STUDIES ON THE INDUSTRIOCLIMAX IN POLAND

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ABSTRACTS

Author presents theoretical assumptions on which the programme of complex research on the management of forest areas situated within the range of the impact of industry was based in the Forest Research Institute. Industrial emissions present an abiotic paranatural ecological factor. Their influence rising in quantitative and areal respect brings about explosive changes of an environment. Through the direct impact on organisms as well as indirect one via alterations in site they cause an ecological catastrophe as a result of which perish primeval natural biocoenoses. This initiates an ecological succession the final stage of which is represented by the industrioclimax. The spatial pattern of vegetation in industrioclimax is similar as under natural, adverse for vegetation conditions and the similarity is manifested by an analogic zonation of plant formations. At the high intensity of limiting factors there occurs a biological desert and along with its lowering there are developed ever more complex formations: grassland, shrub, and forest communities. These spontaneous plant associations represent different productive capacities of sites. Their determination and examination renders possible the delineation of the ecological boundary between forest and various silvicultural zones on areas polluted by industry.

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INTRODUCTION

Damage caused in forest by poisonous compounds (industrial emissions) emitted to atmosphere grow accordingly to the development of the industry. In Poland losses from the impairment of productivity and additional costs of management as well as social losses due to decrease in touristic value and disappearance of the healthy functions of forest were estimated on 1.8 milliards of zloties in 1965 with a trend of an increase to 9.8 milliards of zloties in 1985(Molenda 1969).

It is therefore a serious economic problem dealt with from many years by various scientific institutions. In the Forest Research Institute in 1962 the Section of Forest Management in Industrial Regions was called to being. The problem of the impact of air pollution upon environment and involved consequences for biological production were appraised in Poland many years before the publication of the U Thant report. Complex ecological studies aimed at obtaining basic highlights for forest economy on areas situated within the impact of industrial emissions were initiated in the Forest Research Institute (Obmiński 1969).

THEORETICAL BACKGROUNDS OF ECOLOGICAL STUDIES ON THE IMPACT OF INDUSTRIAL EMISSIONS ON FOREST (Wolak 1969b)

Purpose of studies

The purpose of studies results from the economic importance of forest to which contribute the production of wood and by-products as well as the role played by forests as an area of high green vegetaion even when wood production is unremunerative. Thus the purpose of studies is to examine capability of forest production and possibilities for the existence of forest communities and afforestations where the forest production is impossible or unremunerative.

Particular features of forest production

These are: extensiveness and long production cycle.

Extensiveness consists in fact that forest production takes place in natural, seminatural, and spontaneous forest communities with the use of a unconstraint action of natural forces and with rather slight human interference. Hence results the highlight that forest economy has to observe rules governing forest biocoenoses, particularly because that:
1) Silvicultural treatments have to be concordant with principles determining the direction of natural or spontaneous succession of vegetation, because otherwise the dynamics of association and environmental resistance will act in the opposite direction and annihilate the effect of these treatments.
2) Forest production takes place with maintaining complex cycles and long trophic chains and attempts of shortening these chains or their interruption lead to negative production effects.

The long production cycle amounting to 80-100 years requires the study of constant conditions. Hence both research works on the appraisal of damage caused in stands by industrial emissions and forest ecological studies in vicinity of newly established sources of emission may be only of indirect significance for the forest management of industrial regions, since they do not deal with conditions under which forest production will take place in future, but with the ecological catastrophe itself, connected with the transformation of natural environment to an industrial one.

Indispensable conditions of study areas

From the above mentioned properties of forest production it results that studies on its possibilities or in an extremal case the studying of possibilities of forest or trees existence on areas remaining under the impact of industry ought to be carried out under conditions where industrial emissions act permanently and sufficiently long to form a new biological equilibrium and new ecosystems in which industrial emissions present a significant abiotic factor.

Object of studies

Study object provides forest, but approached from the standpoint of its economic importance and its indirectly economic functions decided by the production and nature of plant community. Thus forest will be of interest for us as plant community with particular consideration to elements of the greatest economic importance, i.e. population of trees. Site conditions govern the forest production and the existence of plant communities and therefore the object of studies will include also sites developing under the impact of industrial emissions.

Industrial emissions

Industrial gases, smokes, and dusts are a by-product of human activity and therefore constitute an anthropogeneous factor. In respect to ecological function they are paranatural abiotic factors. As a constant component of atmosphere they are a climatic factor and bring about the formation of a specific climate of industrial regions. While penetrating into soil they become an edaphic factor and cause the development of specific soils of industrial regions. Thus industrial emissions alter natural patterns of abiotic factors, i.e. primeval site factors and lead to the formation of a new pattern. In this way there are created new sites with an altered production capacity.

Explosive changes in environment

Ecological explosion

An explosive development of industry is a consequence of radical changes in production relations as a result of demographic explosion and technical-industrial revolution. The existence of humanity in the to-day form and numbers is possible exclusively under conditions of a technical civilization, the basic link of which is industrial production and its rapid development. As each production the industrial production is inevitably connected with the formation of certain undesirable by-products and their discharge. Man can only correct the form of industrial emissions and their chemical composition and restrict the quantity of substances discharged to atmosphere per a production unit. Under conditions of a rapid increase in quantity and diversity of emitted substances forecast expect further, quick increase in air pollution. In Poland, particularly the quantity of SO_2 emitted to atmosphere will be increased.

On contrary to other effects of industrial activity the impact of industrial emissions is not limited to the direct neighbourhood of industrial plants but is extended on the distance of many kilometers and alters the environment on areas not subjected to other anthropogeneous influences.

The industriogeneous explosive changes in an environment provide new research tasks for forestry - forecasting of ranges of changes in an environment, because the long production cycle calls for considering to-day conditions which will come after several decades.

Ecological catastrophe

Air pollution on the one hand has a directly toxic impact upon organism bringing about the elimination of species, while on the other it causes the formation of new sites. These new sites are inadequate for recent biocoenoses adapted to previous conditions. This is why where air pollution becomes the dominant ecological factor there comes to an ecological catastrophe with the consequent elimination of not only individual species, but whole biocoenoses. A most eye striking symptom of the industriogeneous ecological catastrophe is dying off forest stands in vicinity of new industrial plants.

Industriogeneous succession

Similarly as each alteration of a dominant ecological factor and involved ecological catastrophe , so the industriogeneous catastrophe is a stimulus to biological succession which is manifested by successive changes in plant associations, i.e. in the succession of vegetation. It is exogeneous succession, usually secondary and regressive one, because it

leads to associations belonging to a less complex formation than natural zonal formations (Forest with us).

Industrioclimax (Wolak 1968, 1969a)

As industrioclimax I define the final stage of industriogeneous succession, i.e. relatively durable and balanced stage of the development of vegetation on areas situated under the impact of industrial emissions. They represent spontaneous plant communities with rather permanent species composition and ecological amplitude equivalent to industriogeneous sites. The concept of industrioclimax is included by anthropoclimax, but has particular features of industriogeneous succession being its final stage. It is conditioned by a local climate of industrial regions, and therefore industrioclimax is a climatic paraclimax. The concept of industrioclimax is in its content close to the primary theory of monoclimax differing from it mainly in this that it attributes the priority climaxforming importance to the local climate.

Vegetation response to industrial emissions is analogical to that to natural climatic factors unfavourable for it, as coldness or drought. The analogy is manifested at the level of plant formation. With the sufficient intensity of limiting factors there is formed an absolute biological desert. Along with their decline the appears at first the open desert formation composed of clumps of vegetation among which occurs nake mineral substrate, then one-layered, compact grassland formation (high alpine meadows, steppe, tundra); further shrub communities (mountain pine, thorny scrub of a dry climate); then impoverished forests (northern taiga, xerothermic forests). Only optimal climatic conditions permit the development of the richest and at most complex plant

formation - the rich in species and multistoreyed forest.

Results of recent studies on industrioclimax

Plant sociological data collected in 1969 and 1970 on the area of the Upper Silesian Industrial Region fully confirmed the above described regularities (Wolak 1970b). In this old region with great concentration of metallurgic, energetic, and chemical industry one can find not only industriogeneous succession but also zonation phenomena characteristic for industrioclimax. Absolute biological desert is to be found only in vicinity of old plants with highly concentrated and toxic emissions, e.g. near the old zinc mill at Szopienice. There also one can find plant associations of desert character composed of clumps in which only three species grow: Silene inflata, Arabis arenosa, and Agrostis vulgaris. In vicinity of industrial plants emitting other chemical compounds the open desert communities have different species composition, e.g. clumps are composed exclusively of grasses. The one-layered sod formation is developed also only locally in vicinity of factories, strongly poisoning air as the mentioned Szopienice or Czarna Huta at Tarnowskie Góry. Species composition of associations changes accordingly to the chemical composition of emissions. The scrub formation, where species of our trees acquire the shrubby habit, has a great range of distribution. Probably all areas on primary sites of dry and fresh coniferous forest in the so-called IInd and IIIrd zone of smoking, and thus all sandy areas with ombrophilous water economy within the Upper Silesian Industrial Region and adjoining to it part of the Kraków province ought to be probably classified to this zone. There were also found adaptation forms of certain species to local ecological conditions. For instance, pine acquires the habit of a creeping shrub, this form revealing full vigour under conditions absolutely lethal for the tree habit form.

There is developed also a specific shrub community: Pinus silvestris - Solanum dulcamara (Wolak 197oa). On poor sites, where stands were reconstructed or recultivated, the shrub formation is represented by shrubby forms of deciduous species: Betula verrucosa, Alnus incana, A. glutinosa, Robinia pseudoacacia, and others. The zone of impoverished forest is at present very extended. Coniferous species die-off on the entire area of Upper Silesian and Kraków Industrial Regions and cannot any longer be an object of forest production. In this area under adequate soil conditions and adequately low pollution of air may exist only stands composed of certain broad-leaved species. The paranatural character of the described zonation within industrioclimax is stressed by the existence of similar exceptions, as on ecologically undisturbed areas. E.g. extrazonal or azonal sites or plant associations, as swampy meadow forests also in industrial regions in the zone of a very severe air pollution do exist. The formation of similar vegetational zonation is to be found also in the course of industriogeneous succession in vicinity of new industrial plants. E.g. the formation of an extensive zone deprived of forest was found close to a nitrogen plant at Puławy (Sokołowski 1969).

Spontaneous plant associations representing various formations and formed under the influence of various intensity of the dominant ecological factor, which in industrial regions are emitted gases and smokes, reflected actual productive potential of sites.

Not observing the phenomenon of spontaneous zonation of vegetation within industrioclimax unevitably leads to an economic failure of industrial recultivation. On the area of the Upper Silesian Industrial Region one can cite examples, where attempts of recultivation or reconstruction of stands yielded negative results. E.g. the so-called protective belt near the

mill Miasteczko, situated probably in the zone of grassland associations, rapidly dies off. Similarly, in the place of repeated afforestations near Czarna Huta, there remained only grassland sods. Also vast areas recultivated or reconstructed with deciduous species on former coniferous forest sites are represented by forest wastelands, since the species introduced do not form stands, but shrubs of several metre height.

PROGRAM OF LONG-TERM RESEARCH

The development of highlights for the management of forest areas in regions remaining under the impact of industry is a crucial project coordinated by the Forest Research Institute. From the economic point of view the determination of the potential, ecological boundary of forest will be the most important task. The delineation of this boundary is planned to result from plant sociological studies. The purpose of plant sociological and ecological research on forest boundary will be the determination of the following forest silvicultural zones:

1. Primary forest zone where forest associations present the final stage of the succession of vegetation and where in this connection the normal forest economy is possible.

2. Facultative forest zone including such areas on which although the spontaneous succession eliminates forest associations, but owing to amelioration treatments and the selection of resistant woody species, the maintaining of substiture forest associations and obtaining productive effects will be possible.

3. Non-forest zone, i.e. areas on which none plant association of forest character may exist. Within this zone (not everywhere) afforestations of parkland character will be possible.

The above task will be executed through the identification, determination, and classification of spontaneous plant associations, and following characteristics of soil conditions as well as the degree and quality of industrial emissions corresponding with individual plant sociological units. In such an approach plant sociological units will become site units (Wolak 1961). Studies on woody species in order to determine their developmental and growth potential will be carried out in the identified plant associations.

There are planned also broader research in ecosystems covering more important groups of organisms and the dynamics of ecological processes.

On the basis of identified silvicultural zones there will be carried out further studies on the reconstruction of coniferous stands and silvicultural studies testing a great number of tree and shrub species.

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