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**VAIA-FROM lessons LearNT to future option**

# **FINAL REPORT**

## **WP2**

**30.7.2022**

## **WP2 - Current approaches for forest SES risk management**

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- 1. Introduction to WP2 objectives, structure (tasks), resources and activities**
- 2. WP2 research methodology (by Task)**
- 3. WP2 Deliverables**

## **1. Introduction to WP4 objectives, structure (tasks), resources and activities**

The WP2 aims to provide the conceptual foundation of the VAIA - FRONT project activities and a comprehensive reference on frameworks and methodologies related to the forest **Socio-Ecological Systems (SES)** risk management. The WP2 refers to the challenges involved in:

- I. development of a comprehensive concept of risk assessment and management,
- II. integration of multiple hazard sources and vulnerability characteristics

The development of a comprehensive concept of risk assessment and management and the integration of multiple hazard sources and vulnerability characteristics has been based on the implementation of a structured review on forest SES risk management to ensure a comprehensive literature review, reflection of real-world activities and involvement of international experts

The following Tasks involve the main activity of the WP2

### **Task 2.1: Implementation of a structured review on forest SES risk management**

The Task 2.1 has implemented a structured review on:

- i) hazard analyses and assessment for past European wind storms (including forest SES impacts);
- ii) assessment of forest SES vulnerability to wind storm;
- iii) cascade of hazards and risks (wind, rains, floods) and interaction between different types of risks;
- iv) forest ecosystem resilience to wind storm;
- v) dynamics and impacts due to short/long-term expected climate variability and societal change
- vi) forest SES risk communication;
- vii) integrated and systemic management of storm damage at various scales.

The structured review has taken advantage of databases such as Forestorm ([www.iefc.net/storm](http://www.iefc.net/storm)) Extreme-Wind-Storms-Catalogue ([www.europeanwindstorms.org](http://www.europeanwindstorms.org)) and NatCatSERVICE ([www.natcatservice.munichre.com](http://www.natcatservice.munichre.com))

The collected literature on the different questions (i-vii) has been organized in a unique database which will be also part of the Vaia Observatory (WP5).

### **Task 2.2 Common terminology as a component for the project harmonisation**

The Task has undertaken the definition of the common terminology. This is seen as a particularly important component of the project harmonisation, given the different uses of technical terms within the broad forest SES risk community.

## **2. WP2 research methodology (by Tasks)**

### **Task 2.1: Implementation of a structured review on forest SES risk management**

The Task 2.1 has considered the objectives of the WP2 to focus on the forest Socio-Ecological Systems (SES) and on the development of a comprehensive concept of risk assessment and management and integration of multiple hazard sources and vulnerability characteristics.

The activities of the Task 2.1 were conducted with the involvement of the research of the TESAF groups (forest management, forest policy and economics, hydrology, remote sensing and forest mechanization) and DAFNAE (forest entomology) departments focusing on abiotic and biotic risks on forest-related system associated extreme climate and weather events.

The working group has established the objective of a bibliographic search that interested the analysis of windstorms and their impacts on European forests and on the systems connected to them through a trans-disciplinary approach. The initial objective related to the SES risk management has then revised in a broader and multidisciplinary perspective aimed at the analysis of windstorms impacts on European forest-related systems through a transdisciplinary perspective. This aims has created the conditions for a broader analysis with the involvement of different experienced researchers and PhD students.

The composition of the working group has been the following: Federica Romagnoli (Forest policy and economy - PhD student), Alberto Cadei (Forest mechanization - PhD student), Maximiliano Costa (Forest management and forest disturbance - PhD student), Davide Marangon (Forest management and forest disturbance - PhD student), Davide Nardi (Forest entomology - PhD student), Giacomo Pellegrini (Hydrology - PhD student), Mauro Masiero (Forest policy and economy – experienced researcher), Laura Secco (Forest policy and economy – experienced researcher), Stefano Grigolato (Forest mechanization – experienced researcher), Emanuele Lingua (Forest management and forest disturbance – experienced researcher) Andrea Battisti (Forest entomology – experienced researcher) Lorenzo Picco (Hydrology – experienced researcher), Francesco Pirotti (Remote sensing – experienced researcher), Raffaele Cavalli (Forest mechanization - experienced researcher).

The multidisciplinary working group composed by the PhD students has met regularly to set up the activity. The activity carried out by the expert researchers consisted in the discussion with the group of PhD students and in addressing them in the analysis and discussion to keep the integration between the different disciplines.

A systematic mapping approach (see Grant and Booth 2009 and James et al. 2016) was adopted to describe the variety of direct and indirect windstorm impacts detected in literature. Considering the multiplicity of disciplines and dimensions involved in the analysis, this approach has been preferred to a systematic review.

To ensure reliability and transparency to our study, the whole literature review process took inspiration from the framework for systematic mapping in environmental science proposed by James L., et al. (2016). The research followed three main steps, each of them composed by several sub-actions: i) Design of the review approach; ii) Papers searching and screening; iii) Data collection and categorization iv) Results discussion and graphical visualization.

As first step, to clearly frame the scope and the “setting” of the review, it has been identified the different sub-systems that compose the European forest-related system. Among these sub-systems, based on current scientific literature, it has been detected those forest-related domains mostly affected by windstorms at European level. They include: forest ecology and silviculture; forest operations and logistics; forest policy and socio-economics; ecosystem services provisioning; geomorphology and forest entomology. These six forests- related domains were defined crucial for gaining a broader understanding of windstorms-forest systems interactions and have underpinned the identification of further dimensions and variables to be included in the analysis.

After having identified the domains of reference, it has moved to key-words identification for papers selection. Keywords identification has been a crucial step to ensure consistency within the review and across the domains identified. Formulation of searching strings followed a two-step procedure: i) first, we identified a query including relevant keywords for all of the six domains: forest\* OR woodland AND wind\* AND disturb\* OR damage; ii) second, for each domain we added few keywords related to specific attributes in order to better tailor the analysis on windstorm impacts in the forest-related domains selected. Ultimately eight queries have been identified and applied (see Table 1).

**Table 1.** List of keywords strings used in *Scopus* database for papers selection

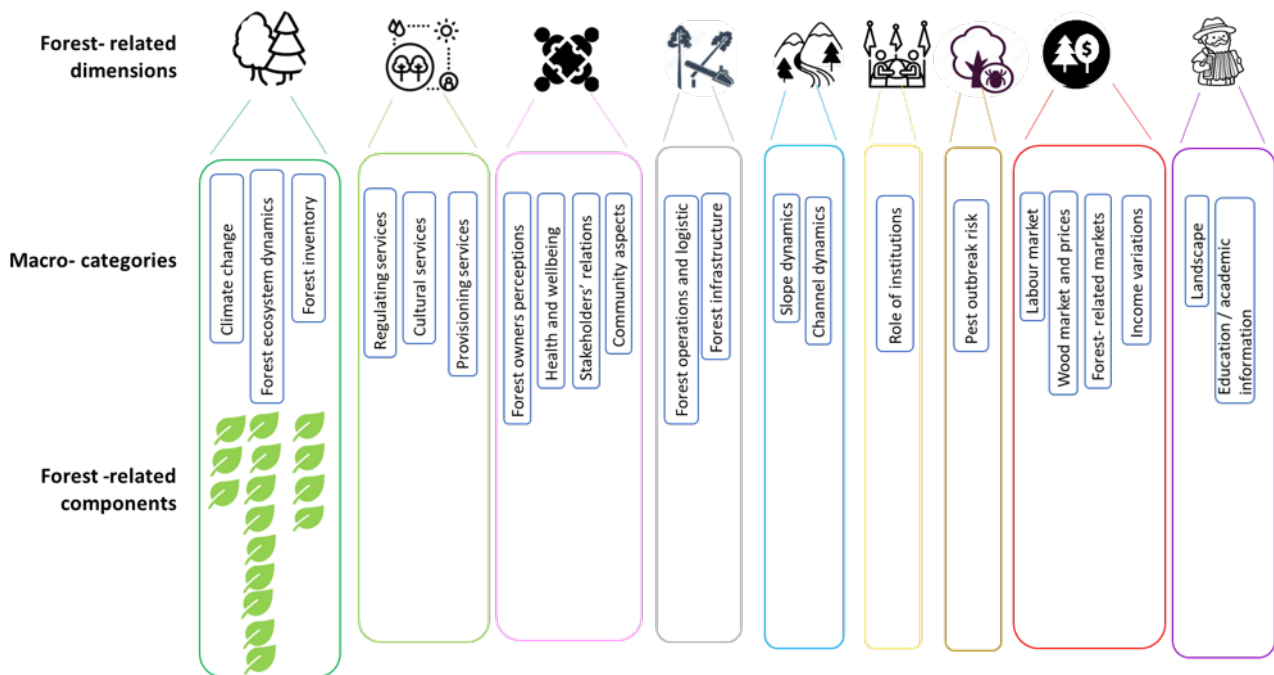
<b>Forest- related domains</b>	<b>Strings of keywords used for papers searching</b>
<b>Forest Ecology and Silviculture</b>	<i>forest* OR woodland AND wind* AND disturb* OR damage* AND ecolog* or management* OR "climat* chang*"</i>
<b>Forest Operations and Logistics</b>	<i>forest* OR woodland AND wind* AND disturb* OR damage* AND harvest* OR "salvage logging"</i>
<b>Forest policy and economic</b>	<i>forest* OR woodland AND wind* AND disturb* OR damage* AND institution* AND govern*</i> <i>forest* OR woodland AND wind* AND disturb* OR damage* AND soc* AND economic* OR financial*</i>
<b>Ecosystem services provisioning</b>	<i>forest* OR woodland AND wind* AND disturb* OR damage* AND ecosystem* AND service*</i>
<b>Geomorphology</b>	<i>forest* OR woodland AND wind* AND disturb* OR damage* AND sediment* or largewood</i> <i>forest* OR woodland AND wind* AND disturb* OR damage* AND flood</i>
<b>Forest entomology</b>	<i>(forest* OR woodland ) AND wind* AND ( disturb* OR damag* ) AND ( beetle* OR pest* OR "bark beetles" OR "wood boring insects" OR "wood-boring insects" OR pathogen* OR outbreak* )</i>

Literature search was performed using the searching strings mentioned above between September and December 2020 in Scopus database via title, abstract and key-words search. To guarantee consistency and reliability in articles selection and screening stages, the main features of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach have been adapted to the scope of the review and combined with the methodology adopted.

Inclusion and exclusion criteria were set to ensure that scientific articles retrieved were in line with the review scope. Only articles matching the following criteria were included in the analysis: i) published in peer review journals; ii) written in English; iii) analysing windstorms impacts on European forests . No limitation regarding the time span were set. Articles based on models and/or simulations were excluded from the analysis. Despite recognizing their importance in studying windstorms-forest system relationships, models and simulations were excluded because we aimed at examine windstorm impacts effectively measured, while models provide predictive analysis and estimations.

The data collection of direct and indirect windstorm impacts was based on a specific hierarchical coding. The core idea of the coding system was grouping windstorm impacts on forest-related components belonging to the same forest-related domain in hierarchical categories to better grasp the cascading effect of windstorms along and among multiple components of forest-related systems.

### Forest- related systems

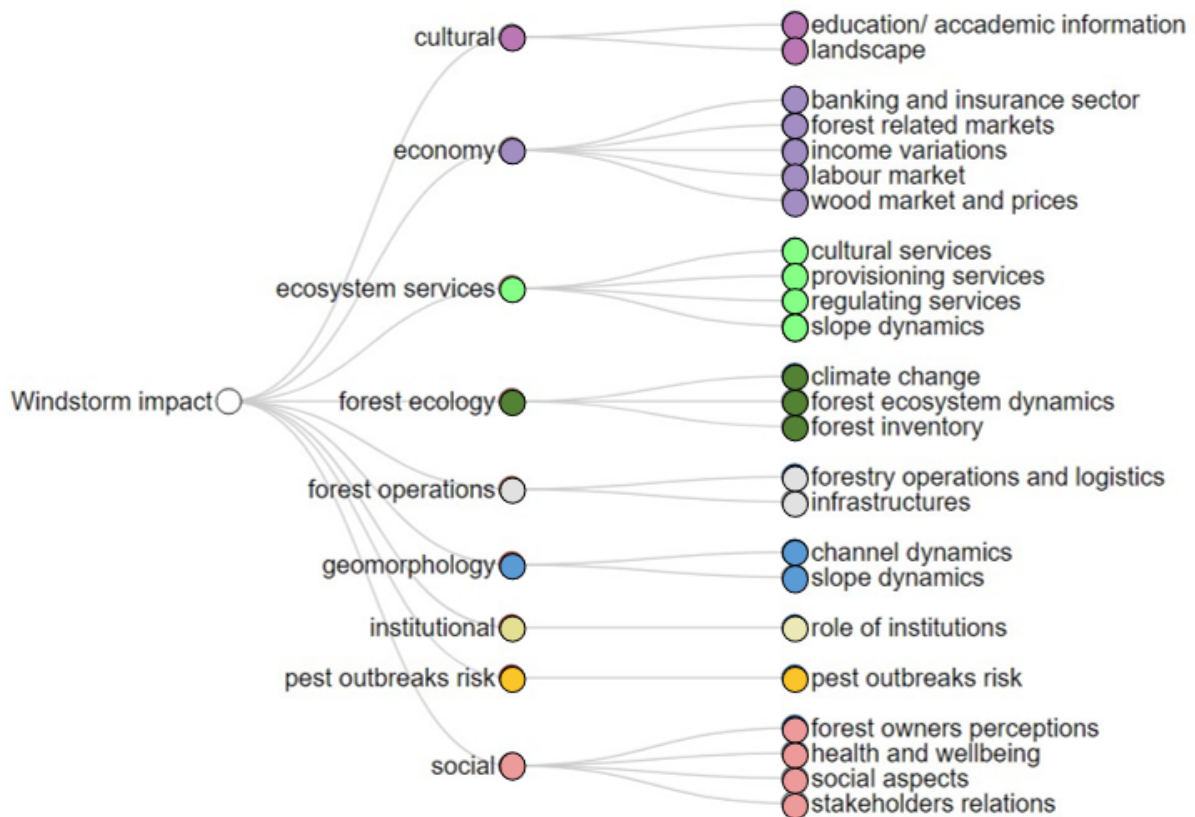


**Figure 2.** A schematic representation of the proposed coding system grouping windstorm impacts on forest- related components

Thus, the forest- related system taken as a whole system was broken down into: dimensions, macro-categories and forest-related components as shown on Figure 1.

Once windstorm impacts were categorized, the impacts have been graphically represented. The visualization of impacts allowed to represent cause-effect linkages among direct and indirect

windstorm impacts, as well as interconnections and cascade effects among different forest-related dimensions (Figure 2).

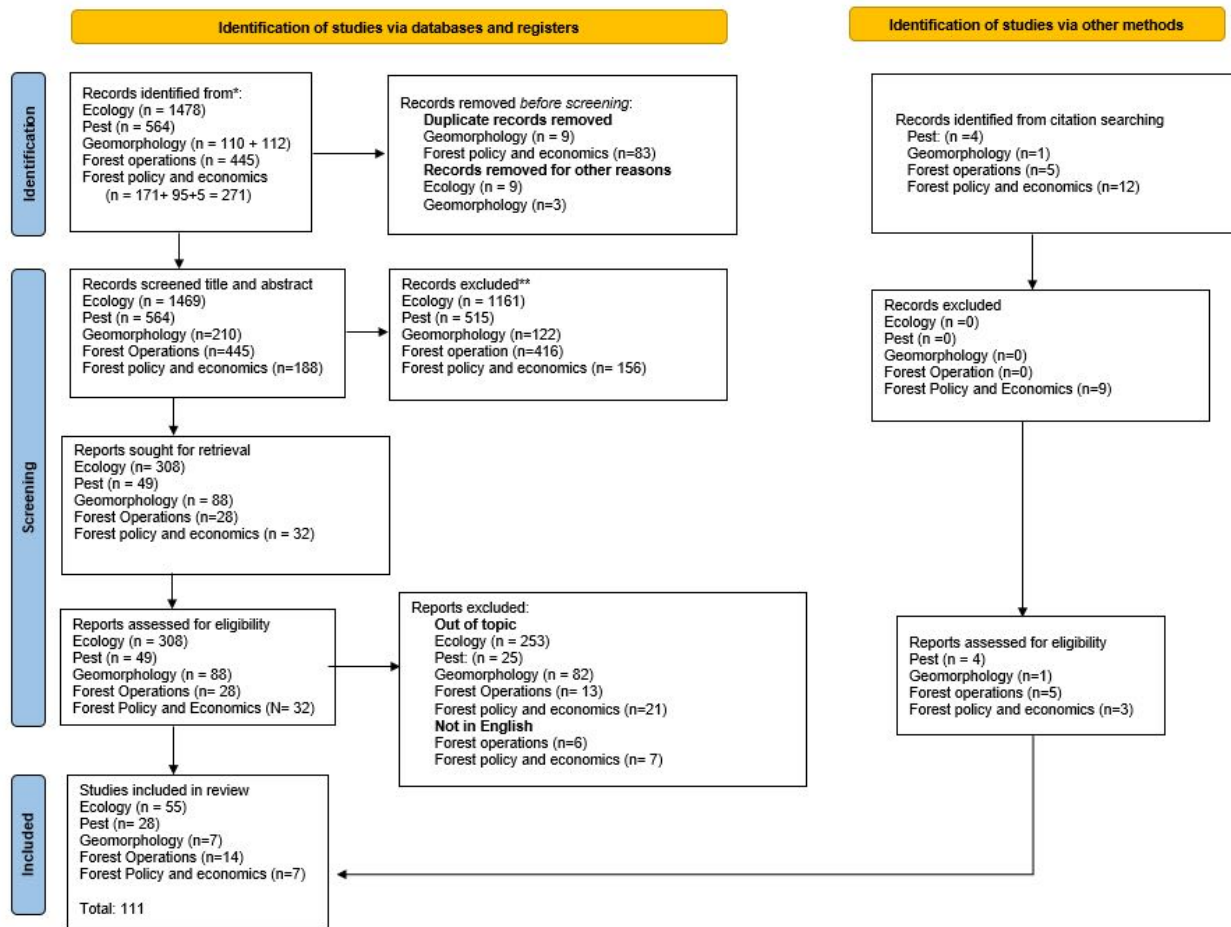


**Figure 2.** forest-related dimensions and macro categories used during the analysis

The searching and screening process is shown in Figure 3. First the searching process has led to the identification of 2.980 articles. After the screening of title and abstracts the number of papers was first reduced to 505 eligible articles.

Secondly, the 505 eligible papers underwent through an in-depth reading procedure to assess compliance with inclusion and exclusion criteria and ensure full pertinence with the scope of the review.

The final pool of scientific publications matching with the review criteria amounted at 98 articles. To the 98 scientific articles found in Scopus database through key-words searching, 13 articles identified from citation searching were added because considered extremely relevant for the scope of the study. The total number of papers categorized amounted to 111.



**Figure 3.** searching and screening process to select the most relevant papers.

The final database is composed of a total of 476 windstorm impacts, 272 related to direct impacts and 204 related to indirect/spillover effects. The lower number of indirect impacts is explained by the fact that 25% of the articles analysed did not outline spillovers connected to windstorm primary impacts.

Direct and indirect windstorm impacts for all the forest-related dimensions considered are reported in Figure 4. The majority of impacts categorized, both for direct and indirect impacts, belonged to environmental-related dimensions (forest ecology, pest outbreaks and geomorphology) that together amounted at 63% of total impacts retrieved. Impacts of windstorm on human- related dimensions considered (namely economic, institutional, social and cultural) at aggregate level accounted only for 13.4% of total direct impacts.

Examining the distribution and interactions between direct and indirect impacts within the forest- related dimensions considered we found that, on a general basis, windstorm impacts can be identified as trans-boundary. In general terms, apart from few exceptions, spillover consequences of direct windstorm impacts spread through multiple forest-related dimensions as shown in Figure 5.



### Direct and indirect windstorm impacts\_

Share of impacts per forest-related dimension

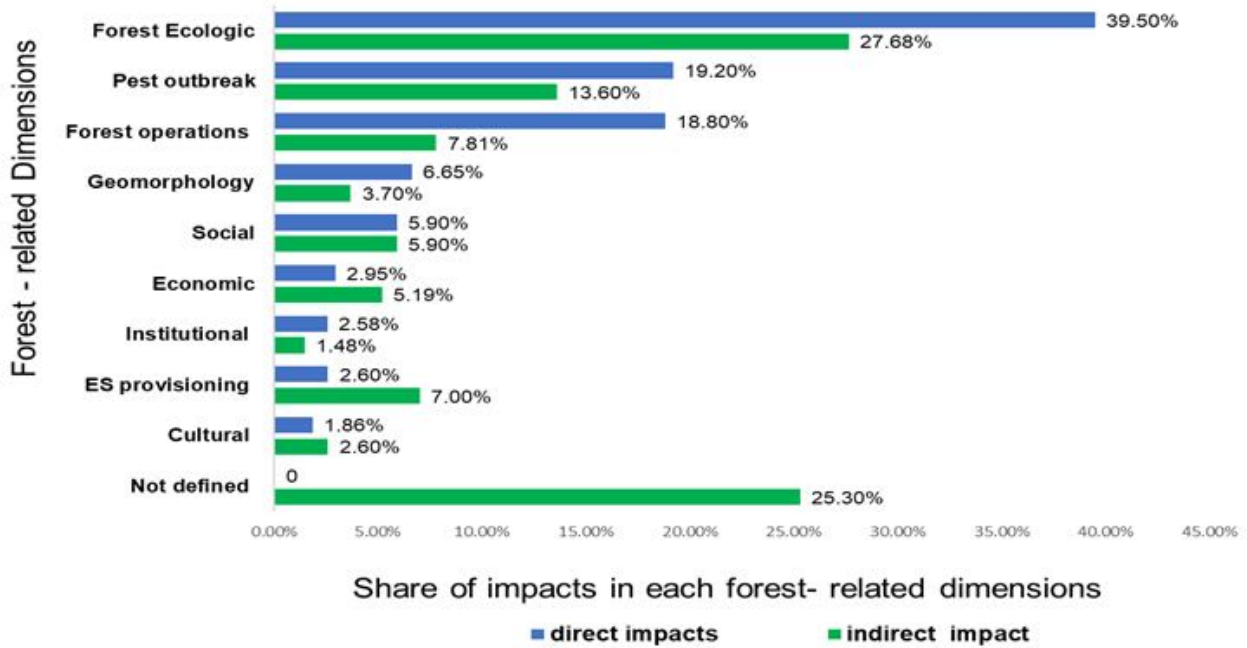


Figure 4. Share of windstorms impacts in forest-related dimensions analysed

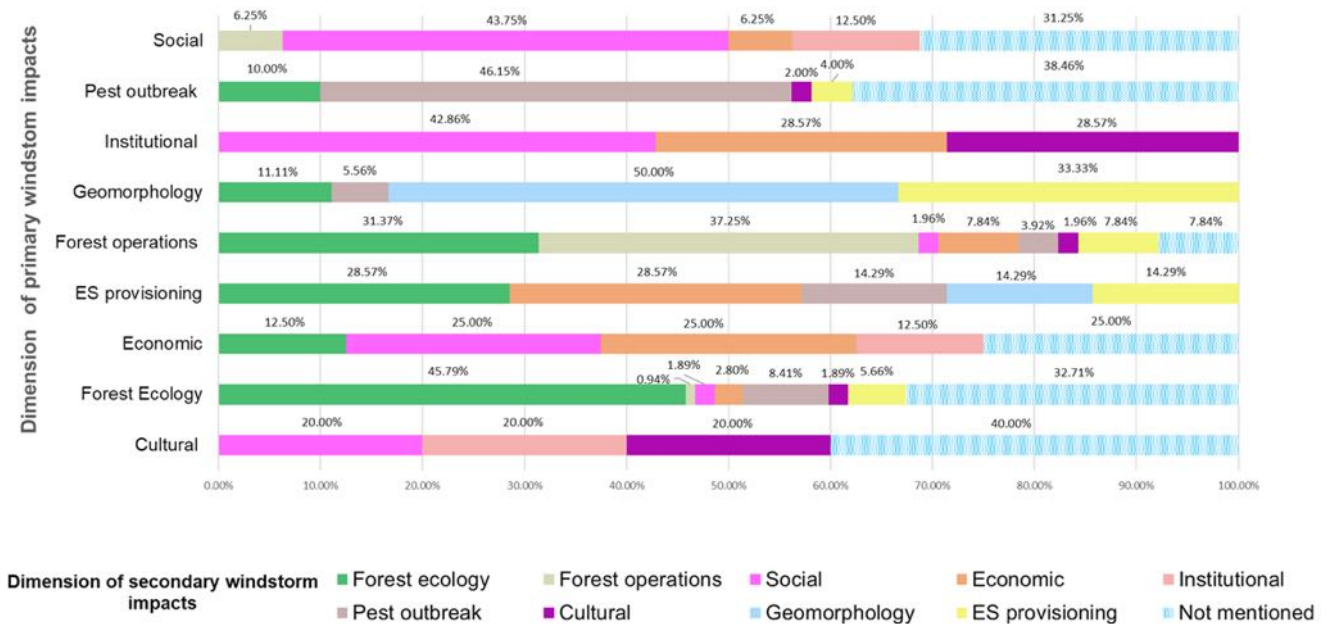


Figure 5. Composition of direct windstorm impacts among the dimensions considered

Inspecting topics and issues analysed within each forest-related dimensions some general patterns can be drawn regarding most common windstorm direct and indirect impacts analysed in literature.

Forest ecology dimension recorded the highest number of impacts, both for direct (39%) and indirect (27.8%) impacts. Being more specific, half of direct windstorm impacts dealing with forest ecology revolved around consequences on forest ecosystem dynamics (51.9 %). In particular attention was placed on windstorms impacts on forest structure, forest species composition and regeneration dynamics. According to our results, direct windstorm impacts at ecologic level mainly provoke consequences in the same dimension affecting several forest ecosystems dynamics and components such as, for example, forest ecosystem biodiversity, forest resistance and forest mitigation effect. Indeed, indirect impacts in forest-ecologic dimension are primarily triggered by changes in forest ecosystems dynamics, and, in minor extent (20%) by cascade effects arising by forest operations.

The analysis of windstorms on European forests and related systems will be presented by the submission within October 2022 of a subject review article as main deliverables (Deliverable 2.2) of the Task 2.1.

### **Task 2.2 Common terminology as a component for the project harmonisation**

The Task 2.2 led to the development of a glossary (Deliverable 2.1) of the most used terms relating to forestry and forest disturbances. The glossary is composed by glossary currently available and merge in to a unique document. The Task 2.2 has therefore provided the glossary in PDF format to be distributed through the website of project according to the guidelines for online distribution and copyright.

In addition, a summary document was prepared of all the references (Milestones 2.1) used for the subject review prepared under the Task 2.2.

### **3. Deliverables (D) and Milestones (M)**

D2.1 – Common terminology glossary (M12) (completed)

D2.2 - Review on the current approaches for forest SES risk management (M24) (Public report) (completed and submission expected for October 2022)

M2.1 – Literature database on forest SES risk management (M9) (Public database) (completed)