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Economic evaluation of mechanized and motormanual options for selective felling of *Quercus pyrenaica* coppices in Leon (NW Spain).

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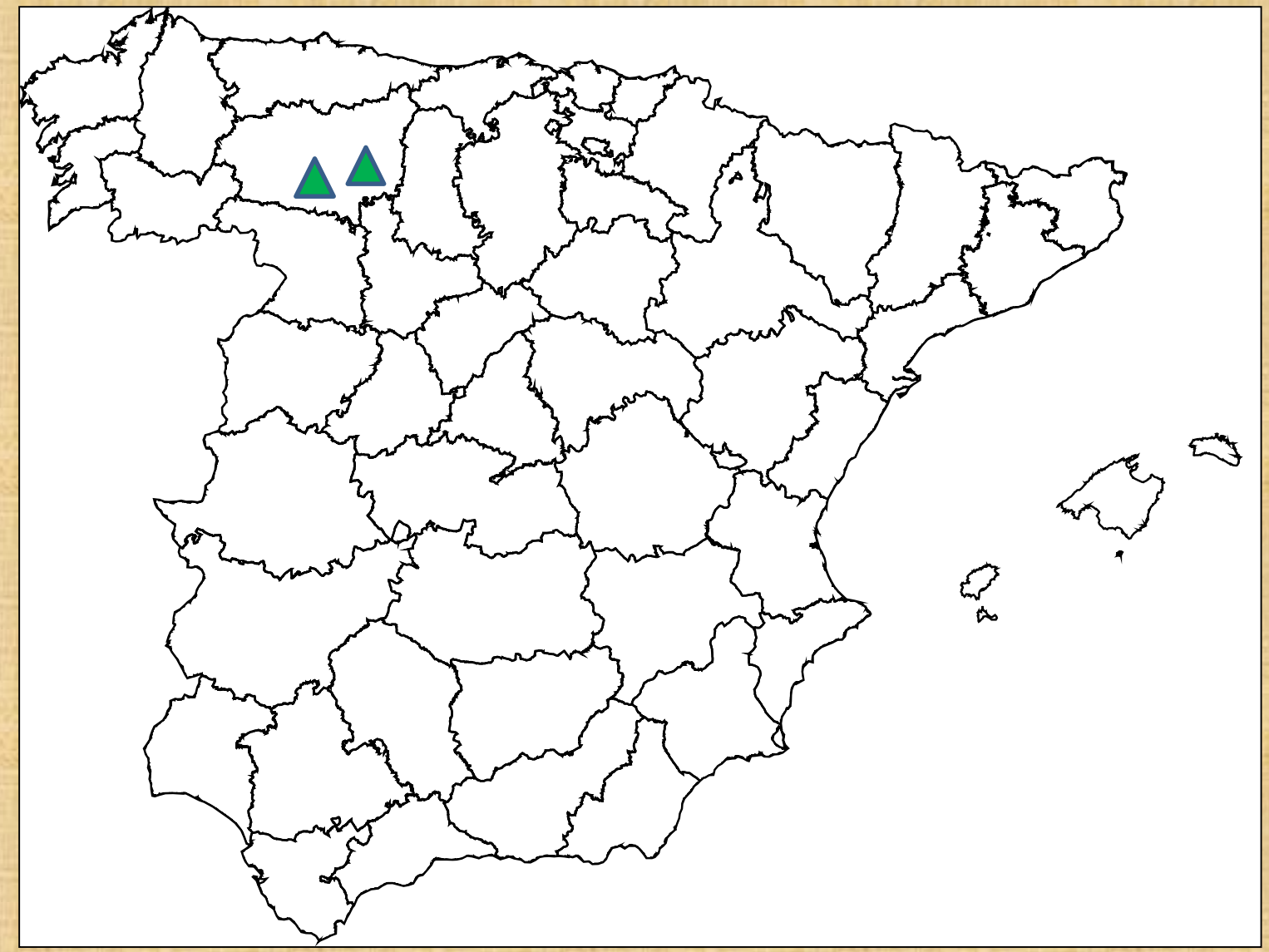
INTRODUCTION: *QUERCUS PYRENAICA* COPPICES

- **Coppice areas represent 64% of Q. pyrenaica total area , that is, 659 000 ha of deciduous oak coppices in Spain.**
- **Main wood destination: firewood (other frequent use: pasture)**
- **Neglected Coppice management in a significant fraction, due to social and technologic reasons. This brings severe constraints, endangering their existence in the long term:**
  - **Deciduous oak forests are getting older, reducing their growth rates and increasing the fire hazards associated to their high densities.**
- **The biomass market is a chance for developing new forest management systems or recovering traditional treatments with new technologies and/or work systems.**

WORK STUDY SITES



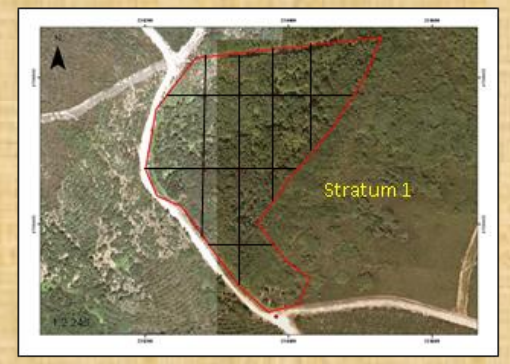
METHODOLOGY

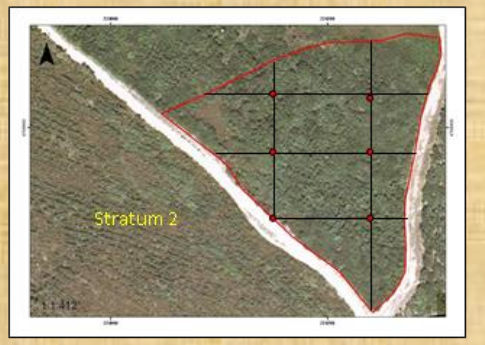
- **Detailed time and motion studies for most operations, frequency studies otherwise, particularly for non-cyclic phases.**
- **Productivity equations fitted by regression techniques, factorial studies using variance and covariance analysis.**
- **Unit cost estimations based on average productivity and hourly cost estimated by standard methods (Forest Energy COST Action, 2012). The following Table shows the hourly costs values (€/effective work hour E_0):**

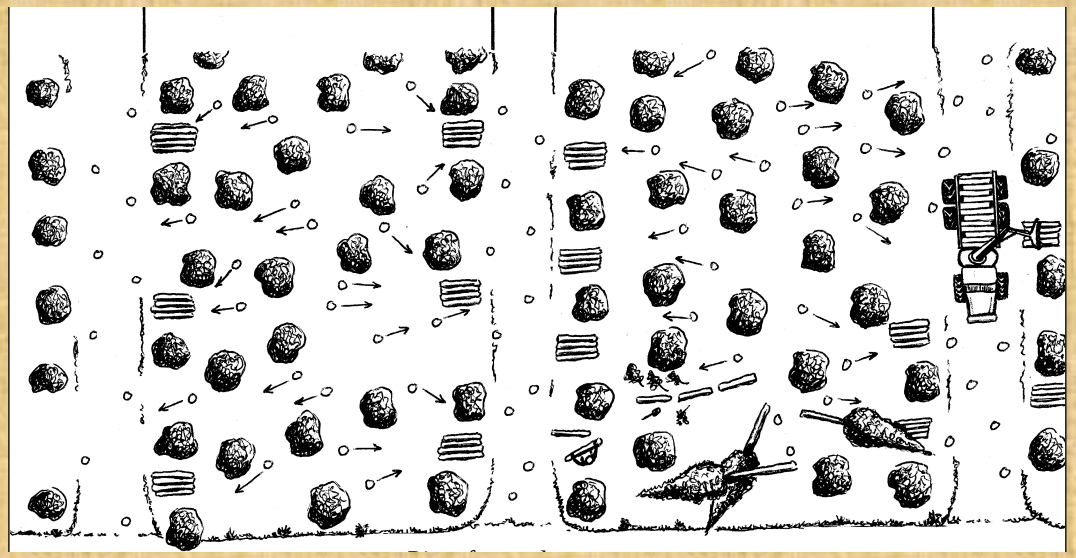
Production factor	Estimated hourly cost (€/ewh)	Production factor	Estimated hourly cost (€/ewh)
Forest operator	17,0	Small Dingo domestic forwarder	74,0
Forest operator with chainsaw	20,0	Medium-sized JD or Ponsse Nordic forwarder	84,0
Conventional forest harvester (JD – Timberjack)	104,0	310 Kw drum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

System 1: Motor-manual CTL (shortwood) harvesting system for firewood / biomass in moderate slope: Motor-manual felling & processing + Forwarding

Studied stands: Strata 1/4 in map below, slope 3-24%, motor-manual felling, delimbing, bunching and stacking. Forwarding with Valmet 860.3 and Dingo forest forwarders through strip and forest roads to landing.





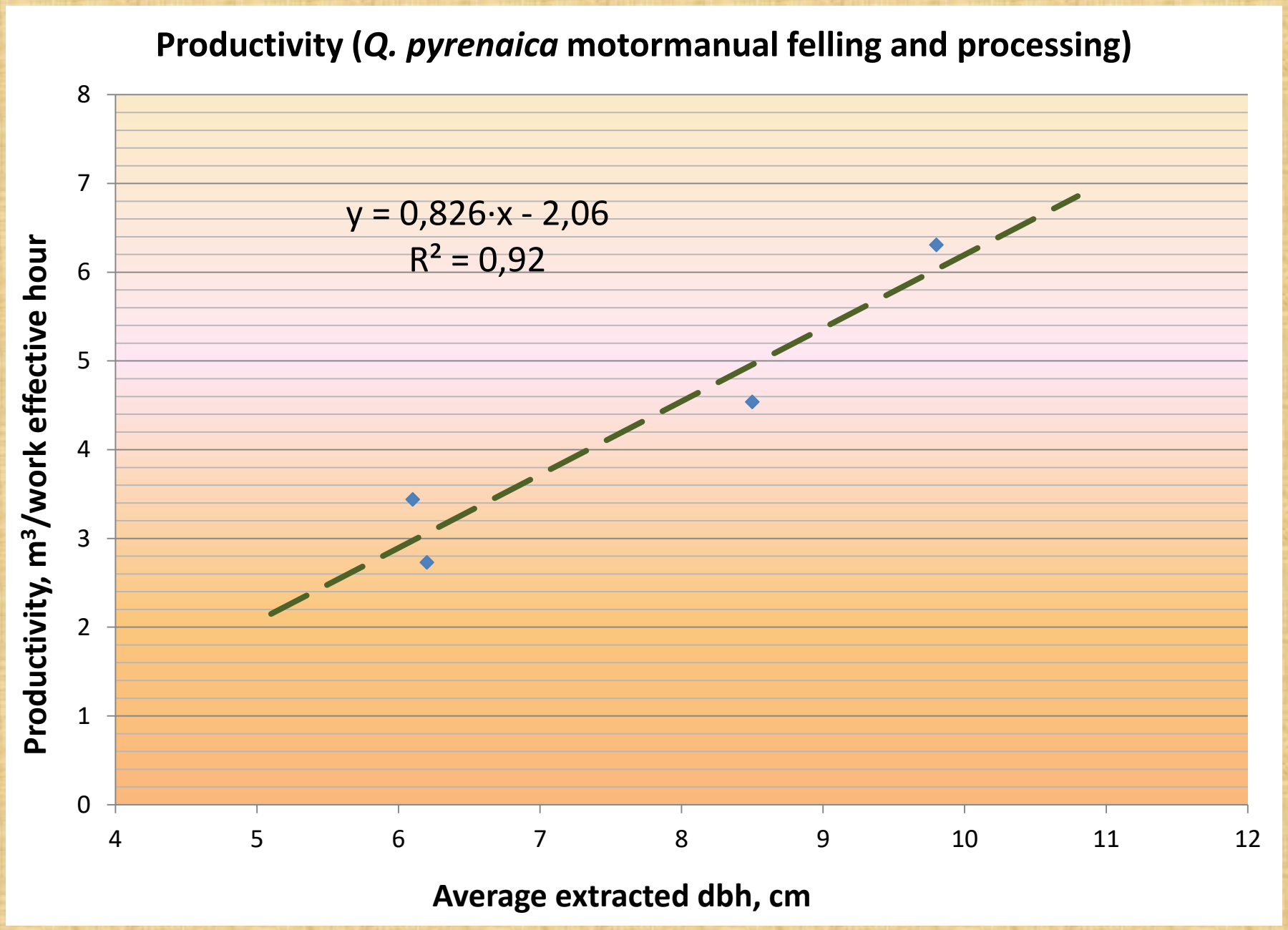


Stratum	Nº felled tres / ha	% Nr felled trees	Average DBh felled trees, cm	Average weigh felled tree, kg	Extracted volume, m^3/ha
1	3171	81,2	8,6	21,8	69,0
2	1106	51,2	8,8	23,7	26,2
3	4358	83,5	4,8	4,2	18,2
4	6949	80,1	5,3	5,5	38,3

Motor-manual felling, delimbing and bucking productivity in coppice thinnings in gente slopes per strata, average manual piling productivity

Productivity felling crew (2 workers), m^3/h	m^3/productive hour	m^3/work hour	m^3/attendance hour	Average ddh, cm
Stratum 1	5,80	**4,54**	2,58	**8,5**
Stratum 2	8,15	**6,31**	4,29	**9,8**
Stratum 3	3,84	**2,73**	1,53	**6,2**
Stratum 4	4,63	**3,44**	2,44	**6,1**
Average piling productivity	4,58	**3,50**	2,24	**----**

Felling and processing average costs ranged from 11,2 to 19,5 €/m^3.


Productivity (Q. pyrenaica motormanual felling and processing)
y = 0,826·x - 2,06
R² = 0,92
Productivity, m³/work effective hour
Average extracted dbh, cm
0
1
2
3
4
5
6
7
8
4
5
6
7
8
9
10
11
12

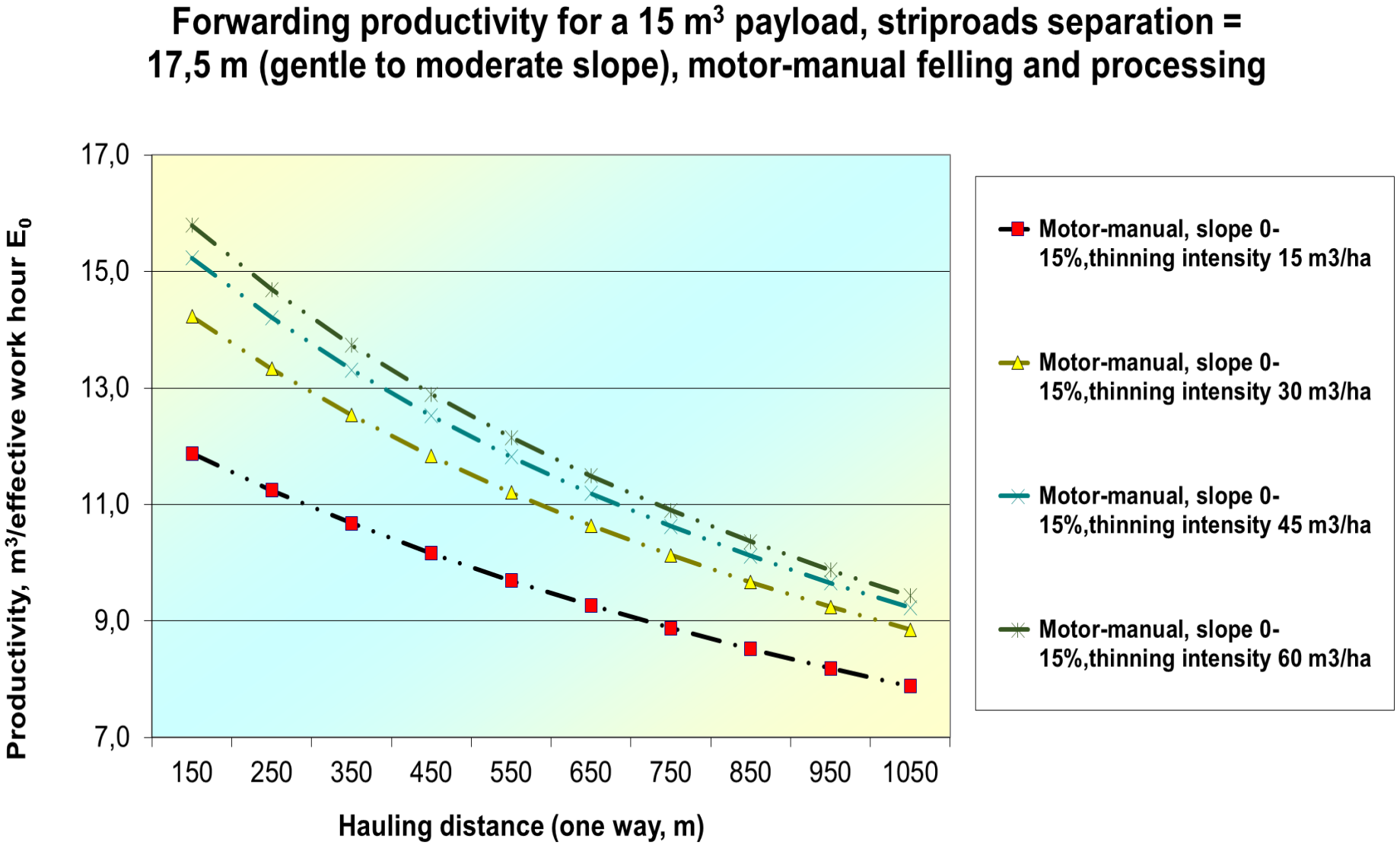
Forwarding productivity for Qp moderate coppice thinnings after motor-manual felling and processing.

$$\text{Productivity } (m^3/h) = P \cdot 3600 / \{2669{,}95 + 1{,}34 \cdot HD + 1{,}99 \cdot [P/(SS \cdot TI \cdot 10^{-4})]\}$$

P forwarder payload, m^3
HD hauling distance, m
SS Striproad separation, m
TI Thinning Intensity, m^3/ha

For thinning intensity = 30 m^3/ha and hauling distance = 500 m, forwarding cost would equal 6,2 €/m^3, and direct harvesting cost would range from 17,4 to 25,7 €/m^3

Forwarding productivity for Qp moderate coppice thinnings after motor-manual felling and processing.

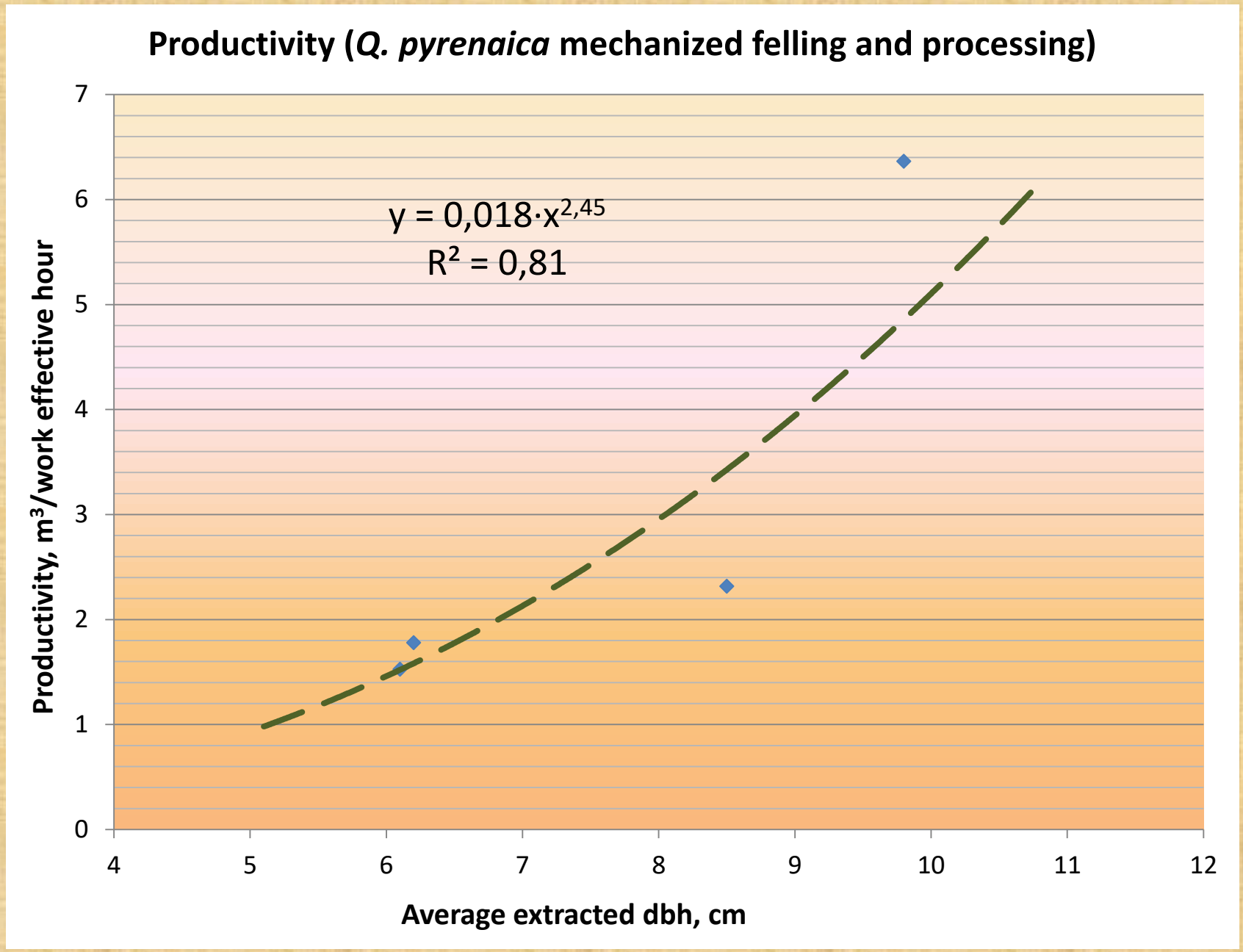


System 2: Mechanized CTL (shortwood) harvesting System for firewood / biomass in gentle/moderate slope: Mechanized felling & processing + Forwarding

Mechanized felling, delimbing, bucking and piling productivity per strata (conventional forest harvesting head)

	Productivity (m^3/productive h)	Productivity (m^3/work h)	Productivity (m^3/attendance h)	Average ddh, cm
Stratum 1	2,575	**2,316**	1,733	**8,5**
Stratum 2	7,927	**6,364**	4,384	**9,8**
Stratum 3	2,165	**1,780**	1,318	**6,2**
Stratum 4	1,646	**1,526**	1,068	**6,1**

Felling and processing average costs ranged from 16,3 to 68,1 €/m^3.


Productivity (Q. pyrenaica mechanized felling and processing)
y = 0,018·x2,45
R² = 0,81
Productivity, m³/work effective hour
Average extracted dbh, cm
0
1
2
3
4
5
6
7
4
5
6
7
8
9
10
11
12

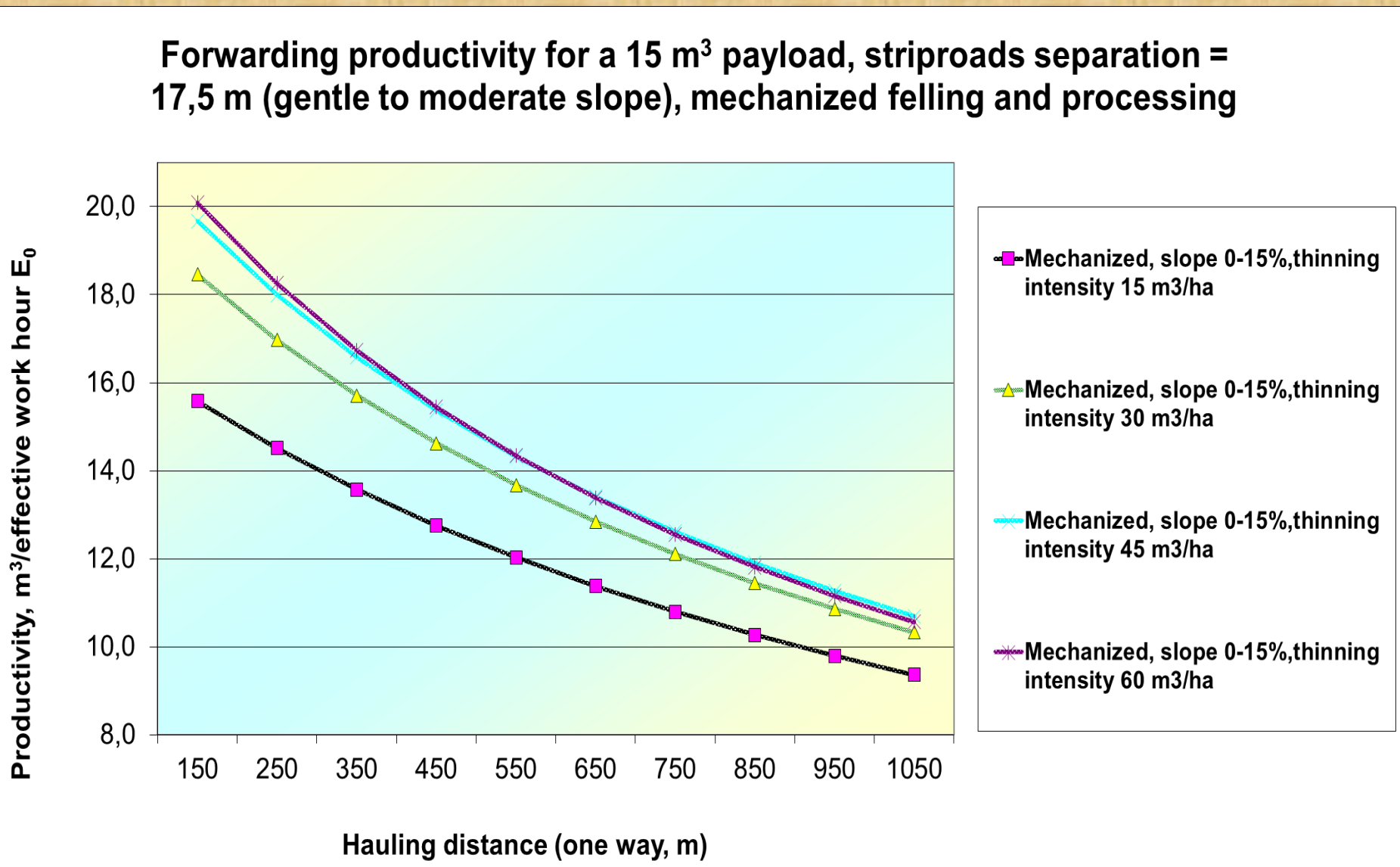
Forwarding productivity for Qp moderate coppice thinnings after mechanized felling and processing.

$$\text{Productivity } (m^3/h) = P \cdot 3600 / \{2001{,}25 + 1{,}34 \cdot HD + 1{,}99 \cdot [P/(SS \cdot TI \cdot 10^{-4})] \}$$

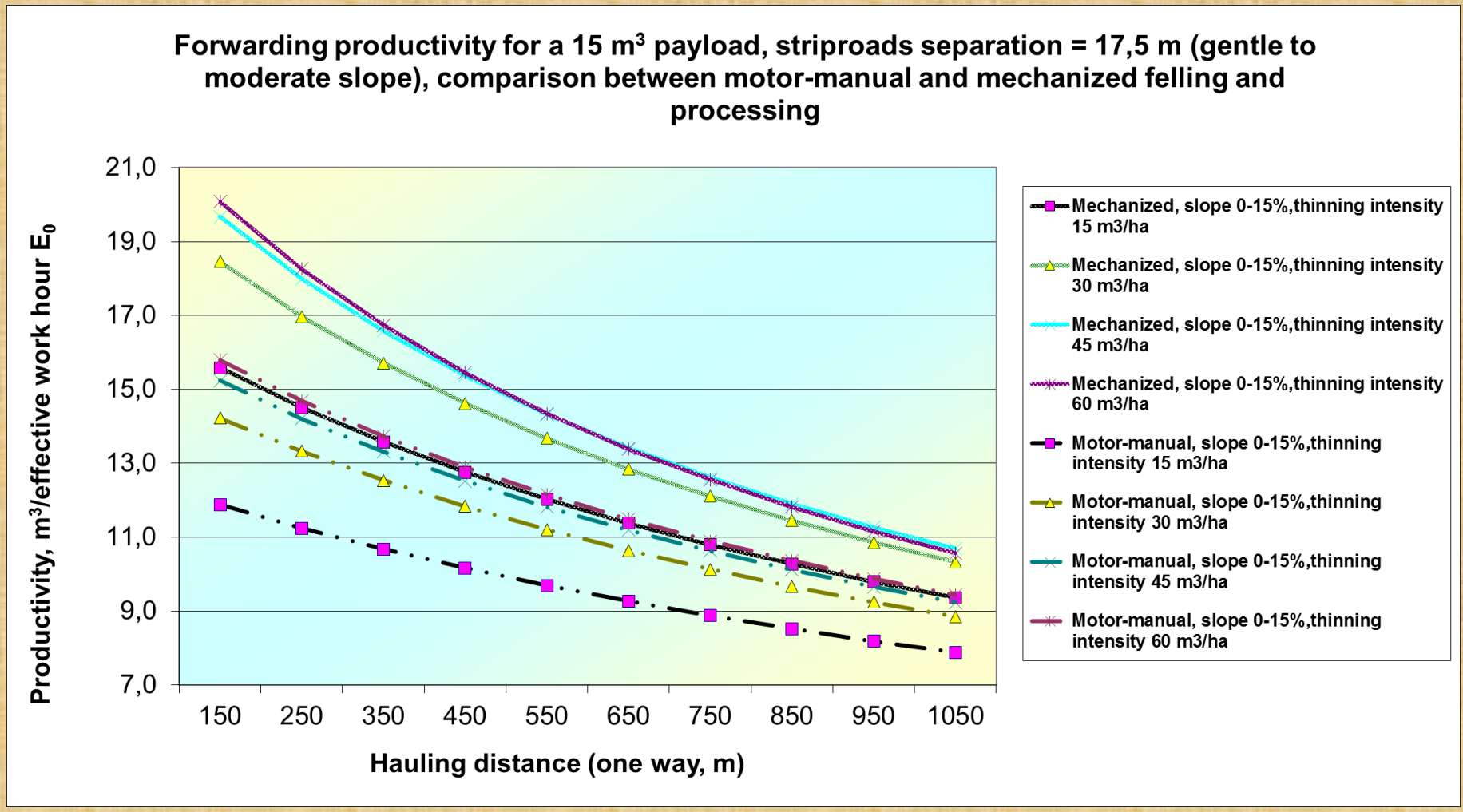
P forwarder payload, m^3
HD hauling distance, m
SS Striproad separation, m
TI Thinning Intensity, m^3/ha

For thinning intensity = 30 m^3/ha and hauling distance = 500 m, forwarding cost would equal 5,2 €/m^3, and direct harvesing costs would range from 21,4 to 73,3 €/m^3

Forwarding productivity for mechanized felling, delimbing, bucking and piling.

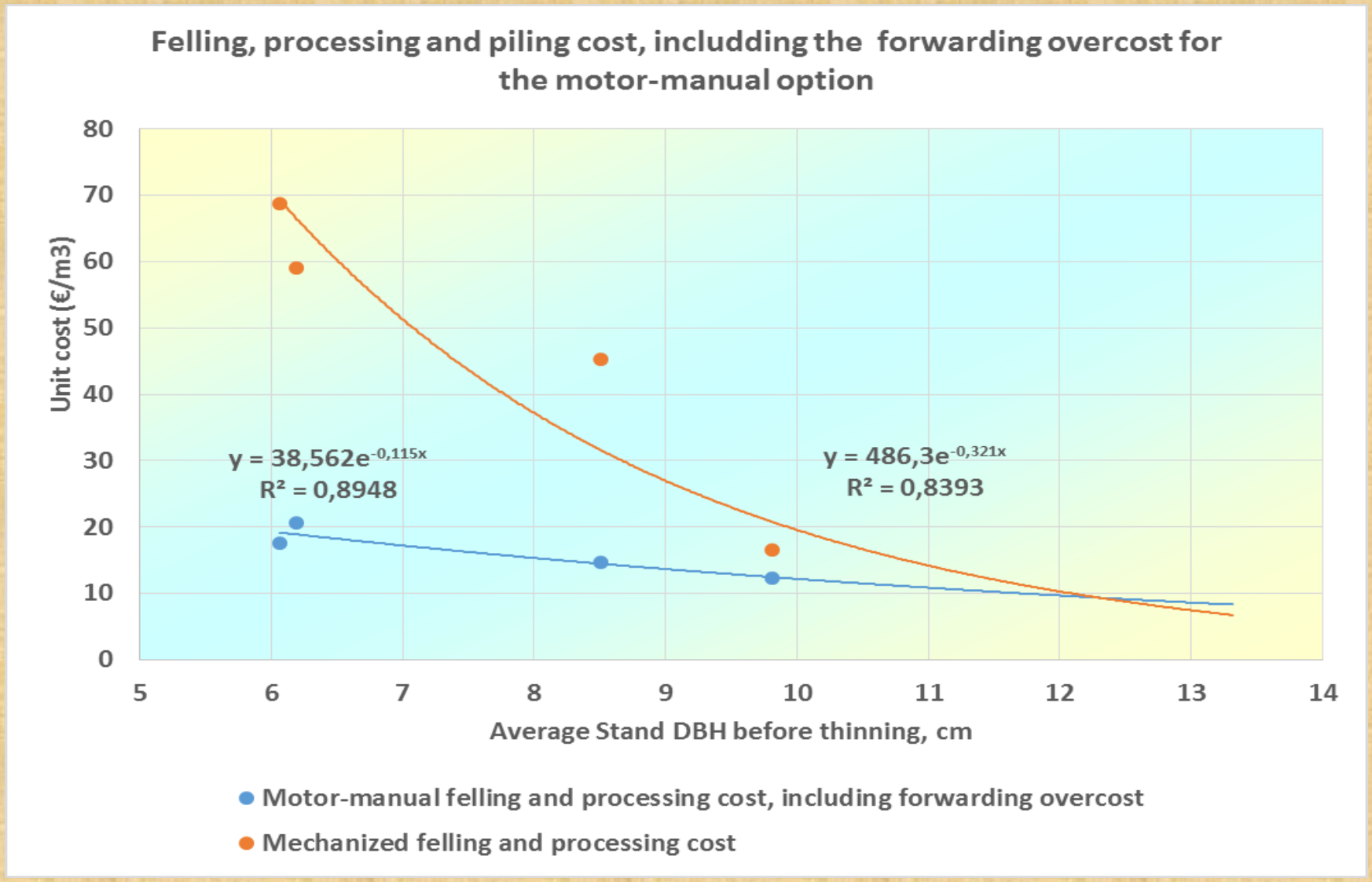


Comparison of forwarding productivity for motor-manual and mechanized felling, delimbing, bucking and piling.



Average extra cost because of the greater productivity for the mechanized option is 0,94 €/m³

Comparison of felling, processing and piling costs between motor-manual and mechanized CTL systems for *Q.pyrenaica* Spanish coppices: limit dbh that would equal mechanized and motor-manual direct cost.



CONCLUSSIONS

· Time studies of ***Quercus pyrenaica*** **moderate to strong coppice thinnings** show **motor-manual felling productivity strongly dbh-dependant, and mechanized option even more sensitive** to tree size.

· **Strong** coppice **motor-manual thinnings** in **stands with dbh from 6 to 10 cm on gentle slopes: hauling off by forwarder allows firewood collection profitability,** even from medium transport distances.

· In the same stands, **mechanization would only get acceptable cost for the bigger dbh and less dense stands**. **The diameter for which mechanized CTL cost would equal motor-manual ones is 12 cm. even when the mechanized option reduces forwarding cost more than 15%.**

LITERATURE

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Thank You for your Attention