Delivery of sustainable supply of non-food biomass to support a resource-efficient Bioeconomy in Europe

S2Biom summer school, Athens, Greece, 17-20 May, 2016

Session 2: Estimation of biomass availability for lignocellulosic biomass

Mapping of the biomass availability and cost supply curves (WP1)

Presenter: Igor Staritsky, DLO - Alterra




This project is co-funded by the European Union within the 7th Frame Programme. Grant Agreement n°608622.

Outline

- **Overall aim of S2BIOM and of WP1- Biomass cost-supply assessment**
- **Types of biomass and biomass potentials in S2BIOM**
- **Principles of assessing biomass potentials**
- **Some results for agricultural residues**
  - Straw potentials
  - Pruning potentials
- **Conclusions & Discussion**

Aim & Specific objectives

- **Main aim of S2BIOM** is to develop Strategies, Roadmaps and Tools at local, regional and Pan-European level for a <u>sustainable and reliable supply</u> of <u>non-food lignocellulosic biomass</u> feedstock.
- **Specific objectives include:**
  - **WP 1:** Provision of <u>easy information access</u> to current +future status biomass resources in EU28; Western Balkans, Ukraine and Turkey.
  - **WP1-WP4:** Common operating data, models, and tools representing the <u>entire</u> biomass supply chain
  - **WP4:** Incorporation of models and tools for environmental, economic and social impact analysis

Value chains focus

Biomass types

Forestry

Agriculture

Non food crops

Toolset for online assessment

End Use

Pre-treatment

Conversion

Small Scale

Large Scale

Toolset for online assessment

Sustainability

Criteria

Indicators

Default values

Toolset for online assessment

Logistics

Supply chain

Transportation

Toolset for online assessment

Presentations Session 2

11:45 – 13:15	Session 2: Estimation of biomass availability for lignocellulosic biomass	
	Mapping of the biomass availability and cost supply curves	Igor Staritsky, DLO - Alterra
	Assessment of the cropping potential and the development of dedicated crops database	Jacqueline Ramírez Almeyda, UniBO
	Calculating the cost of lignocellulosic non-food biomass sources	Raymond Schrijver, DLO - Alterra
	S2Biom Tool box workshop*: biomass availability maps and cost supply curves	Igor Staritsky, Raymond Schrijver, DLO – Alterra

Biomass supply & potentials

Following the BEE assessment (Retenmaier et al., 2008 and Vis et al., 2010), five types of biomass potentials are commonly distinguished to BEE (Torén, J. et al., 2011):

Type of potential	Definition
Theoretical potential	*Is the overall maximum amount of terrestrial biomass which can be considered theoretically available for bioenergy production within fundamental bio-physical limits. In the case of biomass from crops and forests, the theoretical potential represents the maximum productivity under theoretically optimal management taking into account limitations that result from soil, temperature, solar radiation and rainfall. In the case of residues and waste, the theoretical potentials equal the total amount that is produced.*
Technical potential	*Is the fraction of the theoretical potential which is available under the regarded techno-structural framework conditions with the current technological possibilities (such as harvesting techniques, infrastructure and accessibility, processing techniques). It also takes into account spatial confinements due to other land uses (food, feed and fibre production) as well as ecological (e.g. nature reserves) and possibly other non-technical constraints.*
Economic potential	*Is the share of the technical potential which meets criteria of economic profitability within the given framework conditions.*
Implementation potential	*Is the fraction of the economic potential that can be implemented within a certain time frame and under concrete socio-political framework conditions, including economic, institutional and social constraints and policy incentives. Studies that focus on the feasibility or the economic, environmental or social impacts of bioenergy policies are also included in this type.*
Sustainable implementation potential	*Is the result of integrating environmental, economic and social sustainability criteria in biomass resource assessment. This means that sustainability criteria act like a filter on the theoretical, technical, economic and implementation potentials leading in the end to a sustainable implementation potential. Depending on the type of potential, sustainability criteria can be applied to different extents.*

Key starting point for potential assessment

- **EC wanted S2BIOM to assess biomass potential after food and feed demand is satisfied.**
  - We assume a ranking where food and feed demand comes first
  - This implies that the best land is used for food and feed production
  - Residues from feed and food products can be used for non-food uses

Potentials in S2BIOM

- The **Technical potential (as in BEE)** represents the amount of biomass assuming only technical constraints and a minimum of constraints by competing uses (only for food and feed).

- The **Base potential** can be defined as the technical potential, but constrained further by:
  - agreed sustainability standards in CAP (Common Agricultural Policy) for agricultural farming practices and
  - land management as agreed in (national and regional) forestry management plans for forest biomass
  - Waste management as agreed in the EU Landfill Directive
  - RED (Renewable Energy Directive) sustainability criteria.

- The **User-defined potentials** vary in terms of type and number of considerations per biomass type. This flexibility is meant to help the user to understand the effect on the total biomass potential of one type of consideration against the other.

- Scenario years: 2012, 2020, 2030

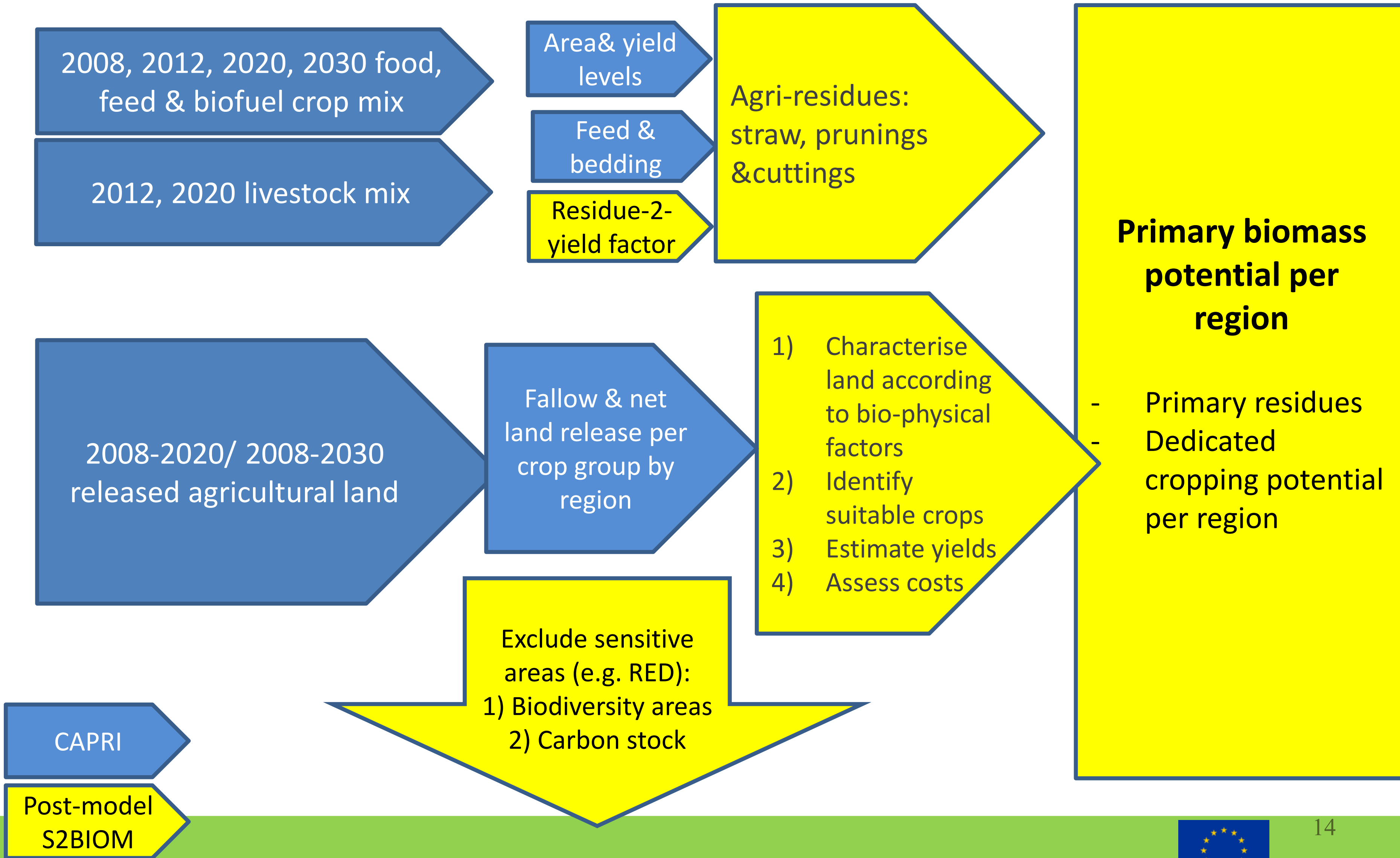
Land availability: key approach starting all agricultural potentials

- **Current land uses & yields**
  - Statistics
- **Future land uses satisfying food and feed demands**
  - CAPRI model: Reference scenario 2020 & 2030
  - Post-model analysis of land use and land use change

Land availability: key approach starting all agricultural potentials

- **CAPRI model: core model used by DG-AGRI to (ex-post & ex-ante) evaluate effects of changes in CAP for markets & production responses at the regional level for the whole EU-28, western Balkans, Turkey and Norway.**
    - Partial equilibrium (PE) model covering agricultural sector
    - CAPRI baseline run 2008-2050, provides intermediate results for 2010, 2020, 2030 and 2050. This baseline run can be seen as the most probable future simulating the European agricultural sector under status-quo policy and including all future changes in policy already foreseen in the current legislation. It also assumes all policy regarding bioenergy targets as agreed until now and further specified in the *Trends to 2050* report (EC, 2013) for as far as affecting agriculture.
- **Post model analysis in S2BIOM to determine agri-residue potentials and unused land resources & suitability for dedicated cropping**

Post-model analysis to estimate, residue potential & unused land



Potential assessment in S2BIOM Example of straw

Guidelines for assessment of **technical** and **base** potentials:

- Estimate the amount of biomass that can technically be produced, harvested and collected given current state of the art land management practices and machineries (**Technical potential**)
- Identify main environmentally and ecological risks involved when producing and/or harvesting the biomass and in what way do they constrain the biomass potential (**Base potential**)
- Estimate and exclude the main uses of the biomass for food and feed applications and exclude these from the potential estimates (**Base & net straw potential**)

Type	Technical potential	Base potential	Net straw potential
Cereal straw	All straw is removed that can technically be removed	All straw that can be removed while maintaining Soil Organic Carbon (SOC).	Subtraction of straw use for animal bedding, animal feed and mushroom production

Technical straw potential

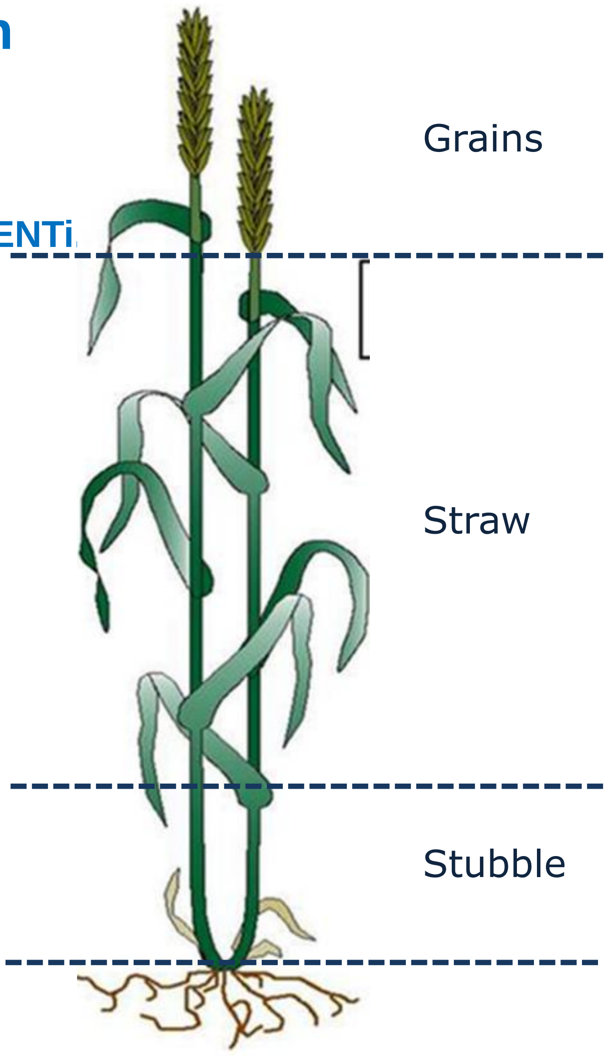
Straw & stubbles produced for cereals, rice, grain maize, rape & sunflower:

RESIDUE_YIELDi = AREAi * YIELDi * RESIDUE_2_YIELDi * DM_CONTENTi

Where:

- RESIDUE_YIELDi = above ground biomass of crop i
- AREAi = Crop area of crop i
- YIELDi = Yield level of the main product (grains/seeds) of crop i
- RESIDUE_2_YIELDi =Residue-to- yield factors for crop i .
- DM_CONTENTi= Dry matter content of crop i

  DM content reported by Scarlat et al. (2010) are as follows:
  - All cereals: 85%
  - Grain maize: 70%
  - Rice: 75%
  - Sunflower: 60%
  - Oil seed Rape: 60%



Technical straw potential: Area & yield data

Current land use: Agricultural statistics (NOT land Cover!)

Name of data source	Spatial coverage	Spatial resolution	Description/relevance
FSS(farm structure survey)	EU-28 + Norway, Switzerland, Croatia	Regional (Nuts2/3)	Data on areas under cultivation per crop
Eurostat annual crop statistics	EU-28	National and for some items regional (NUTS1/2)	Crop statistics are collected on areas under cultivation (expressed in 1 000 hectares), the quantity harvested (expressed in 1 000 tonnes) and the yield (expressed in 100kg/ha).
IACS/LPIS	EU28	Parcel size	Land use per parcel to be aggregated to any regional levels. Disclosure rules make access to these data difficult in some countries.
National agricultural statistics	National & non-EU	National, regional (province, municipality)	Data on areas under cultivation and production levels per crop (group)

Future land use: CAPRI Modelling

CAPRI model used by DG-AGRI to make future assessments of agricultural markets and related land use and livestock changes in response to (CAP, RED) policy changes.

Technical straw potential: Residue to yield factors per crop

	Straw to grain yield ratio (on a dry mass basis)	
Crop	**Scarlat, et .al., 2010***	**BIOBOOST** (Pudelko, et al., 2013)*
Wheat and barley	-0.3629 - LN(yield) + 1.6057	Yield*(0.769-0.129*ATAN((Yield-6.7)/1.5))
Grain maize	-0.1807 - LN(yield) + 1.3373	-0.181*LN(Yield)+1.337
Rice	-1.2256 - LN(yield) + 3.845	-1.226*LN(Yield)+3.845
Rape seed	-0.452*LN(Yield)+2.0475	-0.452*LN(Yield)+2.0475
Sunflower	- 1.1097*LN(Yield)+3.2189	- 1.1097*LN(Yield)+3.2189
Rye	- 0.3007 - LN(yield) + 1.5142	0.9
Oats	-0.1874 - LN(yield) + 1.3002	0.9
Barley	-0.2751 - LN(yield) + 1.3796	0.9
other cereals: triticale, mixes of cereals, etc.	-	0.9

*In both Scarlat et al.(2010) and Pudelko et al. (2013) this refers to above ground residues
LN(yield): refers to the natural logarithm of the yield level
ATAN(Yield-6.7): refers to the arctangent, or inverse tangent, of a number (=yield level -6.7).

Technical straw potential: Residue to yield factors per crop

Straw-to-crop yield ratios as determined by the correlations made on rations published in Scarlat et al. (2010) elaborated in ECOFYS study (Spöttle, et. al. 2013).

Country	Wheat	Barley	Oat	Rye
Denmark	0.89	0.93	1.01	1.03
France	0.90	0.87	1.03	1.05
Germany	0.88	0.89	1.02	1.03
Hungary	1.10	1.04	1.14	1.28
Italy	1.15	1.03	1.14	1.21
Netherlands	0.83	0.88	0.99	1.07
Poland	1.11	1.06	1.12	1.24
Romania	1.25	1.14	1.21	1.28
Spain	1.22	1.10	1.17	1.34
UK	0.86	0.90	0.97	0.97

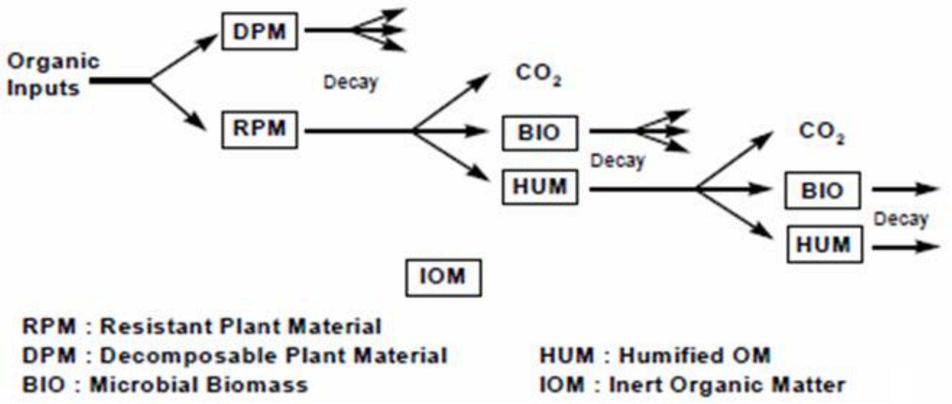
Source: (Spöttle et . al. , 2013, p.27)

From Technical to Base potential

- **Conclusion is that we have calculated the technical potential using:**
  - Yield level
  - Area
  - Residue to yield factor
- **Base potential:**
  - Need to take additional environmental considerations to assess the sustainable removal rate of straw. To assess this we use the MITERRA model

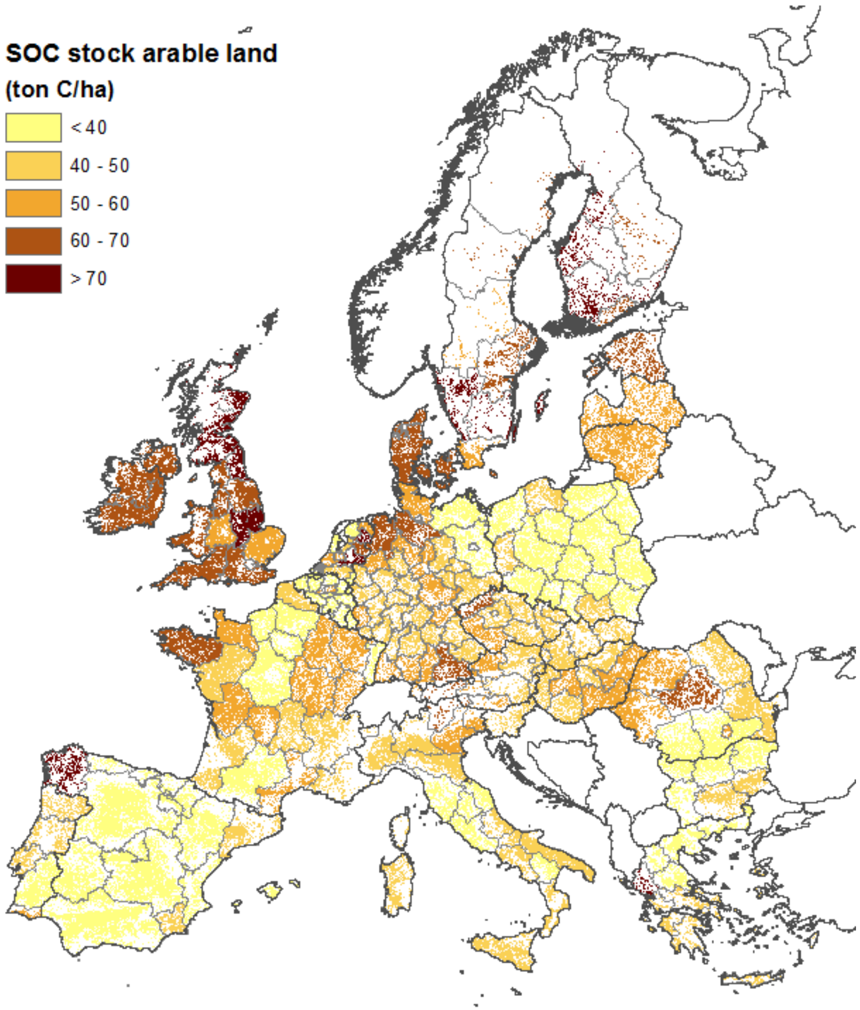
Base straw potential: Maintaining SOC (MITERRA model)

- **SOC balance in MITERRA model:**
  - SOC changes now based on “RothC-26.3”, model for the turnover of carbon in non-waterlogged soils (Coleman and Jenkinson, 1999)
  - RothC allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process



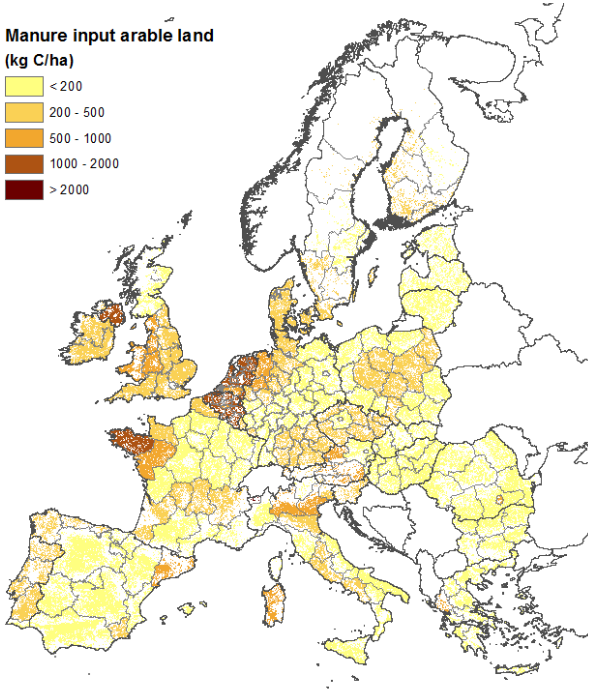
- **Current SOC stock based on LUCAS data (0[illegible])**
  - Average for arable and grassland soils
  - Bulk density with pedo-transfer function
  - Peat soils (>12% SOC) excluded
- **Climate data**
  - Monthly temperature, precipitation and potential evapotranspiration (WorldClim and FAO)
- **Carbon inputs (data for 2010)**
  - Manure (based on N flows and CN-ratio)
  - Crop residues (NUTS2 yield data, harvest index (Vleeshouwers and Verhagen, 2002), residue removal rate)

Current SOC stocks on arable land

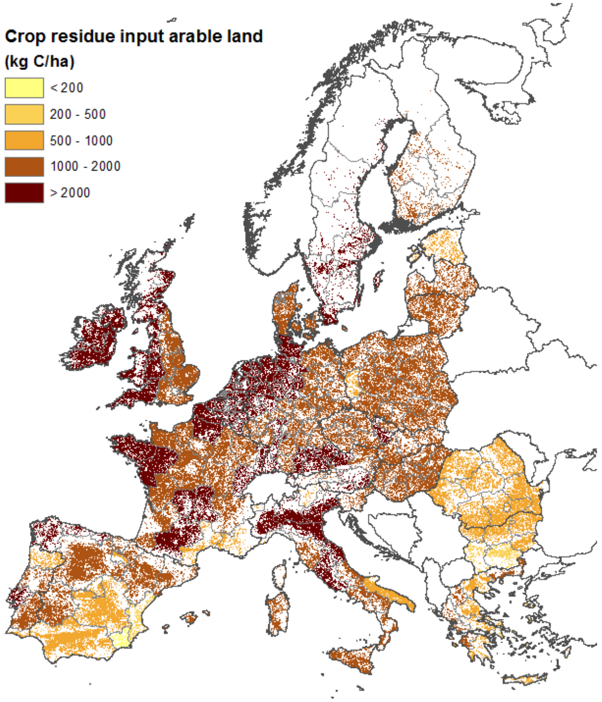


Base straw potential: Maintaining SOC (MITERRA model)

- **C quantified for four components:**
  - Grain yield at NUTS2 level (Eurostat)
  - Above ground residues (according to Scarlat et al., 2010) using yield dependent formula
    Straw : Stubble/chaff = 55:45 ratio
  - Belowground C input 25% of assimilated C (based on Taghizadeh-Toosi et al., 2014)

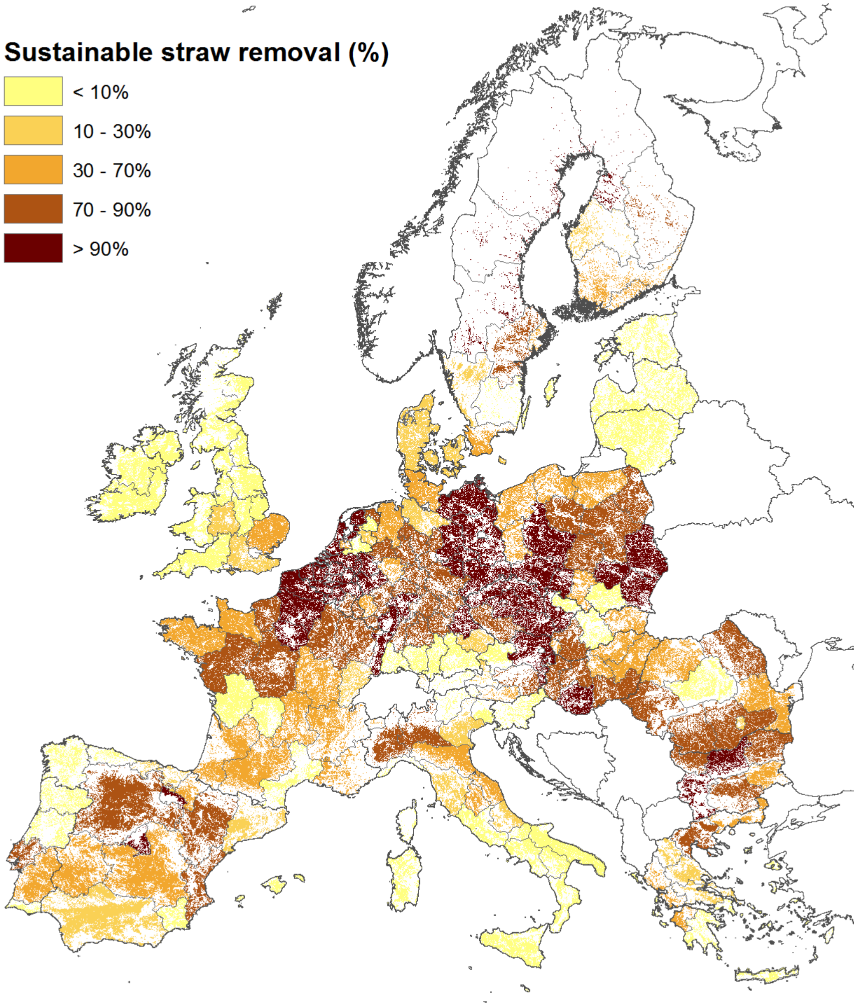


Manure C input



Crop residue C input

Results – Sustainable straw removal rate

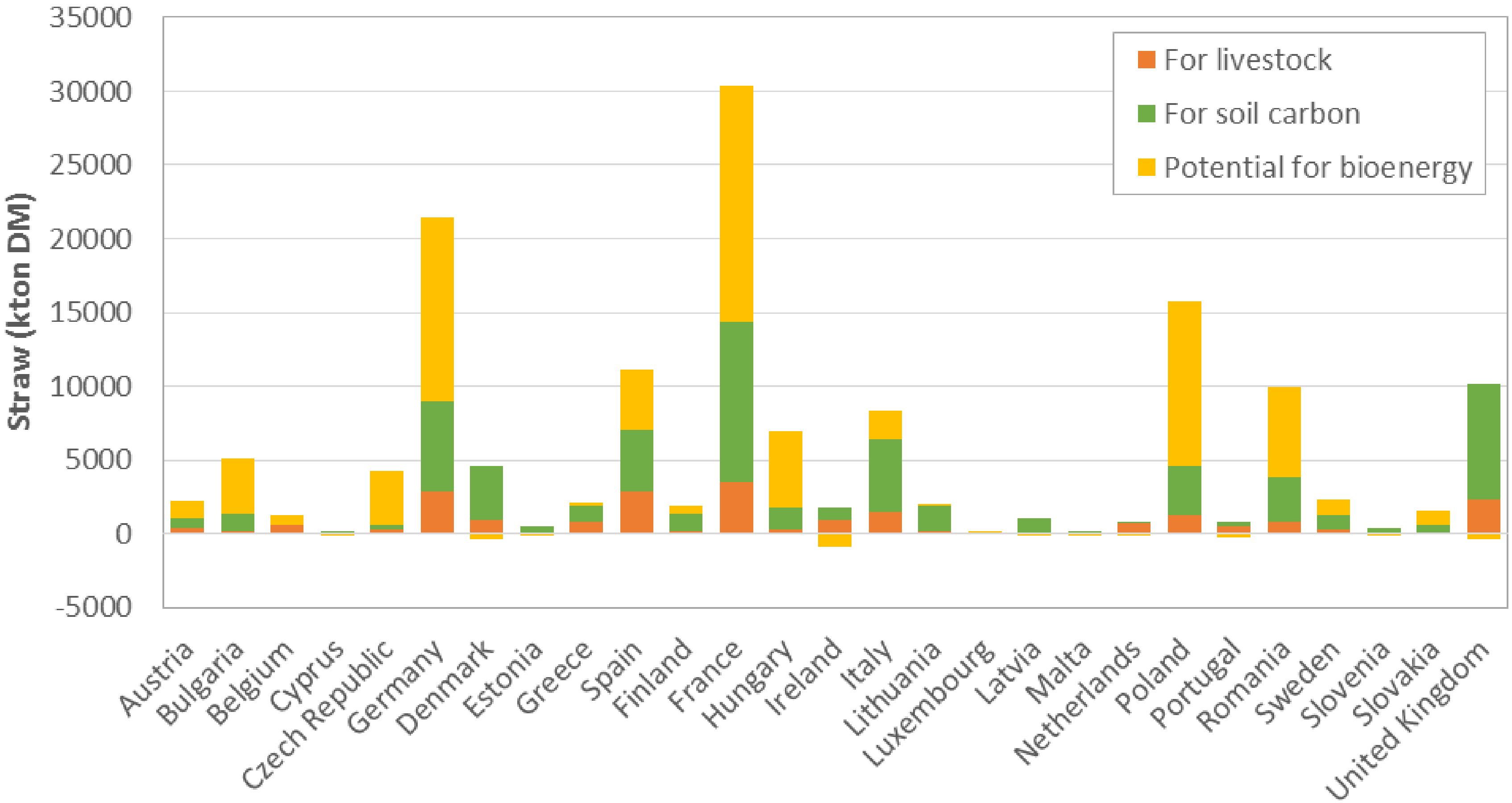


Total straw potential for bioenergy:

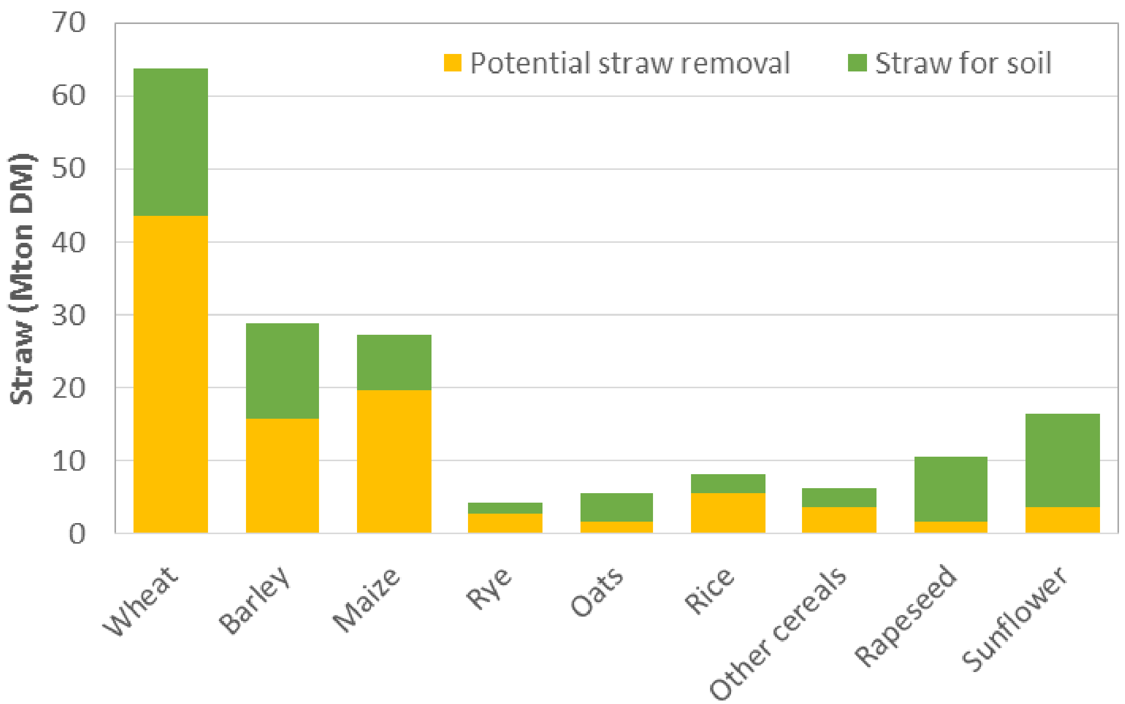
66 Mton dry matter

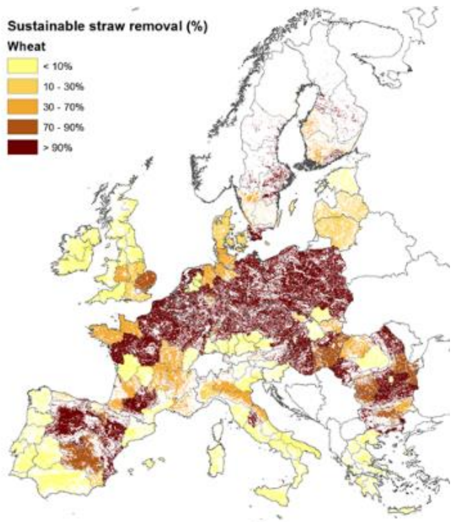
~1100 PJ

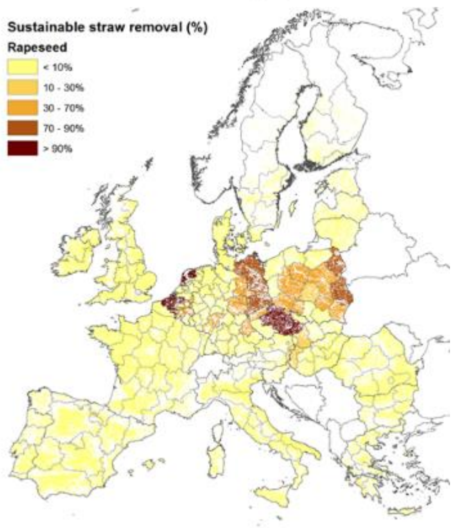
Results – Straw potential per country



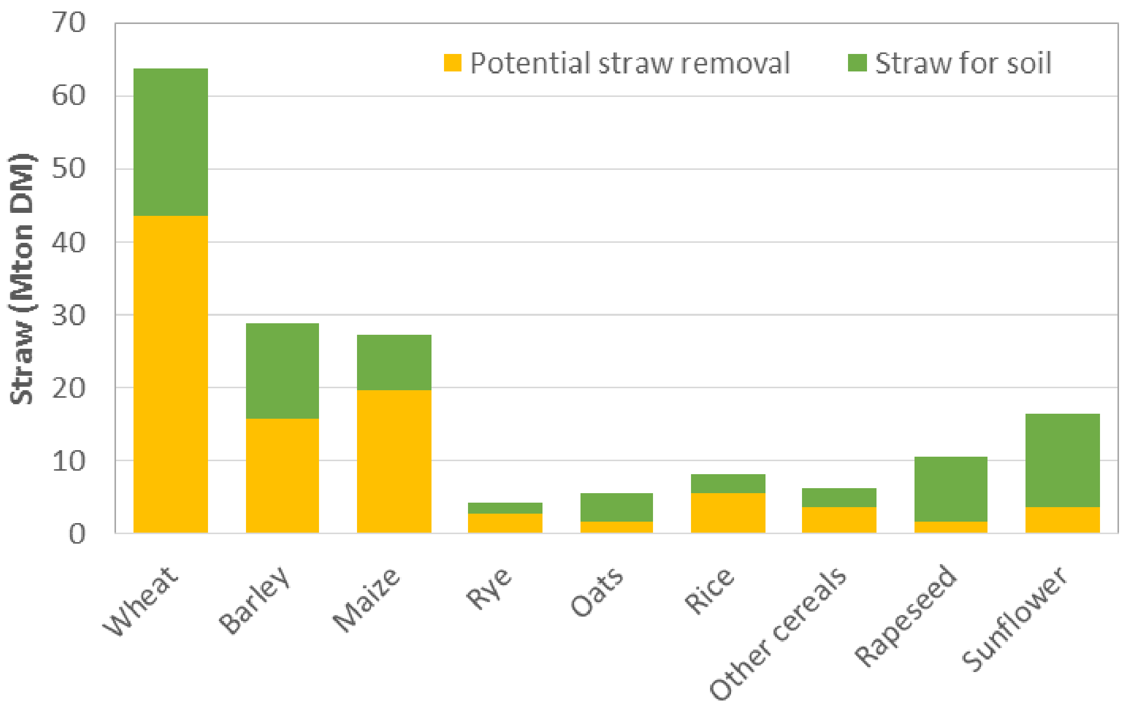
Results – Straw potential per crop

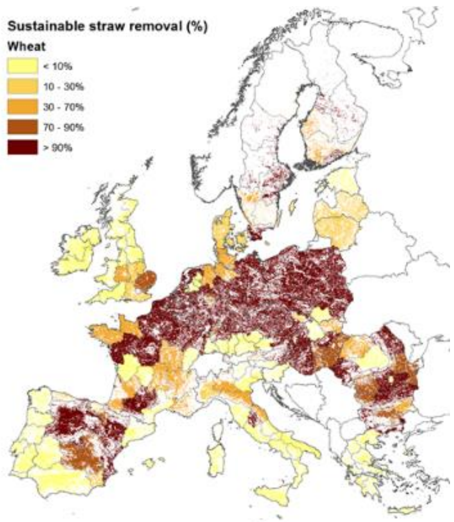


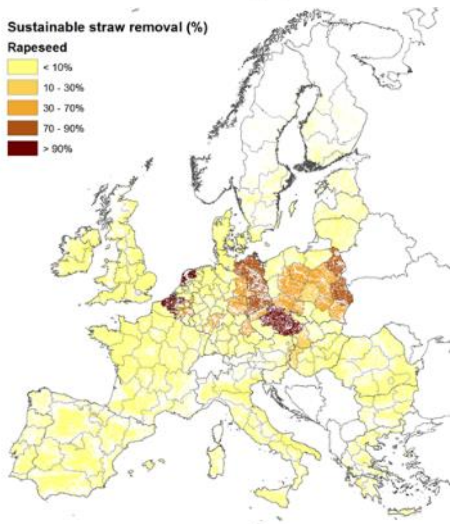




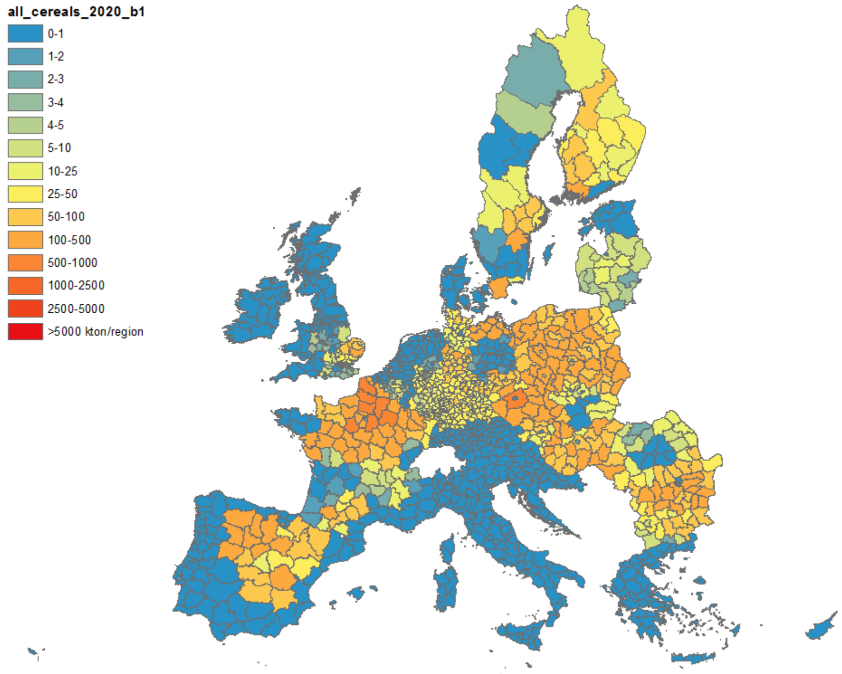
Results – Straw potential per crop





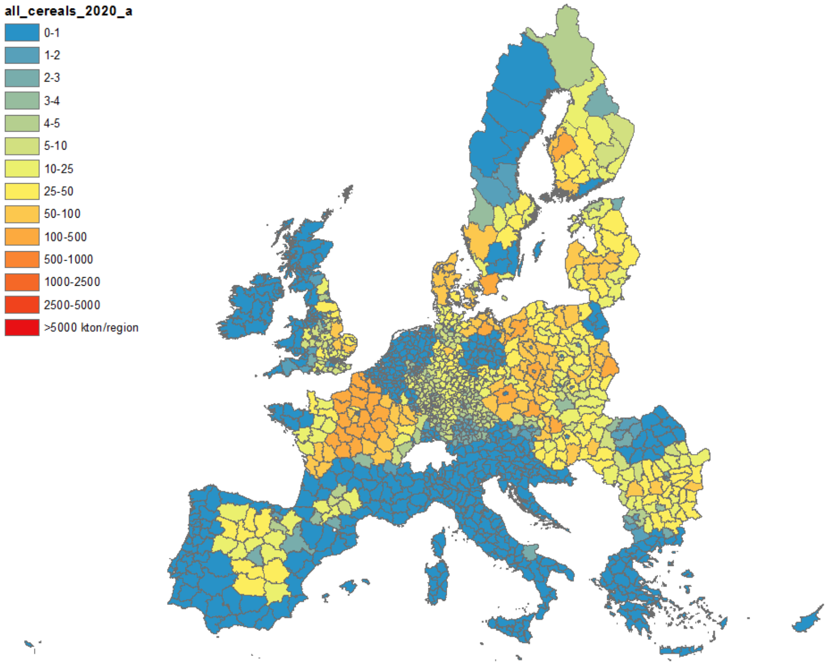


Evaluation straw potentials



Potential while maintaining SOC

EU-28 potential 2020 = 40 mln Kton



Potential at 40% removal rate (from Biomass Policies)

EU-28 potential 2020 = 16 mln Kton

Potential assessment in S2BIOM
Example of prunings-cuttings

S2Biom

Guidelines for assessment of **technical** and **base** potentials:

- Estimate the amount of biomass that can technically be produced, harvested and collected given current state of the art land management practices and machineries (**Technical potential**)
- Identify main environmentally and ecological risks involved when producing and/or harvesting the biomass and in what way do they constrain the biomass potential (**Base potential**)
- Assume additional mobilisation practices to allow a gradual change in the current situation (**Mobilisation potential**)

Type	Technical potential	Base potential	Mobilisation potential
Prunings	All pruned material is available	All pruned material is available that is currently NOT used to maintain the soil or burned in the field (shredded and incorporated in the soil) with a gradual mobilisation towards 2020 and 2030 of the unused shares.	Prunings are available assuming a 20% increase in 2010, 30% in 2020 and 40% in 2030 in current removal rates (instead of burning and shredding and incorporation in soil)

Technical pruning potential

RESIDUE_YIELDi = AREAi * RES_YIELDi * DM_CONTENTi.

Where:

- RESIDUE_YIELDi = total pruning yield of crop i in Ton/Year in dry mass
- AREAi = Crop area of crop i
- RES_YIELDi = Pruning yield Ton/Ha/Year in fresh mass of crop i
- DM_CONTENTi= Dry matter content of prunings of crop i : around 60%

	Greece: M. Mardikis, et al. (2004)	Del Blasi et al. (1996)	Portugal: Diaz and Azevedo (2004).	Serbia: Mladenet al. (2004)
Apples & pears	1.20-2.51	0.1-0.2	0.26-0.28	0.18-0.20
Cherries and other soft fruit	1.2		0.47	0.55-0.79
Nuts and other plantations	0.28	1.9	2.51	2.56
Citrus plantations	1.55-2.90	0.1	0.15-0.17	-
Olives	0.98	0.5-2.6	0.47	-
Vineyards	1.2	0.2-0.8	0.39	2.42

Pruning harvest levels

S2Biom

Country	Used factor	1) Apples, pears & other seed fruit	2) Cherry & other stone fruit	3) Nuts	4) Citrus plantations	5) Olives	6) Vineyards	7) Other permanent crops
Belgium	NL	4.5	3.6					
Bulgaria	Average	2.7	3.3	2.6			2.3	
Czech Republic	Average	2.7	3.3	2.6			2.3	
Denmark	NL	4.5	3.6					
Germany	NL (1,2), FR (6)	4.5	3.6				2.3	
Estonia	PL (1,2)	4.5	4.0					
Ireland	NL	4.5	3.6					
Greece	EL (1,4,5,6), ES (2,5)	1.9	2.5		2.2	2.5	1.2	
Spain	ES (1,2,,3,4,5,6)	4.0	2.5	0.9	6.5	2.5	2.3	
France	ES (1,2,,3,4,5,6)	4.0	2.5	0.9	6.5	2.5	2.3	
Italy	IT (1,2,3,5,6)/Average (4)	2.0	2.8	2.3	4.1	1.9	2.4	
Cyprus	EL (1,4,5,6), ES (2)	1.9	2.5		2.2	2.5	1.2	
Latvia	PL (1,2)	4.5	4.0					
Lithuania	PL (1,2)	4.5	4.0					
Luxembourg	NL (1,2), FR (6)	4.5	3.6				2.3	
Hungary	Average	2.7	3.3	2.6			2.3	
Malta	IT (1,2,3,4,5,6)	2.0	2.8	2.3	4.1	1.9	2.4	
Netherlands	NL (1,2)	4.5	3.6					
Austria	IT (1,2,3,6)	2.0	2.8	2.3			2.4	
Poland	PL (1,2), Average (3)	4.5	4.0	2.6				
Portugal	ES (1,2,,3,4,5,6)	4.0	2.5	0.9	6.5	2.5	2.3	
Romania	PL (1,2,3)/AU (6)	4.5	4.0	2.6			3.0	
Slovenia	PL (1,2,3)/AU (6)	4.5	4.0	2.6			3.0	
Slovakia	PL (1,2,3)/AU (6)	4.5	4.0	2.6			3.0	
Finland	NL (1,2), Average (3)	4.5	3.6	2.6				
Sweden	NL (1,2), Average (3)	4.5	3.6	2.6				
United Kingdom	NL (1,2), Average (3)	4.5	3.6	2.6				
Croatia	PL (1,2,3)/IT (5,6)/AV (4)	4.5	4.0	2.6	4.1	2.5	2.4	
Albania	UA (1,2,3,6), IT (4,5)	5.8	7.2	3.0	4.1	2.5	3.0	
Bosnia and Herzegovina	UA (1,2,3,6),	5.8	7.2	3.0			3.0	
Macedonia	UA (1,2,3,6),IT (5)	5.8	7.2	3.0		2.5	3.0	
Montenegro	UA (1,2,3,6), IT (5)	5.8	7.2	3.0		2.5	3.0	
Serbia	UA (1,2,3,6), IT (5)	5.8	7.2	3.0		2.5	3.0	
Kosovo	UA (1,2,3,6), IT (5)	5.8	7.2	3.0		2.5	3.0	
Ukraine	UA (1,2,3,6), IT (5)	5.8	7.2	3.0			3.0	

EuroPruning
Inventory on average pruning levels (=technical Potential)
(ton wet/ha)

CIRCE (2015). D3.1 Mapping and analysis of the pruning biomass potential in Europe. EuroPruning project (KBBE.2012.1.2.-01).

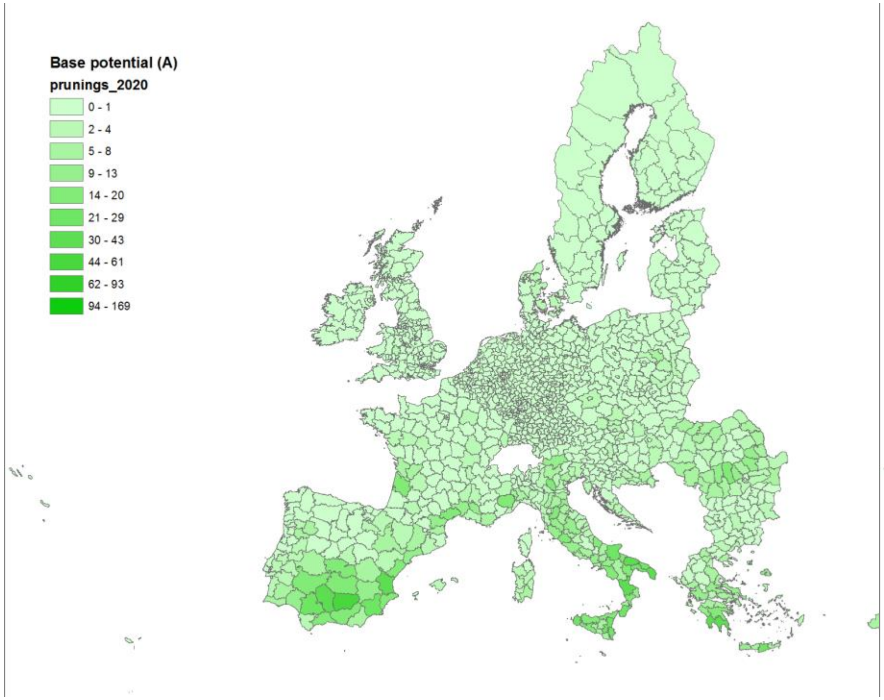
Pruning current practices

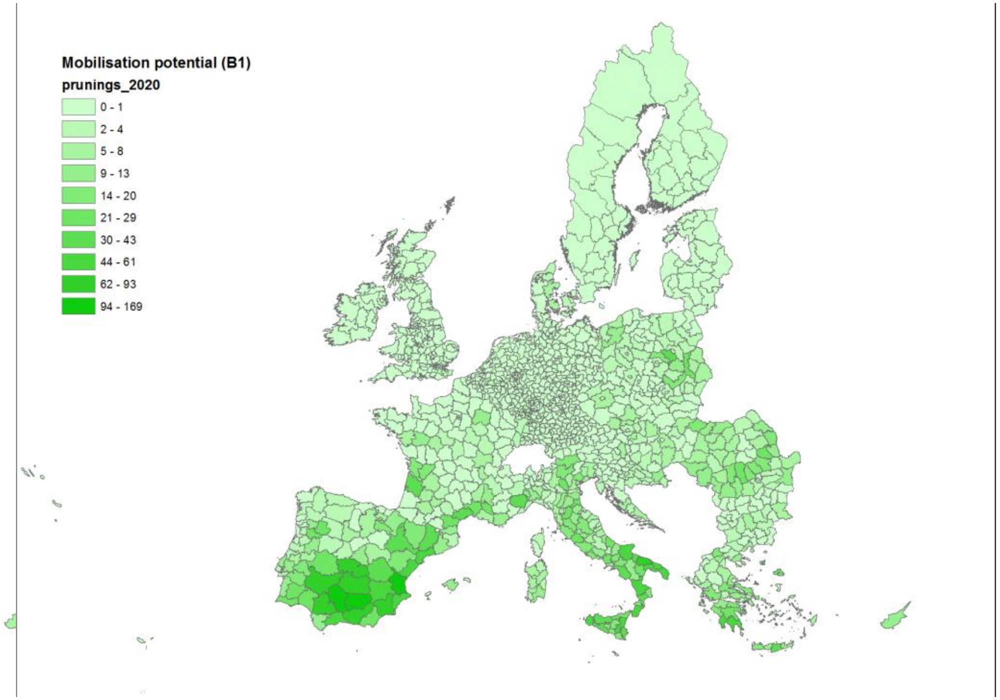
Final use / disposal (%)	Olive	Vine-yard	Seed fruit	Stone fruit	Cherry	Citrus	Almond	Dry fruit	country
Piled and stored at field side	0	2	0	1	1	0	2		ES
Piled and burned at field side	90	95	95	97	97	85	97		ES
Shredded and left/incorporated to soil	5	1	5	2	2	10	1		ES
Local firewood	5	2	0	0	0	5	0		ES
Commercialised for energy	0	0	0	0	0	0	0		ES
Piled and stored at field side		0	1	0				1	FR
Piled and burned at field side		10	1	0				1	FR
Shredded and left/incorporated to soil		80	99	100				99	FR
Local firewood		10	1	0				1	FR
Commercialised for energy		1	0	0				0	FR
Piled and stored at field side	0	0	0	0	0	0	0		IT
Piled and burned at field side	90	35	85	85	85	95	50		IT
Shredded and left/incorporated to soil	5	35	15	15	15	5	20		IT
Local firewood	5	30	0	0	0	0	20		IT
Commercialised for energy	0	0	0	0	0	0	10		IT
Piled and stored at field side		1	1	1					PL
Piled and burned at field side		1	1	1					PL
Shredded and left/incorporated to soil		95	95	95					PL
Local firewood		3	3	3					PL
Commercialised for energy		1	1	1					PL

EuroPruning Inventory on pruning use (% use)

CIRCE (2015). D3.1 Mapping and analysis of the pruning biomass potential in Europe. EuroPruning project (KBBE.2012.1.2.-01).

Pruning potentials

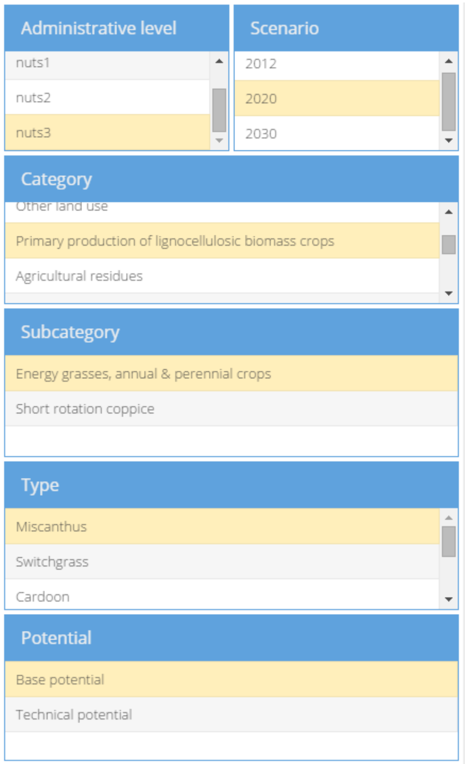


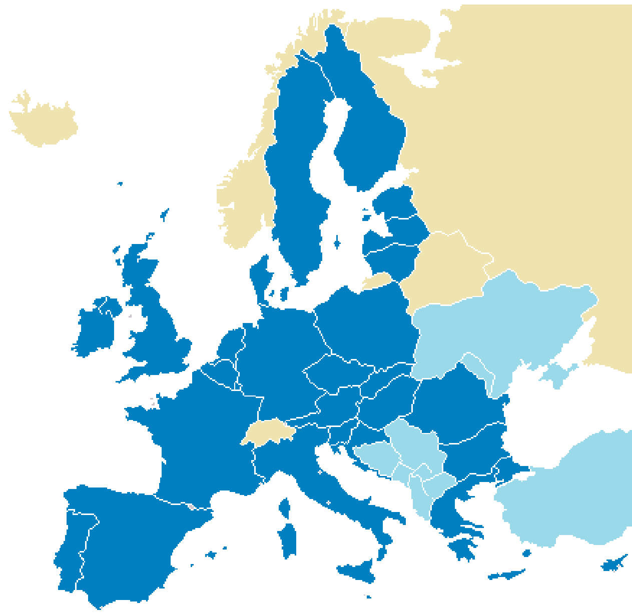


Base Potential
EU-28 potential 2020 = 1.9 mln Kton
(excludes olive pits)

Mobilisation potential
EU-28 potential 2020 = 4.9 mln Kton

Tools: Biomass chain data

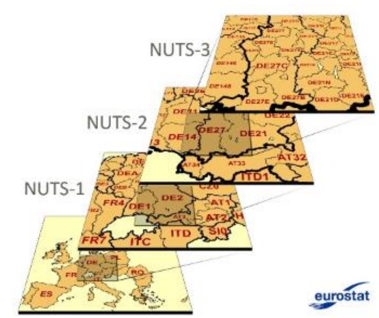




Administrative level

- Nuts 0 IT
- Nuts 1 ITH
- Nuts 2 ITH5
- Nuts 3 ITH51-59

- Nuts 0 EL (ΕΛΛΑΔΑ - ELLADA)
- Nuts 1 EL6 (KENTRIKI ELLADA)
- Nuts 2 EL61 (Θεσσαλία -Thessalia)
- Nuts 3 EL611 (Λάρισα - Larisa)



<u>The focus of the activities is on:</u>

Category: Primary production of lignocellulosic biomass crops

Subcategory: annual & perennial crops

References & further reading

- **Biomass potentials: definitions, assessment approaches, data sources**
  - BEE project reports:
    - Vis, M. & Berg, D. van den et al. (2010). BEE-D5.1: Harmonisation of biomass resource assessments. Vol. I. Best practices and methods handbook. FP7 grant agreement no. 213417
    - Rettenmaier et al. (2009). BEE-D3.1. Status of resource assessments. Version 3. FP7 grant agreement no. 213417
  - Biomass Policies:
    - Elbersen, B.S., Staritsky, I., Hengeveld, G., Lesschen, J.P., & Panoutsou, C. (2015). Guidelines for data collection to estimate and monitor technical and sustainable biomass supply. Deliverable 2.2 of the Biomass Policies project
  - BioBoost:
    - Pudelko, R. , Borzecka-Walker, M. & Faber, A. (2013). The feedstock potential assessment for EU-27 + Switzerland in NUTS-3. D 1.2. BioBoost. Project co-funded by the EUROPEAN COMMISSION FP7 Directorate-General for Transport and Energy Grant No. 282873
  - Ecofys
    - Spöttle, M, Alberici, S., Toop, G., Peters, D., Gamba, L., Ping, S., van Steen, H. , Bellefleur, D. (2013). Low ILUC potential of wastes and residues for biofuels. Straw, forestry residues, UCO, corn cobs. 4 September 2013. Project number: BIEDE13386 / BIENL12798

Discussion

- **Any questions for clarification?**
- **Are the methods and data used familiar to you?**
- **Have you been using similar methods and data?**
- **If yes, what have you done exactly?**
- **What are the main limitations in our biomass assessment approaches? What can we do to improve?**

Thank you for your attention !!

Igor.staritsky@wur.nl
Berien.elbersen@wur.nl

ALTERRA WAGENINGEN UR

Further information:
www.s2biom.eu
http://www.biomass-tools.eu




This project is co-funded by the European Union within the 7th Frame Programme. Grant Agreement n°608622.

Online tools: supply, cost/supply

- **supply and cost/supply viewer**

- **http://S2biom-test.Alterra.wur.nl**

- **Login:**
  - Username: demo
  - Password: helsinki