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Spatial trade-off analysis of short rotation coppice in Belgium

Effects on ecosystem services and biodiversity

Julie Callebaut, Jomme Desair, Maarten Stevens, Salma Elahmadi, Amaury Sonneville, Marijke Steenackers

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Authors:
Julie Callebaut, Jomme Desair, Maarten Stevens , Salma Elahmadi, Amaury Sonneville,
Marijke Steenackers
Research Institute for Nature and Forest (INBO)

Reviewer:
Lieven De Smet

The Research Institute for Nature and Forest (INBO) is an independent research institute of the Flemish government. Through applied scientific research, open data and knowledge, integration and disclosure, it underpins and evaluates biodiversity policy and management.

Location:
Herman Teirlinckgebouw
INBO Brussel
Havenlaan 88, 1000 Brussels, Belgium
vlaanderen.be/inbo

e-mail:
julie.callebaut@inbo.be

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SPATIAL TRADE-OFF ANALYSIS OF SHORT ROTATION COPPICE IN BELGIUM

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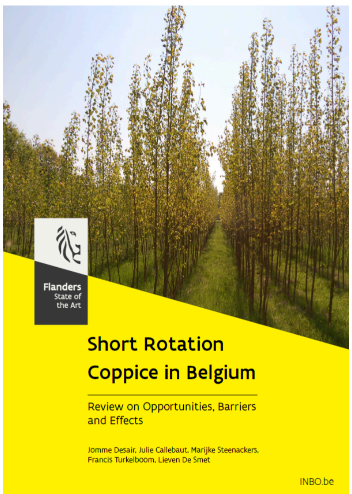
Reading Guide

This report follows the report *"Short Rotation Coppice in Belgium: Review on Opportunities, Barriers and Effects"* (Desair *et al.*, 2022) and provides a complementary view on the potential of short rotation coppice to the report "*The integration of short rotation coppice in Belgian agricultural landscapes. Guidelines and strategies for managing short rotation coppice cultures.*" (Desair *et al.*, 2024). These three studies were conducted as part of the AD-LIBIO-project *"ADvanced Liquid BIOfuels for advanced engine concepts enabled by advanced wood breeding and catalysis"*. This research and development project focuses on wood from short rotation coppice (SRC) as a feedstock for biofuel production. Besides investigating novel engineering methodologies for optimal biofuel production, the potential of short-rotation coppice in Belgium is evaluated.

The first report by Desair *et al.* (2022) gives an idea of the current area of SRC in Belgium, including change over time, and the availability of land for potential expansion of SRC. It explores the potential delivery of different ecosystem services, the potential for biodiversity and the effect on landscapes and its inhabitants. This second report dives deeper into the spatial opportunities and barriers for short rotation coppice. It is a technical report, first discussing the methods used and the assumptions made (§2), followed by an overview of the results for different SRC-scenarios, with the underlying storylines, the spatial translation and the ecosystem services (§3). The discussion goes into more detail on the results and uncertainties, and what this means for the potential development of short rotation coppice (§4). The report ends with conclusions and recommendations (§5). The third AD-LIBIO report investigates how and why short rotation coppice is currently implemented in Belgium and provides insights in how it could be integrated in different farm types and agricultural landscapes (Desair *et al.*, 2024).

Everyone who wants to learn more on the spatial possibilities of SRC in Belgium, and the possible effects on ecosystem services, biodiversity and landscape, is invited to read this report. It was a deliberate choice to keep this report as light and accessible as possible. For more technical information, such as the spatial modelling and underlying data, we refer to the annexes.



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- The individual farmers, cooperatives and entrepreneurs who were interviewed or contacted for their hands-on experience and knowledge with rotation coppice in Belgium. Due to GDPR regulations, we can not name everyone personally, but thank you very much for responding spontaneously to our interview invitations and receiving us in your homes and field to share your valuable insights.
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- Experts within the Flemish government and beyond, providing spatial datasets and insights on how to best use these in the analysis: Inge Liekens, Lien Poelmans, Karolien Vermeiren from VITO, Hilde Verboven and Sofie Marchand from Agentschap Onroerend Erfgoed, Peter Willems and Stijn Vanacker from Omgeving Vlaanderen, Sylvie Danckaert and Tim Baeten from Departement Landbouw en Visserij.
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Abstract

This study presents a comprehensive spatial trade-off analysis of Short Rotation Coppice (SRC) cultivation in Belgium and its impacts on ecosystem services and biodiversity. Through a detailed methodological framework that combines interviews, storyline-based scenarios, and multi-scale modelling, we investigate the ecological and socio-economic consequences of SRC deployment across various land-use scenarios. Both regional and local scale models are applied to quantify ecosystem services such as wood production, carbon storage, water retention, and nature value. The current situation is compared with three different scenarios in which the area of SRC is expanded: SRC as small landscape elements, SRC integrated into agroforestry systems and SRC as intensive cultivation. Evaluating and comparing ecosystem services of these different SRC scenarios, from minimal intervention to intensive cultivation, allows to explore the significant trade-offs in ecosystem functions. The main trade-off of implementing SRC is with agricultural production. The results indicate that SRC delivers more ecosystem services and can host more biodiversity compared to the agricultural land use it substitutes. Biomass production from SRC and agricultural production can also be combined when SRC is planted as small landscape elements or in agroforestry systems. In this way the wider range of ecosystem services delivered by SRC are combined with food production. Planting SRC as small landscape elements, or in combination with agroforestry practices, could therefore potentially be a balanced and achievable vision for the future. We hope that the results of this study can contribute to the discussion on sustainable land use practices where SRC can be considered as an alternative practice, both as a bioenergy resource as well as for the additional ecosystem services it has to offer.

Abstract in Dutch

Deze studie omvat een uitgebreide ruimtelijke trade-off-analyse van de teelt van korte-omloophout (KOH) in België en de impact ervan op ecosysteemdiensten en biodiversiteit. Via een methodologisch kader dat interviews, scenario-verhaallijnen en modellering op meerdere schalen combineert, onderzoeken we de ecologische en socio-economische gevolgen van KOH in verschillende landgebruik-scenario’s. Modellen op zowel regionale als lokale schaal worden toegepast om ecosysteemdiensten zoals houtproductie, koolstofopslag, waterretentie en natuurwaarde te kwantificeren. We vergelijken de huidige situatie met drie verschillende scenario's waarin de oppervlakte van KOH uitgebreid wordt: KOH als kleine landschapselementen, KOH geïntegreerd in agroforestry-systemen en KOH als intensieve teelt. Het evalueren en vergelijken van ecosysteemdiensten van deze verschillende KOH scenario's, maakt het mogelijk om de significante trade-offs in ecosysteemdiensten te onderzoeken. De belangrijkste trade-off van de implementatie van KOH is landbouwproductie. De resultaten geven aan dat KOH meer ecosysteemdiensten levert en meer biodiversiteit kan herbergen dan de landbouw die het vervangt. Landbouw en KOH kunnen echter ook samen gaan wanneer KOH wordt aangeplant als kleine landschapselementen of in agroforestry-systemen. Daarbij worden de geleverde ecosysteemdiensten van KOH gecombineerd met voedselproductie. Het aanplanten van KOH als kleine landschapselementen, of in combinatie met agroforestry-praktijken, zou dus mogelijk een evenwichtige en haalbare toekomstvisie kunnen

zijn. We hopen dat de resultaten van deze studie kunnen bijdragen aan de discussie over duurzame vormen van landgebruik. KOH kan hierbij worden beschouwd als een alternatieve praktijk, zowel als een bron van bio-energie als voor de aanvullende ecosysteemdiensten die het te bieden heeft.

Policy recommendations

This report confirms that, should policy want to increase the amount of woody biomass for the domestic bioeconomy, SRC provides a potential resource. SRC also provides a range of important ecosystem services other than biomass production, and could increase the (bio)diversity of the landscape.

Large scale implementation of intensive SRC directly competes with food production. In our current agricultural system this is undesirable. A potential increase of intensive forms of SRC should be coupled with shifting agricultural production and dietary patterns towards being in line with the carrying capacity of the planet and the Belgian ecosystems. This is necessary to avoid tele-coupling effects where more food with a potentially higher ecological footprint would be imported to compensate for the reduction in available farmland in Belgium.

Small scale implementation and extensive forms of SRC compete less with food production while still providing increased ecosystem services. Integrating SRC on farms as linear or patchy elements can be even beneficial for agriculture by providing pollination services, erosion control. Moreover, the buffer capacity of SRC lessens the environmental impact of agriculture on nearby natural ecosystems. Should policy want to increase biomass production while simultaneously increasing the nature value, nature connectivity and the resilience of the agricultural landscape, while minimising the land taken out of agricultural production, linear SRC provides the best option.

Please refer to the report Desair *et al.* (2022) for policy recommendations related to existing legislation and regulations concerning short rotation coppice (SRC) in Belgium. The report also contains recommendations on removing existing barriers and measures to ensure the potential expansion of SRC does not induce negative ecological, social or economic effects.

Please refer to the report Desair *et al.* (2024) for policy recommendations on how to best integrate different forms of SRC into different farm types as to maximise the private and public benefits and minimise the trade-offs.

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List of abbreviations

ES	Ecosystem services
NVE	Nature Value Explorer
SCEN 0	Scenario 0 - Baseline - current situation SRC
SCEN 1	Scenario 1 - SRC as small landscape elements
SCEN 2	Scenario 2 - SRC as agroforestry
SCEN 3	Scenario 3 - SRC as intensive cultivation
SLE	Small landscape elements
SRC	Short rotation coppice

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1 INTRODUCTION

Short rotation coppice (SRC) is an agricultural crop of which the entire above-ground biomass of fast-growing tree species such as poplar or willow is harvested every two to eight years. Short rotation coppice is a promising woody biomass production system as it limits the pressure on forests and can fit into farm management (Desair et al., 2022). There are many forms of short rotation coppice, from rows of pollard trees to coppice forests, small-scale extensive SRC to more intensive SRC with variations in rotation frequencies. These SRC types differ strongly in required technology, functionalities, cultivars and yielded biomass. For a detailed description of different types of SRC in Belgium, please refer to the report of Desair et al. (2024). For the modelling of ecosystem services in this study, a 'classic' form of SRC is used, with poplar or willow cultivars planted with a density of 12.000 cuttings per hectare and harvested every three to five years with no use of pesticides and limited fertilising. However, a clear distinction between extensive and intensive forms of SRC will be made for the different scenarios.

Short rotation coppice and woody biomass in general is featured across various European Union policies, including the new Common Agricultural Policy (CAP 2023-2027), the Renewable Energy Directive (RED, 2023), and the EU Biodiversity Strategy for 2030. In the new CAP (2023-2027) in Flanders, SRC is integrated into agro-environmental-climate measures[1] under the category of perennial crops with environmental and biodiversity benefits or that are climate change resistant. The EU Biodiversity Strategy for 2030 includes a target of 10% of high diversity landscape features in the agricultural landscape, for which SRC could be applicable. The RED sets targets for increasing the share of renewable energy in the EU's energy mix, with a dedicated role for woody biomass, especially those that do not compete with material use (EU DIRECTIVE, 2023).

In this policy context, this study wants to explore the potential for the cultivation of short rotation coppice in Belgium, for the production of woody biomass. Is there a potential future for short rotation coppice in Belgium and can it play a role in our landscapes? A spatial trade-off analysis, looking at the effects on ecosystem services, biodiversity and landscape, will help answer these questions. This is done by calculating and visually displaying the ecosystem services provided by short rotation coppice, for different scenarios, varying in cultivation intensity and spatial expansion. By comparing these SRC-scenarios, insights can be gained on feasibility and socio-economic limitations. It is important to note that all scenarios and ecosystem services described in this study are *potential* scenarios and *potential* ecosystem services, meaning that caution should be exercised when interpreting the results. These are exploratory scenarios with the goal to gain a better understanding, and under no circumstances should these scenarios be interpreted as real-life situations.

[1] Agro-environmental-climate measures: sowing perennial environmental, biodiversity-friendly or climate-resilient crops. Source: https://lv.vlaanderen.be/steun/perceelsgebonden-steun/perceelsgebonden-ecoregelingen-en-agromilieuklimaatmaatregelen-9

2 Methods

2.1 Workflow

Spatially data-driven research for the Belgian territory has its own particular challenges: spatial datasets are developed and managed on two sides of the language border, and therefore not compatible in most cases. Due to these major differences between Flemish and Walloon datasets, a separate approach is applied for Flanders and Wallonia. The general workflow is however the same and summarised in figure 1. The most recent land use maps[2] form the starting point of the workflow. The current situation of short rotation coppice (parcels declared as SRC on the agricultural use parcels dataset of the same year) is added to the land use map to create the baseline situation (scenario 0). Based on a series of restrictions, an SRC-restriction map is created. Locations with no restrictions serve as search zones for SRC and are used to create the extensive scenario 1 and intensive scenario 3. For each of these scenarios, potential areas and ecosystem services are calculated. The calculation of ecosystem services is entirely based on existing models, in particular the Gobelin model and toolbox (Smets & Stevens, 2019). Scenario 2 on agroforestry is not spatially modelled and follows a qualitative approach. More details on the restriction map, the different scenarios and ecosystem service modelling are provided further in the report.

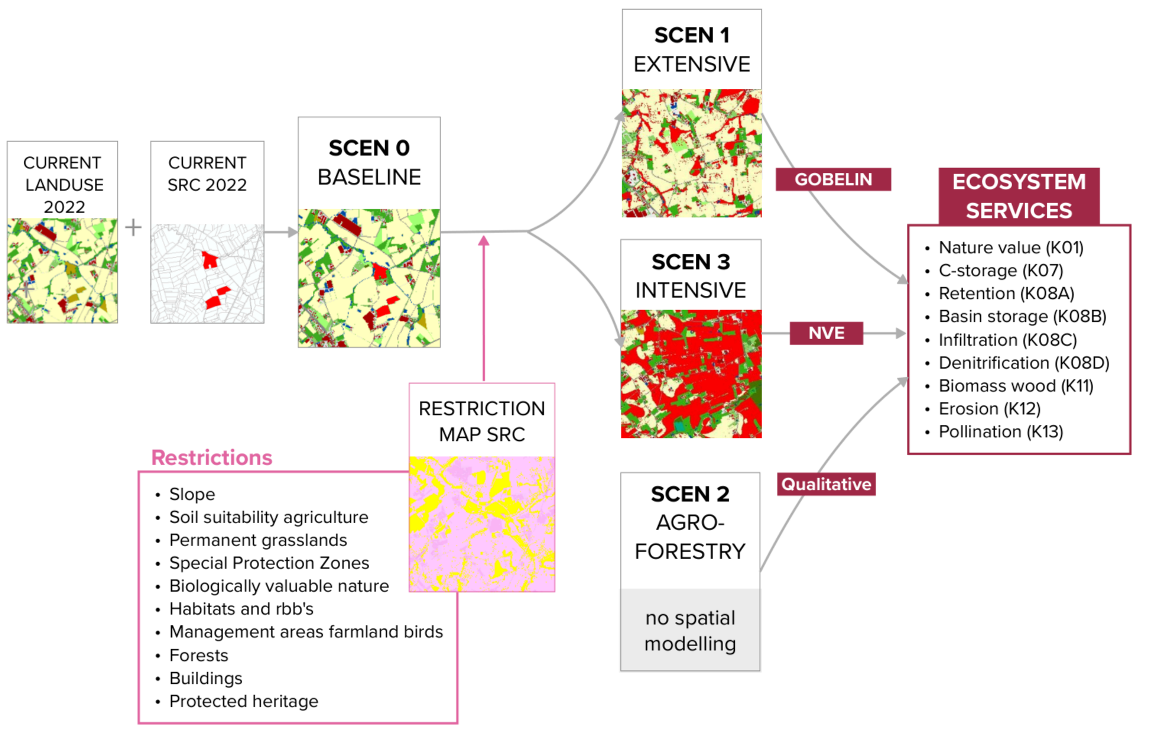

Figure 1: Workflow of the AD-LIBIO project

[2] Most recent version of the land use map available for this study: land use 2022 for Flanders, land use 2021 for Wallonia.

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2.2 INTERVIEWS

During the course of the AD-LIBIO project, a series of in person interviews were conducted with farmers who grow short rotation coppice in Belgium. The goal of these interviews was to get a better understanding of the actual situation of the cultivation of short rotation coppice on the ground. The interviews provided information on the different forms of short rotation coppice, benefits and trade-offs of SRC, and challenges concerning the planting and management of SRC. The interviews allowed us to develop and refine the different storylines and scenarios (see § 2.4) used in this study. They also provided a grounding for the level of delivery of ecosystem services by SRC. More details on the interview results, including policy recommendations can be found in the AD-LIBIO report of Desair et al. (2024).

2.3 RESTRICTIONS

In a densely populated area such as Belgium, open space is under pressure due to many different demands and expectations of multiple stakeholders. As a consequence, the actual conversion of an existing land use to short rotation coppice, will not be feasible, nor desirable in a lot of places. A series of existing restrictions will have to be taken into account (see § 3.1 for the full list of restrictions). These restrictions were made spatially explicit, by conducting a raster analysis in GIS. For each restriction, a separate spatial data layer is available. All these layers were combined into a 'SRC restriction map', showing areas where conversion to SRC is not possible due to one or more restrictions. The different datalayers, selection queries and raster calculations to build the SRC restriction map are available as an ArcGIS Toolbox-model and part of the AD-LIBIO-model (see Annex 1).

2.4 STORYLINES & SCENARIOS

The INBO report of Stevens et al. (2018) *'Nature Outlook 2050 - Inspiration for the nature of the future'*, mentions six major challenges for 2050 (selected with a broad group of stakeholders and experts). The sustainable use of resources is mentioned as one of the six challenges, with an important focus on producing enough biomass as a source of renewable energy and resource for the bioeconomy. The report explores four different paths (viewpoints) for the development of green infrastructure that could respond to these challenges, and what this green infrastructure might look like in 2050. The four viewpoints on nature and society served as inspiration for a number of storylines and scenarios where we consider short rotation coppice as a possible form of green infrastructure for biomass production. The storylines and scenarios were presented to various experts to collect their feedback.

The different **storylines** that are taken into account for the scenario calculations are described in chapter 3. However, it is important to note that there exists a significant divergence of opinion on how to treat biomass within the EU policy. On the one hand, there are stakeholders wanting to turn to biomass as a source of energy. On the other hand there are stakeholders wanting to further develop alternative sustainable and renewable energy sources first (like solar, wind, hydro), before turning to biomass (Andersen *et al.*, s.d.). Keeping this divergence of opinion in mind, the storylines and scenarios used in this study will focus on the possibility to use produce biomass from short rotation coppice regardless of its application.

To explore the potential of SRC in Belgium, including the ecosystem services SRC has to offer, the storylines are translated into a number of different **spatial scenarios**. The current situation of SRC in Belgium serves as a baseline (scenario 0), to compare results of the following 3 scenarios:

1) **SRC extensive**: SRC is planted as small landscape elements (scenario 1)
2) **SRC agroforestry**: SRC is integrated into agroforestry practices (scenario 2)
3) **SRC intensive**: SRC is planted as an intensive cultivation (scenario 3)

Figure 2 gives a visual impression of these 3 scenarios, increasing in intensity from left to right. More details on the different scenarios, including the underlying storylines and spatial translations are given in the dedicated sub-chapters of chapter 3.

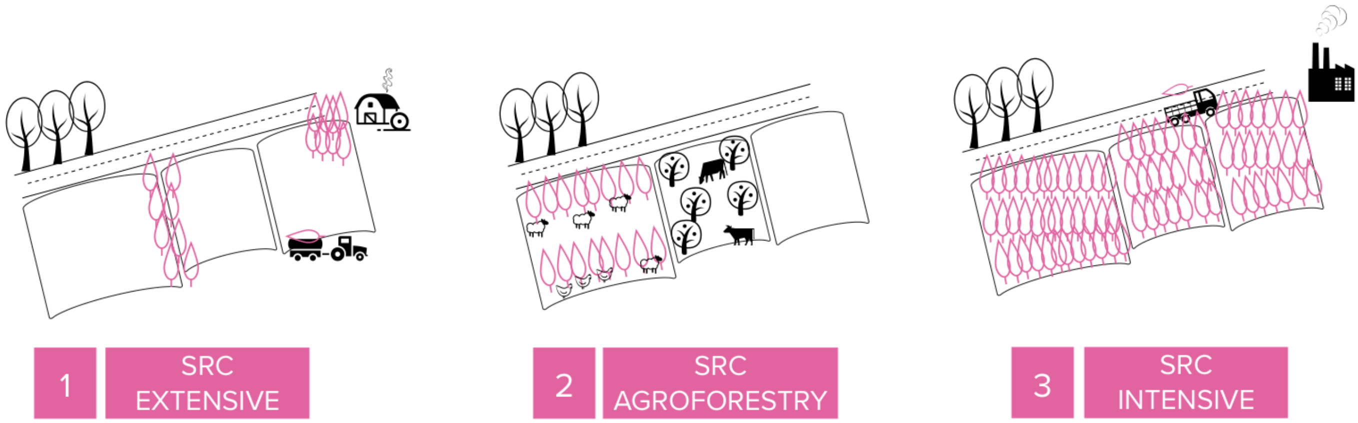

Figure 2: Visual impression of the 3 SRC scenarios used in this study.

2.5 Modelling ecosystem services

The different scenarios described above will be used to model ecosystem services on two scales, both regional (Flanders and Wallonia) and local. We will make use of existing ecosystem services models, namely the Gobelin-toolbox (fit for the regional scale) and the Nature Value Explorer (fit for the local scale). The different model approaches for the regional and local scale are described below, but it is important to note that not all SRC-scenarios will be modelled.

The regional Gobelin-toolbox will be used to model ES of the baseline (SCEN0) and the SRC intensive scenario (SCEN3), as it is possible to make these SRC-scenarios spatially explicit for the regional scale. The local Nature Value Explorer will be used to model ES for the SRC extensive scenario (SCEN1), as the location of small landscape elements is expressed as percentages of parcels, and not made spatially explicit, which makes it impossible to use the Gobelin-toolbox. At the local scale however, the Nature Value Explorer allows the evaluation of changes in ecosystem services when adding small landscape elements within a designated

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area. The SRC intensive scenario (SCEN3) is also evaluated with the Nature Value Explorer to be able to compare the results with the extensive scenario (SCEN1). When using the Nature Value Explorer to evaluate SCEN1 and SCEN3 on a local scale, the reference situation is always the current land use (SCEN0). The SRC agroforestry scenario (SCEN2) will not be modelled due to the high variety of possibilities when integrating SRC in agroforestry systems and the challenge to make this scenario spatially explicit. This is further explained below and in chapter 3 - Results.

2.5.1 Modelling ecosystem services on regional scale

Ecosystem services (ES) refer to the various benefits that humans obtain from the natural environment (Costanza *et al.*, 1997). These services provide a wide range of goods and services that contribute to economic, social, and cultural development and ultimately human wellbeing and quality of life. Ecosystem services are usually categorised into the following groups: provisioning services (eg. tangible products like timber), regulating services (eg. climate regulation), cultural services and supporting services (supports other ecosystem services) (Millennium Ecosystem Assessment (Program), 2005).

To evaluate the potential of short rotation coppice in Belgium, we will calculate the ecosystem services it provides for different scenarios. Changing current land use to short rotation coppice will translate into an altered delivery of ecosystem services.

The Gobelin project on 'green-blue networks' in Flanders developed a method for mapping and monitoring green-blue networks at Flemish scale. A set of spatial indicators, closely linked to the concept of ecosystem services, was developed and calculated as a map in ArcGIS. The calculations are based on a detailed land use map of Flanders (10x10m), and making use of existing ecosystem services models, such as ECOPLAN and Natuurwaardeverkenner (or Nature Value Explorer) (Hendrix *et al.*, 2018; Liekens *et al.*, 2018; Vrebos *et al.*, 2017). For Flanders, the Gobelin model is used to calculate ecosystem services. Although existing models are used, a series of adaptations had to be made due to updated datafiles (e.g. a new version of the land use map using different land use classes like the introduction of temporary grassland), and adding a new land use class for short rotation coppice. The Gobelin-model uses a base table with scores for each ecosystem service (see Annex 2 ES Scores), thus this table had to be updated for short rotation coppice. More details on the adapted Gobelin model, now called the AD-LIBIO model, can be found in Annex 1.

Ecosystem services are calculated separately, but all these different ecosystem services of SRC can be combined into one single map (per scenario), indicating where SRC could potentially contribute to many or few intended functions. These ES hotspot maps can illustrate the multifunctionality of the conversion to SRC (with the important remark that little multifunctionality is not necessarily less valuable than high multifunctionality as it might contribute to one very important function).

For a detailed overview and discussion of ecosystem services, disservices and mixed services to which SRC potentially can contribute, we refer to the first AD-LIBIO report by Desair et al. 2022 (table 4.1). The table shows services and disservices provided by SRC for the following categories: soil quality, above-ground biodiversity, water cycle, agriculture and living environment. In this study, the following ecosystem services will be modelled for short rotation coppice: nature value, carbon storage, water retention, basin storage, infiltration, denitrification, biomass wood, erosion control and pollination. All these ES for SRC are described in the following paragraphs, including how these ES are calculated and which adaptations or new information was necessary for SRC, based on expert input and validation. The ES descriptions are based on the Gobelin report and kept brief. For more technical details we refer to the report by (Smets & Stevens, 2019).

Unfortunately it is not possible to use the Gobelin-toolbox outside of the Flemish context. The datalayers that are needed to feed the models are not available in Wallonia. This means that the calculation of the changes in ecosystem services are only calculated for Flanders. Based on the outcomes for Flanders and taking into account the different land use changes, an estimate of the direction of change for different ES will be done for Wallonia.

Figure 3 provides a summary of potential ecosystem services of short rotation coppice, emphasising the importance of the landscape. In homogeneous landscapes, short rotation coppice can potentially contribute to certain ecosystem services. In diverse, heterogeneous landscapes however, some forms of short rotation coppice might reduce certain ecosystem services.

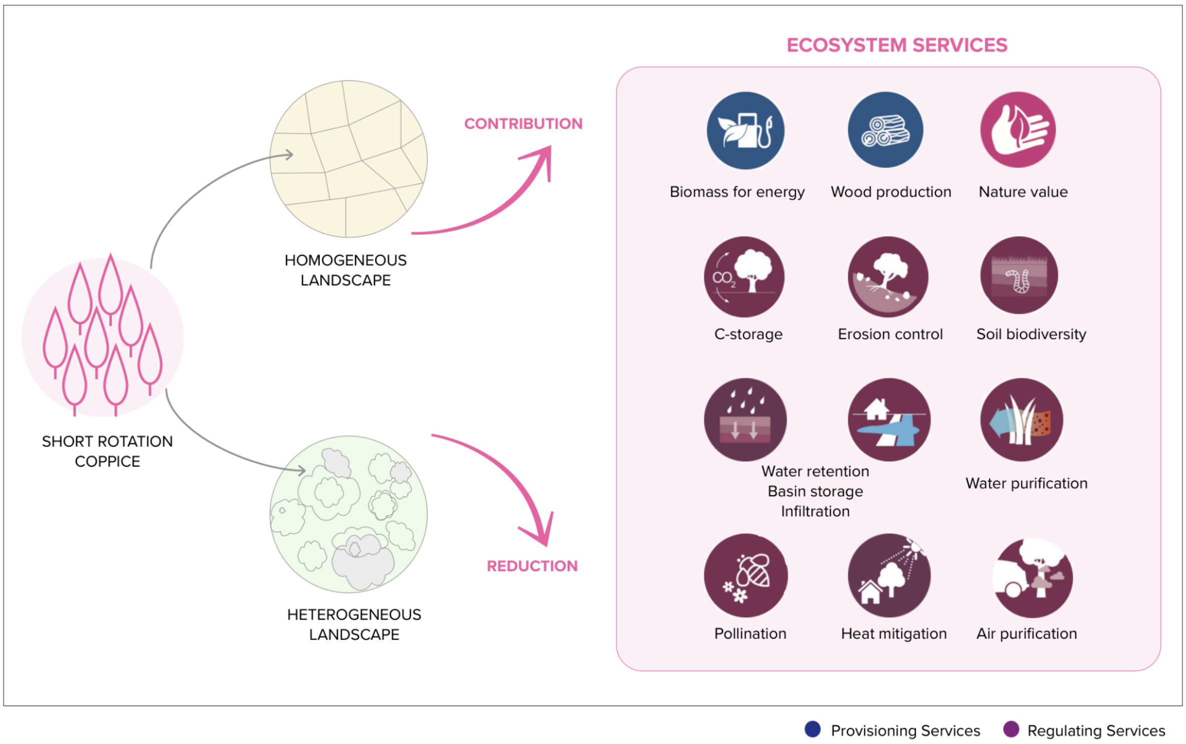

Figure 3: Contribution or reduction of ecosystem services due to planting of SRC in homogeneous or heterogeneous landscapes (based on the graphical abstract from 'Biodiversity in short-rotation coppice' by Vanbeveren and Ceulemans, 2019 and Natuurrapport, Stevens et al. 2014).

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Nature value

This ecosystem service does not reflect the state of nature as such, but rather the main aspects that affect the nature value of a green-blue network, namely:

- **quality**: expressed in terms of biodiversity value of the ecosystem (natural ecosystems score higher than human-influenced systems, old forests score higher than young forests)
- **area**: larger continuous areas score higher (these can host larger populations and are better buffered)
- **spatial cohesion**: functional connectivity between ecosystems increases exchange of species and genes, enhancing biodiversity at the landscape scale.

In the ES-model for nature value, the "Bio_resistance"-table was updated with a new land use class for SRC and adjusted resistance values (more details in Annex 2 ES Scores). This resistance value is assessed for a number of ecoprofiles: forest species, mire/fen/bog species, grassland species and heathland species. The value represents the movement cost for an ecoprofile to travel through a certain land use type, calculated as 1000m/x with x being the indication of difficulty to cross a certain land use. A species of a forest ecoprofile, for example, has no movement cost to travel through forests, but a high movement cost to travel through agricultural land. SRC was scored the same as a 'new plantation' for the movement costs of the different ecoprofiles, as defined by Catchpole (2006).

The land use map was used as the base layer for this ecosystem service: changes in land use or land use management and changes in the spatial cohesion of the network are reflected in the indicator. For more information on the methodology and other spatial layers used for further refinement, we refer to the Gobelin report (Smets & Stevens, 2019).

Carbon storage

This indicator reflects climate change mitigation through reducing carbon dioxide in the atmosphere by sequestering carbon in soils. Carbon storage in vegetation and the litter layer are not taken into account.

The multiple regression model of (Meersmans *et al.*, 2008)[3] is used for this indicator. The amount of organic carbon in soil in Flanders varies as a function of:

- **land use**: land use changes have an impact on the content of organic matter in soil. The land use map is used as a base layer and the regression model works with 4 categories: forest, grassland, farmland or heathland. SRC is assigned to the 'forest' category, but there are some caveats, such as the age of the SRC stock. During the first year of the SRC installation, there is a sparse cover that does not yet match mature forest. Harvesting cycles also play a role: only after the first harvest, there is a massive amount of shoots, creating a dense structure closer to forest. When harvesting SRC and

[3] Meersmans' research has since been partially outdated. The correction factors used related to Walkley & Black's method (Walkley & Black, 1934). With the current C-analyses and Monitoring of soil carbon stocks in Flanders (Cmon project), such correction factors have become redundant.

possibly removing or ploughing the stumps, the C-storage drops. The actual C-storage of SRC will therefore be lower compared to mature forest.

- **soil texture**: percentage of sand, loam and clay and geometric mean grain size (Dg) per texture class plays a role in the regression model.
- **groundwater level**: mean lowest groundwater level and mean highest groundwater level are calculated from the soil map (drainage classes).

Details on the calculation of the total potential soil carbon stock to a depth of 1m for the four land-use classes, are described in the Gobelin report. It concerns regression equations as a function of mean groundwater levels, geometric mean grain size and additional correction factors.

Temporary water retention

Temporary water retention is the capacity to buffer water between periods of high and low precipitation. The retention capacity is the difference between the average highest and lowest groundwater level. The formula for calculating seasonal retention comes from the ECOPLAN model (Vrebos *et al.*, 2017). The result is then multiplied by the retention coefficient of the land use class to help capture the impact of land use. For this, each class from the land use map (including the additional class for SRC) receives a score interpreted as avoided run-off of the land use class. These scores are taken from the Nature Value Explorer for the Urban Environment (Hendrix *et al.*, 2018). The land-use class SRC receives the same score for avoided run-off as the class 'poplars'.

Basin storage

'Basin storage' is interpreted as the availability of an area for water storage to avoid flooding in vulnerable areas. Potentially suitable floodplains are shown by assigning a score to all land use classes of the ADL base map, based on relocatability and combinability with flooding (e.g. buildings which are not relocatable, potential casualties or economic damage, nature value, tolerance to flooding).

Annex 2 shows the full list of land use classes with the corresponding suitability scores for flooding. The scores are based on the key figures used in Chapter 22 of the 2014 Nature Report (Schneiders *et al.*, 2014). Only those scores where there is a demand for flood protection are retained. This is done by taking into account the flood prone areas.

SRC has a relatively high tolerance for temporary flooding, and therefore received score 5 (vegetation adapted to flooding, no special nature value or high tolerance). This score is taken from NARA 2014 (Schneiders *et al.*, 2014). Poplar trees can endure flooding for several weeks during winter time. During the growing season, flooding can be tolerated only for a few days. Willows can support longer periods of flooding compared to popular trees (De Nocker *et al.*, 2007).

Water infiltration

This ecosystem service reflects the infiltration capacity of the soil to the deeper aquifers. The Gobelin-ES model bases this on the depth of the groundwater table and soil texture (Vrebos *et al.*, 2017). Corrections are made for losses due to interception of precipitation water by plants

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and to compaction tied to certain types of land use (Stevens *et al.*, 2018). For a detailed description of the spatial layers, key figures and conversion tables used in the model, please refer to §6.5 Water infiltration of the Gobelin report (Smets & Stevens, 2019).

For different forest types (deciduous forest, alluvial forest, poplars), the model operates with percentage losses of 56% due to interception and soil sealing. The same values are applied for the land-use class SRC.

Denitrification

This ecosystem service shows total nitrogen removal or denitrification. Denitrification occurs mainly in natural areas. The denitrification rate is largely determined by the water saturation of the top soil layer (calculated from the average highest and average lowest groundwater levels).

The model-calculation starts with the map of the potential denitrification rate according to the ECOPLAN method (www.ecosysteemdiensten.be). This map is then multiplied by the land use. The natural classes (the first 10 classes in appendix 2) from the ADL base map (land use) receive score 1, the other classes receive score 0.

The land-use class SRC receives score 1 because it has very little to no nitrogen oxide emissions, even when occasionally fertilised (Hangs *et al.*, 2014). In principle, SRC is rarely fertilised. Only in the most industrial, intensive forms of SRC, this might be the case in the first year after establishment or harvest (Desair et al. 2024).

Biomass wood

Biomass from wood production can be used for multiple purposes, such as manufacturing products and generating energy. Depending on the use, this captures carbon for a short time (when immediately burned) or a long time (when used for building materials).

The ES-model for biomass production multiplies the annual increment (m^3/ha - spill wood = stem and thick branches) by a biomass expansion factor (dimensionless - to include small branches and roots in addition to spill wood) and by a conversion factor (kg DM/m^3 - to convert biomass to dry matter). The final result is thus expressed in kg DM per hectare.

The ES-model calculates the annual increment of spill wood as a function of vegetation type and soil suitability (method from the Nature Report 2016, Van Reeth *et al.*, 2016). Each vegetation type receives an increment score depending on its physical suitability (different combinations of soil texture and drainage classes). The distinguished vegetation types are coniferous forest, deciduous forest and poplar. For SRC, new increment scores were assigned for the different combinations of texture classes and drainage classes (see Table 1). This information was obtained through Michael Weitz, managing director at Lignovis, a German agroforestry company (www.lignovis.com) with vast experience of growing SRC. The yields are expressed in m^3 wood/ha per year, though it should be noted that the SRC for which these yields are expressed are harvested every couple of years rather than yearly.

Table 1: SRC yield rates (m³/ha per year) for different combinations of texture and drainage classes.

Short rotation coppice			Drainage class			
			very dry	**dry**	**wet**	**very - extremely wet**
			(a) very dry	(b) dry (c) moderately dry	(d) moderately wet (e) wet (h) wet soils with relatively high elevation	(f) very wet soils (g) extremely wet soils (i) very wet soils with relatively high elevation
Texture	Z/V/X	sand/peat/dunes		8	15	10
	S/P	loamy sand/light sandy loam	8	14	22	14
	A/L/M/G	loam/sand loam/marl/	10	20	30	20
	E/U	clay/heavy clay	8	18	26	16

On heavier soils, there is a higher accretion of SRC, on lighter soils a lower accretion. On soils that are too dry (drainage class a) it is not possible to grow SRC. These growth rates are averages over the total growth period. In the case of SRC, the increment rate will be immediately higher in the first years, but the biomass will also be harvested faster. At the end of the rotation, the growth of SRC will decrease.

The increment scores of conifer, deciduous forest and poplar are multiplied by a species-specific biomass expansion factor (BEF), to account for the total biomass, including top wood and roots, in addition to the spindle wood. Species specific density data are also taken into account (for more details see Gobelin report). For SRC, the values of poplar were taken. A SRC system has more roots compared to a classic forest image (50% of the biomass is above ground and 50% below ground) but in the increment scores all types of wood are already considered, therefore the aboveground BEF would be lower, avering this out to the same value as poplar.

Erosion control

Protection against soil erosion has multiple benefits such as maintaining fertile soil, reducing mudflows and reducing sediment supply to watercourses and sewers. The ES-model maps this ecosystem service by using the quantitative method of the Nature Value Explorer for rural environments (Liekens *et al.*, 2018). This involves calculating the difference between soil loss from an unvegetated soil and the soil loss from the current land use. This difference is a measure of avoided erosion. The details of this calculation, including the equation formula, key figures, conversion tables and base maps are explained in §6.3 erosion protection in the Gobelin report.

The land use type SRC gets assigned the same values as calculated for forests, as SRC also has a deep and intense root system, and can also be grown on slopes.

The most recent version of the land use map of Flanders (year 2022), uses a number of different land use classes. In most cases, it was possible to assign existing erosion scores to these classes (see ESs Scores in Annex 2). For the land use type 'temporary grassland', a new erosion score is calculated, based on expert judgement:

> In the formula explained below, the original erosion scores of grassland and farmland are used, as temporary grassland can be considered as grass during parts of the year, and more as a field crop during other parts of the year.

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The erosion score for temporary grassland depends heavily on the rotation. The aim is to determine the number of months that temporary grassland can be considered as a field crop or grass. The harvest time and sowing time of the field crop is relevant here, as well as the number of years of grass. For good results:

- temporary grass is best sown in September of the previous year so that there is already ground cover in January
- temporary grass is usually kept in rotation for 2 years (this can also be 1 or 4 years)
- the sowing of winter cereal after grass is best done in mid-Oct-mid-Nov, when the ground cover is 2.5 months less, equivalent to average field crops.

New formula to calculate the erosion factor: 21.5 x grass-score + 2.5 x field-score / (24)
Result: (21.5 x 10) + (2.5 x 500) / 24 = 61
For temporary grassland, a rounded score of 60 will be used as the erosion factor.

Pollination

This ecosystem service indicates the transfer of pollen by animal vectors, mainly by insects such as wild bees, bumblebees, butterflies, flies, and the like. For this purpose, the suitability of the landscape as a habitat for wild bees (based on nesting and feeding habitat) and the distance of that habitat from agricultural crops that depend on pollination for their fruiting are taken into account (adapted method Nature Report, Michels & Stevens, 2016).

Each land use class of the ADL base map is assigned an average score based on the food availability value and a nesting availability value, reflecting its suitability as foraging and nesting habitat for wild bees (see Annex 2). These values are based on Chapter 3 of the Nature Report (Michels & Stevens, 2016, Table 6), after translating the land use classes via a conversion table (see Appendix 1 in the Gobelin report, Smets & Stevens, 2019).

Poplar is a pure wind pollinator and this form of SRC is generally harvested before flowering (takes between 8 and 10 years). Willow, on the other hand, is a pure insect pollinator. For willows, it takes 4 to 6 years for the species to flower, and in general, you will find more insects in willows than in poplar trees. Mostly the trees are however harvested before they start to flower.

In terms of food value, SRC is assigned the same value as coniferous forest, because a flowering period with food value for bees is lacking. As for the nesting value, the value of deciduous forest can be adopted for SRC, as similar nesting opportunities occur at the base of the trunk.

Annex 1 gives an overview of the ES-models (of the Gobelin project), that were used in this study. The model names, a short description and more details on the input and output are given. All Gobelin models had to be adapted to take into account short rotation coppice. These adaptations are also described and further explained in the Annex 2 ES Scores.

2.5.2 Modelling ecosystem services on local scale

In 2012, VITO launched a web application to assess the ecosystem services on a local scale in Flanders. In 2018, this application was revised and introduced under the name of "Nature Value Explorer". After an update in 2021 the tool was also available for Wallonia. The tool allows us to assess the socio-economic impact of changes in land use, expressed in changes in delivery of ecosystem services. It enables to qualify the advantages or disadvantages of land use change, and to quantify and monetise some changes in ES.

Some of the ES models used in Gobelin are based on the models that are also used in the Nature Value Explorer. However, the Gobelin-toolbox uses a raster approach which limits its ability to make statements about ecosystem services at a very local scale. The Nature Value Explorer uses a polygon approach which allows the user to design specific localised measures. This approach makes it very suitable for assessing changes in ecosystem services on the local scale but makes it impossible to use on a regional scale or for a large number of changes in land use.

The Nature Value Explorer uses polygons that can be loaded or drawn to identify the land use changes or “measures''. Measures can for example include implementing deciduous or coniferous forests, heathlands, shrubs, orchards, small landscape elements, buildings, etc. Short rotation coppice is not yet a measure that can be implemented in the Nature Value Explorer. Therefore, the measures of implementing small landscape elements (hedgerows, woodlots, tree rows) and deciduous forests (poplar species) were investigated as a proxy. Small landscape elements often consist of different tree species but provide similar ecosystem services as short rotation coppice. Poplar groves are in terms of species composition very similar to the standard intensive short rotation coppice. This approach aligns with the report of Desair et al. (2024) which broadens the definition of short rotation coppice and describes 7 possible forms, one of which is SRC as hedgerow and one as a coppice forest.

The Nature Value explorer allows to assess changes in a wide range of ES. Here we focused on the ES of nature value, carbon storage, water infiltration, denitrification, wood production, erosion control, pollination and food production. This is in line with the ES assessed with the Gobelin model.

3 RESULTS - SCENARIOS

3.1 RESTRICTIONS FOR ALL SCENARIOS

The potential conversion to SCR will not be possible or desirable in many locations. When considering different scenarios where SRC can potentially be planted in Belgium, a number of constraints are taken into account. It concerns locations where short rotation coppice can not be planted due to technical, ethical or regulatory/legislative restrictions. The following restrictions apply to all scenarios:

- **Technical restriction related to slope**: when harvesting SRC, the use of machines is limited by the slope of the terrain, depending on soil and weather conditions (Aust *et al.*, 2014). Gradients of more than 10% can make use of machines more difficult, and it is therefore advised that the incline of the SRC plantation should not be more than approximately 20% (Becker & Wolf, 2009). The following slope suitability categories are considered for the scenarios: <10% (suitable), 10-20% (limited suitability), >20% (unsuitable). Annex 3 and 4 explain in detail which slope categories were selected as a restriction for SRC cultivation, both in Flanders and Wallonia. In the case of a more extensive SRC management (e.g. SRC as small landscape elements), the use of machines is less likely. Restrictions on slope will not be taken into account in this case.
- **Agricultural suitability:** to avoid competition with food and feed production, the establishment of potential SRC is only considered on soils with low suitability for agricultural crops. For Flanders, the Nature Report 'NARA-T' 2014 (Gossum & Danckaert, s.d.) conducted an evaluation of soil suitability for different crop groups (grassland, arable farming, maize, vegetables and fruit), which led to a series of agricultural suitability maps. The production potential (yield) of different soil types was estimated. Locations that are very suitable and suitable are excluded for potential SRC locations, and this for all crop groups except grassland and maize. Maize, as an important livestock feed crop and species-poor temporary grasslands under intensive use are not considered as a restriction for the potential of SRC. Permanent grasslands will be excluded, as further explained below. Annex 5 provides more details on these agricultural suitability maps and the selection of the excluded agricultural areas. For Wallonia, the exclusion was based on the suitabilities defined in Morelle & Lejeune (2000).
- **Historically permanent grasslands**: due to the high landscape-ecological value, high biodiversity and protection status of permanent grasslands in Flanders and Wallonia, these areas will be excluded from the SRC scenario calculations. The EU Directive on the promotion of the use of energy from renewable sources (2018/2001) also states that highly biodiverse grasslands should not be converted for biomass production.
- **Special Protection Zones**: special areas of conservation of the European Natura 2000 network are protected under the EU Habitat Directive. EU Directive 2018/2001 (Article 29 §3) also states that biomass cannot be made from raw material obtained from land areas with a high biodiversity value designated for nature protection purposes.

- **Flemish Ecological Network**: in areas that are part of the Flemish Ecological Network (VEN - Vlaams Ecologisch Netwerk) it is prohibited to change any form of vegetation, perennial crops or small landscape elements (subject to individual exemption).
- **Biologically valuable nature**: building on the previous EU Directive exclusions, SRC will also be excluded from areas with a high and very high biological value on the Biological valuation map (BVM).
- **Habitats and regionally important biotopes**: locations with the presence of protected habitat types (under the EU Habitat Directive) or regionally important biotopes, are excluded from the SRC scenarios.
- **Management areas for farmland bird species**: an intensive form of SRC (with fully covered large plots) is not advisable in core priority areas for open landscape farmland birds (and, by extension, for grey harrier and meadow birds). The structure, height and possible operations of all forms of SRC are unfavourable for these bird species. Farmland birds avoid structures and elements higher than around 2 metres, tolerating only a few small solitary or linear woody plants in their habitat. In addition to these priority core areas, search zones with potential as core areas are also excluded as a precautionary principle. Some forms of SRC may possibly add value for agricultural birds of semi-open landscape, especially as linear elements, if thoughtfully planned and with appropriate management. However, this needs further investigation (internal advice by Johannes Jansen (INBO)).
- **Forests**: as a principle, it is not desirable to transform existing mature forests into SRC. This would also not be in line with the EU forest strategy for 2023, aiming to protect, restore and enlarge the forests in the EU. Therefore all forest types mentioned on the land use map (deciduous, poplar, coniferous, alluvial and other forests) are excluded.
- **Buildings** and other forms of hard structures, including roads and railways are considered as restrictions, as well as **water** bodies and water elements. Urbanised land use like for example residential areas, private gardens, parks, cemeteries, golf courses are excluded. Multi-purpose land use like airports, recreational areas and industrial sites are excluded. All juridical destinations like sea ports and military domains are excluded.
- **Protected heritage:** when planting short rotation coppice, protected heritage should be taken into account in certain circumstances. Also from a cultural heritage perspective, it may or may not be desirable to plant short rotation coppice in open or closed landscapes. Annex 6 provides more information on how protected heritage was taken into account in the restriction map. It also elaborates on some rules of thumb that can be used as guidance on whether or not to plant short rotation coppice from a cultural historical point of view.

An overview of the spatial data files that were used in the SRC scenarios to determine potential SRC locations and the above-mentioned restrictions can be found in Annex 3 (Flanders) and Annex 4 (Wallonia). The annexes provide details on the data sources and the selection queries.

Restrictions that were not considered:

- **Abiotic restrictions**: SRC does not grow well in unfavourable abiotic conditions, expressed as soil suitability in this study (based on texture, drainage and profile). Data on the soil suitability of native trees and shrubs in Flanders is available via the online expert system BOBO+ (*BOdemgeschiktheid van BOmen en struiken in Vlaanderen*). BOBO+ is the successor of the computer programme BOBO v 1.1 (De Vos, 2000). It works with 5 suitability classes (from very suitable to unsuitable), for every plot in Flanders, based on available soil map information.

Comparison of the BOBO-data for poplar and willow with the soil map information available for SRC plots in Flanders, showed different results. One of the reasons might be that data for *native* species is compared to data for species used on SRC plots. The intersect of a cumulative SRC-file (the sum of all SRC plots in Flanders over the years 2008 - 2021, with a total of 699 plots) with the soil map of Flanders, showed a wide variety in both texture as well as drainage class (see Figure 4).

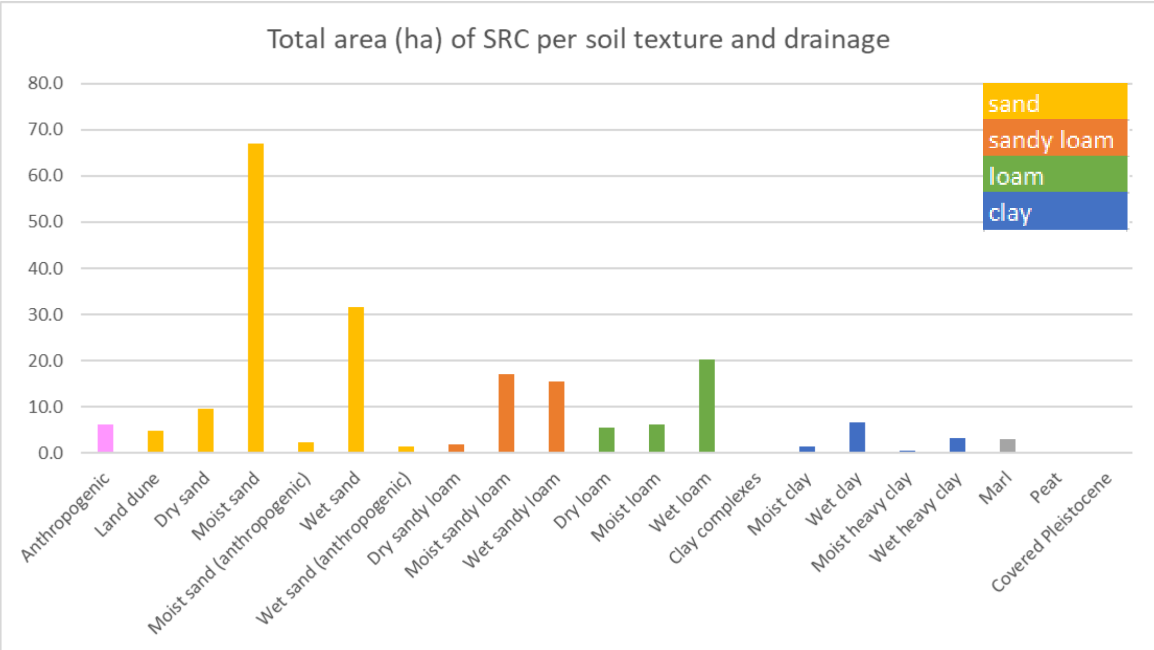

Figure 4: Total area (in hectares) of SRC for different texture and drainage classes.

Due to this variability, soil suitability based on texture, drainage and profile is not used as a restriction to determine search areas for SRC.

- **Parcels under nature management**: this concerns parcels under management of the “Agency for Nature and Forests (ANB)”, “Natuurpunt”, “Regional Landscapes” and others. We chose not to include this category as SRC does not necessarily stand in opposition with nature management. Both ANB and Regional Landscapes have shown interest in SRC in specific cases where it can provide a higher nature value than intensive agriculture. For example “Regional Landscapes” has a SRC case study within the land development project “Water-Land-Schap 1.0”, in the project area "De Laak, een vallei vol kansen" (Flemish Brabant).

3.1.1 Restriction map Flanders

Taking into account the above mentioned series of restrictions, a spatial analysis was conducted where these restrictions were selected from the various datasets, reclassified and merged into one raster, where each raster cell contains the total sum of restrictions. The restriction model (ArcGIS toolbox) including all data operations and data layers is available as an open dataset on Zenodo. The result is a **restriction map** (see Figure 5) showing areas with no restrictions (yellow zones on the map) and areas with one or more restrictions (pink zones on the map). The yellow zones are to be interpreted as **search areas for SRC**, or zones where SRC can *potentially* be planted. These search areas will serve as input for the scenario calculations, where further conditions will apply.

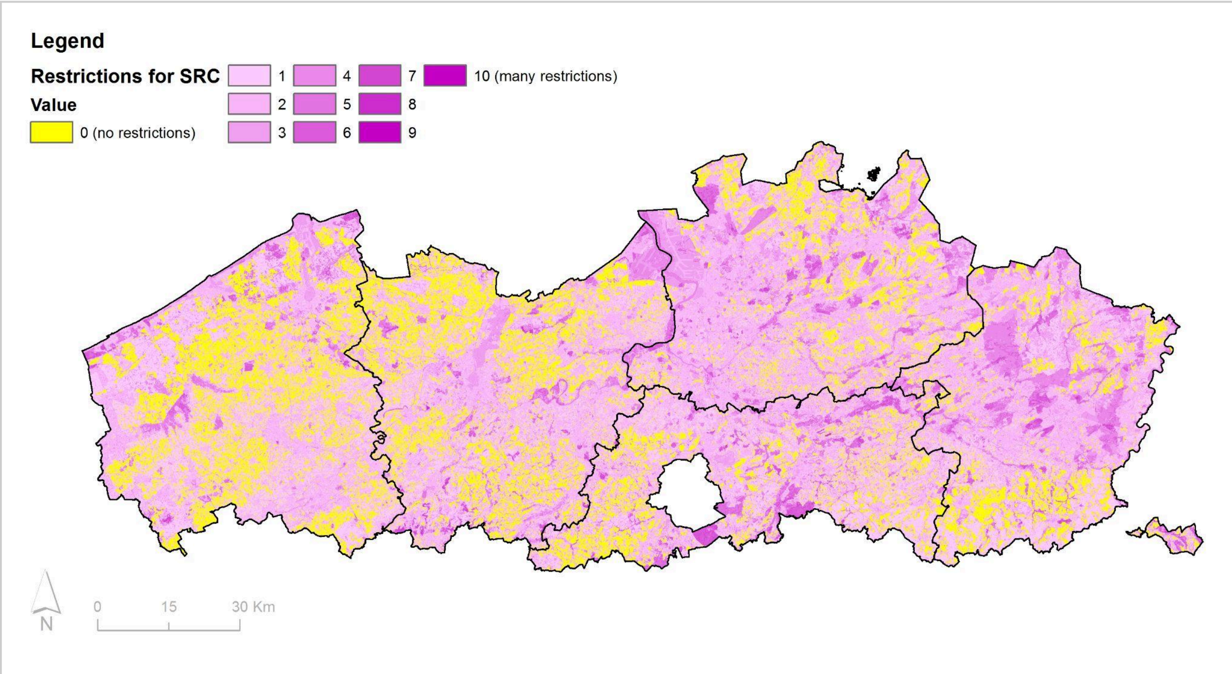

Figure 5: Restrictions (pink) and search areas (yellow) for SRC in Flanders.

These search areas for SRC in Flanders, have an area of around 273.700 ha. The remaining area with one or more restrictions is around 1.088.700 ha. Figure 6 shows the areas in ha for the number of restrictions for SRC in Flanders.

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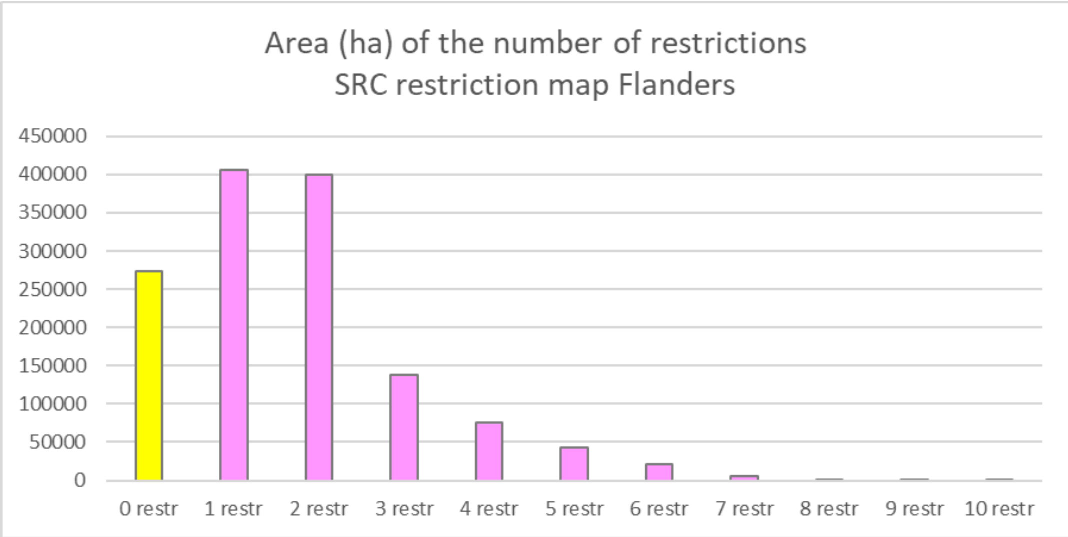

Figure 6: Area (ha) for the number of SRC restrictions ("0 restr" meaning no restrictions, and the other values showing the area for one or more restrictions on a certain location).

When comparing the search areas of SRC with the current land use map of 2022, the majority of these SRC search areas overlap with farmland (see Figure 7 below). The overlap with temporary or permanent grasslands is significantly lower.

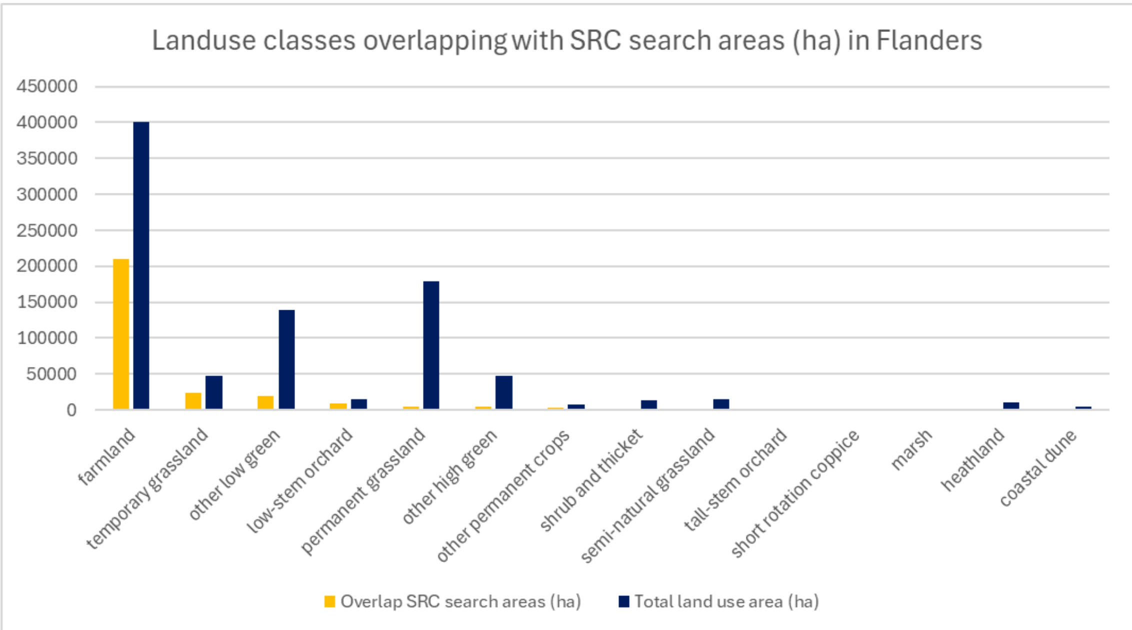

Figure 7: Area (ha) of current land use classes (2022) overlapping with SRC search areas in Flanders.

In total, about 30% of the current agricultural land overlaps with the search zones. Overlaying the search areas for SRC with the agricultural use parcels (status 2022), gives an idea of which crop groups would potentially be replaced. The figure below gives the areas in hectares per crop group, which overlap with search areas of SRC. Agricultural parcels with maize have the highest overlap with SRC search areas, followed by significantly lower overlap areas of grains, seeds and legumes, grassland and potatoes.

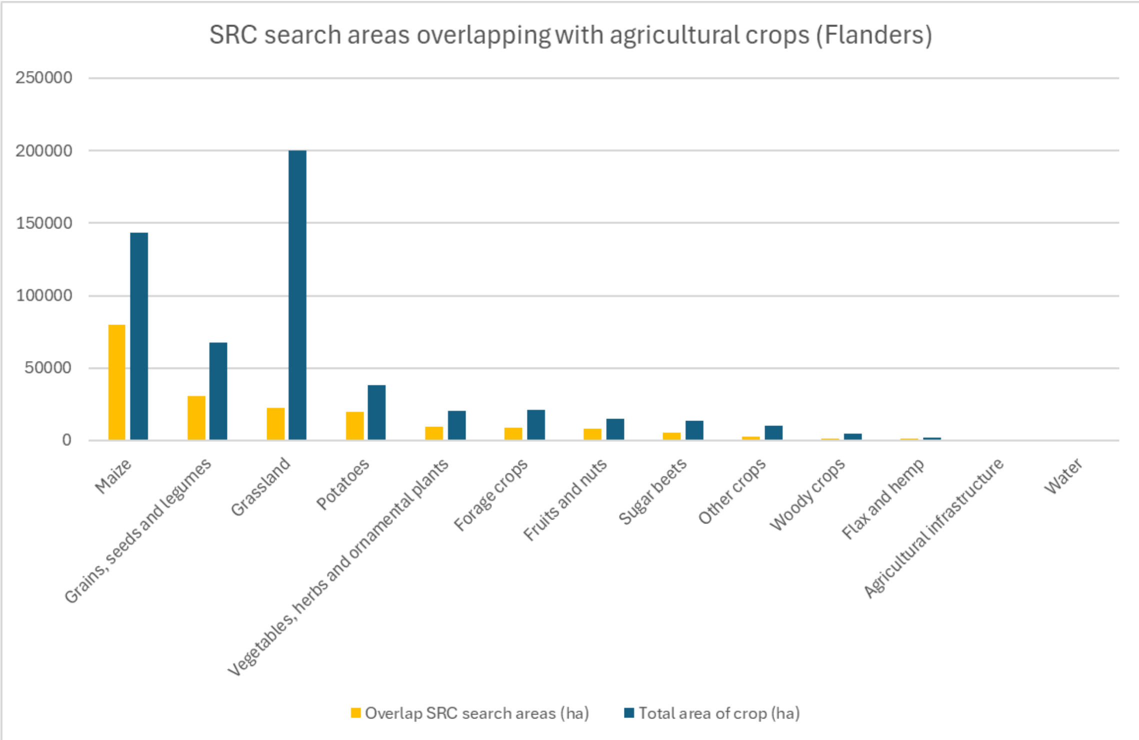

Figure 8: Area (ha) per crop group, of the SRC search areas overlapping with agricultural use parcels in Flanders.

3.1.2 Restriction map Wallonia

A restriction map for Wallonia was created, following a similar methodology as described for the restriction map of Flanders (see paragraph 3.1.1). The datasets used to create the restriction map for Wallonia are however different from the datasets used in Flanders (see the overview in Annex 4). The result is shown in Figure 9, with areas without restrictions for SRC in yellow and areas with one or more restrictions in pink.

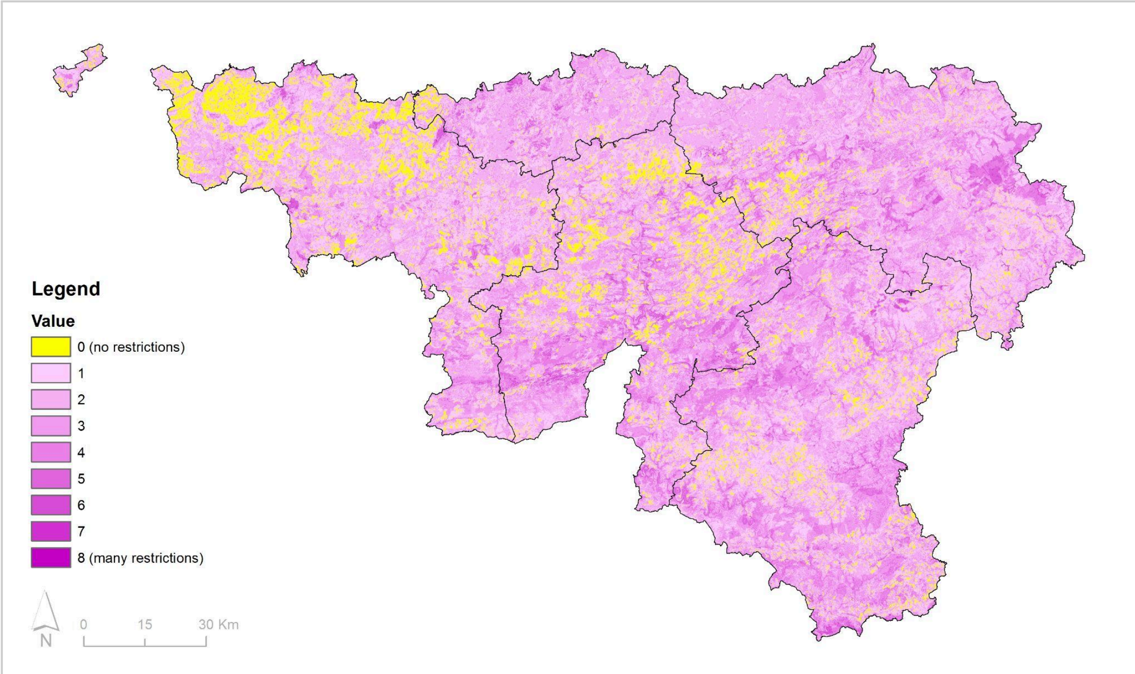

Figure 9: Restrictions (pink) and search areas (yellow) for SRC in Wallonia.

The search areas for SRC in Wallonia, have an area of around 139.334 ha. The remaining area with one or more restrictions is around 1.548.082 ha. Figure 10 shows the areas in ha for the number of restrictions for SRC in Wallonia.

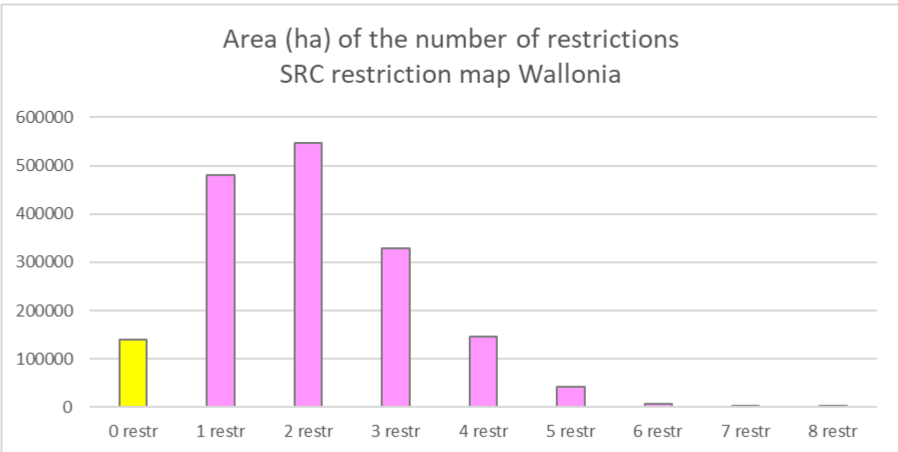

Figure 10: Area (ha) for the number of SRC restrictions ("0 restr" meaning no restrictions, and the other values showing the area for one or more restrictions on a certain location).

When comparing the SRC search areas with the land use map of Wallonia (2018), the majority of these SRC search areas overlap with agricultural land (see Figure 11). The overlap area is around 15% of the total agricultural area. The overlap with the remaining land use classes is significantly lower (around 1% or less of the total area of the land use class). The figure only shows the land use classes which have an overlap with the SRC search areas of minimum 10 ha.

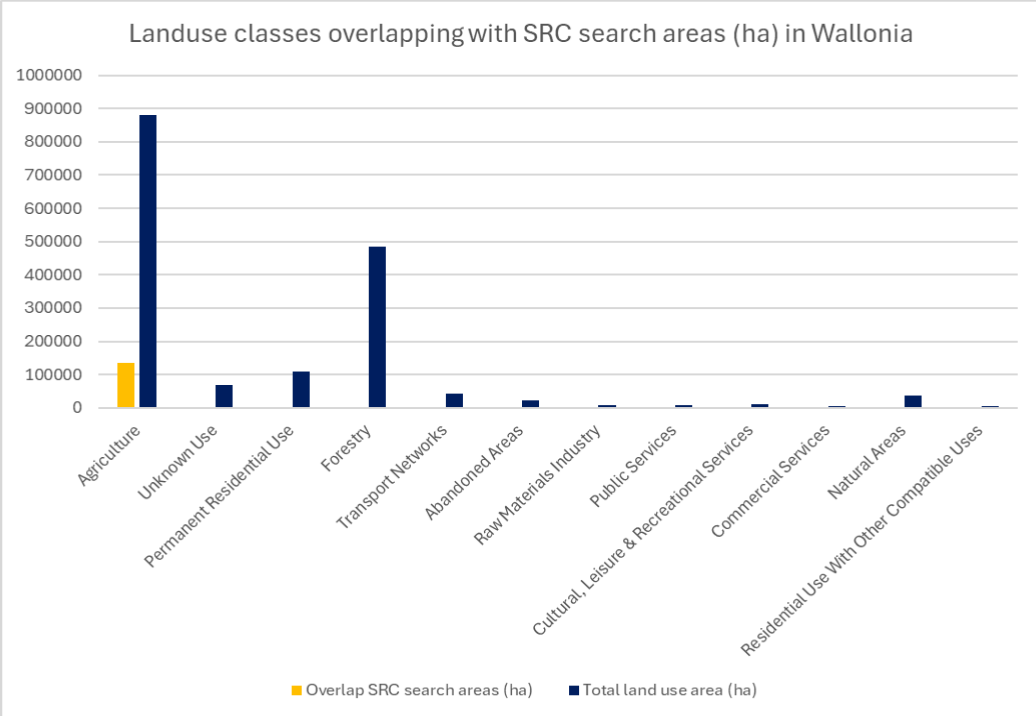

Figure 11: Area (ha) of land use classes (2018) overlapping with SRC search areas in Wallonia.

When overlaying the search areas for SRC with the agricultural use parcels of Wallonia (status 2021), the areas of overlap can be calculated per crop group. Figure 12 shows the areas in hectares per crop group, which overlap with search areas of SRC in Wallonia. Agricultural parcels with cereals and similar crops have the highest overlap with SRC search areas, followed by parcels for fodder production.

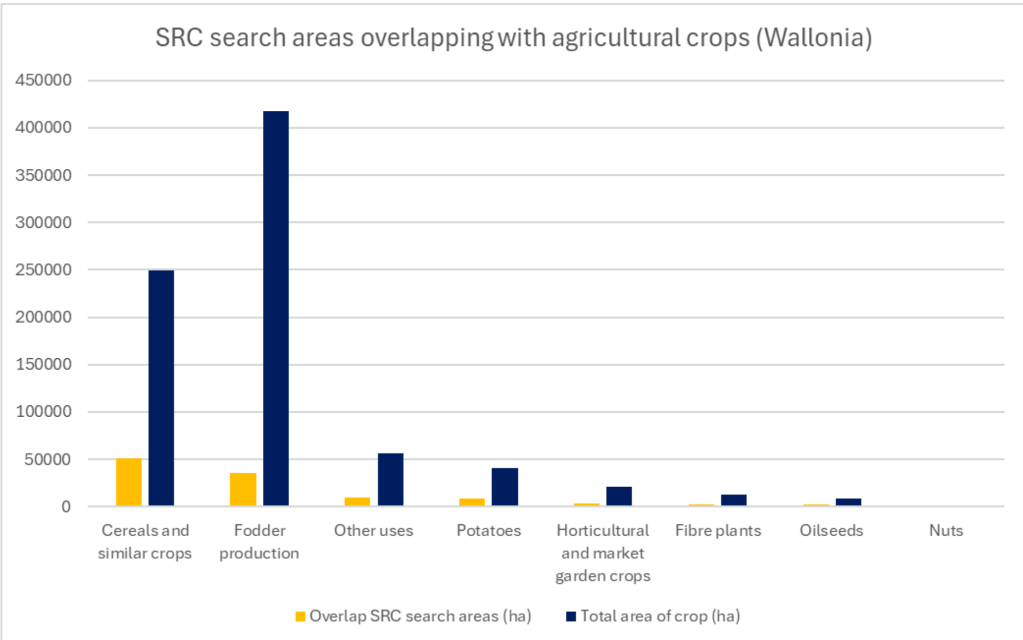

Figure 12: Area (ha) per crop group, of the SRC search areas overlapping with agricultural use parcels in Wallonia.

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3.2 Scenario 0 - Baseline - current situation SRC

3.2.1 Storyline

The **“current situation of short rotation coppice in Flanders”** is based on the inventory of agricultural parcels in the year 2022. It concerns a total of 57 parcels scattered around Flanders, with an area of 46 ha in total. Most of the parcels are smaller than one hectare, with the largest measuring approximately 9,5 ha. This ‘zero scenario’ serves as a baseline to compare to the other scenarios used in this study.

3.2.2 Spatial translation

The 57 SRC parcels of the "Agricultural use parcels" dataset (status 2022), are merged with the land use map (status 2022) to create a land use map with an extra class for SRC. This map is used as the ‘scenario 0’ input layer in the Gobelin model to calculate potential ecosystem services.

3.2.3 ES-model results Flanders

The potential ecosystem services are calculated at the Flemish scale. The small plots of short rotation coppice in the current situation are therefore almost negligible if one interprets the ES results at this Flemish scale. It is only when the results of the current situation (scenario 0) are compared with a more intensive scenario for short rotation coppice (scenario 3) that shifts in potential services can be identified. This will be covered in the discussion.

Figure 13 to Figure 21 show maps for each ecosystem service separately. The maps only show relative scores of the different ecosystem services. The calculated scores are qualitative and are rescaled at the end of each ES-model to scores between 0 and 5 (via equal interval). They show where land use can contribute a lot or a little to a specific ecosystem service compared to the rest of Flanders. They are therefore relative values.

The importance of these ecosystem services depends on context and scale, which is why interpretations at the local scale may differ from interpretations at the Flemish level. The ES calculations with the Gobelin model are only shown at the Flemish level, with no weighting or valuation of the importance of the different functions. For a more local analysis, please refer to the results of the Nature Value Explorer, where such valuations do form an important part.

Nature value

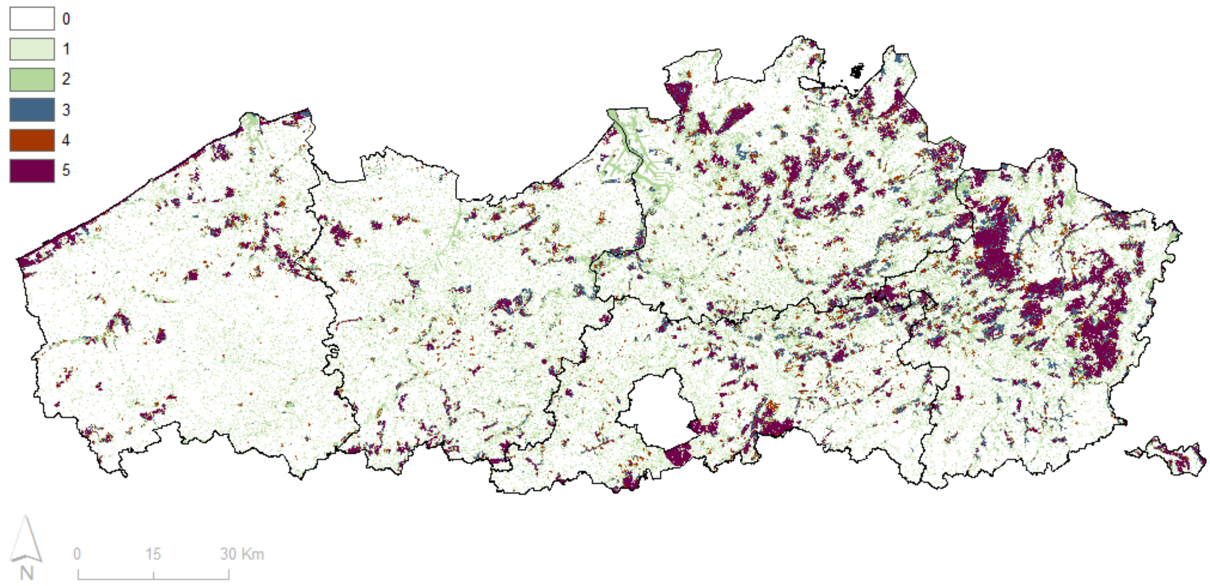

Figure 13: Nature value map (SCEN0). The scores are based on ecosystem quality, area of nature clusters and connectivity.

Carbon storage

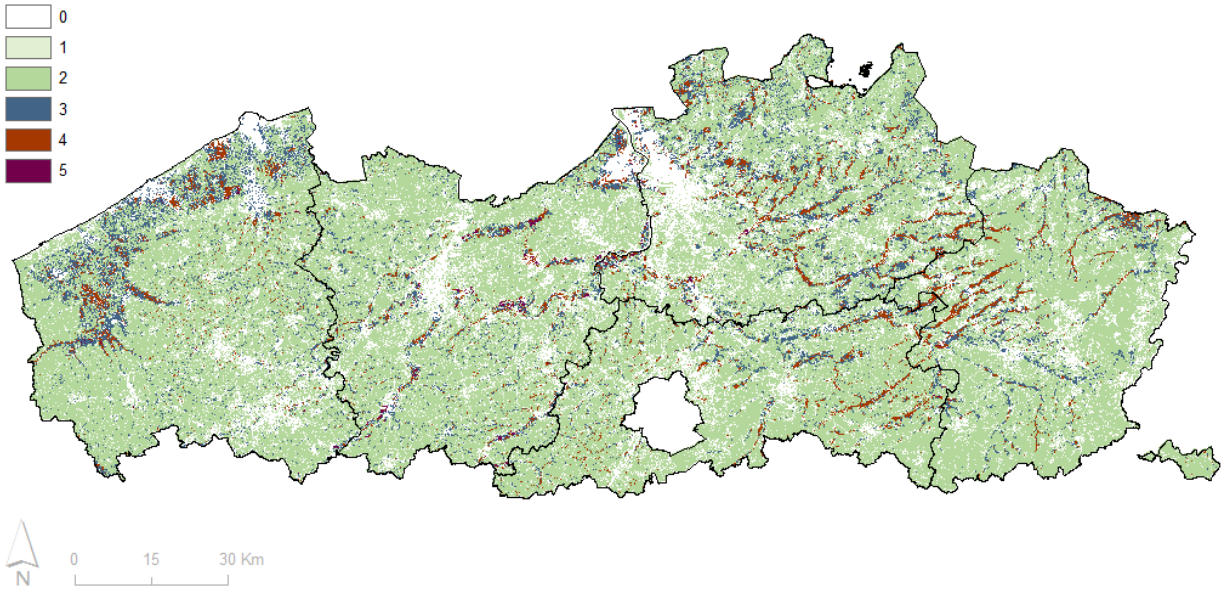

Figure 14: Potential soil carbon storage map (SCEN0). The score indicates the relative importance of an area as a function of the amount of soil carbon, based on land use, soil texture and groundwater level.

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Retention

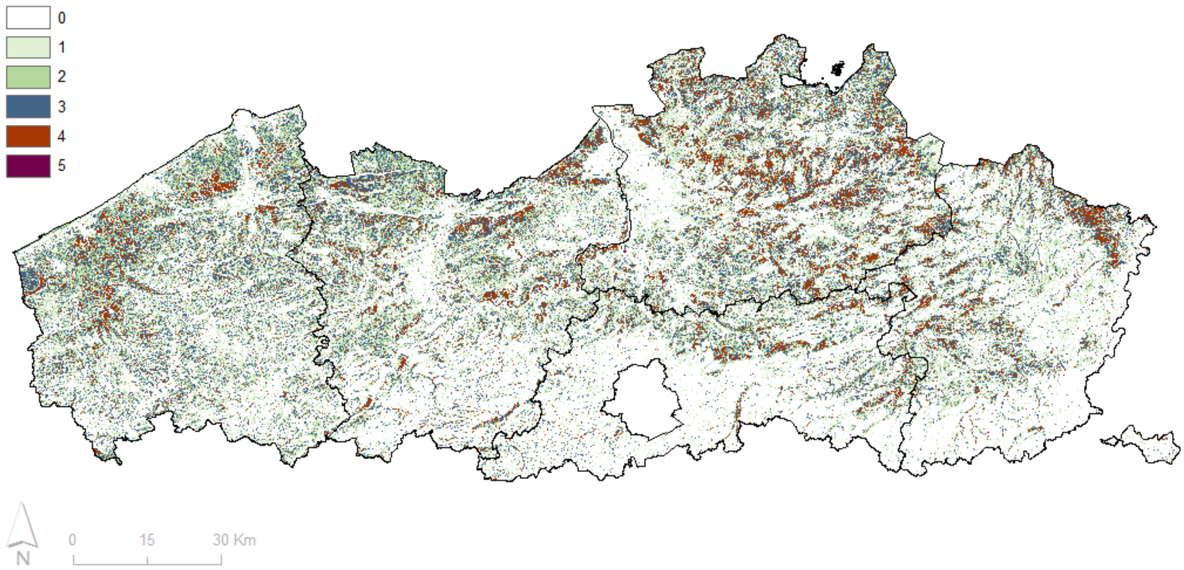

Figure 15: Temporary retention map (SCEN0). The score indicates the relative importance of an area as a function of its capacity to buffer water based on groundwater level and land use.

Basin storage

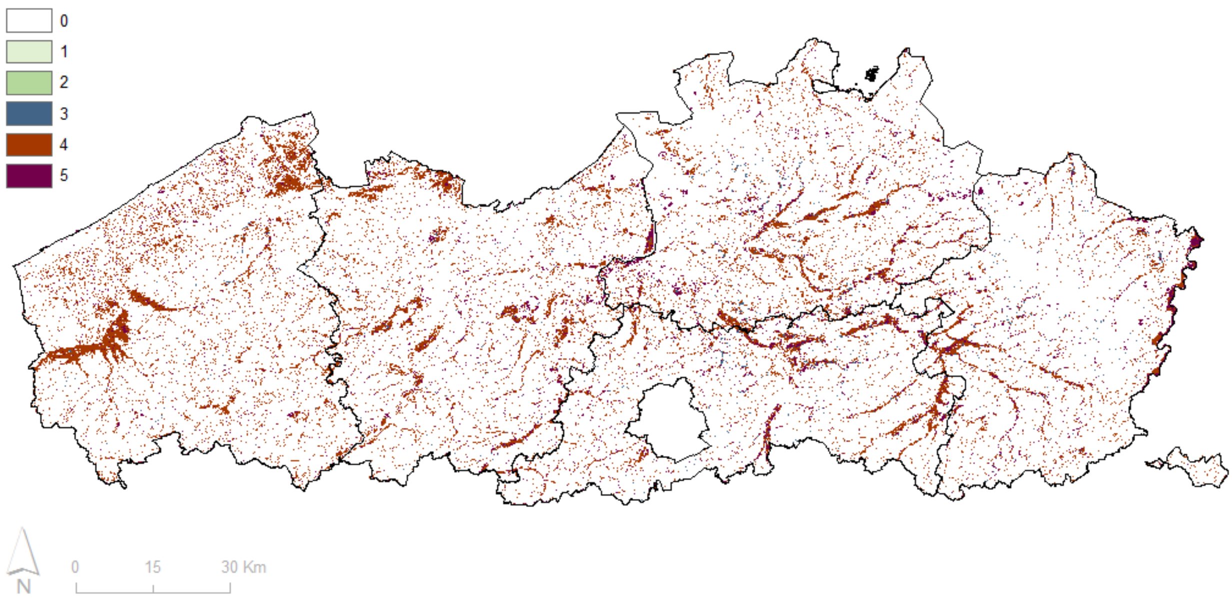

Figure 16: Basin storage map (SCEN0). The score indicates the relative importance of an area in function of flood protection based on displacement and vulnerability of land use.

Infiltration

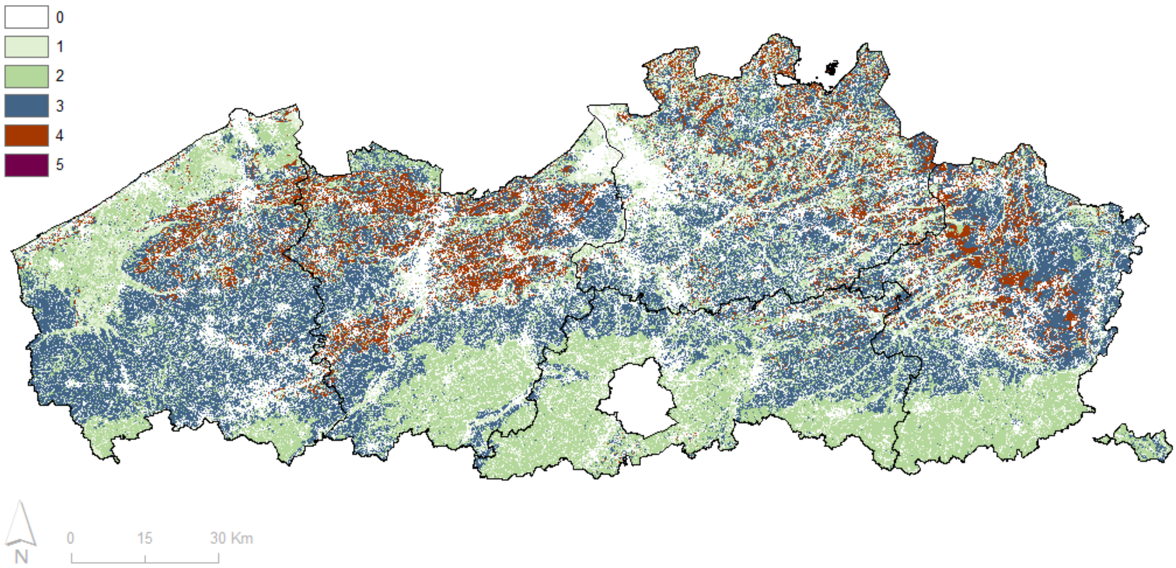

Figure 17: Water infiltration map (SCEN0). The score indicates the relative importance of an area as a function of soil infiltration capacity and land use.

Denitrification

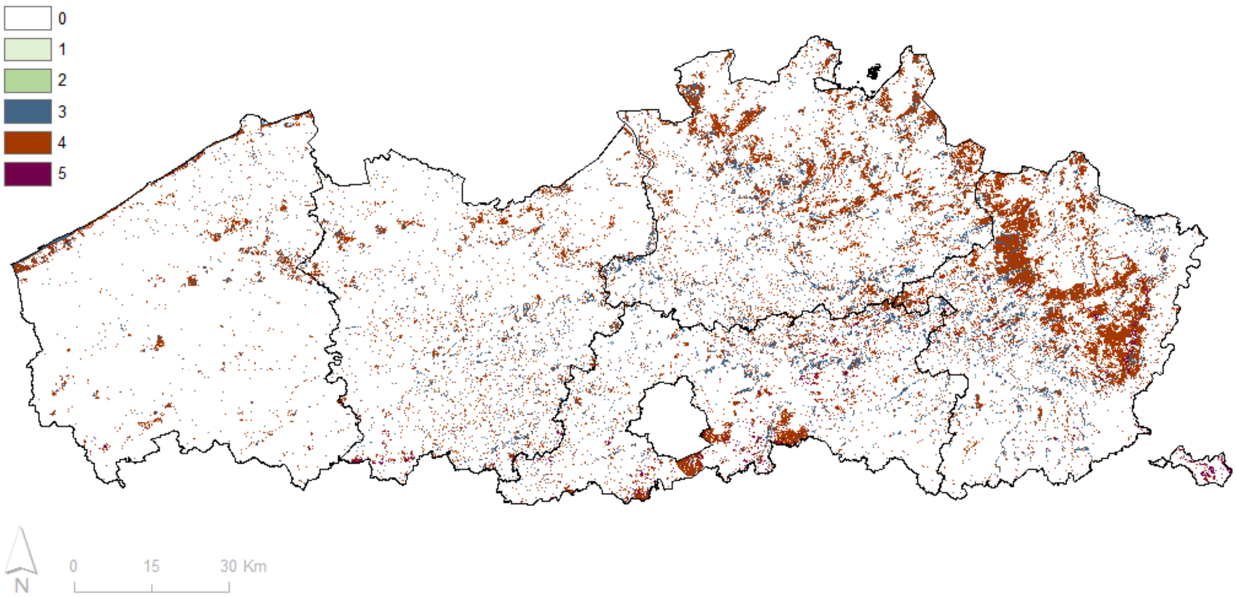

Figure 18: Denitrification map (SCEN0). The score indicates the relative importance of an area as a function of groundwater levels and land use.

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Biomass wood

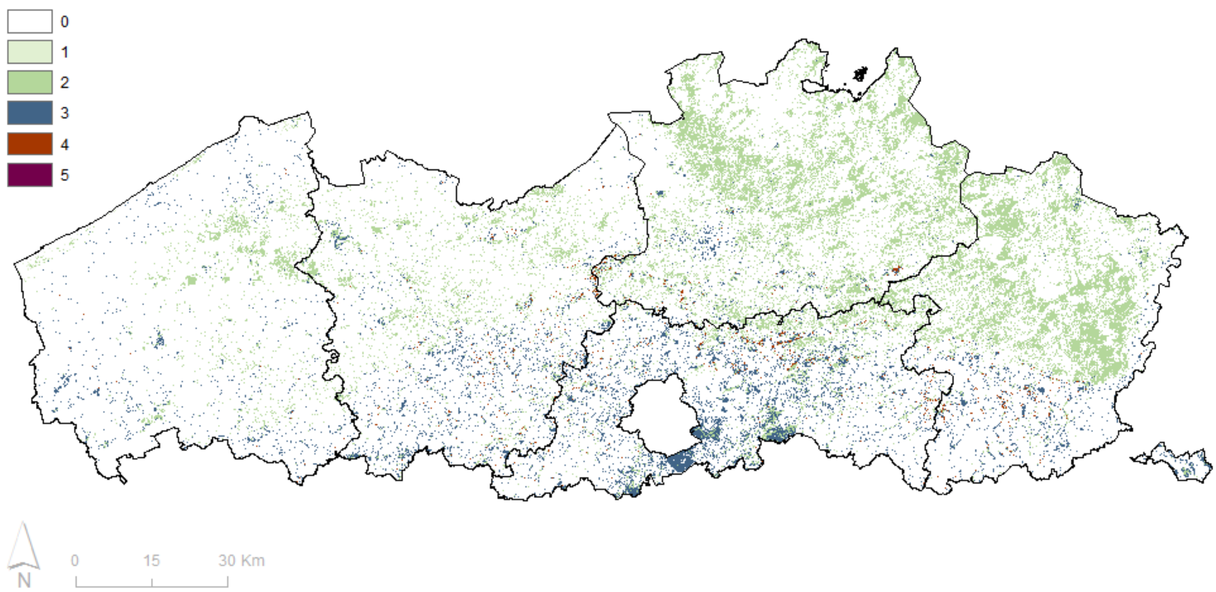

Figure 19: Wood production map (SCEN0). The score indicates the relative importance of an area as a function of soil suitability and vegetation type.

Erosion

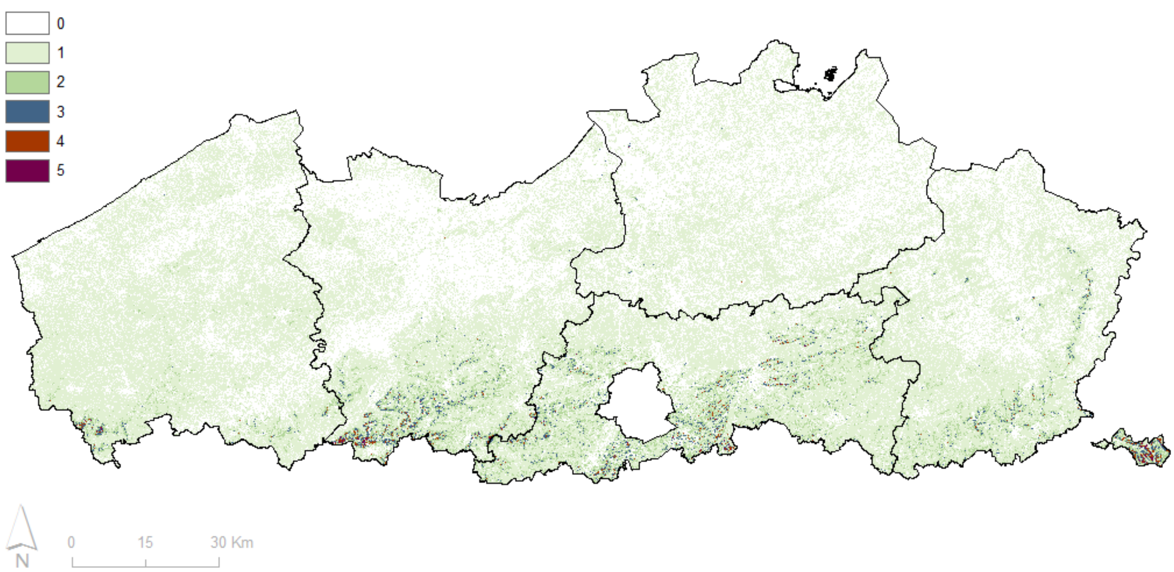

Figure 20: Erosion protection map (SCEN0). The score indicates the relative importance to an area as a function of slope percentage, soil texture and land use

Pollination

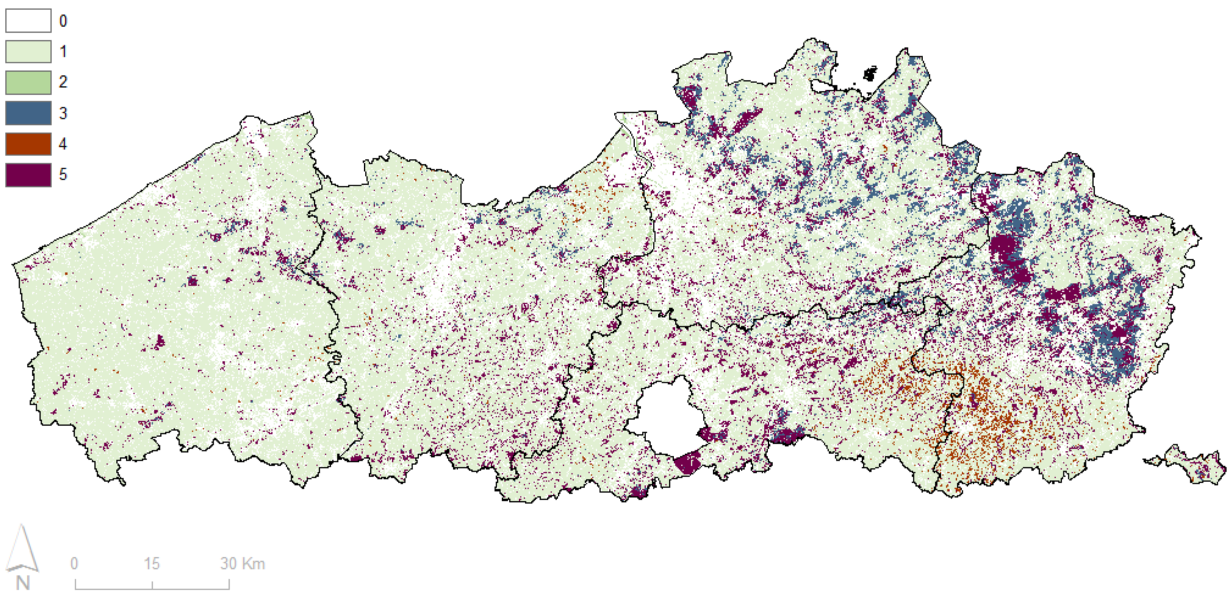

Figure 21: Pollination map (SCEN0). The score indicates the relative importance of green elements as a function of nesting and habitat scores.

3.3 Scenario 1 - SRC as small landscape elements

3.3.1 Storyline

"Short rotation coppice as small landscape elements for local biomass demand and biodiversity"

Due to agricultural upscaling, many small landscape elements (SLE) such as wood edges, thickets, hedges and trees have disappeared. In the context of new policy interest to restore and re-establish small landscape elements, SRC could be seen as a way to regenerate the former (bio)diverse agricultural landscape in a profitable way (Desair et al. 2022). This could be achieved by planting SRC in linear or patchy shapes in between fields or bordering waterways or roads. The biomass could be sold or used on site, depending on local infrastructure, needs and market prices (Desair et al. 2022, 2024). Moreover, introducing well-managed SRCs can enrich biodiversity in an agriculture-dominated landscape (Vanbeveren & Ceulemans, 2019) and provide habitat "stepping stones" in open landscapes (Fry & Slater, 2011).

3.3.2 Spatial translation

The EU Biodiversity Strategy mentions the 2030 objective of covering at least 10% of the Union's agricultural area with high-diversity landscape features. The Nature Restoration Law includes the legally binding target for member states of a positive trend in the share of high-diversity landscape features on agricultural land. The CAP conditionality also requires 4% of arable land at farm level to be devoted to non-productive areas and features.

Based on the above, the 10% target for high-diversity landscape features is split in half, for the spatial translation of this scenario. Within the SRC search areas:

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- 5% of the total productive agricultural area is converted into SRC in the form of small landscape elements.
- The remaining 5% is dedicated to other types of high-diversity landscape features.

Only in the case of agricultural plots which are sensitive to erosion or flooding, the 10% target is applied:

- 10% of the area on highly erosion-sensitive plots is converted into SRC in the form of small landscape elements.
- 10% of the area on fields or non-permanent grassland in flood-prone areas is converted into SRC in the form of small landscape elements. Areas with a high (T10) or medium (T100) probability of flooding are taken into account.

The higher percentage of 10% is applied for these erosion and flood prone areas because SRC can have a mitigating effect on flooding and erosion.

Figure 22 shows the SRC search areas which overlap with areas prone to erosion or flooding. The total area of the overlap is around 18.681 ha. When applying the 10% target (converting 10% of the area to SRC as small landscape elements), it results in an area of around 1.868 ha for Flanders. The 5% target can be applied to the remainder of the SRC search areas (around 255.065 ha, coloured in grey), resulting in an area of around 12.753 ha.

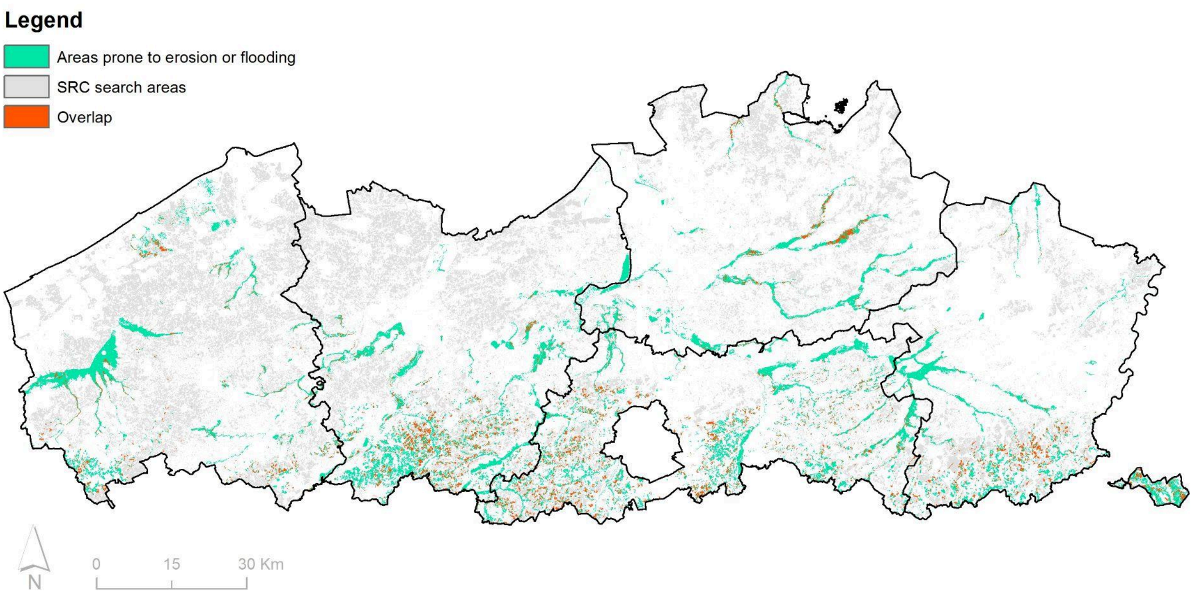

Figure 22: Map showing in red the SRC search areas overlapping with areas prone to erosion or flooding.

3.3.3 ES-model results local scale

For a local analysis of ecosystem services, an area was selected that lies within the SRC search areas, and which is also susceptible to erosion and flooding. The parcel found under these requirements was a plot of farmland (leguminous plants) near to a river (see Figure 23). This plot is located in Flanders but can be seen as an exemplary case for Wallonia as well.

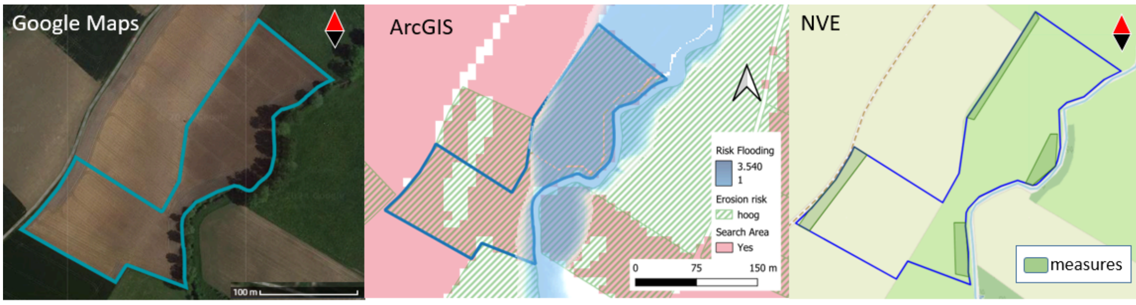

Figure 23: Location of the parcel used in the NVE. Left to right: Google Maps, ArcGIS and NVE.

As described in § 3.3.2, an implementation of 10% SRC as a small landscape element is proposed for scenario 1, when the parcel is sensitive to erosion or flooding. The selected parcel has a total area of 3,19 hectares, meaning that about 3.190 m² within this parcel would change to SRC. The polygons to allocate the measures in the NVE were placed at the top of the slope and along the edge of the river. In this way, these measures could serve both against erosion and as a buffer for potential flooding. Table 2 and 3 show the results of the NVE for the two measures that could be used as a proxy for SRC: small landscape elements and poplar forest.

Table 2: Assessment ecosystem services of 10% SRC as small landscape elements.

Quantitative evaluation	Unit	Current		Future		Difference	
		Low	High	Low	High	Low	High
Food production	€ added value production/ year	2229	3624	1946	3194	-282	-430
Wood production	m³ harvested wood / year	0	0	0	0	0	0
Infiltrationcapacity	m³ / year	7177	7177	7177	7177	0	0
Erosion protection	ton avoided erosion / year	-146	-310	-146	-292	0	18
C-stock soil	ton C / year	7.6	7.6	6.8	6.8	-0.8	-0.8
C-stock biomass	ton C / year	0	0	0	0	0	0
Denitrification	kg N / year	3.5	3.5	9.8	9.8	6.3	6.3
Pollination	'Qualitative'	2.3		2.8		0.5	

Table 3: Assessment ecosystem services of 10% SRC as poplar forest.

Quantitative evaluation	Unit	Current		Future		Difference	
		Low	High	Low	High	Low	High
Food production	€ added value production / year	2229	3624	1974	3217	-254	-407
Wood production	m³ harvested wood / year	0	0	1	1	1	1
Infiltrationcapacity	m³ / year	7177	7177	7177	7177	0	0
Erosion protection	ton avoided erosion / year	-146	-310	-146	-292	0	18
C-stock soil	ton C / year	7.6	7.6	8.8	8.8	1.2	1.2
C-stock biomass	ton C / year	0	0	0.3	0.3	0.3	0.3
Denitrification	kg N / year	3.5	3.5	9.7	9.7	6.2	6.2
Pollination	'Qualitative'	2.3		6.2		3.9	

According to the Nature Value Explorer, SRC as small landscape elements would provide additional services for erosion protection and denitrification. Small landscape elements would store less carbon in the soil and there would be a significant loss in food production. A similar loss of food production was registered when SRC was implemented as a poplar forest. The effect on denitrification and erosion protection is similar as in the case of small landscape elements. The poplar forest does store carbon in the soil and as biomass. It also provides the ecosystem service of wood production.

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3.4 SCENARIO 2 - SRC AS AGROFORESTRY

3.4.1 Storyline

"Short rotation coppice integrated into agroforestry practices"

Due to a variety of benefits and services tackling climate change and decreasing environmental impact, there is a resurgence of interest in agroforestry, being implemented again in the modern landscape (Liniger Hanspeter *et al.*, 2011). The incorporation of SRC on an agroforestry farm can prove to be a good compromise between food production, nature value and woody biomass production. Therefore we consider it as a separate scenario. From 2011 until 2019, about 127 ha of agroforestry has been installed in Flanders, mostly on biological and smaller farms (Reubens *et al.*, 2019). Agroforestry is a land management system that closely interweaves trees or woody vegetation with agricultural practices, such as crops, and/or livestock. It ranges from very simple to complex systems where a wide variety of practices can be used such as alley cropping, contour farming, parkland systems, combining livestock or poultry,… Agroforestry Flanders released a manual on agroforestry in 2019 and proposed two main types of agroforestry, based on the European project 'AGROFORWARD' (Reubens *et al.*, 2019):

> (1) **Silvicultural agroforestry** integrates trees with crops. Crops can be arable crops, horticultural crops, fruit cultivation and even short rotation forestry. The most common form of silvicultural agroforestry is alley cropping where trees are planted in rows forming strips creating spacing on which crops are planted (Morhart *et al.*, 2014). This method leaves space for machinery and the trees only occupy 5% of the land.
>
> (2) **Silvopastoral agriculture** combines trees and grazing livestock. Depending on the proportion of trees it can be referred to as forest grazing or wood pastures. The combination of cattle and a meadow orchard was common practice in Flanders, but is less prominent these days. New forms such as poultry and shrubs of SRC are also possible forms of silvopastoral agriculture. Also the installation of rows of SRC in combination with cattle production have been researched (Smith *et al.*, 2017).

SRC, having characteristics of both forestry and agriculture, can be combined in many possible ways with agroforestry. It can be installed as a biomass crop in the understory layer under larger trees (Figure 24) or fulfil the role of trees in the system.

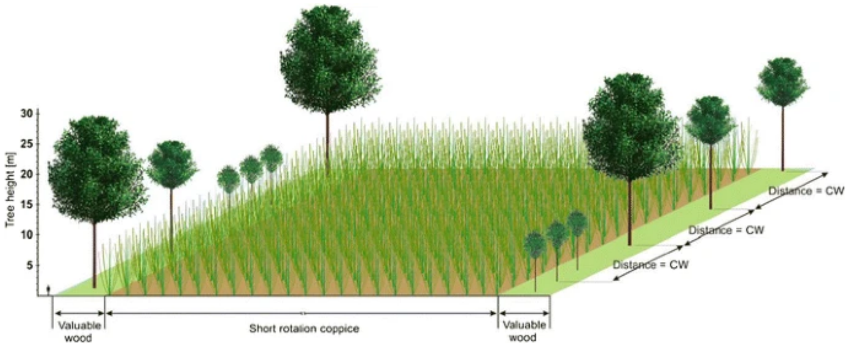

Figure 24: Silvicultural agroforestry with SRC as crop in understory layer (Morhart *et al.*, 2014).

Figure 25: Poultry under SRC in an agroforestry system (Bracke *et al.*, 2020).

3.4.2 Spatial translation

Due to the many possibilities and high variety when it comes to integrating SRC in agroforestry systems, it is a challenge to translate this form of SRC into a spatial explicit ES-model. In addition, these different types of silvicultural agroforestry and silvopastoral agriculture, including the effects of livestock or poultry on the ecosystem, is not taken into account in the current ES-model set-up. These highly diverse and transitional situations demand a higher complexity of ES models which is currently not available. Therefore the ecosystem services of the agroforestry scenario are assessed in a qualitative way.

3.4.3 Ecosystem services

Up until now biomass crops such as SRC are not often integrated into agroforestry systems, although they support and even enhance many of the ecosystem services agroforestry systems are renowned for (Kwapong Nana Afranaa, 2023). There is no specific go-to design and possibilities for integrating SRC are endless. Strategic design remains crucial however, to maximise ecosystem services and optimise possible synergies. All the ecosystem services that are delivered by SRC as small landscape elements are also delivered when SRC is integrated into an agroforestry system. However, this is complemented with additional food production and other agricultural ecosystem services such as shadow for cattle and wind protection for crops.

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3.5 Scenario 3 - SRC as intensive cultivation

3.5.1 Storyline

"Short rotation coppice intensively cultivated for larger biomass demands"

The EU's dependence on foreign fossil fuels, recent high energy prices and risk of supply shortages has shown the need for an alternative energy system. Bioenergy could play a significant role in this transition, and short rotation coppice might be considered as an alternative resource to achieve the EU's renewable energy targets for the mid and long term. Moreover, technological innovation and the shift to a biobased economy is increasing allround demand for biomass, while environmental legislation is protecting forests from further exploitation. To meet the bioenergy demand, large scale SRC is considered to be implemented on all possible parcels where there are no legal or biophysical restrictions and where the potential loss in nature value or soil carbon stock is minimal. Parcels of the highest agricultural quality are not converted into short rotation coppice plantations to balance biomass supply with food production.

3.5.2 Spatial translation

In this potential scenario, all SRC search areas are converted into areas which are fully planted with an intensive form of SRC (see Figure 26). It concerns an area of around 273.700 ha. The SRC search areas are merged with the land use map (status 2022) to create a land use map where all SRC search areas are assigned the class for SRC (code 883). This map (ADL_SCEN3) is used as the 'scenario 3' input layer in the Gobelin model to calculate potential ecosystem services.

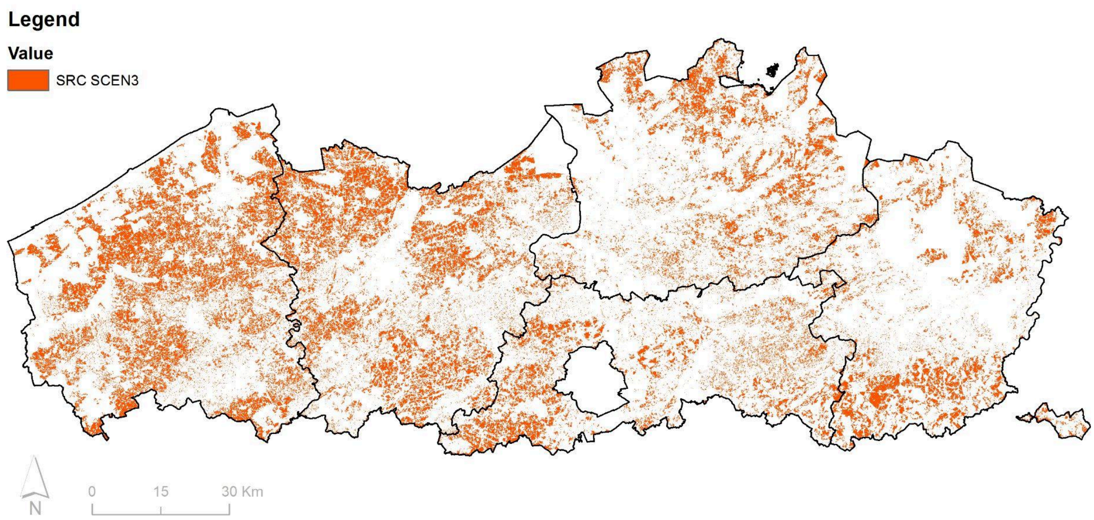

Figure 26: Map showing the potential SRC areas for the intensive scenario (scenario 3).

This scenario is used to push the boundaries of our thinking when it comes to considering the cultivation of SRC on a larger scale. It is however an extreme, hypothetical situation in case there is a high demand for biomass. Comparing a minimal SRC scenario (the current situation with hardly any form of SRC), with a maximum scenario (SRC as an intensive cultivation), allows us to explore future possibilities for SRC. It also allows one to better understand the shifts and trade-offs of ecosystem services, when deciding on deploying SRC on a larger scale. This is not to say that this is a socially, economically or politically feasible scenario.

3.5.3 ES-model results Flanders

Below follows a series of maps for each potential ecosystem service separately. The ecosystem services are calculated at the Flemish scale, using relative scores between 0 and 5. More information on the interpretation of these maps can be found in the introduction of the ES model results for scenario 0 (§ 3.2.3).

Nature value

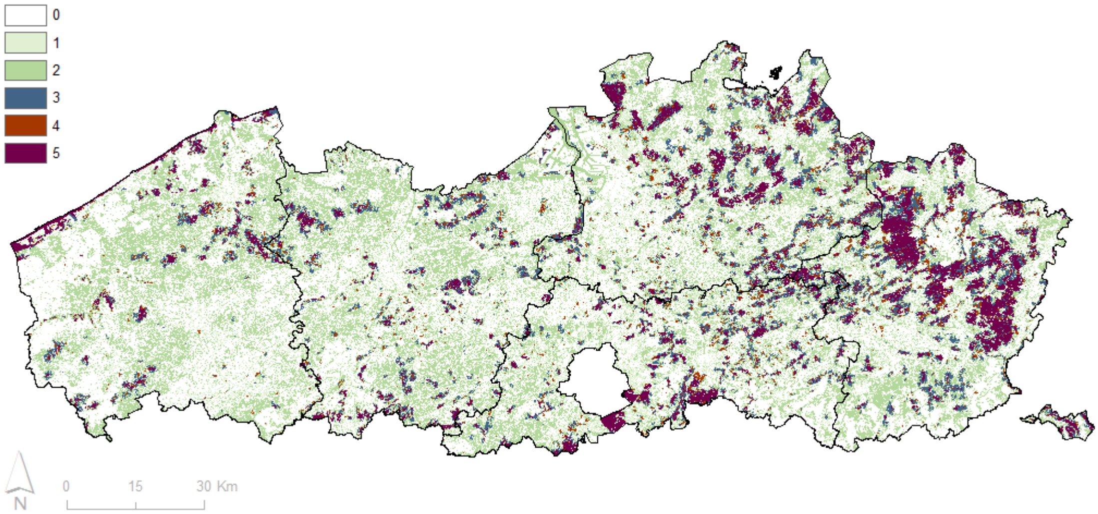

Figure 27: Nature value map (SCEN3). The scores are based on ecosystem quality, area of nature clusters and connectivity.

Carbon storage

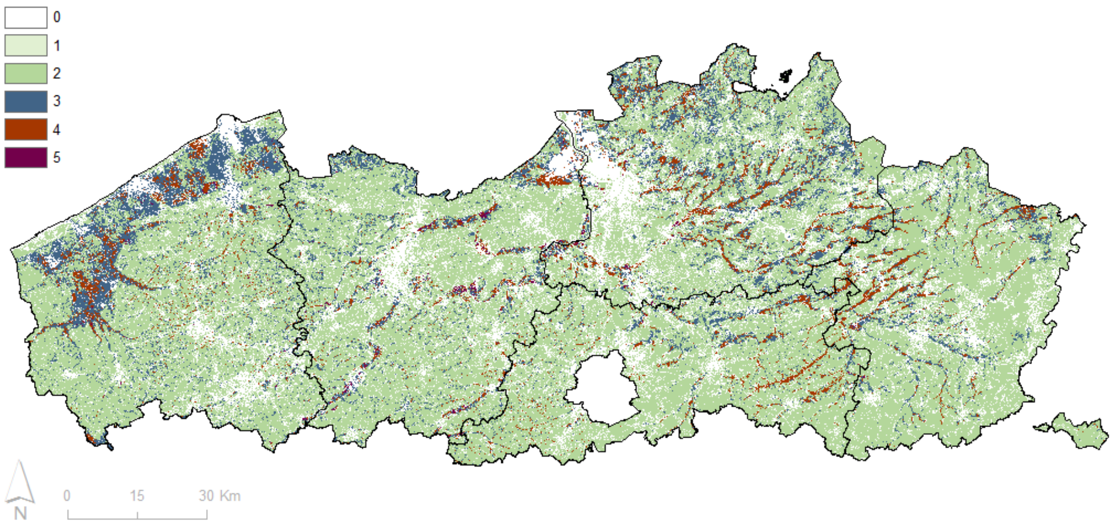

Figure 28: Soil carbon storage map (SCEN3). The score indicates the relative importance of an area as a function of the amount of soil carbon, based on land use, soil texture and groundwater level.

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Retention

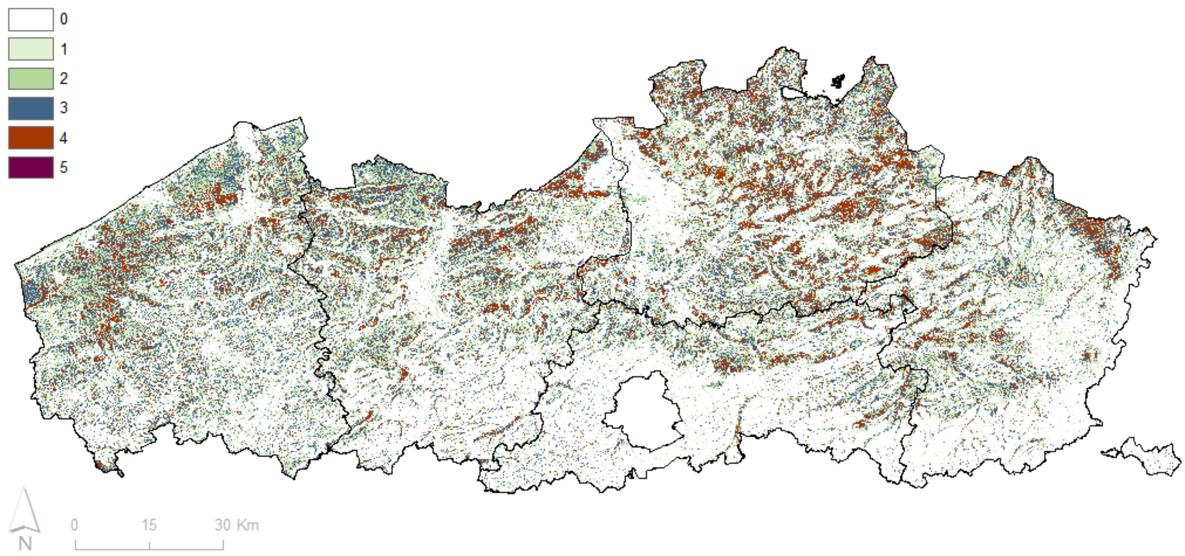

Figure 29: Temporary retention map (SCEN3). The score indicates the relative importance of an area as a function of its capacity to buffer water based on groundwater level and land use.

Basin storage

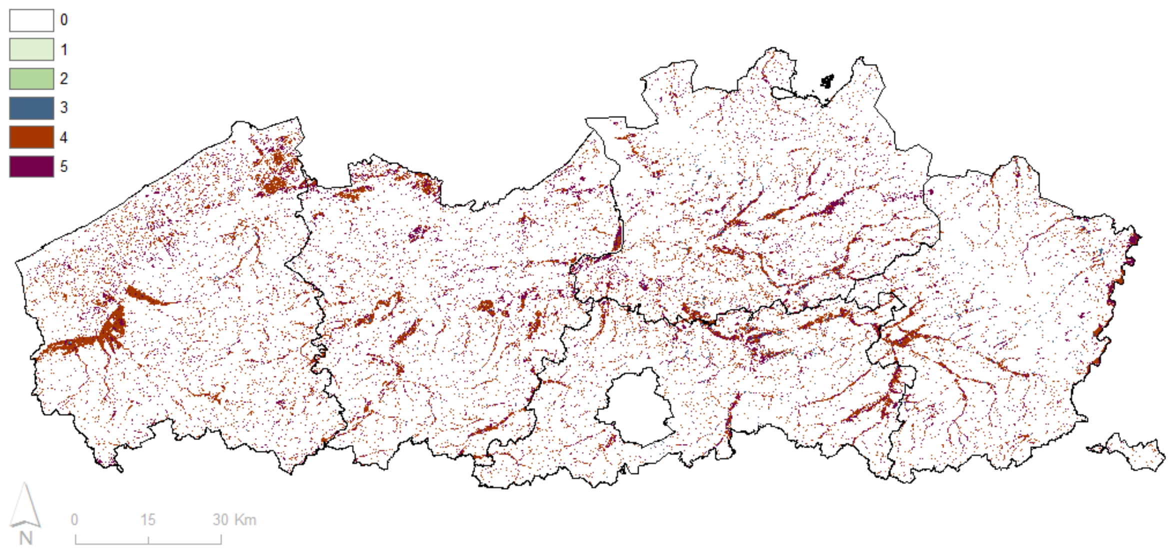

Figure 30: Basin storage map (SCEN3). The score indicates the relative importance of an area in function of flood protection based on displacement and vulnerability of land use.

Infiltration

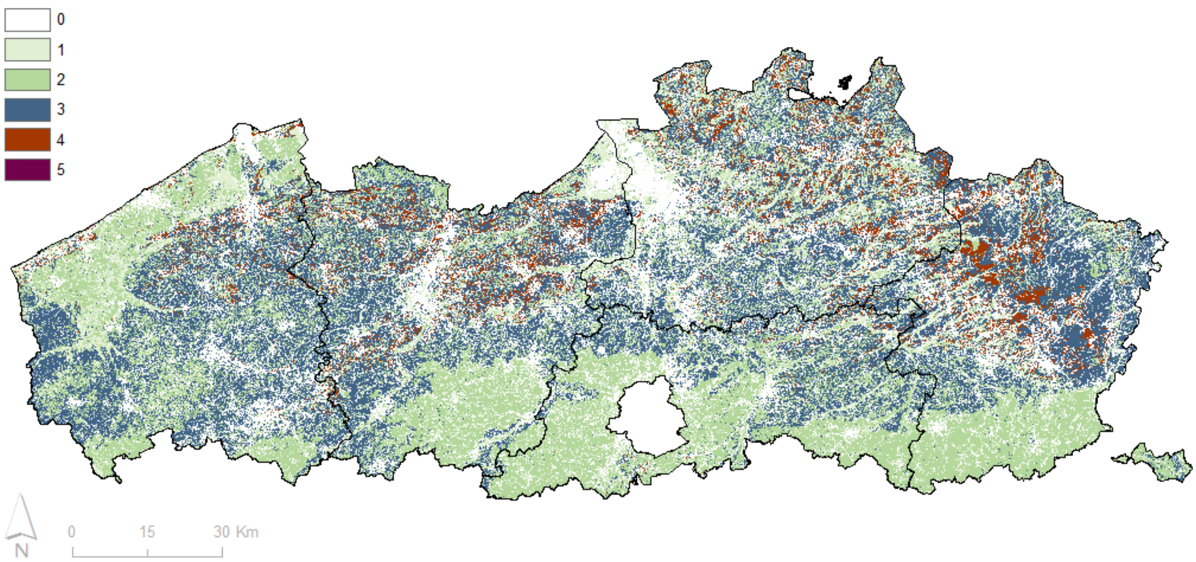

Figure 31: Water infiltration map (SCEN3). The score indicates the relative importance of an area as a function of soil infiltration capacity and land use.

Denitrification

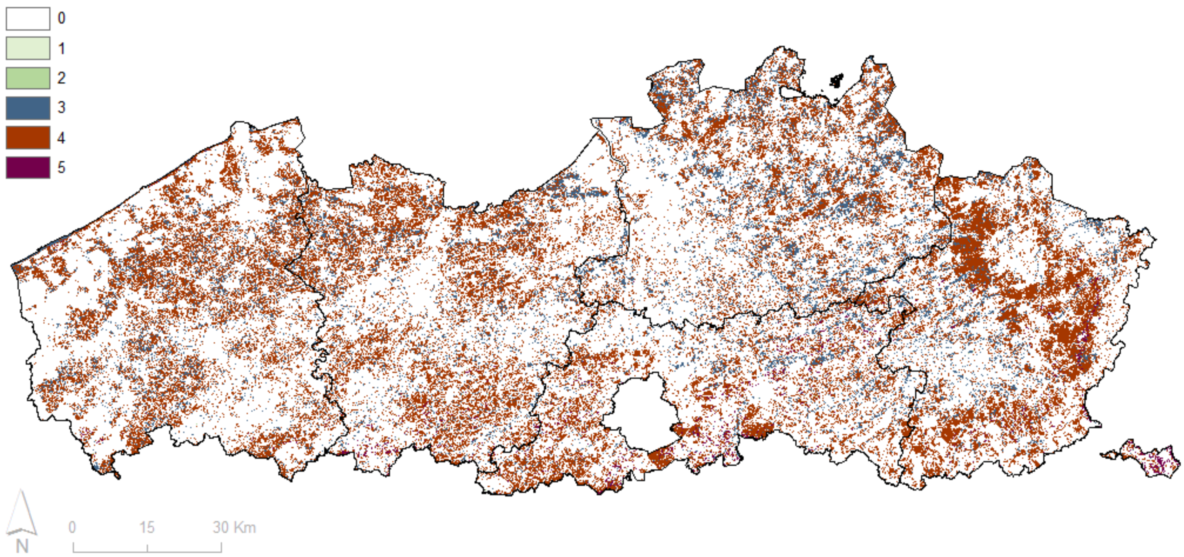

Figure 32: Denitrification map (SCEN3). The score indicates the relative importance of an area as a function of groundwater levels and land use.

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Biomass wood

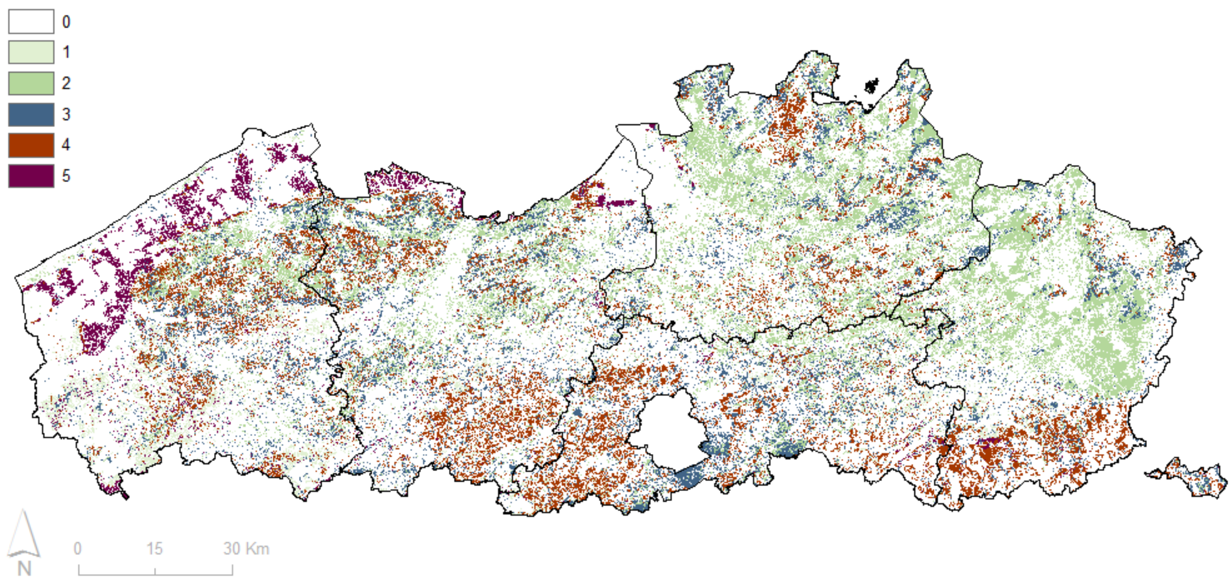

Figure 33: Wood production map (SCEN3). The score indicates the relative importance of an area as a function of soil suitability and vegetation type.

Erosion

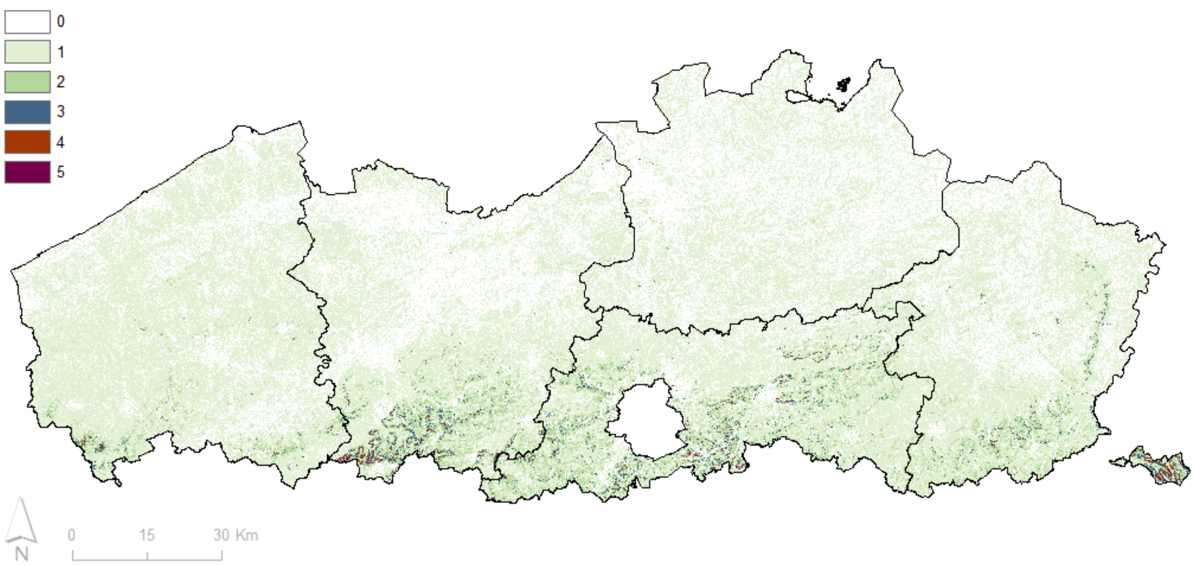

Figure 34: Erosion protection map (SCEN3). The score indicates the relative importance to an area as a function of slope percentage, soil texture and land use

Pollination

Figure 35: Pollination map (SCEN3). The score indicates the relative importance of green elements as a function of nesting and habitat scores.

3.5.4 ES-model results local scale

In scenario 3 all parcels of the search areas are fully covered with SRC. In the Nature Value Explorer, SRC on the exemplary plot is implemented as small landscape elements or poplar trees. In general, similar trends apply as compared to scenario 1 (see § 3.3.3), where the measures 'small landscape elements' and 'poplar' deliver different ecosystem services.

Table 4: Assessment ecosystem services of 100% SRC as small landscape elements.

Quantitative evaluation	Unit	Current		Future		Difference	
		Low	High	Low	High	Low	High
Food production	€ added value production / year	2229	3624	19	32	-2209	-3591
Wood production	m³ harvested wood / year	0	0	0	0	0	0
Infiltrationcapacity	m³ / year	7177	7177	7177	7177	0	0
Erosion protection	ton avoided erosion / year	-163	-327	-3	-8	159	319
C-stock soil	ton C / year	7.6	7.6	<0.1	<0.1	-7.5	-7.5
C-stock biomass	ton C / year	0	0	0	0	0	0
Denitrification	kg N / year	3.3	3.3	60.7	60.7	57.4	57.4
Pollination	'Qualitative'	2.3		6.2		3.9	

Table 5: Assessment ecosystem services of 100% SRC as poplar forest.

Quantitative evaluation	Unit	Current		Future		Difference	
		Low	High	Low	High	Low	High
Food production	€ added value production / year	2229	3624	19	32	-2209	-3591
Wood production	m³ harvested wood / year	0	0	12	12	12	12
Infiltrationcapacity	m³ / year	7177	7177	7177	7177	0	0
Erosion protection	ton avoided erosion / year	-163	-327	-0	-2	162	325
C-stock soil	ton C / year	7.6	7.6	17.9	17.9	10.3	10.3
C-stock biomass	ton C / year	0	0	2.2	2.2	2.2	2.2
Denitrification	kg N / year	3.3	3.3	60.7	60.7	57.4	57.4
Pollination	'Qualitative'	2.3		6.2		3.9	

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4 Discussion

4.1 Challenges and constraints

4.1.1 Areas not considered as SRC search zones

A number of potential areas for SRC described in Desair et al. (2022) were not considered in this study. Public domains, brownfields, wasteland or agricultural or industrial plots which are vacant for extended periods, reforestation projects using SRC for a number of rotations, verges along motorways, railways and waterways, etc. The reason why SRC is not considered on these vacant land types are the temporary characteristics and uncertainty of these land use types. Planting and harvesting of SRC is considered as a significant investment and long-term commitment which is made for several years. The unpredictability of certain land use types, make these not desirable to be taken into account in the various SRC scenarios. Article 29 of the EU Directive on the promotion of the use of energy from renewable sources, also mentions the direct impact on capital financing costs related to policy unpredictability and instability. This explains why the SRC scenarios considered in this study, mainly consist of the potential conversion of agricultural land, under certain conditions. This does not mean that these other land uses do not have any potential for SRC. Owners of these types of land can look into the various ways of implementing SRC as described in Desair et al. (2024) to see which type would fit best to their needs and the local context.

4.1.2 Impacts of SRC that are not assessed

Changes in land use affect multiple aspects and multiple people differently. In the report of Desair et al. 2022, the possible impacts are described more in-depth. In this study we focused on the ES that could be modelled for Flanders and Belgium. This means that a number of impacts of changing land use to SRC are not assessed.

We did not model the changes in food production due to the conversion to SRC. Agricultural land is the land use that is nonetheless most prevalent in the SRC search zones. We however address the effects on food production qualitatively based on the areas and crops that are substituted. A more in-depth analysis of how the reduction of agricultural land would influence the provisioning of food in Belgium would however be necessary and highly interesting.

The impact on the landscape was qualitatively explored in Desair et al. (2022) and also forms a basis of assessing the potential of different types of SRC in different agricultural landscapes in Desair et al. (2024). In this study we included the restriction on implementing SRC in cultural heritage landscapes, but did not assess the impact of implementing SRC on the landscape in general. There are multiple reasons for this omission. First, landscape preferences are personal and dynamic and can depend on the attitudes towards the perceived benefits of climate mitigation (Selman, 2010). Second, the landscape impact depends heavily on the scale and management practices (Desair et al., 2022). Our spatial analysis cannot account for different management practices. It also does not pose limits on the scale of SRC as it only measures if in one cell of 10 by 10 metres, regardless of the cells next to it. Introducing this type of total area restriction per landscape type is only feasible for small-scale interventions and in collaboration with local experts and stakeholders (Lovett *et al.*, 2013). Therefore it is not considered in this national and regional study.

The impact of SRC on different species is not explicitly assessed. The impact of SRC on biodiversity is complex and some species will benefit while others will not (Desair et al., 2022). In this study the nature value is modelled as the capacity of a landscape to host and connect populations of different kinds of species. However, this does not allow for assessing the impact on specific species that might be more or less desirable in the context of nature restoration or conservation. The possibility for SRC to host specific species or to serve as a stepping stone between specific populations needs to be regarded on a case-by-case basis as this depends on the populations present, the species characteristics and the management of the SRC. Once again this was not possible to assess with a region-level ES-model.

The economic impact of SRC is also not addressed in this study. It is clear that the choice to plant SRC is influenced by economic considerations (Desair et al. 2024). Studies on the expansion of SRC based on farm-level economic models exist for the UK (Alexander *et al.*, 2014) and Germany (Kröber *et al.*, 2015). A similar analysis would be possible for Belgium, building on the work of El Kasmioui & Ceulemans, 2012 who did a financial feasibility analysis for both farmers and investors. This was however not in the scope of our research and as demonstrated by Desair et al., 2024, economic considerations are just one of the many reasons for planting SRC in Belgium.

4.1.3 Limitations of ES models

While ecosystem services models like Gobelin and the Nature Value Explorer can provide useful insights to nourish debate or further research, the results must be interpreted with caution and a clear understanding of the assumptions made. Data limitations are a significant constraint, as numerical data for short-rotation coppice, specific to the Belgian situation, is scarce. Moreover, the delivery of an ecosystem service depends heavily on the local situation and the type of SRC that is implemented, the way it is managed and the actual demand and use of these services (for a more in-depth discussion on the types of SRC see the report of Desair et al. 2024). When adapting the Gobelin model, we mainly relied on expert opinions and judgments. For most ecosystem services, the conversion to a single score (see the ES Scores table in Annex 2) is an oversimplification, which can lead to inaccuracies or false accuracy.

Another limitation of ES models comes from their limited scope. Nature has many values, covering instrumental (nature as a means to a desired human end), intrinsic (value of nature, considered and expressed by people, as an end in itself) and relations (importance to society regardless of use values) (Pascual *et al.*, 2023). The lens of ES through which we assess the values of nature is already reductionist and originates from an economic dominated valuation (Pascual *et al.*, 2017). The ES that we are regarding in this study are chosen mainly in an opportunistic way, building on what was already developed within our own institute. However, this means that some values of nature are scarcely or not covered. In our analysis we focus

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mainly on instrumental values and include only the one ES which reflects the intrinsic value of nature (nature value) and none to reflect the cultural aspects of instrumental values, nor any relational values. This unbalance should be taken into account when interpreting the results of the study. A more balanced and in-depth discussion on the different values of SRC can be found in the report of Desair et al. (2024).

A last limitation of ES models comes from their inherent technocratic nature which tends to obscure some normative choices that are behind these models and de-politicize some of the choices that can be made based on the outcomes (Jacobs *et al.*, 2023; Turnhout *et al.*, 2013). With our choice of ecosystem services to regard in this study, with the restrictions that we chose to apply and which not, we have favoured certain values of nature and certain worldviews. While all of these choices can be justified, they should be taken into account when interpreting the results. We have deliberately not weighed the different ecosystem services against each other as this is a societal choice that needs to be made and not one that we could incorporate in this study[4]. It should therefore not be interpreted as posing that all these ES are equal in importance nor that we imply that all people will value them in the same way. This study can merely help in further decision making where also social justice should be regarded to cope with the limitations of this study (Schaafsma *et al.*, 2023). Practically this would mean that before deciding on measures to limit or expand SRC in certain areas or on certain land uses, the values of different stakeholder groups should be regarded, the limitations and underlying assumptions of this study should be communicated and local and practical knowledge should also be taken into account. Once again we can refer to the report of Desair et al. (2024) where some of these aspects are covered and which is thus complementary with this report.

4.1.4 Effects of climate change

SRC is a long-term investment, and yields of SRC could potentially be affected as a result of climate change. This could have an impact on the economic viability of SRC and its role in energy production (Alexander et al., 2014). Moreover, food production will also be impacted by climate change (European Environment Agency, 2019). Hence, the implementation of SRC could increase already existing competition with food production both on a local scale through competing water consumption and shade as on a global scale through tele-coupling effects (Desair et al., 2022). On the other hand, SRC could be especially interesting for providing shade to neighbouring crops and for animals (see section on agroforestry).

Climate change not only causes drought and heat, but can also bring large amounts of precipitation. In that case, SRC, due to its high-water consumption, could contribute to the growth of agricultural crops by decreasing the water table height. SRC yield will be affected to a much lesser extent by increasing precipitation: on the contrary, most willows grow very well or even better at higher water levels (Meiresonne, 2006). In other words, the temporal prediction of SRC suitability could be an important element to consider in further studies.

[4] In fact this means that all ecosystem services that were taken into account for this study have a weight of '1'. All other ecosystem services which were not quantified, have a weight of '0'.

4.1.5 Differences in spatial data between Flanders and Wallonia

In our report we attempt to assess the environmental impact of SRC in Belgium. However, much of the data on the environment is only available on a regional basis as the environment is a competence of the regions. This means that previous ecosystem models, such as the Gobelin model, have also been developed on a regional scale. The Nature Value Explorer functions for the whole of Belgium but the underlying data sources are nonetheless also different for Wallonia and Flanders. This fragmentation is a clear hindrance for any study that wants to make claims about the whole of Belgium and this is also reflected in our limited results for Wallonia.

The differences in underlying spatial data become apparent when comparing the SRC search areas with the land use map of Flanders and Wallonia (Figure 7 and Figure 11). It is notable that almost all SRC search areas in Wallonia fall within agricultural land, as where the SRC search areas in Flanders are spread across different land use classes. This can be explained by a very different structure of the land use maps in both parts of the country:

- Land use map Wallonia: besides the land use class 'agriculture', other classes are predominantly related to industry, energy production, transport networks, services and residential use. Classes like 'abandoned zones' or 'natural zones', are broad or a mix of different land uses. Most of these land use types have been excluded as SRC search areas, except for the classes 'agriculture', 'commercial agricultural production', 'grasslands', 'arable lands' and 'christmas trees'.
- Land use map Flanders: a different categorization is used, with more detail in the 'natural' land use classes (different types of forest, grasslands, other low green, other high green etc.).

4.2 ES Scenario comparison Flanders

In this section the changes in ecosystem services between the baseline scenario (scenario 0) and the most intensive and large-scale implementation of SRC (scenario 3) are discussed for Flanders. When interpreting the results it should be kept in mind that modelling ecosystem services on larger scales is always a hypothetical exercise and that the exact numbers give a false impression of accuracy. This is why the results will mainly be discussed as relative changes in the delivery of ecosystem services between the two most extreme scenarios. The table below gives a summary of these changes for the ecosystem services calculated on Flemish scale.

Table 6: Summary table showing the difference in area per score of delivery of ecosystem services from 0 (no delivery) to 5 (highest delivery) between the current situation of SRC (scenario 0) and the scenario with SRC as an intensive cultivation (scenario 3).

	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5
Nature value (K01)	▽ high	▽ medium	△ high	△ medium	▽ low	▽ low
C-storage (K07)	no difference	no difference	▽ medium	△ medium	△ low	△ low
Retention (K08A)	no difference	▽ low	▽ medium	△ low	△ medium	△ low
Basin storage (K08B)	no difference	no difference	no difference	▽ low	▽ medium	△ medium
Infiltration (K08C)	no difference	△ low	△ medium	▽ medium	▽ medium	no difference
Denitrification (K08D)	▽ high	△ low	△ low	△ medium	△ high	△ low
Biomass wood (K11)	▽ high	△ medium	△ medium	△ medium	△ high	△ medium
Erosion (K12)	▽ medium	△ medium	△ medium	△ low	△ low	△ low
Pollination (K13)	no difference	▽ high	no difference	△ high	▽ low	▽ low

Difference:
- high: > 68.122 ha
- medium: < 68.122 ha
- low: < 10.000 ha
- no difference

△ increase

▽ decrease

Nature value

When introducing SRC on a large scale in Flanders, we see that the overall nature value in Flanders increases. A large area (more than 68.122 ha, which is 5% of Flanders) not or scarcely providing a nature value in the baseline scenario, is elevated to a score of two or three. This can be explained by the large number of agricultural parcels having a lower nature value compared to when converted to SRC. Likewise, there is a small area that decreases in nature value due to SRC only having a relatively medium nature value. Probably it concerns the other green areas ('high other green' and 'low other green' of the land use map) that are substituted by SRC in the model.

Spatially we can observe from figure 13 and 26 that those areas that change from score zero or one to score two or three are evenly spread around Flanders. The parcels that increase to score three or higher often seem to be located close to already existing areas with high nature values. This should not come as a surprise, as connectivity is one of the main determinants for nature value, which increases when SRC is planted on agricultural land. The functional core for the nature value is enlarged and the connectivity with other functional cores increases. Visually it is not possible to distinguish which areas with high nature value are losing nature value.

This shows that in general more species will be able to cross the Flemish landscape when large scale SRC is introduced. It is important to note however, that the ecoprofiles defined in the ES-model are not real species but an archetype of a species. Highly specialised species, which are often also the most endangered, most probably have higher habitat requirements and will therefore not necessarily profit as much as generalist species by this increase in SRC. This was also observed in West Flanders to be the case (Dochy, 2011).

Carbon storage

The ES-model indicates that carbon storage will increase under large scale SRC planting. This change is mostly taking place from score two to three and a smaller increase to categories four and five. The carbon storage is calculated in function of the land use, water table and soil type. As the latter two remain the same, the difference in delivery can only be attributed to the land use change.

Spatially, the changes take place mainly in those areas where there is already a high potential carbon stock. The changes are most remarkable in the region of the Polders and in floodplains, those soils with a wet and clay character. In these regions the agricultural lands are substituted by SRC, increasing their potential stock.

It should be noted that these hypothetical carbon stocks could also be lost very quickly in case the SRC is harvested and the root systems taken out or ploughed into the soil. This very invasive procedure would release most of the carbon stock that was built up from not disturbing the soil under SRC.

Temporary water retention

Introducing SRC on a large scale means a shift to higher scores for water retention, most prominently from score 2 to score 4. The model calculates the difference between the highest and lowest water table, multiplied by the avoided run-off which is based on the land use. SRC, like all forested areas, receives the highest score of 10, while agricultural land receives 9 (see Annex 2). The fairly marked changes in scores are therefore mostly attributable to changes from other land uses than agriculture (e.g. other green) to SRC.

The spatial analysis confirms this as there is no visual difference between the maps of scenario 0 and 3. This means that differences can only be found in small plots and not in large swaths of land that are converted like is the case for agriculture.

Basin storage

Introducing SRC leads to a moderate increase in parcels that can withstand inundations and therefore contribute to basin storage of water. The most marked change is from score 4 to 5. This signifies that mainly those parcels that were already to a high degree capable of resisting inundations are transformed to SRC, a land use that is also very capable of resisting inundations. This is not illogical as those land uses that would not be able to store water or that cannot resist inundation like built infrastructure are not modelled to be transformed into SRC. This in contrast to land uses often found in floodplains like grasslands.

The difference is not visually distinguishable, supporting the above analysis that mostly the already well-adapted parcels of score 4 change to SRC with score 5.

These results could call into question the real benefit of SRC in floodplains, which is an often cited beneficial location (Dworak *et al.*, 2007), as it seems like this is not necessarily the case.

However, what is not captured by the model is the ability of the SRC to mitigate flooding, decreasing the need for the basin storage potential of the land further away from the stream. On the other hand, this effect can also have detrimental effects as it can cause floods to occur more downstream (European Commission. Joint Research Centre. Institute for Energy & European Environment Agency, 2008).

Water infiltration

There is a moderate decrease in the amount of water that can be infiltrated when SRC is planted on a large scale in Flanders. The most prominent changes are from score 3 and 4 to score 2. The infiltration is a function of the soil and the land use which intercepts a part of the water. As the change in score 4 to 2 is not in the order of magnitude as the changes in land use to SRC, the soil seems to be a more important variable. Therefore the loss in water infiltration can be explained by the higher interception of SRC on those soils that are already to a higher degree impermeable, exacerbating the effect.

This is confirmed in the maps as the clay and loamy soils do not change remarkably in scores, while the loamy sand and sand regions are decreasing in score, especially in Western and Eastern Flanders.

It should be noted however that the modelling of infiltration capacity does not take into account the "ploegvoor" that is very often formed on agricultural soils that are often ploughed. In fact, agriculture even receives a higher score than forests due to its lower interception and thus higher hypothetical infiltration of water that falls on the parcel. This is probably an overestimation and certainly does not hold when there is no vegetation on the agricultural parcels and a lot of water will run-off.

Denitrification

For denitrification there are very significant changes, mainly from score 0 to scores 3 and 4, but also to score 1, 2 and 5. The denitrification potential in Flanders therefore increases significantly when introducing SRC on a large scale. The denitrification potential is calculated in function of the height of the water table, as anoxic circumstances are necessary for the denitrification, and the land use, as the input of nitrogenous fertilisers reduces the impact of denitrification. As SRC receives much less fertiliser than other agricultural uses, it was scored as having a higher potential to denitrify. All non-nature land uses that are changed to SRC therefore will increase in denitrification potential. This includes all the major land uses that would be substituted with SRC as indicated by Figure 7. The maps confirm that the increase of denitrification is occurring at almost all locations that overlap with the SRC search areas of figure 5.

It should be noted that the installation of SRC influences the height of the water table. As the trees use much water, the water table can decrease, especially during dry spells in spring or summer. Averaged over a year, the water use of SRC is on the other hand generally lower than other highly productive crops or grasslands (Fischer *et al.*, 2018). These mechanisms are not regarded in the models but would influence the denitrification potential of SRC: negatively on a small temporal scale, but positively on a larger temporal scale. Another point to take into consideration is that the model uses a binary of “natural” and “non-natural” land uses. Arguably this is a strong simplification and some land use classes such as “other high green” and “permanent grassland” would also not receive any fertilisers. Therefore these modelled changes should be interpreted as a potential increase that will mainly be real on agricultural parcels and only when the SRC is managed in a more extensive way.

Wood production

When introducing SRC on a large scale, the produced woody biomass increases significantly. This occurs especially from score 0 to score 4 but also to all other scores. This reflects mainly the change from agricultural production to woody biomass production.

When looking at the maps for scenario 0 and scenario 3 we can see that most areas that already provide the service of wood production maintain the same score. This is confirmed by the difference map in Annex 8 which is almost identical to the search zones for SRC in Figure 5. This is logical as most modelled land use changes are from agricultural areas to SRC while only little wood-producing classes like low stem orchard, other high green and shrubs and thicket, are substituted.

The land use with the highest amount of woody biomass production is SRC. This can visually be confirmed by the fact that deciduous forests, like for example the Sonian Wood to the South of Brussels and coniferous forests, like for example in the west of Flanders, are only falling into score 3 and 2 respectively in both scenario 1 (Figure 19) and 3 (Figure 32). Partly this can be explained by the fact that in the model the increment scores for SRC on the most suitable soils were higher than the increment scores for poplar, deciduous or coniferous forests to begin with. This also means that SRC is in fact planted on soils of high suitability, which are in this case often agricultural lands. This can be appreciated on Figure 32 as parts of the loam plateau in the South of Flanders are populated with SRC in scenario 3 but can also be confirmed by Annex 8 which shows that the maximum modelled biomass production is 21,3 ton DM/ha, which corresponds to the 30 m^3/ha that was reported in Table 1 to be the maximum attainable yield.

Even though there is a substantial increase in score 5 for woody biomass production when implementing SRC on a large scale, the majority of the change takes place in score 4 and lower. This points to the fact that also a large number of suboptimal parcels are populated with SRC. The maps show an increase in score 5 predominantly in the Polders, where the wet clay is the second most suitable soil for SRC according to Table 1 with a yield of 26 m^3/ha. The other parcels in score 5 are visually hard to distinguish but are located in the valleys where wet loam provides the best soil for SRC. The yields for score 4 are between 18 and 24 ton DM/ha and occur mainly on dry loam to clay, wet loamy sand or very wet loam soil. These can be found throughout Flanders in all provinces and agricultural zones but with a higher concentration on the loam plateau in Limburg and at the South of East Flanders and West of Vlaams Brabant. The fact that here the scores of five are not attained is due to the restriction for the

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preservation of the most productive zones for agriculture which is excluding the moderately wet loam soils.

We stated multiple times throughout the report that exact numbers should be interpreted very carefully as these models contain possible large errors. For the production of biomass, which is at the core of the Ad-Libio project in the context of which this report is written, we will make an exception to get a grasp of the order of magnitude of biomass production that SRC could contribute in Flanders. The mean production of a SRC parcel in the intensive scenario in Flanders is 13,95 ton DM/ha. The total biomass that would be produced in the intensive scenario would be about 3,8 million tons of DM for the whole of Flanders. Most parcels are rather productive with about 180.000 hectares of SRC yielding more than 12 ton DM/ha which is reported to be the average yield in Belgium (Meiresonne, 2006).

Based on this result the conclusion could be drawn that it would be less beneficial to plant forests instead of SRC as the latter would provide less woody biomass. This is even more the case when considering the fact that the scores of the forest land uses are reflecting the already full-grown forests. In the first thirty years there will be much less woody biomass supplied from these growing forests, while SRC provides a more constant supply of woody biomass from the start. Of course forests are more multifunctional, provide both high and low quality wood and have a higher nature value than SRC, which make them still the most preferred long term solution for providing woody biomass.

Nonetheless, the advantages of both systems (constant and fast production of biomass and high yield of biomass over time) could be combined through kickstarting afforestation and reforestation projects through SRC where the climax species (like oak or beech) are planted simultaneously but not harvested and can take over from the SRC after a cycle or two (Thomaes & De Keersmaeker, 2011).

Erosion protection

The introduction of SRC on a large scale leads to moderate increases in erosion protection, mainly from score 0 to scores 1 and 2. There are also small increases in scores 3, 4 and 5.

Spatially we can see that the increases from score 0 to 1 are predominantly found in less hilly areas such as Western Flanders and Antwerp, the other scores increase mainly on the slopes of more hilly terrain such as the Flemish Ardennes and Flemish Brabant. While the size of the change from score 0 to 1 is most remarkable, the changes on the slopes are arguably the most important as these are also the most erosion-prone areas.

Pollination

For pollination there is a marked increase from score 1 to 3 and a small drop in scores 4 and 5. The change from score 1 to 0 can easily be explained by SRC being modelled to provide an average habitat for pollinators and it is mainly replacing agricultural land and grassland which are modelled to provide a rather low quality of habitat for pollinators. The drop in scores 4 and

5 are due to the substitution of SRC of shrubs and thicket land use, which are modelled to provide a good habitat for pollinators.

Spatially we can see a quite even spread of the increase in scores. The drop in scores 4 and 5 is visually not distinguishable.

It is important to note that some of the agricultural classes do provide a good habitat for pollinators, such as those crops that depend on this pollination and that are cultivated organically. This is not taken into account within this model.

Food production

The ecosystem service of food production was not modelled with the Gobelin model. It can however be assessed through looking at the areas of agricultural land that are substituted by SRC. It is clear that there is a stark decrease of agricultural production when implementing SRC on a large scale as most of the area considered (about 70%) is on agricultural land. To be specific 189.191 ha of agricultural parcels registered in the "Landbouwgebruikspercelen" database would be converted to SRC in scenario 3. This is a reduction of the total agricultural land by about 30%. The main crops being substituted are maize (80.000 ha), grains, seeds and legumes (30.000 ha), grassland (22.000 ha) and potatoes (20.000 ha). As the crop that is being produced on a parcel varies year by year, it is difficult to estimate the long-term shift of crops that would be substituted by SRC and the subsequent reduction in food production. Nonetheless, it is clear to see that the majority of the crops that are substituted (about 60% if we do not consider grains, seeds and legumes) are for animal protein production or first generation biofuels and not directly for human consumption.

4.3 ES Hotspot map Flanders

Are landscapes becoming more multifunctional, delivering more ecosystem services, when bringing in SRC? Based on the different modelled ecosystem service maps, a **hotspot map** can be calculated, showing the sum of all ecosystem services which score above-average (score >3). For each raster cell, the number of ecosystem services is calculated that score above-average (>3). This hotspot map gives an idea of the concentration or highest occurrence of ecosystem services in Flanders. By comparing the hotspot map of scenario 0 (baseline) and scenario 3 (intensive SRC), the gain of ecosystem services by SRC can be calculated.

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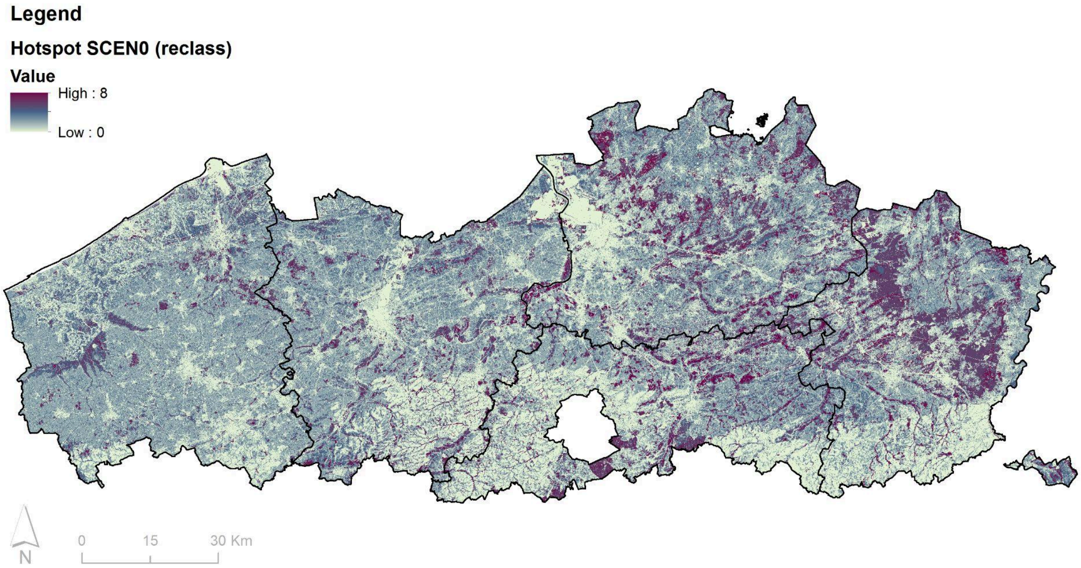

Figure 36: Hotspot map of ecosystem services which score above-average, for scenario 0 (current situation SRC)

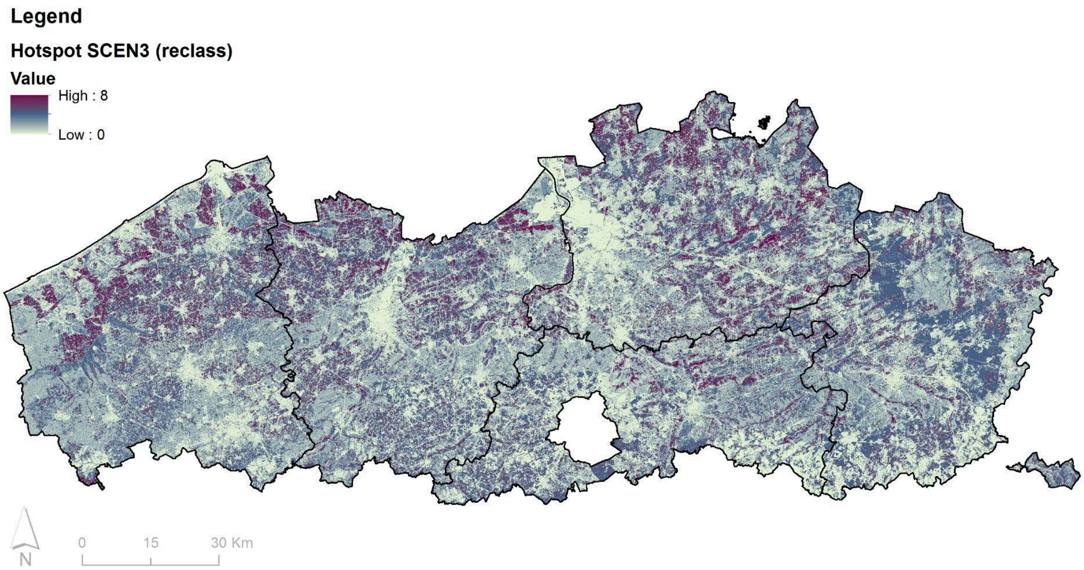

Figure 37: Hotspot map of ecosystem services which score above-average, for scenario 3 (SRC as intensive cultivation)

Figure 38 compares the calculated areas of the different scores of the hotspot maps. The current situation of SRC (scenario 0) has higher values in the lower score range (score 0 and score 1), compared to the situation where SRC is an intensive cultivation (scenario 3). In the higher score range (score 2 and up), the potential situation with more SRC shows higher values, indicating larger areas with multiple ecosystem services.

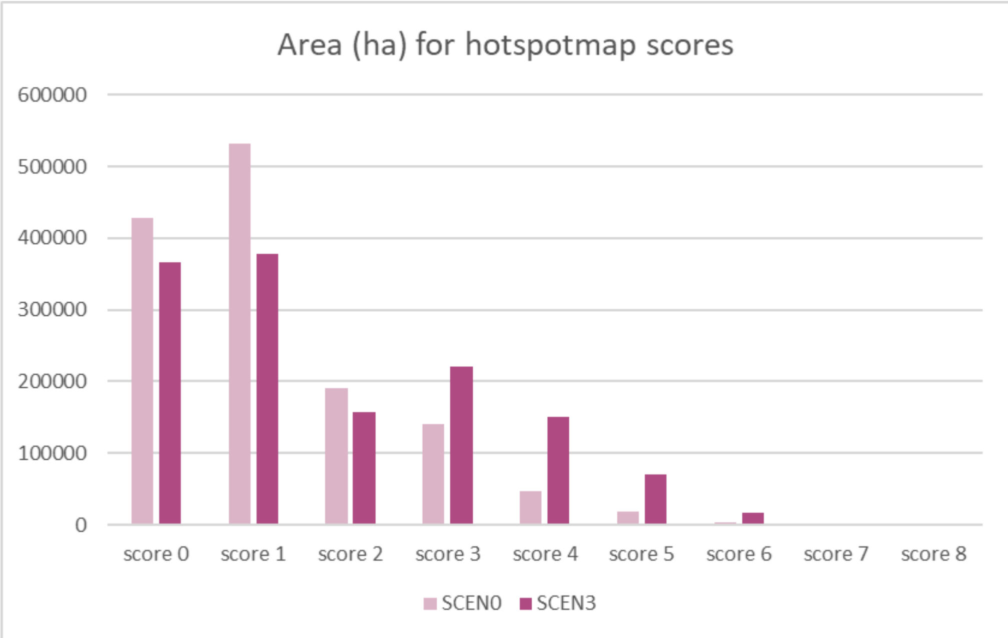

Figure 38: Areas (ha) of the different hotspot map scores (sum of all modelled ecosystem services)

Introducing SRC on a large scale does indeed make the landscape more multifunctional. We see a marked shift in area from score zero and one to scores two, three and four. This can be explained by the agricultural parcels that are predominantly substituted by the more multifunctional land use of SRC. Agricultural land scores high for the ecosystem service of food production which was not modelled in this exercise and therefore is not incorporated into this calculation.

Nature value is not part of this hotspot map showing the total calculation of ecosystem services. The separate approach for nature value compared to the other ecosystem services is due to the different value typology. Biodiversity is about the intrinsic value of nature, while the other ecosystem services highlight the benefits of nature for humans, or the anthropocentric (relational and instrumental) values of nature. Furthermore, biodiversity is crucial for the stability of ecosystem service delivery in the longer term. High biodiversity increases the resilience of ecosystems to disturbances such as climate change or invasive species (Smets J., Stevens M., 2019).

When interpreting these hotspot maps, take into account that these values are not weighted, which gives the impression that every ecosystem service is valued equally. This is of course not the case: all ecosystem services are valued differently depending on the stakeholder and the local context. As we are providing an assessment for the whole of Flanders, this weighing is not part of the exercise.

Annex 7 gives a full breakdown of the areas calculated for each ecosystem service separately. Areas are calculated for each score (score 0 to score 5), featured on the ecosystem service maps of chapter 3 (ES-model results for each scenario). By comparing the calculated areas between scenario 0 (baseline) and scenario 3 (intensive SRC), shifts in ecosystem services can be observed. The most prominent changes in calculated areas between the scenarios are visualised in a summary table, in the following chapter.

4.4 Hypothetical changes in ES for Wallonia

For Wallonia there are no ecosystem services models on a regional scale. Therefore we are limited to hypothesise how the implementation of the different scenarios could influence the delivery of ecosystem services in Wallonia. Such an exercise needs to start with comparing the differences and similarities between the two regions concerning the amount and current land uses that would be substituted with SRC. Unfortunately, also here there are limitations due to different classifications, which should be taken into account when interpreting the results.

Concerning the amount of land that would be substituted to SRC, it is apparent from Figure 9 and 11 that the search area for SRC is smaller in Wallonia compared to Flanders. Both in absolute terms, with 139.334 ha for Wallonia as opposed to 273.700 ha in Flanders, as relative with this area being 8% of the surface of Wallonia as opposed to 20% in Flanders. Visually, we can distinguish the main zones in which the SRC could potentially be planted, which are mainly in the Leemstreek and the Condroz. These zones are marked by loamy soils and high agricultural productivity. To a lesser extent there are also some patches in the Ardens.

The current land use (scenario 0) that SRC would replace in full within scenario 3 would be predominantly agricultural. It is even so that the next largest land use class is following up with only a fraction of the land use, not even amounting to one percent compared to agricultural land that would be substituted. Therefore in our analysis for Wallonia, we can concentrate on the impact of changing agricultural land to SRC.

Nature value

Like in Flanders, introducing SRC on agricultural land will probably have a beneficial effect on nature value. Two factors will influence the extent to which this value is increased. The first factor is the increase in heterogeneity in the landscape. While some of the SRC search areas in Flanders are very homogenous agricultural lands, this is to a lesser extent the case in Wallonia. This means that nature is already better connected in Wallonia and connectivity gains from SRC might therefore be less marked than in Flanders. Secondly, as was seen in the models for Flanders, the gains in scores 4 and 5 for nature value, and thus the most valuable areas, are predominantly adjacent to where there are already cores of high nature value. While both Flanders and Wallonia have a very dire conservation status of protected habitats (INBO, 2019; SPW environment, 2021) different spreads in cores of high nature value can influence the final result.

A last consideration is the scale of the potential SRC implementation, which is of importance. Where in Flanders a vast area would potentially be planted with SRC, in Wallonia this total area would be smaller, but also in size of the parcels. As we know that SRC is mainly a good habitat for generalist species and that more demanding species only use it as a stepping stone, the real added value of large implementation in Flanders will be rather low, while the patchy implementation in Wallonia might be more successful for increasing nature value.

Carbon storage

Just as in Flanders we can expect the potential soil organic carbon stock to increase when introducing SRC on a large scale. Because in Wallonia SRC would almost exclusively be planted on agricultural land, we could even expect it to be an even more marked relative increase than in Flanders where also some land uses with a high potential stock are converted such as shrubs and semi-natural grassland. The gain in Wallonia would of course not be an absolute gain as only a smaller area is converted.

However, this effect could be mitigated by the fact that in Wallona the land use class of agriculture includes grassland in the fodder production class. 31.729 ha of the category of "Prairie et fourrage" would be substituted by SRC in scenario 3. It is impossible to estimate the permanent character of these grasslands, but their soil organic carbon will most probably not be as high as the natural and historic grasslands which were excluded from being planted with SRC. Nonetheless, the inclusion of this category in agricultural lands could have the effect that the potential carbon stock is not increased as much as would be expected if the same definition of agricultural land were taken as in Flanders.

Temporary water retention

The temporary water retention will probably increase in Wallonia as it does in Flanders under large scale implementation of SRC. In Flanders this was mainly due to the substitution of SRC of other land use classes than agricultural classes. This means that the gains in Wallonia will probably not be as marked as in Flanders. Other differences could come from different fluctuations in the water table. As the soils in Wallonia are less sandy, the difference between the low water table (GLG) and the high water table (GHG) could be lower than in Flanders. This would mean that the temporary water retention in Wallonia is lower, but also that it is less needed in that case.

Basin storage

Basin storage can also be expected to increase for Wallonia, as it did in Flanders. However, as we saw in Flanders that in fact most farmers already had crops in the areas prone to inundation that were adapted to it, we can expect the same to happen in Wallonia.

Two additional considerations should be made. First, grasslands make up a large part of the agricultural area substituted by SRC in scenario 3 in Wallonia. The gains in basin storage would therefore probably be less marked than in Flanders. On the other hand, Wallonia has a proportionally higher flood-prone area, especially in the loamy areas where much of the SRC would be implemented (Halbardier & Becker, 2021). This would increase the impact. The net effect is hard to estimate.

Water infiltration

According to the ES-model of Flanders, water infiltration decreased under large scale implementation of SRC. The effect was largest on those soils that were already less permeable. Therefore the decrease could even be higher in Wallonia which has more loamy, clay and stony soils.

Denitrification

Denitrification can be expected to increase in Wallonia as it did in Flanders under large scale SRC implementation. Due to the larger share of agricultural land that would be converted to SRC, this increase would even be more marked. The effect of the water table in Wallonia is difficult to take into consideration but would of course influence the final result.

Wood production

Just as in Flanders, wood production would increase significantly in Wallonia under large scale implementation of SRC. In absolute numbers the effect would be much lower as the area being converted to SRC is not even half as large in Wallonia as it is in Flanders. The soil quality of the parcels in the Loam area in Wallonia would be very suitable for SRC, as would the clay soils in the rest of Wallonia. Therefore it is possible that the productivity of SRC is higher in Wallonia than in Flanders where there are more sandy soils. To provide an estimate of the possible total biomass yielded in Wallonia under the most intensive scenario, we could take the average yield of SRC in Flanders and multiply it with the surface of search areas in Wallonia. This would result in about 1,9 million ton DM for the whole of Wallonia.

Erosion protection

In analogy with Flanders, the erosion protection would increase in Wallonia when SRC would be implemented on a large scale. As slopes increase in Wallonia, this effect will arguably be relatively greater in Wallonia. Combined with the erosion-prone nature of loamy soils, this could be an additional benefit of planting SRC in Wallonia against soil erosion.

Pollination

The effect of the large scale implementation of SRC in Wallonia on pollination would probably be also beneficial, as would be the case in Flanders. Additionally, as SRC is almost exclusively substituting agricultural land, this effect would be higher. About 10% of the agricultural crops that SRC would substitute are insect pollinated. If the grasslands are considered to be solely fodder with little to no diversity, SRC would effectively increase the habitat for pollinators in Wallonia as well.

Food production

The area currently used for food production that would shift to SRC under scenario 3 is with 111.670 ha about 15% of its total area under agricultural production. The main crops being substituted are cereals and similar crops (50.000 ha) and fodder crops (35.000 ha). Also for

Wallonia it is clear to see that a large share of the crops that are substituted are for animal protein production or first generation biofuels and not directly for human consumption.

4.5 ES Scenario comparison local scale

The Nature Value Explorer (NVE) was applied in this study for two reasons: (1) it can deliver a quantitative evaluation of the ESs when implementing SRC in the SRC search areas and (2) by trying out two different measures in the NVE (small landscape elements and poplar forest) for SRC, it is possible to compare which NVE-measure is more representative for SRC.

While currently there is no specific measure for SRC present in the NVE, we evaluated the measures of small landscape elements (SLE) and poplar forest as replacement for SRC. From the results it is clear that SLE do not register wood production as an ecosystem service. SLE seems to have a negative effect on carbon storage in the soil and no effect on carbon storage in its biomass. Poplar forests on the other hand, deliver biomass and store carbon in the soil and biomass. The remaining ecosystem services that are provided, such as food production, infiltration capacity, erosion prevention, denitrification, and pollination, have the same effect and magnitude for both measures. Because biomass production is at the core of the choice to plant SRC, we can conclude that the measure ‘poplar forest’ is more representative for short rotation coppice than small landscape elements.

Naturally, this simplification introduces some over- and underestimations of the harvestable wood a poplar stand provides. The wood production of poplar forest per hectare will be expressed in solid wood. In reality SRC delivers small branches and twigs every few years. A second remark is the carbon storage in the soil, which depends on rotation cycles and the implemented land use after the SRC. The results should be analysed with care.

Here we will discuss the ecosystems provided by the poplar forest as measure for scenario 1.

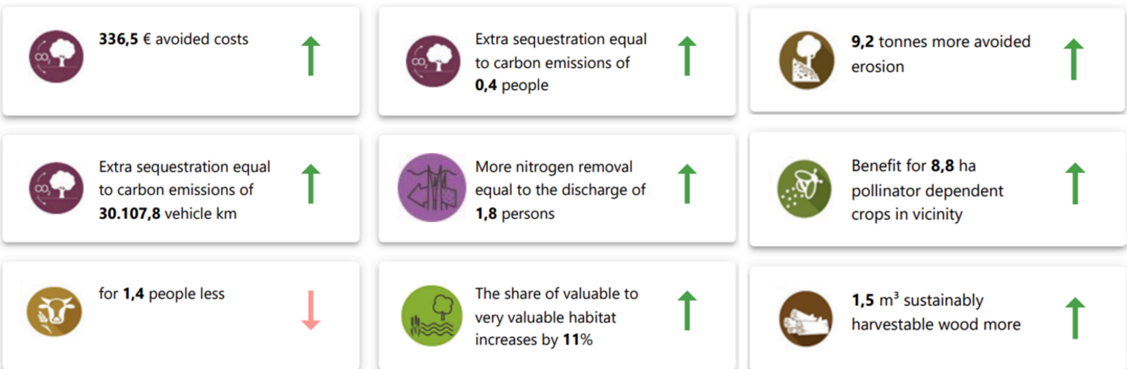

Figure 39: Dashboard from the NVE of the services delivered by 10% SRC

Nature value

The implementation of a linear poplar forest causes a rise in nature value of the parcel of 11%. The nature value is calculated differently in the NVE than with the Gobelin tool. All the measures are scored according to their rarity, biological quality, vulnerability and substitutability. While the scores for each measure are not publicly available, it is clear and logical that a poplar forest receives a higher score than agricultural land. As SRC has a much higher tree density than a poplar forest, the biological value will probably differ. The rarity would be higher, the biological quality would be lower as fauna is not regarded in the calculations and the density of SRC inhibits most plants to grow underneath. The vulnerability would probably be lower as the high amount of trees gives more insurance effects in the ecosystem, but on the other hand the low genetic diversity could also increase the vulnerability. The substitutability is for both a poplar and for SRC high.

Carbon storage

A linear poplar forest stores carbon in the soil and in its biomass. The provided carbon storage in soil and biomass in comparison with the original agricultural land use is 1,5 ton C/year. This will probably be an underestimation for SRC as the root system of SRC gets more developed than that of poplar forests and partly die off during harvest, to regrow again afterwards. This is an extra carbon input into the soil. Also the carbon in the biomass will probably be higher as was also modelled in Gobelin. However, the wood will of course be of lesser quality and if used for energy, will not be contributing that much towards climate mitigation as a full-grown poplar might when used for materials.

Water infiltration

The infiltration stays the same before and after implementation of a poplar forest. The infiltration capacity is calculated in the same way as the Gobelin model, taking into account the soil characteristics, height of the water table and the interception by the vegetation. While agricultural land has a lower interception and should therefore, just like in the Gobelin model, have a higher infiltration capacity than the linear poplar forest, this is not reflected in the results. This can be explained by the fact that we chose a parcel in a flood prone area where probably the water table is very high, therefore not allowing any infiltration, regardless of the interception. The interception of a poplar forest is probably lower than for a SRC, but this is an error that was also introduced in the Gobelin model where all forest types had the same score.

Denitrification

A linear poplar forest removes nitrogen from the soil when substituting arable land. The denitrification potential of the patches is 9,7 kg of Nitrogen per year, 6,2 kg more than the agricultural parcel could. This ES is calculated differently than in the Gobelin model, estimating the denitrification based on the nitrogen load of the groundwater in the parcel. The gain in denitrification comes from the avoided washout through substituting agricultural land use and therefore limiting the above-ground nitrogen input. The difference between a linear poplar forest or SRC would probably be limited regarding the denitrification potential as both measures are limiting the nitrogen input.

Wood production

Planting a linear poplar forest increases the wood production of the parcel to 1 m^3/year. These estimates are based on the Sim4Tree tool (Daelemans *et al.*, 2015) which uses the tree species in combination with the soil suitability for this tree to estimate the annual increment. The wood production is calculated for round wood and therefore not including the BEF that was used in the Gobelin model. For SRC the NVE would therefore report no wood production at all as the wood cannot be considered as roundwood. Nonetheless, from our estimates done for Gobelin, we know that the annual increment of SRC will be higher than for a linear poplar forest, if regarding all types of woody biomass and not just the trunk. To make the comparison, the NVE would report a production of 0,6 ton DM/year for the selected parcel, when taking the biomass expansion factor and the wood density of Gobelin for poplar (Smets J., Stevens M., 2019). Taking into consideration the total area of the parcel selected in NVE as being 3,19 hectares, this would mean an average yield of 2 ton DM/ha.

Erosion control

Planting a linear poplar forest on an erosion-prone parcel decreases the estimated erosion with 0 to 18 tons of soil per year. The NVE uses the same formula that also underpins the Gobelin tool. However, at this small scale it seems difficult to draw conclusions on the erosion protection measure as the interval includes zero. SRC would potentially have a higher erosion protection through an increased interception of the water falling directly on the soil. However, there could be less soil cover with SRC, limiting this effect.

Pollination

Pollination increases when planting a linear poplar forest. The NVE calculates the service through assessing the nesting suitability and the food sources for pollinators of a land use, as does the Gobelin tool. However, the NVE adds a component which is the demand for pollination from nearby crops. Therefore the score becomes very place specific. This is of course not taking into account the need of nature itself for pollinators. SRC would have a lower suitability for pollinators as the trees normally do not reach the age where they start to flower as opposed to the linear poplar forest.

Food production

The NVE model also allows us to calculate the food production gain or loss from implementing a measure. When planting linear poplar forests of 0,32 hectares there is a loss of agricultural production that could feed 1,4 people per year which means a financial loss for the farmer of between €254 and €407 of foregone profits for this food. The amount of people that could be fed by this parcel is calculated based on the average area a Flemish person would need to meet its dietary requirements. However, this of course does not take into account that a part of the food that we produce in Belgium is used for export and that we also import food. Therefore we cannot interpret this as real loss of food but rather as the opportunity cost when not using this complete area to feed Flanders.

In Scenario 3 all of the land is converted to SRC which leads to higher effects of the ecosystem services. Interestingly, the increase is not linear as would be expected. The ecosystem services of carbon sequestration, food production, denitrification and biomass production scale less than linear, meaning that they do not increase tenfold as the area does. On the other hand, nature value and erosion protection scale more than linear. The whole substitution of the parcel with poplar forest significantly decreases the area for which pollinators provide their services.

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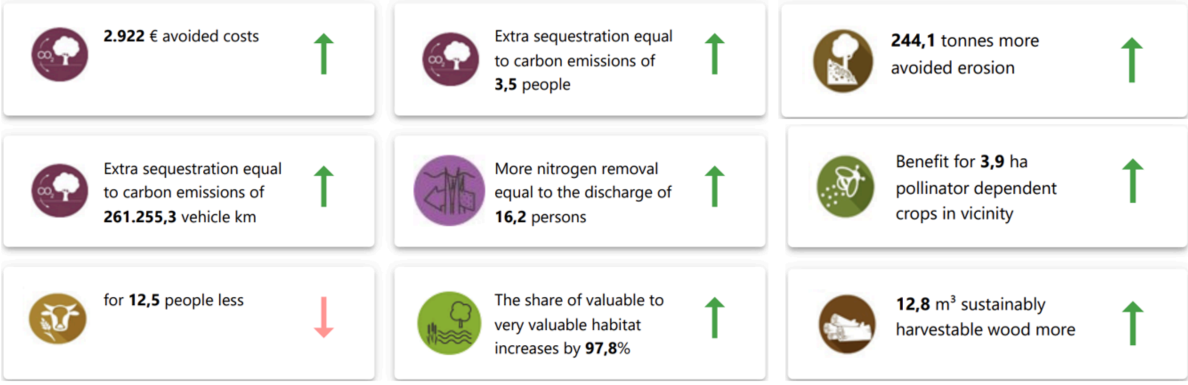

Figure 40: Dashboard from the NVE of the services delivered by 100% SRC

From this exercise we can conclude that the main trade-off when introducing SRC on an agricultural parcel is between the lost agricultural production and the gain in all the other estimated services. Even in scenario 1 where the decrease of food production is minor the effect on erosion control, C-storage and climate mitigation is major. It shows that installing SRC provides benefits to the farmer but most importantly society, which are paid for in lost agricultural production.

4.6 SRC AS PART OF AGROFORESTRY

There is no method available to calculate the differences in ES when installing SRC as part of an agroforestry system. However, with the above calculations for local, small scale implementation of SRC we can make an estimated guess.

Depending on how SRC is implemented, it can contribute to the **nature value** of a parcel, as did the whole substitution in scenario 3 and the partial substitution of scenario 1. SRC contributes to biodiversity when combined with cultivated areas of arable food crops in alley-cropping (Haughton *et al.*, 2016). Incorporating SRC, either in the form of silvicultural or silvopastoral agriculture, will add up to the **carbon sequestration** of the farmland. SRC reduces soil respiration and even acts as a net carbon sink by expanding the root structure and transferring carbon to the soil (Harris *et al.*, 2017; Morrison *et al.*, 2019). In an alley-cropping agroforestry system, extra environmental benefits are delivered in the form of erosion control, protection against evaporation and **retention** (Lamerre *et al.*, 2015). On larger fields, agroforestry systems with SRC reduce the risk of soil **erosion** and provide a more protective microclimate for arable crops (Rutz, Dominik & Dimitriou, Ioannis, 2015). Where SRC is combined with cattle, the tree leafs can be valorised as livestock fodder and where combined with chickens SRC also has a positive effect on their well-being without negatively affecting the production of SRC (Stadig *et al.*, 2020).

We can conclude that much of the ES delivered by the small scale implementation of SRC are also provided in agroforestry systems. The main difference is however that the agroforestry is specifically designed with SRC as a productive element within the farm management and therefore we can assume that even more care will be taken to maximise the benefits and minimise the trade-offs than SLE on a regular farm.

5 COMPARISON OF THE SCENARIOS

In this report we compared three different scenarios for the integration of more SRC in our Belgian landscape with the current baseline. Below, the figures of land use change towards SRC are summarised for all scenarios in Flanders except scenario 2 (SRC as agroforestry).

Tabel 7: Overview of SRC area estimations, for different SRC scenarios in Flanders

Scenario	Region	**Area of SRC (ha)**	**Biomass (ton DM/year)**
SCEN 0 - Baseline: current situation SRC	Flanders	46	642
	Wallonia	31	432
	Belgium	77	1.074
SCEN 1 - SRC as small landscape elements	Flanders	14.621	203.963
	Wallonia	8.360	116.623
	Belgium	22.981	**320.586**
SCEN 3 - SRC as intensive cultivation	Flanders	273.700	3.818.115
	Wallonia	139.334	1.943.709
	Belgium	413.034	**5.761.824**

Currently there are only 46 hectares of SRC in Flanders. Introducing SRC as small landscape elements with 10% in flood-prone and erosion-sensitive zones and 5% outside of these zones, would increase the potential area to 14.621 hectares. If on the other hand all SRC search areas would be planted full with SRC, the potential area of SRC in Flanders would increase to 273.700 hectares. For Wallonia, there is less potential for SRC with the most intensive scenario yielding 136.521 ha, almost exclusively on agricultural land while an integration as small landscape elements would yield 8.360 ha. For reference, the current forest area for Flanders is estimated to be 145.000 ha[5] and for Wallonia 560.000 ha[6].

When considering the amount of biomass that these scenarios would yield, the most intensive scenario would produce about 1,9 million ton DM for Wallonia and 3,8 million tons of DM for Flanders, adding up to a hypothetical 5,7 million ton DM. Scenario 1 would yield 0,3 million ton DM for the whole of Belgium. For reference, the current supply of wood in Flanders is estimated to be 0,3 million tons DM per year (Vandekerkhove et al., 2014) while for Wallonia this is about 1,6 million tons DM per year[7].

In all scenarios we could see that SRC delivers most ecosystem services more than the land use it substituted. While the regional and local models cannot be compared one to one, it is most probable that SRC as a small landscape element or in agroforestry will deliver the same ecosystem services with less trade-offs than the intensive SRC. The main trade-off of implementing SRC is with agricultural production. The amount of agricultural land that would be substituted in scenario 3 would be about 190.000 in Flanders and 110.000 in Wallonia. This is of course a very substantial amount. The picture changes slightly when only regarding the

[5] https://www.vlaanderen.be/inbo/indicatoren/oppervlakte-bos-in-vlaanderen (consulted on 25/06/2024)
[6] http://etat.environnement.wallonie.be/contents/indicatorsheets/RESS%204.html (consulted on 25/06/2024)
[7] http://etat.environnement.wallonie.be/files/Publications/EEW%20en%2010%20Infographies%20-%20Traductions/The%20Walloon%20environment%20en%2010%20infographics-10-Forests.pdf (consulted on 25/06/2024, density factor of 0,41 ton DM/m^3 used from Smets and Stevens, 2019)

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substitution of those crops that are directly used for human consumption, which amounts to about 70.000 hectares in Flanders and 60.000 in Wallonia. This reduction should not come as a surprise as about 50% of all crops grown in Flanders are fodder crops (Platteau & Van Bogaert, 2024). Future dietary changes and increasingly stringent environmental measures for animal husbandry farms will probably decrease the demand for these fodder crops and therefore increase the availability of land for other (agricultural) uses. It is highly unlikely however, and arguably undesirable that this area would be used completely for SRC.

Scenario 1 gives a much more balanced and achievable vision for SRC for the future. With 14.621 ha, the surface of SRC as small landscape elements in Flanders would contribute to an increase in a number of ecosystem services while limiting the competition with food production. The area still surpasses the pledged 10.000 hectares of re- and afforestation of the Flemish government. However, the linear nature of the plantations would be a more socially acceptable way of planting trees on agricultural land as it can be rightfully framed as regeneration of a former, more diverse and resilient, agricultural landscape. Moreover, it would probably not increase the prices of agricultural lands to the same extent as afforestation or conversion to SRC plantations could, limiting the distributional justice problems. In scenario 2 we overcome the contradictions between SRC and agriculture in the form of agroforestry. While this of course requires more knowledge of the farmers, the results could be beneficial as discussed). The services that are provided by the SRC can be beneficial for agricultural production and thereby minimise the trade-offs and maximise the synergies.

6 CONCLUSION

Belgium still has a large potential for increased woody biomass production through different forms of SRC. The amount of land that hypothetically could be available for SRC ranges up to 410.00 hectares. Most of the land is now under agricultural production. SRC delivers a range of ecosystem services that are beneficial to both private owners (wood production, pollination for farmers) and society (erosion risk management, flood mitigation, carbon sequestration, supporting biodiversity). It delivers most of these services to a higher degree than the agricultural production it primarily would substitute in our expansion scenarios, though there is of course a marked trade-off with food production. Therefore, any expansion of SRC should be accompanied by a transition of the agricultural system to avoid tele-coupling effects and unwanted socio-economic effects. The expansion scenario where SRC is planted as small landscape elements is the most promising, as it generates the same ecosystem services but minimises the trade-off with food production. SRC can be even successfully integrated into agricultural production in the form of agroforestry.

In the scenario of expanding SRC as small landscape elements, the available woody biomass could increase by 0,3 million tons of dry matter per year. In our most intensive expansion scenario, the woody biomass production for Belgium would increase with 5,7 million tons of dry matter per year, which is a stark increase from the estimated 1,9 million tons of dry matter that are currently being produced each year in Belgium. While we do not presume that any of the two scenarios will be played out in the future, our exercise does point at the realistic possibility of increasing our domestic production of woody biomass and the role that SRC could play in this.

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8 APPENDIX

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Annex 1 Adlibio model

This Annex gives an overview of the different models used in the AD-LIBIO project. The first 3 models ('ADL_basiskaart_2022', 'Restrictions' and 'Scenarios') were developed for the project. The other models to calculate ecosystem services are entirely based on the Gobelin model', with the necessary changes discussed in § 2.5.1. The spatial datafiles used in the models are explained in Annex 3 and 4.

Annex 1: Overview of the different models used in the AD-LIBIO project.

Model name (ArcGIS Toolbox)	**Description** (ES = ecosystem service)	**Input** (spatial data layers)	**Output** (rasters)
ADL_basiskaart_2022	Model to create an updated baselayer (current landuse including SRC), to use in the Gobelin models.	- landbouwgebruikspercelen_2022 - niveau1_vla_2022_v3	ADL_basiskaart_2022 (landuse map including SRC)
Restricties	Model to create a restriction map of locations where SRC is excluded.	- Helling (slope) - FG_akker, FG_fruit, FG_groenten (soil suitability maps for agriculture) - ps_hpg_besch_grsl_20190205, LbGbrextractie20230626 (permanent grasslands) - natura2000, ps_ven (protected areas) - BWKhabitat_v2023 (valuable nature and habitats) - Bgavs (management areas farmland birds) - niveau1_vla_2022_v3, niveau2_vla_2022_v3, niveau3_vla_2022_v3, niveau4_vla_2022_v3 (construction, water bodies, forests)	koh_restrictions
Scenarios	Model to create the baselayers (landuse with SRC search zones) used in the different scenarios.	- koh_restrictions - koh_zoekzones (SRC search areas) - ADL_basiskaart_2022	ADL_SCEN3
K01_Natuurwaarde	ES Nature value	- table resistances - land use map level 1 - plots under nature management - old forest - Biological Valuation Map	K01_Natuurwaarde
K07_Copslag	ES Carbon storage	- K00_GBN_basiskaart - GBN_basistabel - drainage_inclPol_vol (drainage classes from soil	K07_Copslag

		map, including Polders) - textuur_inclPol_vol (texture classes from soil map, including Polders) - GBN_tbl_pct_bodem - GBN_tbl_grondwater	
K08A_retentie	ES Retention	- K00_GBN_basiskaart - GBN_basistabel - GLG_tpi (average low groundwater level, taking into account topographic position index) - GHG_tpi (average high groundwater level, taking into account topographic position index)	K08A_retentie
K08B_komberging	ES Basin storage	- K00_GBN_basiskaart - flood-prone areas - GBN_basistabel	K08B_komberging
K08C_infiltratie	ES Infiltration	- K00_GBN_basiskaart - GBN_basistabel - 06_1_1_PotentieleInfiltratie.tif	K08C_infiltratie
K08D_denitrificatie	ES Denitrification	- K00_GBN_basiskaart - GLG_tpi (average low groundwater level, taking into account topographic position index) - GHG_tpi (average high groundwater level, taking into account the topographic position index)	K08D_denitrificatie
K11_biomassa_hout	ES Biomass wood	- K00_GBN_basiskaart - GBN_basistabel - GBN_tbl_houtaanwas (conversio table for binary maps of crops) - text_drain_combine_K11 (map of all texture and drainage combinations in Flanders)	K11_biomassa_hout
K12_erosie	ES Erosion	- K00_GBN_basiskaart - GBN_basistabel - textuur_inclPol_vol (texture classes of the soil map, including Polders) - Reliëf_LSFactor_10m (uit ECOPLAN)	K12_erosie
K13_bestuiving	ES Pollination	- K00_GBN_basiskaart - GBN_basistabel - GBN_tbl_landbouwgewassen	K13_bestuiving

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ANNEX 2 ES SCORES

The table below gives an overview of all the scores used in the different ecosystem service models. Scores are given to all land use classes used in the model. This table corresponds to the base table of the Gobelin model (GBN_basistabel), completed with the scores for the new land use class ‘short rotation coppice’. The latest version of the land use map (2022) uses a number of different land use classes, hence the score-table differs slightly from the original one used in the Gobelin model.

Tabel X: Overview of scores for all ecosystem service models, and this for each land use class

Label	Value	K07_Carbon storage	K08A_Retention	K08B_Basin storage	K08C_Infiltration	K08D_Denitrification	K11_Biomass wood	K12_Erosion	K13_Pollination
shrub and thicket	1	4	8	4	56	1	0	10	90
deciduous forest	2	1	10	3	56	1	2	1	85
poplars	3	1	10	5	56	1	3	1	85
coniferous forest	4	1	10	3	56	1	1	1	55
alluvial forest	5	1	10	5	56	1	2	1	85
semi-natural grassland	6	4	10	4	72	1	0	10	90
heathland	7	3	10	3	78	1	0	10	95
coastal dune	8	3	7	5	100	1	0	800	20
marsh	9	4	9	5	61	1	0	10	52
mudflats and salt marshes	10	4	9	5	72	1	0	500	42
farmland	11	2	9	4	78	0	0	500	20
non-registered agriculture	12	2	9	4	78	0	0	370	20
tall-stem orchard	13	1	5	3	56	0	0	10	65
low-stem orchard	14	1	5	4	72	0	0	50	65
temporary grassland	15	2	9	4	78	0	0	60	20
other forests	16	1	5	4	56	0	2	1	30
permanent grassland	17	4	10	4	78	0	0	10	25
other permanent crops	18	2	9	4	78	0	0	500	20
building	19	0	0	1	0	0	0	0	0
other low green	20	4	7	4	72	0	0	10	25
other high green	21	1	5	4	56	0	2	1	30
road	22	0	0	2	0	0	0	0	0
railway	23	0	1	2	0	0	0	0	25
water	24	0	0	5	0	0	0	0	0
other	25	0	0	2	0	0	0	0	0
lane trees	26	1	5	4	71	0	2	1	30
low street green	27	4	7	4	72	0	0	10	25
short rotation coppice	883	1	10	5	56	1	4	1	55

Annex 3 Spatial data files Flanders

Overview of the spatial data files used in the SRC scenarios.

Spatial data Flanders	Use in the SRC scenarios
Land use Flanders, status 2022 Filenames: ● Niveau1_vla_2022_v3 (Land cover) ● Niveau2_vla_2022_v3 (Urbanised Land Use) ● Niveau3_vla_2022_v3 (Multi-purpose land use) ● Niveau4_vla_2022_v3 (Juridical Destinations) Source: Departement Omgeving	Landuse baselayer for Gobelin model (ecosystem services) For the AdLibio project, an extra land use class (Value 883) was added for short rotation coppice, based on the agricultural use parcels registered as short rotation coppice. This new raster is called ADL_basiskaart_2022 Restriction for SRC: Different types of construction and water bodies are excluded for SRC. ● Niveau1_vla_2022_v3: selection of raster Value = 19 (Building) OR Value = 22 (Road) OR Value = 23 (Railway) OR Value = 24 (Water) OR Value = 25 (Other) ● Niveau2_vla_2022_v3 (Urbanised land use): all land use codes are excluded ● Niveau3_vla_2022_v3 (Multi-purpose land use): all land use codes are excluded ● Niveau4_vla_2022_v3 (Juridical destinations): all land use codes are excluded Different types of forests are excluded for SRC. Selection of raster Value = 2 (Deciduous forest) OR Value = 3 (Poplars) OR Value = 4 (Coniferous forest) OR Value = 5 (Alluvial forest) OR Value = 16 (Other forests)
Agricultural use parcels, status 2022 Filename: Landbouwgebruikspercelen_2022 (Lbgebrperc2022) Source: Departement Landbouw en Visserij	Selection of parcels with short rotation coppice (code 883 in field 'HFDTLT')
Slope map (Watertoets) The slope map for the purpose of the water assessment shows	Technical restriction for SRC harvest: <10% (suitable)

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the slope (in %) of the site in a grid of 5 by 5 metres. The slope map is classified into 4 classes in accordance with the table of runoff coefficients as appended to Annex VIII of the water assessment decision: slopes less than 0.5%, from 0.5 to 5%, from 5 to 10% and slopes greater than 10%. Filename: Helling Source: VMM	10-20% (limited suitability) >20% (unsuitable) Restriction for SRC: Selection of raster value = 4 (>10%)
Agricultural suitability maps: crop suitability for 5 crop groups (grassland, arable farming, maize, vegetables and fruit). Agricultural experts estimated production potential of different soil types, for a specific crop group. Filenames: ● Fysische geschiktheid voor akkerbouw ● Fysische geschiktheid voor fruit ● Fysische geschiktheid voor gras ● Fysische geschiktheid voor groenten ● Fysische geschiktheid voor maïs Source: INBO (NARA-T 2014)	5 suitability classes based on yield: ● very suitable (100%) ● suitable (80%) ● moderately suitable (60%) ● slightly suitable (40%) ● unsuitable (15% - 20%) Restriction for SRC: Locations that are very suitable (Value = 100) and suitable (Value = 80) for arable farming, vegetables and fruit are excluded (overlap of all values).
Historically permanent grasslands (HPG 2019) Contains all historically permanent grasslands and all permanent grasslands (in the Flemish Ecological Network) in Flanders that are protected by nature legislation Filename: ps_hpg_bsch_grsl.shp Source: ANB	All permanent grasslands are excluded for SRC Restriction for SRC: Selection of all polygons

Permanent grasslands (5 years) Any parcel that is maintained as 'Grasses and other herbaceous forage' for a period of five consecutive years becomes 'Permanent Grassland'. Filename: LbGbrextractie20230626 Source: Departement Landbouw en Visserij	All permanent grasslands are excluded for SRC Restriction for SRC: Selection of STAT_BGV = 'BG'
Special Protection Zones (Natura 2000 areas) Filename: natura2000_201301.shp Source: ANB	Locations of special protection zones, are excluded for SRC. Restriction for SRC: Selection of all polygons
Flemish Ecological Network Filename: ps_ven.shp Source: ANB	Areas within the Flemish Ecological Network are excluded for SRC Restriction for SRC: Selection of all polygons
Biological valuation map (period 2000-2023), including habitats and regionally important biotopes Filename: BWKhabitat_v2023 Source: INBO	The following features are excluded for SRC: ● Selection of values "z" (biologically very valuable), "wz" (complex of biologically valuable and very valuable elements) and "w" (biologically valuable) from the "valuation" field (= "EVAL") ● Selection of habitats and regionally important biotopes. SQL expression: (HAB1 <> 'gh') OR (HAB2 <> 'gh' AND HAB2 <> '') OR (HAB3 <> 'gh' AND HAB3 <> '') OR (HAB4 <> 'gh' AND HAB4 <> '') OR (HAB5 <> 'gh' AND HAB5 <> '')
Management areas for farmland bird species (2017) Filename: Bgavs.shp Source: VLM	Core areas (*Kern15000ha, Kern25000ha, Priokern*) and search zones (*Zoekzon*e) are excluded for SRC (see priority-field). Restriction for SRC: selection of all polygons

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Protected heritage Designation objects (protections and determinations)	Restriction for SRC: selection of all polygons of the following datasets ● Bes_arch_site (Protected archaeological site) ● Bes_landschap (Protected landscape) ● Bes_monument (Protected monuments) ● Bes_sd_gezicht (Protected town or villagescape) ● Erfgoedls (Heritage Landscape) ● 'Unesco_buffer' and 'Unesco_kern' (UNESCO World Heritage Site)
Potential soil erosion map by parcel (2023) Filename: Potbdmerosiepp_2023.shp Source: Databank Ondergrond Vlaanderen (DOV)	Selection of values 'very high' and 'high' from the field 'Total_erosion'.
Flood hazard maps Fluvial dataset, current scenario (hCC) Filename: waterdiepte_FLU_hCC_T100.tif Source: VMM	Delineate flood prone areas
Traditional landscapes (map and description features and policy preferences) Source: UGent	Location of small landscape elements

Annex 4 Spatial data files Wallonia

Spatial data Wallonia	Use in the SRC scenarios
Land use map of Wallonia, 2018 Filename : WAL_UTS__2018 Source : Géoportail de la Wallonie	A land use map including current occurrence of SRC is created based on the agricultural use parcels registered as short rotation coppice. This new raster is called CurrentLU_Reclass. Restriction for SRC: All land uses are excluded for SRC, except Agriculture, Commercial agricultural production, Grasslands, Arable lands and Christmas trees. Abandoned areas are also excluded for SRC, although these represent 1.3% of Wallonia. These are defined as abandoned agricultural, residential and industrial, transport and basic infrastructure areas. These areas are not in use and can no longer be used for the original purpose without major restoration work. Selection of values '1_1' (Agriculture), '1_1_1' (Commercial Agricultural Production), '1_1_1_A' (Grasslands), '1_1_1_B' (Arable lands), '1_1_1_C' (Christmas trees) from the field « WALOUSMAJ »
Agricultural use parcels, 2021 Filename: SIGEC_PARC_AGRI_ANON__2021.shp Source: Géoportail de la Wallonie	Selection of parcels with short rotation coppice (code 883 in field 'CULT_COD').
Slope map The slope map is created from the Digital Elevation Model LiDAR 2013-2014 with a spatial resolution of 1 m. The slope is expressed as a percentage (%) and classified into 9 categories: <1%, 1-3%, 3-5%, 5-7%, 7-10%, 10-15%, 15-27%, 27 -58% and	Technical restriction for SRC harvest: <10% (suitable) 10-20% (limited suitability) >20% (unsuitable) Restriction for SRC:

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slopes > 58%. Filename : RELIEF_WALLONIE_MNP_2013_2014__CLASSES.tif Source: Géoportail de la Wallonie	Selection of classes >= 6
Agricultural soil suitability Filenames: Bodem_wal.shp (Carte des sols de la Belgique de l'IRSIA) 'Bodem_wal selection' exported as 'BestSoils.shp'	Most suitable soils for agriculture were excluded for SRC using a method elaborated by Morelle & Lejeune (2000). The method determines the agricultural soil quality in Wallonia based on texture and drainage. Restriction for SRC: selection from the field "SIGLE_REST" of values containing: ● Ub or UA or UB (heavy clay with good drainage) ● Eb or EA or EB (clay with good drainage) ● Ab or AA or AB (silt with good drainage) ● Lb or LA or LB (sandy silt with good drainage) ● Lc or LD (sandy silt with moderate drainage) ● Zd or ZD (sand with low drainage)
Permanent and diversified grassland Filename: ecotopes2022_v419 Source: LifeWatch ERIC	Restriction for SRC: Selection of values "130" (Permanent monospecific productive grassland) and "135" (Diversified shrubland and grassland) from the field LCCSb
Special Protection Zones (Natura 2000 areas) Filename: NATURA2000__PERIMETRES.shp Source: Géoportail de la Wallonie	All locations of special protection zones are excluded for SRC. Restriction for SRC: Selection of all polygons
Nature conservation areas Areas derived from the law of 12 July 1973 on nature conservation. Filenames:	All locations within nature conservation areas are excluded for SRC. Restriction for SRC: Selection of all polygons

● CONSNAT__CSIS.shp (Underground cavities of scientific interest) ● CONSNAT__RAMSAR.shp (Ramsar sites) ● CONSNAT__RES_FOR.shp (Forest reserves) ● CONSNAT__RN_AGR.shp (Private nature reserves) ● CONSNAT__RN_DOM.shp (National nature reserves) ● CONSNAT__ZHIB.shp (Humid areas with biological interest) Source : Géoportail de la Wallonie	
Biological valuation map (Period 2000-2023) Filename: BWK.tif Source: VITO	Restriction for SRC: Selection of values "z" (biologically very valuable), "wz" (complex of biologically valuable and very valuable elements) and "w" (biologically valuable) from the "valuation" field (= "EVAL")
Farmland bird species Filename: Beheergebieden-akkervogels-Wallonie_Bruine-kiekendief Source: INBO	Restriction for SRC: Selection of all polygons

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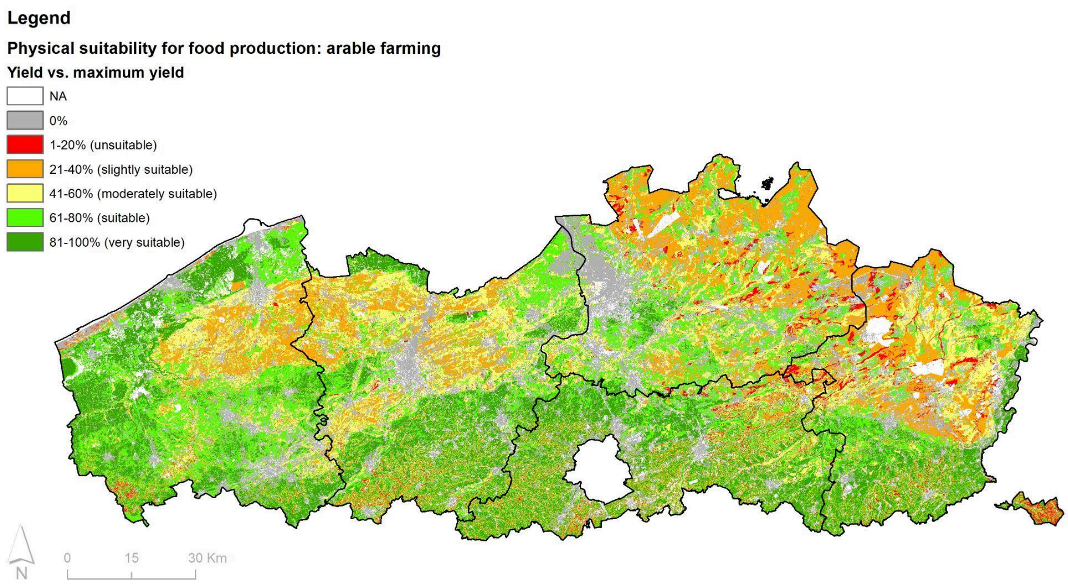
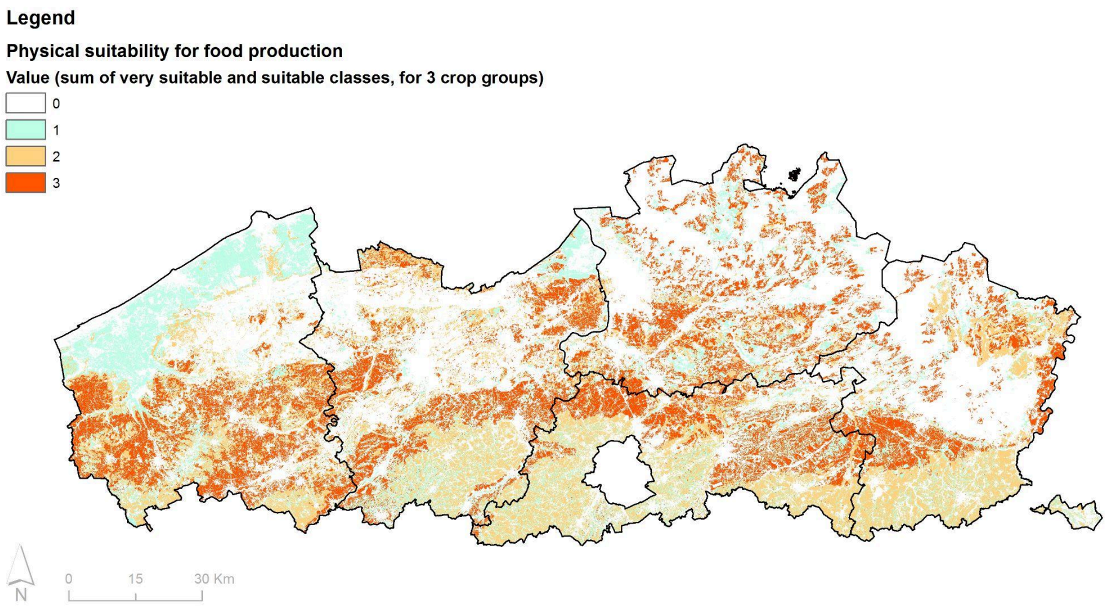
ANNEX 5 AGRICULTURAL SUITABILITY

The map below shows the physical suitability for food production, and this for the crop group 'arable farming'. Suitable and very suitable areas are marked in green. Similar maps exist for the other crop groups (grassland, maize, vegetables and fruit).



To select locations to be excluded from SRC scenarios, all the green classes (suitable and very suitable) were selected for all crop groups, except grassland and maize. For each crop group, a raster was created with values 0 and 1, with value 1 standing for the green, most suitable classes. When calculating the sum of all these rasters, the highest value (value 3 marked in red on the map below), visualises all locations most suitable for all crop groups. These locations are excluded for SRC.



Annex 6 Protected heritage

When planting short rotation coppice, protected heritage sites such as protected landscapes, protected archaeological sites, protected town and village sites, heritage landscapes, protected monuments and UNESCO World Heritage Sites should be taken into account (see Figure X).

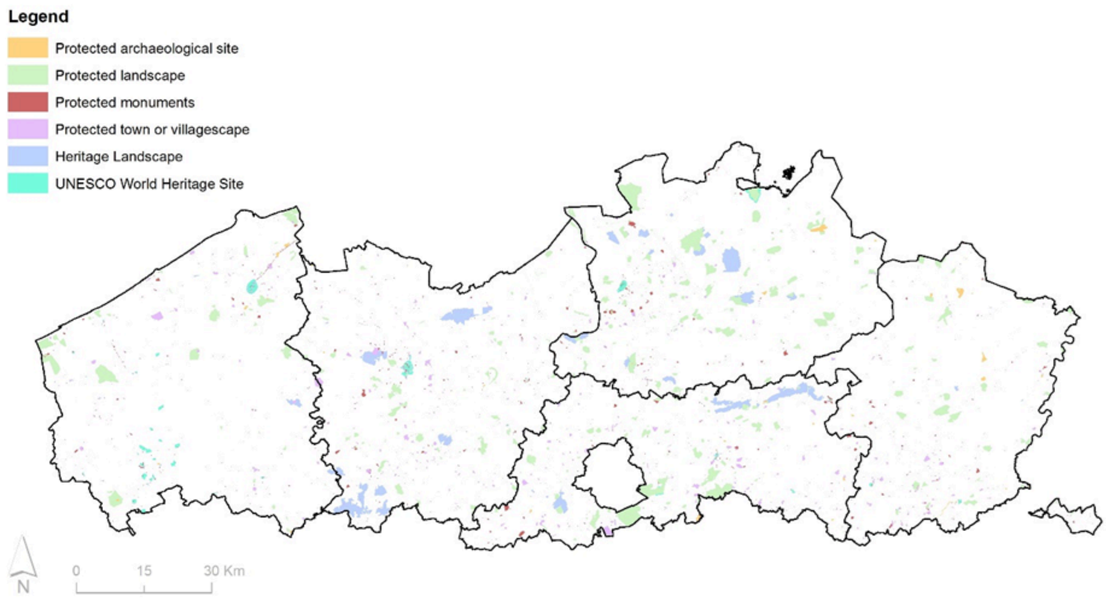


Figure X: Protected heritage features in Flanders, taken into account for the SRC restriction map.

Vegetation alterations or changes to landscape features fall under the generic authorisation requirements of protected heritage sites. Therefore it is best to always take these into account. Annex 3 shows the GIS layers of protected heritage taken into account in the restriction map.

There are also specific authorisation duties and prohibitions per decree. These may contain even more specific conditions or prohibitions. It therefore remains necessary to check the protection decree on a case-by-case basis. However, a protection is always tailor-made, making it impossible to state in general terms what is or is not allowed. This has to be checked on a case-by-case basis in the individual protection decree and the Immovable cultural heritage Decree or Decision as far as the generic permission obligations are concerned. Certain changes to protected heritage may require a permit or authorisation. Some interventions may also be prohibited. This customisation is difficult to represent spatially in a uniform way.

However, protected heritage does not always need to be limiting or restrictive for short rotation coppice. There are protections where, for example, the replanting of tree rows or wood edges is even encouraged, or forest expansion is certainly among the possibilities. As long as it fits within the heritage values of that protection, but this has to be assessed on a case-by-case basis.

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The Agency for Immovable cultural heritage uses a number of rules of thumb for whether or not to plant additional woodland, wooded borders and/or rows of trees, based on cultural history. These rules of thumb are applied to the map showing the evolution of open and closed landscapes and are non-binding in nature. These rules of thumb can serve as guidelines for whether or not to plant short rotation coppice from a cultural history perspective, and are best applied judiciously, depending on the history of the local baseline situation.

The *preliminary version* of the rules of thumb provides insight into possible restrictions on short rotation coppice from a cultural-historical point of view, provided we can consider short rotation coppice as a form of forest or timber edge, with effects on open and closed landscapes.

Possible restrictions on the planting of short rotation coppice, from a cultural historical point of view are:

- not in historical open farmland complexes
- not in historical open grassland complexes
- not in existing heathland areas
- not in (castle) parks, gardens and designed landscapes
- not in areas with intact avenue systems
- not in unwooded watercourses, water meadows
- not in protected or heritage landscapes where the aim is to preserve the open countryside
- not on archaeological sites that benefit from an open landscape for their preservation or perception
- not where bocage or coulisse landscape is well preserved or easily restored

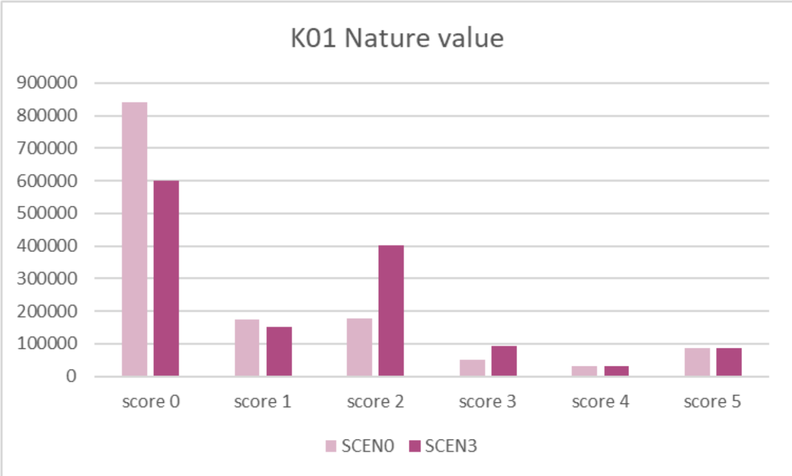
For more information see:

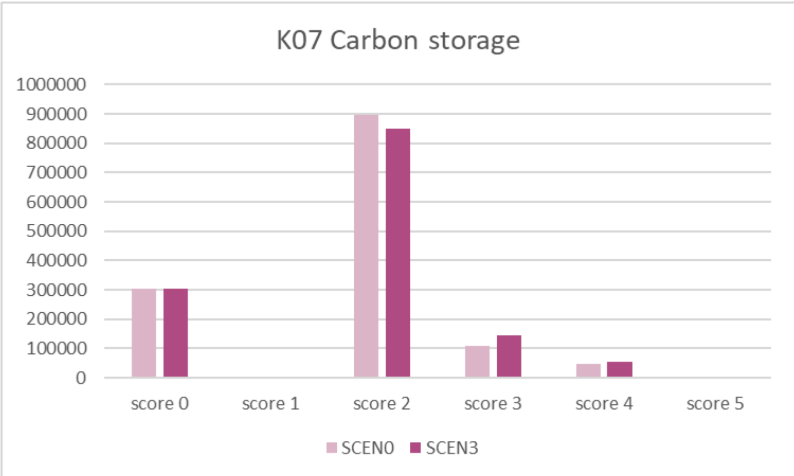
- "Mapping historical landscapes with wooded edges and tree rows. Explanation on the digitisation of open and closed landscapes using historical maps" by De Vroey et al, 2024.
- "Digitisation of historical land use and analysis of land use changes in Flanders (1778-2022). Results of deep learning (AI) image classification applied to three historical maps" by De Keersmaeker et al, 2024.

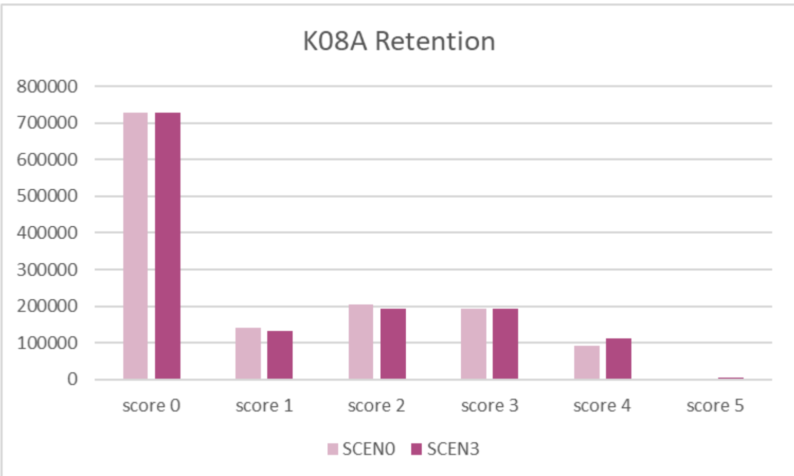
The final versions of both the rules of thumb and the map showing the evolution of open and closed landscapes, will be published during 2024.

Annex 7 ES Model results

When running the AD-LIBIO model to calculate ecosystem services, the result is a map showing scores from 0 to 5 for that specific ecosystem service. The higher the score, the higher the service offered in that specific location. The graphs below show the areas calculated from these maps, for each ecosystem service, and for each score (score 0 to score 5). Values for score 0 indicate that the ecosystem service is not offered. Higher values for the higher scores indicate a higher delivery of the ecosystem service.







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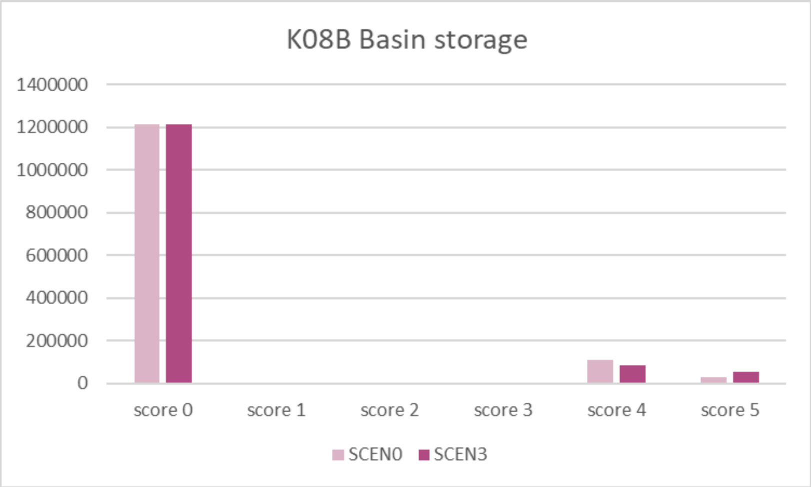
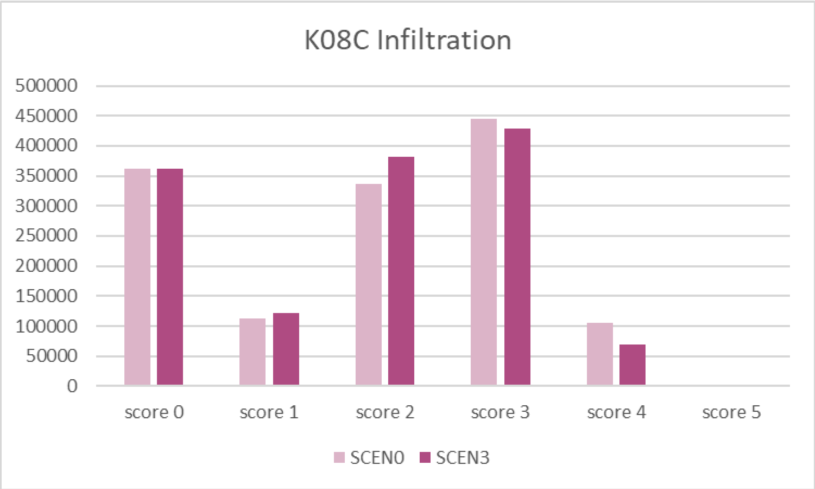
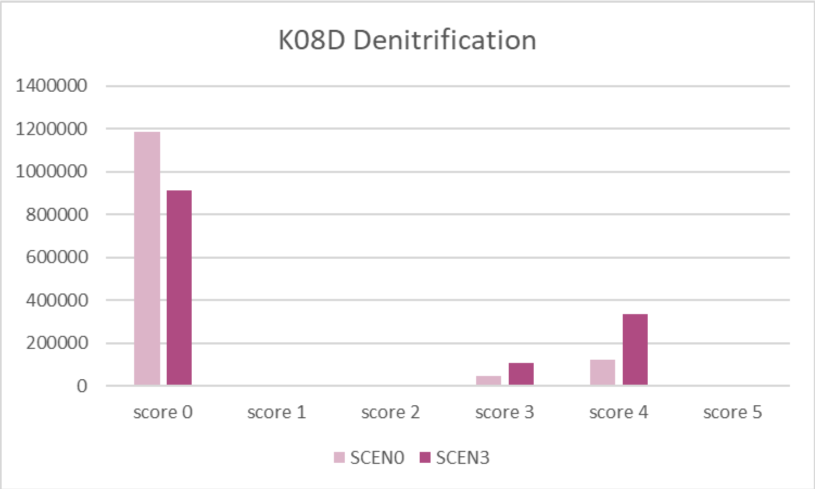
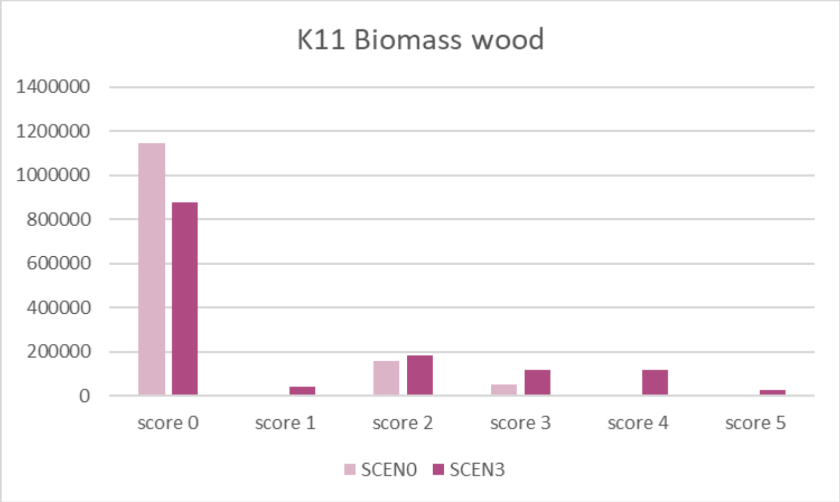
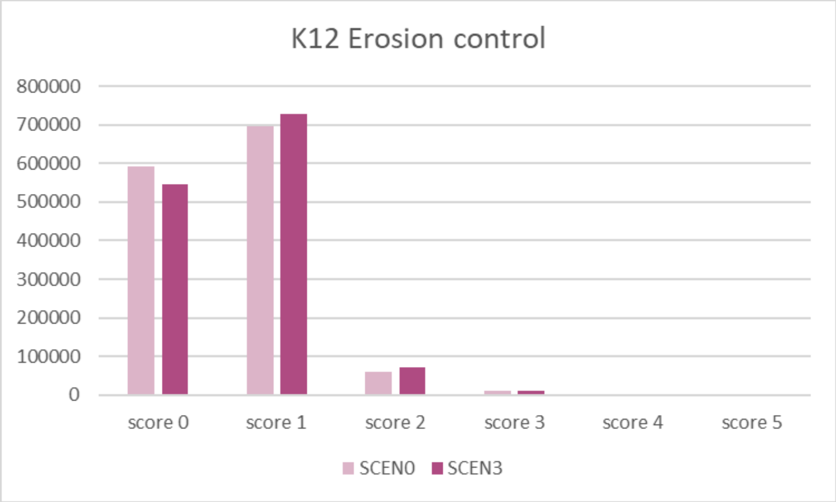
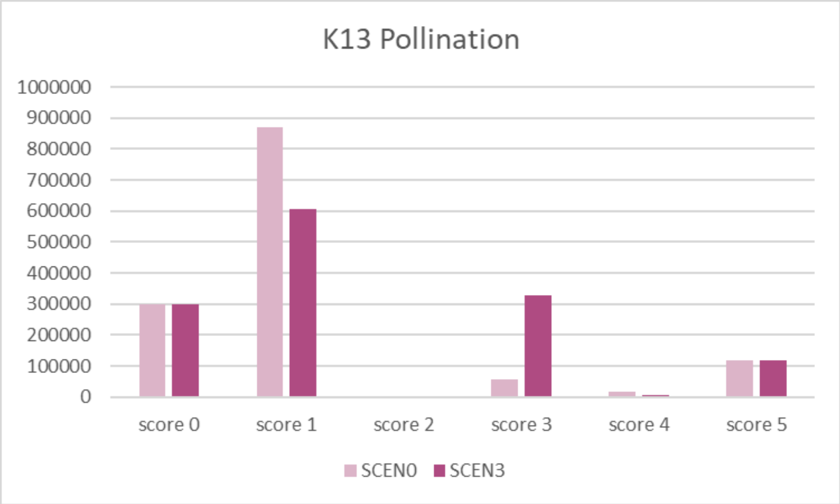

K08B Basin storage
1400000
1200000
1000000
800000
600000
400000
200000
0
score 0
score 1
score 2
score 3
score 4
score 5
SCEN0
SCEN3


K08C Infiltration
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
score 0
score 1
score 2
score 3
score 4
score 5
SCEN0
SCEN3


K08D Denitrification
1400000
1200000
1000000
800000
600000
400000
200000
0
score 0
score 1
score 2
score 3
score 4
score 5
SCEN0
SCEN3







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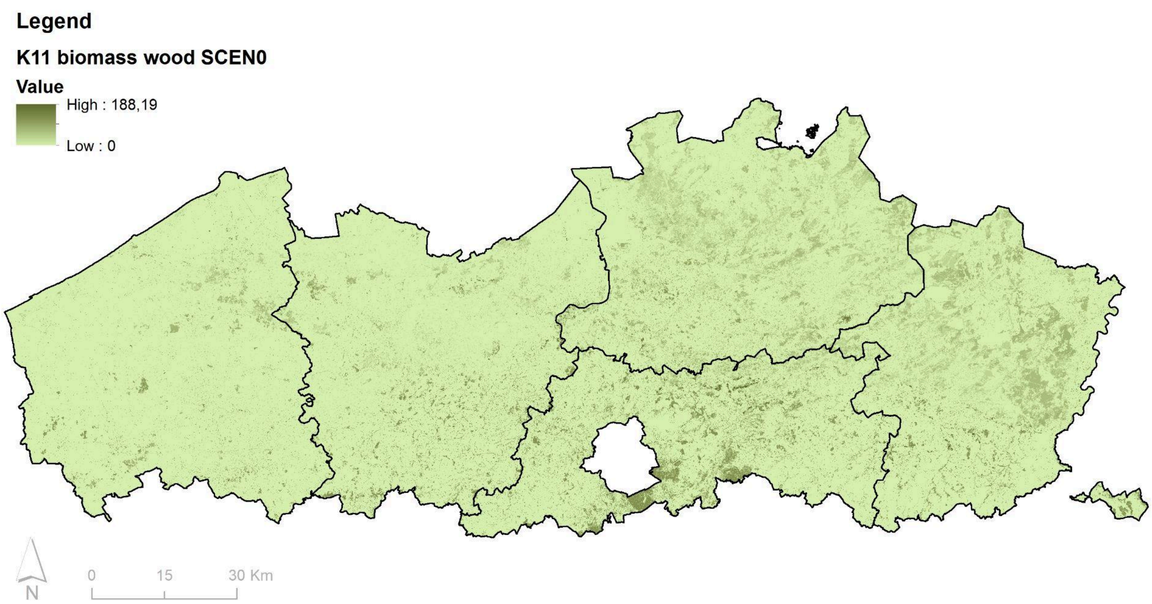
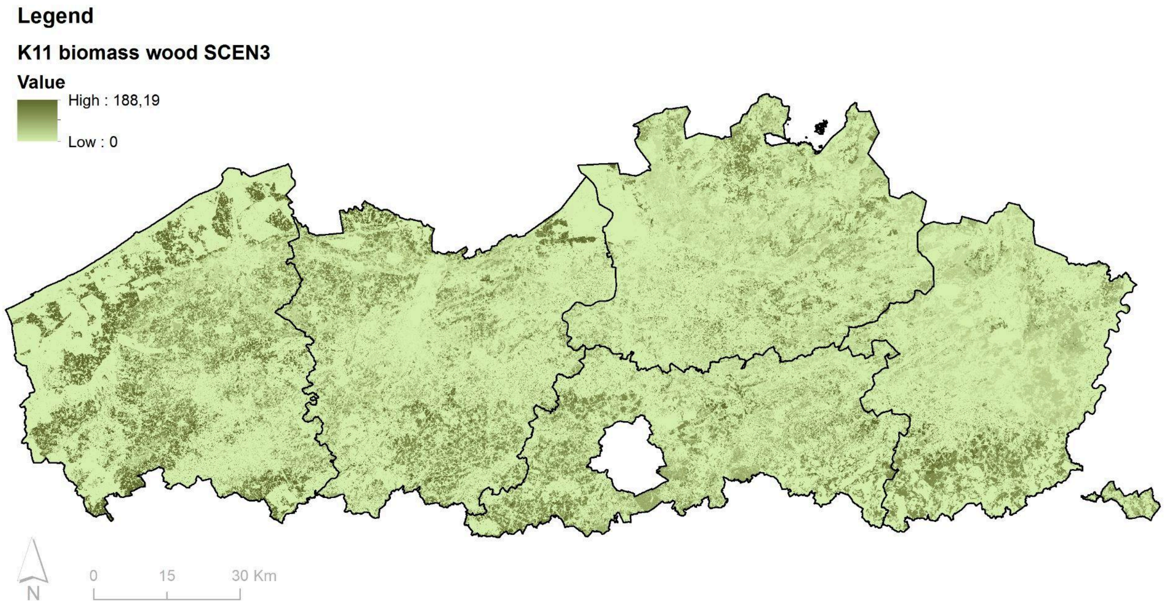
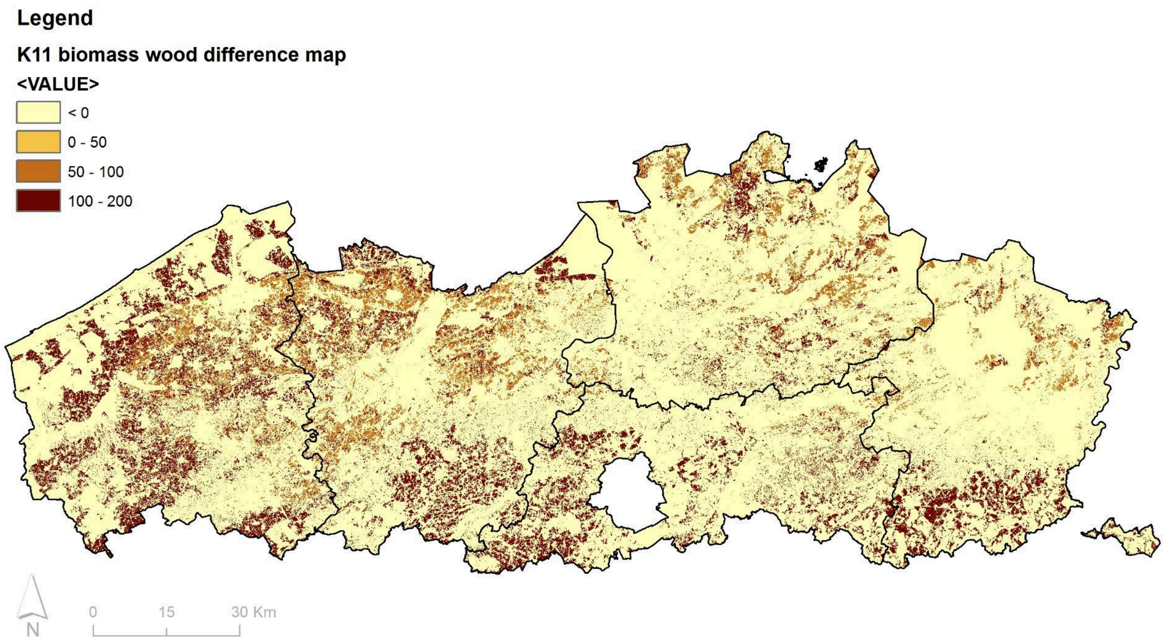
ANNEX 8 ES BIOMASS WOOD

For the different ecosystem services, all model results in the report are shown in relative scores from 0 to 5. This is a deliberate choice, as to avoid interpretation of the delivery of ecosystem services in absolute terms for which the models are not suitable and no confidence intervals could be reported. For the ecosystem service 'biomass wood' however, we make an exception because of the nature of the project Ad-Libio which requires a rough estimation of the biomass delivery potential. The maps below show the biomass production expressed in kg DM per grid cell of $100m^2$. To transform these to tons of DM per hectare the value should be divided by ten. The biomass production is shown for scenario 0 (current situation) and for scenario 3 (SRC as intensive cultivation). The last map is a difference map (values of scenario 3 minus scenario 0), indicating where the biggest differences are in biomass production, when comparing the two scenarios.







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