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Introduction to the report volumes for the 16th IPE

by

H. LIETH

Contents

1. The climate
2. The vegetation
3. The soil
4. Final remarks
   Summary - Zusammenfassung
   References

The initial invitation to the 16th IPE included the statement that the vegetation of the "Midatlantic" region of the United States contains interesting aspects of disjunct species distribution, endemism and physiognomy as well. All these characteristics of the vegetation need to be seen in the context of environmental parameters the changes of these through the last millions of years, the species migration caused by these changes or even the origin of new species.

In several papers of the two volumes from the 16th IPE parts of these interesting aspects of the Carolina vegetation are treated. In this volume (1) especially the papers of C. PARKS, J.P. DEY, H.R. DELCOURT, and P.A. DELCOURT are dealing with certain portions of this problem: origin of ornamental plants, lichen distribution, and postpleistocene vegetation history. Specific environmental conditions and changes are discussed in these papers to suggest possible reasons for the existence of species in this area and their migration into or out of this region. Out of the environmental factors climate and soil are usually covered to the extend that the regional facts or processes are understood or at least described.

In two specific papers by P. ROBINSON, climate and physiography of the region is explained coherently while the soil conditions are dealt with in several individual papers of both volumes. For the mountain province this is done in this volume by D. PITTILLO and G. SMATHERS and for some coastal plain soils by N.L. CHRISTENSEN. The description of soils for other provinces will follow in volume 2.

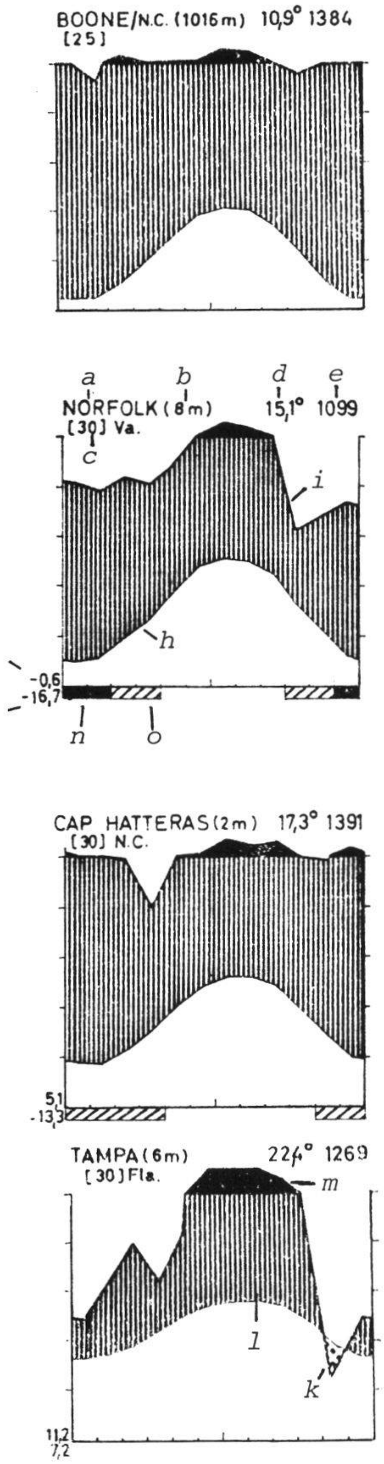
The reader of these reports from the 16th IPE will certainly be well informed about the special conditions of the places visited, may it be the flora, the vegetation, the climate, or the soil. What is needed as introductory remarks is the placing of these facts into the global context. For several problems of disjunct species it is necessary to compare where are similar climates as in the Carolinas, since similar climates also enhance chances for similar life forms, same species, genera or families, similar physiological adaptations etc.

The discussion of the soils in several papers contains for European readers the problem that mostly American terminology is used which is not yet understood internationally.

These two problems are therefore the main objective for this introduction along with the presentation of a few facts about the Carolina vegetation elaborated by the author and his students.

1. The climate of the Carolinas and their equivalent in the world.

In order to compare climates for the purpose of vegetation science we use the conventions of the climate diagram atlas by WALTER and LIETH (1961-67). The elements of these diagrams are explained in figure 1 using several stations from the region: Boone, N.C., in the Carolina mountains, Norfolk, Va., a coastal station in Virginia, Cape Hatteras, N.C., on the Outer Banks of North Carolina and Tampa in Florida. The elements of the diagrams are labelled with letters on the stations Norfolk and Tampa. Boone has some elements missing normally included in a diagram.



The elements of the diagram are:

a - station
b - altitude
c - number of years of observation (if two numbers the first stands for temperature, the second for precipitation)
d - mean annual sum-total of precipitation in mm
f - mean daily minimum of the coldest month
g - lowest temperature measured
h - monthly means of temperature
i - monthly means of precipitation

The respective entries start with January on the northern hemisphere and with July on the southern hemisphere.

The monthly means of temperature (h - thin line) and of precipitation (i - thick line) are drawn as curves. Both stand in a fixed proportion to each other; ten degrees centigrade corresponding to a precipitation of twenty mm. Using this proportion GAUSSEN (1954) has established for the mediterranean region a strictly arid period to prevail as soon as precipitation goes below the temperature curve (k - dotted area), and a humid period as soon as precipitation exceeds temperature (l - hatched area).

Precipitations above 100 mm are printed in the scale of 1:10 and marked in black (m).

By the relationship of temperature with precipitation 1:2 we characterize unfavourable seasons caused by water-shortage. Unfavourable seasons caused by frost are indicated for each month along the abscissa by special blocks. They are black (n) in case the mean minimum of a month falls below zero centigrade, and hatched (o) in case the absolute minimum lies below zero.

Fig. 1. Entries to climate-diagrams according to the convention used in WALTER and LIETH (1961-1967).

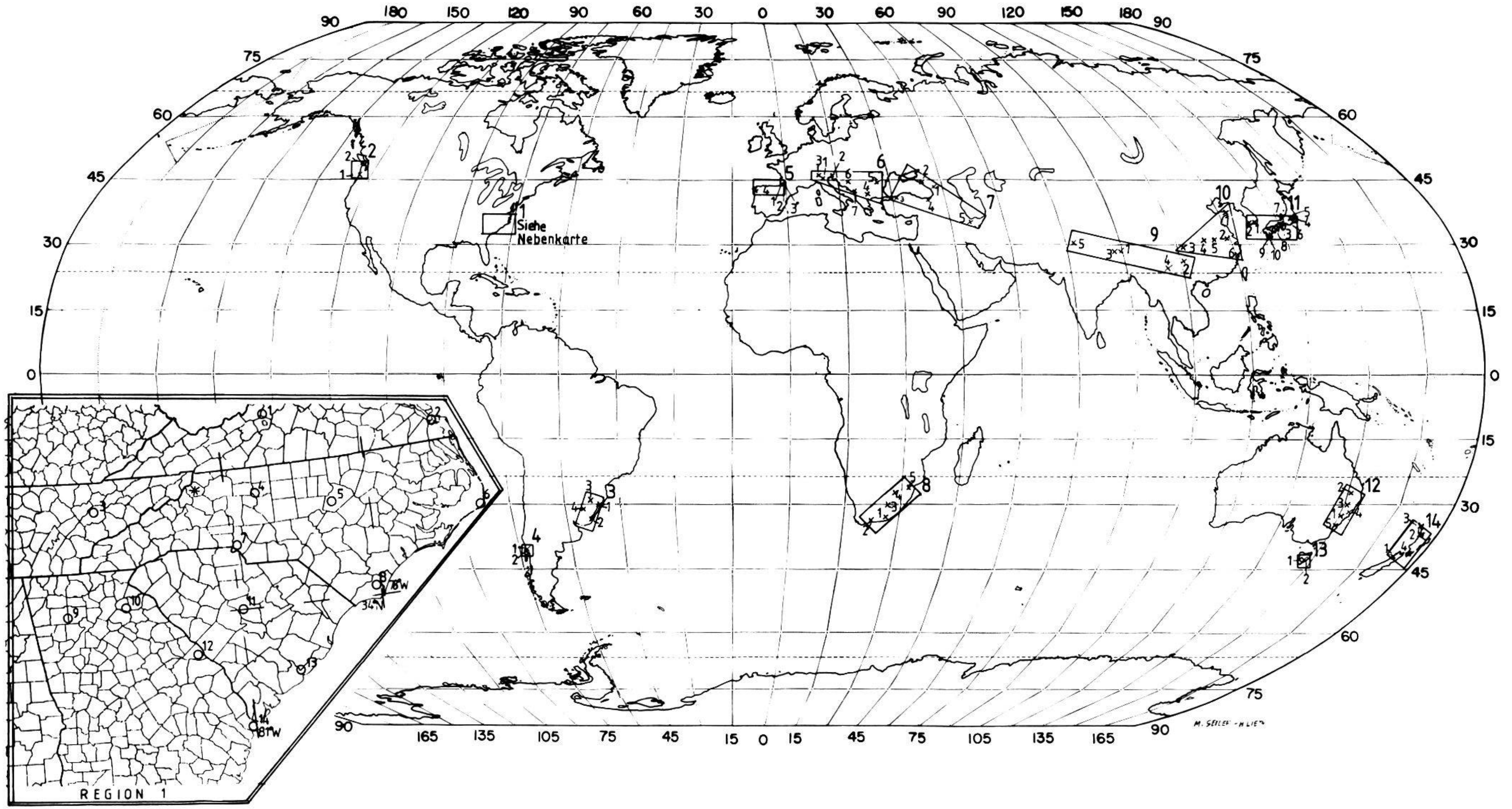


Fig. 2. The comparison of the climate of the region visited by the 16th IPE with similar climates in other parts of the world, using climate diagrams. The numbers on the maps correspond to the sequence in which the diagrams for each region are presented. The * in region 1 indicates the position of Boone, N.C. shown in fig. 1.

In fig. 2 we show regions of the world where we can expect climates similar to that of the Carolinas. For each region we show a few diagrams for comparison. The grouping and numbering on the map follows the order in which the accompanying climate diagrams are presented on the next eight pages.

In region 1 we present a selection of diagrams for the south-eastern United States in geographical context. With stations shown on the map, the general climate trends can be seen and probably more easily extrapolated across the boundaries of North Carolina for which more detailed explanation of the climate exist in the papers by ROBINSON (1979, this volume) and PITTILLO and SMATHERS (1979, this volume).

The stations in the Carolinas allow us to compare temperature and precipitation gradients from North to South and from East to West, the latter mostly reflecting altitudinal changes.

The climate of the Carolinas belongs to the moist, warm temperate type 5 in the definition of WALTER and LIETH (1961). This type is found in the northern hemisphere going eastward in isolated spots in Portugal, Spain, France, Italy, the Balkan peninsula, south of the Caucasus, on the south slopes of the Himalaya range, in middle and northern China, Korea, and southern Japan.

In the southern hemisphere we find similar climates in Chile, southern Brazil, the eastern mountain range of south Africa, Tasmania, the north island of New Zealand and the northern part of her south island.

The main features of climate type 5 are wet hot summers and mild winters with occasional freezing spells. A similar effect can be reached in Mediterranean climates when the rainfall which peaks here in winter is high enough during the summer months to offset the hot temperatures. Under these constraints parts of the Pacific coast from Oregon to Washington, larger portions of the Mediterranean region, a wider area in Chile and some south-eastern portions of Australia may be comparable to our study area.

Besides the climatic elements included into the diagrams several more are important for vegetation studies. Of these, two more should be discussed here: The frequency of destructive storms and the vegetation period.

Destructive tropical storms, called hurricanes in the south-eastern United States are discussed as a climatic element by ROBINSON (1979, this

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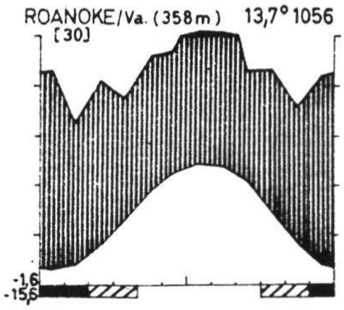

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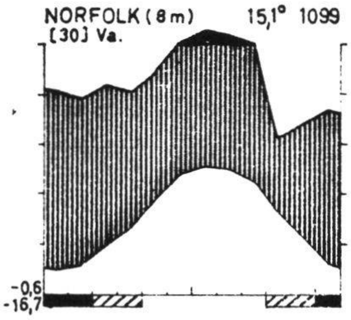

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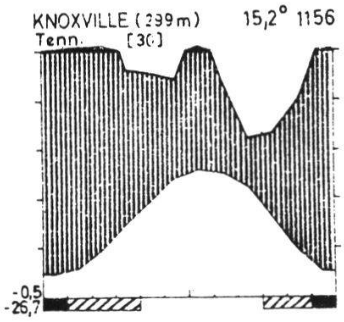

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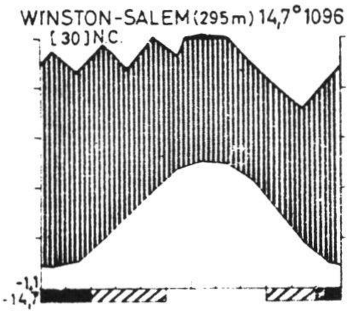

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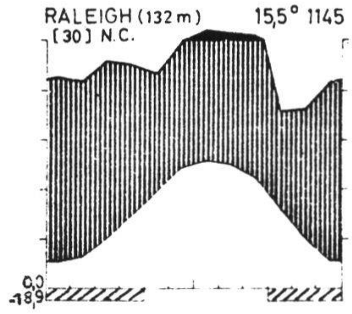

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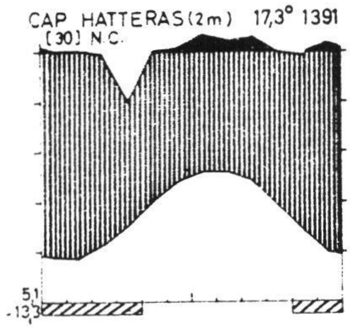

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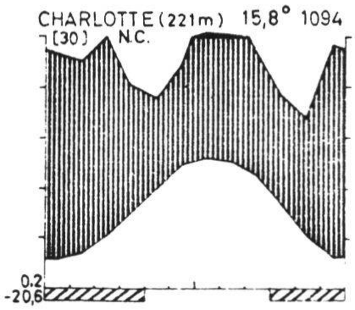

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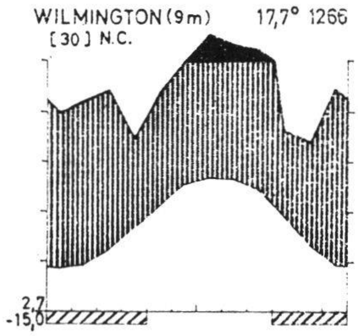

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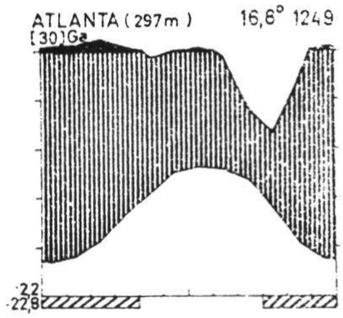

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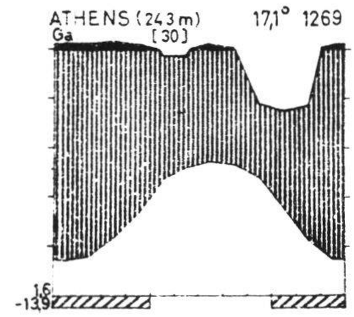

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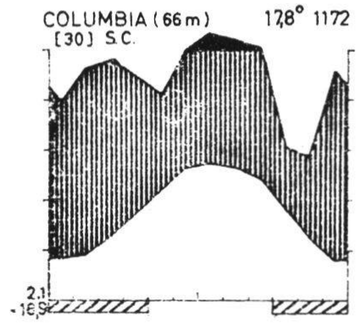

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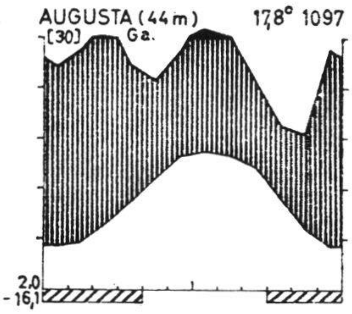

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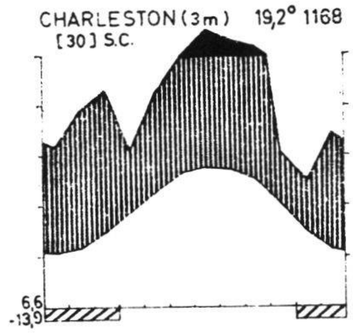

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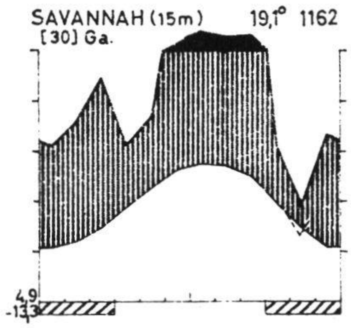

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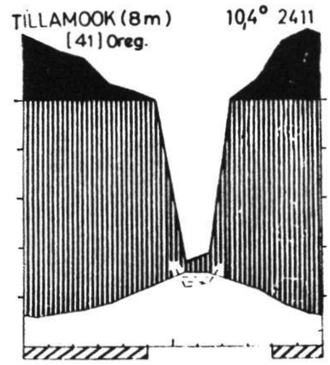

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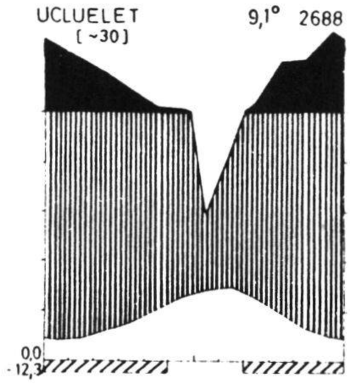

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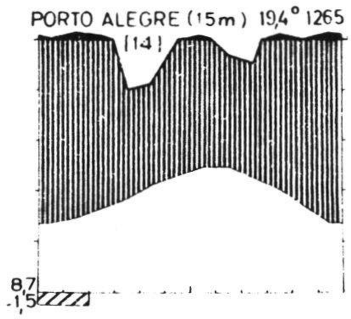

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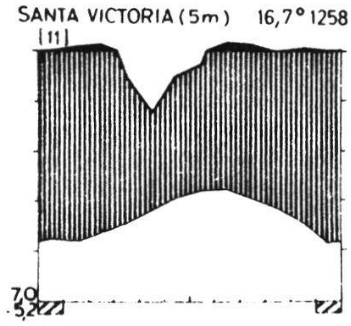

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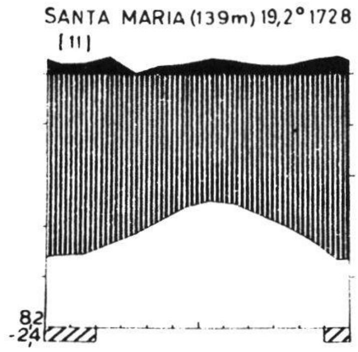

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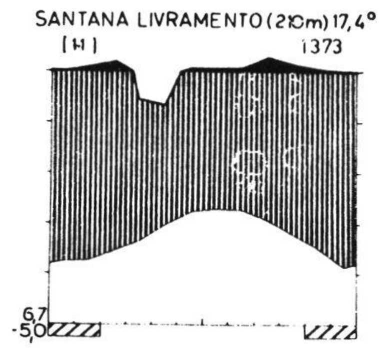

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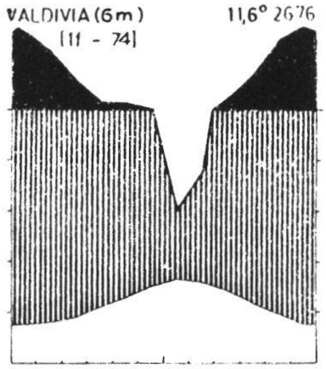

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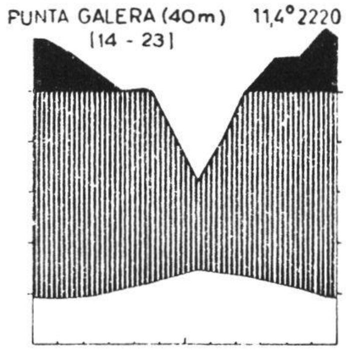

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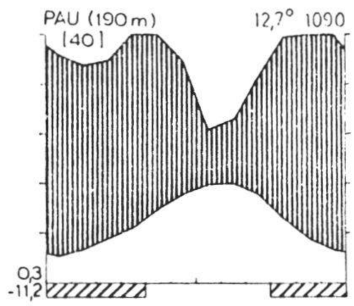

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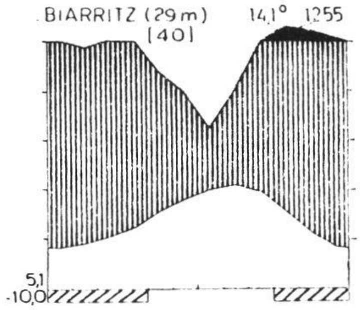

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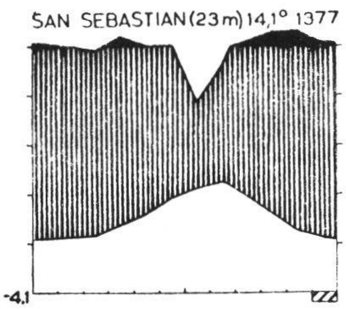

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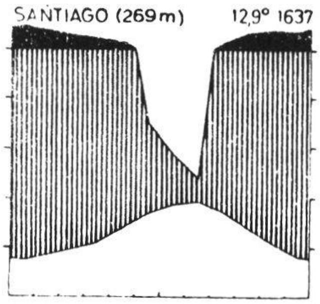

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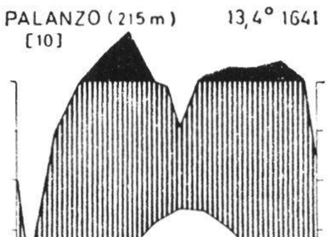

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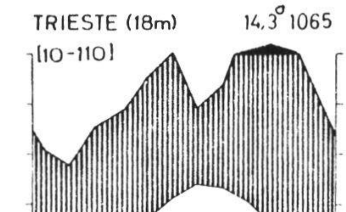

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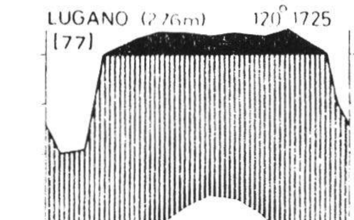

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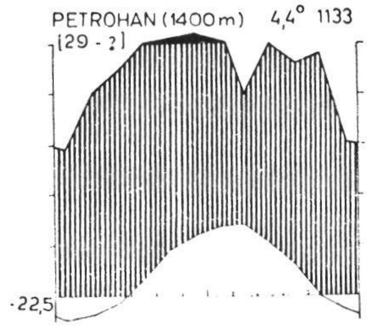

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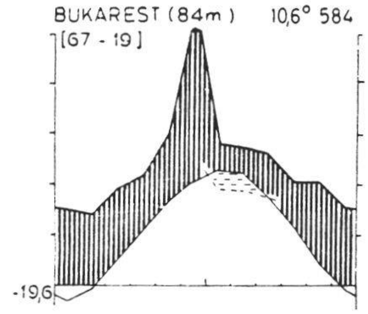

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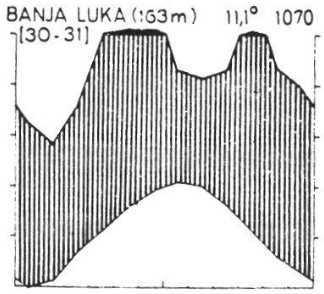

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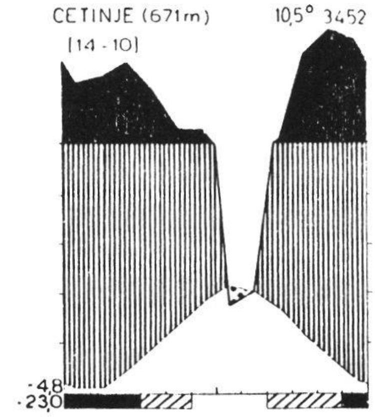

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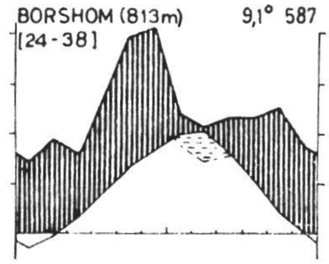

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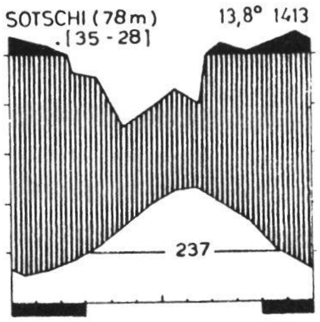

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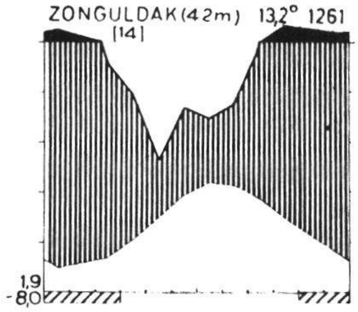

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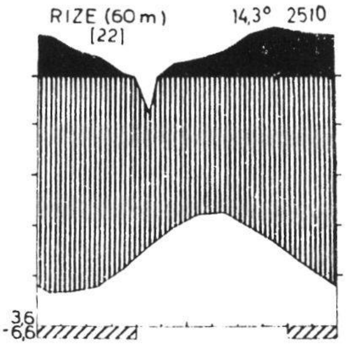

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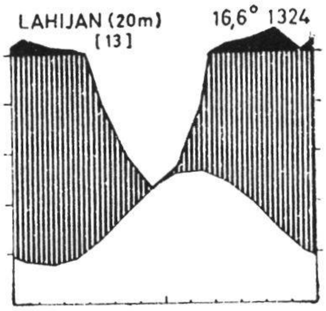

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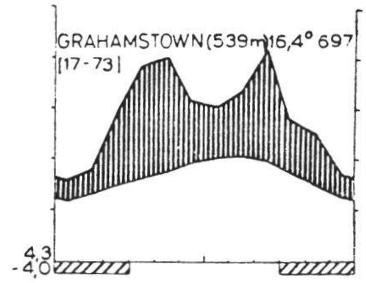

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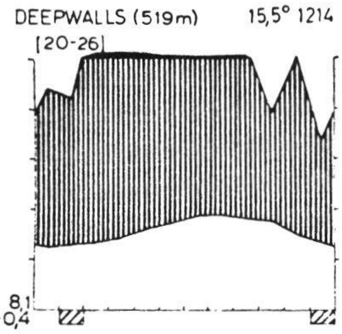

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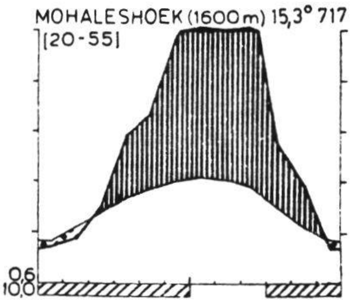

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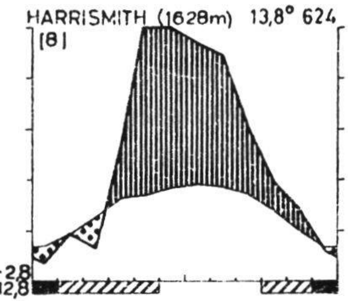

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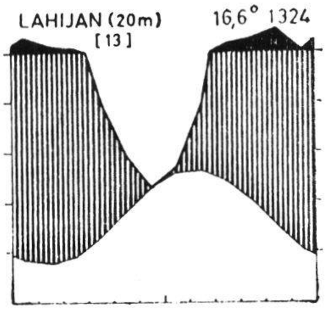

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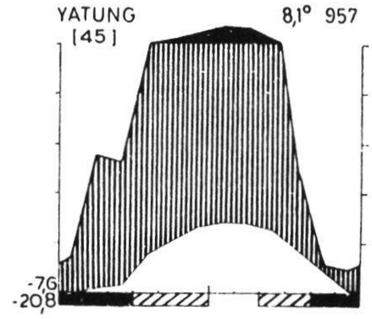

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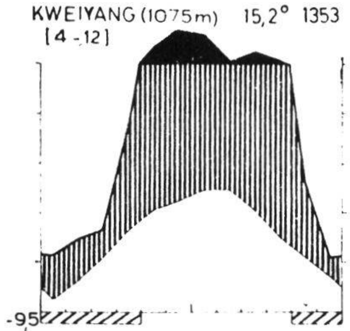

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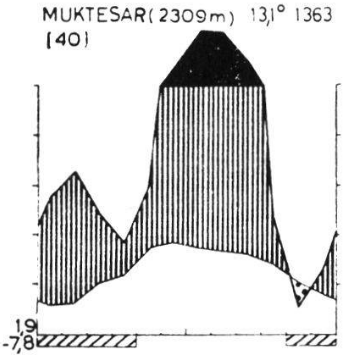

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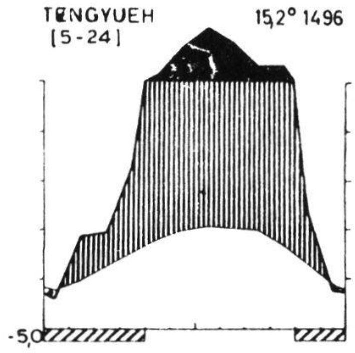

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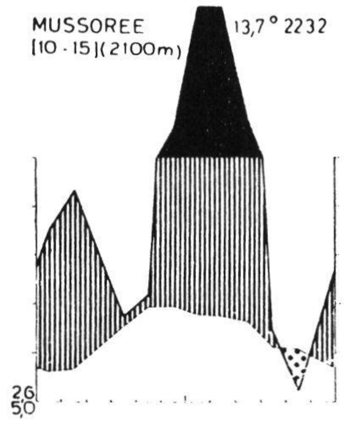

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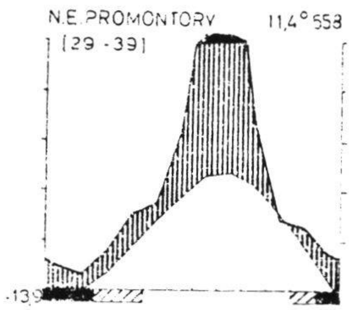

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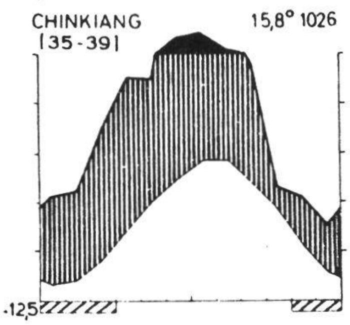

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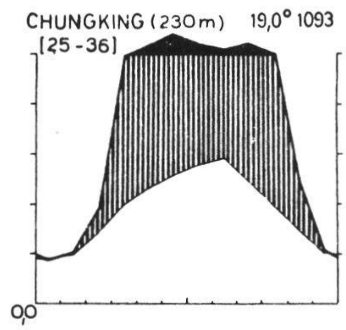

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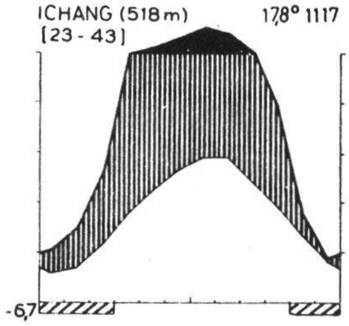

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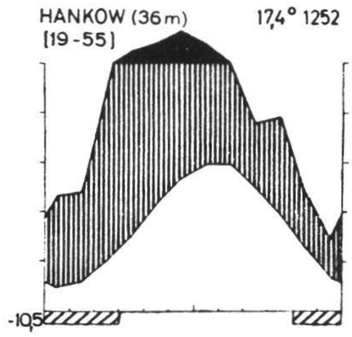

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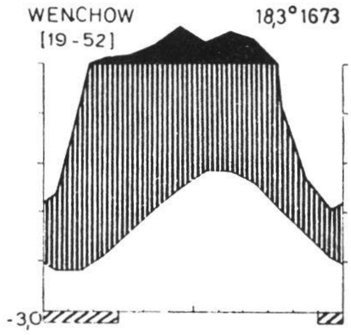

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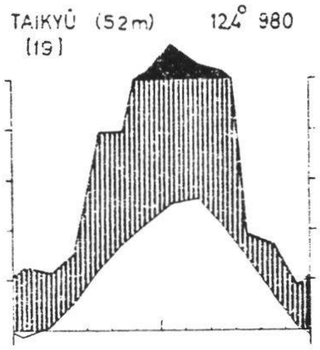

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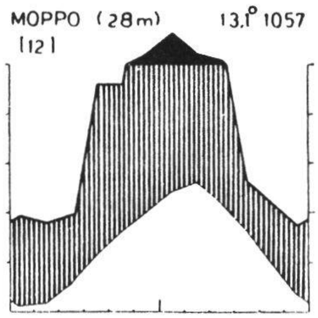

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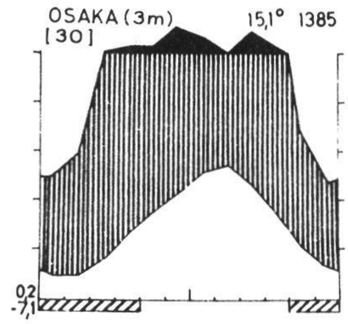

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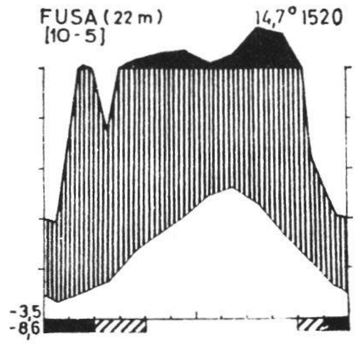

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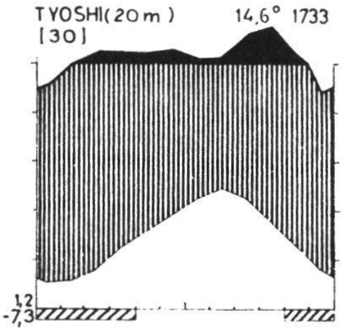

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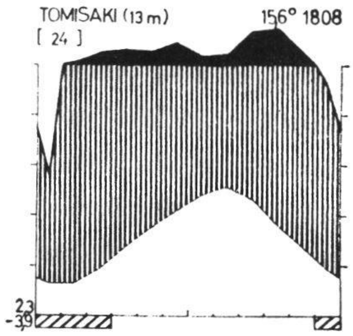

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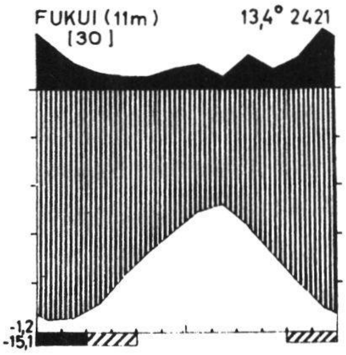

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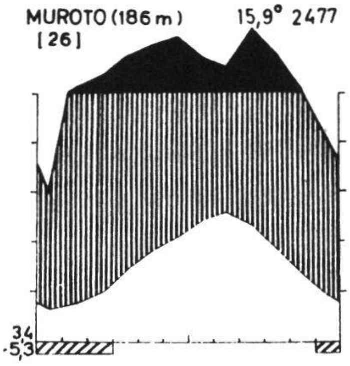

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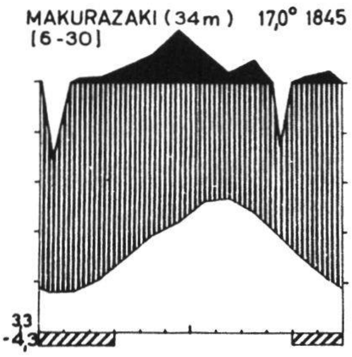

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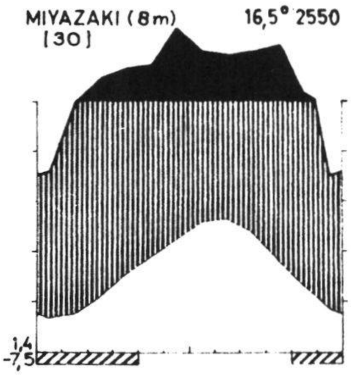

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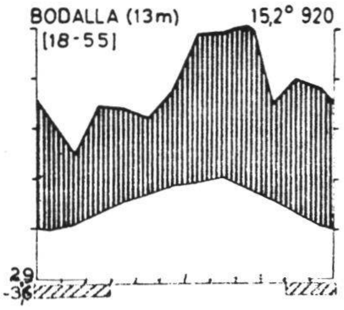

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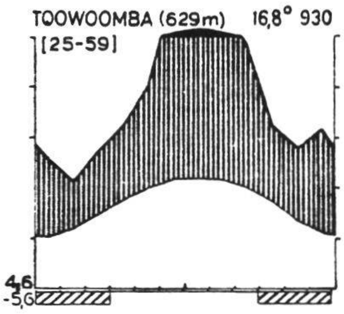

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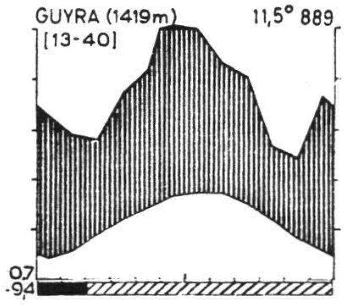

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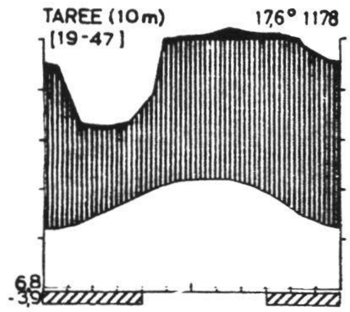

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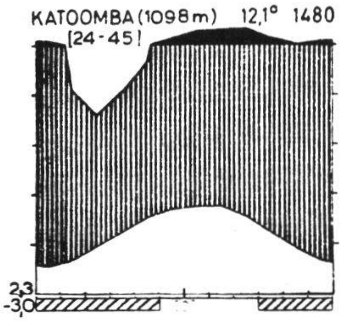

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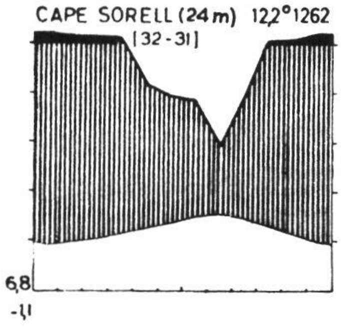

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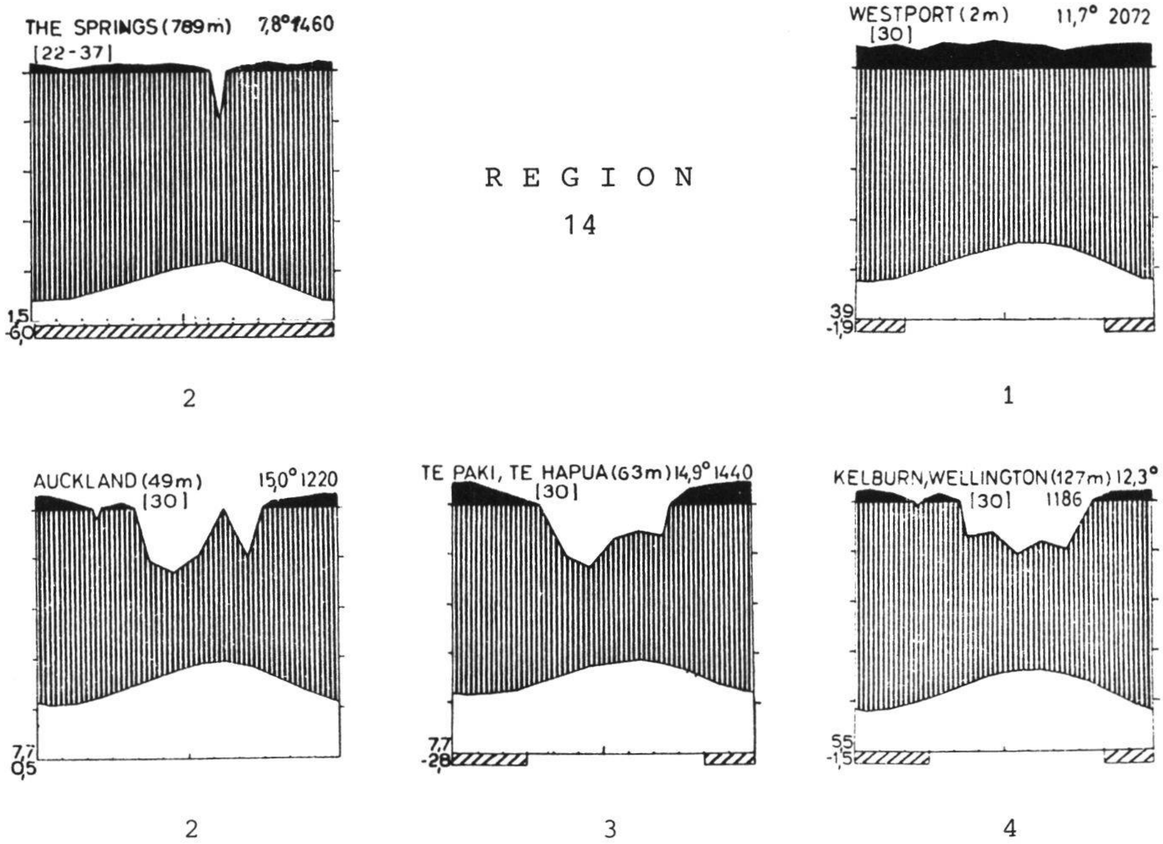


volume). These storms are frequently so severe that enormous damage to the vegetation occurs. The area visited by the 16th IPE suffers to a different degree from such high wind speeds. Fig. 3 shows for the south-eastern United States how many times destructive storms have hit various parts of this region within 55 years. From the area we visited the north Carolina coast suffers obviously the most under these destructive wind forces. The impact of these storms upon the vegetation is only matched by the "freezing rain" storms in the piedmont and lower mountain provinces. Especially hard hit is the coast-line from Morehead City to Naggs Head. The effect of the high winds and for the accompanying ocean waves can be seen at several points on the outer banks where new inlets were formed, beach fronts were washed away or shifting dunes moved into forested land.

Fig. 3 contains also distribution patterns for several species. The data are taken from RADFORD, BELL and AHLES (1968). Their relation to the climatic variables will be discussed in the next chapter.

An important feature of the climate in a strongly seasonal area of the world is the arrival of spring, the arrival of fall and by the combination of the two phenological events the length of the photosynthetic period. The

-·-·-·- S.c. = *Sabatia calycina* (Lam.) Heller
------- S.d. = *S. dodecandra* (L.) BSP.
-··-··- S.g. = *S. gentianoides* Ell.

. = Mountain counties with *S. campanulata* (L.) Torrey

o = Counties in which *Dionaea muscipula* Ellis (Venus fly trap) occurs

+ = Counties in the Carolinas in which *Shortia galacifolia* T. & A. (Oconee Bells) occurs

╫ = Counties in the Carolinas in which *Hudsonia montana* Nuttall and

╫╫ = *H. ericoides* L. occur

x = Counties in which *Sabal palmetto* Lodd. ex Schultes occur.

Fig. 3. Frequency of tropical storm destructions in 55 years (1901-1955) in the South-Eastern United States redrawn from the USWB map in DICKSON (1960), and examples for the distribution of rare, endemic or regionally selective species in the Carolinas.

measure commonly used for this time span is the freeze free period. This is applicable for most practical purposes. However, for vegetation studies the photosynthetic period is the more appropriate measure. For North Carolina the best indicator for the beginning of the vegetation period (arrival of spring) is the flowering of the redbud (*Cercis canadensis*) and the dogwood *(Cornus florida)*. The flowering of these two species occurs synchroneous with the leaf shooting of all common deciduous tree species. The end of the vegetation period for the fall is indicated by the leaf coloration. The most common species and best suitable for this measure are tulip poplar (*Liriodendron*) *tulipifera*) and red maple (*Acer rubrum*). The length of the vegetation period can be calculated by substracting "yearday spring" from "yearday fall".

The phenological events described here were measured across North Carolina by a network of observers, initiated specifically for this purpose. The evaluation of the observations for the three years 1970-1972 by READER (1973) is presented in fig. 4, 5 and 6.

For both phenological events spring and fall calender dates (month/ day) and in parenthesis the yeardays are given in figs. 4 and 5 respectively.

The evaluation was done manually on a 'Symvu' relief plotting showing the county centers. Data from almost all counties allowed us to interpolate accurately enough on the plot.

Fig. 6 presents the time difference in days between fall and spring arrival for the same 3 years. These relief maps show consistantly the south-east coastal plain with the longest vegetation period and the north-west high mountain area between Boone and Mt. Mitchell with the shortest vegetation period. It is interesting that the southern Smokey Mountains have as favourable a vegetation period as the much lower northern Piedmont section of North Carolina.

The comparison of the climate in the region visited by the 16th IPE faces us with the problem that the elevational distance in this area is equivalent to several thousand km in a north-south extension. This in itself is a specific regional climatic property not matched by too many other areas in the world. Such a wide range of temperature on several mountain ranges over a short distance provides a high number of ecological niches for plant species which might have been filled during the areas of glacial shifts and may explain the enormous species richness in the southern Smokey Mountains.

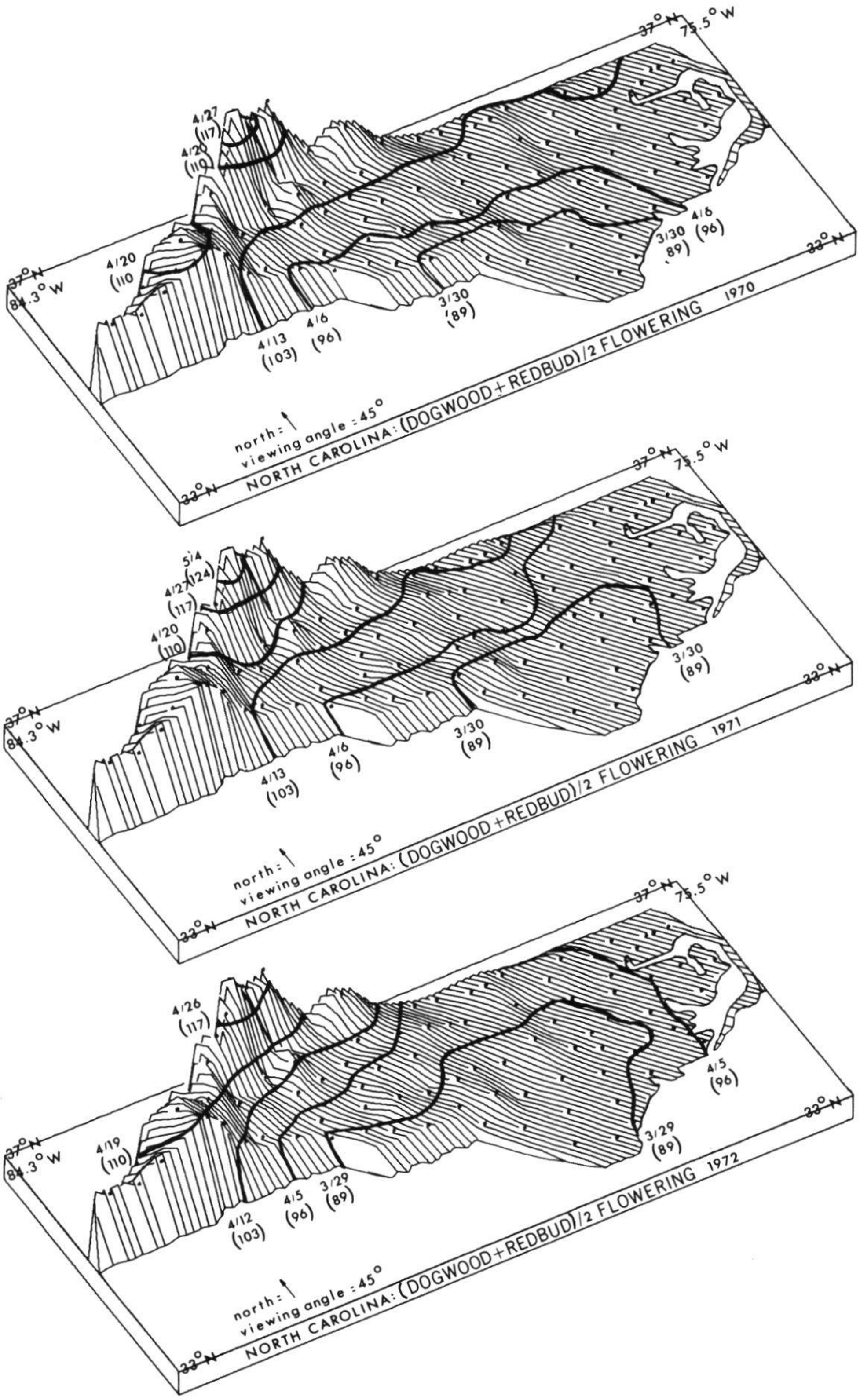


Fig. 4. Arrival of Spring in North Carolina = $\frac{\text{dogwood + redbud flowering}}{2}$ for the years 1970-1972. The isolines for calenderdates and (yeardays) are drawn into a 'Symvu' plotting of the orographic profile of North Carolina.

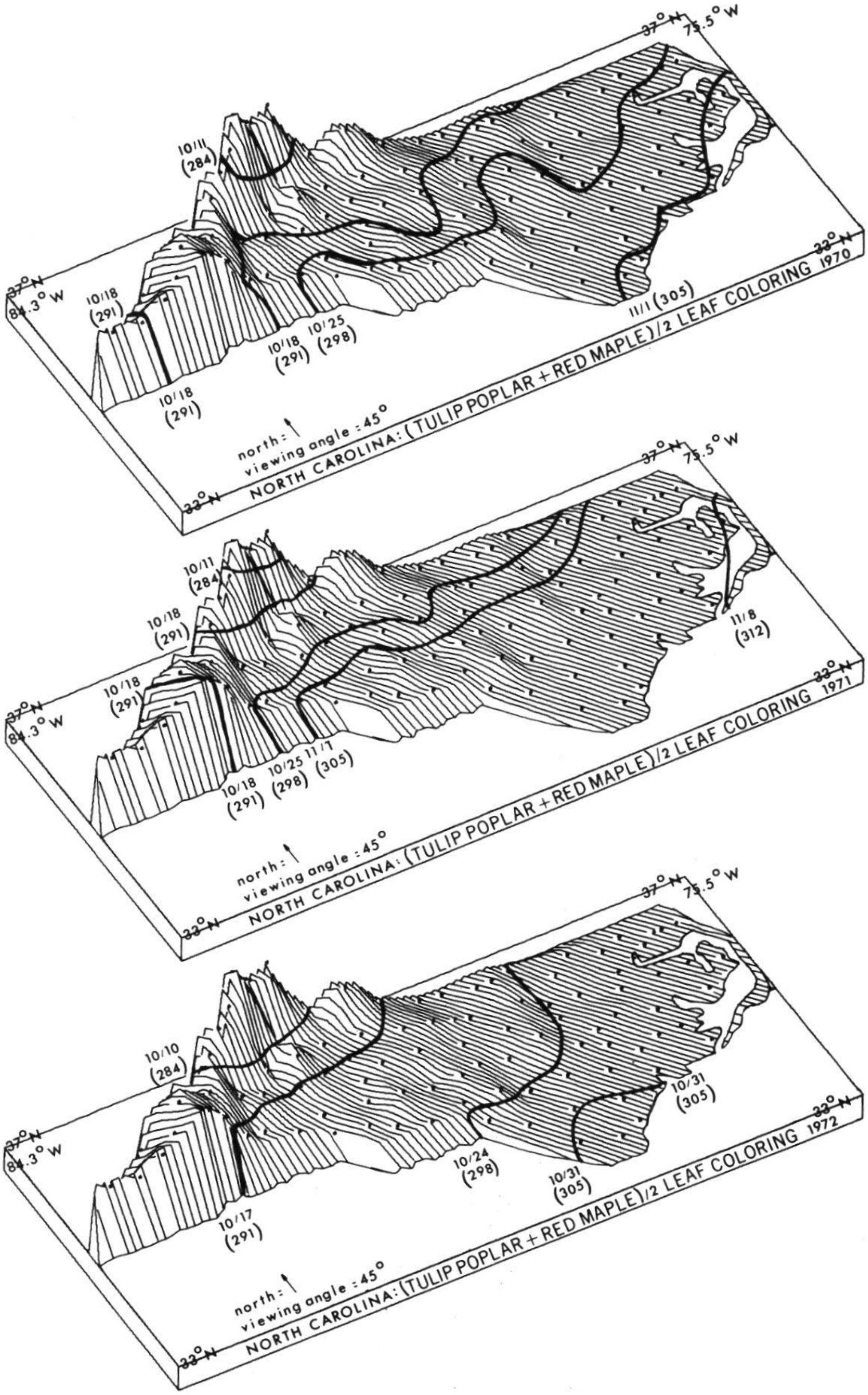


Fig. 5. Arrival of Fall in North Carolina = $\frac{\text{tulip poplar + red maple leaf coloring}}{2}$ for the years 1970-1972.
The presentation of the data is the same as in fig. 4. Tulip poplar = *Liriodendron tulipifera*, Red maple = *Acer rubrum*.

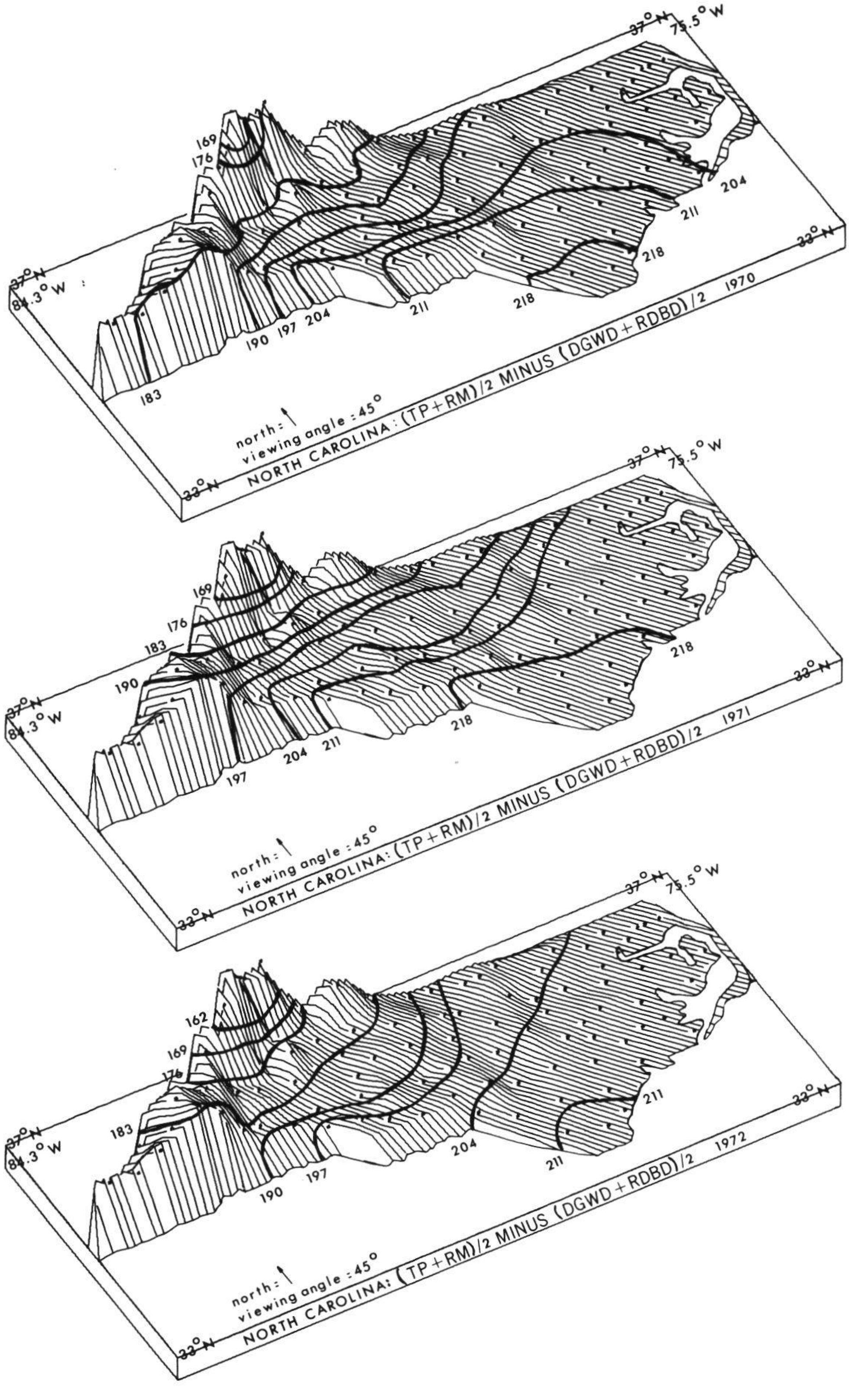


Fig. 6. Length of the vegetation period in North Carolina for the years 1970-1972. The relief map is the same as in figs. 4 and 5.

2. Vegetation or species distribution pattern and climate.

To analyze how disjunct species distribution, endemism as well as vegetation types may be influenced by climatic forces North Carolina offers excellent opportunities. The difference in elevation from near sea level at the coastal plain to more than 2000 m at the peaks of several mountains provides climatic analogues from subtropical climate to boreal. It is logical, therefore, that several northern species find their southern limit in the Carolinas, usually in the mountains, but not always, as was demonstrated during the field trip on *Hudsonia ericoides* L. (see fig. 3). Numerous species of the South reach their northern limit in the coastal plain of North Carolina. One of the most interesting species seen during the IPE is *Sabal palmetto* Lodd. ex Schultes which has its northernmost stand in the south-east corner of North Carolina (see fig. 3). From the other two *Arecaceae* is *Sabal minor* (Jacquin) Persoon more frequent in the coastal plain and *Serenoa repens* (Bartram) Small reaches South Carolina just in the south-east, e.g. Jasper and Beaufort counties where we saw it on Hunting Island.

Several endemic species occur in smaller areas either in the coastal plain or in the mountain. Three examples are shown in fig. 3: *Shortia galacifolia* T. & G. the Oconee bells; *Hudsonia montana* Nuttall, and *Dionaea muscipula* Ellis the venus fly trap. For all the endemic species the ecoclimatic investigations are largely pending. For such studies it appears as if climatic parameters like seasonality or extreme forces like devastating forces are as important as the standard factors temperature and precipitation. Besides climatic parameters one can also expect that all soil properties may be important for the habitat that maintains the existence of endemic species.

The decision whether climatic or edaphic parameters provide the main limiting factors for the species in the Carolinas is difficult to obtain in many cases for more frequent plants. As an example we show in fig. 3 several *Sabatia* species restricted to the savannas and swamps of the coastal plain. While the three species delineated in fig. 3 for the Carolinas show a clear affinity to the coastal plain other species of this genus have disjunct oc-

Table 1. The terminology of the 7th approximation and some in Europe commonly used names for soil types.

Order	Suborder	Designation of similar types of soil of former classification systems
Entisol	Aquent	Little developed gley (all areas)
	Psamment	Raw soil, ranker, alluvial sandy soils (all areas)
	Fluvent	Raw soil, ranker, alluvial soils of loam and clay with changing humus contents in the lower profile
	Orthent	Raw soil, ranker originating from silty or clay rock, decreasing humus content in lower levels
Vertisol	Torrert	Vertisols (Smonitzes) with dry solum the year round
	Ustert	Vertisols, soaking and shrinking several times yearly, and open cracks > 90 days
	Xerert	Vertisols, soaking and shrinking once yearly, and open cracks through > 60 days
	Udert	Vertisols with almost continuously moist solum
Inceptisol	Aquept	Gley, pseudogley, tundragley, marshes and similar soils
	Andept	Soils containing large quantities of allophanes and/or vulcanic ash (andosoils)
	Umbrept	Ranker and brown soil with dark coloured decaying or raw humus horizons
	Ochrept	Ranker, brown soil and pelosols with light coloured mull or mor horizons
	Plaggept	Plaggensoils
	Tropept	Tropical soils of little weathering
Aridisol	Orthid	Desert soils, semi-desert soils, solontshaks ranker, raw soils, rendzina or similar soils in areas without B_t-horizon
	Argid	Desert soils, semi-desert soils, solonez or similar soils with B_t-horizon
Mollisol	Rendoll	Rendzina soils and similars rich in humus
	Alboll	Pseudogleys rich in humus (planosols) solonez, solode and similar soils
	Aquoll	Gleys rich in humus, solontshak and solonez partly grassland soils and similar soils
	Boroll	Black soils, brunizems with < 8^{o} yearly mean temperature
	Udoll	Brunizems, black soils with > 8^{o} yearly mean temperature
	Ustoll	Castanozems and similar soils
	Xeroll	Burozems and similar soils

Table 1 (continued)

Order	Suborder	Designation of similar types of soil of former classification systems
Spodosol	Aquod	Gley-podsol (all areas)
	Humod	Humus-podsol (under heath vegetation)
	Orthod	Podsol-brown soil and humus-iron podsols
	Ferrod	Iron-podsols
Alfisol	Aqualf	Stagnogley, pseudogley-parabrown soil and similar soils
	Boralf	"Fahlerde" (cooler climates) and similar soils
	Udalf	Parabrown soil (temperate-cool areas)
	Ustalf	Mediterranean soils (cinnamon coloured soils and similar soils (predominantly mediterranean to tropical areas)
	Xeralf	Similar to Ustalf, but drier
Ultisol	Aquult	Reddish coloured gley with clay movement
	Udult	Red yellow podsolic soils, jeltozems and similars (with an A_h-horizon relatively poor in humus)
	Ustult	Similar to udult, but drier
	Xerult	Similar to ustult, but still drier
	Humult	Rubrozems (with A_h-horizon rich in humus)
Oxisol	Aquoz	Groundwater laterites and similar soils
	Humox	Red brown latosols and other humus rich soils
	Orthox	Latosols, mainly moist, yearly mean temperature > 22° C
	Ustox	Latosols, intermittendly moist, yearly mean temperature > 19° C
	Torrox	Latosols, nearly year round dry
Histosol	Fibrist	High mor and others of little decomposition
	Hemist	Low mor (medium humification) peat-stagnogleys
	Saprist	Low mor (strongly humified) "Anmoorgley" "Tangelrendzina" and other mineral soils with > 4 dm humus cover

currances in the mountains e.g. *S. campanulata*. The common environmental force for this species is the occurrence of peat bogs. The general sensivity of several species in this genus to edaphic conditions is reinforced by the species *S. stellaris* which occurs only on brackish marshes and is therefore confined to the tidewater region.

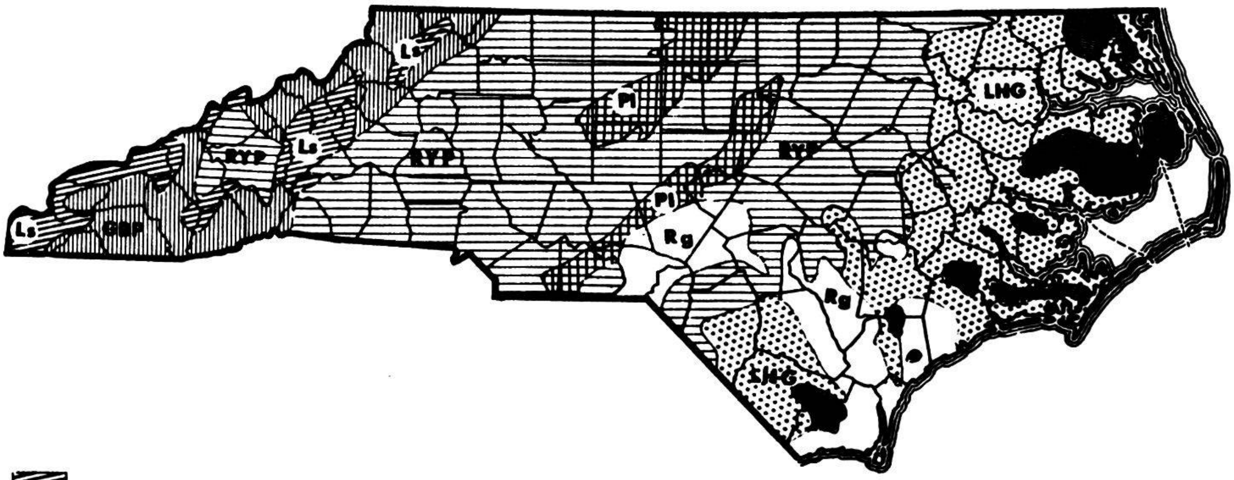
Some elements used to construct the climate diagrams are especially useful when structural features of the vegetation are compared. The similarity of life forms, physiognomy, leaf properties etc. for the regions outlined on the world map in fig. 2 are generally known. They were studied in detail among other correlations between climate variables and structural properties of the vegetation by BOX (1978).

Another interesting aspect of the regional climate similarities is the comparison with the regions from where woody species commonly cultivated in North Carolina originate. From the respective paper by PARKS (1979, this volume) we learn that the majority of these plants originate in the regions shown in fig. 2.

3. The soils of the Carolinas.

It is the common experience of phytogeographers that similar climates produce similar soils from comparable parent material. A general overview of the soil types in the area visited was provided as a lecture at the beginning of the field trips. Written reports, however, are only provided along with vegetation descriptions from a few regions. While the oral presentation used terminology generally familiar to vegetation scientists the written reports include terms little known outside of America. We therefore include a table in which the latest terminology of the "7th approximation" is paralleled with terms commonly used in Europe. The table was translated from SCHACHTSCHABEL, BLUME, HARTGE and SCHWERTMANN (1979).

Since no other summary report on the soils of the Carolinas is provided we include as fig. 7 a map of the great soil groups of North Carolina, redrawn from LEE (1955). The legend to this map contains the old and the approximate new nomenclature according to table 1.



Ls Lithosol	Entisol (Orthent)
GBP Gray-Brown Podzolic	Inceptisol
RYP Red-Yellow Podzolic	Ultisol
Pl Planosol-Red-Yellow Podzolic	Mollisol-Ultisol
Rg Regosol	Entisol (Psamment) and Spodosol (Humod)
LHG Low-Humic Gley	Spodosol (and Fluvent)
M Muck	Histosol

Fig. 7. The great soil groups of North Carolina from LEE (1955). The legend uses old terminology (from LEE) and the approximate equivalent of the 7th approximation according to table 1.

4. Final remarks.

The introduction to this volume was intended to be a supplement to the papers presented in the two report volumes for the 16th IPE. We have provided the background information needed to understand the papers included in volume 1. If we see that some of the papers still pending for volume 2 need further introduction we will furnish that at the beginning of volume 2.

As an organizational basis for the understanding of distribution maps for species and vegetation types, it is custom in America to use political boundary maps. We therefore include as fig. 8 the county outline map for the Carolinas which also contains the delineation of the physiographic provinces.

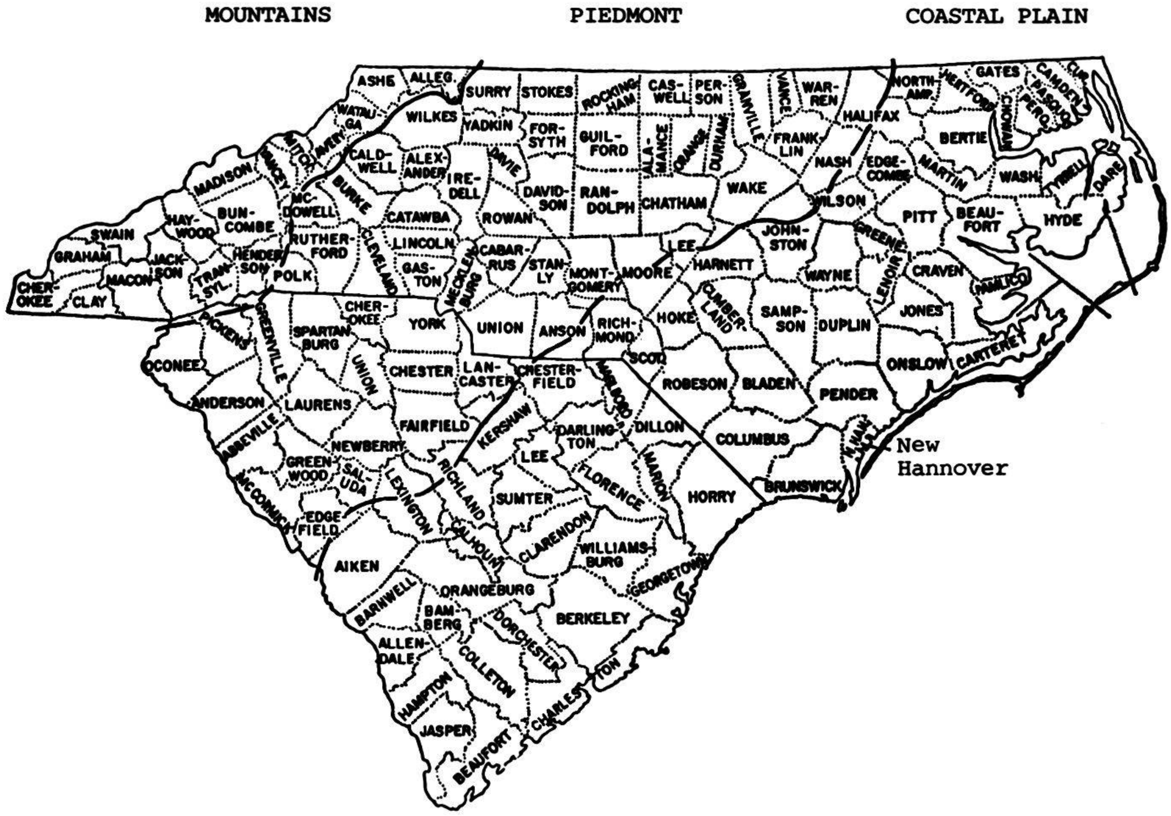


Fig. 8. The physiographic provinces and the names of the counties in the Carolinas. Distribution maps for plants in the United States are commonly drawn over county outline maps. Note that in newer maps of physiograhic provinces the tidewater province is separated from the coastal plain province. See ROBINSON (1979, this volume) for more detail on the physiography of North Carolina.

We hope that the many discussions during the IPE as well as the many problems touched in the written reports will stimulate further research in this most interesting area of the North American continent.

Summary

The paper intends to furnish information needed to better understand the following papers. Besides some geographical details the paper deals basically with 4 different subjects:

1. Comparison of the climates of the Carolinas with regions of the world with similar climates. For the comparison climate diagrams from WALTER and LIETH (1961-1967) are used.
2. Additional climate attributes, such as seasonality and destructive windforce are discussed.
3. Some general features of the soil type in North Carolina and the terminology of the 7th approximation are presented. The latter is tabulated parallel to the terms commonly used by European soil scientists.
4. The distribution pattern of several species, common as well as endemic, are discussed with respect to climate and soil. The need for intensive studies in this area of research is specifically stated. This fact was one of the reasons why the 16th IPE was invited to the Carolinas.

Zusammenfassung

Die vorliegende Arbeit enthält die Informationen, die zum leichteren Verständnis der folgenden Beiträge notwendig sind. Neben geographischen Angaben werden 4 weitere Themen behandelt:

1. Das Klima in den Carolinas wird mit ähnlichen Klimaten anderer Regionen der Erde verglichen. Dabei werden Klimadiagramme nach WALTER und LIETH (1961-1967) verwendet.
2. Weitere Klimaeigenschaften wie Vegetationsperiode und destruktive Windstärken werden behandelt.
3. Die allgemeinen Bodentypen in Nord Carolina werden angegeben, die Terminologie der "7th approximation" wird erläutert an Hand einer Tabelle, die diese Terminologie den in Europa üblichen Termini gegenüberstellt.
4. Die Verbreitungsmuster mehrerer Arten, häufig endemischer Form, werden in Zusammenhang mit Klima- und Bodenfaktoren behandelt. Dabei wird ausdrücklich auf die Notwendigkeit von ökologisch-bioklimatischen Studien zum Verständnis der Artenverbreitung hingewiesen. Die Anregung zu solchen Studien zu geben, war einer der Gründe für die Einladung, an der 16. IPE in die Carolinas teilzunehmen.

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