University of West Hungary
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a Ph.D. Thesis

Analysis of traffic safety of roadside afforestations in the Sopron-Fertőd region

Written by

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1. Introduction

The functions of forest edge, shelterbelts and tree rows are similar to each other. They enclose and protect nature against artificial works and show that there is an undisturbed nature over them. Since the tree rows and windbreaks are eventually borderlands, the being or lack of them is not conspicuous. Despite of that the linear afforestations are formed as buffer zones along roads, settlements or agricultural areas, their duty is to decrease the harmful emissions of human environment. That is why they need such respect as the protected suburban forests or the well treated city parks.

The aim of road afforestations is to form the harmonious contact between traffic and nature, while increasing the safety of traffic, ensure optical guiding, and defend against strong wind and snowdrifts.

The specifications of road afforestations are cleared-out by the 1970s. Changes happened on several fields of afforestations (use of species, grove afforestations, maintenance, etc.), but the majority of statements are eternal.
There are supports several international co-operations, which are dealing with the sustsainable traffic infrastructure. In pursuit of efficient transporting, automatical traffic control, optimized road maintenance or minimal environmental emissions, it emphasises increase of traffic safety and the examination of the effect of roadside objects on traffic.

The common international goals, like the achievement of *self explaining road* or *forgiving roadside* can ensure the exception of stopping outside the road without collusion. The close environment of roads should not contain hazardous objects, just energy occlusives and safety barriers. The results of these investigations leaded to the conception of roadside *safety zones.* The required width depends on the type of the road, the amplitude of traffic, the planning speed, the width of traffic line, the roadside environment and its vegetation.

2. Objectives

The goal of the author is to call attention to the current conditions of the seen but unknown, sometimes cruel, another time glorified, regulated, but irregularly managed windbreaks and afforestations. Such as suggest possibilities for the future perspectives and necessary interventions.

The objectives are the following:

- revise of the regulations and expectations of afforestations,
- qualify the structural conditions of rows and windbreaks,
- analyzing the placement and regenerating possibilities,
- surveying the protection efforts, the developing and restoration methods,
- reappraise the breakthrough factor of shelterbelts,
- and research the afforestation solutions which support the safety of traffic.

3. The method of investigation

The author summarized his road afforestation research by the knowledge and results of different field of studies. Through field studies like analyzing a shelterbelt-system on the agricultural areas Répce-sík and comparing the 50 years old plans and conceptions of establishments with their realized goals of today. As a part of the windbreak network he started dealing with snow-protection belts, alleys and hedgerows. From this point he extended the study for the main road afforestations of Sopron-Fertőd region and other forest belts in Győr-Moson-Sopron county. Analyzing the operation of windbreaks the author turned to the field of wind speed decreasing and snow deposition effect of forestations.

Participating in the research *Establishment and maintenance of woody biotope-systems* (OTKA, T 043417) the author also worked together with the Hungarian Roads Public Company and described windbreaks protection against snowdrifts.

The aim of scientific literature studies was to give an overview of road afforestation publications of the last five decades, by this way the changing of expectations and goals in time can be traced. The Hungarian and

international literature underlying the experiments, hypotheses and support of results.

Parallel with analyses of windbreaks the author started the research on road afforestation types along the 84th and 85th main road sections of the region. Besides analyzing the vegetation plans, the author assigned several road sections for deep survey. He examined the conditions determining the location and quality of trees and the effect of the rows on the traffic.

He completed the work with airflow studies, interested in the multi-functionality of non-forest afforestations, the connections between traffic safety and road side trees, the regeneration and new planting possibilities.

4. The summary of results

4.1. Environment of roads

Among other environmental conditions the vegetation along infrastructure effect the flow of transportation and traffic safety much more than the surface coverage or the terrain. The author states that the surface formations like cuttings and embankments have less effect on traffic like trees.

The stems of trees carry much more risk than other static objects on the roadside. The diameter at breast height, the distance between stems, the rows distance from the traffic line highly effect the outcome of road living accidents. The author worked out a hazard factor based on recorded data of trees and other forested sites of the roadside. The examination was carried out by describing the structure, health and other measurable factors.

4.2. Shelterbelts and windbreaks

With the help of statistical evaluation it can be proved that the snow deposition on the wind effected side of the belt regularly shows a decreasing tendency through the sheltered side. Exceptions are those situations where the exposed side is dense or the lack of margin effect the snow catching much more on the protected side. By the regression curves based on the snow measurements in the environment of windbreaks it can be introduced by numbers how the structure, the distances and other objects like hedgerow influence the protection functions.

The author disclosed more evidence by the structure analyses for the reason for existence of shelterbelts. He confirmed that multi-functionality of such vegetations types have different favorable effects on their environment.

4.3. The breakthrough factor and porosity

The forest literature use breakthrough factor for describing windbreaks, which comes from the quotient of wind speed measured on the wind protected and exposed side. During his examinations the author found that this estimated value can not describe the changing of wind speed and inner conditions of the stands. By measuring the windbreak gaps with digital interpretation, the rate of gaps and filled parts of the windbreaks surface can be described by the porosity which shows the vegetations effect on airflow.

The author stated that the best solution is designing the wind effected side permeable and the protected side opened. In this situation the wind decreasing effect and smooth snow deposition can be reached. Similar effects are also available with open-permeable, open-closed, permeable-permeable and permeable-closed structures which can not ensure the proper distribution of snow but fulfill other functions.

The author found that a tree- or hedgerow can effect positively the wind speed decreasing function. They can also help snow deposition due to their turbulence rising effect. Trees supporting a windbreak can be useful when the direction of hazardous wind changes occur.

The width of a windbreak is usually determined by the free and useable area on roadside. A shelterbelt can not be closer than 10 meters to the road because of safety and snow depositional reasons. Smaller distance can be used when the hazardous wind direction demonstrably closes in acute angle with the axle of the forestation.

4.4. Reformation and regeneration of shelterbelts

When reconstructing a shelterbelt the continuous protection and other functions must be sustained. On areas with high average wind speed the reformation only can be started on the protected side by cutting either whole tree rows. After the health examination of structural trees the thinning of the

effected side possible but in lower rate than on the protected side to keep the favorable airflow conditions.

The author supports the possibility of selective cutting that include long-term regeneration like the selective systems of forest management. During the regeneration the goal is to keep diversity of the different part of the shelterbelt. By cutting rows, gaps or just a tree, it will effect the airflow but it must remain the character of the shelterbelt.

The results of field studies show that a dense 5-10 years old windbreak will not block the airflow as a wall. It has a good snow depositing potential, better than the older ones. In this situation the snow deposition is much higher on the protected side and whole snow demand can be more than in an opened mature belt.

The structured windbreak, the changing of lower and higher trees, a diverse marginal zone, the turbulence rising effect of inner rows are increasing the capacity of the afforestation. The lack of hedges on the protected side is not effecting the function of the belt, just in case when the road is too close to the windbreak. The width of the windbreak has lower effect on the capacity, but the failures of structure and diversity effects more. The height differences have similar effects like the average height of the belt. Besides big surface and diverse formations the wind effected side can be permeable and protected side closed if the transition is secured.

The author defines the good structured windbreak by the following:

- the wind effected side is completed with a tree or a hedgerow
- the margin effected side is permeable, higher than the previous row(s)
- the section between the margin and the canopy is opened
- the stem-spacing is thinning to the direction of the protected side
- the tree heights of the inner rows are variable (multilevel stand)
- the protected side is steep or staged
- the margin on the protected side does not grow further than the canopies

4.5. Reformation of roadside tree rows

The distance measured from the traffic line and the distance between the stems of a row can be renew in some steps. The original, usually 4-5 meters stem-system can be developed by cutting every second stems, growing the distances by this way. After this outside the original axle of the row second tree row can be planted, usually 1-2 meters farther on like before. In two years forestation can be reformed, and new structure can ensure the continuity. The renew should be started on the wind protected side of the road, and after 3-5 years, after strengthening of plantings, the works can continue on the other side. When the regeneration on both sides starts at the same time the protection of the planting material must be properly secured by posts and wind deflector grids.

Choosing of species is determined by several objective and subjective factors. The growth rate, the matured height, the density and form of the canopy, the diameter of the stem, or the resistance against pollutions can be chosen from the literature. But useable area and goal of afforestation or the landscape will also affect the assortment.

5. Scientific results (Theses)

1. The author stated that the wind permeability of the shelterbelts can be determined by measuring the porosity (P) of the wind effected and wind protected side. The rate of the opened and closed surface on both side of the belt can be expressed with numbers. The relation of the two values conclude the changing of wind speed in the shelterbelt. If the rate of wind protected and wind effected porosity (P_v/P_k) is between 1,6-5,0 it is a well structured windbreak. Instead of the breakthrough factor this is a more simple and preciously measureable value for description. While the breakthrough factor (L) use the wind measurements and does not examine the inner spacing, the porosity consider the changes of the density.

2. It was found that the distance between the road and trees of rows or windbreaks, due to traffic safety regulations need to be at minimum 10 meters. In tree rows the distance between stems have to be at least 20 meters or maximum the double of the mature canopy diameter. The stems diameter at breast height need to be kept between 10-30 centimeters. This way the maximum safety can be guaranteed and the tree rows will keep their character. If the secure distance can not be achieved the maximum distance must be kept on the available area. The elimination of trees with hazardous diameter, the increasing of side- and stem distances can be reformed and sustained with planned management.

3. The dissertation laid down that the turbulence rising proportioned structure, the gappy, wind permeable, staged or multileveled stands have much more snow catching capability as the traditional windbreaks with triangle or trapezoid cross-sections, where the transition of canopies realized with straight contours. The incomplete and distributed windbreaks snow deposition effect can be 2-3 times more than a standard windbreaks. By analyzing snow catching wind breaks the author found that the wind effected side must be denser than the protected. The author pointed on in case of increasing the capacity of the windbreaks they have to be combined with tree rows or hedgerows. The statistical analyzes showed that the linear afforestations before and after the windbreaks have positive effect on the deposited snow volume.

4. The hazard factor (V_f) which is determined by the location of the trees, parameters showing structure conditions and using the results of observations, suitable for the comparison of threats of accidents on different road or tree row sections. The formula of the hazard factor: $V_f=d_{1.3}/(L_ú*D_t)+K$ (where $d_{1.3}$ is the diameter at breast height $L_ú$ is the distance from the road, D_t is the distance between stems and K is a correction factor depending on branchyness, health and other conditions. The author stated that with the help of the hazard factor the probability of hazardous effects on traffic can be determined. When the usable area is not able for maintaining safe tree rows other afforestation method need to be applied (hedgerow or tree row with hedges).

5. Using windbreaks as snow catching belts the distance from the traffic line need to be at least 7 meters with edge or 10 meters without edge, but it is not reasonable to keep more distance than 20 meters. A windbreak consist of two hedgerows of the wind effected side, two-three rows of trees and one hedgerow on the protected side with 5-6 meters width altogether it is sufficient as snow defending windbreak. A windbreak wider than this have to be wood production efforts beside protection functions to be economically well founded.

6. By analyzing windbreaks the author's conclusion is that the continuous protection effects can be secured also in case of regeneration. He determined and verify more methods for reformation. The pointwise or group cuttings cause less injury. Selective cutting is the most tolerant method but the cutting can mechanized, the renewable area can be developed by cutting rows or parts of the windbreaks enjoying the protecting effect of the remaining side.

6. List of publications

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