Interreg
Baltic Sea Region

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND

Baltic ForBio

Forest Energy Atlas

User Guide

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Contents

1 The Baltic ForBio project

The Baltic ForBio project carried out in 2017-2021 aimed to increase production of renewable energy in the Baltic Sea Region by improving the capacity of public authorities, forest and energy agencies, organizations of forest owners and entrepreneurs as well as forest advisory organizations to promote the harvest and use of logging residues and small trees from early thinnings.

Based on available technologies and research results, the project developed cost-effective and sustainable harvest methods, decision support tools, guidelines and training programs for harvest of logging residues and small trees as well as innovative business models for developing small-scale bioenergy plants in rural area in the Baltic Sea Region.

The project consortium consisted of 13 partner and 4 associated organizations from 6 countries.

The project was funded by the Interreg Baltic Sea Region Programme.

The Forest Energy Atlas (GIS platform and database) that is described in this user guide has been produced in close cooperation with key stakeholders for presenting spatially explicit estimates of forest biomass potentials.

2 Starting with Forest Energy Atlas

You can use Forest Energy Atlas in an internet browser. Chrome is recommended for best functionality. Web address is https://forest-energy-atlas.luke.fi

Five countries have been included in the Forest Energy Atlas: Sweden, Finland, Latvia, Estonia and Lithuania.

The start page gives the user of the Forest Energy Atlas an overview of the database and the tools that are available as well as the organisations that have contributed with biomass potentials.

By pressing the button the left column moves out of sight and only the map is visible (Figure 1).

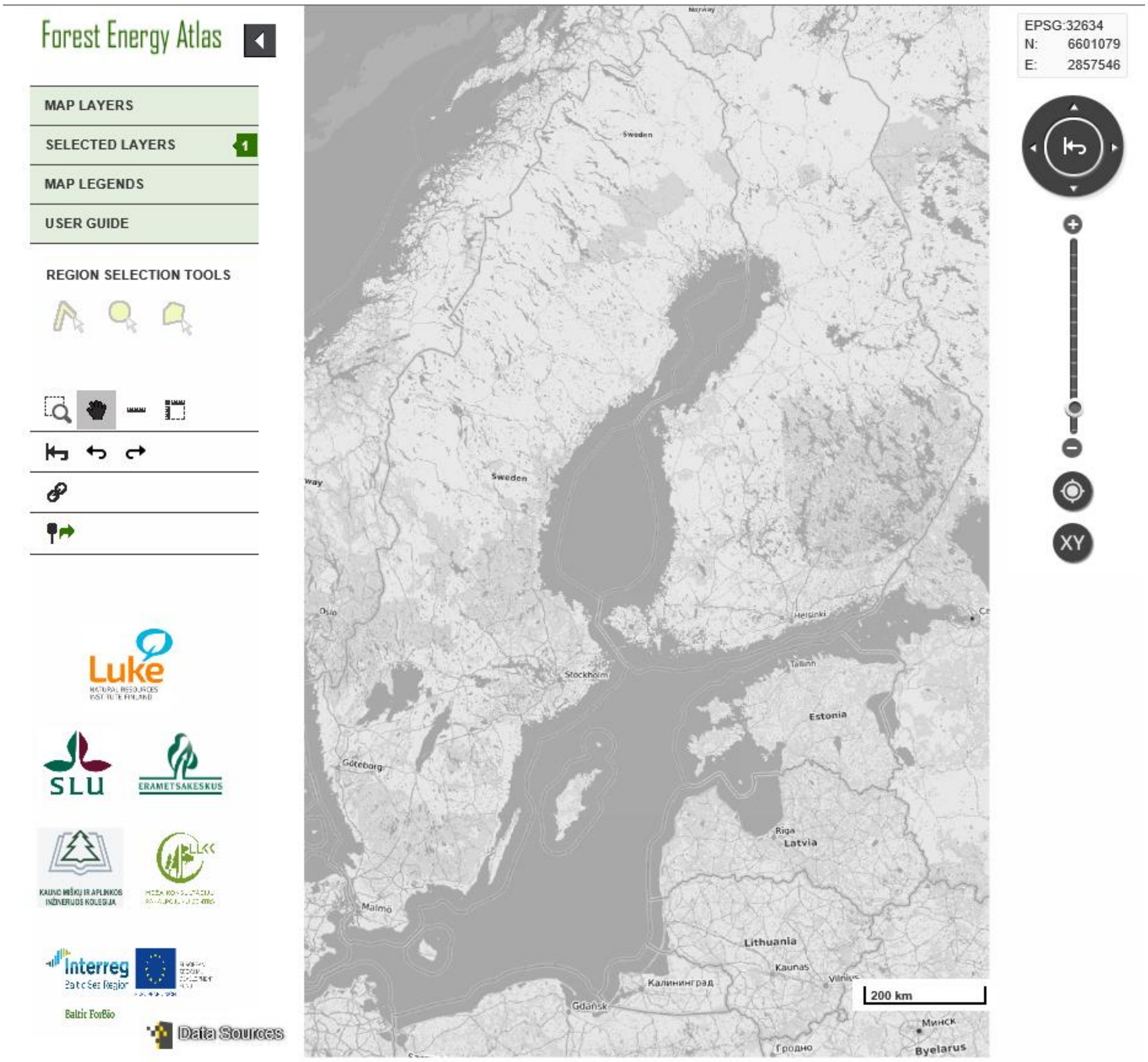


Figure 1. Start page

3 Map layers page

The map layers menu is the entry page to the biomass database that the user has access to in the Forest Energy Atlas (Figure 2). It includes biomass data from all the organizations that have contributed with biomass potentials. The data of a map layer are in a 1 km x 1 km grid. The user has the possibility to use the search function for retrieving information on specific map layer or data provider.

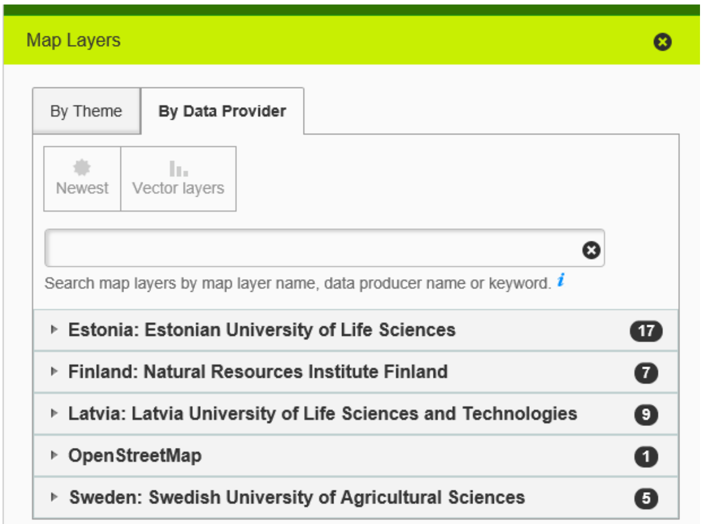


Figure 2. The search menu

In the following example the “small-diameter trees” keyword has been used to retrieve information on small-diameter tree potentials from the different countries (Figure 3). When the user selects one or more of the maps these maps can then be seen at the selected layers page.

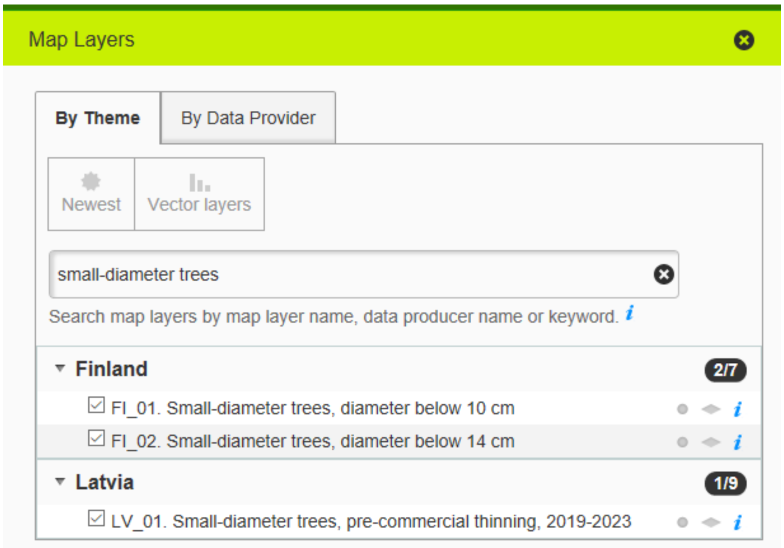


Figure 3. Resulting map layers when “small-diameter trees” keyword was used

4 Selected layers page

In the selected layers page the user can view and process the map layers that have been added there from the “Map Layers Page”. The background map is loaded on default when the Forest Energy Atlas is initiated (Figure 4). All map layers can be made more or less transparent and even totally hidden.

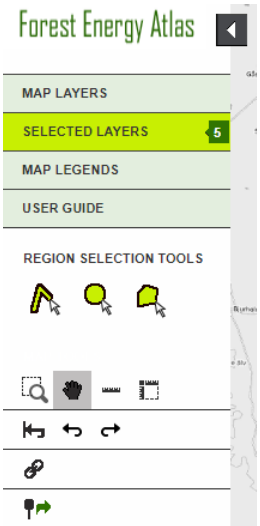


Figure 4. Selected areas window

In the following example the small-diameter trees layer maps from Estonia Finland and Sweden have been selected in the Map Layers page for viewing (Figure 5)

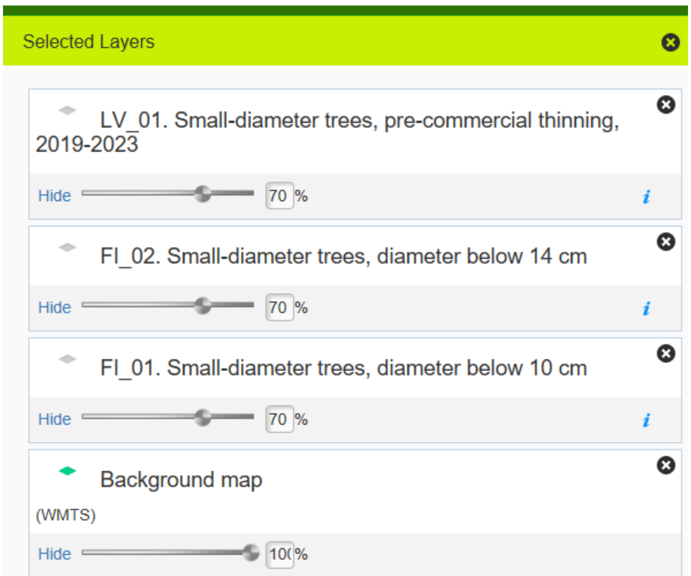


Figure 5. The Selected Layers window when “small-diameter trees” was selected

Region selection tools

These tools are used in order to select an area in a map layer and get information on the amount of biomass in that specific area.

Free outlining:	Draw an area on the map. The application will calculate the harvesting potential within it. Start drawing by clicking on the map and finish it by double-clicking. Calculation is done based on the outlined area and the selected map layers. The data of a map layer are in a 1 km x 1 km grid. If a single grid cell centroid is inside the polygon drawn by a user, the cell will be included in a summary.

In the following example (Figure 6) an area in Finland was drawn on the map with the help of the free outlining tool. In the resulting table we can see how much the harvesting potential of small-diameter tress is in this particular area. The results can be saved as an .xlsx or a .csv file.

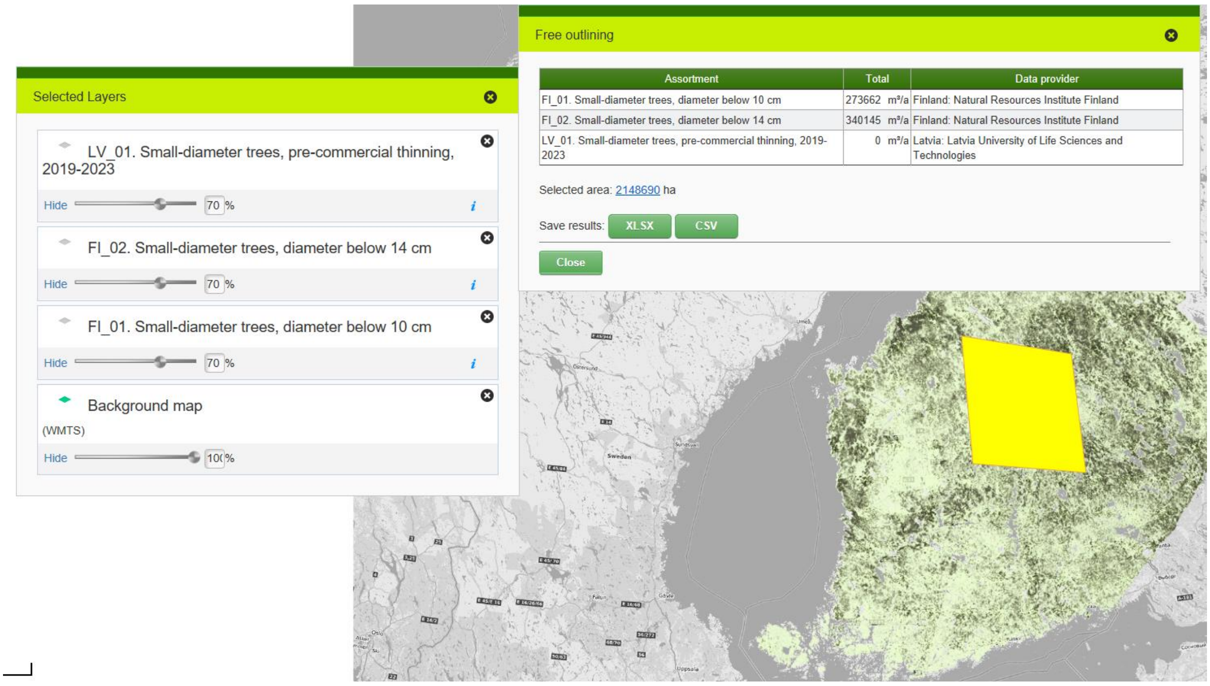
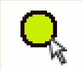


Figure 6. Application of the free outlining tool

Area selection based on central point 	Define first the central point and set then the distance (in km) from which the potential is calculated.

When this tool is selected the user has to click on the map in order to indicate where the central point of the selected area will be. Once the central point has been selected the user has to input the distance from the central point that the biomass potentials will be calculated.

Distance as a circle radius (as the crow flies): A circle is drawn from the selected centroid with the given radius. The data of a map layer are in a 1 km x 1 km grid. If a single grid cell centroid is inside the circle, the cell will be included in a summary (Figure 7).

In the following example (Figure 8) an area in Finland was drawn on the map with the help of the area selection based on central point tool. In the resulting table we can see how much the harvesting potential of small-diameter trees is in this particular area. The results can be saved as an .xlsx or a .csv file.

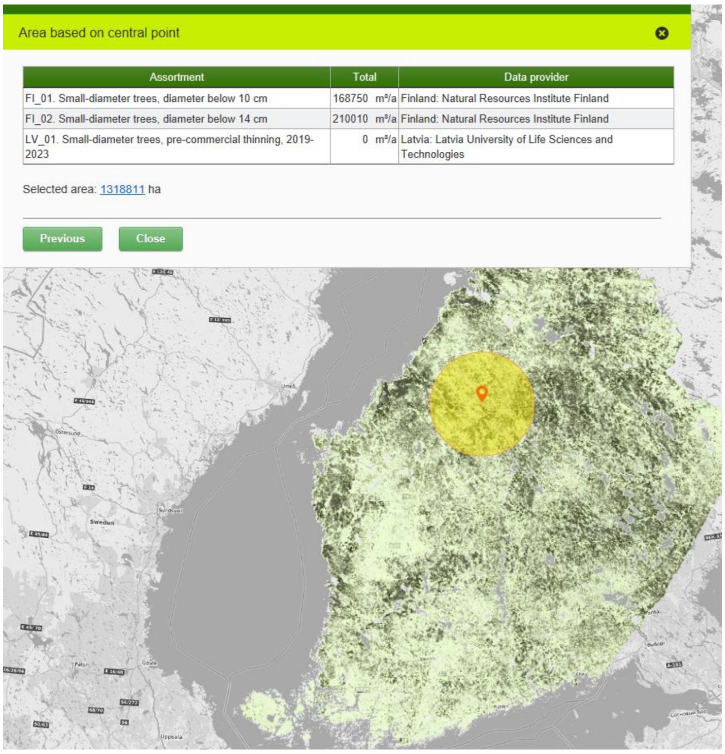


Figure 7. Application of the Area selection based on central point tool

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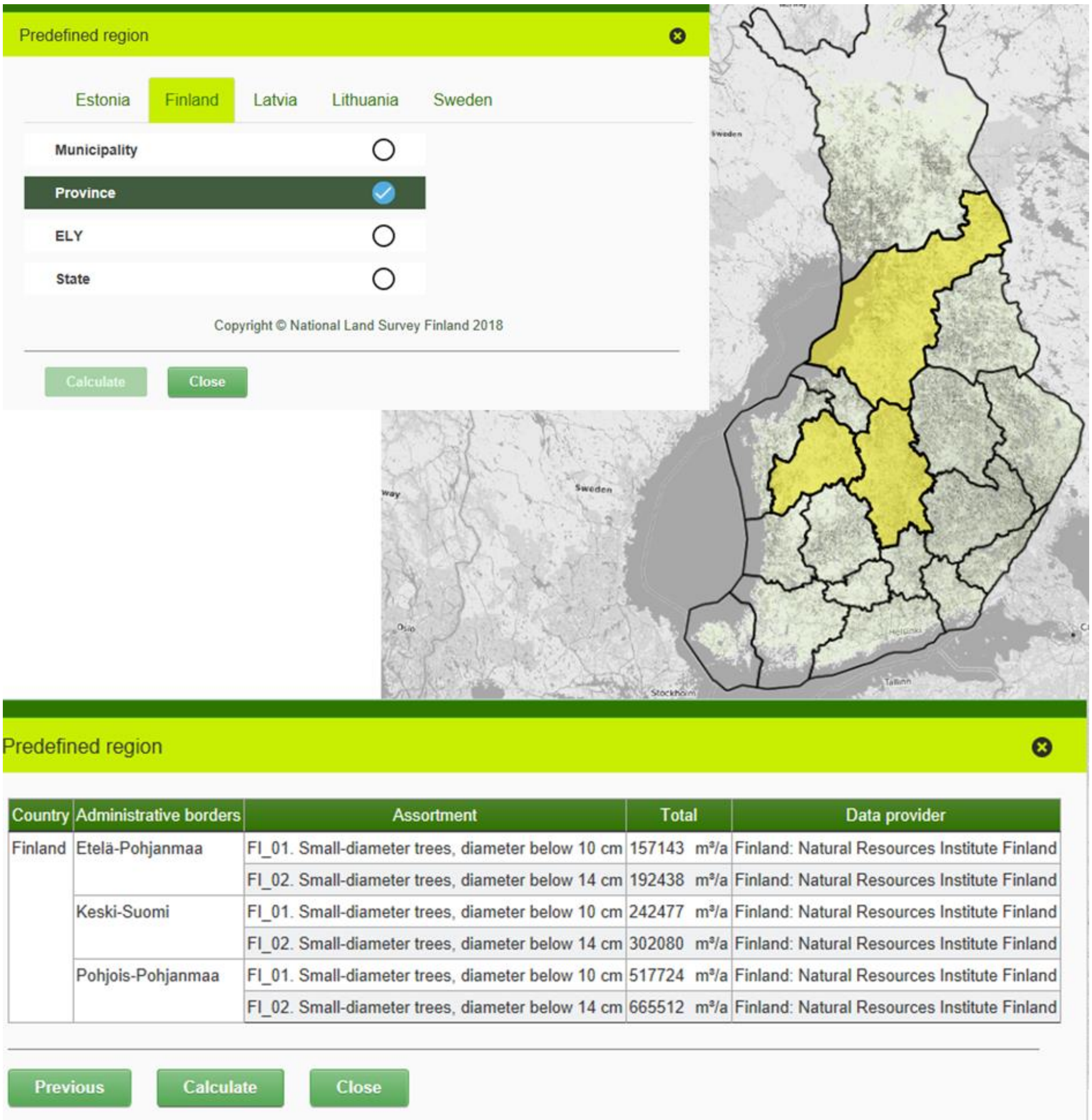
Predefined region	First choose the country in which you wish to assess forest potentials. After that, select the administrative boundary type and afterwards select regions of interest on the map. Finally the calculation is performed.

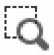
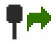
In the following example (Figure 8) three of the Finnish provinces were selected for the calculation of the biomass potential. After that the provinces are selected the *Calculate* button has to be pressed. In the resulting table (Figure 8) we can see how much the harvesting potential of small-diameter trees is in the selected Finnish provinces. The results can be saved as an .xlsx or a .csv file.



Country	Administrative borders	Assortment	Total		Data provider
Finland	Etelä-Pohjanmaa	FI_01. Small-diameter trees, diameter below 10 cm	157143	m³/a	Finland: Natural Resources Institute Finland
		FI_02. Small-diameter trees, diameter below 14 cm	192438	m³/a	Finland: Natural Resources Institute Finland
	Keski-Suomi	FI_01. Small-diameter trees, diameter below 10 cm	242477	m³/a	Finland: Natural Resources Institute Finland
		FI_02. Small-diameter trees, diameter below 14 cm	302080	m³/a	Finland: Natural Resources Institute Finland
	Pohjois-Pohjanmaa	FI_01. Small-diameter trees, diameter below 10 cm	517724	m³/a	Finland: Natural Resources Institute Finland
		FI_02. Small-diameter trees, diameter below 14 cm	665512	m³/a	Finland: Natural Resources Institute Finland

Figure 8. Application of the Predefined region tool

Other tools in brief

	Zoom in the map view.
	Pan the map by dragging it with a mouse.
	Measure a line on the map.
	Measure an area on the map.
	Move to the default map view
	Move to the previous map view
	Move to the next map view
	Link to map view
	By clicking the map you can select a new location for your map marker and even customise the marker

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5 Exercises on running the tool

1) Find the potential amount of amount of logging residues and stumps in the Swedish county of Västerbotten.
2) Find the potential amount of Pulpwood in the Swedish municipality of Falun
3) Find the potential amount of timber in the Swedish counties of Västerbotten and Jämtland
4) Find the potential amount of stumps in the Finnish province of Etelä-Pohjanmaa.
5) Use the free outlining tool in an area of the map

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6 Considerations on using the Forest Energy Atlas

1) The data describe annual harvesting potential of different energy wood and timber assortments.
2) The assortments, used input data and calculation methods vary from country to another. Therefore, care should be taken when aggregating results from different countries.
3) The potentials have been calculated for forests available for wood supply taking national constraints for energy wood harvesting into account.
4) The results show either the technical or the theoretical harvesting potential of energywood. In reality availability is further limited by the wood selling behavior of forest owners and the capability of buyers to pay for wood.
5) The results have been harmonised regarding spatial resolution (1 x 1 km^2) and metadata.
6) In Finland and Sweden the calculation was based on national forest inventory data. The original results have been calculated at regional level. Therefore, the disaggregated results for smaller areas in Forest Energy Atlas are more unreliable.
7) In Estonia, Latvia and Lithuania stand-level inventory data was utilised. These data are not based on statistical sampling and are, therefore, prone to bias.
8) For more detailed description of the data and calculation procedures see the metadata.

7 Metadata

Sweden

Energywood potentials
Country: Sweden Date:2019-07-31 Name: Dimitris Athanassiadis Organisation: SLU Address: Skogsmarksgränd Phone: +46907868304 E-mail: Dimitris.athanassiadis@slu.se
1. General information This assessment was part of project Baltic ForBio funded by the Interreg Baltic Sea Region Programme (https://www.slu.se/en/departments/forest-economics/forskning/research-projects/baltic-forbio/). The project was carried out in 2017-2020. The harvesting potentials in Sweden were calculated for the following assortments: • Branches – logging residues (pine, spruce and birch together) • Stumps (pine and spruce together) • Sawlogs (Pine and spruce together) • Pulpwood (pine, spruce and birch together) • Bark (pine, spruce and birch together)
1.1 Decision support system used in assessment Regional forest biomass potentials were calculated with the HEUREKA forest planning tool (Swedish Forest Agency, 2015).
1.2 References and further reading Swedish Forest Agency 2015. Skogliga konsekvensanalyser 2015 - SKA-15. Rapport 10:2015. Available at: https://www.skogsstyrelsen.se/globalassets/statistik/skogliga-konsekvensanalyser/skogliga-konsekvensanalyser-ska-rapport-10-2015.pdf

2. Output considered in assessment **Valid for scenario:** Maximum sustainable removal		
	Choose (one or more)	**Additional information**
Main output	☒Branches – logging residues ☒Stumps ☒Bark ☒Pulpwood ☒Saw logs	
Forecast	Forecast period for the biomass supply assessment	Start year 2010 End year: 2109 Results presented for period 2035-2039

3. Description of scenarios included in the assessments	
Scenario title	**Description**
Maximum sustainable removal	The theoretical (maximum sustainable) harvesting potentials of pulpwood, saw-logs, bark, branches (logging residues), and stumps from final fellings and thinnings is the maximum potential procurement volume of these assortments that is available from the Swedish forests. The theoretical harvesting potentials were estimated using the sample plots of the Swedish National Forest Inventory that were measured in the years 2008–2012 and the reference scenario in SKA 15 (Swedish Forest Agency 2015.). The reference scenario assumes that Swedish silvicultural practices will not change and annual fellings will still be at a level that is regarded as sustainable, that environmental legislation will not change and that climate change will be light.

4. Forest data characteristics		
Characteristics	**Check**	**Additional information**
Level of detail on forest description	☒High ☐Medium ☐Low	NFI data with many and detailed variables down to tree parts.
Sample plot based	☒Yes ☐No	NFI sample plot data from 2013-2017.
Stand based	☐Yes ☒No	
Grid based	☒Yes ☐No	Multi-Source NFI data (http://skogsdataportalen.skogsstyrelsen.se/Skogsdataportalen/) utilized when distributing regional potentials to 1 km2 resolution.

5. Forest available for wood supply: Valid for scenario: Click here to enter text.		
Category	**Area, 1000 ha**	**Additional information**
Total forest area[1]	28300	
Forest area not available for wood supply	Ca 4500	
Partly available for wood supply		
Forest Available for wood supply (FAWS)		

5.1 Additional information on area base

If some information on area base did not fit in the table above, it can be added here

The areas with some kind of nature protection were removed from the map.

6. Temporal allocation of fellings

Valid for scenario: Maximum sustainable removal

Allocation method	**Additional information**
☐Optimization based without even flow constraints ☐Optimization based with even flow constraints ☐Rule based with no harvest target ☒Rule based with static harvest target ☐Rule based with dynamic harvest target	
Describe harvest target:	
Describe objective function if optimisation	

[1] Forest defined as in: FAO. 2012. FRA 2015, Terms and Definitions. Forest Resources Assessment Working Paper 180. 36 p. Available at: http://www.fao.org/3/ap862e/ap862e00.pdf.

7 Forest management;

Valid for scenario: Maximum sustainable removal

7.1 Representation of forest management		
Representation of forest management	☒Rule based ☐Optimization ☐Implicit	**Additional information**

7.2 General assumptions on forest management Valid for scenario: Maximum sustainable removal	
Please, mark those statements from the list that apply to the management represented by scenario or mark "cannot answer". If a statement does not apply, explain in what way the scenario management deviates from the statement. In case no answer can be given, explain why. *If needed copy table for scenarios*	
Check (one or more)	**Additional information**
☒Complies with current legal requirements ☐Complies with certification ☒Represents current practices ☐None of the above ☐ No information available	Forest management follows science-based guidelines of sustainable forest management

7.3 Detailed assumptions on natural processes and forest management Valid for scenario: Maximum sustainable removal		
Parameter	**Check (one or more)**	**Additional information**
Natural processes	☒Tree growth ☒Tree decay ☒Tree death ☐Other?	
Silvicultural system	☒Even-aged ☐Uneven-aged	
Regeneration method	☒Artificial ☒Natural	
Regeneration species	☒Current distribution ☐Changed distribution	

Genetically improved plant material	☒Yes ☐No	
Cleaning	☐Yes ☒No	
Thinning	☒Yes ☐No	
Fertilization	☒Yes ☐No	

7.4 Detailed constraints on biomass supply

Valid for scenario: Maximum sustainable removal

Parameter	**Check (one or more)**	**Additional information**
Volume or area left on site at final felling	☒Yes ☐No	
Constraints for residues extraction	☐Yes ☒No ☐N/A	Maximum sustainable removal
Constraints for stump extraction	☐Yes ☒No ☐N/A	Maximum sustainable removal

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8. External factors

Valid for scenario: Maximum sustainable removal
External factors besides forest management having effect on outcomes

Factor	Check	Additional information
Economy	☐Yes ☒No	Click here to enter text.
Climate change	☒Yes ☐No	Climate change effects according to RCP4.5. The RCP 4.5 is a scenario of long-term, global emissions of greenhouse gases, short-lived species, and land-use-land-cover which stabilizes radiative forcing at 4.5 W m^{-2} (approximately 650 ppm CO2-equivalent) in the year 2100 without ever exceeding that value.
Calamities	☐Yes ☒No	Click here to enter text.
Other external	☐Yes ☒No	Click here to enter text.

9. Allocation to grid

Explain how the results were allocated to 1 km^2 grid used in Forest Energy Atlas.
The calculations have as a starting point the condition of the forest in year 2010. The period that the potentials represent is 2035-2039. The felling behaviour of the forest owners was not taken into account.
Step 1
The forestry map that shows total biomass in the Swedish productive forests (http://skogsdataportalen.skogsstyrelsen.se/Skogsdataportalen/) was used as a starting point for the calculations. This forestry map has been developed through a processing of data from the national laser scanning that the company Lantmäteri performed and test sites from the Swedish forest inventory. Biomass is reported at the pixel level 12.5 x 12.5 meters and is a measure indicating the volume content of stemwood plus logging residues and expressed in tons of dry matter per hectare (tons of DS/ha). Stumps are not included. The amount of biomass is calculated differently for different tree species and age (tree height, average diameter) and depending on where in Sweden one is located. Marklund and Petterson's functions are used for the calculations. Biomass functions for spruce, pine and birch are taken from (http://pub.epsilon.slu.se/8782). The maps give a very good idea of the amount of biomass for larger geographic areas, real estate, forests or stands.
Step 2
For every pixel (12.5 x 12.5 meters) in the forestry map described in Step 1 it was calculated the amount of biomass it contains and then also the proportion of the total biomass in each county each pixel represents.
Step 3
The theoretical potentials of the each assortment in each pixel were calculated by multiplying

the proportion of the total biomass each pixel represents (see step 2) with the Maximum sustainable removal (either m3sub or ton DS) of each assortment in each county in the selected time period (2035-2039).

Step 4

The areas with some kind of nature protection were removed from the map. A raster map for every assortment was created. The pixel size was increased to 1km x 1km.

10. Units and conversion factors

Indicate the original units of all assortments and the conversion factors for the energy assortments (i.e. saw logs and pulpwood excluded)

10.1 Original units of the assortments

- Branches: ton dry substance per year
- Stumps m3 solid under bark per year
- Saw m3 solid under bark per year
- Pulpwood (pine, spruce and birch together)
- Bark : ton dry substance per year

10.1 Conversion factors

Add / delete rows, if needed. List the conversion factors in relation with the original unit. m^3 (sob) = solid cubic metres over bark; t (dry) = tonnes dry matter.

Assortment	**m^3 (sub)**	**t (dry)**	**MJ**	**MWh**	**Reference**	**Note**
Branches (logging residues	1.382	1	17323.2	4.812	WeCalc	https://www.skogforsk.se/produkter-och-evenemang/verktyg/wecalc/
Bark		1	17323.2	4.812		
Pulpwood	1	0.534	9324	2.590		
Sawlogs	1	0.534	9324	2.590		
Stumps	1.969	1	16488	4.580		

Estonia

Energywood potentials

Country: Estonia
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1. General information

This assessment was part of project Baltic ForBio funded by the Interreg Baltic Sea Region Programme (https://www.slu.se/en/departments/forest-economics/forskning/research-projects/baltic-forbio/). The project was carried out in 2017-2020.

The harvesting potentials in Estonia were calculated for the following assortments:

- Logging residues from final fellings, pine
- Logging residues from final fellings, spruce
- Logging residues from final fellings, broadleaved
- Stumps from final fellings, pine
- Stumps from final fellings, spruce
- Firewood from thinnings (trees smaller than pulpwood-size and low quality)
- Firewood from final fellings (trees smaller than pulpwood-size and low quality)
- Pulpwood from thinnings, pine
- Pulpwood from thinnings, spruce
- Pulpwood from thinnings, birch
- Pulpwood from thinnings, aspen
- Pulpwood from final fellings, pine
- Pulpwood from final fellings, spruce
- Pulpwood from final fellings, birch
- Pulpwood from final fellings, aspen
- Sawlogs from thinnings, pine
- Sawlogs from thinnings, spruce
- Sawlogs from thinnings, birch
- Sawlogs from thinnings, aspen
- Sawlogs from thinnings, black alder
- Sawlogs from thinnings, other species
- Sawlogs from final fellings, pine
- Sawlogs from final fellings, spruce
- Sawlogs from final fellings, birch
- Sawlogs from final fellings, aspen
- Sawlogs from final fellings, black alder
- Sawlogs from final fellings, other species
- Bark from pulpwood and sawlogs, all species

- Logging residues from thinnings, pine
- Logging residues from thinnings, spruce
- Logging residues from thinnings, broadleaved

1.1 Decision support system used in assessment

For biomass availability assessment for Estonia no separate decision support systems were employed.

1.2 References and further reading

Eesti puitkütuste potentsiaali hindamine mudelpuude meetodil [An analyse trees based assessment of wood based fuels potentsials jn Estonia]. 2006. Koost: Muiste, P., Padari, A., Paas, T., Kütt, S., Moor, K. SA Keskkonnainvesteeringute Keskus poolt finantseeritud 2008. aasta metsandusprogrammi uurimisprojekti nr.25 aruanne. 28 lk.

Eurostat. 2019. Roundwood removals by type of wood and assortment. Available at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=for_remov&lang=en. Accessed 4 Sep 2019.

Metsa korraldamise juhend. 2009. Keskkonnaministri määrus nr. 2. Kinnitatud 16.01.2009. [Rules of the forest management planning. Ministry of Environment, Regulation No 2 from 16.01.2009], RT lisa 2009, 9: 104 (in Estonian)

Pach, M., Sansone, D., Ponette, Q., Barreiro, S., Mason, B., Bravo-Oviedo, A., Löf, M., Bravo, F., Pretzsch, H., Lesiński, J., Ammer, C., Đodan, M., Peric, S., Bielak, K., Brazaitis, G., del Río, M., Dezzotti, A., Drössler, L., Fabrika, M., Fonseca, T., Corona, P. 2018. Silviculture of Mixed Forests: A European Overview of Current Practices and Challenges. In: Bravo-Oviedo A.; Pretzsch H.; del Río M. (Ed.). Dynamics, Silviculture and Management of Mixed Forests (185−253). (Managing Forest Ecosystems).10.1007/978-3-319-91953-9_6.

Padari, A., Muiste, P., Mitt, R., Pärn, L. 2009. Estimation of Estonian Wood Fuel Resources. Baltic Forestry, 15 (1), 77−85.

Saarman, E., Veibri, U. 2006. Puiduteadus [Woodscience]. Eesti Metsaselts Tartu. 560 lk.

Sirgmets, Risto; Kaimre, Paavo; Padari, Allar (2011). Economic impact of enlarging the area of protected forests in Estonia. Forest Policy and Economics , 13 (3), 155−158.10.1016/j.forpol.2010.11.006.eritud 2008. aasta metsandusprogrammi uurimisprojekti nr.25 aruanne. 28 lk.

Metsa korraldamise juhend. 2009. Keskkonnaministri määrus nr. 2. Kinnitatud 16.01.2009. [Rules of the forest management planning. Ministry of Environment, Regulation No 2 from 16.01.2009], RT lisa 2009, 9: 104 (in Estonian)

Pach, M., Sansone, D., Ponette, Q., Barreiro, S., Mason, B., Bravo-Oviedo, A., Löf, M., Bravo, F., Pretzsch, H., Lesiński, J., Ammer, C., Đodan, M., Peric, S., Bielak, K., Brazaitis, G., del Río, M., Dezzotti, A., Drössler, L., Fabrika, M., Fonseca, T., Corona, P. 2018. Silviculture of Mixed Forests: A European Overview of Current Practices and Challenges. In: Bravo-Oviedo A.; Pretzsch H.; del Río M. (Ed.). Dynamics, Silviculture and Management of Mixed Forests (185−253). (Managing Forest Ecosystems).10.1007/978-3-319-91953-9_6.

Padari, A., Muiste, P., Mitt, R., Pärn, L. 2009. Estimation of Estonian Wood Fuel Resources. Baltic Forestry, 15 (1), 77−85.

Saarman, E., Veibri, U. 2006. Puiduteadus [Woodscience]. Eesti Metsaselts Tartu. 560 lk.

Sirgmets, Risto; Kaimre, Paavo; Padari, Allar (2011). Economic impact of enlarging the area of protected forests in Estonia. Forest Policy and Economics , 13 (3), 155−158.10.1016/j.forpol.2010.11.006.Eesti puitkütuste potentsiaali hindamine mudelpuude meetodil [An analyse trees based assessment of wood based fuels potentsials jn Estonia]. 2006. Koost: Muiste, P., Padari, A., Paas, T., Kütt, S., Moor, K. SA Keskkonnainvesteeringute Keskus poolt finantse

2. Output considered in assessment

Valid for scenario: Long-term continuous removal based on norm stand Long-term continuous removal based on norm stand

Please, add rows if needed to describe differences between scenarios or describe differences in additional information.

	Choose (one or more)	**Additional information**
Main output	☒Small-diameter trees ☒Stemwood for energy ☒Logging residues ☒Stumps ☒Bark ☒Pulpwood ☒Saw logs	Logging residues, stumps and bark assessment is only available on the final felling areas.
Forecast	Forecast period for the biomass supply assessment	Start year 2019 End year 2028.

3. Description of scenarios included in the assessments Please, provide a short description of each scenario. *Please, add or delete rows for scenarios if needed.*	
Scenario title	**Description**
Long-term continuous removal based on norm stand	Scenario is built up on a norm stand principle that is applied on today's annual allowable cutting area for final fellings and thinnings. The annual allowable cutting area is distributed between a) strictly protected forests, b) protection forests and c) commercial forests. Category a. forests are excluded from the management, category b. forests are accounted as 50% of the allowable annual cutting area under management (Sirgmets et al. 2011) and category c. forests are managed following the legislative arrangement applicable in Estonia without management restrictions (Pach et al. 2018). For the scenario depending on the categories the area calculation is carried out on six stand bonity classes for eight dominating tree species groups (Scots pine, Norway spruce, Betula sp., European aspen, black alder, grey alder, European ash, other species). The calculation is carried out based on formulae 1 in Appendix 18 in Rules of Forest Management planning (Metsa korraldamise juhend 2009). According to the scenario the total annual harvesting potential of roundwood (firewood + pulpwood + sawlogs) is 10.2 mill. m3 (over bark). In 2017 roundwood removals in Estonia totaled 11.4 mill. m3 (Eurostat 2019).
Other general information	

4. Forest data characteristics		
Characteristics	**Check**	**Additional information**
Level of detail on forest description	☒High ☐Medium ☐Low	
Sample plot based	☐Yes ☒No	
Stand based	☒Yes ☐No	Stand-level forest inventory data from Estonian Forest Registry (data state 01.05.2018). Estonian land cover base map (data state 01.05.2018). Estonian soil distribution map. EELIS map layers (habitat protection and management restriction data).
Grid based	☒Yes ☐No	Satellite images. Estonian LiDAR data.
Other information	Stand-level forest inventory data – available https://register.metsad.ee/#/. Estonian base map – available https://geoportaal.maaamet.ee/est/Andmed-ja-kaardid/Topograafilised-andmed/Eesti-pohikaart-110-000-p30.html.Stand-level forest inventory data – available https://register.metsad.ee/#/. Estonian base map – available https://geoportaal.maaamet.ee/est/Andmed-ja-kaardid/Topograafilised-andmed/Eesti-pohikaart-110-000-p30.html.	

5. Forest available for wood supply: Valid for scenario: Long-term continuous removal based on norm standLong-term continuous removal based on norm stand .		
Category	**Area, 1000 ha**	**Additional information**
Total forest area[2]	2447	Result of GIS calculations (Base Map)
Forest area not available for wood supply	281	Result of GIS calculations (Base Map, EELIS)
Partly available for wood supply	368	Result of GIS calculations (Base Map), EELIS)
Forest Available for wood supply (FAWS)	1798	Result of GIS calculations (Base Map, EELIS)
5.1 Additional information on area base If some information on area base did not fit in the table above, it can be added here		

[2] Forest defined as in: FAO. 2012. FRA 2015, Terms and Definitions. Forest Resources Assessment Working Paper 180. 36 p. Available at: http://www.fao.org/3/ap862e/ap862e00.pdf.

6. Temporal allocation of fellings If the method differs between scenarios, report on each scenario separately. Valid for scenario: Long-term continuous removal based on norm stand	
Allocation method	**Additional information**
☐Optimization based without even flow constraints ☐Optimization based with even flow constraints ☐Rule based with no harvest target ☒Rule based with static harvest target ☐Rule based with dynamic harvest target	
Describe harvest target: The target in long-term continuous removal is set on the basis of calculated norm stand principle. The norm stand is calculated for all stands according to a dominating tree species falling into categories b and c (described above) and for each stand bonity class. The formulae is as follows (Metsa korraldamise juhend 2009):	
$$L_y = \sum \frac{P_i}{AK_i + 5}$$	(1)
where, L_y is size of forest land area following long-term continuous removal based on norm stand principle (Ha), P_i is an area of a subcompartment (Ha) and AK_i is allowable cutting age of the particular stand on subcompartment (year).	
Describe objective function if optimisation	

7 Forest management; Valid for scenario: Long-term continuous removal based on norm stand		
7.1 Representation of forest management		
Representation of forest management	☒Rule based ☐Optimization ☐Implicit	**Additional information** All the management is carried out on the basis of current forest management principles and applicable regulation (e.g. Pach et al. 2018)All the management is carried out on the basis of current forest management principles and applicable regulation (e.g. Pach et al. 2018)

7.2 General assumptions on forest management Valid for scenario: Long-term continuous removal based on norm stand	
Check (one or more)	**Additional information**
☒Complies with current legal requirements ☐Complies with certification ☒Represents current practices ☐None of the above ☐ No information available	Forest management follows science-based guidelines of sustainable forest management (Pach et al. 2018).

7.3 Detailed assumptions on natural processes and forest management Valid for scenario: Long-term continuous removal based on norm stand		
Parameter	**Check (one or more)**	**Additional information**
Natural processes	☒Tree growth ☒Tree decay ☐Tree death ☐Other?	On calculation of assortment outcome on stand level, the standwise models were employed (Padari et al. 2009)
Silvicultural system	☒Even-aged ☐Uneven-aged	
Regeneration method	☒Artificial ☒Natural	
Regeneration species	☒Current distribution ☐Changed distribution	
Genetically improved plant material	☐Yes ☒No	
Cleaning	☐Yes ☒No	
Thinning	☒Yes ☐No	
Fertilization	☐Yes ☒No	

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7.4 Detailed constraints on biomass supply

Valid for scenario: Long-term continuous removal based on norm stand
Long-term continuous removal based on norm stand

Parameter	**Check (one or more)**	**Additional information**
Volume or area left on site at final felling	☒Yes ☐No	5 m3/ha retained trees are left in final fellings on site on the felling areas smaller than 5 hectares. 10 m3/ha retained trees are left in final fellings on site on the felling areas larger than 5 hectares (Padari et al. 2009).
Constraints for residues extraction	☒Yes ☐No ☐N/A	No residues is allowed to extract from alvar forests and boreal heath forests.
Constraints for stump extraction	☐Yes ☒No ☐N/A	

8. External factors

Valid for scenario: Long-term continuous removal based on norm stand
External factors besides forest management having effect on outcomes

Factor	**Check**	**Additional information**
Economy	☐Yes ☒No	
Climate change	☐Yes ☒No	
Calamities	☐Yes ☒No	
Other external	☐Yes ☒No	

9. Allocation to grid

The results were allocated to 1 km^2 grid used in Forest Energy Atlas.
All forest land in the grid was covered by standwise wood potential data that was distributed based on dominating tree species (MA - pine, KU - spruce, KS – birch sp, HB - aspen, LM – black alder, LV – gray alder, SA - ash, XX – other species), stand bonity classes (0-5 classes) and forest categories (a, b and c category). For the grid value the areas of renewable cut and thinnings were summed up based on two destinction a) stands already reached the allowable cutting age and b) stands that will reach the allowable cutting age within next 10 years.

10. Units and conversion factors

Indicate the original units of all assortments and the conversion factors for the energy assortments (i.e. saw logs and pulpwood excluded)

10.1 Original units of the assortments

10.1 Conversion factors

Add / delete rows, if needed. List the conversion factors in relation with the original unit. m^3 (sob) = solid cubic metres over bark; t (dry) = tonnes dry matter.

Assortment	m^3 (sob)	m^3 (sob)	t (dry)	MJ	MWh	Reference	Note
Logging residues from final fellings, pine	1		0,423	8164	2.270	Saarman, E., Veibri, U. 2006. Puiduteadus. Eesti Metsaselts Tartu. 560 lk. Eesti puitkütuste potentsiaali hindamine mudelpuude meetodil. 2006. Koost: Muiste, P., Padari, A., Paas, T., Kütt, S., Moor, K. SA Keskkonnainvesteeringute Keskus poolt finantseeritud 2008. aasta metsandusprogrammi uurimisprojekti nr.25 aruanne. 28 lk.	Energy density at 40% moisture
Logging residues from final fellings, spruce	1		0,375	7024	1.953		
Logging residues from final fellings, broadleaved	1		0,491	8788	2.443		
Stumps from final fellings, pine	1		0,423	8164	2.270		
Stumps from final fellings, spruce	1		0,375	7024	1.953		
Firewood from thinnings, all	1		0,432	7796	2.167		

Assortment	m^3 (sob)	m^3 (sob)	t (dry)	MJ	MWh	Reference	Note
Firewood from final fellings, all	1		0,432	7796	2.167	Saarman, E., Veibri, U. 2006. Puiduteadus. Eesti Metsaselts Tartu. 560 lk. Eesti puitkütuste potentsiaali hindamine mudelpuude meetodil. 2006. Koost: Muiste, P., Padari, A., Paas, T., Kütt, S., Moor, K. SA	Energy density at 40% moisture
Pulpwood from thinnings, pine	1		0,423	8164	2.270		
Pulpwood from thinnings, spruce	1		0,375	7024	1.953		
Pulpwood from thinnings, birch	1		0,539	9706	2.698		
Pulpwood from thinnings, aspen	1		0,418	7202	2.002		

Pulpwood from final fellings, pine	1		0,423	8164	2.270	Keskkonnainvesteeringute Keskus poolt finantseeritud 2008. aasta metsandusprogrammi uurimisprojekti nr.25 aruanne. 28 lk.	
Pulpwood from final fellings, spruce	1		0,375	7024	1.953		
Pulpwood from final fellings, birch	1		0,539	9706	2.698		
Pulpwood from final fellings, aspen	1		0,418	7202	2.002		
Sawlogs from thinnings, pine	1		0,423	8164	2.270		
Saw logs from thinnings, spruce	1		0,375	7024	1.953		
Saw logs from thinnings, birch	1		0,539	9706	2.698		
Saw logs from thinnings, aspen	1		0,418	7202	2.002		
Saw logs from thinnings, black alder	1		0,440	7868	2.187		
Saw logs from thinnings, other species	1		0,491	8788	2.443		
Assortment	**m^3 (sob)**	**m^3 (sob)**	**t (dry)**	**MJ**	**MWh**	**Reference**	**Note**
Saw logs from final fellings, pine	1		0,423	8164	2.270	Saarman, E., Veibri, U. 2006. Puiduteadus. Eesti Metsaselts Tartu. 560 lk. Eesti puitkütuste potentsiaali hindamine mudelpuude meetodil. 2006. Koost: Muiste, P., Padari, A., Paas, T., Kütt, S., Moor, K. SA Keskkonnainvesteeringute Keskus poolt finantseeritud 2008. aasta metsandusprogrammi uurimisprojekti nr.25	Energy density at 40% moisture
Saw logs from final fellings, spruce	1		0,375	7024	1.953		
Saw logs from final fellings, birch	1		0,539	9706	2.698		
Saw logs from final fellings, aspen	1		0,418	7202	2.002		
Saw logs from final fellings, black alder	1		0,440	7868	2.187		
Saw logs from final fellings,	1		0,491	8788	2.443		

other species						aruanne. 28 lk.	
Bark from pulpwood and saw logs , all species	1		0,432	7796	2.167		
Logging residues from thinnings, pine	1		0,423	8164	2.270		
Logging residues from thinnings, spruce	1		0,375	7024	1.953		
Logging residues from thinnings, broadleaved	1		0,491	8788	2.443		

Lithuania

Energywood potentials

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1. General information

This assessment was part of project Baltic ForBio funded by the Interreg Baltic Sea Region Programme (https://www.slu.se/en/departments/forest-economics/forskning/research-projects/baltic-forbio/). The project was carried out in 2017-2020.

The harvesting potentials in Lithuania were calculated for the following assortments:

- Small-diameter trees in stands dominated by coniferous tree species
- Small-diameter trees in stands dominated by broadleaved tree species
- Firewood in stands dominated by coniferous tree species
- Firewood in stands dominated by broadleaved tree species
- Logging residues in stands dominated by coniferous tree species
- Logging residues in stands dominated by broadleaved tree species
- Stemwood in grey alder stands
- Stumps in stands dominated by coniferous tree species
- Stumps in stands dominated by broadleaved tree species

1.1 Decision support system used in assessment

Energy wood potential in Lithuania is estimated in two operations: a) definition of annual allowable cut rate calculated using Optina model (Deltuvas and Miseikis 1975; Vitunskas 1988; Anonymous 2008) and approved by the government of Lithuania; and b) depending on annual allowable cut, amount of energy wood from final and intermediate fellings are defined in Manual of forest management planning (Anonymous 2012).

1.2 References and further reading

Anonymous 1994. Lietuvos Respublikos miškų įstatymas [Forest Law of Lithuanian Republic] (https://www.e-tar.lt/portal/lt/legalAct/TAR.5D6D055CC00C/asr).
Anonymous 2008. Dėl Pagrindinių miško kirtimų normos nustatymo metodikos patvirtinimo [Concerning the approval of forest annual cut rate methodics] (https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.324629?jfwid=-fxdp7b0p).
Anonymous 2010. Dėl miško kirtimų taisyklių patvirtinimo [Concerning approval of forest felling rules] (https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.364764).
Anonymous 2011. Dėl miškų inventorizacijos ir ūkinių priemonių projektavimo darbų kokybės vertinimo metodikos patvirtinimo [Concerning methodics of quality assessment of forest inventory fieldwork and management planning] (https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.403238/wElQmyohQE).
Anonymous 2012. Miškotvarkos darbų vykdymo instrukcija [Manual of forest management

planning], p 21 [https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.370142].
Anonymous 2017. Lietuvos miškų ūkio statistika [Lithuanian statistical yearbook of forestry]. Aplinkos ministerija, Valstybinė miškų tarnyba. Kaunas, Lututė, p. 184.
Anonymous 2018. Dėl metinės valstybinių miškų pagrindinių miško kirtimų normos 2019–2023 metams patvirtinimo [Endorsment of annual felling rate in State's forests for the period 2019-2023].https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/daa3b7019f8111e8aa33fe8f0fea665f?jfwid=-m92g8jidj.
Deltuvas R., Miseikis F. 1975. Model normalizaciji vozrastnoj struktury lesov [Model to normalize the age structure of forests]. In Proceedings of scientific conference on the improvement of methods to estimate and plan the extent of final and intermediate forest felling. Kaunas, pp. 22–25.
Kuliešis A., Kulbokas G. 2009. Assessment of Growing Stock Components for Data Harmonization in International Reporting. Lithuanian Case Study. Baltic forestry, 15 (1): pp. 58–64.
Kuliešis A., Kasperavičius A., Kulbokas G., Brukas V., Petrauskas E., Mozgeris G. 2017. Lithuania. In: Barreiro S., Schelhaas MJ., McRoberts R., Kändler G. (eds) Forest Inventory-based Projection Systems for Wood and Biomass Availability. Managing Forest Ecosystems, vol 29. Springer, Cham.
Tebėra 2007. Medynų kirtimo atliekų apskaičiavimo modelis [Modeling of logging residues in felled stands]. Report, Valstybinis miškotvarkos institutas.
Vaičys M., Beniušis R., Karazija S., Kuliešis A., Raguotis A., Rutkauskas A. 2006. Miško augaviečių tipai. Kaunas, Lututė.
Vitunskas D. 1988. Naucno-metodiceskoje obosnovanije i razrabotka eskizov drevesinopolzovanija (Methodological framework and improvement of timber use planning). In: Forest inventory and management planning. Inter-University proceedings, Kaunas, pp. 40–51.

2. Output considered in assessment

Valid for scenario: Maximum sustainable removal

	Choose (one or more)	Additional information
Main output	☒Small-diameter trees ☒Logging residues ☒Stumps ☒Firewood ☒Stemwood in grey alder dominated stands	Please refer to Anonymous 2012 for energy wood availability in relation to energy wood assortment, felling type, stand dominating species and soil type. Availability of all energy wood assortment types are presented separately as "conifer" or "broadleaved" depending on stand-dominating tree species.
Forecast	Forecast period for the biomass supply assessment	Provided energy wood potential estimation is based on actual forest inventory data and does not include forecasting.

3. Description of scenarios included in the assessments

Scenario title	Description
Maximum sustainable removal	Present maximum harvesting potential based on allowable harvesting level and forest management guidelines.

4. **Forest data characteristics** Information on data sources and use of data sources.		
Characteristics	**Check**	**Additional information**
Level of detail on forest description	☐High ☒Medium ☐Low	Plot-based NFI and stand-level data with many and detailed variables down to tree descriptors. (Kuliesis and Kulbokas 2009, Kuliesis et al. 2017).
Sample plot based	☒Yes ☐No	Principles, modeling and calculations of annual maximum available cut (including energy wood potential) is carried out referring to sample-plot based NFI (Kuliesis and Kulbokas 2009, Kuliesis et al. 2017).
Stand based	☒Yes ☐No	Actual stand level forest inventory data are used to define energy wood potentials in every stand of forested area (Anonymous 2012, Kuliesis and Kulbokas 2009, Kuliesis et al. 2017). The stands have been surveyed in 2009-2018 and the data updated to 2018 with growth models. Realized fellings or other forest management operations have not been recorded.
Grid based	☐Yes ☒No	
Other information	Quality of Lithuanian forest inventory is assessed annually by Lithuanian State Forest Service according to Anonymous 2011.	

5. Forest available for wood supply: Valid for scenario: Maximum sustainable removal		
Category	**Area, 1000 ha**	**Additional information**
Total forest area[3]	2090	Only forest land actually covered by forest is included
Forest area not available for wood supply	186	This forest land consist of forest reserves and special-purpose forest land, national legislation marked as Group I and Group II forest land.
Partly available for wood supply	320	This forest land consist of protective, or Group III forests.
Forest Available for wood supply (FAWS)	1584	Exploitable, or Group IV forests
5.1 Additional information on area base Comprehensive statistics of Lithuanian forests can be found in Lithuanian statistical yearbook of forestry (Anonymous 2017). Due to felling restrictions for Group I and Group II forests, energy wood potential was provided for Group III and Group IV forest sites only.		

[3] Forest defined as in: FAO. 2012. FRA 2015, Terms and Definitions. Forest Resources Assessment Working Paper 180. 36 p. Available at: http://www.fao.org/3/ap862e/ap862e00.pdf.

6. Temporal allocation of fellings If the method differs between scenarios, report on each scenario separately. Valid for scenario: Maximum sustainable removal Please, add information such as variables in the objective function, tolerance of the even flow constraints in case of optimization, methods for the dynamic harvest target.	
Allocation method	**Additional information**
☐Optimization based without even flow constraints ☐Optimization based with even flow constraints ☐Rule based with no harvest target ☒Rule based with static harvest target ☐Rule based with dynamic harvest target	Please refer to Anonymous 1994, Anonymous 2010, and Anonymous 2012 for more information.
Describe harvest target: Harvesting in State's forestry sector is determined by Government of Lithuanian Republic and is set to 3.62 million solid cubic meters annually for the period 2019-2023 (Anonymous 2018). Harvesting target is not predetermined for the private forest owners and annual cut might be reduced from maximum allowable cut by decisions of the owners. Fellings in private forest of the country over the years 2012-2016 amounted an average 2.9±0.13 million solid cubic meters per year and should be similar during upcoming five years (Anonymous 2017).	
Describe objective function if optimisation	

7 Forest management; Valid for scenario: Maximum sustainable removal		
7.1 Representation of forest management		
Representation of forest management	☒Rule based ☐Optimization ☐Implicit	**Additional information** Please refer to Anonymous 1994, Anonymous 2010, and Anonymous 2012 for more information.

7.2 General assumptions on forest management Valid for scenario: Maximum sustainable removal	
Please, mark those statements from the list that apply to the management represented by scenario or mark "cannot answer". If a statement does not apply, explain in what way the scenario management deviates from the statement. In case no answer can be given, explain why. *If needed copy table for scenarios*	
Check (one or more)	**Additional information**

7.3 Detailed assumptions on natural processes and forest management

Valid for scenario: Maximum sustainable scenario

Parameter	**Check (one or more)**	**Additional information**
Natural processes	☒Tree growth ☒Tree decay ☒Tree death ☐Other?	
Silvicultural system	☒Even-aged ☐Uneven-aged	
Regeneration method	☒Artificial ☒Natural	
Regeneration species	☒Current distribution ☐Changed distribution	
Genetically improved plant material	☐Yes ☒No	
Cleaning	☒Yes ☐No	
Thinning	☒Yes ☐No	
Fertilization	☐Yes ☒No	

7.4 Detailed constraints on biomass supply

Valid for scenario: Maximum sustainable scenario

Parameter	Check (one or more)	Additional information
Volume or area left on site at final felling	☒Yes ☐No	Retention of at least 5 standing trees and snags per ha after final fellings (Anonymous 2010).
Constraints for residues extraction	☒Yes ☐No ☐N/A	Retention of 5 m3/ha of logging residues onsite after final fellings. (Anonymous 2010).
Constraints for stump extraction	☒Yes ☐No ☐N/A	Removal of only Norway spruce stumps in certain soils is legislated so far. Please refer to Anonymous 2010, 2012.

8. External factors

Valid for scenario: Maximum sustainable scenario
External factors besides forest management having effect on outcomes

Factor	Check	Additional information
Economy	☐Yes ☒No	Click here to enter text.
Climate change	☐Yes ☒No	Click here to enter text.
Calamities	☐Yes ☒No	Click here to enter text.
Other external	☐Yes ☒No	Click here to enter text.

9. Allocation to grid

The results were allocated to 1 km^2 grid used in Forest Energy Atlas.
The results were calculated for each forest stand according stand-level inventory data and subsequently accumulated within grid at 1 km × 1 km resolution.

10. Units and conversion factors

Indicate the original units of all assortments and the conversion factors for the energy assortments (i.e. saw logs and pulpwood excluded)

10.1 Original units of the assortments

All the assortments are given in solid cubic metres over bark.

10.1 Conversion factors

Add / delete rows, if needed. List the conversion factors in relation with the original unit. m^3 (sob) = solid cubic metres over bark; t (dry) = tonnes dry matter.

Assortment	**m^3 (sob)**	**t (dry)**	**MJ**	**MWh**	**Reference**	**Note**
Small-diameter trees, coniferous						
Small-diameter trees, broadleaved						
Firewood, coniferous						
Firewood, broadleaved						
Logging residues, coniferous						
Logging residues, broadleaved						
Stemwood, grey alder						
Stumps, coniferous						
Stumps, broadleaved						

Finland

Energywood potentials Country: Finland Date:2019-12-03 Name: Perttu Anttila Organisation: Natural Resources Institute Finland (Luke) Address: Yliopistokatu 6 B, 80100 Joensuu, Finland Phone: +358 50 391 3088 E-mail: perttu.anttila@luke.fi
1. General information This assessment was part of project Baltic ForBio funded by the Interreg Baltic Sea Region Programme (https://www.slu.se/en/departments/forest-economics/forskning/research-projects/baltic-forbio/). The project was carried out in 2017-2020. The harvesting potentials in Finland were calculated for the following assortments: Stemwood for energy from 1st thinnings Stemwood for energy from 1st thinnings (smaller than pulpwood-sized trees) Logging residues from clear fellings, pine Logging residues from clear fellings, spruce Logging residues from clear fellings, deciduos Stumps from clear fellings, pine Stumps from clear fellings, spruce.
1.1 Decision support system used in assessment Regional energywood potentials were calculated with MELA forest planning tool (Siitonen et al. 1996; Hirvelä et al. 2017).
1.2 References and further reading Anttila P., Muinonen E., Laitila J. 2013. Nostoalueen kannoista jää viidennes maahan. [One fifth of the stumps on a stump harvesting area stays in the ground]. BioEnergia 3: 10–11. Anttila P., Nivala V., Salminen O., Hurskainen M., Kärki J., Lindroos T.J. & Asikainen A. 2018. Regional balance of forest chip supply and demand in Finland in 2030. Silva Fennica vol. 52 no. 2 article id 9902. 20 p. https://doi.org/10.14214/sf.9902 Hakkila, P. 1978. Pienpuun korjuu polttoaineeksi. Summary: Harvesting small-sized wood for fuel. Folia Forestalia 342. 38 p. Hirvelä, H., Härkönen, K., Lempinen, R., Salminen, O. 2017. MELA2016 Reference Manual. Natural Resources Institute Finland (Luke). 547 p. Hynynen, J., Ojansuu, R., Hökkä, H., Siipilehto, J., Salminen, H. & Haapala, P. 2002. Models for predicting stand development in MELA System. Metsäntutkimuslaitoksen tiedonantoja 835. 116 p. Koistinen A., Luiro J., Vanhatalo K. 2016. Metsänhoidon suositukset energiapuun korjuuseen, työopas. [Guidelines for sustainable harvesting of energy wood]. Metsäkustannus Oy, Helsinki. ISBN 978-952-5632-35-4. 74 p.

Mäkisara, K., Katila, M., Peräsaari, J. 2019: The Multi-Source National Forest Inventory of Finland - methods and results 2015.

Muinonen E., Anttila P., Heinonen J., Mustonen J. 2013. Estimating the bioenergy potential of forest chips from final fellings in Central Finland based on biomass maps and spatially explicit constraints. Silva Fennica 47(4) article 1022. https://doi.org/10.14214/sf.1022.

Natural Resources Institute Finland. 2019. Industrial roundwood removals by region. Available at: http://stat.luke.fi/en/industrial-roundwood-removals-by-region. Accessed 22 Nov 2019.
Ruotsalainen, M. 2007. Hyvän metsänhoidon suositukset turvemaille. Metsätalouden kehittämiskeskus Tapio julkaisusarja 26. Metsäkustannus Oy, Helsinki. 51 p. ISBN 978-952-5694-16-1, ISSN 1239-6117.

Siitonen M, Härkönen K, Hirvelä H, Jämsä J, Kilpeläinen H, Salminen O et al. 1996. MELA Handbook. 622. 951-40-1543-6.

Äijälä, O., Kuusinen, M. & Koistinen, A. (eds.). 2010. Hyvän metsänhoidon suositukset: energiapuun korjuu ja kasvatus. Metsätalouden kehittämiskeskus Tapion julkaisusarja 30. 56 p. ISBN 978-952-5694-59-8, ISSN 1239-6117.

Äijälä, O., Koistinen, A., Sved, J., Vanhatalo, K. & Väisänen, P. (eds). 2014. Metsänhoidon suositukset. Metsätalouden kehittämiskeskus Tapion julkaisuja. 180 p. ISBN 978-952-6612-32-4.

2. Output considered in assessment

Valid for scenario: Maximum sustainable removal

Please, add rows if needed to describe differences between scenarios or describe differences in additional information.

	Choose (one or more)	**Additional information**
Main output	☒Small-diameter trees ☒Stemwood for energy ☒Logging residues ☒Stumps ☐Bark ☐Pulpwood ☐Saw logs	”Stemwood for energy from 1st thinnings” consists of trees that fulfill size requirements of forest industry and trees smaller than that. “Stemwood for energy from 1st thinnings (smaller than pulpwood-sized trees)” includes only the latter part.
Forecast	Forecast period for the biomass supply assessment	Start year: 2015 End year: 2044 Results presented for period 2025-2034

3. Description of scenarios included in the assessments	
Scenario title	**Description**
Maximum sustainable removal	The maximum sustainable removal is defined by maximizing the net present value with 4% discount rate subject to non-declining periodic total roundwood removals, energy wood removals and net incomes, further the saw log removals have to remain at least at the level of the first period. There are no sustainability constraints concerning tree species, cutting methods, age classes or the growth/drain -ratio in order to efficiently utilize the dynamics of forest structure. Energy wood removal can consist of stems, cutting residues, stumps and roots. According to the scenario the total annual harvesting potential of industrial roundwood is 80.7 mill. m3 (over bark) for period 2025-2034. In 2018 removals of industrial roundwood in Finland totaled 68.9 mill. m3 (Natural Resources… 2019).
Other general information	

4. Forest data characteristics		
Characteristics	**Check**	**Additional information**
Level of detail on forest description	☒High ☐Medium ☐Low	NFI data with many and detailed variables down to tree parts.
Sample plot based	☒Yes ☐No	NFI sample plot data from 2013-2017.
Stand based	☐Yes ☒No	
Grid based	☒Yes ☐No	Multi-Source NFI data from 2015 (Mäkisara et al. 2019) utilized when distributing regional potentials to 1 km2 resolution.
Other information	-	

5. Forest available for wood supply:

Valid for scenario:

Category	Area, 1000 ha	Additional information
Total forest area[4]	Forest and scrub land 22812	Forest land 20278 and scrub land 2534
Forest area not available for wood supply	Forest and scrub land 2979	Forest land 1849 and scrub land 1130
Partly available for wood supply	Forest and scrub land 2553 (includes in FAWS, below)	Forest land 1149 and scrub land 1404.
Forest Available for wood supply (FAWS)	Forest and scrub land 19833	Forest land 18429 and scrub land 1404

5.1 Additional information on area base

If some information on area base did not fit in the table above, it can be added here

In MELA calculations all the scrub land belonging to the FAWS belongs to the category "Partly available for wood supply", but there are no logging events on scrub land regardless or the category.

6. Temporal allocation of fellings

If the method differs between scenarios, report on each scenario separately.

Valid for scenario: Maximum sustainable removal

Please, add information such as variables in the objective function, tolerance of the even flow constraints in case of optimization, methods for the dynamic harvest target.

Allocation method	Additional information
☐Optimization based without even flow constraints ☒Optimization based with even flow constraints ☐Rule based with no harvest target ☐Rule based with static harvest target ☐Rule based with dynamic harvest target	
Describe harvest target:	
Describe objective function if optimisation See item 3 above (max NPV with 4 % discount rate).	

[4] Forest defined as in: FAO. 2012. FRA 2015, Terms and Definitions. Forest Resources Assessment Working Paper 180. 36 p. Available at: http://www.fao.org/3/ap862e/ap862e00.pdf.

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7 Forest management;

Valid for scenario: Maximum sustainable removal

7.1 Representation of forest management

Representation of forest management	☐Rule based ☒Optimization ☐Implicit	**Additional information** Treatments, among of the optimization makes the selections, are based on management guidelines (e.g. Äijälä etc 2014)

7.2 General assumptions on forest management

Valid for scenario: Maximum sustainable removal

Please, mark those statements from the list that apply to the management represented by scenario or mark "cannot answer". If a statement does not apply, explain in what way the scenario management deviates from the statement. In case no answer can be given, explain why.

If needed copy table for scenarios

Check (one or more)	**Additional information**
☒Complies with current legal requirements ☐Complies with certification ☒Represents current practices ☐None of the above ☐ No information available	Forest management follows science-based guidelines of sustainable forest management (Ruotsalainen 2007, Äijälä et al. 2010, Äijälä et al. 2014).

7.3 Detailed assumptions on natural processes and forest management

Valid for scenario: Maximum sustainable removal

Parameter	**Check (one or more)**	**Additional information**
Natural processes	☒Tree growth ☒Tree decay ☒Tree death ☐Other?	Tree-level models (e.g. Hynynen et al., 2002).
Silvicultural system	☒Even-aged ☐Uneven-aged	
Regeneration method	☒Artificial ☒Natural	
Regeneration species	☐Current distribution ☒Changed distribution	Optimal distribution may differ from the current one.

Genetically improved plant material	☐Yes ☒No	
Cleaning	☒Yes ☐No	
Thinning	☒Yes ☐No	
Fertilization	☐Yes ☒No	

7.4 Detailed constraints on biomass supply

Valid for scenario: Maximum sustainable removal

Parameter	**Check (one or more)**	**Additional information**
Volume or area left on site at final felling	☒Yes ☐No	5 m3/ha retained trees are left in final fellings. Final fellings can be carried out only on FAWS with no restrictions for wood supply.
Constraints for residues extraction	☒Yes ☐No ☐N/A	Retention of 30% of logging residues onsite (Koistinen et al. 2016)
Constraints for stump extraction	☒Yes ☐No ☐N/A	Retention of 16–18% of stump biomass (Muinonen et al. 2013; Anttila et al. 2013)

8. External factors

Valid for scenario: Maximum sustainable removal
External factors besides forest management having effect on outcomes

Factor	**Check**	**Additional information**
Economy	☐Yes ☒No	
Climate change	☐Yes ☒No	
Calamities	☐Yes ☒No	
Other external	☐Yes ☒No	

9. Allocation to grid

The results were allocated to 1 km2 grid used in Forest Energy Atlas.
The results were calculated for 15 regions with MELA. Subsequently the results were distributed on a grid at 1 km × 1 km resolution by weighting with Multi-Source NFI biomasses as described by Anttila et al. (2018).

10. Units and conversion factors

Indicate the original units of all assortments and the conversion factors for the energy assortments (i.e. saw logs and pulpwood excluded)

10.1 Original units of the assortments

All the assortments are given in solid cubic metres over bark.

10.1 Conversion factors

Add / delete rows, if needed. List the conversion factors in relation with the original unit. m^3 (sob) = solid cubic metres over bark; t (dry) = tonnes dry matter.

Assortment	m^3 (sob)	t (dry)	MJ	MWh	Reference	Note
Stemwood for energy from 1st thinnings, pine	1	0.39	6876	1.91	Hakkila (1978)	Energy density at 40% moisture
Stemwood for energy from 1st thinnings, spruce	1	0.38	6646	1.85	Hakkila (1978)	Energy density at 40% moisture
Stemwood for energy from 1st thinnings, broadleaved	1	0.49	8756	2.43	Hakkila (1978)	Values for birch. Energy density at 40% moisture.
Stemwood for energy from 1st thinnings (smaller than pulpwood-sized trees), pine	1	0.39	6876	1.91	Hakkila (1978)	Energy density at 40% moisture
Stemwood for energy from 1st thinnings (smaller than pulpwood-sized trees), spruce	1	0.38	6646	1.85	Hakkila (1978)	Energy density at 40% moisture
Stemwood for energy from 1st thinnings (smaller than pulpwood-sized trees), broadleaved	1	0.49	8756	2.43	Hakkila (1978)	Values for birch. Energy density at 40% moisture.

	Logging residues, pine	1	0.395	7470	2.08	Hakkila (1978)	With needles. Energy density at 40% moisture.
	Logging residues, spruce	1	0.425	7731	2.15	Hakkila (1978)	With needles. Energy density at 40% moisture.
	Logging residues, deciduos	1	0.5	9035	2.51	Hakkila (1978)	Value for birch, without leaves. Energy density at 40% moisture.
	Stumps, pine	1	0.475	8503	2.36	Hakkila (1978)	Energy density at 40% moisture
	Stumps, spruce	1	0.435	7586	2.11	Hakkila (1978)	Energy density at 40% moisture

Latvia

Energywood potentials

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1. General information

This research was part of project Baltic ForBio funded by the Interreg Baltic Sea Region Programme (https://www.slu.se/en/departments/forest-economics/forskning/research-projects/baltic-forbio/). The project was carried out in 2017-2020.

The calculation of forest energywood potential was done in summer of year 2019 by Latvian Rural Advisory and Training Centre subsidiary Forest Advisory Service Center in collaboration with Latvia University of Life Science and Technologies.

The forest energy wood potentials in Latvia were calculated for the following assortments:

- Small diameter trees from pre-commercial thinnings, biomass in solid m^3
- Logging residues from commercial thinnings and selective final fellings, biomass in solid m^3
- Firewood from commercial thinnings and selective final fellings, assortment in solid m^3
- Logging residues from clear fellings, assortment in solid m^3
- Firewood from clear fellings, assortment in solid m^3

1.1 Decision support system used in assessment

Calculations were accomplished by Latvia University of Life Science and Technologies Forest Faculty developed program ‘’Meža eksperts’’ (Forest Expert). The main purpose of the program is forest management planning and it also contains the biomass calculation algorithms – to calculate the potential biomass amount respecting specific forest stand parameters.

1.2 References and further reading

G. Priedītis, I. Šmits, I. Arhipova, S. Daģis, D. Dubrovskis, „Prediction models for estimating diameter at breast height in Latvia's forests” 17th European conference of Information Systems in Agriculture and Forestry, 11- 14.07.2011.;
Salvis Daģis, „Intellectual algorithms for optimisation of forest management planning”, Latvia, 2007;
Salvis Daģis, „Evaluation of forest tree distribution model using artificial neural networks”, The European Simulation and Modelling Conference Proceedings, Malta, 2007;
Salvis Daģis, „Information system requirement analysis and specification in forest management planning process”, 9th International Conference on Enterprise Information Systems, Funchal, Madeira – Portugal, 2007;
Salvis Daģis, Sergejs Arhipovs, Dagnis Dubrovskis, „The growth of trees motion mathematical models and their adaption the Latvia circumstances”, Proceedings of the Second International Scientific Conference Biometrics and information technologies in agriculture: Research and Development, Kaunas, Lithuania, 24-25 November 2006;

Salvis Daģis, “Intellectual algorithms for optimisation of forest management planning”. The 8th international thematic issue Computer Science of the RTU scientific proceedings series Applied Computer Systems and the 48th RTU International Scientific Conference, 2007. (submitted for publication); Ingus Smits, Salvis Dagis, “Tasks and Data Precision Problem in Forest Management Planning Information System”, E-Activity and Leading Technologies 2007 proceedings. Porto, Portugal, 2007; Šmits I., Dagis S. Algorithms for estimating forest inventory parameters from data acquired by remote sensing methods. 10th International Conference on Enterprise Information Systems, Proceedings. Barcelona, Spain, Proceedings, 12- 16 June, 2008.

2. Output considered in assessment		
	Choose (one or more)	**Additional information**
Main output	☒Small-diameter trees ☒Stemwood for energy ☒Logging residues ☒Firewood ☐Stumps ☐Bark ☐Pulpwood ☐Saw logs	
Forecast	Forecast period for the biomass supply assessment	Start year: 2019 End year: 2048 Results presented for six 5-year periods 1.period 2019-2023 2.period 2024-2028 3.period 2029-2033 4.period 2034-2038 5.period 2039-2043 6.period 2044-2048

3. Description of scenarios included in the assessments	
Scenario title	**Description**
	Optimized removal based on net income profile rate by 3% of forest capital value. By determination a discount rate of 3%, the net income profile is calculated after which the optimization is made. Main objective is to have a stable net income from forest management in the long term. The method is based on sum up eventual incomes from different management operation by arranging the forest stand compartments in order of priority. Priority is determined by extent of the age of forest stand (mature or overgrown), need of tending. Pre-commercial thinnings were planned for the stands where height of trees is up to 12 meters and number of trees per ha exceed normal number of trees (1600 trees) according to existing forest legislation. For the first periods calculated amount of pre-commercials thinnings and selective final fellings have higher intensity due large areas of belated thinnings and not performed selective final felling on appropriate condition, also suitable from economic aspects. However these activities are prevalent in optimization model, therefore forest management activities on these areas were planned as soon as possible. For the future stands after eventual clear feelings, software during regeneration already plan normal number of trees per ha, so for these stands amount of pre-commercial thinnings is reduced. Once the calculated net income profile is achieved, all other eventual management activities in forest stands are moved to the next period, where they are again updated, calculated, and ranked in order of priority. For each forest stand available for harvesting, software calculated special felling priority index, which is based on how much the particular stand exceeds cutting age or cutting diameter, respecting certain tree species. The same for basal area parameter in commercial thinnings and for selective final fellings. Additionally in felling priority index is respected forest site type and financial rentability for certain forest stand. In optimization, the software includes forest stands with highest felling priority index first of all. According to the scenario the total annual harvesting potential of roundwood (firewood + pulpwood + sawlogs) is fluctuating from 13 mill. m^3 to 14 mill. m^3 (over bark). In 2017 roundwood removals in Latvia totaled 12.89 mill. m^3 (Eurostat 2019), while according data of State Forest Service total wood removal from forest land was accounted for 11.4 mill. m^3.

4. Forest data characteristics

The input data are stand-level forest inventory data.
The data used for calculation were obtained from Forest State Register (hereafter FSR) in February of year 2019. FSR is the national level data base, managed by the state authority State Forest Service Republic of Latvia, who stores, gathers and updates forest inventory data for all type of forest owners and the data on management operation performed.
The input data covers 92% of total forest land including state owned forests, municipality forests and private forests. Proportion 92% was assumed by comparison forest area registered in FSR to forest area ascertained during National Forest Inventory.
Initially FSR is based on forest inventory data, what forest owners submit to State Forest Service at least once per 20 years. Afterwards forest stand main parameters, such as growing stock, age, diameter, height, etc. are annually updated by tree growth models. It is mandatory to all forest owners to report to the State Forest Service about all the management operations carried out and this information has been entered in to FSR. For state forests, which consist 49% of Latvian total forest area, forest inventory data in FSR is updated continuously after every significant forest management operation done.

Characteristics	**Check**	**Additional information**
Level of detail on forest description	☒High ☐Medium ☐Low	FSR data
Sample plot based	☐Yes ☒No	
Stand based	☒Yes ☐No	FSR data
Grid based	☐Yes ☒No	
Other information	According to the Forest State Register forest land area is 3.35 million ha, of it forest occupies 3.04 million ha large area. According data of National Forest Inventory (2018), forest area consist of 3.233 million ha. The balance of FSR data and National forest Inventory data is 0.193 million ha, mainly naturally overgrowth agriculture lands that complies to forest stands criteria, but so far are not included in FSR due lack of formal process and initial forest inventory.	

5. Forest available for wood supply:		
Category	**Area, 1000 ha**	**Additional information**
Total forest area[5]	3040	FSR data
Forest area not available for wood supply	175	Nature protected areas, FSR data Forestry activities prohibited in 102 100 ha. Prohibited final felling and commercial thinnings in 72 900 ha.
Partly available for wood supply	233.8	Nature protection areas, FSR data. Not allowed final felling on area 33 100 ha and not allowed clear felling on area 200 700 ha.
Forest Available for wood supply (FAWS)	2865	FSR data

5.1 Additional information on area base

During calculation has been respected forest management restrictions for certain forest stand, laid down by legislation and as remark included in FSR, and for these forest stands energy wood potential is calculated only for management operations allowed. Unfortunately voluntary protected areas and strait protection belts along watercourses were not respected during calculations.

6. Temporal allocation of fellings	
Allocation method	**Additional information**
☐Optimization based without even flow constraints ☒Optimization based with even flow constraints ☐Rule based with no harvest target ☐Rule based with static harvest target ☐Rule based with dynamic harvest target	

Describe harvest target: Assumed wood removal volumes in the coming years remain consistently at wood felling level of 13 to 14 million m^3 per year, what is 10% to 30 % above of felling level in past 10 years.
Describe objective function if optimization. Optimized removal based on net income profile rate by 3 % of forest capital value.

[5] Forest defined as in: FAO. 2012. FRA 2015, Terms and Definitions. Forest Resources Assessment Working Paper 180. 36 p. Available at: http://www.fao.org/3/ap862e/ap862e00.pdf.

7 Forest management;		
7.1 Representation of forest management		
Representation of forest management	☐Rule based ☒Optimization ☐Implicit	Forest management applied is based on optimization, to have stable net income from forest management in the long term. In optimization obtained wood removal volumes for the coming years have increase from 10% to 30% compare to current wood felling levels, fluctuating from 13 up to 14 million m^3 per different periods.

7.2 General assumptions on forest management	
Check (one or more)	**Additional information**
☒Complies with current legal requirements ☒Complies with certification ☒Represents current practices ☐None of the above ☐ No information available	Partly complies with certification, FSC and PEFC.

7.3 Detailed assumptions on natural processes and forest management		
Parameter	**Check (one or more)**	**Additional information**
Natural processes	☒Tree growth ☒Tree decay ☒Tree death ☐Other?	
Silvicultural system	☒Even-aged ☒Uneven-aged	Even aged silvicultural system are implemented after clear fellings while uneven aged silvicultural system could form after selective main felling.
Regeneration method	☒Artificial ☒Natural	
Regeneration species	☒Current distribution ☒Changed distribution	For Scots pine (*Pinus sylvestris L.*), Norway spruce (*Picea abies (L.) H.Karst.*) and Birch (*Betula pendula Roth., Betula pubescens Ehrh.*) stands regeneration is planned by the same tree species, but for stands of other tree species composition, regenerated tree species could be changed according to the legislation requirements and good forest practice.

Genetically improved plant material	☐Yes ☒No	
Cleaning	☐Yes ☒No	
Thinning	☒Yes ☐No	
Fertilization	☐Yes ☒No	

7.4 Detailed constraints on biomass supply

Parameter	**Check (one or more)**	**Additional information**
Volume or area left on site at final felling	☒Yes ☐No	50% of tree stemwood cutting residues (tops, assortment residues etc.) are excluded from potential raw material for biomass. The criterion is based on technological aspects.
Constraints for residues extraction	☒Yes ☐No ☐N/A	For forest stands on drained peat soils and on some wet mineral soils, assumption for available biomass were estimated in proportion of 70% from total amount, for forest stands on mineral soils, on wet mineral soils and on drained mineral soils assumption for available biomass were estimated in proportion of 50% of total amount. Forest stands on very dry and poor mineral soils and on wetlands were excluded from calculations for energy wood potential. The criterion is based on technological, biodiversity and soil fertility aspects.
Constraints for stump extraction	☐Yes ☒No ☒N/A	

8. External factors		
Factor	**Check**	**Additional information**
Economy	☒Yes ☐No	
Climate change	☐Yes ☒No	
Calamities	☐Yes ☒No	
Other external	☐Yes ☒No	

9. Allocation to grid

The results were allocated to 1 km^2 grid used in Forest Energy Atlas.

Available biomass or firewood amount were primarily calculated on stand level, and were summed up for grids. In case a forest stand was located on several grid cells, the percentage of forest stand area located in each grid cell was calculated and the stand's potential allocated to the cells accordingly.

10. Units and conversion factors

10.1 Original units of the assortments

All the assortments are given in solid cubic metres over bark.

10.1 Conversion factors

Assortment	**m^3 (sob)**	**t (dry)**	**$m^{3 loose}$**	**MJ**	**MWh**	**Reference**	**Note**
Small diameter trees from pre-commercial thinnings;	1		3				
Logging residues from commercial thinnings and selective final fellings;	1		3				
Firewood from commercial thinnings and selective final fellings;	1						
Logging residues from clear fellings;	1		3				
Firewood from clear fellings;	1						