LONGTERM CHANGES IN SPECIES COMPOSITION OF SWISS BEECH FORESTS

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ABSTRACT - Even in so called undisturbed forest ecosystems there have always been all sorts of changes in structure and species composition going on. The presented study tries to distinguish between natural changes in species composition due to the natural forest life-cycle and new occurring, possibly man induced changes in forest vegetation, which have happend within the last thirty years. General trends have been elaborated and different causes drawn up. More detailed results concerning beech forest are presented and discussed in a broader context with other recent studies conducted in Europe to the same topic.

KEY WORDS - vegetation changes, climate change, beech forest, Switzerland.

INTRODUCTION

Forests have always been subject to changes independently from the time-span considered. The time scale of changes may vary from weeks, months or years to decades, centuries or millenia. These changes don't happen by chance only, they are part of regular processes, either based on the constitution of the plants or on changing environmental conditions (Fischer, 1995). The compostion and structure of actual forests must not be the same as the future ones. Forest development can be seen as a regeneration cycle with different phases. According to Mayer *et al*. (1980) the cycle can be divided into a rejuventation-, initial-, optimal-, terminal- and decomposition phase (compare also Fischer 1997). This cycle runs more or less continuously and permanently in every nature-near forest and under more or less constant environmental conditions. Additionally, there are often fluctuations in the time-scale of a few years but with only minor impact on the on-going forest life-cycle process. However, as soon as the environmental conditions are becoming subject to changes, then these cycles will be influenced and overlaid by other changes inducing processes. These processes may be both directed or chaotic but also changes such as of fluctuations with intrinsic triggering must not be excluded (see e.g. Klötzli, 1995). In practise it is often difficult to distinguish these different changes and even more difficult to find the reasons causing such processes. Not very seldom a complex combination of all sorts of cyclic, fluctuating, directed

and chaotic changes is presented by nature, so that the explanation and classification of the single factor must be seen as best approximation and can't be defined in a definite way. Nevertheless we need the knowledge of ongoing processes in terms of trend-analysis to detect changes in their early beginnig. The time-span available for adaptation and reaction to the new conditions will depend on the moment recently induced processes can be detected.

Material and Methods

On a thirty kilometer wide transect across Switzerland, starting from Schaffhausen in the North to Chiasso in the South, more than 300 relevé plots have been resurveyed in 1994. The "old,, relevés mostly from the late fifties and early sixties have been stored in a forest-database at the WSL in Birmensdorf. Relevé plots for resurveying have been selected according to the following criteria: The position of the site must have been rediscoverable with a certain reliability, so that the location of the earlier and present relevé can be considered as identical. No management and/or major natural disturbance must have happened in the periode between the surveys. All the relevés were taken in mesic forests in the colline and submontane belt up to an elevation of 800m a.s.l., in the northern part of Switzerland mostly belonging to the *Galio-Fagion* type E&K 7/8 (Ellenberg & Klötzli, 1972). The investigated relevé area was 100-400m^2. Species determination and nomenclature was conducted after Hess *et al*. (1976-80). According to the old relevés the new ones have been investigated with the Braun-Blanquet-methode. Every given pair of relevés has been analyzed on its changes in species composition and species frequency. Presence, absence, relative variation and new occurrence have been evaluated on the species level. For the interpretation the indicator values by Landolt (1977) and Lindacher (1995) have been applied.

Results

As a result of the resurvey in the northern part of Switzerland more than 150 given pairs of relevés were obtained. Examples are given in fig. 1 and fig. 2.

Preliminary statements were given by Klötzli 1995, respectively Klötzli et al. 1996. In summarized form they are resumed in table 1. Detailed results over the whole transect are given by Carraro *et al*. 1999.

	periode [years]	persistent	disappeared	new
Relevés of beech forests of northern Switzerland	30-58			
range		30-86	14-70	0-200
average		50	50	35
		all values in percent and rounded		

index nr. new relevé	90			altitude:	500
author new relevé:	GRUNDMANN A.	locality:	Kloster	exposition:	ESE
index nr. old relevé:	8838	x-coordinate:	685 310	inclination:	0%
author old relevé:	KLOETZLI F.	y-coordinate:	258 670	association:	(E–K) rev. 7a

persistent species

Year of survey	old 1965	new 1994
T-Fagus silvatica	2	3
T-Picea excelsa	–	1
T-Carpinus betulus	3	1
T-Quercus sp.	3	3
S-Fagus silvatica	–	1
S-Picea excelsa	–	1
H-Fagus silvatica	1	2
H-Picea excelsa	1	1
H-Acer pseudoplatanus	1	1
H-Hedera helix	1	2
H-Quercus sp.	1	1
H-Carpinus betulus	–	–
H-Prunus avium	–	–
Lamium montanum	3	1
Oxalis acetosella	1	2
Galium odoratum	2	1
Milium effusum	1	1
Carex silvatica	1	–
Phyteuma spicatum	–	–
Carex digitata	–	–

disappeared species

	old 1965	new 1994
T-Prunus avium	–	
T-Tilia cordata	–	
T-Fraxinus excelsior	–	
H-Lonicera xylosteum	–	
H-Acer campestre	–	
H-Evonymus europaea	–	
Luzula pilosa	1	
Viola riviniana	1	
Deschampsia cespitosa	–	
Hieracium silvaticum	–	
Carex umbrosa	–	
Dryopteris carthusiana	–	

new species

	old 1965	new 1994
H-Hedera helix		–
S-Acer pseudoplatanus		–
S-Rubus sp.		–
H-Quercus sp.		1
H-Tilia cordata		–
H-Fraxinus excelsior		–
H-Rubus sp.		2
H-Sorbus aucuparia		–
H-Viburnum opulus		–
Pulmonaria obscura		–
Pyrola secunda		–
Anemone nemorosa		–
Polygonatum multiflorum		1
Veronica montana		–
Dryopteris filix-mas		–

number		
	absolut	% old
persistent	20	69
disappeared	9	31
new	9	29

Fig. 1 - Comparison of old and new relevé

index nr. new relevé:	61		altitude: 800
author new relevé:	GRUNDMANN A.	locality: Wasserwil	exposition: NW
index nr. old relevé:	0232	x-coordinate: 677900.0	inclination: 5%
author old relevé:	KUHN	y-coordinate: 244550.0	association: [E–K] new: 7a

persistent species

Year of survey	old 1967	new 1994
B-Fagus silvatica	3	4
B-Picea excelsa	1	2
B-Abies alba	2	1
B-Quercus sp.	1	–
S-Fagus silvatica	1	1
S-Abies alba	–	1
K-Fagus silvatica	–	2
K-Abies alba	1	1
K-Acer pseudoplatanus	–	1
K-Hedera helix	–	1
K-Rubus sp.	–	1
K-Fraxinus excelsior	–	1
K-Sorbus aucuparia	–	–
Lathyrus vernus	2	–
Viola silvestris	1	–
Anemone nemorosa	1	–
Phyteuma hemisphaericum	1	–
Carex silvatica	1	–
Calamagrostis villosa	–	1
Carex digitata	–	–

disappeared species

	old 1967	new 1994
S-Corylus avellana	1	
S-Calamagrostis arundinacea	–	
S-Calamagrostis montana	–	
S-Lonicera xylosteum	–	
S-Rosa sp.	–	
K-Lonicera xylosteum	–	
K-Sorbus aria	–	
K-Quercus sp.	–	
K-Ulmus scabra	–	
Carex montana	2	
Mycelis muralis	–	
Clematis vitalba	–	
Fragaria vesca	–	
Brachypodium silvaticum	–	
Solidago virga-aurea	–	
Veronica officinalis	–	

new species

	old 1967	new 1994
S-Ilex aquifolium		1
S-Fraxinus excelsior		–
S-Sorbus aucuparia		–
K-Ilex aquifolium		1
K-Acer platanoides		–
K-Prunus avium		–
K-Prunus laurocerasus		–
K-Sambucus nigra		–
K-Viburnum opulus		–
K-Lonicera alpigena		–
Oxalis acetosella		1
Phyteuma spicatum		–
Poa nemoralis		–
Allium ursinum		–
Luzula luzuloides		–

number	absolute	% old
persistent	12	54
disappeared	15	45
new	10	37

Fig. 2 - Comparison of old and new relevé showing the appearance of laurophyllous exotics

The direction of the general shift can be derived from the individual characteristics of all particular species according to their increase or decrease. Table 2 summarizes the results as an overview.

Results	Possible explanations
▪ Increasing frequency of: – climax species (Fagus sylvatica, Carex sylvatica, Veronica montana ...) – nitrophilous species, growing also in poor light conditions (Sambucus nigra, Prenanthes purpurea, Carex pendula ...)	– maturing forests – aerial input of nitrogen: 30-50 kg /ha year
▪ Decreasing number of mesophilous species (= species growing in forest gaps) (Fragaria vesca , Salvia glutinosa, Aegopodium podagraria...)	– more closed canopy with increasing age of forests
▪ Decrease in acidophilous and oligotrophic species (Vaccinium myrtillus, Carex pilulifera, Teucrium scorodonia, Veronica officinalis, Melampyrum pratense...)	– effect of nutrient input may predominate effect of acid rain
▪ Decreasing number of montane species (Sambucus racemosa, Lonicera alpigena, Polystichum lobatum, Aruncus sylvestris, Veronica latifolia ...)	– climatic effect
▪ Increasing number and frequency of: – evergreen broad-leaved (=laurophyllous) species (Ilex aquifolium, Hedera helix {-> climbing!}) – laurophyllous exotics (Prunus laurocerasus, Lonicera div. spec., Cotoneasterdiv. spec.)	– climatic effect -> mild winters
▪ Deacreasing number of species per relevé -> loss in biodiversity	– maturing forests

The main differences point to lower average light conditions, lower pH, higher nutrient contents and higher temperatures.

As mentioned above changes according to different processes can be distinguished.

Lower light conditions due to increased age of the forests with denser canopies decrease the number of mesophilous species which grow preferably in forest gaps. On the other hand climax species occur with increased frequency. These effects can be seen as part of the natural cycling process for forest development.

Another group of processes points to the aerial input of nitrogen, in Switzerland in the order of 30-50 kg per ha and year (Klötzli, 1993). The effects are shown by increasing frequency of nitrophilous species which also grow in poor light conditions. Simultaneously, acidophilous, oligotrophic species decrease. This might be to the contrary of the common opinion of acidification presently going-on due to acid rain but can be explained by the overlay and obvious predominance of the effect of nitrification. As a third major process a climatic effect can be detected. It is shown by both the decreasing number of montane species and increasing number of thermophilous species. The second group is not only represented by indigenous species especially the evergreen broad-leaved - so called laurophyllous - species such as *Ilex aquifolium* and *Hedera helix*. Climbing Ivy (fig. 1) may

be seen as an indicator for milder winter conditions (Dierschke, 1994). In addition there are other, non-native species of the same plant functional type, spreading from the garden into adjacent forests (fig. 2). These species may be seen as an integrated indicator for climate induced and probably sustained changes in recent times.

Discussion

Whereas changes due to maturing forests can be seen as part of the natural cycle of vegetation complexes discribed by Mayer *et al*. (1980), changes due to nitrification and climate change must be seen as anthropogenically induced. There is no evidence for natural causes for such changes neither for the occurence of similar processes in former times. The appearance of ornamental laurophyllous exotics in forests has been observed in the surroundings of Zürich by Landolt 1993, by Sukopp & Wurzel (1995) in the Rheinland (Germany) and points even to a biome shift from deciduous to evergreen broad-leaved forest in some places in southern Switzerland (Klötzli *et al*. 1996, Carraro *et al*. 1999, Klötzli & Walther, 1999). This effect is supposed to be induced by the changing climate. It becomes reinforced by the fact that on the upper end of the belt considered, montane species are decreasing. The interpretation is appropriate to explain this finding as an upward movement of these species as it was shown by Hofer (1992) and Grabherr (1994) for higher altitudes.

The increasing number of nitrophilous species has been mentioned also by Kuhn (1992), Runge (1994) and Grabietz & Fiedler (1996). Grabietz & Fiedler (1996) also postulate that vegetation reacts very slowly on increased acidity input as single effect, especially on soils with high buffering capacity. They also corroborate the finding that increased nitrogen input may predominate the effect of acidification.

The overall massive loss in species diversity may be seen as an effect of maturing forests. Schmidt (1993) comparing historic and recent conditions of the vegetation of forests pointed out a drastic decline in number of species (ca. 50%) after a period of 35 years. In contrast Brunet *et al*. (1996) showed a general increase in species diversity once management has been intensified. It is explained by the increase of ruderal species. Also Gabrietz & Fiedler (1996) could show an increase of more heliophilous species. They explained it with an opening of the canopy due to loss in vitality of the forests.

However, analyzing changes in forest ecosystems we must be aware of any sorts of complex influences. Even undistured forest sites show an amazing „flow-through" of species in a period of thirty years, which must be considered with special care and not overinterpreted in studies of shorter duration. Runge (1995) explained this „flow-through" as an almost unrecognizeable, continuous coming and going. The same process discribes Klötzli (1995) comparing it with driving clouds with varying winds. Further he explains that there is no prediction possible which „population cloud" will touch the surface of a given plot and which one will be driving past and away.

Only the evaluation of a whole set of data displays the pattern of possible trends. Accordingly, some directed changes can be separated from the background-noise of natural fluctuations and from the natural process of the forest's life-cycle.

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Zusammenfassung

Auf einem dreissig Kilometer breiten Transekt quer durch die Schweiz wurden in der kollinen und submontanten Stufe über 300 Waldaufnahmen aus den späten fünfziger und frühen sechziger Jahren wiederholt und paarweise ausgewertet. Die daraus abgeleiteten Trends lassen sich in drei Kategorien einteilen.

Einerseits zeigte sich mit dem vermehrten Auftreten sogenannter Klimaxarten und gleichzeitiger Abnahme von mesophilen Arten ein Effekt der natürlichen altersbedingten Verdunkelung des Waldes. Während dieser Prozess als Teil des natürlichen Waldzyklus gesehen werden kann, traten darüberhinaus aber noch weitere Verschiebungen in der Artenzusammensetzung auf, wofür andere Faktoren hauptverantwortlich sein dürften.

Die Zunahme nitrophiler Arten, welche gleichzeitig nicht sehr grosse Ansprüche an die Lichtbedingungen stellen, sowie die Abnahme oligotropher Arten können als Folge des anthropogen bedingten Nährstoffeintrages durch Niederschläge gesehen werden. Im weiteren lassen die Abnahme montaner Arten sowie die Zunahme immergrüner, breitblättriger - sogenannt laurophyller - Arten auf einen Temperatureffekt schliessen. Vergleiche mit anderen Langzeit-Untersuchungen aus dem mitteleuropäischen Raum lassen den Schluss zu, dass die erhaltenen Resultate nicht nur für die Buchenwälder der Schweiz sondern auch über die Landesgrenzen hinweg ihre Gültigkeit beibehalten dürften.

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