2 Wood production

2.1 Overview

Forest biomass provides a range of ecosystem services, e.g. through the provision of round wood for construction and furniture production. The 'wood production' ecosystem service model calculates round wood production that is used to produce wood products. Although there are fewer productive forests in urban areas than in rural areas, some city trees can also be used in the context of wood production. In addition, the wood production model is a necessary input for two other models: biomass production for energy and carbon sequestration. For this reason, the model has been included in the urban ecosystem service set.

Four output maps (i.e. actual wood production, biophysical suitability for wood production, the monetary value of actual wood production, potential wood production) have been produced for the ecosystem service 'wood production' (see Table 2.1). These maps have been produced to show what the capacity of an area is for wood production (suitability and potential), given environmental characteristics and how much is actually growing in an area (actual production and the incremental monetary value). The biophysical suitability and potential wood production maps are included in the model output to provide insight into which areas can potentially provide higher service flows, which can facilitate spatial planning processes.

The output map has been produced by combining existing spatial data for the Netherlands with maps developed by RIVM for the Natural Capital Model. Tables 2.1 and 2.2 provide an overview of the input and output maps to model the ecosystem service 'wood production'. The original input maps for groundwater levels and soil biophysical units (Alterra, 2006 and Alterra, 2016) contained data gaps for most built-up areas. These maps have been adjusted to cover urban areas as well, using additional datasets from TNO (2015).

Table 2.1. Output maps generated for the ecosystem service 'wood production'.

Output map	Unit	Short description
Biophysical suitability wood production	Score between 0 and 1	Biophysical suitability for wood production based on potential wood production.
Potential wood production	m^3 wood ha^{-1} yr^{-1}	Potential wood production, given soil texture, drainage and current land use.
Actual wood production	m^3 wood ha^{-1} yr^{-1}	Actual wood production in currently forested areas.
Monetary value actual wood production	€ ha^{-1} yr^{-1}	Monetary value of the actual wood production.

Table 2.2. Input maps applied to estimate the ecosystem service 'wood production'.

Input	Unit	Short description	Source
Agricultural crop parcels	Land cover types for crops	Types of crops found on arable fields	RVO 2013
Groundwater level from the soil map*	Groundwater level in cm	Spatial information on groundwater level and soil structure to roughly 1 metre depth	Alterra 2006
Soil biophysical units*	Soil biophysical units	Defines areas with similar soil characteristics and hydrological activity (BOFEK2012)	Alterra 2016
Min & max Groundwater level	Groundwater level in cm	Defines maximum and minimum average groundwater levels	NHI 2016
Ecosystem unit map	Ecosystem unit classes	Ecosystem unit classes map for the Netherlands in 2013	CBS 2017

*The original maps have been supplemented with data from TNO (2015), so that the maps also fully cover urban areas.

2.2 Modelling the ecosystem service

The service 'wood production' results in four output maps. The modelling of these four maps is described in the following sections. Figure 2.2 provides a schematic overview of the way input data has been modelled in order to produce the output maps for the ecosystem service 'wood production.'

2.2.1 Monetary value of actual wood production

The monetary value of the actual wood production is calculated according to (Function 4, Figure 2.2):

$$\textbf{Monetary value of wood production} = \textbf{wood price} \times \textbf{actual wood production}$$

Given the available information on forest cover in the Netherlands, a distinction is made between three forest types: coniferous, deciduous and mixed forest. The average wood price, based on data provided by Demey et al. (2013) and Liekens et al. (2013), has been estimated as 46.15 €/m^3 for coniferous, 42.63 €/m^3 for deciduous and 44.39 €/m^3 for mixed wood (corrected from 2010 to 2016 € value).

2.2.2 Actual wood production

The actual wood production depends on the annual increment and the fraction of wood that is harvested per year (Function 3, Figure 2.2):

$$\textbf{Actual wood production} = \textbf{annual increment} \times \textbf{harvest factor}$$

The fraction harvested (*harvest factor)* is based on the 6th National Forest Inventory and is estimated as: 0.373 for deciduous, 0.531 for coniferous and 0.466 for mixed forest (Schelhaas et al., 2014). The annual increment can be estimated, given specific soil texture and soil drainage groups, for different forest types (Table 2.3) according to Vandekerkhove et al. (2014).

Soil texture
Four soil texture groups have been defined, based on the texture codes given in the map with the soil biophysical units (BOFEK2012, see Alterra 2016). These four texture groups have been grouped into two texture types: light soils and heavy soils, used for the definition of the drainage classes. Table 2.4 gives the reclassification of the soil types found in the map with the soil biophysical units (BOFEK2012) into eight main texture classes. Table 2.5 shows the reclassification of these 8 texture classes into 4 texture groups and two texture types.

Soil drainage
Input maps with the average minimum (GLG) and maximum (GHG) groundwater level (NHI, 2006) have been reclassified into nine soil drainage classes, according to Finke et al. (2010) as given in Figure 2.1. As the groundwater level maps do not cover the Wadden islands in the north of the Netherlands, the groundwater level from the soil map has been reclassified into the same nine hydrological classes according to a reclassification table based on expert judgement (available on request). In both cases, a distinction has been made between two texture types: light soils and heavy soils as defined in Table 2.5. The nine drainage classes have been regrouped into four drainage groups according to Table 2.6 in order to estimate the annual increment.

Table 2.3. Wood increment (m^3/ha/yr) per soil texture and drainage class combination for three forest types.

Soil texture/drainage	Texture	Drainage			
		very dry	dry	moist-wet	wet
Mixed forest	class/class	1	2	3	4
peat & sandy soils	1	4	6	6	5
loamy sand soils	2	5	8	8	6
(sandy) loam soils	3	3	11	10	7
(heavy) clay soils	4	3	9	10	6
Coniferous forest	class/class	very dry	dry	moist-wet	wet
peat & sandy soils	1	7	9	7	2
loamy sand soils	2	8	10	8	2
(sandy) loam soils	3	4	10	7	2
(heavy) clay soils	4	4	8	6	0
Deciduous forest	class/class	very dry	dry	moist-wet	wet
peat & sandy soils	1	4	6	6	5
loamy sand soils	2	5	8	8	6
(sandy) loam soils	3	3	11	10	7
(heavy) clay soils	4	3	9	10	6

Table 2.4. Reclassification of the soil classes from the BOFEK map (soil physical properties) into soil texture classes.

BOFEK Code	Texture	BOFEK Code	Texture	BOFEK Code	Texture	BOFEK Code	Texture
101	V	303	S	321	S	412	E
102	V	304	Z	322	Z	413	E
103	V	305	Z	323	Z	414	E
104	V	306	Z	324	Z	415	U
105	V	307	S	325	S	416	L
106	V	308	S	326	Z	417	L
107	V	309	Z	327	Z	418	E
108	V	310	Z	401	E	419	E
109	V	311	Z	402	E	420	E
110	V	312	S	403	E	421	E
201	U	313	S	404	U	422	U
202	E	314	S	405	U	501	E
203	V	315	S	406	L	502	L
204	V	316	S	407	E	503	U
205	Z	317	S	408	L	504	L
206	Z	318	S	409	L	505	L
301	Z	319	S	410	E	506	L
302	Z	320	Z	411	E	507	A

Table 2.5. Classification of soil texture classes into four texture groups and two texture types.

Texture class	Code	Texture group	Code	Texture type	**Code**
A: loam soils	1	(sandy) loam soils	3	Heavy	2
E: clay	2	(heavy) clay soils	4	Heavy	2
L: sandy loam soils	3	(sandy) loam soils	3	Heavy	2
P: light sandy loam soils	4	loamy sand soils	2	Light	1
S: loamy sand soils	5	loamy sand soils	2	Light	1
U: heavy clay soils	6	(heavy) clay soils	4	Heavy	2
V: peat	7	peat & sandy soils	1	Heavy	2
Z: sandy	8	peat & sandy soils	1	Light	1

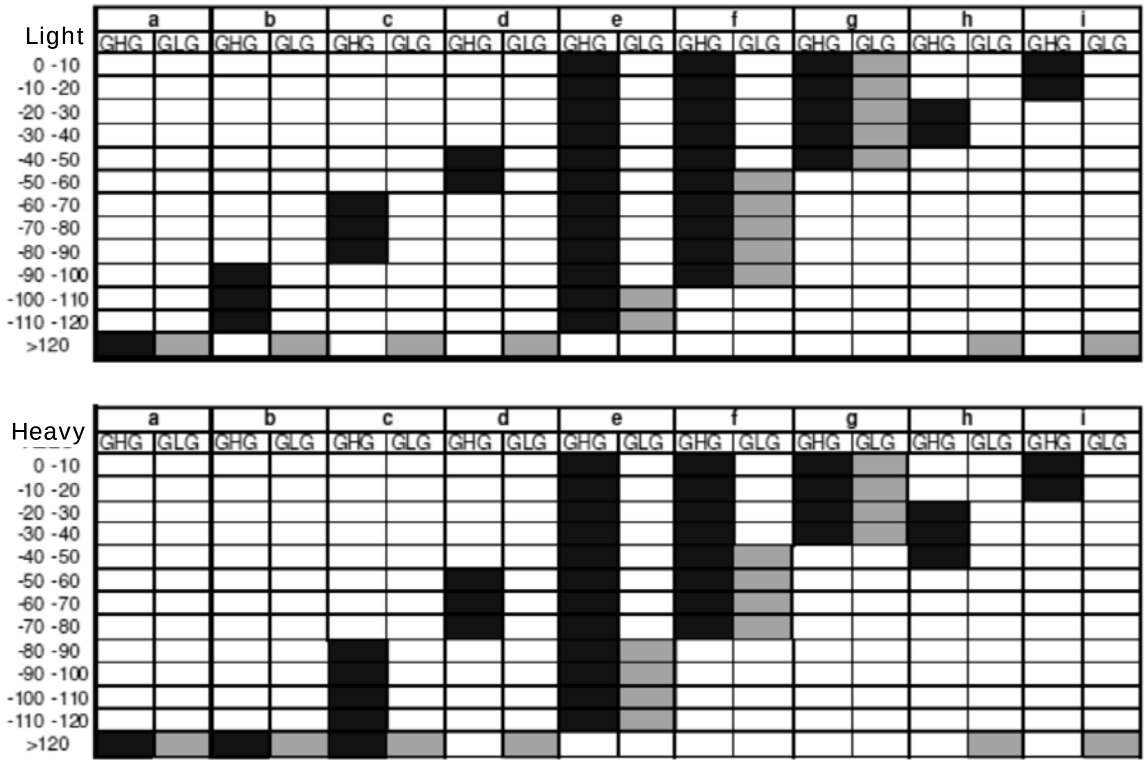

Figure 2.1. Definition of the average minimum (GLG, grey boxes) and maximum (GHG, black boxes) groundwater levels for the nine drainage classes for light (sandy & loamy soils) and heavy (clay & peaty) soils according to Finke et. al. (2010).

Table 2.6 Information from 'Drainage group' knowledge table necessary for reclassification (Function 1, Figure 2.2).

Drainage class	Description	Drainage group	Code
A	excessively drained soils (very dry)	Very dry	1
B	well-drained soils (dry)	Dry	2
C	moderately well-drained soils (medium dry)	Dry	2
D	insufficiently drained soils (moderately wet)	Moist-wet	3
E	rather poorly drained soils with groundwater permanently (wet)	Moist-wet	3
F	poorly drained soils with groundwater permanently (very wet)	Wet	4
G	extremely poorly drained soils (very wet)	Wet	4
H	poorly drained soils with backwater (temporary groundwater) (very wet)	Moist-wet	3

I	rather poorly drained soils with backwater (temporary groundwater) (wet)	Wet	4

Table 2.7. Applied maximum growth rates (m^3/ ha. year) for the agricultural and non-agricultural soils for various drainage and texture classes according to Vandekerkhove et al., (2014).

Non-agricultural soils				
Texture / Drainage	Very dry	dry	moist-wet	wet
peat & sandy soils	12	16	9	6
loamy sand soils	12	16	12	11
(sandy) loam soils	10	16	18	9
(heavy) clay soils	10	15	20	7
Agricultural soils				
Texture / Drainage	Very dry	dry	moist-wet	wet
peat & sandy soils	15	20	12	9
loamy sand soils	15	20	15	14
(sandy) loam soils	11	18	20	12
(heavy) clay soils	11	17	22	9

2.2.3 *Potential wood production*

The simulation of the potential wood production [m^3/ha. year] is based on Vandekerkhove et al. (2014). According to this study, the potential wood production differs between agricultural soils that have been fertilized and non-agricultural soils as shown in Table 2.7. For each texture group and drainage group, the most productive tree species has been selected to calculate potential wood production. The locations of the agricultural areas are based on the input map with the agricultural crop parcels. Given the crop-type, the parcels are reclassified as agricultural; the rest of the area is defined as non-agricultural.

2.2.4 *Biophysical suitability for wood production*

The map with the potential wood production is normalized to generate the map with the biophysical suitability for wood production as follows (Function 2, Figure 2.2):

$$\begin{aligned}&\boldsymbol{Biophysical\ suitability\ for\ wood\ production}\\&\quad = \boldsymbol{potential\ wood\ production}\\&\quad\ / \boldsymbol{maximum\ of\ the\ map\ with\ the\ potential\ wood\ production}\end{aligned}$$

2.3 Remarks and points for improvement

- The new data on vegetation (Appendix I, coverage of each grid cell with trees and tree height) could be combined with information on forest type from the LCEU map and incorporated into the model.
- The National Forest Inventory (Nederlandse Bosinventarisatie, NBI) could be used to improve the input maps. The 6th National Forest Inventory (Schelhaas et al., 2014) was finished in 2014, providing statistical data for approximately 3,000 sites. More comprehensive was the 4th NBI (then named Bosstatistiek), but the dataset is older

(1980s). The 6th NBI can be found by clicking on the following link: http://www.probos.nl/publicaties/overige/1094-mfv-2006-nbi-2012. CBS and Wageningen University & Research have developed a wood production model based on the 6th NBI data that should be compared (and possibly integrated) with this model.
- The national model STONE (Wolf et al. 2003) can be used to incorporate fertilization data (N and P). This is preferable to the current reclassification made using the LCEU dataset.
- Currently, Belgian data on wood prices is used. Wageningen Economic Research also provides similar data that could be used in future versions of the model. See: http://agrimatie.nl/Binternet_Bosbouw.aspx?ID=1005&Lang=0&sectorID=3303

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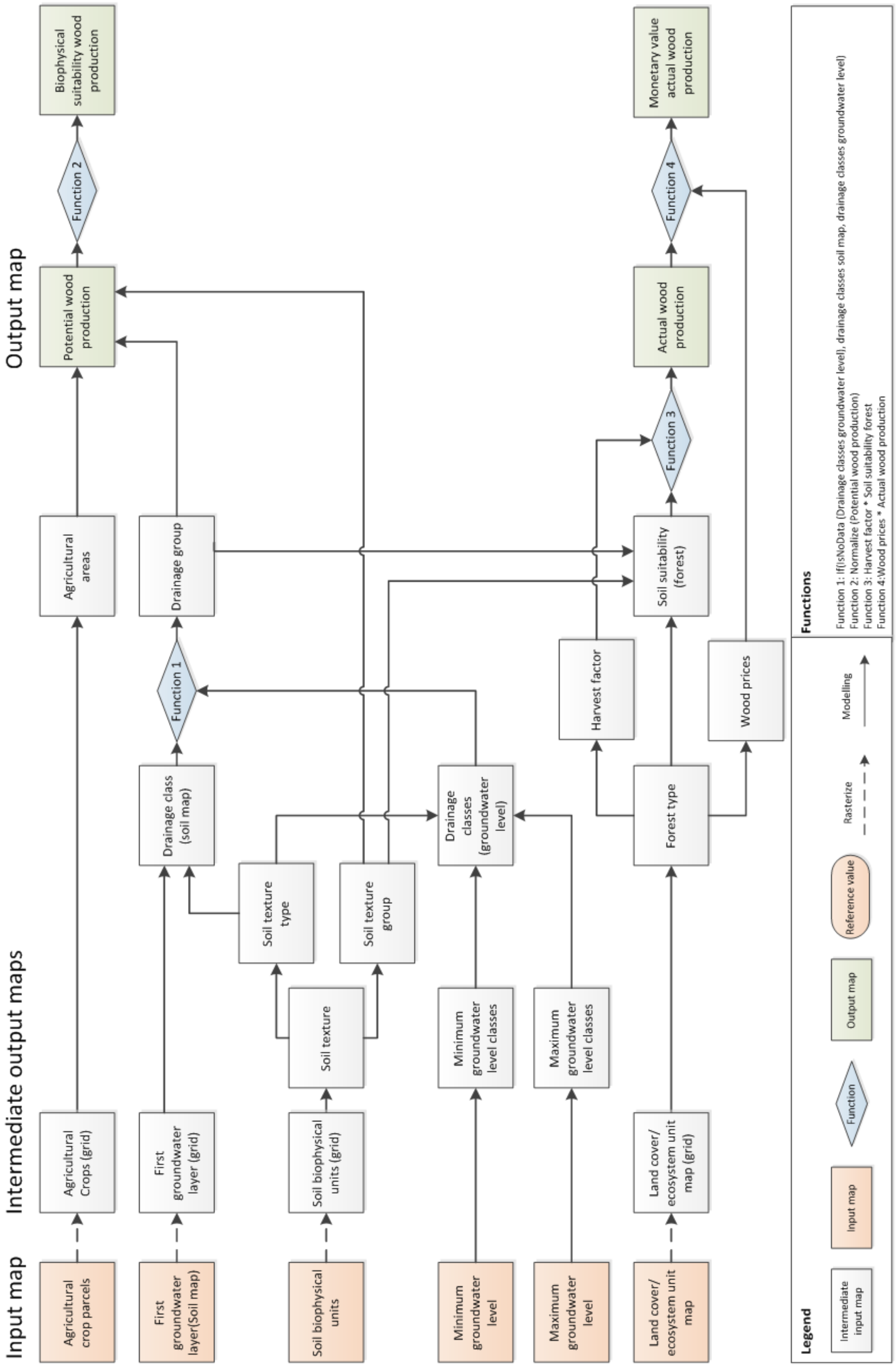

Figure 2.2 Schematic overview of 'wood production' model.