THINNING: WORKING TIMES, PRODUCTIVITIES AND UTILIZATION COSTS IN A PINE FOREST

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ABSTRACT: thinning interventions in artificial coniferous stands are fundamental for the correct development of this kind of forests. However, these utilizations have often a negative stumpage value and so they can be conducted only if funded by funding programs like Rural Development Programme. One way to improve this negative aspect is the application of high mechanization level in order to decrease operations costs. The aim of this work was consequently the analysis of work productivity of a thinning intervention, performed with a high level of mechanization, in a pine forest in Italy. Obtained results showed a substantially negative budget of the utilization but strongly influenced by pruning operation, which is not common in such yards, and so it is possible to assert that high level of mechanization could consistently improve coniferous thinning yards' economy.
Keywords: biomass, harvesting, wood chip

1 INTRODUCTION

In the period between 30's and 70's Italian territory was characterized by an intensive activity of artificial coniferous stands plantation. Estimated surface of these artificial stands is about 1.300.000 ha [1]. Pine species were the most utilized for this activity, in particular black pine (*Pinus nigra* Arn.) in mountainous zones and stone pine (*Pinus pinea* L.) in coastal ones. The principal aim of these artificial plantations was recovering soil characteristics and promoting the affirmation of indigenous broad leaves species.

Great economical efforts were done for the establishment of such stands but instead practically no thinning intervention were conducted and so the aim of forest restoration of these lands is actually disregarded [2]

These interventions have been rarely conducted because of the lacking of economic income linked to the scarce economic valorization of attainable wood assortments from such forest operations [3].

One possible way to reverse this situation is advanced or intense level of mechanization use in such interventions [4].

The main problem in doing this is linked to the characteristics of the major part of Central-South Italy forest enterprises which are mainly small family business with poor level of technological advancing in their machinery [5].

Considering what written above accurate studies on advanced mechanization level forest yards planning and productivity are needed, in order to analyze forest operations' cost and assessing the best possible alternative for utilization's scheduling [6].

This work aims to analyze working times, productivities and utilization costs, that influence the economic advantage of planning options, regarding thinning operation in a pine plantation. The study was made to a pine forest of about 40 years old, made up by 95% of stone pine (*Pinus pinea* L.) and by 5% of maritime pine (*Pinus pinaster* Aiton), located in "Spinicci" (Municipality of Tarquinia) and managed by Agrarian University of Tarquinia.

2 MATERIALS AND METHODS

2.1 Study area and forest yard description

Study area is located in "Spinicci" locality within the Municipality of Tarquinia. Surface area is 22,96 ha, stand age is 40 years and plants density is 180 n/ha. Study area's location is given in Figure 1.

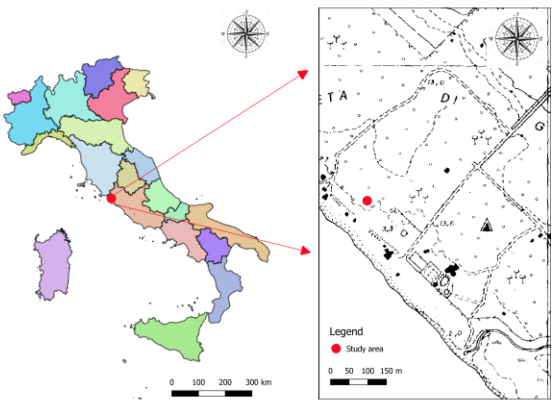

Figure 1: study area location

Forestry intervention consisted in a selective phytosanitary thinning in which only died or ill individuals were felled.

Working system was SWS (Short Wood System) with motor-manual felling and processing trough Husqvarna 346 XP chainsaw. The same machine was used for pruning branches up to a distance of 1,5-2 m from the stem using a Manitou MRT 1840 lift truck to reach highest branch of the plants. Extraction operation was performed by John Deere 1110D forwarder and biomass comminuting was conducted with a Pezzolato PTH 1200-1000 chipper powered by a Xerion 4500 Claas tractor. Wooden material loading within the chipper was conducted with a LHO model L160.Z.78 hydraulic loader.

2.2 Field relieves and data elaboration

Conducted field relieves consisted in:

- Overall biomass and harvested biomass estimation through tally in sample plots
- Work productivity analysis through time table with the methodology developed by Picchio et al. [7]. In particular gross productivity (PHS_0) and net productivity (PHS_{15}) were evaluated. Net Productivity was calculated taking into consideration all delay times up to 15 minutes.
- Cost analysis through machinery cost evaluation with [8] methodology

Figure 2: forwarder John Deere 1110D

3 RESULTS AND DISCUSSION

3.1 Biomass estimation

Results of biomass estimation are given in Table I.

Table I: biomass estimation for the stone pine artificial stand

Parameter	**Measure unit**	**Pre-intervention Value**	**Post-intervention Value**
Stand age	yr	40	40
Density	N/ha	180	110
average dbh	cm	41.0	41.4
average height	m	17.5	17.5
Basal area	m^2/ha	19.35	6.85
Stand Volume	m^3/ha	284.040	100.020
Harvested Volume	m^3/ha	---	184.020
Biomass	t_{fm}/ha	176.100	62.020
Biomass	t_{dm}/ha	104.240	36.680
Harvested Biomass	t_{dm}/ha	---	114.080
Harvested Biomass	t_{fm}/ha	---	67.560

From the reported above Table I it is possible to notice the consistent amount of the intervention which, even if regarding only died or ill plants, had a percentage of harvested biomass of almost 65% in volume.

3.2 Work productivity analysis

Results of work productivity evaluation are given in Table II.

Table II: work productivity analysis

Felling-Processing-Pruning [t_{dm}/(h*worker)]		Extraction [t_{dm}/(h*worker)]		Comminuting [t_{dm}/(h*worker)]	
PHS_0	PHS_{15}	PHS_0	PHS_{15}	PHS_0	PHS_{15}
3.95	1.94	4.06	3.77	8.99	7.77

As it is possible to notice extraction and comminuting showed good performances with relatively high productivity and few delay times (7% for extraction and 14% for chipping), instead the worst operation according to our results resulted to be felling-processing with low work productivity and 51% of delay times.

This is mostly linked to pruning operation, which is very rarely conducted in forestry interventions, which obviously negatively affected work productivity.

3.3 Cost analysis and hypothesis of stumpage value

Cost Analysis' results are given in Table III.

Table III: cost analysis

Operation	€/h	€/m^3	€/t_{fm}	€/t_{dm}
Felling-Processing-Pruning	35.16	4.84	5.37	9.04
Extraction	142.66	24.36	27.02	45.51
Comminuting	351.22	12.10	13.40	22.60
Total	529.04	41.30	45.79	77.15

Considering a price for wood chips at landing site of 45 €/t_{dm} (taken by market analysis conducted in the zone) we had a negative stumpage value of -32.15 €/t_{dm}.
So in this case advanced mechanization use not allowed to a positive balance of the yard. However costs were considerably lower than other yards' ones with a lower level of mechanization [9,10].
Possible implementations are:

- Using not SWS but TLS (Tree Length System) which is more feasible to wood chips production
- Mechanizing also felling operation trough the use of feller-bunchers or harvesters, this is obviously linked to the improvement of forest operators' skills attainable through appropriate training courses

4 CONCLUSIONS

A proper yard's cost evaluation is the primary step for forestry interventions' assessment and planning allowing to put into practice forest utilizations suitable under not only economic aspect but also for what concerning environmental and social ones.

Obtained results of the economic evaluation of a advanced mechanization level yard of thinning in artificial stone pine stand lead to a negative stumpage value. However results are encouraging because improvements, in comparison to low level mechanization yards, are evident. Notwithstanding this other implementations are needed in order to obtain positive stumpage values.

5 REFERENCES

[1] D. Romano, I rimboschimenti nella politica forestale italiana, Quad. Di Monti e Boschi. 3 (1987).

[2] R. Picchio, A. Lo Monaco, R. Venanzi, F. Latterini, Rinaturalizzazione dei rimboschimenti di pino nero (Pinus nigra Arnold): corrette metodologie di utilizzazione forestale e valutazione degli assortimenti, Rinaturalizzazione Dei Rimboschimenti Di Pino Nero (*Pinus Nigra* Arnold) Corrett. Metodol. Di Util. For. e Valutazione Degli Assortimenti. (2018) 29–55.

[3] S. Savelli, R. Cavalli, S. Baldini, R. Picchio, Small scale mechanization of thinning in artificial coniferous plantation, Croat. J. For. Eng. J. Theory Appl. For. Eng. 31 (2010) 11–21.

[4] S. Baldini, F. Di Fulvio, G. Laudati, Analisi della filiera di biomassa legnosa proveniente da interventi di diradamento: un caso di studio in una pineta dell'Italia centrale, For. Silvic. For. Ecol. 7 (2010) 177.

[5] S. Baldini, R. Cavalli, F. Piegai, R. Spinelli, F. Di Fulvio, F. Fabiano, S. Grigolato, G. Laudati, N. Magagnotti, C. Nati, Prospettive di evoluzione nel settore delle utilizzazioni forestali e dell'approvvigionamento del legname, in: Proc. Atti Del Terzo Congr. Naz. Di Selvic. per Miglioramento e La Conserv. Dei Boschi Ital. Firenze, 2009: pp. 717–728.

[6] P.S. Mederski, M. Bembenek, Z. Karaszewski, A. Łacka, A. Szczepańska-Álvarez, M. Rosińska, Estimating and modelling harvester productivity in pine stands of different ages, densities and thinning intensities, Croat. J. For. Eng. 37 (2016) 27–36.

[7] R. Picchio, M. Maesano, S. Savelli, E. Marchi, Productivity and energy balance in the conversion into high forest system of a Quercus cerris L. coppice in Central Italy, Croat. J. For. Eng. 1 (2009) 15–26.

[8] G. Hippoliti, Appunti di meccanizzazione forestale, Studio editoriale fiorentino, 1997.

[9] S. Baldini, Picchio R. 2001-Primo diradamento con messa a punto di nuove metodologie di lavoro in una pineta dei Cimini, Linea Ecol. 6 (n.d.) 47–54.

[10] F. Fabiano, F. Piegai, Diradamenti in impianti artificiali di conifere, Prod. e Costi per Prod. Di Cippato. Sherwood. 136 (2007) 23–29.

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