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BIOMASS POOLS AND PRIMARY PRODUCTIVITY OF NATURAL AND MANAGED ECOSYSTEM TYPES IN A GLOBAL PERSPECTIVE

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ABSTRACT

The paper presents net primary productivity values and biomass data useful for the work in landscape management. The respective data compiled in a computer file at the University of Osnabrück are presented and some examples for their use in global primary productivity research are described.

RESUMEN

Este artículo presenta valores de productividad primaria neta y datos de biomasas útiles para el trabajo de ordenación del paisaje. Se presentan los datos respectivos, compilados en un fichero de ordenador en la Universidad de Osnabrück, y se describen algunos ejemplos para su utilización en la investigación sobre la productividad primaria global.

INTRODUCTION

The biomass structure together with the productive power of the vegetation provide unique data for a landscape. Information on net primary production is of special utility for agriculture and forestry. Also, the esthetic value of the landscape is influenced by the percentage of the annual productivity accumulated in standing crop. The standing crop is even more impressive, if its structure consists of tall trees, and profusely flowering bushes, or if it provides support for large varieties and populations of animals. The landscape manager is therefore well advised to keep these natural properties of ecosystems as a major decision factor in his planning process.

While it is logical that the landscape manager works basically with the natural properties of his own home region, he should always keep the option open to change the structure or productive potential of a given landscape to a state either more desirable, more interesting, easier to manage or more productive.This includes introduction of features from exotic areas. It is therefore convenient to understand the relevant features from a variety of places compared with the endogenous ones.

The present paper provides on a global scale the major characters of vegetation types relating to primary productivity in a computer map.

The data published in this paper are extractions from a computerized data file which may be obtained at cost from the author. Request should be made with reference to DATA-VW.

THE EXCERPTS FROM THE DATA-VW-FILE

The basic tables for the study contain net primary productivity and biomass density values in weight units per surface area unit per year for a variety of vegetation formations, or individual vegetation types grouped by continents and countries.

The following tables are available:

Table 1: Biomass characteristics of vegetation formations distinguished by Schmithüsen.

Table 2: NPP- and biomass amounts for different vegetation types as they are available in our computer file.

Table 3: Extraction of all entries with both variables, NPP and Biomass amount listed in table 2.

These tables were originally prepared to assess the CO_2 accumulation in standing crops for the Osnabrück Biosphere Model. The entries were calculated from the analysis of Schmithüsen's atlas to obtain the vegetation type area sizes and from the DATA-VW collection as listed in table 2 for the biomass densities.

The increased amount of data for biological and environmental parameters generated in the last decade has enabled us to revise the Miami and Montreal models for global net primary productivity (NPP) patterns (Lieth, 1972; Lieth and Box, 1972). These models consisted of regression equations for NPP vs annual mean temperature and annual average sum total precipitation or mean annual actual evaporation together with the optimized interpolation routine of SYMAP for generating a global NPP pattern based on over 100 meteorological stations covering most areas of the globe.

The earlier method was improved here by entering the natural productivity variations due to soil fertility. This was done by calculating regression lines for individual soil types over the entire climate range where the soil type is found. The soil type for each station was identified from the FAO/ UNESCO soils map. The mean distance of this line from the regression line for the total data set was then used to calculate a soil fertility factor. The factors cannot be calculated for all soil types because data are still missing for several soils.

The NPP values for each meteorological station were calculated with the procedure given in Table 1 and then used to compile the E-value package of the SYMAP program. After several trials to optimize the interpolation routine of the SYMAP program we arrived at the map given in Figure 1, which we call the Hamburg Model (Esser *et al.*, 1982).

The total NPP values for the world on this new map are similar to those in the Miami Model map. The pattern, however, shows greater differences. The main change is the fact that the tropical regions appear now somewhat less productive and the temperate regions more productive (Lieth and Whittaker, 1975).

In order to facilitate the reading of NPP values from the map in Figure 1 we present in Figure 2 the enlarged section for the Mediterranean countries. It must be said, however, that more stations are needed to give a clear picture of the NPP pattern across these countries, as it was done for Central Europe by Aselmann and Lieth (1984) and for Mozambique by Barreto and Soares (1972).

This method has been successfully applied in many cases where other assessments were unavailable. A double check during logging opera-

Figure 1. The net primary productivity pattern of the world calculated with the "Hamburg model" using climate and soil factors to predict productivity.

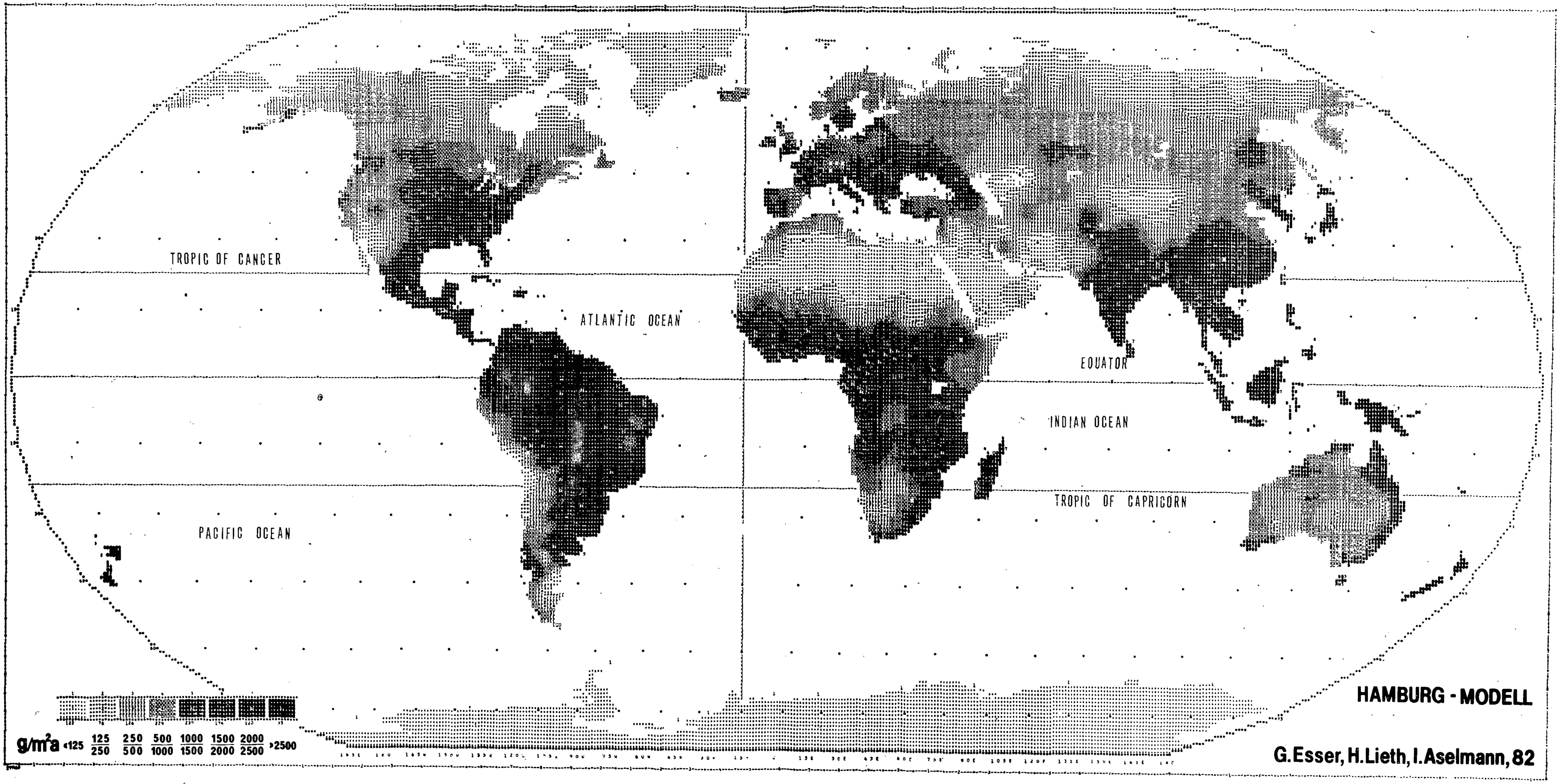
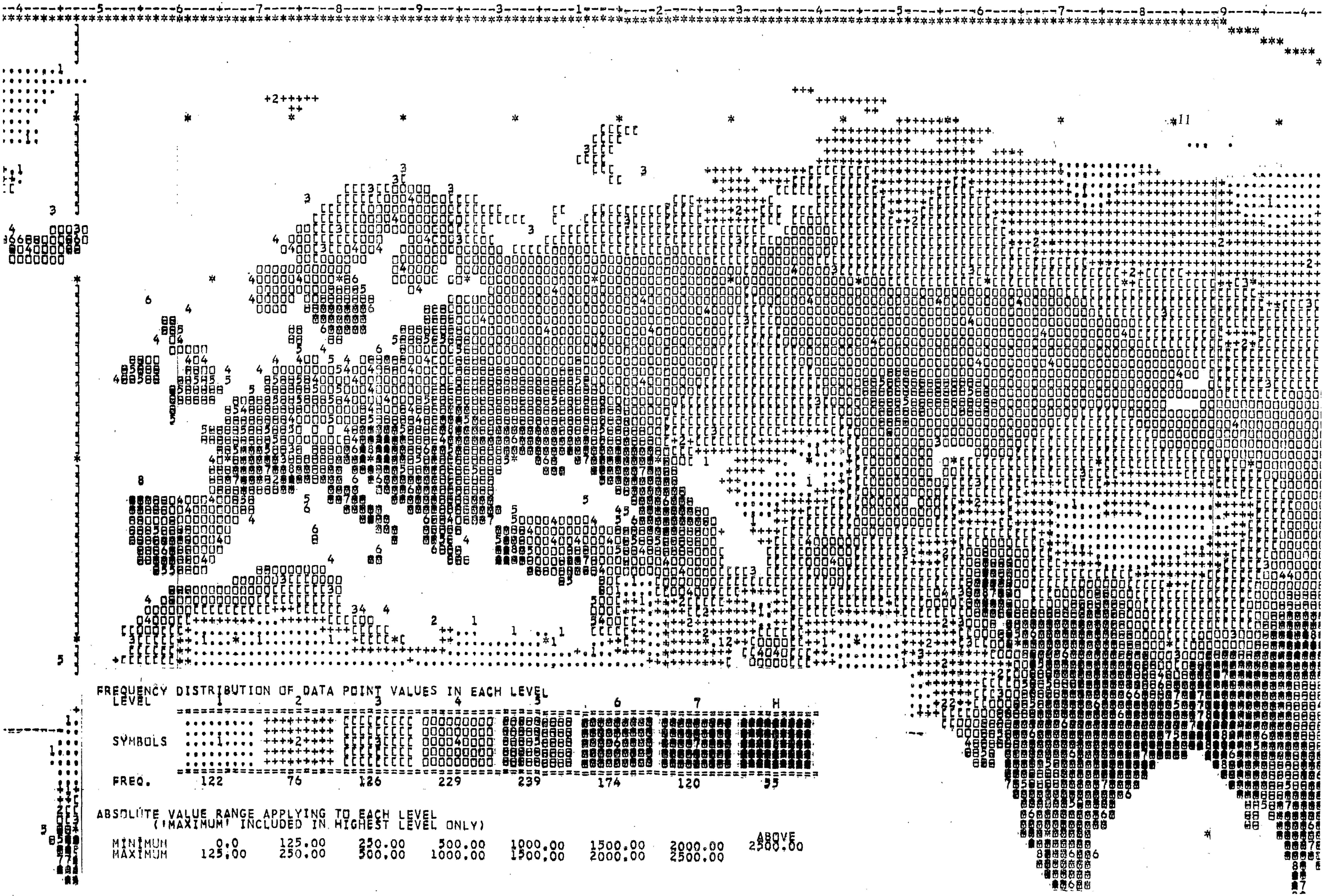


Figure 2. Enlarged section of fig. 1 showing the area of Eurasia. This figure is not more accurate than fig. 1 but provides convenient reading. Using the same equations as published in this paper regional maps can be developed with sufficient accuracy for planning purposes.



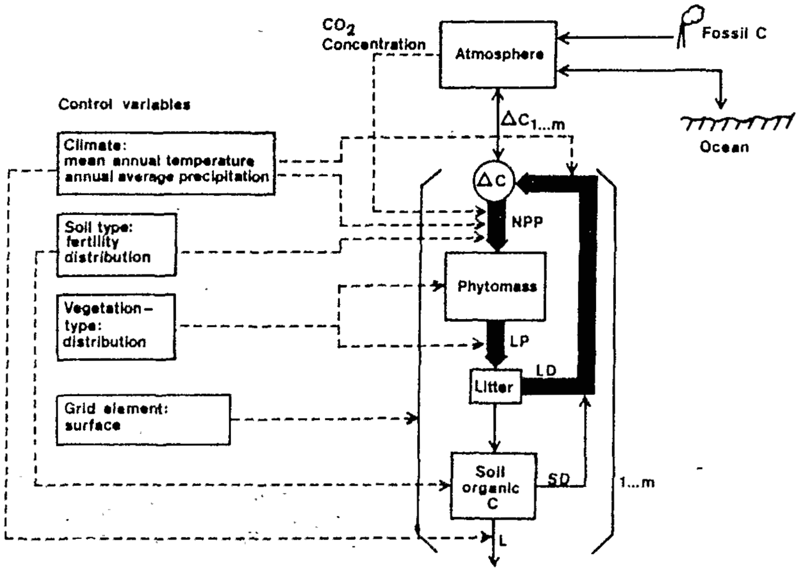
tions and with agricultural yield statistics has been used to establish useful correlations and monograms.

For the region of northern Spain our map predicts a total NPP of 500 - 1000 g dm/ m^2.y. Reading from the stepwise calculations of this figure it is evident that the NPP is mainly limited by precipitation except on the mountain peaks. For the purpose of further uses it might be useful if a Hamburg Model type map were elaborated for the individual countries.

The values given in this paper are useful for many geoecological applications. One application now intensively elaborated by the team at Osnabrück is the evaluation of the impact of the biosphere upon the global carbon cycle. This required many more details about the vegetation than were needed for this paper. These variables were combined into a model structured according to Figure 3. The model enables us to simulate adequately the flux of carbon produced by industry and traffic through the atmosphere and biosphere into the ocean. The complete model and some of its application will soon be published by Esser (in preparation).

Landscape managers with more awareness of the ecological potential of places would certainly bring the values of landscape parts better into the decision making process than is practised today. Awareness coupled with the basic understanding of the biological potential is the best foundation for the discussion of priorities among the planning group. This paper intended to give some important facts as they relate to biological productivity and standing phytomass.

Figure 3. The gross structure of the Osnabrück Biosphere Model (acc. to Esser 1984).



Structure of the OSNABRÜCK BIOSPHERE MODEL for calculation of carbon dynamics in the terrestrial biosphere. The large brackets enclose the model structure on the level of each of the *m* ($m = 2433$) grid elements that yields the carbon balance of each grid element for one year ($C_{i...m}$). The sizes of the arrows and rectangles represent the relative importance of the paths and pools.

The equations for the calculation of fluxes and pools use the control variables (independent variables) indicated by dotted arrows. C carbon, NPP net primary productivity, LP production of herbaceous and woody litter, LD decomposition of litter, SD decomposition of humic compounds in the soil, L leaching of organic compounds.

Table 1. Sequence of calculations to arrive at the NPP values for the locations in the Hamburg Model

Step 1: Take annual average temperature and average total sum of precipitation for a given location.
Calculate NPP values in g dm/m^2 . y, using the following 2 equations:
eq. 1:
NPP = 3000 (1-e$^{-0.00064 \cdot Pr}$) for precipitation
eq. 2:
NPP = 3000/(1+e$^{1.315 - 0.119 T}$) from temperature
Compare NPP from both calculations, take the lowest number (applying Liebig's law of the minimum).

Step 2: Locate station on the FAO/UNESCO soils map and read soil unit.
Read soil factor from table 1.
Multiply final result of step 1 with this factor.
The result is the final value for NPP to be used.

BIBLIOGRAPHY

ASELMANN, I. and LIETH, H., 1984: Über die Jährliche Trockensubstanzproduktion in Mitteleuropa. Progress in Biometeorology, vol. 3, pp. 101-119.

BARRETO, L. S., and SOARES, F. A., 1972: Carta provisoria da productividade primaria liquida ues ecosistemas terrestres de Moçambique. Rev. Cienc. Agron. Lourenço Marques 5: 11-18.

ESSER, G., ASELMANN, I., LIETH, H., 1982: Modelling the carbon reservoir in the System Compartment "Litter". Mittlg. Geolog.-Palaontolog. Inst. Univ. Hamburg SCOPE/UNEP Sonderband 52, 39-58, Hamburg, Geolog.-Palaontolog. Institut.

ESSER, G., 1984: The significance of biospheric carbon pools and fluxes for the atmospheric CO_2: A proposed model structure. Progress in Biometeorology 3, 253-294.

LIETH, H., 1972: Modeling the primary productivity of the world. Nature and Resources 8 (2), 5-10, UNESCO, Paris.

LIETH, H., BOX, E. O., 1972: Evapotranspiration and Primary Productivity; C. W. Thornthwaite Memorial Model Publications in Climatology 25, 37-46, Elmer (New Jersey).

LIETH, H., WHITTAKER, R. H. (eds.), 1975: Primary Productivity of the Biosphere. 339 p.