

Fine firewood collection after motor-manual pruning in *Quercus ilex* open forests in Salamanca (Western Spain).

Eduardo Tolosana, Rubén Laina, Rocío Martínez.Ferrari, Marina Martín

E.T.S.I. de Montes, Forestal y del Medio Natural. Universidad Politécnica de Madrid. eduardo.tolosana@upm.es



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Objective

Productivity and cost evaluation of fine firewood extraction after different types of motor-manual pruning (shape pruning and regular (fruiting) pruning in Holm oak (*Quercus ilex*) "dehesa" forests (meadows with scattered trees) in gentle slopes: Study in firewood forwarding, transport to landing & chipping



Shape pruning. leaves 4-6 big branches, shaping the crown for producing more acorns. Firstly performed ≥ 20 years after the first regular pruning. Produces coarse firewood, collected and sold in the market, and also fine firewood ($\varnothing \leq 10$ cm), normally left on the ground



Regular (fruiting) pruning. the first at 50 years old (75 cm of perimeter at breast height), after shape pruning it is performed every 6-12 years. It produces fine fire-wood ($\varnothing \leq 10$ cm), usually left on the terrain

Methodology

Detailed time and motion studies for most operations, frequency studies otherwise, particularly for non-cyclic phases.

Productivity equations fitted by regression techniques, factorial studies using variance and covariance analysis.

Unit cost estimations based on average productivity and hourly cost estimated by standard methods (Forest Energy COST Action, 2012). The following Table shows the used values (€/effective work hour E0):

Production factor	Estimated hourly cost (€/ewh)	Production factor	Estimated hourly cost (€/ewh)
Forest operator	17,0	Small Dingo domestic forwarder	74,0
Forest operator with chainsaw	20,0	Medium-sized JD or Ponsse Nordic forwarder	84,0
Conventional forest harvester (JD – Timberjack)	104,0	310 Kw drum chipper with crane and truck tractor head	142,5

Results

Table 1: Firewood (coarse and fine) produced in shape and regular pruning, as a function of dbh (cm)

	Pruning type	Product	Equation	Relative error, %	Adjusted R ²	Estimated Standard Error
Fresh weigh, kg	Shape pruning	Coarse firewood	FW=0,089·d ^{2,16}	5,1	56	0,35
		Fine firewood	FW=0,10·d ^{2,03}	4,5	64	0,29
	Regular pruning	Fine firewood	FW=1,16·d ^{1,26}	4,5	64	0,29
Dry weigh, kg	Shape pruning	Coarse firewood	DW=0,06·d ^{2,16}	4,8	56	0,35
		Fine firewood	DW=0,07·d ^{2,20}	3,3	92	0,25
	Regular pruning	Fine firewood	FW=0,86·d ^{1,26}	4,8	64	0,29

Table 2: Studied stands: 5 Strata with different proportion of pruning types, gentle terrain. Only fine firewood collected, except in Stratum 3 (coarse firewood also collected)

Stratum	Surface (ha)	Fine firewood from regular pruning, fresh tonnes/ha	Fine firewood from shape pruning, fresh tonnes/ha	Fine firewood, total, fresh tonnes/ha	Coarse firewood, fresh tonnes/ha	Total firewood, fresh tonnes/ha
1	18,8	6,47	15,25	21,72	0	21,72
2	15,3	5,22	7,8	13,03	0	13,03
3	10,6	11,7	7,91	19,61	11,67	31,29
4	13,7	5,9	8,81	14,72	0	14,72
5	42,5	4,91	7,12	12,03	0	12,03

Table 3-: Productivity and cost of pruning, firewood forwarding, truck extraction to landing and chipping.

Pruning					Small truck extraction to landing and chipping at landing			
	Average time/ tree (work hours, 2 workers)	Productivity (fresh tonnes /work hour)	Cost per tree (€)	Unit cost (€/ fresh tonne)		Productivity (fresh tonnes/work hour)	Hourly cost (€/work hour)	Unit cost (€/ fresh tonne)
Strata 1-4	0,86	0,51	31,8 €/tree	72,55	Fine and coarse firewood	6,2	178,5	28,79
					Fine firewood	5,0		35,70
Firewood forwarding								
Stratum	Productivity (fresh tonnes /work hour)	Hourly cost (€/work hour)	Unit cost (€/ fresh tonne)					
1	5,6	84	14,99					
2	4,7		17,93					
3	8,3		10,17					
4	3,9		21,80					
5	8,3		10,10					

If half the pruning cost is considered as related to the coarse firewood production, the other half + forwarding, extraction and chipping are direct costs of fine firewood chips. Even with the best work method, Cost at landing = 82,1 €/fresh chip tonne.

If the best work method (leaving and forwarding whole branches, not piling the fine firewood) were also adopted, but pruning cost were assigned totally to coarse firewood production, the direct cost of fine firewood chips would reduce to 45,8 €/fresh chips tonne from fine firewood at landing, slightly over the present market costs.

Conclusions

- In Holm oak (*Quercus ilex*) open forests in Spanish Mediterranean areas ("dehesas"), fine firewood collection and forwarding for chipping at landing is significantly less costly if branches are left without crosscutting and piling.

- Even so, and without charging pruning cost on fine firewood production, observed costs are slightly under profitability level in present market circumstances.

- More research is well worth to improve the pruning cost and to reduce costs by performing the joint extraction of fine and coarse firewood when both were produced.



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