EIP-AGRI Focus Group
Forest Practices & Climate Change

MINIPAPER 7: Decision Support Systems & Tools

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1. INTRODUCTION

What's the mini paper about?

Forests are expected to meet a number of societal needs and provide a range of ecosystem services. Navigating the delivery of mixed management objectives to provide services including timber production, wildlife habitat provision and carbon sequestration for climate change mitigation in the face of a changing climate is complex. Forest owners, managers and practitioners want to know how to adapt current stands and create new forests with the best chance of surviving future changes in temperature, more frequent episodes of extreme weather and other changes. Systems and tools are important for forestry in a changing climate, to inform actions to adapt to change and mitigate against increasing levels of carbon dioxide (CO_2). A range of tools and systems have been developed for Forest managers to answer these questions, support key decisions and draw on expertise and knowledge available.

The aim of this mini-paper is to describe how decision support systems (DSS) and tools (DST) can benefit forest managers, in addition to local knowledge. We explain how DSS/DST can be used by practitioners to plan and implement climate change adaptation (CCA) measures and to inform decisions concerning forestry to mitigate climate change. A DSS /DST is defined herein as 'an information system, typically computer-based, to support forest management, operations and planning decisions'. We identify and evaluate a number of DSS/DST. Guidance is not considered to be a tool or system, but rather a form of knowledge exchange, which is beyond the scope of this document and is detailed in minipaper six. Our evaluation draws upon a rapid survey of experts and ForestDSS.org, a database of forestry DSS/DST. The main strengths of the work presented is: a) the compilation of DSS/DST from across Europe and evaluation for application to inform forestry climate change adaptation and mitigation decision making, b) our summary of the systems, tools and toolboxes available and their strengths, weaknesses and potential improvements from the perspective of users and c) suggested opportunities for future improvements.

Why is this mini paper needed?

This mini-paper provides a compilation and evaluation of systems and tools for forest practices and climate change across Europe, in order to ease access and knowledge to potential users. A Community of Practice has developed a repository of systems under the umbrella of a European-wide framework (**forestryDSS.org**), this community has developed information standards for decision making in sustainable, multifunctional forest management. Furthermore, the current exchange project **SuFoRun** (supported by the European Union's H2020 research and innovation programme) is focused on forestry and climate change interactions, including the development of adaptive forest management tools and will run until 2020. Beyond these endeavours, information concerning DSS/DST and wider collaborative work is limited; being focused within country organizations, on specific tools or within disciplinary groups and there are a number of reports citing overall, low forestry DSS/DST uptake. Therefore, this minipaper is intended to take a European overview to raise awareness of available systems and tools, their scope and potential. We identify several aspects of 'state of the art' alongside problems related to user-friendliness, geographic scales and data homogenization. We then move on to identify research needs and knowledge gaps on DSS and tools and, where possible, make suggestions as to how these might be overcome. Finally we note the new systems and tools which are either currently under development (e.g. GO+) or being updated to take into account the latest climate projections.

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2. DISSERTATION

Decision Support Systems and Decision Support Tools

A DSS/DST consists of software with a database system or reference tables, knowledge (modelling) system, and user interface with prediction and/or stimulation capabilities. Tool boxes contain multiple DSS/DST (e.g. AFM-Toolbox and AltFor) typically hosted on one website. Systems and tools have long been popular in forestry sector applications and advanced in computer technology have led to improvements. Forest DSS/DST have been developed through the utilization of climate sensitive growth algorithms and driven by multiple climate scenarios, which has resulted in a suite of new applications.

In this section we first explain what these systems and tools can do to support adaptation, mitigation and specific risks, with examples from across Europe and one from America. The main model types are empirical (EM), process-based (PBM) and hybrid models. Twenty one forestry DSS/ DST or Toolboxes are presented (Table 1), including systems and tools for adaptation and mitigation separately alongside those which can be used to answer questions concerning both, in-combination. We then move on to present strengths and weaknesses identified and the key issues emerging

What can these tools do and what questions can they address?

A number of tools are in use in the forestry sector to inform decisions concerning **adaptation to climate change**. In particular, they support decisions concerning how to approach species diversification. There are similar tools for climate matching which are typically designed to inform 'assisted migration' and 'genetic evaluation', i.e. where stands of tree species will be grown using seed sourced from further south or climates that will one day match that of the forest in question e.g. ESC and IKS of ONF (Table 1). These tools are designed to answer questions such as a) what species will grow well on this site in future, given the ground conditions and what we know about a given species? b) What will the projected future climate be like at a given location in a given year, c) what are the risks to this stand from climate change and d) how will the future climate impact the growth of current stands? Examples are presented below:

Tools to assess biome shifts (IKS of ONF) to inform decisions concerning assisted migration:

- **Climate matching tool** (http://193.185.149.20/t4f/cmt/). A web-based tool to identify regions where forest reproductive material may be suitable for adapting forestry to reduce the impacts of climate change through assisted migration. The tool identifies locations where the current climate is most similar to the future climate of a selected European site, for a range of possible climates (from General Circulation Models) for different climate periods (for example 2030s, 2050s and 2080s) and different scenarios. This version of the model covers only sites in Europe.

Tools to assess site conditions and their suitability for certain tree species, given the future climate include:

- **ESC (UK).** (https://www.forestry.gov.uk/esc).The Ecological Site Classification Decision Support System (ESC-DSS) is a web based system to guide forest managers and planners to select species which are both ecologically suited to the site and best suited to future climate conditions over the projected rotation. ESC can also be used to project changes in growth and ecosystem service provision to the end of the century. Free to use and access, ESC has a user friendly interface and training is available to support public and private forestry application.
- **breedR** (http://www.trees4future.eu/tools/breedr.html). A statistical R-package for genetic evaluation of trees, 'breedR' aims to assess the genetic value of individuals under a number of situations, including spatial autocorrelation, genetic/environment interaction and competition.

Another suite of tools consider **mitigation of climate change by forestry activity**, i.e. carbon sequestration from new woodland creation, from existing stands and from changes in tree growth and biomass as a result of climate change. A number of these tools and models are associated with direct climate change mitigation from silviculture. There are empiric forest models which are used across a range of scales, from stand scale, up to international accounting. These models can calculate the net CO_2 removal by afforestation and are commonly used by European countries for carbon accounting and reporting (e.g. CBM-CFS country wide forest runs by

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2050). The empirical models can only take into account climatic effects if the input data (productivity) is adjusted beforehand.

The tools which assess carbon sequestration from silviculture typically calculate the quantity of carbon in the stand (each year / decade / other) and the type of wood products (using Life Cycle Analysis) to estimate the expected carbon storage through substitution with non-wood products. For example:

- **CO2FIX** (http://www.trees4future.eu/transnational-accesses/alt-for.html). A stand-scale forest carbon model including financial, carbon accounting and bioenergy modules which can answer questions about the volume of carbon a forest can sequester and which species and management approach would provide greatest carbon sequestration.
- **MELA (**http://mela2.metla.fi/mela/mela/index-en.htm). A multiple scale DSS for Finnish conditions to answer questions concerning production potential and forest management. MELA outputs are used by different organisations for different purposes, e.g. national greenhouse gas reporting.

Tools to assess specific risks

Climate change is having a direct impact on trees and woodlands and will continue to do so. A number of DSS/DST have been developed or are being developed to assess specific risks to current stands and, implications to future stands. The DSS/DST which assess direct risks are highly variable depending on country, species, risk and scale over which the risk is considered. Models which estimate the impact of climate change on tree physiology and growth tend to be process-based models; they estimate the impact of climate change variables on biomass production, e.g. the change in carbon storage expected as a result of increased frequency of drought, rising temperatures or wind risk (e.g. GO+, ForestGales) (Table 1).

Examples: tools which assess the risk of stand damage, dieback / water vulnerability (Bioclimsol, ARCHI, BILJOU, ForestGALES and WINDA-GALES):

- **BILJOU** calculates the water balance of a coniferous or broadleaved stand. With climatic data for the past or/and the future, it is possible to estimate the risk to be in water stress. The model was developed by the National Institute for Agricultural Research (INRA) in France.
- **ARCHI** is a method to describe the crown vitality of several trees species including Oak, Fir, Douglas fir, Atlantic cedar and Chestnut. Trees are assessed on the basis of different classes of development in order to determine whether trees are, resilient, dying or stressed. Therefore, foresters can choose to fell trees or retain them within the stand.
- **BIOCLIMSOL** is a method to evaluate drought vulnerability for a range of trees species. The first step is to evaluate the crown decay of dominant trees. Where more than 20% of trees/ha are dead, the stand is declared a "dying stand". A first correlation is assessed between the climate and the water balance for the vegetation season in previous years. Bioclimsol calculates a map to show the risk of stand mortality in a given year. This method is tested in the LIFE project "FORECCAST", and will be developed as a smartphone application.
- **ForestGales and WINDA-GALES.** ForestGALES enables forest managers to estimate the probability of wind damage to any conifer stand in Britain. It calculates the wind speed that would be expected to damage a stand, the current risk of overturning and stem breakage, the change in risk over the life of the crop and the effect on risk of thinning and creation of brown edges. WINDA-GALES has similar function, it can be used to evaluate the impact of climate change on the probability of wind damage and can be used to evaluate measures for adaptation.

Tools for advice and education on forestry and climate change

Tools have been developed to support climate change extension services to deliver education and advice, such as those in Sweden (http://skogensklimatrad.skogsstyrelsen.se/) (Minipaper 1. Box 2).

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Strengths & Weaknesses

This section presents strengths and weaknesses identified in relation to the tools and systems outlined above. The main strengths of using a DSS/DST to inform decisions concerning adaptation of forests to the changing climate is due to the unique combination of processes and theoretical approaches within one application. This enables the user to consider a wider range of options and scenarios than would otherwise be possible. These tools enable the user to rapidly digest multiple-variables with a high level of complexity. Outputs can be fed into forest management planning directly, so that decisions about future suitability of species, planting, management options, etc. can be taken into account at the planning stage. At present, a number of tools and systems have been developed which are focused on forestry activity only it is, however, important to consider tools for wider landscape concerns and land use change, which was beyond the scope of this work. For DSS/DST designed for the purpose of climate change mitigation, their main strength is often the ability to support both mitigation and adaptation simultaneously. Another advantage is that they tend to operate using standard forestry input data and produce forestry output data, which are easy for the user to understand.

Across Europe, there is variability in the type, range and applicability of tools, in part this is to be expected as many tools have been developed to address region specific risks or concerns, for example tools to consider increasing fire risk are common in the Mediterranean but have yet to be developed in the UK.

The overarching weaknesses common to current tools and systems is accessibility; many tools we considered are restricted by license or registration requirements, however a number *are* freely available and web-based for immediate and repeat access. The scale across which different tools apply is highly variable; we found that tool-boxes are typically applicable across a greater geographic area. One of the main weaknesses mentioned by users and developers of the tools was the lack of validation of output data and a need to increase real world application. For systems which have been designed to work across a wide geographical area, users reported constraints on local accuracy, which can reduce confidence and limit real world application. Tools developed for mitigation were constrained by assumptions required to match national data in-order to model requirements, which can lead to gaps in local parameters (e.g. soils, stump data) and constrain accuracy. Finally, it was emphasized that DSS/DST should complement, not replace local knowledge.

Key Issues

Our evaluation of selected DSS/DST considered type, geographic range, accessibility, data input/output, development opportunities and capacity for multi-sectorial assessment. It was not possible to review all tools and systems due to access restrictions. For those we did evaluate, issues concerning the projections of climate change, accessibility, application and communication emerged and we present these in this section:

Projections: Many forest DSS/DST simply do not take account of climate change in their outputs. There is considerable opportunity to integrate future climate projections into models to improve their capacity. However, projections require data under set conditions and require species trial data, which may be available for only a limited number of species, time periods or growing conditions. For those DSS / DST that do take into account current projections, there is a time lag between the release of the latest set of climate projections and updates to the DSS/DST to reflect the new projections. There are currently 69 DSS contained in ForestDSS, accompanied by country reports, case studies and lessons learnt only eleven of these DSS include a component on climate change. Furthermore, where tools and systems are developed collaboratively, one key challenge is to keep them current and updated after the project is completed and include the latest climate projections.

Although the minority of DSS/DST contain a component on climate change, the majority contained in ForestDSS have been applied to study climate change impacts. In these applications, the models are typically linked with process–based models in order to adjust growth rates. Therefore, when tool (e.g. MELA, ESC or EFISCEN) are documented in a model repository such as ForestDSS, they generally present the core model (without linkage to other models), presented as static empirical model which doesn't reflect full application potential.

Accessibility and Application: Although many DSS/DST are freely accessible on the web, a number are restricted by license, registration or user expertise requirements. Whilst practitioners might be aware that a tool or system had been developed, access or immediacy of access can pose a major barrier to use. For several

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tools which assess a specific risk, they do not help the potential user to understand why they should follow the recommendations in the output from the DSS. Furthermore, where practitioners are restrained by resources (cost, time etc.) the default option is to not use the tool, but rather adopt a 'business as usual' approach for the short term, foreseeable future and this can delay decision making which takes into account future climate change. A good systems understanding is required to be able to interpret the results and apply them to practice which can constrain use; many DSS and tools seem to be specialist research tools and not accessible to the average forest user. Case study examples of application, training and 'hand-holding' by experts can, however, help to overcome some of these constraints.

Communication: A barrier to the use of DSS and DST to adapt and mitigate climate change is language and communication between those who develop tools and systems and the end user. It is therefore important to provide guidance and training to practitioners so that they can interpret the results and apply these to a specific area with confidence. Tools and systems should be developed with end users in mind and attention given to language barriers through use of appropriate terminology, explanation of key terms and acronyms and the use of case studies to show how the DSS/DST outputs can be applied in realistic forestry settings.

Cross Regional Application: Models tend to be specifically tailored to the country of origin. The exception is 'The European Forest Information SCENario Model' (EFISCEN), a large-scale forest model that projects forest resource development on regional to European scale. The model is suitable for the projection of forest resource development for a period of 50 to 60 years.

3. CONCLUSIONS

It is apparent from the information presented in this minipaper that there are opportunities to develop a number of forestry decision support tools and systems which are yet to take into account climate change, by integrating GCM data. Where tools and systems have been developed to take projections into account, there is a need to do more to bridge the gap between the research community, practitioners and developers to ensure DSS/DST designed for forest managers are not perceived as prohibitively specialist, answer questions that need answering and to enable users to interpret and apply the results. Perhaps through new partnership or collaborations where practitioners with good site knowledge and model developers with understanding of forest functionality and physiology can work together on real world problems. As one of the respondents to our survey explained *"creating a DSS which can be used at multiple scales and retain local accuracy is a challenge and lesson learnt".* For those DSS and DST which take account of the changing climate and considered 'state of the art', more work to validate species and other outputs is required to encourage practitioners to apply the tool outputs. One important gap in current provision of DSS/DST are tools to support decision making in relation to mixed species stands, addressing this need will continue to increase in priority since forest managers are being encouraged to plant mixed species to increase resilience and decrease risk from climate impacts.

Producing peer-review publications of DSS/DST findings and case studies is important in order to communicate findings, validate tools and encourage application, share lessons learnt and support further development of similar systems in other regions and countries. Creating DSS/DST which can be used across multiple scales e.g. used a national scale and retain local accuracy will remain a future development challenge. Finally, we suggest there is a need for better DSS/DST which can integrate forestry adaptation with other land use changes as a result of climate change.

4. RESEARCH NEEDS

Primary research needs identified, in priority order include:

1. A new Decision Support system for mixed species, mixed age stands
2. Research to identify how to better communicate risk and uncertainty and work with uncertainty in such as ways as to
   - Lever behaviour to adapt/mitigate to climate change

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- Increase use and application of DSS/DST.

3. A new repository of DSS/DST with search facility to identify what DSS/DST can answer which climate change question – perhaps with GIS map of geographical coverage of the DSS/DST.

Due to constraints imposed by license requirements and our limited knowledge of specific user groups, it was not possible to consider all DSS/DST or Toolboxes which might be used to assess forest practices under climate change. There is a strong need for a user group to access multiple systems and tools to compare different DSS/ DST and work with users of these tools to understand the practicalities of real world application.

Practitioners collectively identified a need to address the paucity of published evidence to inforce DST/DSS credibility e.g. BIOCLIMSOIL. There is also a need to undertake research to evaluate DSS and tools used by region or application type, to identify voids and obtain data on use / data consistency. We found opportunities to develop tools by working alongside end users (why, how, benefits) (e.g. AFORCE) and to develop training in specific / multiple applications. Furthermore, there are opportunities to research and evaluate tool use by region or application type to identify voids and obtain data on use / data consistency.

5. IDEAS FOR INNOVATION

- Develop an application which tailors your 'forestry / climate change' question to the application available to answer it or lets you know if there's no application to address your question.
- Horizon Scanning: development of current and new tools and systems to take into account the 2018 **UKCIP projections.** Develop these as phone/tablet applications for a forestry audience.
- Gap analysis (review potential to increase geographic range of current tools / tools which are good but overlook CCA / tools which could be applied for mitigation purposes).
- Develop online 'hand-holding' sessions between DSS/DST users and developed to walk them through the process, increase confidence and decrease the time required for practitioners to learn a new tool.
- Create a repository of DSS/DST case studies to encourage wider use and application.
- Work with users so that they can identify mechanisms which will bridge the gap between the research community and practitioners, to increase DSS/DST use.
- Identify how to integrate the latest trend in DSS development using DSS-like computer games into adaptation and mitigation decisions.

Further research needs coming from practice, ideas for EIP AGRI operational groups and other proposals for innovation can be found at the final report of the focus group, available at the FG webpage **https://ec.europa.eu/eip/agriculture/en/content/focus-groups/new-forest-practices-and-tools-adaptation-and**

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6. REFERENCES

Links to the tools mentioned in this minipaper are direct hyperlinks, listed in Table 1.

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Table 1. Selected Forestry Decision Support Systems and Tools

	Name	Full Name	Country	Spatial Scale	Temporal Scale	Goods/Services dimension	Access	Description / Comments	Existing best practices
1	AFM-Toolbox	AFM Toolbox	Austria	Stand level Forest level	Long term (Strategic) Medium term (tactical)	Non-market services and Market wood products	Web-based and open access.	Web-based, multifaceted. DS Toolbox for experts and practitioners. Interface has options to support analysts and multiple query types and scenarios with applications in GIS. Includes examples of application from across Europe with some applications in at least 10 countries outside the host country (Austria).	State of the art tool to assist in forest management under climate change. The tools presented provide approaches and principles to adaptive management and interactive tools to support planning.
2	BILJOU	BILJOU©	France	Stand level Forest level	Long term (Strategic) Medium term (tactical)	Non-market services and Market wood products	Non-commercial use only, registration required.	Open source DST designed for the international community of forest managers, teachers, students and researchers.	Integrated online simulation. User focused solutions. Will increase understanding of mechanisms driving interactions between forest ecosystems, climatic and edaphic environments.
3	BIOCLIMSOL	BIOCLIMSOL (part of FORECCAST EU LIFE Project)	France	Stand Level Forest Level	Medium term Short Term	Vulnerability for Market and Non-Market services and products	Under development. Will be web-based.	Method to evaluate drought vulnerability for a range of species, starting with a crown decay assessment and then correlation between climate and water balance. Species to include oak, fir, Douglas fir.	Project will create digital maps tracking the main ecological factors affecting plants and different hypotheses of climatic evolution.
4	Climate matching tool	Climate Matching Tool	EU wide	Stand level Forest level	Long term (Strategic)	Market wood products	Trees4Future Project	Free tool to identify regions where forest reproductive material may be suitable for adapting forestry to reduce the impacts of climate change through actions of assisted migration	User friendly. Instant immediate access and no expertise required to use. Could be improved by providing guidance on how to interpret the results (ended 2016).
5	ClimChAlp	ClimChAlp	Austria	Stand level	Long term	Non-market services Market wood products	ClimChAlp.	Web based DSS to explore adaptation options for silviculture in secondary Norway spruce forests.	Single species, single country DSS, takes account of future climate.

6	CO2 Fix	CO2 Fix (AltFor)	Alterra / Netherlands	Stand level	Long term	Non-market services Market services	Alterra	CO2FIX is a stand-scale forest carbon model including financial, carbon accounting and bioenergy modules. CO2 Fix uses a simple modelling framework that quantifies the C stocks and fluxes in a forest stand. It calculates changes in carbon stocks in all C pools over time.	AltFor offer three models, including CO2 Fix. They also offer ForGEM, a process-based individual tree model with genetic interactions and wind effects and FORSPACE: a forest landscape model including the effect of herbivory and fire.
7	DSD	Decision Support Dobrova	Austria	Stand level	Long term Medium term	Market wood products Non-market services	DSD.		
8	EcologicalSiteClassification	Ecological Site Classification (ESC)	UK	Forest level Regional/ national / Stand	Long term Medium term Short term	Market wood products Non-market services	EcologicalSiteClassification.	Free, web based DSS for UK Forests to explore adaptation options, including species diversification for current and future stands taking into account climate changes for next century. Output is a prescription of options.	59 Species included to date and more being added regularly. Options to tailor input data, user-friendly, training available, case studies of real application.
9	EFISCEN	European Forest Information Scenario Model	EU	Regional/ national level	Long term Medium term	Market wood products Non-market services	EFISCEN.		
10	ForClim	ForClim	Global	Stand Regional National	Long-term	Market wood products Non-market services	License required	Developed by Forest Ecology Group of ETH, Zurich. Tested for Northern hemisphere temperate forests.	One of the few models to show/ consider multiple impacts in-combination
11	**ForestGales**	ForestGales	UK &other countries (StormRisk	Stand Regional National	Long-term Medium term	Market wood products Non-market services	Free, registration required	ForestGALES allows the analysis of wind climate effects on the stability of a conifer forest. It can be used to assess risk over time via predicted growth from yield tables or alternatively current risk from mensuration data.	Developed by Forest Research, UK. Tested for Northern hemisphere temperate forests. Recently adapted as part of Stormrisk project to allow model to run in partner countries

12	GO+	GO+ (CNPF & INRA)	France	Stand Level Forest Level	Long term Medium term Short term	Market wood products Non-market services	Under development	New DST being developed to calculate carbon balance of a stand for the next 100 years given future climate conditions. Outputs to include prescription for foresters of best silvicultural recommendations.	Go+ is expected in 2019.
13	Heureka	Heureka PlanWise	Sweden	Forest level	Long term Medium term	Market wood products Non-market services	Heureka	Free software developed by Swedish University of Agricultural Sciences. Covers DS process from data inventory to tools for species selection and alternatives with multi-criteria decision making techniques.	Combined DSS software which covers forest planning process from start to finish.
14	Hi-sAFe	Hi-sAFe Model	France (INRA)	Forest level	Long term Medium term	Market and non-market services	Free to download after registration	Hi-sAFe is a 3-D mechanistic simulation model representing tree and crop growth, taking into account light, water and nitrogen competition between trees and annual or perennial crops. Three tree species available include walnut, clonal poplar and wild cherry.	Hi-sAFe can address questions concerning adaptation using species diversification and alternative cover systems approaches. Other species can be simulated if there's sufficient data.
15	LANDIS	LANDIS	United States	Forest level Regional/ national level	Long term Medium term Short	Market wood products Non-market services	LANDIS.		
16	MAPSS	Mapped Atmosphere-Plant-Soil System	United States	Regional/ national level	Long term	Non-market services	MAPSS.	MAPSS is a landscape- to global-scale vegetation distribution model that was developed to simulate the potential biosphere impacts and biosphere-atmosphere feedbacks from climatic change.	

17	MELA	MELA forest DSS	Finland	Stand level Forest level Regional level National	Long term	Market wood products Non-market services	http://mela2.metla.fi/mela/mela/index-en.htm	DSS tailored to Finnish conditions. Supports production potential and forest management.	MELA outputs are used by a range of organizations and purposes, including Finnish greenhouse gas reporting.
18	SADfLOR	SADfLOR - Forest and Natural Resources	Portugal	Forest level Regional/ national level	Long term	Market non-wood products Market wood products	SADfLOR web-based.Decision support techniques	Web based DSS for forestry and natural resources.	
19	SGIS	Skog GIS/ Gaya-Skog GIS	Norway	Forest level Stand level	Long term	Market non-wood products Market wood products	SGIS.		
20	Sim4Tree	Sim4Tree	Belgium	Regional/ national Stand Forest	Long term Medium term	Market wood products Non-market services	Sim4Tree		
21	WINDA-GALES	WINDA_GALES	Sweden	Stand Forest	Long term Medium term	Market non-wood products Market wood products		WINDA-GALES uses the distributed windfield (sensitive to changes in the vegetation cover) in estimating the probability of wind damage.	This DST can be used to evaluate the impact of climate change on the probability of wind damage. It can evaluate measures for adaptation and mitigation, e.g. it can assess the impact of increased tree planting to create new woodland or expand current woodland area to 'lock up' carbon and woodland management activity to increase carbon storage in standing timber and wood products and impact of land use change.