SCIENTIFIC PRINCIPLES FOR THE ECOLOGICAL RECONSTRUCTION OF THE NORWAY SPRUCE STANDS AFFECTED BY DEER

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Received October 10, 2007

The durable management of the deer-damaged Norway spruce artificial forest ecosystems should start from the economic target fixed, *i.e.* the functional efficiency of the forest. Since forestry management should meet this aim, a first step should be to specify clearly a few scientific bases regarding the ecological reconstruction of the Norway spruce ecosystems affected by biotic disturbing factors. In this respect, the issues related to the damage caused by deer will have to take into account a number of forest planning, forest-technical and economic bases. These are fundamental elements of the durable management, based on the ecology of the ecosystems in the mountain forest areas exposed to the action of this biotic disturbing factor.

Key words: Norway spruce; Deer; damage.

INTRODUCTION

Forest management is generally meant to take care of and change the forest ecosystem in order to turn to account its produce and qualities. The future development of the forestry activity should start from the trends registered worldwide as for the management of forest resources and from the need to improve the way of managing the standing crops [1, 2, 3, 4, 9].

Forestry regulations should provide an adequate framework for the promotion of a durable management, paying more attention to the preservation and improvement of the biodiversity and to the rational and continuous valorization of the multiple ecological and social-economic functions of the forest ecosystems [5, 6, 10].

Having in view these aspects, the scientific bases for a durable management of forests should take into account the three categories, of management principles: a) the technical principles (continuity and a sustained management); b) the economic principles (increasing the yield capacity of the forests, increasing, to a maximum, the quality of the produces); c) the social principles (meeting the general and local needs with produces of the forests, carrying out the conditions for the maximum use of the protective role of the forests) [7, 8, 11, 12, 13, 14, 15].

MATERIALS AND METHODS

The researches for substantiate the sustainable management systems of mountain ecosystems have been done in representative areas from ecological and economical impact generated by the deer damages on the Norway spruce stands. So the field research was located in Norway spruce sands from the north of Romania.

It was made a synthesis based on the research in the problem regarding the mapping of deer damages on large forest areas, in the problem regarding the structural characteristics that are specifically to Norway spruce stands damaged by deer, in the problem regarding the elaboration of the prognosis models specify to the development stage in artificial Norway spruce ecosystems from North of Romania, in the problem regarding the repartition of the volume to primary and dimensional assortments in artificial Norway spruce stands and in the problem regarding the growth elements in artificial Norway spruce stands.

RESULTS

Forest planning principles

When choosing the bases for forest planning (regime, treatment, composition, exploitability, rotation) by which one can define the optimum structures towards which the stands and the forest should be led in order for them to carry out adequately the functions assigned, more and more special attention shall be paid to the preservation of biodiversity, to providing the stability of the stands and of the forest which is to be planned as a whole.

Among the forest planning bases, composition and exploitability are essential elements, having a key-role in the durable management of the artificial, deer damaged Norway spruce ecosystems, on which the sylviculturist can intervene in a significant way, to direct the evolution of this category of artificialized mountain ecosystems, first of all to restore the ecological balance of these forests.

In the areas exposed to risk of deer action, the combination of species determined for a stand aims at harmonizing the mix of species, with regard to the ratio and the way of grouping them, taking into account the ecological requirements, the social-economic requirements and the functional efficiency at any time of the existence of the stands. In the areas exposed to risk of deer action, the target composition of the newly established stands should have in view the formation of optimum structures in respect of their composition, the adjustment of the numbers of trees per area unit respectively, seeing that problems may occur related to the optimizing of the density of the stands as well. These desiderata will be attained by increasing the ratio of broad-leaved trees, by keeping the species of silvo-cynegetic interest disseminated in the stand and also observing the modern concept of keeping and increasing the biodiversity of the forests.

The quality of being exploitable, assigned to a tree or a stand at the time when harvesting becomes necessary, in order to carry our with a maximum benefit the aims of forest management, corresponds to a certain state of the tree or of the stand and can be ascertained in reality only by identifying it in situ (for instance the frequency of the damage in the Norway spruce stands) and by the correlation with a number of theoretic experimental parameters determined in order to find out the state of maximum efficiency of the stands. If these conditions are not observed, both the yield capacity of the forests in general and that of deer-damaged Norway spruce stands in particular, as well as their efficiency in the ecological, social or economic functions they have, will always be lower than the potential they may reach.

Exploitability age is an individual feature of each stand, and is determined *versus* the functions assigned, the silvic-productive and eco-protective potential of the station, the state of each stand and how urgent its regeneration is respectively. For the deer-damaged Norway spruce stands, from the point of view of the planning basis considered when establishing scientific principles for a durable management of this category of mountain ecosystems the following may be significant: the absolute exploitability and the exploitability of the maximum economic effect.

Grouping the deer-damaged Norway spruce stands according to the regeneration urgency shall be done taking into account specific forestry criteria (structural character of the stands – density, qualitative characteristics of the stands – age and damage frequency, regeneration – the ratio of seedling within the stand, initial sorting of the stands – the percent of wood having stem decay within the deer damaged Norway spruce stands, dimensional sorting of the stands – the percent of decrease of dimensional range as a result of the presence of wood having trunk rot within the deer-damaged Norway spruce stands [10, 12].

Forestry-technical principles

Recuperation of the ecological balance in the Norway spruce artificial stands, seeing that during the past years there has not been noticed significant damage caused by deer from the point of view of the number of damaged trees and of the affected area, has in view, first of all, increasing the stability of these against snow and wind, for which it is most important to increase their inner resistance and outlining the directions for a durable, medium and long term management.

Setting up the crops is one of the key points for a successful establishment and directing the stands towards polyvalent functional structures, able to meet multiple requirements, in order to keep the stability of the newly established natural and artificial forests as unaltered as possible, governed by the biological laws characteristic to the dynamic balance of the forest ecosystems, without affecting their resistance structure [8, 10].

According to the ecological criterion, the areas with deer action risk, those species and compositions with natural potential will be promoted which are as close as possible to the ones of the natural ecosystems which have vegetated in the area, thus providing, ever since the crops have been established, the conditions necessary for the stability of the forest ecosystems, with high functional efficiency. Ensuring ecological stability becomes the fundamental criterion when determining the composition of the future stands.

In the regeneration compositions in the areas known as vulnerable to the action of deer, in stations specific to coniferous and beech mix, it is recommended to increase the ratio of broad-leaved trees (beech, mountain sycamore maple, ash tree) even up to around 50–60 % in order to diversify from the very beginning the horizontal structure specific to these stands and to make it possible to create stands having optimum stability parameters.

The attendance work and that of directing the stands, which will be carried out during the development of the stands, will focus on attaining the target composition proposed, on diversifying the specific vertical profile, on maintaining the stability parameters between optimum values according to the forest area where the work takes place and ensuring the qualitative and phyto-sanitary corresponding to the goal had in view when establishing forestry crops. Well structured sycamore maples, beech, alder tree, birch tree, poplar, willow will be maintained wherever it is possible, in the areas exposed to the unfavorable action of deer, in order to reduce the pressure exerted on Norway spruce.

The work of ecological reconstruction of deer-damaged stand is that complex of forestry interventions – regeneration, attendance and protection of the stands, as well as recovery of the biotope; the aim of this work is to harmonize the structure of these stands with the site potential and the functions assigned, usually in the direction of natural ecosystems structure. The scientific motivation of the ecological reconstruction is in the fact that destructured stands have a diminished biodiversity, which in its turn diminishes their stability, eco-protective and productive functionality[6].

When planning the work of ecological reconstruction of deer-damaged stands, a fundamental element is determining the optimum time for the intervention. In order to determine it, it is essential to take into account the time interval required by the recovery, determined depending on the age of the stands, on the deer-damage frequency and on the density value index.

The optimum time for applying the ecological reconstruction work in a deer damaged Norway spruce stand is considered the age at which it is proposed to begin the ecological reconstruction work in a stand; the result is the least number of years of recovery depending on the structural conditions (density index) and on the deer-damage frequency. In other words, the optimum time for the application of the ecological reconstruction is the age of the stand affected by deer, which, subject to the work of rehabilitation of its functionality results in the shortest interval of recovery.

Economic principles

The wood yield, the increase in volume of the regular stands have, during their lifetime, a characteristic rate, which at a given time begins to decrease, becoming ever weaker towards the old age of the stand. This variation makes the economic efficiency of the stands change according to their age. Usually expressed as the average growth of the total wood yield per year and hectare, the economic efficiency of a regular stand changes exactly in the same way, following a bell shaped curve, reaching a maximum at the beginning, to decrease slowly, in time [1, 7].

The moment when the economic efficiency of a stand begins to decrease, it has to be replaced. In the case of deer-damaged Norway spruce ecosystems, it is necessary to measure the effect produced by the injuries caused by barking and eating (the effect of stem decay), from the point of view of specific wood yield and yield capacity, on this category of stands.

It has been found that the maximum of the current growth of total yield corresponds to maximum average percent of damage in the deer-damaged Norway spruce stands which are part of the production unit under observation. The time interval when the elements specified are at their maximum value coincides with the age at which the Norway spruce stands are exposed to a maximum risk of snow damage. Subsequently these stands will be potentially exposed to windfalls [10] (Fig. 1).

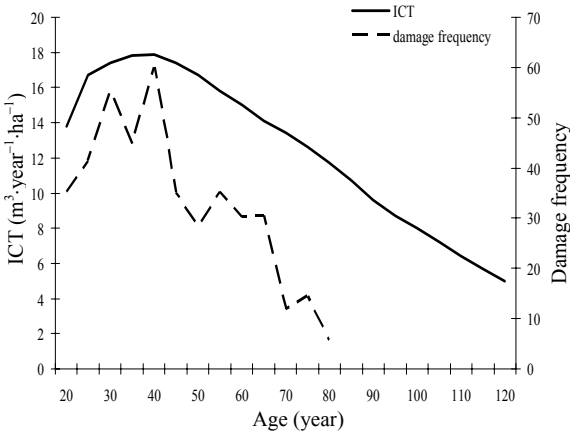

Fig. 1. Dynamic of the current growth of total yield (I_{CT}) correlated with damage frequency and with the age stand.

These findings demonstrate as well the need to include the Norway spruce stands from age-class two in the first emergency regeneration specific to deer-damaged Norway spruce stands, seeing the effects caused by the damage percent having increased to a maximum, correlated with the age of the injuries and especially with the ratio of wood with rot, on the average growth of the yield and yield capacity of the Norway spruce stands affected.

The action of deer, by barking and bark eating (which causes the occurrence trunk rot) on Norway spruce stands, expressed by the structuring of primary and dimensional sots, is significant. This is supported by the fact that the most significant losses expressed in percents are found with the superior sorts, i.e. trees for timber (thick I, thick II and thick III) which is the most expensive wood for timber [10, 13, 15].

CONCLUSIONS

The perturbation of forest biocenoses in certain areas, organized according to the laws of natural ecosystems in report with management strategy, was possible by replacing the former natural stands having polyvalent functional structures capable of meeting multiple requirements, with artificial single-crop systems.

Artificial forest crops, very far form the natural forest pattern, are unstable and cannot survive without permanent and extra energy consuming human interventions, meant to replace the self-adjustment functions of the natural ecosystems; hence the multiple damage registered in these artificial forest crops, a large-scale consequence of the ecological disorder being the damage caused by deer to the Norway spruce artificial stands established in place of former natural forests having natural stable structures, in the stage where coniferous trees are mixed with beech.

The measures that the person in charge with forest-management can recommend in order to reduce the deer damage are mainly concerned with creating and attending the newly established stands as well as with the ecological reconstruction of the forests affected, acting in order to: a) determining the timeliness and need of ecological reconstruction of the Norway spruce stands affected by deer in different degrees, by including them in regeneration emergency classes; b) establishing the stands according to the composition of natural stands that used to vegetate in the forest areas affected; c) tending of stand operations within stands which show little damage caused by deer (< 30%) will be targeted to the periodical elimination of damaged trees; d) avoiding clear felling which favors the growth of feeding basis for deer during the vegetation period, as opposed to the lack of it during winter time; e) maintaining the necessary ecological equilibrium between predatory animals and primary consumers.

There are three moments when one can act efficiently in order to stabilize this category of mountain ecosystems: a) the first one is when establishing the stands, by choosing the species, *i.e.* by determining the composition of the stand and the planting design; b) the second is when the seedling have grown and tending of stand operations should be applied, such as cleaning (especially) and thinning; c) the third moment is when determining the regeneration emergency specific to deer-damaged stands according to their structural and qualitative characteristics generated by the presence of injuries, which, in fact, implies starting again the specific work of forest establishing, attendance and exploitation.

The durable management of deer-damaged artificial forest ecosystems should start from the economic target determined by the destination assigned, by the functional efficiency of the forest for the entire time span of its development.

In conclusion, it can be stated that there are three elements which the sylviculturist should take into account when managing the Norway spruce stands affected by biotic disturbing factors: a) the forest management – which establishes the

general directions of standing crop management; b) forest-technique – which establishes the specific technical directions of management, particular for each stand; c) the economic factor – which establishes the timeliness and the necessity of ecological reconstruction of certain categories of trees affected by deer.

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