Vegetation changes in the Speulderbos (The Netherlands) during the period 1958-1988

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Report 23

The WINAND STARING CENTRE, Wageningen (The Netherlands), 1990

ABSTRACT

Hommel, P.W.F.M., E.E.J.M. Leeters, P. Mekkink and J.G. Vrielink, 1990. Vegetation changes in the Speulderbos (The Netherlands) during the period 1958-1988. Wageningen (The Netherlands), The Winand Staring Centre. Report 23.
9 pp.; 1 fig.; 2 tables.

Patterns of vegetation changes were studied in a 950 ha large forest area. The changes are interpreted in terms of either enrichment or impoverishment of the environment. Correlations were studied between these changes and factors such as forest management, soil, forest history, and distance to the nearest farmland. The study was carried out with the computer system ARC-INFO, which allows analysis and statistical manipulation of intricate overlay patterns. The paper presents some of the major conclusions of the study. First, enrichment dominates throughout the area both in old forest sites and in heathland afforestations, and also on all soil types. Second, within 250 m from the nearest farmland, enrichment is significantly higher than in the more central parts.

Keywords: forest ecology, nitrogen deposition, ARC-INFO.

ISSN 0924-3062

This report was published before as:
Hommel, P.W.F.M., E.E.J.M. Leeters, P. Mekkink and J.G. Vrielink, 1989. Vegetation changes in the Speulderbos (the Netherlands) during the period 1958-1988. In: E. Sjögren (ed.), Forests of the world: diversity and dynamics (abstracts). Uppsala, 1989. Stud. Plant Ecol. 18, pp. 109-112.

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The WINAND STARING CENTRE is continuing the research of: Institute for Land and Water Management Research (ICW), Institute for Pesticide Research, Environment Division (IOB), Dorschkamp Research Institute for Forestry and Landscape Planning, Division of Landscape Planning (LB), and Soil Survey Institute (STIBOKA).

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The vegetation of many forests in the Netherlands is changing rapidly. This is due not only to air pollution, but also to the fact that the great majority of the Dutch forests is relatively young, originating from a recent period of extensive afforestation of heathland, which had its peak between 1860 and 1940. Moreover, vegetation changes are induced by forest management (including change of stand), tillage and fertilization, and may vary according to differences in soil, hydrology, et cetera. This implies that within a given forest area, vegetation and vegetation changes may show very intricate patterns, which are hard to interpret in an ecological sense.

The Speulderbos research project aims at a systematical study of such patterns of vegetation and vegetation changes. The methodology developed implies a systematic map overlay procedure, supported by comparison of old and recent relevé data and chemical analyses of soil samples. The overlay procedure is executed with the computer system ARC-INFO, which allows analysis and statistical manipulation of very intricate overlay patterns.

The study area, the Speulderbos, is a 950 ha large forest area situated in the central part of the Netherlands. It comprises both centuries-old forest sites and heathland afforestations of different ages (but none younger than 1885). A wide variety of plant communities is found, which can, however, all be classified as *Quercion robori-petraeae*. All the soils have a sandy texture and most of the soil types common in Dutch forests are present. The water-table is very deep. The area is largely surrounded by other forests, the nearest coherent region of farmland being situated at a distance of 3 to 7 km. However, several smaller agricultural enclaves adjoin the Speulderbos. The nearness of farmland is of importance as a potential source of air polution, viz. deposition of nitrogen (mainly ammonium), causing eutrophication and acidification of soils.

The maps involved in the overlay procedure are vegetation maps compiled in 1958 and 1985/1988, a soil map (including data on tillage and fertilization), a map depicting forestry aspects (such as nature and age of stands, both in 1958 and in 1988), a zonation map indicating the distance to the nearest farmland, and a map indicating various types of forest history. The latter map is based not only on old and recent topographical maps, but also on archival cadastral information. All the maps have a scale of 1 : 10 000.

To study vegetation changes, the vegetation maps had to be combined into one, which implies that their legends had to be made comparable. Therefore, all the plant communities discerned were allotted to one of five community groups indicative for

trophic levels (1). Vegetation change can thus be defined as a shift from one level to another and be interpreted as either enrichment or impoverishment of the environment. Autogenic succession, not involving any change in availability of nutrients, is thus not taken into account.

In the field, vegetation changes are observable in various ways. For instance, in most types a significant increase in nitrogen indicators (e.g. *Dryopteris dilatata* and *Corydalis claviculata*) can be observed. On the other hand, vegetation types dominated by either *Vaccinium vitis-idaea* or *Vaccinium myrtillus* have decreased strongly, whereas in old beech forests the cover of *Leucobryum glaucum* shows a dramatic decrease, locally even from over 30% to almost nil.

Table 1 summarizés the relative significance of enrichment and impoverishment in terms of hectares. It appears that over 50% of the area is enriched, over 10% even moderately to strongly. On the other hand, impoverishment is hardly of any significance (< 5%). The distribution of the vegetations showing either enrichment or impoverishment is shown in Figure 1.

A first analysis of the pattern of environmental changes leads to some interesting conclusions. First, it is apparent that enrichment dominates throughout the area both in the old forest sites and in heathland afforestations, and also on all the soil types (Table 2). Still, it proves that there is a clear relation between the distance to the nearest farmland and the average degree of enrichment. Within 250 m from the nearest farmland, enrichment is significantly higher than in the more central parts of the forest. At greater distances, variation in enrichment is caused by other factors. The main factor is soil type, the average degree of enrichment being significantly higher on the poorest type, the Regosols (2). This may be explained by the low adsorption capacity of these soils for ammonium.

The relation between history of the forest (including age of the forest site) and enrichment is more complex, since age and former land use are strongly correlated with other factors. For instance, afforestation of former fields is largely tied to plaggen soils, which are found near the present agricultural enclaves. On the other hand, relatively young afforestations of heathland (1870-1885) are largely tied to the Regosols.

Still, forest history as such is also of interest. In 1958, former oak coppice was marked by a relatively eutrophic vegetation. Further enrichment of these sites during the period 1958-1988 was consequently rather low. Next, there is a considerable difference in enrichment between old high forests and heathland afforestations on the Leptic Podzol soils. Enrichment in the old forests on these relatively rich (well buffered) soils is surprisingly high. Here, we find a combination of the oldest forest sites and the highest average age of stands of the Speulderbos. This implies that both accumulation of nitrogen in the litter and uptake of nitrogen into the biomass of

the stand are very low (3), which may result in a higher vulnerability of old stands on old forest sites to air pollution. Our data on the relation between age of the stand and average degree of enrichment seem to support this hypothesis.

Table 1. Relative significance of enrichment and impoverishment in the Speulderbos (1958-1988).

	Shift (*)	Area (ha)
Strong enrichment	+3	9
Moderate enrichment	+2	70
Slight enrichment	+1	237
Unchanged	0	257
Slight impoverisment	-1	27
Moderate impoverishment	-2	1
Unknown (**)	?	331
Not relevant (***)	x	26

(*) Shift from one trophic level (community group) to another (see text).
(**) No spontaneous vegetation present in 1958 and/or 1988
(***) Recreation grounds, tree nurseries, et cetera.

Table 2. Average enrichment in the Speulderbos (> 250 m from nearest farmland)

Forest history	Leptic Podzol ('Holtpodzol')	Humic Podzol ('Haarpodzol')	Regosol ('Duinvaag')	Total
Old forest formerly coppice)	+ (106)	? (<1)	++ (1)	+ (108)
Old forest (formerly high forest)	++ (317)	+ (3)	+++ (3)	++ (323)
Old heathland afforestation (1830 - 1870)	+ (17)	++ (4)	+++ (1)	+ (22)
Young heathland afforestation (1870 - 1885)	? (<1)	? (<1)	+++ (3)	+++ (3)
Total	++ (440)	++ (8)	+++ (8)	++ (456)

+ : 0 to +0.5; ++ : +0.5 to +1.0; +++ : more than +1.0 (see Table 1). The area in hectares is given in brackets.

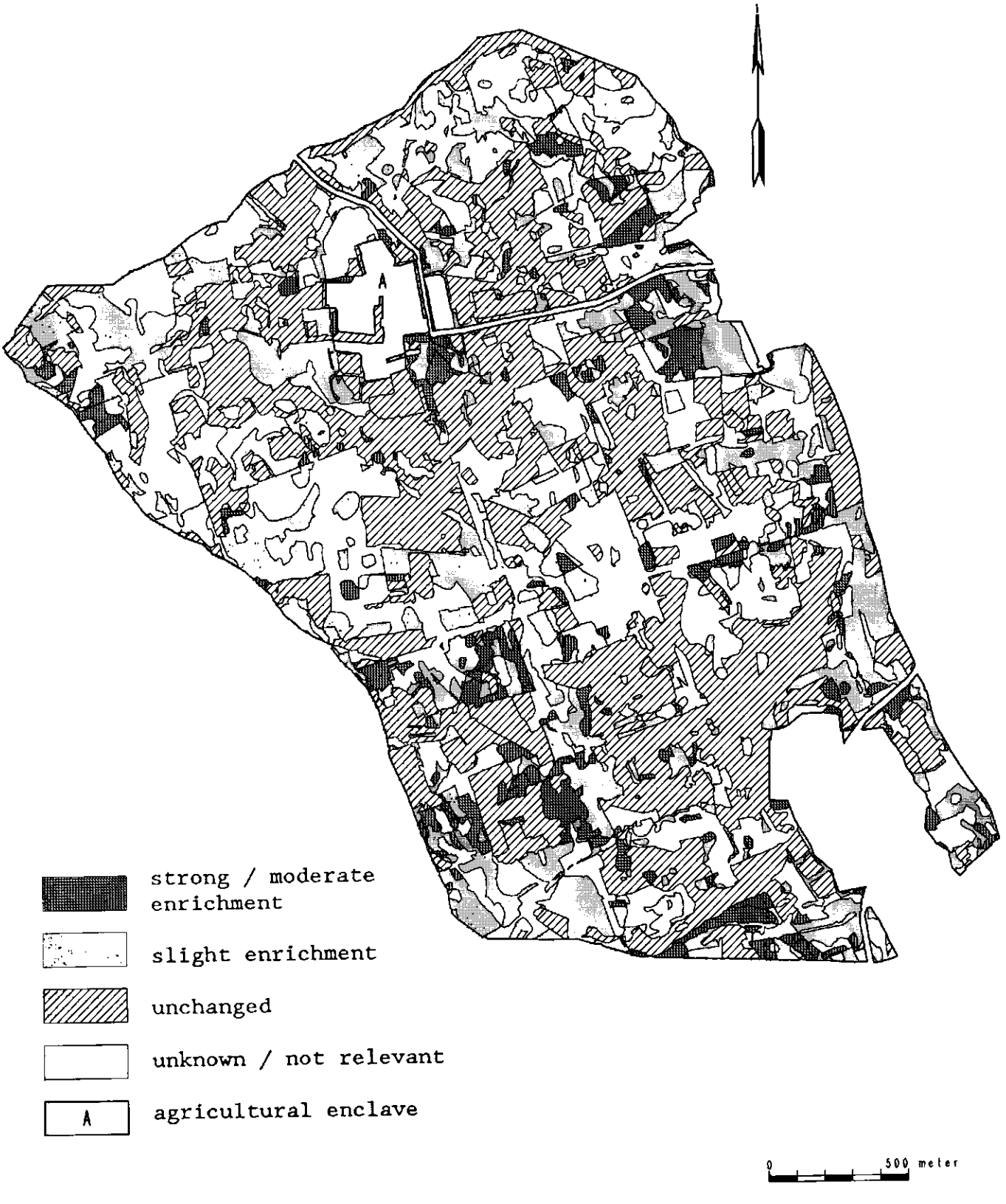

Figure 1. Environmental changes in the Speulderbos as indicated by the vegetation.

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