From Tree to Region: Evaluating Tree Species Diversity in Tropical Rainforests, Examples from French Guyana

J.-F. Molino, D. Sabatier, P. Birnbaum & M.-F. Prevost

Introduction

Our knowledge of tree species diversity in tropical rainforests comes from two different approaches. The first one is taxonomic and floristic surveys, based on the study of herbaria collections, and the second one is field inventories on permanent or semi-permanent plots.

Floristic studies are still incomplete in most parts of the tropical world. Many plant families strongly need to be accurately revised, species unknown to science are frequently collected and have to be described and named. Such works give estimations of species richness at regional, national or continental scales but according to the disparity of collection densities they do not account for the geographical variations of both species richness (i. e. number of species) and diversity (i. e. the properties of the species mixture).

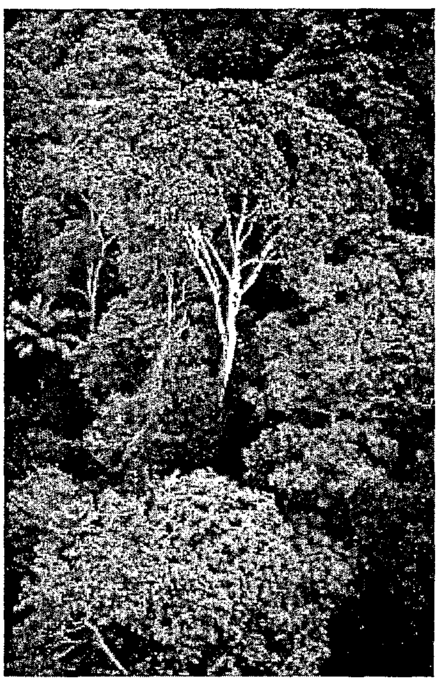

Fig. 1: Emergent tree near an old gap, Montagne Cacao. Example of canopy structure generated by natural disturbance.

On the other hand, exhaustive field inventories give true measures of species diversity but are hardly possible on large surfaces (for tree species studies, plots range usually from 1 to 20 ha, very rarely up to 50-100 ha). Data collected show not only high levels but also important variations of tree densities and species richness (e. g. in French Guyana, 450 to 800 individuals/ha and 130 to 200 species/ha, for trees with DBH – diameter at breast height – above 10 cm [4, 6]), but also that inventoried plots are never large enough to allow any extrapolation of the results to a larger scale.

In other words, tree species diversity, which is an aspect of tropical rainforests heterogeneity, is very high at all scales, but also very variable, and we do not know how to measure or estimate it at intermediate scales (10 to 10 000 km^2).

But it is just at these intermediate scales that there is a great need of information today, either for biodiversity conservation or for forest management purposes.

Since the mid-80s, our team of ORSTOM's botanists have conducted ecological studies in French Guyana, through field inventories of forest trees. A census of the tree community covering about 30 ha has been made in various locations all over the country, but particularly in two research stations, Piste de St. Elie's (5°18'N, 53°3'W) and Les Nouragues (4°5'N, 54°40'W). The numerous botanical vouchers collected during this work have been deposited in Cayenne's Herbarium (CAY), contributing to the global floristic knowledge of the region (see Flora of the Guianas series and Flora Neotropica monographs).

Starting from these basic works, we now aim at investigate intermediate scales using new methods and tools. Hereafter our goal is to present, at each scale of study, the relevant aspects of tree species diversity and the problems to be solved to achieve a multi-scale evaluation method.

Local level

The main factor determining the qualitative and quantitative characteristics of the species mixture around a tree is local dominance (i. e. the outnumbering of one species over others). Unevenness of local dominance, which results in different specific dispersion patterns and variations in species mixture, has a lot of causes, among which the most often cited is disturbance (mortality and structural disorganization) [4] (Fig.1).

Plot level

Rainforest tree species are often very reactive to faint environmental variations. Such a fine tuning leads to short-distance changes in community composition [5].

This drift generates between-community (β) diversity which is combined at the plot level with within-community (α) diversity.

Then it is almost impossible to measure independently α and β diversity. In practice, to point out spatial variations of the species mixture within a plot, one has to discretize the whole diversity into pinpoint values measured on adjacent small surfaces (Fig. 2a & b).

Comparison between observed and theoretical variations in local diversity values emphasizes the importance of local dominance, which reflects uneven dispersion of some species.

Interpreting local-scale images of the forest is a major challenge and the real blocking point on the way to regional-scale evaluation of biodiversity.

Among many interrelated/correlated data collected from within the forest ecosystem in a 3-D space (Figs.2 & 3), which are visible from above, on a 2-D image (Fig. 4).

Is biodiversity well correlated to one (or more) characteristics of forest canopy's remote views?

Landscape level

Between-plots comparison of species richness emphasizes the different sources of β diversity, both environmental (topography, variations in water availability and/or microclimate) and historical (distribution and frequency of perturbations, rhythm and nature of subsequent regeneration [1, 2]) (Fig. 5).

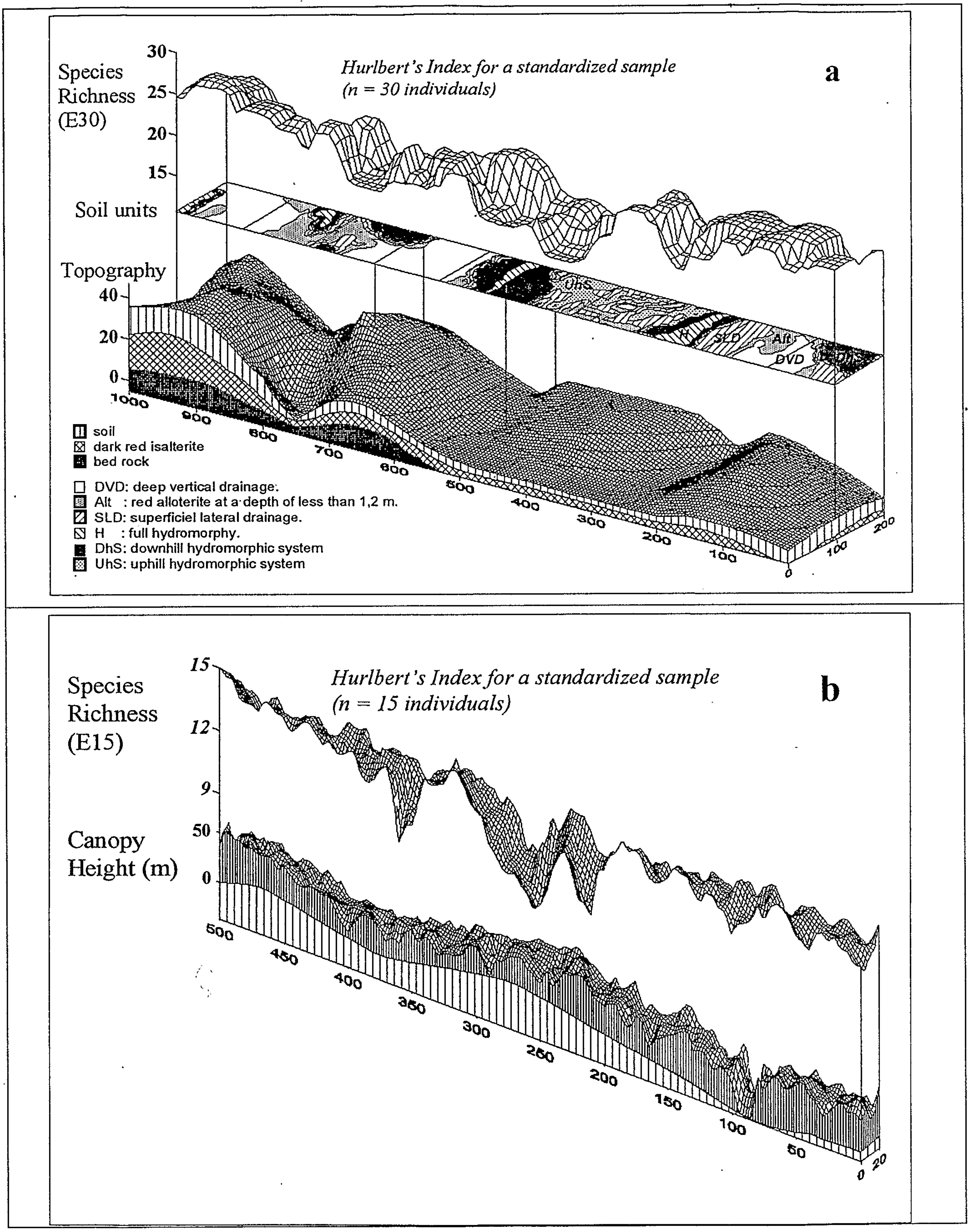

Fig. 2: Variations of tree species richness are not obviously linked to environmental changes. Examples from an undisturbed forest Piste de St. Elie. a: 10 ha plot, trees with DBH > 10 cm, edaphic factors. b: 1 ha plot, understorey trees with 2 cm < DBH < 10 cm, comparison with canopy upper surface.

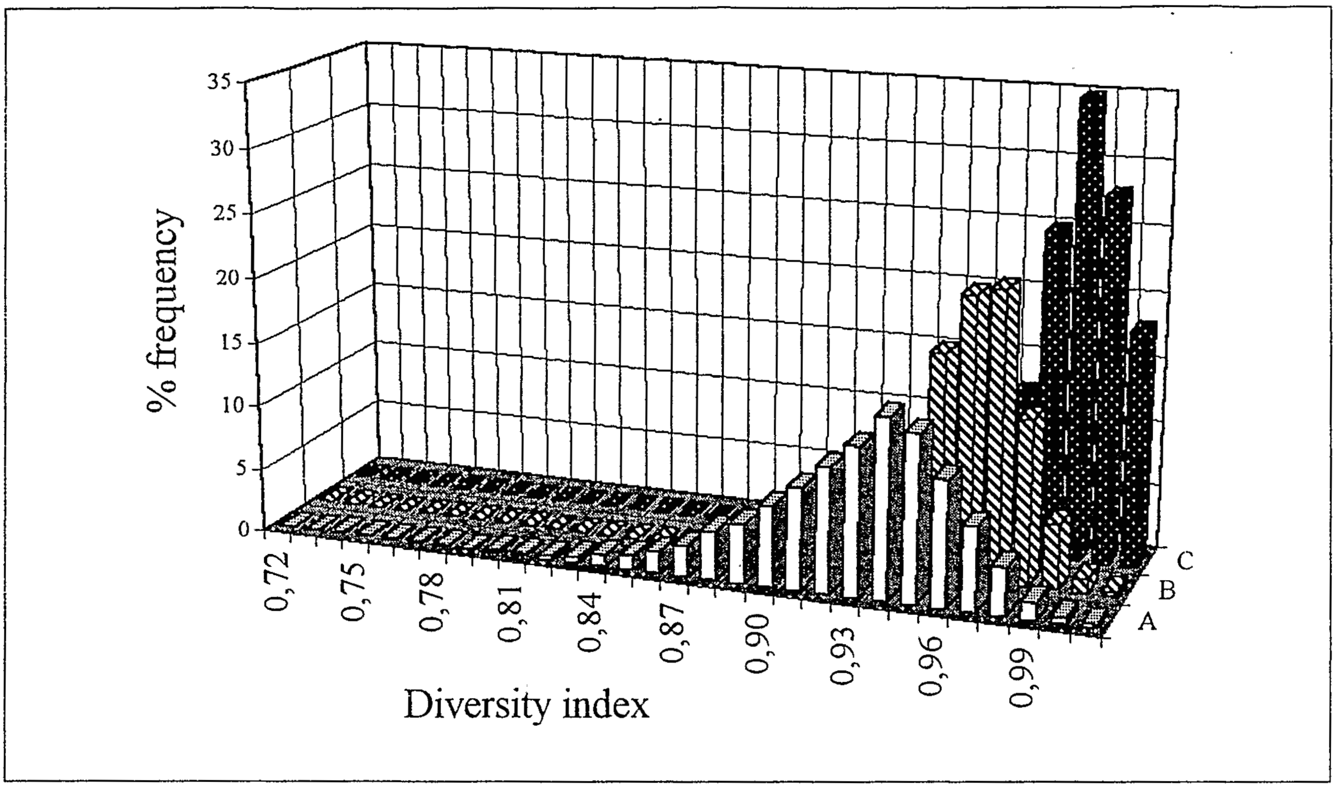

Fig. 3: Distribution of the local diversity values. A: Observed Hurlbert's Index values (see Fig. 2A). B: Theoretical values for a random species dispersion model (weak local dominance). C: Theoretical values for an over-dispersion model (no local dominance).

Fig. 4: Both structural and radiometric heterogeneity of the canopy roof reflect species diversity. Comté flat, near Nancibo.

The expression of these factors on the canopy in terms of roughness, grain of crowns or spectral variations can be more or less easily mapped on a picture (Fig. 6), following patterns scarcely perceptible at plot level.

Regional level

The main challenge at regional scale (Fig.7) is to identify biogeographical units, i. e. areas in which all landscape units share the same patterns of variations and have a common floristic potential. Understanding the rules underlying these patterns is part of the evaluation method.

Conclusion

There is today an urgent need for new methods of biodiversity evaluation at landscape and regional scales. Field studies on limited areas are still necessary, but we should now find a way to extrapolate

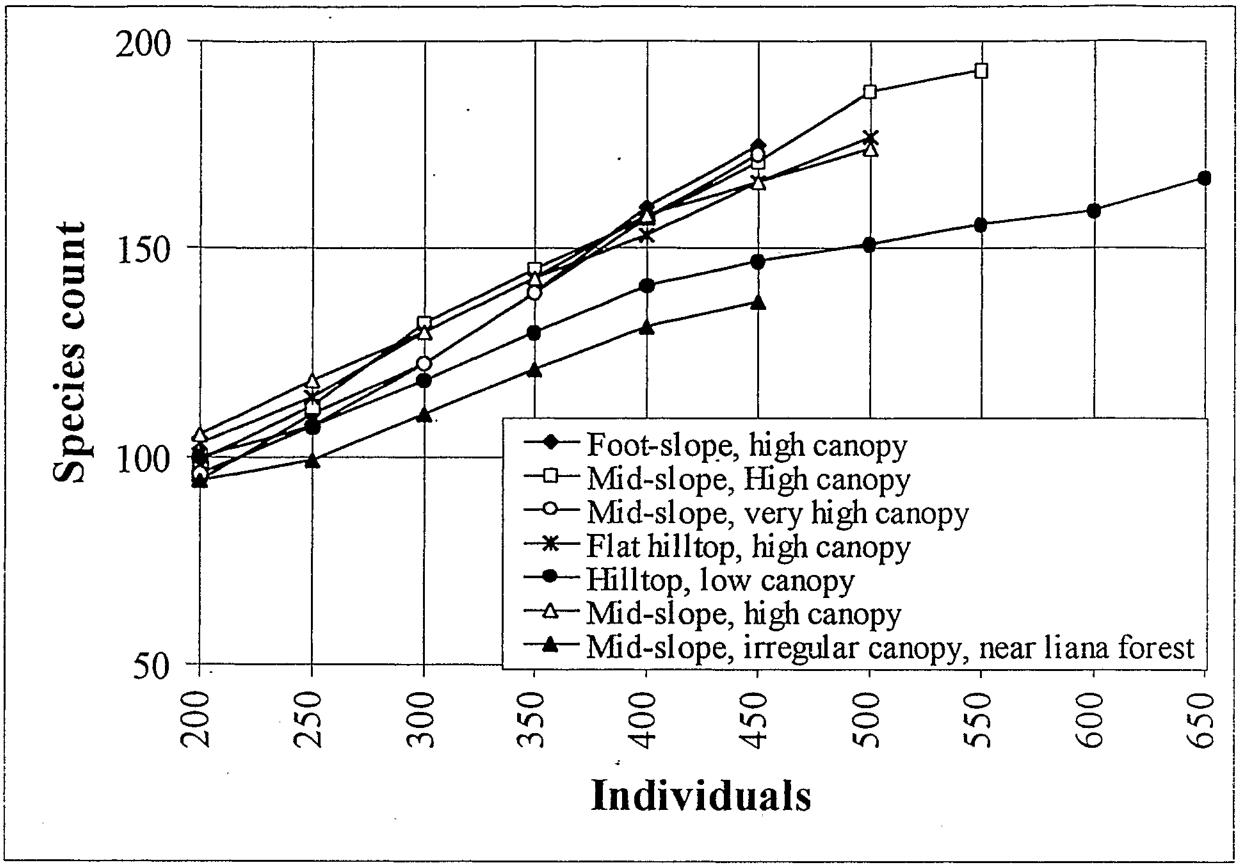

Fig. 5: Changes in species richness among seven 1-ha plots distributed along a topographic gradient, Les Nouragues station. Liana forest represents a high degree and frequency of perturbation.

from these scattered, local-scale measures to regional-scale evaluations, which necessarily involve remote-sensing and modeling tools.

Acknowledgements

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Selected references

[1] BIRNBAUM, P., 1997 – Modalités d'occupation de l'espace par les arbres en forêt guyanaise. Thèse de Doctorat Univ. Paris VI, 221 pp.

[2] BRÜNIG, E.F. & Y.-W. HUANG, 1989. – Patterns of tree species diversity and canopy structure and dynamics in humid tropical evergreen forest on Borneo and in China. In Holm-Nielsen, L. B., I. C. Nielsen & H. Balslev (Eds.) : Tropical forests. botanical dynamics,

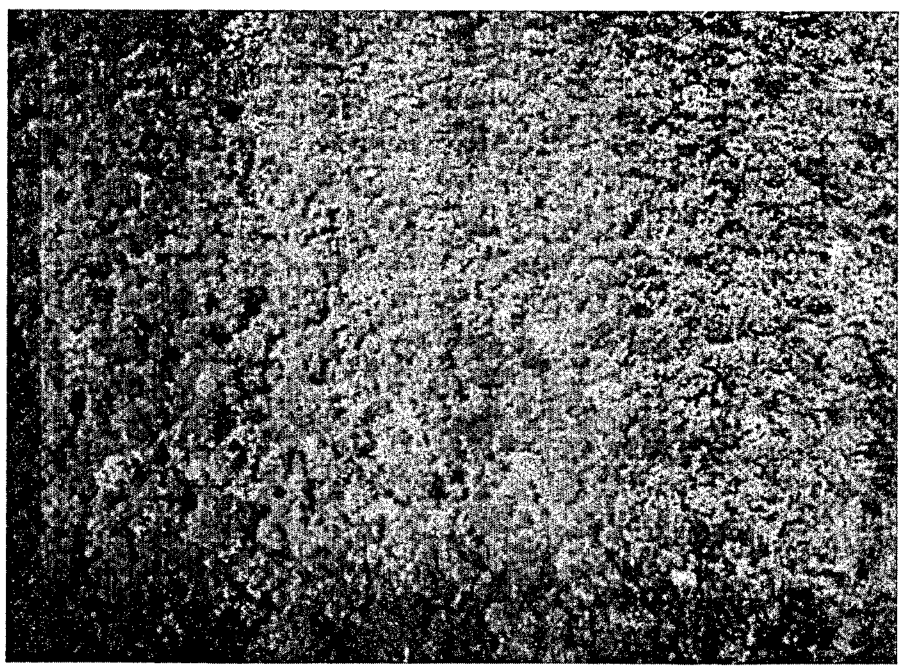

Fig. 6: Patterns of structural and radiometric heterogeneity of the canopy roof reflect changes in the tree community related to edaphic factors as well as recent or historical events. Inini region, near Dorlin.

Fig. 7: Landsat view of Sinnamary Basin, 17/08/1988 (data processing: A. Minghelli, Maison de la Télédétection, Montpellier).

speciation and diversity. Academic Press: 75-88.
[3] HURLBERT, S.H., 1971. The non concept of species diversity: a critique and alternative parameters. Ecology, 52: 577 - 586
[4] PREVOST, M.-F. & D. SABATIER, 1996 - Variations spatiales de la richesse et de la diversité du peuplement arboré en forêt guyanaise. In: Guillaumet, J.-L., M. Belin & H. Puig (Eds.) – Actes du Colloque "Phytogéographie tropicale. Réalités et perspectives", Paris, 6-8 Juillet 1993. ORSTOM. pp. 263-277.
[5] SABATIER, D., M. GRIMALDI, M.-F. PREVOST, J. GUILLAUME, M. GODRON, M. DOSSO & P. CURMI, 1997 – The influence of soil cover organization on the floristic and structural heterogeneity of a Guianan rain forest. Plant Ecology 131:81-108.
[6] SABATIER, D., 1993 – Diversité des arbres et du peuplement forestier en Guyane. In: Actes du Congrès SEPANGUY "Gestion de l'écosystème forestier et aménagement de l'espace régional", Cayenne, 16-17 Février 1990. pp. 41-48.

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Functional Role of Biodiversity in Forest Ecosystems of Caucasus

Mikhail V. Pridnya

Abstract

The structural organization of forest ecosystems is largely determined by following functional population and coenotic mechanisms.

Centuries-old exchange of the genetic information, forming integrated genetic funds of populations of the dominants in ecosystems, causes its organization. The subordinated circles are connected by population systems and coenotic mechanisms and are adapted by the vital forms and cycles of development to the environment formed by dominants. In populations of sympatric species the spatial structure of populations, species, phytocoenosises and formations prevails.

The special role in forming of phytocoenosises and formations as organized components of ecosystems and landscapes belongs to the phenomena of constitution (incumbation) of circles of vegetation, which are brightly expressed in a subalpine belt on Caucasus. Incumbation of circles are characteristic for the east beech, common birches, high-mountainous maple, Rhodoretums = Caucasian and yellow, bilberry heath = Caucasian and ordinary, and also subalpine tall herbaceous vegetation.

The differentiation of populations of Caucasian fir on phenotypes of different efficiency forms structural elements of phytocoenosises, in which the circles are allocated dominant and subordinated within the limits of one coenopopulation. The similar phenomenon is revealed and in populations of a number of grassy species (Synskaja, 1948). Thus the high productivity phenotypes occupy positions of the leaders, whose growth submits to the law of rank behaviour, rather than the formation coenocells being caused.

At a number of the vital forms the organization of populations raises by formation of extensive durable clones (rhodoretums, aspen), and also – by self-inoculations between copies *(Parrotia persian).*

The organization of ecosystems is defined by volume and structure of the phenotypical and coenotypical information, in this aspect the decoding of a role of a biodiversity of Colches and Girkanian tertiary relict centres is important. Taxons of different geological age of a number of ecosystems are reliable objects for revealing laws of functional organization of ecosystems. A saturation by them of a number ecosystems: Girkanian, Colches, Mediterranean and boreal, is natural

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Some texts were slightly modified by the editors, mainly in order to overcome language problems, and the text was not revised again by the author. It was not meant to change the contents, but if the modification resulted in a different meaning, it is solely the responsibility of the editors.

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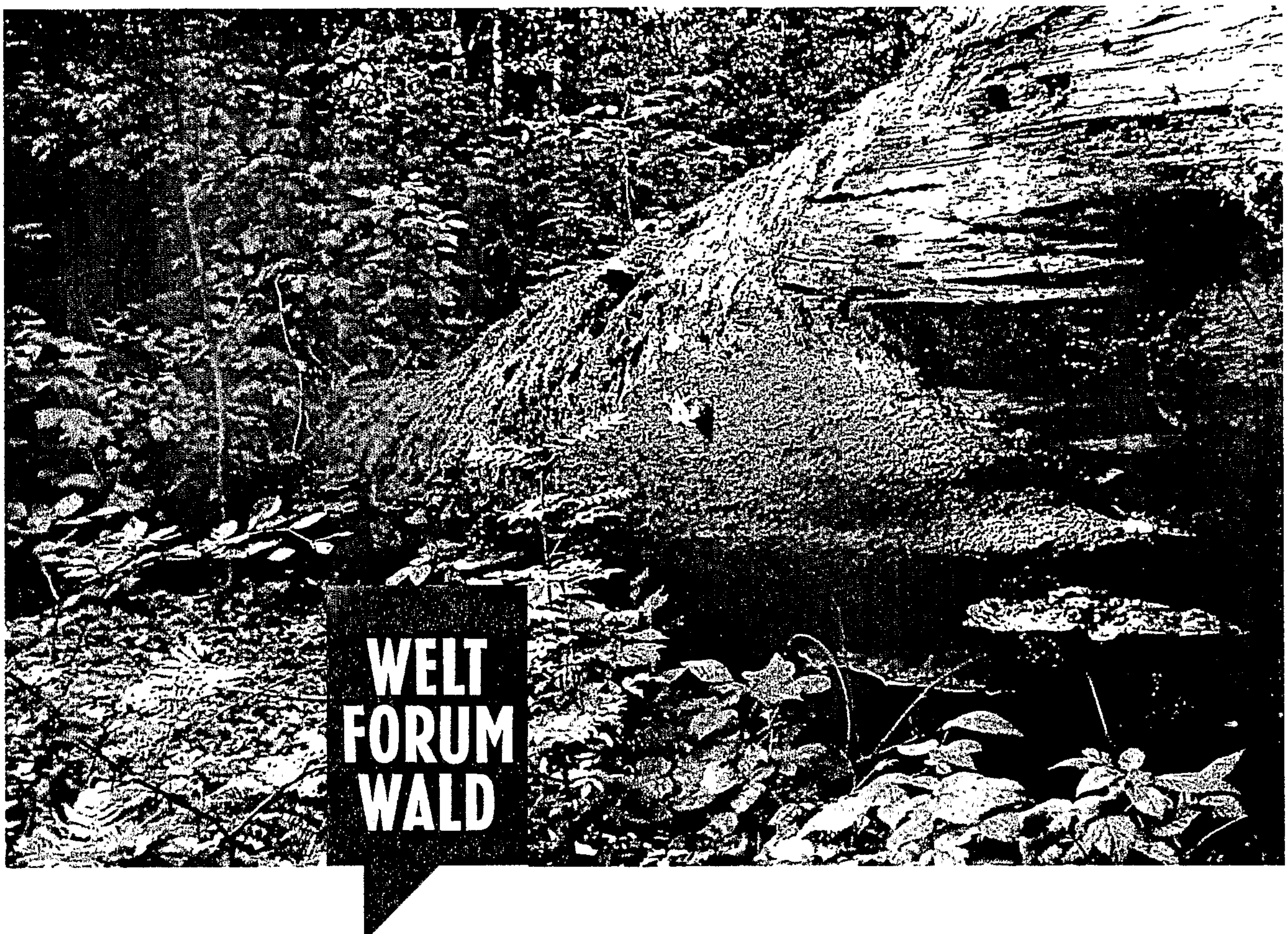

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