Grant Agreement 823805 MAIL H2020 MSCA RISE 2018

Estimation of carbon stock in forest products

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The task aims to:

- Identify and quantify the carbon in forest products (HWPs)
- Outline the possible wood products (saw wood, pulpwood , etc.)
- Quantify the stored Carbon

- ***The task focuses on:***
- Identification of the future forest species in MLs pilot areas under projected afforestation modules
- Calculation of the carbon stored in wood products
- Checking and adjustment of all the quantification of carbon products

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The three categories of semi-finished wood products

(Regulation (EU) 2018/841 of the European Parliament /Council of 30 May 2018, IPCC Guidelines, 2019)

The definitions designated by **FAO** (2017):

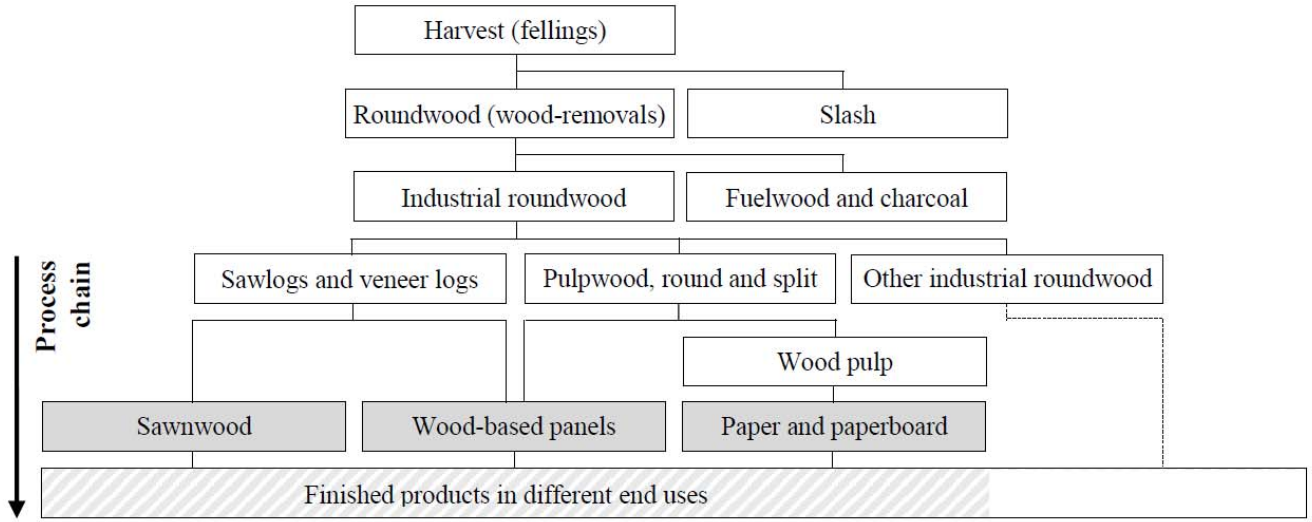
Paper & paperboard

Wood-based panels

Sawn wood

Wood chips & Particles

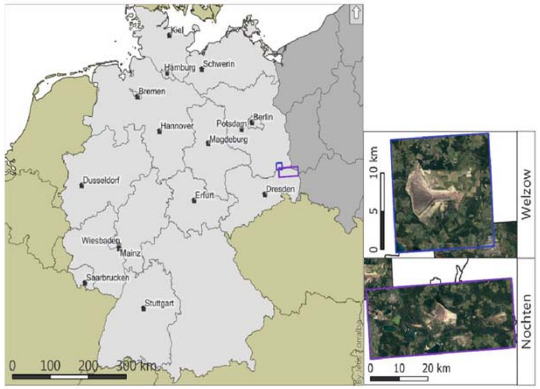
Wood residues



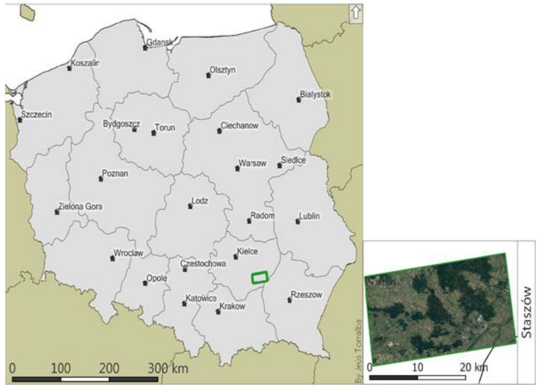
Source: IPCC 2014

ALLOCATION AND IDENTIFICATION OF THE FOREST AREAS

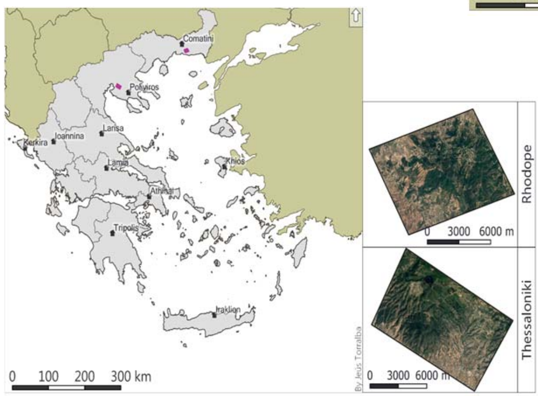
GERMANY



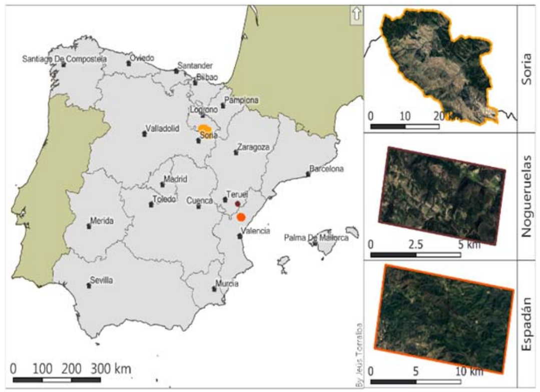
POLAND



GREECE



SPAIN



PROPOSED AFFORESTATION SPECIES IN THE PILOT SITES

Degree of marginality

1. MLs with high plantation suitability
2. MLs with low plantation suitability
3. Potentially unsuitable lands

Country	Species
Germany	*Pinus sylvestris* *Picea abies*
Poland	*Pinus sylvestris* *Quercus spp.*
Spain	*Pinus halepensis* *Pinus pinaster* *Pinus nigra* *Pinus sylvestris*
Greece	*Pinus halepensis* *Pinus brutia* *Quercus frainetto*

ESTIMATION OF FUTURE BIOMASS

GERMANY

Pinus sylvestris **40%**

Picea abies **60%**

POLAND

Pinus sylvestris **30%**

Quercus spp. **70%**

GREECE

Pinus brutia **50%**

Pinus halepensis **50%**

Quercus frainetto

✖ interventions

✖ final clear cuttings for wood extraction

SPAIN

Pinus halepensis **30-20%**
Pinus pinaster **70-80 %**

Pinus nigra **70-80 %**
Pinus sylvestris **20-30%**

REVIEW OF EXISTING GROWTH MODELS YIELD TABLES

Carbon estimation values

Marginality class 1 (second lowest SI)

- **without** silvicultural intervention (thinnings)
- **with** silvicultural intervention (thinnings)

Marginality class 2 (lowest SI)

- **without** silvicultural intervention (thinnings)
- **with** silvicultural intervention (thinnings)

GERMANY

30/35 years **50** years
Final cut at **100** years

GREECE

Pinus brutia / Pinus halepensis

30 years **50** years
Final cut at **90** years

Quercus frainetto

30 years **45** years
Final cut at **90** years

POLAND

30 years **50** years
Final cut at **100** years

SPAIN

30 years **50** years
Final cut at **90 - 120** years

CONSIDER THINNING AND INTERMEDIATE TREATMENTS

Marginality class scenarios that correspond to each species in the Greek pilot sites, thinning scenarios and mixture proposed for each scenario

Forest species		Forest species	Mixture	Silvicultural treatments
Marginality class 1 (second lowest SI)	14	*Pinus halepensis & Pinus brutia*	50%	No thinnings
				One thinning on 30 years
	Va	*Quercus sp.*	50%	No thinnings
Marginality class 2 (lowest SI)	11	*Pinus halepensis & Pinus brutia*	-	No thinnings
				One thinning on 30 years

Progress of the number of trees per ha (N) throughout the production monitoring period for each thinning scenario in the Greek pilot sites

Scenarios			Marginality class 1 (second lowest SI)		Marginality class 2 (lowest SI)
		Species	***Pinus halepensis & Pinus brutia***	***Quercus sp.***	***Pinus halepensis & Pinus brutia***
		Initial planting (N)	**2500**	**2500**	**2250**
No thinning scenario	**1st year**	**Loss due to unsuccessful planting (40%)**	1250	2250	1500
	45 years	**Loss due to natural selection (10%)**		2025	
	50 years	**Loss due to natural selection (20%)**	1000		1200
	90 years	**Loss due to natural selection (20%)**	800	1822	960
Thinning scenario	**1st year**	**Loss due to unsuccessful planting (40%)**	1250	2250	1500
	30 years	**Loss due to thinning (10%)**	1125		1350
	45 years	**Loss due to natural selection (10%)**		2025	
	50 years	**Loss due to natural selection (20%)**	900		1080
	90 years	**Loss due to natural selection (20%)**	720	1822	864

Units: number of trees

DESTINATION OF THE HARVESTED WOOD FROM MLs PLANTINGS

FINAL CLEAR CUTTINGS ↺ **CARBON STOCKING** ↑

Where will the products become absorbed within the Greek market?

What is the framework of market demand and use of wood products of these forest species?

(a) oak forests are gradually degraded but when cuttings are performed in these forests their wood usually ends up in fuelwood

(b) wood from coniferous species in Greece is not appropriate for sawn wood, but suitable for pellets

BIOMASS AND CARBON OF FINAL WOOD PRODUCT

Biomass and Carbon estimation for *Pinus halepensis* for the aboveground and belowground components and total tree for the **no thinning** scenario

Yield estimation data	Quality	Age	N	V	V	ABG C (kg)/tree				C AGB	C BGB	Total C	Total C
		years	tree/ ha	m3/ ha	dm3/ tree	branch >7cm	branch 2-7cm	branch < 2cm	Stem	kg/ tree	kg/ tree	kg/ tree	kg/ ha
Montero	11	30	2038	30.2	14.8	1.2	1	2.6	4.5	9.3	2.9	12.2	24859.9
MLs			1500	22.2	10.9	0.9	0.7	1.9	3.3	6.8	2.1	9.0	18297.3
Montero	11	50	1305	65.8	50.4	4.1	3.5	8.8	15.3	31.7	9.8	41.5	54164.9
MLs			1200	60.5	46.3	3.8	3.2	8.1	14.1	29.1	9.0	38.2	49806.8
Montero	11	90	766	106.5	139	11.2	9.6	24.3	42.3	87.4	27	114.4	87668
MLs			960	133.5	174.2	14.0	12.0	30.5	53.0	109.5	33.8	143.4	109871.1
Montero	14	30	1481	53.3	36	2.9	2.5	6.3	11	22.6	7	29.6	43875.2
MLs			1250	45.0	30.4	2.4	2.1	5.3	9.3	19.1	5.9	25.0	37031.7
Montero	14	50	1006	107.1	106.5	8.6	7.4	18.6	32.4	67	20.7	87.6	88161.9
MLs			1000	106.5	105.9	8.5	7.4	18.5	32.2	66.6	20.6	87.1	87636.1
Montero	14	90	608	165.5	272.2	21.9	18.8	47.6	82.9	171.2	52.9	224.1	136235.3
MLs			800	217.8	358.2	28.8	24.7	62.6	109.1	225.3	69.6	294.9	179257.0

Biomass and Carbon estimation for *Pinus halepensis* for the aboveground and belowground components and total tree for the **thinning** scenario

Yield estimation data	Quality	State	Age years	N tree/ha	V m3/ha	V dm3/tree	ABG C (kg)/tree				C AGB kg/tree	C BGB kg/tree	Total C kg/tree	Total C kg/ha
							branch >7cm	branch 2-7cm	branch < 2cm	Stem				
Montero	11	Before thinning	30	2038	30.2	14.8	1.2	1	2.6	4.5	9.3	2.9	12.2	24859.9
MLs				1500	22.2	10.9	0.9	0.7	1.9	3.3	6.8	2.1	9.0	18297.3
Montero	11	Thinning	30	86	0.3	3.5	0.3	0.2	0.6	1.1	2.2	0.7	2.9	247
MLs				150	0.5	6.1	0.5	0.3	1.0	1.9	3.8	1.2	5.1	430.8
Montero	11	After thinning	30	1952	30.1	15.4	1.2	1.1	2.7	4.7	9.7	3	12.7	24777.5
MLs				1350	20.8	10.7	0.8	0.8	1.9	3.3	6.7	2.1	8.8	17136.1
Montero	11	Before thinning	50	1305	65.8	50.4	4.1	3.5	8.8	15.3	31.7	9.8	41.5	54164.9
MLs				1080	54.5	41.7	3.4	2.9	7.3	12.7	26.2	8.1	34.3	44826.1
Montero	11	Before thinning	90	766	106.5	139	11.2	9.6	24.3	42.3	87.4	27	114.4	87668
MLs				864	120.1	156.8	12.6	10.8	27.4	47.7	98.6	30.5	129.0	98884.0
Montero	14	Before thinning	30	1481	53.3	36	2.9	2.5	6.3	11	22.6	7	29.6	43875.2
MLs				1250	45.0	30.4	2.4	2.1	5.3	9.3	19.1	5.9	25.0	37031.7
Montero	14	Thinning	30	86	0.3	3.5	0.7	0.6	1.5	2.6	5.4	1.7	7.1	987.8
MLs				125	0.4	5.1	0.4	0.3	0.9	1.6	3.2	1.0	4.2	359.0
Montero	14	After thinning	30	1952	30.1	15.4	3.1	2.7	6.8	11.8	24.4	7.5	32	42887.4
MLs				1125	17.3	8.9	0.7	0.6	1.6	2.7	5.6	1.7	7.3	14280.1
Montero	14	Before thinning	50	1006	107.1	106.5	8.6	7.4	18.6	32.4	67	20.7	87.6	88161.9
MLs				900	95.8	95.3	7.7	6.6	16.6	29.0	59.9	18.5	78.4	78872.5
Montero	14	Before thinning	90	608	165.5	272.2	21.9	18.8	47.6	82.9	171.2	52.9	224.1	136235.3
MLs				720	196.0	322.3	25.9	22.3	56.4	98.2	202.7	62.6	265.4	161331.3

Biomass and Carbon estimation for *Quercus frainetto* for the aboveground and belowground components and total tree, **only no thinning** scenario

Yield estimation data	Quality	Age	N	V	V	ABG C (kg)/tree				C AGB	C BGB	Total C	Total C
		years	tree/ ha	m3/ ha	dm3/ tree	Foliage	Branch	Bark	Stem	kg/ tree	kg/ tree	kg/ tree	kg/ha
Kossenakis	Va	30	5900	53.2	6.67	0.79	1.2	0.92	3.76	6.7	1.87	8.57	50563.0
MLs			2250	20.3									19282.5
Kossenakis	Va	45	4300	67.7	11.65	1.38	2.1	1.61	6.56	11.7	3.26	14.96	64328.0
MLs			2025	31.9									30294.0
Kossenakis	Va	90	3870	109.2	20.89	2.48	3.76	2.89	11.75	20.9	5.85	26.75	103522.5
MLs			1822	51.4									48738.5

CARBON FIXED BY WOOD PRODUCT (ACCOUNT FOR SPECIES SPECIFIC CARBON CONVERSIONS)

BCEF for expansion of merchantable growing stock volume to above-ground biomass (BCEFS)

Climatic zone	Forest type	Growing stock level (m3)				
		<20	21-40	41-100	101-200	>200
Subtropical	Pines	6.0	1.2	0.6	0.55	
	Hardwoods	5.0	1.9	0.8	0.66	
Temperate	Pines	1.8	1.0	0.75	0.7	
	Hardwoods	3.0	1.7	1.4	1.05	0.8

Default conversion factors for each HWP category (2019 IPCC)

HWP category	CF (Mg C/ m3)
Sawn wood (coniferous)	0.225
Sawn wood (non-coniferous)	0.28
Wood based panels	0.269
Paper and paperboard	0.386
Wood chips, wood particles, wood residues	0.229

ESTIMATION OF THE TOTAL C STOCK IN WOOD PRODUCTS IN THE PILOT SITE AREA

$$Total\ C_{\ wood\ products} = Wood\ product\left(\frac{C\ tones}{ha}\right) * area\ of\ MLs\ (ha)$$

Volume (m3/ha) and C stock (tn/ ha) of HWPs in the pilot sites of T**hessaloniki** and **Komotini**, Greece for the **no thinning** scenario

Species	SI	Treatments	Harvested Wood Products (m3/ha)		Carbon pool (m3/ha)	C stock (tn C/ha)		
			Wood chips & particles	Wood residues	Oak forest	Wood chips & particles	Wood residues	Oak forest
Pinus halepensis & *Pinus brutia* (100%)	11	None	66.74	66.74		18	18	
Sum			66.74	66.74		18.35	18.35	
Pinus halepensis & *Pinus brutia* (50%)	15	None	108.88	108.88		30	30	
Quercus frainetto (50%)	Va	None	-	-	51.42	-	-	24
Sum			108.88	108.88	51.42	30	30	24

Volume (m3/ha) and C stock (tn/ ha) of HWPs in the pilot sites of **Thessaloniki** and **Komotini**, Greece for the **thinning** scenario

Species	SI	Treatments	Harvested Wood Products (m3/ha)		Carbon pool (m3/ha)	C stock (tn C/ha)		
			Wood chips & particles	Wood residues	Oak forest	Wood chips & particles	Wood residues	Oak forest
Pinus halepensis & *Pinus brutia*	11	1 thinning + final clear cut	60.32	60.32		33	33	
Sum			60.32	60.32		33	33	
Pinus halepensis & *Pinus brutia* (50%)	15	1 thinning + final clear cut	98.2	98.2		27	27	
Quercus frainetto (50%)	Va	None	-	-	51.42	-	-	24
Sum			98.21	98.21	51.42	27	27	24

C stock in the pilot site of **Thessaloniki**, Greece for the **no thinning** scenario

Method	MLs Type	Area (ha)	C stock (tn C/ha)			Overall MLs C stock (tn C)		
			Wood chips & particles	Wood residues	Carbon pool	Wood chips & particles	Wood residues	Carbon pool
A	High plantation suitability	2596.9	30	30	24	77.9	77.9	62.8
A	Low plantation suitability	1887.3	18	18	0	34.0	34.0	0.0
B	High plantation suitability	4377.4	30	30	24	131.3	131.3	105.8
B	Low plantation suitability	243.6	18	18	0	4.4	4.4	0.0
C	High plantation suitability	4391.9	30	30	24	131.8	131.8	106.1
C	Low plantation suitability	161.5	18	18	0	2.9	2.9	0.0

C stock in the pilot site of **Komotini**, Greece for the **no thinning** scenario

Method	MLs Type	Area (ha)	C stock (tn C/ha)			Overall MLs C stock (tn C)		
			Wood chips & particles	Wood residues	Carbon pool	Wood chips & particles	Wood residues	Carbon pool
A	High plantation suitability	568.9	30	30	24	17.1	17.1	13.7
A	Low plantation suitability	1809.6	18	18	0	32.6	32.6	0.0
B	High plantation suitability	2024.8	30	30	24	60.7	60.7	48.9
B	Low plantation suitability	788.7	18	18	0	14.2	14.2	0.0
C	High plantation suitability	2241.5	30	30	24	67.2	67.2	54.2
C	Low plantation suitability	572	18	18	0	10.3	10.3	0.0

C stock in the pilot site of **Thessaloniki**, Greece for the **thinning** scenario

Method	MLs Type	Area (ha)	C stock (tn C/ha)			Overall MLs C stock (tn C)		
			Wood chips & particles	Wood residues	Carbon pool	Wood chips & particles	Wood residues	Carbon pool
A	High plantation suitability	2596.9	27	27	24	70.1	70.1	62.8
A	Low plantation suitability	1887.3	17	17	0	32.1	32.1	0.0
B	High plantation suitability	4377.4	27	27	24	118.2	118.2	105.8
B	Low plantation suitability	243.6	17	17	0	4.1	4.1	0.0
C	High plantation suitability	4391.9	27	27	24	118.6	118.6	106.1
C	Low plantation suitability	161.5	17	17	0	2.7	2.7	0.0

C stock in the pilot site of **Komotini**, Greece for the **thinning** scenario

Method	MLs Type	Area (ha)	C stock (tn C/ha)			Overall MLs C stock (tn C)		
			Wood chips & particles	Wood residues	Carbon pool	Wood chips & particles	Wood residues	Carbon pool
A	High plantation suitability	568.9	27	27	24	15.4	15.4	13.7
A	Low plantation suitability	1809.6	17	17	0	30.8	30.8	0.0
B	High plantation suitability	2024.8	27	27	24	54.7	54.7	48.9
B	Low plantation suitability	788.7	17	17	0	13.4	13.4	0.0
C	High plantation suitability	2241.5	27	27	24	60.5	60.5	54.2
C	Low plantation suitability	572	17	17	0	9.7	9.7	0.0

LIFESPAN OF WOOD PRODUCTS FROM MLS

$$C(i + 1) = e^{-k}.C(i)$$

where:
i = year

C(i) = the carbon stock of the harvested wood products pool in the beginning of year i, Gg C

k = decay constant of first-order decay given in units of year-1 (k =ln(2)/HL, where HL is half-life of the harvested wood products pool in years.)

Inflow(i) = the inflow to the harvested wood products pool during year i, Gg C year-1

ΔC(i) = carbon stock change of the harvested wood products pool during year i, Gg C year-1

Source: ANNEX III of European Decision 529/2013

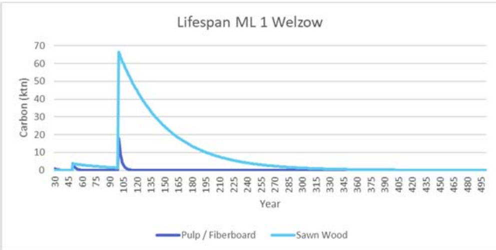
Average half-life of the product

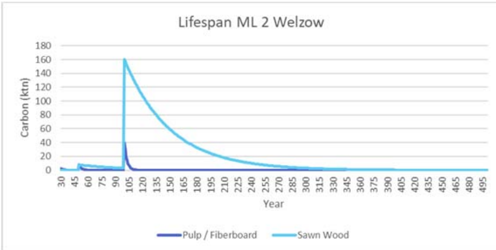
Pulp/Fiberboard = 2 years

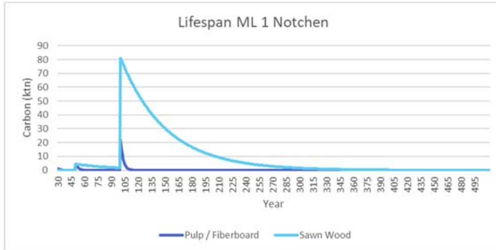
Wood Panels = 25 Years

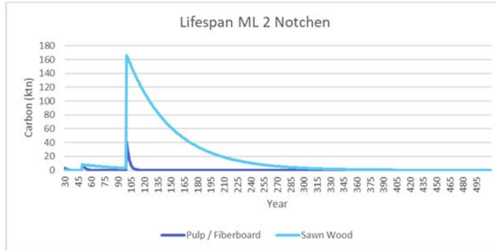
SawnWood = 35 Years

GERMANY









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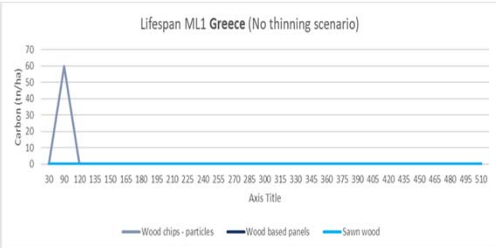
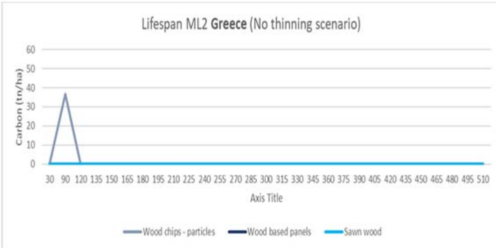
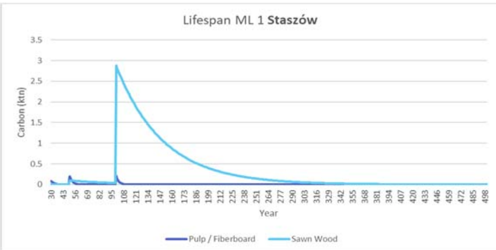
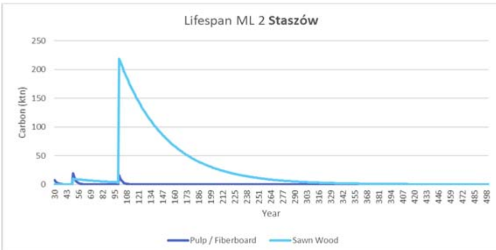




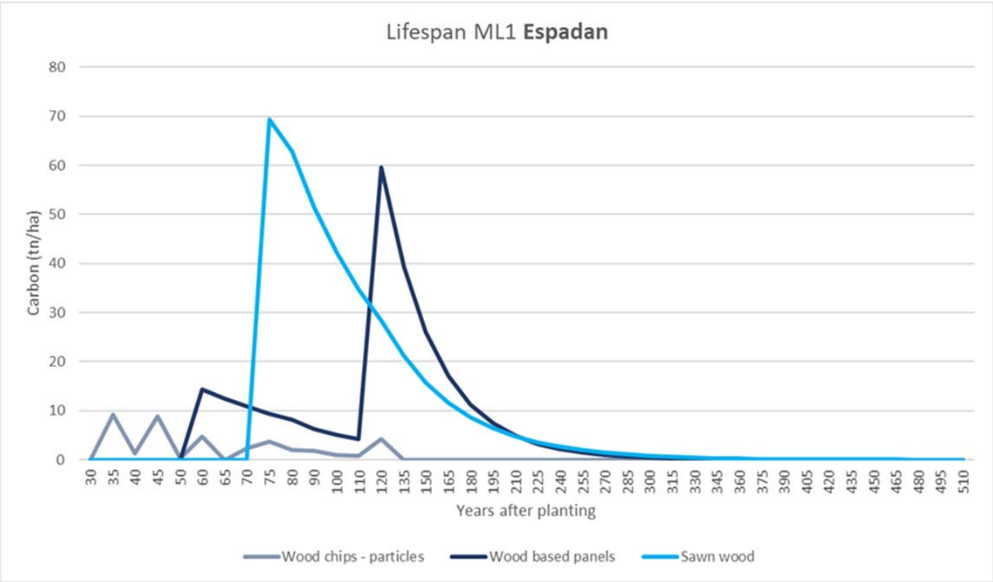
POLAND



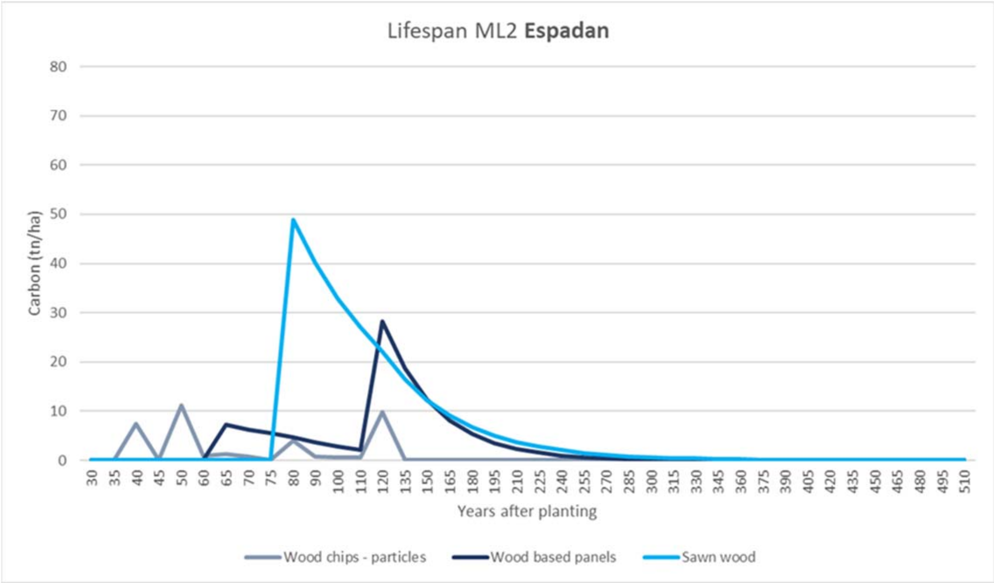


SPAIN

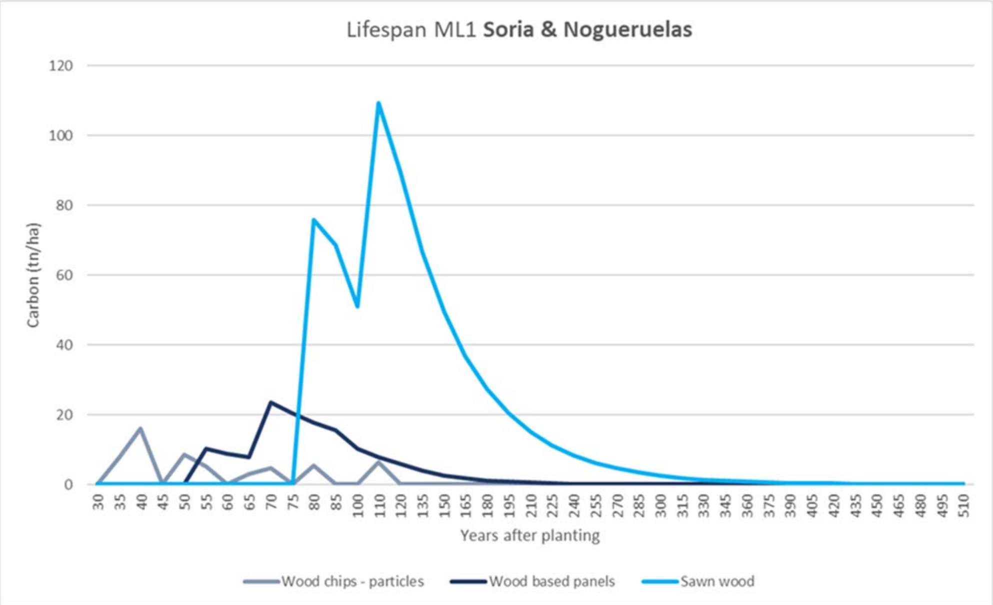
ML1 Pilot site Espadán (***P. pinaster* & *P. halepensis***)



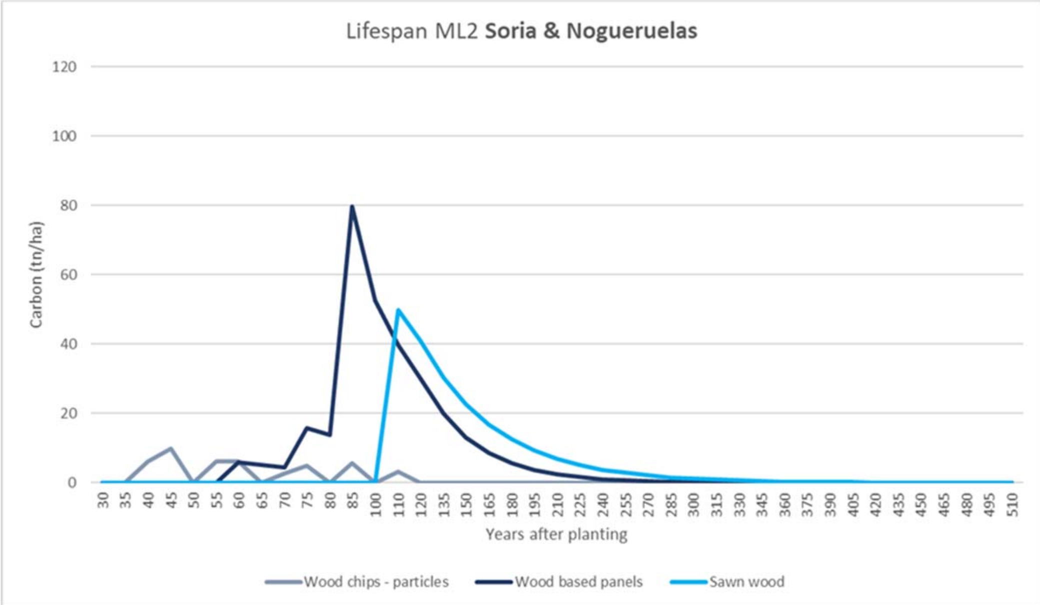
ML2 Pilot site Espadán (***P. pinaster* & *P. halepensis***)



ML1 Pilot sites Soria and Nogueruelas (***P. nigra* & *P. sylvestris***)

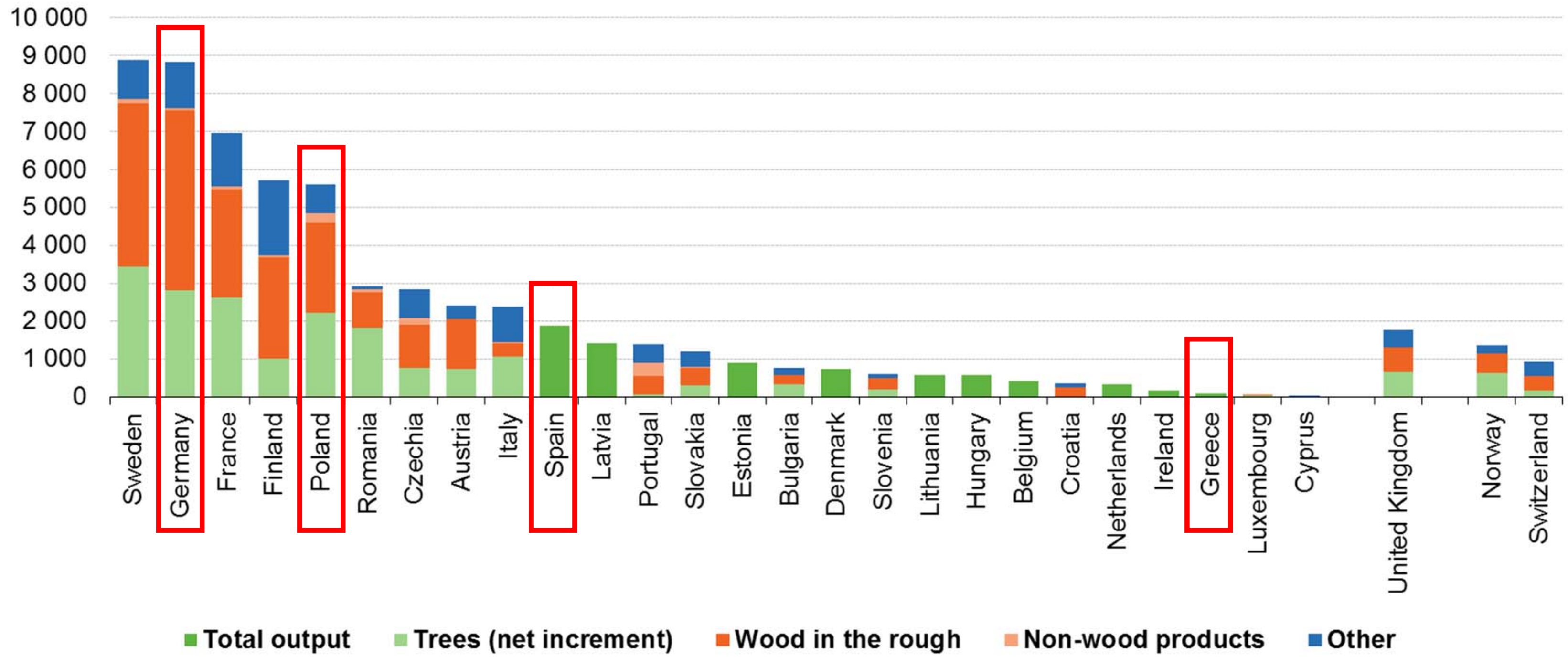


ML2 Pilot sites Soria and Nogueruelas (***P. nigra* & *P. sylvestris***)



Output of forestry and logging by type, 2018

(million EUR, current prices)



Note: Malta: not applicable

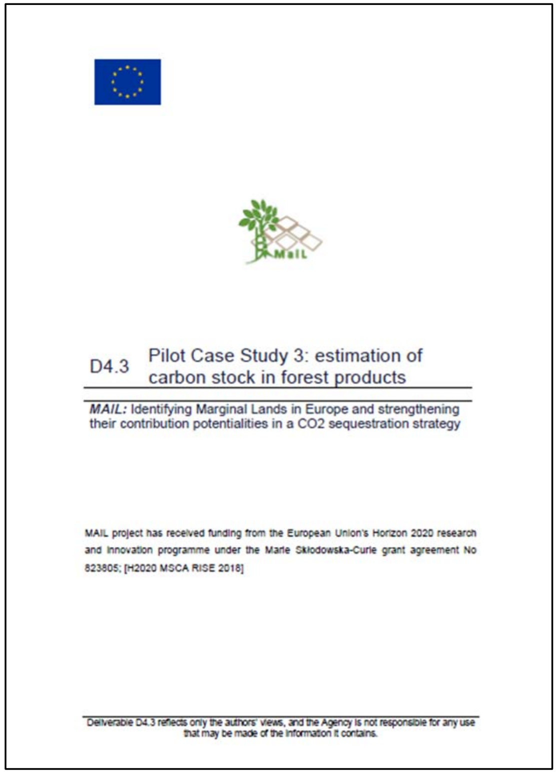
Changing the demand for wood products can consequently have an important role in the global carbon cycle and the fight against climate change.

CONCLUSIONS

- The carbon stored in HWP depends greatly on the lifespan of the HWP, which is determined by their type
- The type of marginal land (high or low suitability for plantings) affects the amounts of HWP, as well as the time of their harvest, which may be carried out later in areas with lower SI, as in the case of Spain.
- In cases where only short-lived products are expected to be harvested (e.g. Greece), the established forest acts as a carbon sink until the final cut. Due to the category of HWP (fuelwood) it is considered almost instantly as C emissions
- In the case of Spain, where wood-based panels and sawn wood could potentially be harvested from MLs, at least 1 ton C/ha of harvested woodland can continue to be stored in HWP for approximately 200 years after the final cut.
- On the cases of the Germany and Poland is clear that the sawnwood products will stock higher value of carbon, once it has considerable production. That is showing also that based on the wood products from this areas, at least 1 ton C/ha can continue stored for approximately 700 years after the final cut.

D4.3 Report

A detailed review regarding estimation of carbon stock in forest products can be found at MAIL's website www.marginallands.eu



D4.3 Pilot Case Study 3: estimation of carbon stock in forest products

MAIL: Identifying Marginal Lands in Europe and strengthening their contribution potentialities in a CO2 sequestration strategy

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