize the point and suggest that, in order to place forestry practice on a fundamental basis, forest typology ought to be concerned first and foremost with the description, investigation and classification of forest ecosystems. However, as »ecosystem» is a broad, categorical concept — Lindeman defined it inclusively as »any system composed of physical, chemical and biological processes active within a space-time unit of any magnitude» — its meaning must be narrowed to make it useful.

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[1] The contributions, written by Aichinger and Dansereau, were supplied at the meeting of the symposium, and that of Tüxen after the meetings in Montreal. Therefore, they could not be included in this summary, presented at the Congress.

The identification and delimitation of individual, concrete forest ecosystems as particular space-time units, can proceed on the basis of various criteria whose selection will depend primarily on purpose. Thus the silviculturist might normally choose to make the forest ecosystem coincident in area with a significant forest community: — a phytocoenose or a »cover type». In such a case, the time dimension of the ecosystem might be taken as the period wherein this phytocoenose or cover type maintains a recognizable identity. (This is the commonest approach, for most students have come to the ecosystem concept via phytosociology. Thus, for example, the biogeocoenose of Sukachev, the biochore of Etter, are both delimited by the phytocoenose.) On the other hand the land manager, interested in the productivity of particular areas of the earth's surface, might define his significant ecosystem by tracing the physiographic boundaries of a land unit such as a watershed, or a glacial landform. Here the ecosystem would probably be considered as unlimited in time, embracing a continuing cycle of vegetational change. (Note the homology with the limnologist's ecosystem which is circumscribed physiographically. Attention might also be drawn to the Ukrainian school of silvicultural-ecologists who define ecosystem units within the framework of an »edaphic net».) Still another approach promoted by the *frequent* absence in nature of discrete boundaries in either space or time, where vegetation and landform are concerned, would make mutual and reciprocal use of both biotic and environmental criteria in order to arrive at useful ecosystem units. Such, for example, are the ecosystems defined by outlining areas believed capable (on the basis of ecological knowledge, studies of sucession, etc.) of supporting specific kinds of vegetation, soils, etc.; in other words, with the potentiality for development of particular ecosystems. The expectation is that initial diversity will eventually dissolve in the unity of an equilibrium state or »climax», at least in the absence of unnatural disturbance. (Here can be placed the approaches of Cajander and the Finnish school defining »forest types», of Daubenmire defining »habitat types» and of Hills defining »land types».)

The »climax» concept is currently the subject of much controversy. It is criticized at least in some of its definitions for imputing universal validity to the idea of directional change (development to specific final states of equilibrium) in ecosystems and in their parts (biotic communities, soils). Possibly the concept has a valid use regionally, if given precise meaning in terms of structure, of composition and of stability within a space-time framework. For example, a definition of the »climax» as a particular kind of self-perpetuating system of maximum productivity with a specific spatial organization may accord with observed facts in certain localities, thus providing an acceptable basis for the recognition of useful ecosystem units; elsewhere the same definition may prove inappropriate and in practice misleading. Thus the *a priori* use of the »*climax*» concept as a tool for the delimitation of concrete ecosystems cannot be justified. Alternatively, the concept of the ecosystem as an area supporting an empirically determined cycle of biotic communities may be universally acceptable. Boundaries of such land-based ecosystems can be set in terms of the biotic communities which tend to persist for the longest period during the normal cycle, i.e. those of maximum stability. In short, as the ecosystem itself is not »given» in nature or inherent in reality, it cannot be discovered by research; the best that can be done is to seek the most logical and useful basis or bases for defining its limits. (The same statement can be applied to units of vegetation, soil, geomorphology, and climate equally as well as to the ecosystem.)

The *classification* of defined forest ecosystems must be based on features representative of the whole rather than of the parts only. This is to say that a fundamental classification must use both biotic and physiographic criteria, since neither alone can give an adequate expression of the ecosystem as a dynamic functional entity. If, for example, a similarity between two ecosystems can be established both in vegetation and in site (ecotope), then a similarity also in developmental tendencies can be assumed. Such an assumption is less sure when resemblances are established on the sole basis of vegetation or of soil or of physiography. Concerning its justification, classification can be applied to phenomena showing continuous or gradient variability as well as to those whose attributes are discrete. In terms of all characteristics and their variability in space and time no classification can be made, but by *purposeful selection* of limited characteristics it is possible to develop generic concepts around which a useful classification can be built.

Study and analysis of the inner workings of the ecosystem — its productivity through processes of transformation and circulation of energy and matter — is the normal and necessary accompaniment of description and classification. An understanding of the form and intensity of the interactions within the ecosystem will refine the basis of classification and will assure that the types differentiated are of maximum significance to forestry. Furthermore, studies of process and function add the fundamental dimension of development in time, thus further illuminating the subject.

Continuous geographic variability over the surface of the earth makes necessary the organization of forest ecosystem typology within a framework of biotic-physiographic regions. By regionalizing, the variability of the universe is reduced to manageable proportions. Also, the principle of regionalization guards against uncritical extrapolation from knowledge gained in one area to other, spatially removed systems. Furthermore, it is worth emphasizing again that concepts themselves may need to be regionalized. The value of such ecological ideas as »succession» and »climax» must be tested regionally; where found appropriate and useful they can be retained, elsewhere they must be redefined to fit the regional facts or discarded. It is a good geographic dictum, pertinent in the present context too, that principles cannot be discussed apart from the study of specific examples of actual problems.

In a number of countries today the delimitation, description, examination and classification of forest ecosystems is proceeding. As the direction of this work is dependent at any given time and place on a number of consideration, most important of these being purposes foreseen, individuality of the geographic region, and knowledge available, it does not seem feasible or indeed possible to outline a universally applicable methodology. Approaches to this important field of work will undoubtedly continue to differ within as well as between the major forest zones of the world, even when a universally acceptable conceptual basis has been found. And as previously suggested, the »universally acceptable» basis will probably consist of a system of *regional* principles.

There is, no doubt, much benefit to be obtained from the practical testing of approaches of the different schools, in order that their applicabilities to various regions for various purposes may be assessed. In this regard, a need exists for the widest possible dissemination of concepts, methods, techniques of application and results. Demonstrations of applied typology in countries host to international forestry conferences would be particularly effective.

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During the long discussion which followed, Prof. Krajina and Dr. Linteau acted as vice-chairmen part of the time.

Some of the speakers have sent in their own abstracts, but mostly we have relied on Dr. Rowe's summary of the discussion. Prof. R. Tüxen, who took part in the Symposium, has since sent us a paper, which we have printed here as an appendix to the discussion.

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G. A. Hills (Canada). Prof. Krajina in his interesting summary of the written contributions to this symposium has concluded that »Hills considers biota and time less important than macroclimate and landform in the development of vegetation and soil.» Hills did, however, not agree with this conclusion and attributed the error to Krajina's failure to recognize the true nature of the ecosystem as a dynamic circulatory system.

Hills claimed that Krajina continued to follow the traditional cause-and-effect philosophy. This, he said, was indicated by Krajina's statement that biotic and abiotic components of the ecosystem are merely the opposite sides of the same coin. This view requires that they be viewed as separate and opposing entities, one of which must be the cause and hence the more important, the other the result and therefore the less important.

Hills then suggested that a better understanding of circulatory causal systems, such as ecosystems, may be obtained by viewing them as a crystal globe.

Since the succession of observations must be fitted within a single ecosystem, it is essential that an adequate reference feature be chosen during the initial observation. Since the features within the ecosystem are continuously changing, it is essential that the reference feature be one which changes the least, namely landform.

Hills explained that although he proposed that landform be established as the basic reference feature during the first observation, this does not mean that this feature is observed separately from the other features even during the first observation. Neither does it mean that landform is considered to be the more important. In a circulatory causal system the causal agent is actually the entire system operating during a specific period of time. The result is the change in the entire system which is effected during this same period.

Hills illustrated this principle by referring to the development of a podsol soil profile during several rotations of pine. Contrary to the cause-and-effect school of thought, the white pine in itself did not cause the podsol profile. Podsols are not found under white pine under all circumstances, for in certain climatic regions they are found under pine on some soil materials and not on others. Neither is parent material the cause of podsol profiles since podsols do not consistently occur on specific parent materials in all climatic zones. Nor is climate the cause since podsols are not found on all materials under all vegetation types within any climatic region.

Actually, the cause of the podsol soil profile development is a number of mutually dependent interactions between a specific combination of vegetation (and associated biota), landform and climate operating during a definite period of time.

P. R. Wycherley (Malaya). Firstly I would like to bring to your attention some of the problems of ecologists in the tropics:

Compared with the temperate regions, the number of ecologists are far fewer in the tropics; they work for financially poorer institutions and are frequently beset by pressing practical problems. In that the training in temperate institutes is often better and the best workers are retained as teachers, the tropical worker is denied consultation with such authorities who are in the position to advance the methods of ecology and understand from personal experience the complexity of tropical vegetation problems. We feel that the temperate region workers are making yet ever more advanced refinements of techniques and principles which cannot be applied to the very rich flora and complex vegetation of the tropical rain forest within the lifetime of present botanists. Therefore classification for purposes of vegetational mapping and land utilization must be by other methods than those offered by the contending schools of thought represented by the papers presented here.

Meanwhile it is urgent that studies should be made on the functions of the tropical rain forest for their fundamental importance and their possible aid in developing rational modes of agriculture and forestry. The tropical rain forest is rapidly vanishing under the advance of human influence and if the study of its function must await its refined classification, the opportunity may be lost for ever.

We must proceed with the study of function and be honest enough to accept as »types» the first examples studied in detail, even if these do not in fact represent modes in the range of variation. I believe that many of the »types» accepted by temperate region ecologists fall in fact into the former category.

Before leaving this topic I would appeal to any who have opportunity through Sabbatical leave or grants for fundamental research to work in the tropics both to help us by advancing tropical ecology and to broaden their minds on the range of problems which exist. Some have done so but many more are needed.

In the classification of vegetation many of us would prefer the nomenclature to be free from climatic or edaphic associations, e.g. such names as »cloud forest» or »mangrove swamp forest», which may prejudice our thinking; either that such conditions lead invariably to a particular type of vegetation or that a particular type of vegetation is dependent upon the particular conditions associated with the name given.

I would not agree with a definition of the »climax» as a particular kind of self perpetuating system of maximum productivity with a specific spatial organization as far as the tropical rain forest is concerned. The undisturbed tropical rain forest would undoubtedly be accepted as the regional climatic climax in any system; it is self-perpetuating and has a specific spatial organization in any sub-region, but what does maximum productivity mean? If it refers to increment in dry matter, that does not obtain in a stable climax. The assumption that there was such an increment in the tropical rain forest climax was a serious error in principle of pre-war Philippine forest policy. If the meaning of maximum productivity is maximum circulation, it will be difficult to determine this in the tropical rain forest, let alone in putative alternatives. Self-perpetuation in the sense of being the terminal phase of known series would appear to be an adequate criterion.

G. S. Puri (India). Although the climate of India is mainly tropical, there are also temperate areas with temperate vegetation. Indian workers are therefore in the fortunate situation that they can compare and find what concepts of temperate zone ecology are useful. They perhaps now lay emphasis on the time factor, conceiving the climax as a continually developing interacting system of vegetation and environment dating back to the last ice age, or to Eocene times. The classification of Indian vegetation by Champion has provided a basis for later refinements. It brings in soil and climate as well as vegetation, and though the types are floristic and not physiognomic they are related to the environment and time.

The visit of Sukachev in 1954 stimulated the organization of an Indian council for Ecological Research. Another organization »International Society of Tropical Ecology» has stimulated interest outside India in her problems. However, the enlistment of more help from temperate zone ecologists is solicited.

W. R. Day (Great Britain). If an ecosystem is a dynamic entity then it must involve change, and this must be reflected in some observable phenomena. The rate of growth in the plant or the change in condition of the soil body must be put down in some way.

Concerning systematization, it is surely more important to state the limitations of the work than to strive for completeness.

J. J. Barkmann (Netherlands). The Braun-Blanquet system does recognize the use of dominants at certain levels. The total complement of species is of course the most important characteristic. Tüxen has successfully used the Braun-Blanquet system in all regions, in the tropics as well as in the arctic. I agree fully with the ecosystem concept but would like to ask Dr. Krajina how he recognizes his units in nature.

V. J. Krajina answered that he recognizes ecosystems by means of phytocoenoses in relatively undisturbed conditions.

A. Küchler (USA). As Dr. Puri pointed out there is little reason for conflict as our differences chiefly involve terminology. The vegetation maps on exhibit appear at first to be irrelevant to this ecosystem topic but they are not. They show that if workers arrive at different results this is probably due to the different conditions they work in.

S. A. Cain (USA). Formation of types is a process of abstraction from nature, and it must always be provincial.

Different approaches are necessary for different conditions. Species-poor northern vegetations are suitably described by constant dominants. In richer forests, with more ecological equivalents, the Braun-Blanquet system using character species is appropriate. The most useful characteristic of the very rich tropical forests is physiognomy, for composition is so variable that equivalencies are often only possible in terms of genera or families.

As classification is artificial and purposive, it cannot be extended too far without encountering difficulties.

A. Lafond (Canada). We must first consider the classification of vegetation and ecosystems from the standpoint of their use. In the abstract there seems to be no end to classification. On the other hand, if you use the forest associations, they are for one practical purpose — in our country for forest management. The aim is to look for limiting factors and define a system from which to get controlling features useful in silviculture. Units of definite existence can be found, with clear relationships to climate and soil. They may not be absolute but they are useful.

I. Kagis (Canada). Ecologists are fortunate in the name of their science, meaning »household», but in this sense there is much difference of opinion and controversy as to what the »household» consists of in terms of its contents. The various speakers have discussed many aspects of ecology, but the dynamic element has not been emphasized enough. For example, in the »prairie provinces» of Canada, the name Pinus-Cladonia type is too static, it leaves out the other species which may also occupy the same site (for example Oryzopsis sp.) as well as omitting the dynamic processes. Ecosystems can best be characterized by the dynamic pattern, i.e. by the sequences of communities that follow one another.

G. W. Selleck (Canada). »Ordination» of vegetation is an alternative to classification, but there is no reason why both cannot coexist. The differences of opinion between the different schools are not of basic importance.

A. Kalela (Finland). In my contribution to this symposium I have tried to explain the basic ideas of the Finnish theory of forest types. Cajander's concept of the forest types is rather complicated and therefore it is often misunderstood. I should like to use this opportunity to correct some misinterpretations.

Many ecologists seem to think that the Finnish theory does not pay enough attention to the dynamics of the forests. This objection is not justified. It is true that the basic units of the Finnish forest types are stable climax communities, but in each forest type we also include, besides its climax stage, all the successional forest stands which have a tendency to develop towards the climax. Thus the basic idea of the whole system is a clearly dynamic one.

It has also been claimed that the Finnish forest type system pays too little attention to the physiographic components of the forest ecosystems, to the microclimate and to the soil. It is true that like other phytosociological systems this also builds its units primarily on the basis of the vegetation. But from the very beginning we have tried to build the units so, that they would be uniform and harmonic also with regard to the other components. In addition it has been emphasized that not all physiographic factors are equally important. As we know, only such growth factors as light, temperature, various nutrients, water supply and so on are really important. It is also possible that the unfavorability of one of these factors can be compensated by the favorability of some other factor. Furthermore, we must still take the competition prevailing everywhere in the vegetation into consideration. Thus a total correspondence between the site and the vegetation probably does not always exist.

The argument which most often has been raised against Cajander's school is that it does not pay enough attention to the tree layer. With regard to this criticism, the following facts may be pointed out. The Finnish classification considers the whole vegetation. The tree cover holds principally the same position as the other vegetation layers. The Finnish theory has been primarily developed for the boreal forest zone. This zone is poor in tree species everywhere and particularly in Northern Europe. Many of the boreal tree species have in addition a fairly wide ecological amplitude and therefore they are not very good indicators for the forest site proper. Already in his earliest papers Cajander states that each forest type in its climax stage is always dominated by certain tree species, one or several. In the secondary forests the case, however, is often different. On extreme habitats the tree cover can be almost the same through all stages of the succession; as for instance the jack pine forests on the dry sandy flats here in the northeastern Canada and the Scotch pine forests on similar habitats in Northern Europe. On better sites, however, the tree cover is in the beginning of its development usually formed by pioneer species, which gradually give place to stronger competitors so that the tree layer undergoes many changes during its progress towards the climax. In the ground vegetation the balance is generally reached in some decades, in the tree layer it perhaps takes centuries. Therefore in the secondary forests the ground vegetation is often a more sensitive indicator for the site conditions than the trees. In spite of the fact that the trees often have a fairly strong effect of their own upon the ground vegetation, it is possible, according to the Finnish theory, to classify — at least in the boreal region — the forest, using the ground vegetation as the most important indicator, although not as the only one.

A. MEDWECKA-KORNAŚ (Poland). C'est dommage, que notre colloque n'a pas place en terrain. La discussion est plus facile, quand elle a comme une base le concret groupement végétal; plusieurs fois les méthodes de classification des forêts, qui se semblent très differentes en théorie, conduisent en practique à résultats semblables.

Les recherches, ayant comme le but une classification détaillée des forêts, se composent de deux étapes: de travaux en terrain et de leur interpretation, qui est une partie plus théoretique. C'est importante de trouver surtout la platforme commune en cette premières parties des travaux — cela permettra comparer les resultats de differents études independant de l'interpretations par leur auteurs.

En phytosociologie central-europeenne la méthodique des traxaux en terrain est bien elaborée, et les relevés (completes listes des espèces) sont necessaires pour distinguer et classifier les differentes associations. Ces associations sont caracterisées pas seulement par les »éspèces caracteristiques» mais par toute combinaison des espèces, par biologie et exigences ecologiques specifiques et ct. Quand à la place de l'association végétale nous voudrions décrire et classifier les écotypes il faut poser la question comment éxecuter en terrain les recherches, quelle doit être leur methodologie et le plan? Est ce que la déscription des ecosystems est practique et possible pour un chercheur, comme la déscription des associations dans le sense de l'école central-europeenne?

La platforme commune parmi l'école central-europeenne et les autres est possible dans le cas, quand les déscriptions et classification des forêts sont basées sur les completes listes floristiques.

D. MUELLER-DOMBOIS (Canada). Vertical stratification of the ecosystem is generally accepted as providing for a good common basis of ecological study (vertical stratification = inclusion of all major components, i.e. trees, lesser vegetation +mosses, lichens, soil substratum, physiographic position, ecoclimate) but the delimitation of its spatial extent lacks definition. It should not be too small a unit as to be impractical for forestry purposes, on the other hand it should not be so large, as for example to include a whole mountain side or cover type. It should correspond to the definition of habitat by Nichols which applies to an area of »relatively uniform environment». This is not a precise definition — it will never become precise — but it is a »common sense» definition. If one deals with relatively undisturbed forests, the spatial extent of the practical ecosystem may be conveniently indicated by the phytocoenose. If the area has been disturbed recently and one does not know anything about the original forest vegetation pattern, the size of the unit may be indicated by genetical soil features and by soil moisture regime. The phytocoenose is only vaguely indicated under disturbed conditions.

The advantage of dealing with the phytocoenose (under the above described limitations) as a medium for recognizing the spatial extent of the ecosystem is the *facilitation* to locate biologically equivalent (or, better, similar) areas. For example, the same ecosystem may occur on several landforms within a region and then may occupy different physiogeographic positions. This is more difficult to find out by attempting to recognize the ecosystems through the soil and physiographic characteristics. In the latter approach there may be a tendency to separate more units than necessary.

The purely phytosociological approach may not work in recently disturbed areas, because of the great influx of intolerant weed vegetation that is controlled by ecoclimate rather than edaphic conditions. Consequently the phytocoenosis in the proper sense is less evident under such conditions and a purely floristic approach may result in too large units. However, it is important to note that the units are still the same, whether they are occupied by forests or have been cut-over subsequently (minor changes may be excluded here). Thus an ecosystem has various facies (or stages as pointed out by Kagis a moment ago), but all these have to be described within the unit and should not be separated as new ones or we would end up with a large number of units of impractical value. Thus, the concepts of succession and climax (or of relative stability, according to Tansley) are of great practical importance and must be recognized in forest site classification for the purpose of clarity.

The ordination approach to vegetation appears to be less efficient in species whose delimitation in regard to light and other variables can be observed with obvious ease. One pretends to be objective by doing a systematic count, but one is subjective in relating the variables to the distribution pattern. In tracing single species in relation to always only one variable at a time, the complexity of compensating variables may be underestimated.

G. A. HILLS. In upholding the methods used by the plant sociology school Mueller-Dombois stated that they too looked at the features of relief, geologic materials and soil profile as soon as they had established the type of vegetation. Mueller-Dombois claimed that this school of plant sociologists were employing the same approach as Hills, since it did not matter which type (vegetation type or landform type) was established first.

Using the diagrams of physiographic and vegetation types which Mueller-Dombois had drawn on the blackboard, Hills pointed out that it was not simply a matter of describing either the physiographic features which were associated with a specific vegetation type or the vegetation features which were associated with a specific physiographic type.

Hills' approach is a more complex procedure of establishing physiographic types in which successional series of vegetation types can be fitted. This involves the simultaneous establishment of both physiographic and forest types, a procedure which renders this approach — according to Hills — unique among classifications of ecosystems.

O. L. LOUCKS (Canada). A science of vegetation is quite impossible without classification along classical lines. An extremely interesting and useful new approach is pioneered by the work of Dr. Bakuzis using synecological coordinates; he has worked out an objective and accurate way of establishing environmental correlations along gradients.

D. MUELLER-DOMBOIS remarked here that succession should be studied within units established under conditions of stability. Bakuzis' work is essentially autecological, and it can be approached through studies of classified types.

R. W. BECKING (USA). Where pioneer work is being done in a region it is necessary that full phytosociological lists be published. This the editors of many periodicals are reluctant to do. They want to cut down the list to only the »important» species, but complete records of the analytical data are essential to the advance of knowledge in this field. It is also important that the *location* of sample plots be reported. Where there are different approaches to vegetation classification, workers representing these approaches should study the same areas and compare results. The tests of a system are three: 1. Can the units that are defined be mapped? 2. Does the work take adequate account of *all* the vegetation? 3. Does it have practical value for soils and environment as well as vegetation?

G. A. HILLS remarked that the same completeness of description should be applied to soils.

P. R. WYCHERLEY. Prof. Becking wishes complete species lists to be published but finds that this is blocked by editorial policy in most conventional journals. I can appreciate both the desirability of the availability of full species lists and detailed observations for those who find them essential for comparative work and the opinion of an editor who believes this will serve the interests of a minority only and that better use could be made of the journal's space. I suggest that such material should be tabulated and deposited in the archives of the journal (a note to this effect would appear in the publication) and distributed to those interested by means of stencilled sheets or microfilm copies on request.

P. GREIG-SMITH (Great Britain). Ordination is not to be equated with any one technique, e.g. continuum analysis. There is as much room for discussion on ctiteria of ordination as on criteria of classification. The advantage of an ordinational approach is that it will expose the units of a classification based on the same criteria whereas a classification approach may obscure the presence of continuous variation.

V. J. KRAJINA remarked that semantics often confused the issue, for instance »ordination» should not be considered equivalent to »classification».

J. L. FARRAR (Canada). As scientists we are placing too much emphasis on classification. We should be concerned with understanding natural phenomena. We should seek to understand the operation of the various environmental factors and the role played by the various organisms in ecosystems. As we learn more of these natural phenomena, we will be in a better position to classify ecosystems. We will realize too that it is wrong to seek a universal basis for classification. Each new situation will require a new classification. The units will be recognized as arbitrary subdivisions of a continuum.

Classification is of great importance in land management; it has little or nothing to do with science. Scientists can best contribute to the classification of ecosystems by seeking a better understanding of the component phenomena.

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REINHOLD TÜXEN (Deutschland): *Diskussionsbemerkung (Appendix)*.

Eine gemeinsame Plattform pflanzensoziologischer Arbeit über die ganze Erde zu finden, deren Methoden und Begriffe ebenso allgemeinverständlich sein würden, wie Ergebnisse vergleichbar wären, ist vielleicht im Augenblick eines der erstrebenswertesten Ziele der pflanzensoziologischen Forschung überhaupt. Seine Erreichbarkeit scheint möglich. Die Zeit ist also reif für eine Diskussion dieser Frage.

Der Gegenstand unserer Bemühungen ist das Pflanzenkleid, die Vegetation der Erde. Jeder Pflanzensoziologe versucht mit der ihm eigenen Individualität die Einheiten dieses Pflanzenkleides, die Pflanzengesellschaften (plant communities) zu erkennen, zu beschreiben und in ihren Lebensäusserungen und -ursachen zu verstehen.

Die gemeinsamen Anstrengungen, eine einheitliche Ausgangsbasis zu finden, sollte aber nicht nur der Betrachtung des Waldes, sondern der gesamten Vegetation der Erde gelten, gleichgültig ob ihre Einheiten natürlich oder vom Menschen geschaffen sind.

Grundsätzlich lassen sich drei Möglichkeiten denken, um eine gemeinsame Ausgangsbasis zu finden:

1. Man könnte die Hoffnung hegen, dass durch die erleichterten Reise- und Forschungsmöglichkeiten über den ganzen Erdball in absehbarer Zeit ein genialer Geist völlig neue Begriffe und Methoden, die überall anwendbar seien entwickeln würde.

2. Man könnte auch sich ausmalen, dass aus den verschiedenen bisherigen Auffassungen von Begriffen und Methoden eine Synthese geschaffen würde unter Hineinbeziehung der besten Ideen von verschiedensten Autoren.

3. Endlich könnte aber auch unter den bestehenden Arbeitsweisen eine sein, die sich in vielen Teilen der Erde bewährt hat, und die — unter Umständen mit einigen Modifikationen — auch in anderen ohne weiteres anwendbar wäre und brauchbare Ergebnisse verspräche.

Weil die erste Möglichkeit einer reinen Spekulation entsprungen ist, die zweite sich kaum oder wenigstens nicht bald verwirklichen lassen wird, so bleibt wohl nur die dritte als ernstlich diskutierbar übrig.

Keine pflanzensoziologische Arbeitsweise hat sich in Europa und in allen anderen Erdteilen so unentwegt entwickelt, angepasst und die empfangene Kritik produktiv assimiliert und sich so im Laufe der letzten Jahrzehnte durchgesetzt und immer weiteren Raum gewonnen, dabei wandlungs- und ausbaufähig bleibend, wie diejenige von Josias Braun-Blanquet. Keine andere hat zugleich auch ebenso viele Wissenschaften und zahlreiche Wirtschaftszweige befruchtet, wie diese, die ausser in zahlreichen anderen Schritten in seinem Handbuch (1951) und soeben wieder in einem alle brennenden Probleme zeitnahe behandelnden Aufsatz (1959) niedergelegt ist.

Es fällt schwer, sich ein Gebiet der Erde oder eine Vegetation vorzustellen, in denen diese Arbeitsweise nicht befriedigende Ergebnisse in fast allen Fragen der Pflanzensoziologie liefern könnte.

Von einer »Krise» dieser Methode zu sprechen, bedeutet sicherlich eine Verkennung der ihr innewohnenden lebendigen und gesunden Kräfte. So wenig eine Reihe von Autounfällen, die durch nicht genügend ausgebildete Fahrer hervorgerufen werden, eine Krise des Verkehrswesens bedeutet, so wenig sagt die im Augenblick fast ausschliesslich durch lokal oder doch territorial arbeitende Autoren herforgerufene Zersplitterung der Systematik über die lebendigen Entwicklungskräfte und weltweiten Anwendungsmöglichkeiten der Braun-Blanquet-Lehre aus. Eine grossräumige Synthese aller Einzelarbeiten wird diese Aufspaltungstendenz, die sich schon jetzt selbst zu Ende geführt hat, gewiss bald nach ihrem Erscheinen überholt haben, und die nur örtlich beschränkte Brauchbarkeit mancher bisheriger Versuche ebenso klar erweisen, wie die ungebrochene Anwendbarkeit der gesamten Lehre.

Keineswegs wird es aber nötig sein, auf die Assoziationen zu verzichten und sich auf die Verbände zurückzuziehen, die bei genauer Betrachtung die gleichen Probleme bieten würden wie die Assoziationen. Die Schwierigkeiten werden auf diese Weise nicht gelöst, sondern nur hinausgeschoben.

Diese sollen aber weder zu eng und zu lokal, noch zu weit gefasst sein. Eine auf Grund grosser Erfahrungen sorgfältig abgewogene Mittelstellung wird ohne Schwierigkeiten, wie wir glauben, alle Beanstandungen gegen die floristische Fassung der Assoziationen gegenstandslos machen. Im übrigen hat Braun-Blanquet selbst erst neuerdings (1959) wieder betont, dass für die Fassung der Assoziationen bei aller entscheidenden Bedeutung des Treuebegriffs das Vorhandensein von Charakterarten allein nicht das Entscheidende sei, dass aber ebenso wenig nur die Artenkombination als solche ausschlaggebend sein könne. Hier wäre auch an die geistreichen Ausführungen von Tuomikoski (1942) zu erinnern, der darauf hinwies, dass die Charakterarten ja nur ein Sonderfall der Differentialarten seien.

Die weitere Entwicklung der Pflanzensoziologie wird übrigens kaum von solchen Autoren gefördert werden, die als mehr oder weniger theoretisierende »Outsiders» darüber sprechen, ohne selbst aktiv darin mitzuarbeiten, sondern mehr von jenen, die sehr umfangreiche eigene praktische Arbeit geleistet haben, und die viele Pflanzengesellschaften über grosse Areale aus eigener Anschauung in ihrer floristischen Zusammensetzung gründlich kennen. Um diesen schwer errungenen und kostbaren Schatz der Älteren unter uns möglichst fruchtbar werden zu lassen, sei der Vorschlag erlaubt, dass unsere jüngeren Mitarbeiter so viel und so lange wie möglich zu aktiver Mitarbeit von Land zu Land oder noch besser von Kontinent zu Kontinent ausgetauscht werden möchten, um die Vegetation selbst und die Arbeitsweise erfolgreicher Forscher und Lehrer und ihres Institute aus eigener Anschauung genügend gründlich kennen zu lernen. Wir meinen, dass dann in verhältnismässig kurzer Zeit aus eigenstem Erleben heraus, sich die besten Arbeitsweisen finden liessen, die überall anwendbar sind, und dass zugleich auch das Verständnis und die Achtung für andere Arbeitsrichtungen ebenso wachsen müsste, wie die eigene Kenntnis der Vegetation entlegener Gegenden.

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The Chairman then asked the Secretary of the meeting, Dr. Rowe, to try to formulate a final summary of opinions.

J. S. Rowe:

Final Summary of Opinions

In view of the concern in forestry with both vegetation and the land on which it grows and is perpetuated, and recognizing the ecological bonds uniting the two (forest and site), it seems appropriate that the general idea of the *ecosystem* be adopted as a fundamental concept for the description, classification and investigation of forests.

Unit forest ecosystems can be defined and delimited spatially and temporally in various ways, and recognition of the distinction between vegetation-centered and land-centered ecosystems is necessary if misunderstanding is to be avoided. Attention to the mutual and reciprocal use of both vegetation and land in setting the boundaries of useful ecosystem units is recommended. Complete descriptions of ecosystem units, in terms of both biota and physiography, is strongly urged in order to assist correlative studies by others.

As neither the forest vegetation (phytocoenose) alone nor forest site (ecotope) alone is an adequate indicator of the ecosystem whole, classification ought to be based on significant features of both. Only in this way can the dynamic similarities of ecosystems be established. Techniques of ordination and gradient analysis will prove useful in detecting similarities and differences between ecosystems.

As a field wherein there is continual transformation and circulation of energy and matter with the production of organic materials, each ecosystem can be characterized by function, i.e. by the form and intensity of its own processes. An understanding of the dynamics of ecosystems is essential if they are to be controlled; such understanding will also refine classification and assist in the definition of types of maximum use for forestry. Therefore the study and analysis of forest ecosystems should be directed to their functional processes as productivity systems as well as to the ecology of their parts, and not only to their composition and structure.

Ecosystems are geographic entities, and they are not readily systematised without reference to the earth's surface. A system of regions, selected on the basis of homogeneity of biota and landform, provides the necessary framework within which description and classification of forest ecosystems is given precision. Also, within biotic-physiographic regions the development of useful principles is facilitated.

Although approaches to forest ecosystem typology will probably continue to take different lines from area to area due to geographic individuality and to differences in purpose and in available knowledge, it should be possible to formulate an acceptable system of concepts, and a fundamental terminology, that will permit the ready exchange of methods and results between different workers in this field. It is recommended that particular attention be given to this as the necessary basis for international, co-operative work.

Concluding remarks by the Chairman, Dr. Hustich:

Before we break up, could we decide that a Committee of Canadian ecologists shall work out the conclusions of to-day's papers and discussions and forward them to the World Forestry Congress next year in Seattle?

This was approved by the audience.

And now, thank you all for your patience. I hope you will dream about ecosystems...

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SELOSTUS:

SYMPOSIO

METSÄTYYPEISTÄ JA METSÄ-EKOSYSTEEMEISTÄ

Elokuun 24. päivänä 1959 pidettiin Montrealissa IX Kansainvälisen kasvitieteellisen kongressin »Forest Botany Section'issa» metsätyyppien ja metsäekosysteemien luokittelua käsittelevä symposio. Keskustelun alustukseksi oli 18 tutkijaa (s. 4) ennakolta lähettänyt monistetun kirjoituksen. Edeltäkäsin valmistellun ohjelman mukaisesti useimmat niistä käsittelivät tärkeätä kysymystä, voidaanko metsätyyppien ja metsäekosysteemien luokittelulle löytää yhteinen pohja. Lisäksi selvittelivät eräät kirjoitukset klimaks-käsitteen erilaisia tulkintoja sekä fysiognomisen järjestelmän käyttöä troopillisten metsien luokituksessa. Symposio antoi siten monipuolisen kuvan tämän hetken kasvillisuustutkimuksista.

Symposion oli kongressin ohjelmakomitean pyynnöstä valmistanut prof. Ilmari Hustich, joka myös toimi symposion puheenjohtajana. Prof. Aarno Kalela osallistui symposioon laajalla kirjoituksella (s. 40) ottaen osaa myös keskusteluun (s. 105). Kirjoittajien joukossa oli edelleen prof. Viljo Kujala. Suomalainen metsäntutkimus oli siten hyvin edustettuna tässä kansainvälisessä symposiossa. Sihteerinä toimi tohtori J. S. Rowe Kanadasta. Hän on laatinut keskustelun referaatit, joskin suurin osa puheenvuoroista on osanottajien itsensä kirjoittamia.

Kirjallisuusluettelo käsittää ainoastaan ne teokset ja kirjoitukset, joihin symposion osanottajat ovat kirjoituksissaan viitanneet. Tästä huolimatta lienee luettelo laajin ja monipuolisin maassamme julkaistu kasvillisuustutkimusta käsittelevä bibliografia. Se antaa siten huvän kuvan eri maissa tällä alalla suoritetusta uutterasta työstä.

Seuraavassa julkaistaan otteita prof. V. J. Krajinan symposion keskustelua varten valmistamasta kirjoitusten yhteenvedosta (s. 107).

Metsien luokittelu ekosysteemien pohjalla

VLADIMIR J. KRAJINA

Tansleyn (1935) ekosysteemi on kokonaisuus, joka käsittää paitsi eliöt myös niiden ympäristön. Ekosysteemit ovat hänen mukaansa yksi tapa rajoittaa ja luokitella olemassa olevia moninaisia fysikaalisia järjestelmiä. Niitä on sarja laadultaan ja kooltaan mitä erilaisimpia, maailmankaikkeuden kokonaisuudesta aina atomiin asti.

Käsitteenä Tansleyn ekosysteemi on periaatteessa oikealla pohjalla, mutta se on ekologian käyttöön liian lavean ylimalkainen ja tarkemmin rajoittamaton. Se tosin sopii paremmin synekologian kuin autekologian tarpeisiin, mutta vaatii täydennyksekseen sarjan konkreettisia eriarvoisia synekologisia yksiköitä. Tältä kannalta Friederichsin (1930) käsite 'Holocön' voisi olla käyttökelpoisempi, muttei sekään vielä ole niin kaavamaisen selkeä kuin Sukatševin (1944) biogeokenoosi. Biogeokenoosin voimme määritellä ekosysteemeihin perustuvan synekologian perusyksiköksi. Sukatšev pitää sitä maastossa paikallisesti rajoitettavana yksikkönä ja ehdottaa vastaavalle luokkakäsitteelle nimitystä biogeokenoosityyppi. Mutta koska käytämme kasviyksilöstäkin samaa nimeä (esim. Pseudotsuga Menziesii) kuin koko lajista, vaikka tiedämme että lajin rajoittaminen edellyttää useiden yksilöiden perustalla tehtyä abstraktiota, niin vastaavasti biogeokenoosin ja biogeokenoosityypin käsitteellisellä erottamisella ei juuri ole käytännössä merkitystä.

Sukatševin biogeokenoosi käsittää osinaan biokenoosin, johon kuuluvat fytokenoosi, tsookenoosi ja mikrobiokenoosi, sekä toisaalta ekotoopin, johon puolestaan kuuluvat klimatooppi ja edafotooppi. Viitattakoon tässä Arnborgin (s. 13) lausumaan, jonka mukaan »eri koulukuntien metsätyyppiluokituksen ainoana yhteisenä vertailupohjana on se, joka saadaan hyvin huolellisesti analysoimalla sekä kasviyhdyskuntia ja maaperää että myös ilmaston, aikatekijän, ihmisen ja eläinmaailman vaikutusta näihin. Meidän on opittava lukemaan, mitä kasviyhdiskunnat ja kasvit ilmaisevat maapohjasta puiden kasvupaikkana. Metsätyyppi on metsän käytön yksikkö.» Samaan tapaan sanoo Linteau (s. 64): »Maaperä- ja kasvillisuustutkimuksen yhteistyö tulee myös tekemään mahdolliseksi saada selville kunkin kasvupaikan normaalit mahdollisuudet ja syyt puuntuoton tilapäiseen puutteellisuuteen sekä tulee siten myös antamaan viitteitä siitä, minkä toimenpiteiden avulla viimeksimainittu on korjattavissa.»

Kasviyhdyskunta, fytokenoosi, kuuluu olennaisena osana biogeokenoosiin. Sen perusyksikkö — olisi esitettävä Zürich-Montpellier -koulukunnan mukaisena assosiaationa, soveltamatta kuitenkaan koulukunnan luonnehtijalajioppia jäykän dogmaattisesti. Mainitun oppijärjestelmästä poikkeamisen tueksi viittaan Ellenbergin (s. 26, vrt. myös Krajina s. 50) lausuntoon: ». . . luonnehtijalajien tai ylipäänsä yksikköön selvästi keskittyvien lajien merkitys on yhä vähenemässä, ja ne jäävät merkityksellisiksi ja ratkaiseviksi vain järjestelmän laaja-alaisimpia yksiköitä (alliansseja, luokkia ja lahkoja) rajoitettaessa». Ellenberg ja samoin useat muut eurooppalaiset kasvillisuustutkijat siis ovat samaa mieltä tämän korjauksen välttämättömyydestä. Se olisi myös omiaan saattamaan venäläiset ja pohjoismaiset (ruotsalaiset ja suomalaiset) koulukunnat taipuvaisemmiksi yhteisen perustan omaksumiseen. Niinpä sanoo Kujala (s. 56): ». . . jokainen kasvi pystyy ilmaisemaan jotakin siitä kasviyhdyskunnasta, jossa se kasvaa, ja kaikki lajit yhdessä voivat silti luonnehtia tyypin, vaikkei siinä olisi yhtäkään luonnehtijalajia Braun-Blanquetin koulukunnan esittämässä mielessä». Kalela (s. 40) esittää samansuuntaisia ajatuksia. Jotkut kasvisosiologit kenties eivät ole ehdotuksesta samaa mieltä, koska se heidän mielestään näyttäisi merkitsevän Braun-Blanquetin floristisen järjestelmän loppua. Mutta järjestelmän periaatteiden joustamaton noudattaminen metsien luokittelussa voisi aiheuttaa ankaria vastaväitteitä etenkin käytännön metsämiesten taholta. Aina tosin tulee olemaan kasviassosiaatioita, jotka ovat selvimmin tunnettavissa luonnehtijalajeistaan sekä niiden ohella muista lajistollisista piirteistään ja koko ekotoopistaan. Kuitenkin muutamista kasviassosiaatioista tulevat puuttumaan tuollaiset niihin selvästi keskittyvät lajit, vaikkakin niissä aina on, paitsi niiden omia erottajalajeja, myös toisia, jotka ovat allianssin, lahkon ym. luonnehtijalajeja. Nämä assosiaatiot, olipa niissä luonnehtijalajeja tai ei, erottuvat selvästi muista osoittamalla ominaisilla kasvusuhteillaan (esim. puiden pituus ja läpimitta) riippuvaisuutta niille ominaisesta ekotoopista.

Tässä yhteydessä haluan tähdentää kahta Rowen ja Scamonin esittämää samansuuntaista ajatusta. »Metsien typologialle saadaan yhteinen pohja keskeisestä ekosysteemi-käsitteestä, johon olennaisina osina kuuluvat metsän sekä bioottiset että ympäristötekijät.» (Rowe s. 82). ». . . näyttää mahdolliselta löytää yhteinen perusta metsätyyppien luokittelulle, kun kasvillisuus- ja kasvupaikkatutkimus eivät kumpikaan vaadi etusijaa siinä . . .» (Scamoni s. 89). Nämä ajatukset ovat sopusoinnussa joko ekosysteemi- tai biogeokenoosikäsitettä käyttävän holokenoottisen näkökannan kanssa.

Major (1951) aivan oikein tähdensi, että samoin kuin Jenny (1941) esittää maaperän ominaisuudet riippuviksi maata muodostavista tekijöistä yhtälön $s = f\ (cl, p, r, 0, t)$[1] mukaan, samoin voidaan myös otaksua, että kasvillisuus riippuu samoista tekijöistä vastaavan kaavan mukaisesti: $v = f\ (cl, p, r, o, t)$. Itse asiassa näitä kahta yhtälöä voidaan pitää Tansleyn ekosysteemin tai Sukatševin biogeokenoosin matemaattisena esityksenä. Viiden riippumattoman muuttujan (cl, p, r, o, t) lukumäärää ei voi vähentää niinkuin jotkut kasvupaikan luokittelijat ovat taipuvaisia tekemään. Ei pidä aliarvioida eliöiden (kasvien ja eläinten) sekä aikatekijän osuutta metsän nimenomaan sekä maaperän että kasvillisuuden muotoutumiseen. Daubenmire (s. 22) sanoo: »Voidaan tuskin olla eri mieltä siitä, että on turvauduttava yksinomaan kasvipeitteeseen, kun halutaan määrätä, mitkä ympäristötekijäin yhdistelmät ovat biologisilta vaikutuksiltaan eniten toistensa kaltaisia . . . Silloinkin kun kasvillisuutta käytetään ensisijaisena perusteena ekosysteemityyppiä rajoitettaessa, ympäristön ominaisuudet usein ovat erittäin käyttökelpoisia luonnehtimaan merkitseviä erikoisuuksia.»

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[1] cl = ilmasto, p = kallioperä, r = maanpinnan muodot, o = eliöt, t = aika.

»Ekologiaa lähinnä kiinnostaa, miten suurissa määrin ja kuinka nopeasti aine ja energia kiertävät tietyn ekosysteemin kautta. Miltei yhtä tärkeätä on kuitenkin, minkälaisia eliöitä kuuluu tiettyyn ekosysteemiin ja mikä on niiden osuus sen rakenteessa ja asema sen organisaatiossa. Siis sekä kvantitatiivinen että kvalitatiivinen puoli on otettava huomioon kuvattaessa ja vertailtaessa ekosysteemejä». (Evans 1956.)

Ollakseen yleisesti hyväksyttävä järjestelmän on otettava huomioon ainakin kaikki makroskooppiset kasvit. »Puut ja aluskasvillisuus yhdessä käyttävät hyväkseen kasvupaikan suhteellisen tehokkaasti, koska yhteyttävät solukot ovat jakaantuneena hajalleen sen maanpäällisiin osiin ja juuret laajalti maan pintaosiin.» (Ovington s. 73).

Hillsin (s. 33) ehdotuksissa metsien luokitteluksi luemme seuraavaa: »Tietyn paikan mahdollista kokonaistuottoa rajoittaa sen suurilmaston ja 'landformin' yhteinen potentiaalinen energia.» 'Landform'-käsitteeseensä Hills lukee kuuluvaksi »ei pelkästään maanpinnan muodot, vaan mantereiden koko kiinteän ja nestemäisen pintakerroksen», joten voimme päätellä, että hän Majorin esittämistä kasvillisuuden ja maaperän muodostumiseen vaikuttavista viidestä erillisestä tekijästä pitää eliöitä ja aikatekijää muita vähemmän merkitsevinä. »Koska suurilmasto ja 'landform' yhdessä eivät ainoastaan ole potentiaalisen tuoton perustana, vaan myös toiminnallisesti säätelevät toisistaan riippuvien kasvillisuuden, maaperän ja kasvustoilmaston yhteiskehitystä, niin suurilmaston + 'landformin' pohjalla rajoitetut yksiköt sopivat ekosysteemiluokittelun perusyksiköiksi». »Puulajittaisten metsätyyppien, aluskasvillisuustyyppien ja maaperäprofiililuokkien välisillä yleisillä korrelaatioilla ei ole paljoakaan arvoa. Mutta kasvillisuustyypit ja maaperäprofiililuokat sentään antavat tärkeitä viitteitä tuottoisuustasojen vaihteluista, mikäli niitä käytetään suurilmaston + 'landformin' pohjalla muodostettujen yksiköiden puitteissa.»

Mutta ei edes Hillsin käsitys ole niin jyrkästi ristiriidassa yleisen ekosysteemikäsitteen kanssa kuin ehkä saattaa näyttää. Tosiasiallisesti Hills jatkaa Clementsin ekologis-bioklimaattista tietä, kun hän ensiasteisena tehtävänä pitää ilmastollista jakoa käyttämällä yhdessä 'landformin' ja suurilmaston tuntomerkkejä, ja suosittelee toissijaista kasvillisuuden ja maaprofiilin mukaista alajakoa. Itse asiassa enimmät eurooppalaiset ekologit tavallisesti menettelevät juuri samoin. He tutkivat kasviassosiaatioita eri ilmastovyöhykkeiden piirissä, jotka usein ovat jo erotetut ennenkuin he käyvät kasviyhdyskuntia ja niiden ekologiaa yksityiskohtaisesti tutkimaan. Tosin useimmat ekologit tietenkin yhä edelleen nimittävät ilmastovyöhykkeitä mieluummin ilmastollisten kliimakskasviyhdyskuntien kuin niitä aiheuttavien syiden mukaan, mutta tämähän on vain saman mitalin toinen puoli.

Yleisesti kuitenkin ollaan yhtä mieltä siitä, että useimmilla tropikkialueilla kasvillisuuden väliaikainen luokitus tulee olemaan fysiognomiaan ja vasta toisessa tilassa biokenooseihin perustuvaa. Tämä on myös Ellenbergin (s. 26), Küchlerin (s. 60) ja Webbin (s. 98) käsitys.

Kun kliimaks-käsite metsäkasvitieteessä johtaa näennäisesti ristiriitaisiin tuloksiin, niinkuin Medwecka-Kornasilla (s. 68) Puolassa ja Purilla (s. 77) Intiassa, on muistettava, että alun alkaen luonnontilaiset metsät ovat helpommat tutkia, ja arvostella niiden kliimaksmuodon suhteen. Itse asiassa eivät edes polykliimaks- ja monokliimaks-käsityskannatkaan ole niin poikkeavia ja vastakkaisia kuin asia usein tulkitaan.

Vastaavasti Gleasonin käsitys kasviyhdyskuntien yksilöllisyydestä voidaan ymmärtää näkökantana, jossa aikatekijän sekä sekundaarisen ja primaarisen sukkession fylogeneettistä merkitystä on tähdennetty enemmän kuin eräissä muissa. Tällä kasvien fylogeniassa niin tärkeällä tila-aika-tekijällä on niin suuri vaikutus myös kasviyhdyskuntien alueelliseen jakaantumiseen, että tämä todellisuudessa tulee olemaan paljon suppeampi kuin vastaavien kasvupaikkojen.

Mitä tulee kasvillisuuden vaihtelun vähittäisyyteen, 'continuumiin' Curtisin ja McIntoshin tarkoittamassa mielessä, se ei ole yksinomaan kasvillisuudelle ominaista. Sama voidaan todeta kivilajeista, maalajeista ja ilmastoista. Kasvillisuudessa 'continuumia' voidaan tutkia ordinaatiomenetelmällä (Goodall 1954, Greig-Smith 1957, Bray & Curtis 1957), mutta se ei voi korvata luokittelua. Nähtävästi johtui vain onnettomasta väärinkäsityksestä, että vaihtelun vähittäisyyden olemassaoloa jouduttiin käyttämään todisteena kasvillisuuden luokittelun oikeutusta vastaan. Jokainen tiede luokittelee tutkimuskohteensa. Kuten Daubenmire (s. 22) mainitsee, ilman luokittelua kasvillisuuden tutkiminen ei ole mahdollista. Tätä lausumaa hieman muuttaen voidaan sanoa, että ilman luokittelua ei voi olla ekosysteemejä tutkivaa tiedettä eikä ekologiaa. Eikä itse asiassa tiedettä ollenkaan.

Haluaisin päättää sanottavani toteamalla, että Tansleyn holokenoottinen näkemys ekosysteemistä, parhaiten mukautettuna biosfeerin luokitteluun Sukatševin biogeokenoosi-käsitettä käyttämällä, voisi yhdistää kaikki synekologiset koulukunnat samaan tehtävään: muuttamaan tuntematonta tunnetuksi. Eri koulukunnat saattaisivat löytää tämän kaavan puitteissa omat tehtävänsä ja soveltaa sitä omiin tarpeisiinsa (Aichinger 1954, Kalela 1954, Zlatník 1954—56, Rowe s. 82).

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