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THE MANAGEMENT OF PINE STANDS SITUATED OUTSIDE THEIR HABITAT

Cristinel CONSTANDACHE, Lucian DINCĂ

"Marin Drăcea" National Institute for Research and Development in Forestry (INCDS), 128 Eroilor Blvd., Voluntari, Ilfov County, Romania; E-mail: cicon66@yahoo.com; dinka.lucian@gmail.com

Corresponding author: cicon66@yahoo.com

Abstract

Pines stands from outside their areal were created from 1972 in field and plain areas with the purpose of substituting degraded stands (oaks) or derived ones (linden, hornbeam). These cultures had a good evolution up to the age of 30-35 years, after which they were affected by drought and/or breaks with an effect on their stability, protection, regeneration functions and forest continuity. The degree of damaged caused and the danger that this phenomenon poses in disordering the ecologic equilibrium requires the adoption and appliance of complex silvo-technical measures and works. The present paper shortly presents data regarding the current state of pine stands situated outside their areal as well as their ecological reconstruction solutions. These solutions were scientifically sustained based on the results of investigations realized during 2015-2018. The ecological reconstruction works of pine stands located outside their areal are necessary for improving their current structure, as well as their capacity for ensuring regeneration and their transition towards other forest zonal types. The recommended ecological reconstruction solutions intend to reestablish a natural forest type by substituting pine stands from lands located in "natural" stations or slightly altered towards a natural forest type. This can be achieved by restoring-substituting pine stands situated in moderately degraded lands with improved vegetation conditions.

Key words**:** *pine stands from outside their areal, damages, drying, ecological reconstruction*

INTRODUCTION

Pine stands from outside their habitat are located in Romania in the silvo-steppe area (especially black pine stands) and in hill ones (black pine and Scots pine), on lands with different site conditions. These stands were introduced from the year 1972 in order to replace some degraded stands (generally oak ones) or derived ones (linden, hornbeam). As such, at the present moment their age varies between 35 and 40.

Pine trees were also frequently used in the afforestation of degraded lands from the silvo-steppe area [7] up to higher areas [8]. They have a good behaviour when mixed with different broad-leaved species [11, 12] and with the white sea buckthorn on very strongly degraded lands [5]. Pine plantations from degraded lands have offered good results only after the implementation of special field management/consolidation works [5, 13].

Pine cultures from outside their habitat had a good evolution up to the age of 30-35 years, after which they were affected by climatic changes (drought, wind, etc.). The damages were moderately up to strongly in the external silvo-steppe with extreme conditions (drought) and moderate up to weak in the hill areas [6]. In this manner, the stand's structure has degraded (the number of trees and their consistency has reduced, sometimes even considerably), affecting their stability, protection functions and landscape [3, 14]. Significant damages (entire drying) were registered for Norway spruce, fir and Douglas fir cultures extended outside the habitat. Their decline will be accentuated in the following decades, especially in the hilly areas [2, 10].

The amplitude caused by damages on resinous stands situated outside the habitat and the danger that this phenomenon poses in disordering the ecological equilibrium requires the adoption and appliance of complex measures. These measures regard the ecological reconstruction of the affected stands and the steady return to the natural forest type. The ecological reconstruction of natural ecosystems has favourable effects in increasing their biodiversity, in diversifying

ecosystem services [1], in reshaping the landscape and in forest regeneration and continuity.

Replacing resinous stands located outside their habitat must be substantiated with care in order to avoid new crises [2, 9]. These types of works are recommended as emergency when the stand's health state and vigour significantly decreases, without the possibility of a natural rectification. This situation is caused by a decrease in consistency, soil sodding and compacting or by the regeneration of some species with a reduced ecological value.

The present paper presents the state of pine stands situated outside their habitat and their ecological reconstruction solutions, based on the results of investigations realized during 2015-2018.

MATERIALS AND METHODS

Field investigations were realized in order to achieve the intended objectives, followed by data interpretation. Taking into consideration the diversity of the research's situations (stands, site conditions etc.) and objectives, representative pine stands located on lands with different site conditions from the East part of Romania were analysed.

One of the main objective was to identify the ecological factors that limit ecological reconstruction and the regeneration of pine stands located outside their real. The current state of pine stands in relation with the action of some harmful agents was also taken into study. The structural and qualitative characteristics of stands located outside their habitat has a special importance as it helps in creating an overview of their regeneration state, structure, stability and capacity.

In order to attain the purpose of the investigations, ecological reconstruction experiments were realized in pine stands located outside their habitat from lands with different site conditions (five experimental blocks).

The research surfaces and experimental blocks were situated in the following forest districts: Iasi, Bacău, Vrancea, Buzău, Galaţi, Cluj and INCDS "Marin Drăcea" - BE Vidra.

Observations and measurements (the entire measurement of the base diameter and heights on species, the inventory of the number of trees and shrubs on species) were realized in the research surfaces, followed by an evaluation of their consistency and health state. In addition, other elements were also determined: seedling composition and characteristics, coverage composition and degree, herbaceous vegetation etc.). Representative images were captured in areas with important characteristics for the intended purpose.

Tree heights were measured with the Vertex dendrometer, while the diameter was measured on two directions with a caliper.

The health state was expressed through the defoliation degree. As such, its evaluation was realized based on the forests' state evaluation methodology.

In order to emphasize the stands' structural characteristics, an experimental distribution analysis was realized for the main biometric parameters through the theoretical distribution functions (normal, beta) that correspond to the horizontal structure. Another analysis method for the stands' structure was represented by the analysis of correlations between different qualitative and quantitative characteristics, through general statistical methods.

The stands' quality study and establishing dependency connections between different qualitative and quantitative characteristics has involved the usage of a structure analysis in regard with the site conditions.

RESULTS AND DISCUSSIONS

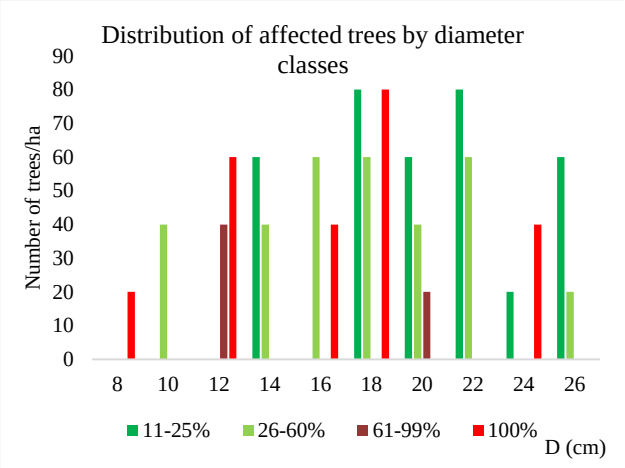
During the last period of time, as an effect of climatic changes, pine stands (Scots and black) located outside their habitat have suffered damages caused by drought (drying) and sometimes by windfalls and snow [7]. The lands on which these types of stands were created are diverse from the point of view of geomorphologic and pedosite conditions. Affected pine stands were identified from the external silvo-steppe area (with severe climatic conditions) up to the area with oaks, namely hills with altitudes of up to 400 m (500 m, in Transylvania's plateau). The lands

were both normal and degraded. The most frequent damages were drying – especially in silvo-steppe and breaks (stem, crown) caused by wind and snow – in the oak area as well as in the interior silvo-steppe.

Vegetation conditions were analysed in order to emphasize the purpose of factors that cause the evolution and behaviour of pine stands, in correlation with the harmful factors.

The health state of pine stands located outside the habitat

The realized investigations have emphasized the stands composed of a single species as the most vulnerable ones. They are dense (plantation schemes of 1,0x1,0 m or 1,0x1,5 m), without on time management works (cleanings), situated in the steppe/silvo-steppe area and in the oak sub area, with ages between 30-40. At this age, the pine's water necessary is reported as maximum [4].



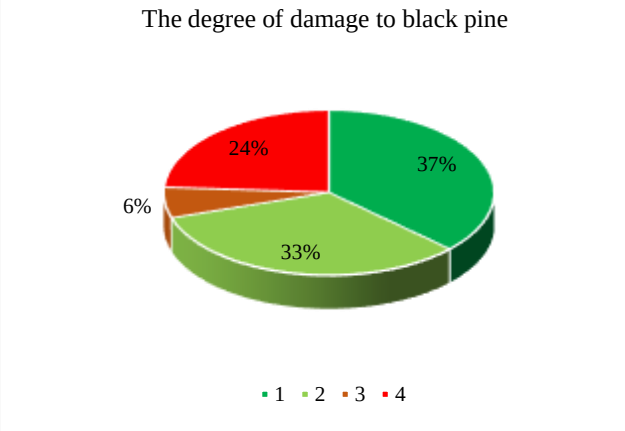


Fig. 1. Damage characteristics for u.a. 40B, UP II Rareş, OS Galaţi.
Source: original.

Scots pine was more strongly affected by the above-mentioned conditions, in comparison with the black pine.

The analysis of the pine damages degree has shown that the percentage of damaged trees (affected by drying in a percentage of over 25%) is of over 50% in most of the analysed situations (Fig.1, 2), and can reach even 75 – 77%. The largest percentage of damaged trees is observed in most stands located in the silvo-steppe area, in places were extraction works were not implemented.

Fig. 2. Black pine stand (40 years old) strongly damaged with cherry and manna regeneration, u.a 40B, U.P. II Rareş, OS Galaţi.
Source: original.

Besides drying, pine stands from outside their habitat have suffered damages caused by wind and snow. As such, in most of the analysed situations, a significant percentage of the number of trees in vegetation (over 70%) presents different defects. Breaks predominate for Scots pine, while the black suffers more from bending/ leaning due to the pressure exercised by adherent snow and winds. The most important damages were recorded in pine stands located in the internal silvo-steppe, up to the superior vegetation levels.

The height distribution and the number of trees per diameter classes (Fig. 3) emphasises the degraded structure of black pine stands affected by drought.

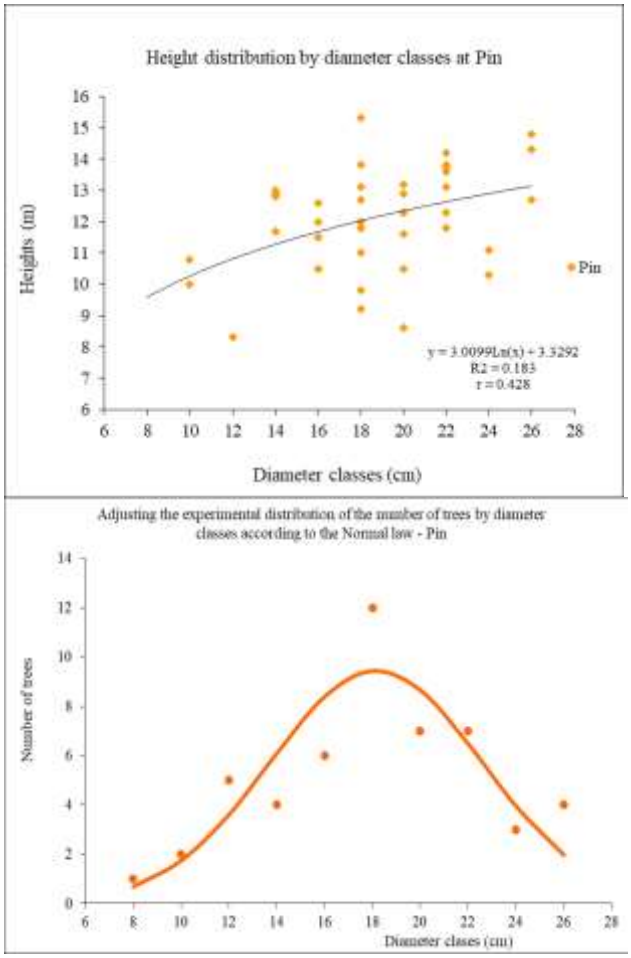


Fig. 3. Height distribution and the number of trees per diameter classes (u.a 40B, U.P. II Rareş, OS Galaţi). Source: original.

Generally speaking, the damages were moderate to strong in the external silvo-steppe and moderately to weak in the superior vegetation levels where strongly damaged species (over 60%) were extracted through silvotechnical works. As such, the number of trees and their consistency was significantly reduced.

In approximately 50% of the analysed situations, the pine stands included broad-leaved species (Fig.2) that have regenerated naturally (originating from the old substituted stands). Their role is essential in ensuring consistency and the stands' structural diversity [15].

The investigations realized in regard with the evolution of pine stands located on lands from different site conditions sustain the fact that nature tries to restructure ecosystems with a too high degree of uniformity. The intervention periods and means are different than the ones used by a forester. The necessary silvicultural management measures must take into account the complexity of site conditions, stand characteristics as well as their evolution directions.

The urgency of interventions with ecological reconstruction works

Intervention urgencies with ecological reconstruction works were established based on the stand structure and degree of damage. However, establishing ecological reconstruction solutions is difficult as it requires different solutions and techniques, based on the site conditions and other characteristics of the affected stands.

The urgency of intervening with ecological reconstruction works in pine stands located outside their habitat is differentiated based on consistency, damage degree and the structural characteristics of the affected stands.

As such, the following intervention urgencies were differentiated based on the obtained researches:

-very strongly affected stands (with over 60% trees affected by drought or breaks, or with the consistency under 0.4), pure, without natural regeneration – Ist degree urgency (reconstruction);

-strongly affected stands (26-60% trees affected or a consistency under 0.6), pure or mixed with broad-leaved species (20-40%), without or with a weak natural regeneration from unwanted species – IInd degree urgency (reconstruction);

-strongly affected stands (26-60%), 0.6 – 0.8 consistencies, mixed with broad-leaved species (at least 30%), with a natural regeneration with valuable local species (on at least 30% of the surface or covering 0.3 of the surface): permanent maintenance works; reconstruction/helping natural regeneration/additions – III^{d} degree urgency;

-weakly-moderately affected stands (11-25%) – maintenance works and additions, IVth degree urgency.

The ecological reconstruction works of pine stands located outside their habitat are necessary both for improving the current situation (consistency, composition, etc.), as well as for restoring their capacity for ensuring regeneration and a transition towards other zonal forest types. The proposed

ecological reconstruction works are: substituting, restoring-improving, helping natural regeneration.

Taking into consideration the biological particularities of pine and their predisposition towards damages, the ecological reconstruction works, namely introducing or promoting local species with a high ecological value intend to create stands resistant to the action of damaging factors. At the same time, their hydrological efficiency and anti-erosion are increased, helping them easily regenerate naturally and ensuring the continuity of forests and their protective functions.

The ecological criteria for choosing species for the ecological reconstruction of pine stands located outside their habitat was the basis for technical recommendations. According to this criterion, only healthy and robust forests composed of proper species adapted to site conditions area capable of superior functionalities that can respond to multiple economical, hydrological, anti-erosion, hygienic, sanitary and landscape requirements that can activate in complete stability and a high economic profitability. Compositions with the main species that correspond to site conditions were recommended. Using a large number of species in afforestation compositions can lead to an increased biodiversity, tree resistance towards the impact of harmful biotic and abiotic factors and, implicitly, to improving their stability.

The ecological reconstruction solutions imply a reverse to the natural forest type by substituting pine stands from lands situated in "natural" stations or slightly changed and steadily switching them to a natural forest type. This can be achieved by restoring-substituting pine stands located in degraded field stations with extreme site conditions (with an advanced degradation, superficial, skeletal soils, high slopes, drought etc.). Restoration-improving solutions were proposed (where pines had a percentage of 25-50%) in mixture with broad-leaved species and shrubs, with the switch towards a natural forest in a subsequent stage.

The intervention methods with ecological reconstruction works were differentiated based on the stand's damage degree and site conditions:

For *very strongly and strongly damaged* stands, pure, without a natural regeneration or with a weak regeneration and/or from improper species:

-on plain lands or weakly inclined (slope < 10 degree) – substituting through erased cuttings (floorings smaller than 3 ha);

-on inclined lands (10-25 degrees) – substituting through erased cuttings (in strips with a length of approximately 3 x the average stand's heights on 1/3 of the stand's surface);

-degraded lands, moderately up to strongly eroded - tree restoration on strips with a 1 - 3 length, average stand heights, for 1/3 of the stand;

-on degraded lands with large slopes and high erosion risk – ecological reconstruction through improving the stand's composition in holes with 1-3 diameter, average stand heights, located in the points with the highest damage intensity, with consistencies under 0.6.

For *strongly damaged* stands, composed of pines and broad-leaved species and with a natural regeneration of valuable local species, the silvicultural intervention direction is to manage the stands through silvotehcnical works, extracting pine species affected by drought, selecting/promoting local broad-leaved species naturally installed through maintenance/helping seedling works; completing holes through plantations or direct sowing.

Extracting damaged trees will be realized without harming the remaining trees, the seedling or the soil. The harmed natural regenerated seedlings will be cut back.

The interventions will be differentiated through their spreading within the stand, consistency, age and presence of natural regenerations, as follows:

-if the damaged trees are uniformly or relatively uniformly distributed, the ones that can no longer be maintained will be extracted, keeping only the samples that present damages/drought under 40 %.

-if the damages were produced focused (in bunches or clusters), the extraction of damaged trees is mandatory. The intention is

to level as much as possible the growth space for the remaining trees within the holes; in stands with already existing holes, the affected samples will still be extracted; in both cases, plantations or direct sowings will be realized in the resulted holes (larger than 300 m^2), with species proper for the station; for the rest of the stand, the growing spaces will be levelled, encouraging broad-leaved species and/or natural regenerations;

-in the situations with a strongly developed sub-stand, the eradication of stubs from arbustive species is necessary in the holes destined for afforestation.

M*oderately damaged* stands where the damaged trees percentage varies between 11 and 25% of the total number of trees, can be managed by applying maintenance cuttings, followed by promoting broad-leaved species and opening regeneration holes (conservation cuttings).

CONCLUSIONS

In 75% of the analysed situations, the presence of naturally regenerated broad-leaved species was observed. They originate from the substituted stands and have an important role in ensuring the consistency and structural diversity of pine cultures; the higher diversity of pine stands in mixture with broad-leaved species manifests in an increased stability, adaptation to site conditions and a capacity for natural regeneration.

Evaluating the vulnerability of resinous stands from outside their habitat is necessary in the conditions of climatic changes in order to know the evolution direction of the stands and for prioritizing future interventions of managing and regenerating pine stands.

The urgency of interventions and means of ecological reconstruction were established based on the stand's structure and degree of damage. The establishment of ecological reconstruction solutions was realized based on site conditions, requiring different compositions and techniques.

Ecological reconstruction works for pine stands located outside their habitat are necessary both for improving the current situation (consistency, composition, etc), as well as for their capacity in ensuring regeneration and for a transition towards other forest types.

The ecological reconstruction of pine stands must take into account the naturally regenerated species as belonging to "the biocenosis memory" as well as the need for creating more stable biocenosis with a higher ecological value.

The recommended ecological reconstruction solutions target the recursion to the natural forest type by substituting pine stands from lands located in "natural" stations or slightly changed and steadily moving towards a natural forest type. This can be achieved by reshaping-substituting pine stands located in moderately eroded degraded lands with improved vegetation conditions. In the case of lands with extreme site conditions (with an advanced degradation, superficial, skeletal soils, high slopes, drought, etc.), reshaping-improving solutions with pine and broad-leaved or shrub species (where the pine has a percentage of 25-50% were proposed), while switching towards a natural forest is postponed for a future stage.

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