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Practical risk and resilience assessment: a methodology for implementation of Mountain Risk Management and Prevention Strategy (STePRiM)

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Abstract

Mountain territories are highly exposed to natural phenomena which threaten people, assets and infrastructures. Those phenomena induce both direct consequences (damage) on objects but also indirect consequences due to critical infrastructures failures. For instance, road closures due either to rock falls, floods, snow avalanches, landslides will have long-term, remote, economic, social consequences which somehow characterize the territory resilience.

To reduce risk, local authorities, State, infrastructures managers combine structural and non-structural measures such as protection measures, land use control plans, preventive information. In this context, challenging decision-making issues appear to define and choose the best measures and strategies for a given territory.

The French ministry for Ecological Transition (directorate for risk prevention) (MTE/DGPR), responsible for risk management, has designed and proposed a new innovative framework to help local authorities choosing and also funding their risk management strategies in mountain areas (STePRiM : Mountain Risk Management and Prevention Strategy). It consists in a first step of risk diagnosis followed by a step of prioritization between possible options. Due to large-scale assessment, it remains difficult to carry out detailed and complex risk and resilience analysis for all sites.

A specific, incremental methodology is required. This paper describes a practical methodology and emphasizes constraints and requirements for practical resilience analysis. Based on the example of CCPHG, it first recalls how risk and resilience concepts are communicated with technical experts and stakeholders. It then describes how direct and indirect risks are addressed in a consistent but pragmatic way. Results are provided in order to be used and connected with the decision-aiding processes involving stakeholders and considering their preferences and priorities.

1 Introduction

Mountains risks induce direct material, human and indirect consequences on exposed people and assets. Those risks have specific geophysical and socio-economic characteristics. Mountain geography, due to its slope and relief strongly influences and triggers intense and most often rapid phenomena such as rock falls, landslides, torrential debris flows, snow avalanches, earthquakes, glacier outburst, tsunamis in lakes (1). In a context of climate change, specialists anticipate an increase in the number of events occurrence or intensity of phenomena especially in mountains (2).
1.1 Risk management

In the context of natural phenomena, risk is classically defined as a combination of hazard and vulnerability, which is somehow equivalent to the combination of frequency and severity in an industrial, technological context. Hazard combines the intensity and frequency of phenomena. Direct vulnerability is the estimated nature of the physical damage and its value (for each element at risk) resulting from a combination of spatial exposure and potential losses. Natural risk reduction strategies are based on both non-structural measures, e.g., risk zoning maps, preventive information and protective structures, aiming at reducing causes and mountain natural phenomena effects on exposed elements, which may be severely damaged because of, e.g., debris flow impacts, overflowing, scouring, deposition for torrential floods (Figure 1).

**Figure 1.** Risk is reduced through non-structural and structural measures (e.g. in the context of torrential risks).

Critical infrastructures (energy, water, communication and transport networks) failures (3) have major consequences on territories in human and economic terms: they cut off logistical supply circuits, the transmission of information and access to essential services (security, health) (Figures 2 a,b).

**Figure 2.** Damage to transport infrastructures due to torrential floods.
For roads, direct vulnerability concerns users, vehicles and infrastructures (road itself, bridges...) whereas indirect vulnerability analysis focuses on the remote or delayed damage associated with the loss of the linking function of a critical infrastructure.

**Figure 3.** Indirect vulnerability analysis relates to consequences of loss of linking function of a critical infrastructure.

Quantitative multi-risk assessment have been widely addressed with very detailed and advanced methods (5,6) including climate changes issues (2). Advanced methods (e.g. based on graph theory) do exist to analyse networks resilience (7) with specific studies for roads exposed to natural hazards and calculate costs due to cut-offs (8). Networks structural properties and indicators such as betweenness or centrality allow to identify accessibility of a territory and critical nodes, roads (9,10) with links to decision-aiding specific issues (11). However, despite of their high interest, they may remain difficult to implement in practice in engineering and operational context due to required skills and data.

1.2 The STePRiM : a new integrated risk management framework

Mountain risks affect spatially constrained areas in terms of availability of safe buildable areas. Mountains risks is also specific due to the nature of land use and agricultural, touristic development which lead to constraints in terms of accessibility. Promoted by the MTE/DGPR, the STePRiM is an emerging framework based on official specifications document (1). It is put in place in collaboration between French State, its technical services and local authorities. This new system complements the natural risk prevention plans (PPR)¹ which remain the main tool for considering risks into land-use control and planning. All French mountain areas are concerned, i.e. the Alps, Pyrénées, Corsica, the Massif Central, the Jura, Vosges and overseas territories.

The StePRiM aims to increase the territory’s resilience through its sustainable development. The aim is to define a strategy, which is translated into an operational programme broken down in actions to achieve reasonable objectives and corresponding to improvement of knowledge and awareness of risks, risk forecasting and monitoring, warning and crisis management, consideration of risks in urban planning, reduction of vulnerability and protection works. It addresses mountain (multiple) risks management in a collective partnership with all stakeholders of the territory including public authority (State, local elected representatives) and also civil society and infrastructures managers. Its objective is to initiate and encourage pilot approaches for natural risks integrated management in

¹ [https://www.ecologie.gouv.fr/prevention-des-risques-naturels](https://www.ecologie.gouv.fr/prevention-des-risques-naturels)
mountain areas\(^2\). The objective of this paper is to present a part of the implementation process of the STePRiM methodology focusing on the assessment of indirect vulnerability and risks linked to the failure of critical road networks exposed to natural phenomena. It first describes the STePRiM framework and then proposes an application to a test-case recently implemented in Pyrénées mountains.

\section{Methodology and results}

\subsection{Building the methodology for StePRiM implementation}

The STePRiM aims to increase the territory's resilience through its sustainable development. The aim is to define a strategy, which is translated into an operational programme broken down in actions to achieve reasonable objectives and corresponding to: improvement of knowledge and awareness of risks, risk forecasting and monitoring, warning and crisis management, consideration of risks in urban planning, reduction of vulnerability and finally protection works. Figure 4 shows the overall proposed methodology.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{methodology.png}
\caption{Overall methodology for the definition of the STePRiM including the progressive passage from risk analysis (diagnosis) to risk management (establishment of the strategy, prioritisation of actions, decision-making process).}
\end{figure}

It addresses mountain (multiple) risks management in a collective partnership with all stakeholders of the territory including public authority (State, local elected representatives) and also civil society and infrastructures managers. Its objective is to initiate and encourage pilot approaches for the integrated management of natural risks in mountain areas\(^3\). The STePRiM methodology is based on three essential steps corresponding to 1) risk diagnosis, 2) protection and mitigation devices analysis and finally 3) the proposal and selection, prioritization of actions, solutions over the territory. The STePRiM process is somehow original in that it combines technical analysis and decision support phases with local stakeholders over a wide territory to build a risk management strategy (Figure 5). It also extends the more common, traditional only analysis of local, direct effects of phenomena on directly impacted objects and activities. The STePRiM starts with the assessment of classical risk components (hazard, vulnerability and exposure). While risk

\(^2\) (e.g.) \url{http://risknat.org/girn-alpes/index.html}, \url{https://www.bafu.admin.ch/bafu/fr/home/themes/dangers-naturels/info-specialistes/gestion-integree-des-risques.html}

\(^3\) (e.g.) \url{http://risknat.org/girn-alpes/index.html}, \url{https://www.bafu.admin.ch/bafu/fr/home/themes/dangers-naturels/info-specialistes/gestion-integree-des-risques.html}
assessment is done statically at a given time, the STePRiM approach also considers the resilience by taking into account the temporal aspect related (e.g.) to indirect damage due to networks cut-offs or through the assessment of efficacy, reliability and maintainability of protection works (Figure 6).

**Figure 5.** The StePRiM approach embeds risk analysis and evaluation at a wide territorial scale.

![Image](image1)

Source: Methodological STePRiM framework (12)

**Figure 6.** Core concepts of risk and resilience.

![Image](image2)

Source: STePRiM framework (12) adapted from Tacnet et al., in (13)

Three types of damage (direct material, direct human and indirect) are therefore considered in the approach for each type of stakes (dwelling, persons), phenomenon (landslide, rock falls, floods etc.) and scenario. Both of them can be assessed either quantitatively (monetary in euros) or qualitatively using scores, notes (0 to 1, 1 to 10) or, finally, using verbal forms (low, medium, high damage) (Figure 7).

**Figure 7.** Principles of the simplified methodology for analysing direct multiple risk

![Image](image3)

Source: StePRiM framework (12,14)
Direct damage may either be tangible, material (destruction of buildings, infrastructure, vehicles) or intangible, immaterial (death, injured people, environmental damage). Tangible indirect damage corresponds, for example, to loss of operations or accessibility. Intangible indirect damage (not addressed in StePRiM framework) may correspond to psychological disorders, effects on socio-cultural heritage and environmental damage.

When dealing with a territorial approach, the problematic concerns also the determination of vulnerability and indirect risks linked to critical infrastructures failures. This vision is not classically embedded in risk management plans. It therefore extends the more traditional analysis of local, direct effects of phenomena on directly impacted issues. The application below describes its principles but also emphasizes new needs and challenges.

2.2 Application area and practical issues

The Community of municipalities Pyrénées Haut-Garonnaises (CCPHG)\(^4\) is located in South-West of France. Its area is 631 km\(^2\) located in the Pyrenees mountain range with a population of 15,545 (25 hab./km\(^2\)). It gathers 76 municipalities with two thirds of them being in mountainous areas exposed to landslides, rock falls, plain and torrential floods, snow avalanches, wildfires. To build a strategy for risk reduction, understanding territorial and socio-economic features, in relation with the transport network structure, is essential. The Montréjeau area is dependent on the Saint-Gaudens area, which generates a lot of commuting. On the other hand, the area of Bagnères-de-Luchon is relatively autonomous (80% of the people living in this area work there) (Figure 8-b). 81% of jobs are located in the tertiary economy making this area the first one in terms of development of tertiary activities are most developed. This illustrates the importance of the tourism economy based on mountain activities (ski resorts, hiking...) and thermal baths (Figure 8-b). The north piedmont area is very well served with the motorway nearby. The train lines also allow reaching main cities of Toulouse, Tarbes and Pau... However, mountainous geography of this territory makes travel, mainly by private cars, difficult. The railway line has been closed since 2014, and its reopening is planned in the coming years after a major overhaul. The Pique and Garonne valleys are well served with a national road accessing to Spain. As soon as one leaves the main roads, access is more complicated (15).

On this basis, the goal is to estimate the indirect damage caused by the cutting of roads by natural phenomena: it requires knowing cut-off zones and the value of lost time and the remote impacts on economic activities (tertiary, industrial activities...). Several advanced, detailed analysis exist to assess networks disruption and resilience (7) but in practice, when working on a wide territory, the analyst may face some difficulties. Several data, to be broken down by type of phenomenon, are indeed necessary to make this analysis:

- Normal and increased travel times (resp. \(T_{\text{nominal}}\) and \(T_{\text{deviation}}\)) are needed. They may be difficult to calculate, hence the idea of using real traffic data. Getting traffic on the different routes (comparing sources based on vehicle counts and data from GPS providers databases is an option, which appears possibly costly);
- Cut-off times (real or estimated) according to the nature of the phenomena and their magnitude are also important. Analysing real events constitutes a reference (to avoid the risk of misinterpreting data corresponding to an accident, for example). In our context, the approach has consisted in designing standard tables to determine the duration of cut-off considering to several criteria;
- Identification of possible diversion routes may not be obvious (this can be obtained either by using "shortest path" type algorithms or from data) (9–11).

The section below shows how direct and indirect consequences have been addressed based on available information and implementation constraints. Direct material exposure and human damage are first addressed (section 2.3.1). Indirect damage is calculated in section 2.3.2. Expert assessments are formalized in simplified tables to support this process.

\(^4\) https://cc-pyreneeshautgaronnaises.fr/
2.3 A simplified methodology to calculate direct and indirect damage

2.3.1 Direct material exposure and human damage on roads

Direct material exposure associated with road traffic as showed in tables is calculated as follows (numerical values are given as examples):
- Average daily traffic (\( \text{AvT} \)) in vehicles/day: 200
- Average speed (\( \text{AvS} \)) in km/h: 50
- Time between 2 vehicles (\( \text{TimeV} \)) in s: \((24\text{h/day}.3600\text{s/h})/\text{AvT} = (24.3600)/200 = 432 \)
- Spacing between 2 vehicles (\( \text{SpaceV} \)) in m: \((\text{TimeV}.\text{AvS}.1000\text{m/km}) / 3600\text{ s/h} = (432.50.1000) / 3600 = 6000 \)
- Length of exposed road section (\( \text{ExpoL} \)) in m: 300
- Direct material exposure rate (number of vehicles on exposed road section) (\( \text{DMER} \)): \( \text{ExpoL}/\text{SpaceV} = 300/6000 = 0.05 \)

Direct human damage as showed in table 4 is calculated as follows (numerical values considering a high intensity avalanche event is given as an example):
- Average human exposure rate (\( \text{AvHER} \)) in persons/vehicle: 1.8
- Letality rate (\( \text{LetalR} \)): 0.1 or 10\% (considering vehicle protecting effect, possible rescue)
- Direct material exposure (\( \text{DMER} \)): 0.05 (5\%)  
- Reach probability (ratio between phenomenon range and length of exposed road section) (\( \text{ReachProba} \)): 0.6 (60\%)

\[
\text{Direct Human Damage (on road) (DHD) in persons} = \text{AvHER} \cdot \text{LetalR} \cdot \text{DMER} \cdot \text{ReachProba} = 1.8 \cdot 0.1 \cdot 0.05 \cdot 0.6 = 0.0054
\]

2.3.2 Indirect damage on roads

Several levels of analysis of road networks exist depending on whether the problem corresponds to a planning phase (construction of a new road, a new equipment in relation
with existing networks capacities) or the dynamic operation phase (traffic monitoring and management, analysis of travel times with or without interruptions, management of diversions). Here, we only consider a simplified process to contribute to assessment of the indirect vulnerability associated with the loss of the linking function of a critical road infrastructure. The goal is to first assess where the cut-off zones are and then, secondly, the level of consequences and the cost to economic activities associated with a traffic interruption. The overall approach follows the same logical path as that classically implemented for the analysis of direct damage: identification of hazards (phenomena cutting roads), exposure (traffic), damage (duration, costs). The steps are implemented in the context of road networks for each phenomenon, each scenario associated with a given frequency and intensity:

- Identification of the threat: Where are the roads that can be cut? By what? How often? With what intensity? For how long? With what consequences?
- Identification of the damage: what is the origin, the cause of the cut? What will be the duration of the cut?
- Analysis of exposure: what is the nature of the roads that may be closed (international, national, regional, departmental, municipal)? What is the nature and volume of traffic (people, freight, volume, number) (Figure 9–a)?
- What are the possible diversions if a section is cut (Figure 9-b)?
- Analysis of the consequences: What will be the lost access? How much will road cut-off increase access time (for the different services or sectors of activity)?

**Figure 9.** Global territorial network analysis: traffic and possible diversion paths.

In practice, this translates into the following implementation phases:

- Identification and location of the phenomena and their effects (e.g. flooding, scouring, etc.) likely to cut the road. For each phenomenon, effect, for a given frequency level, determination of the intensity of the phenomenon (or of one of its effects);
- For a given phenomenon (effect) and intensity level, estimate the duration of the cut-off $D_c$ . It depends on the type of road, the nature of the phenomenon and its intensity
A table based on expert assessment is proposed (Table 1). It defines the selected duration ratios according to the nature of the phenomenon and its magnitude;

- The equivalent indicator for damage is the lost time resulting from increase in travel time. For a road cut-off section removing access to an exposed area, determination of the lost time ($t_{\text{lost}}$) compared to the normal situation. $T_{\text{normal}}$ represents the travel time without any traffic disruption, $T_{\text{diversion}}$ represents the travel time when using the diversion. An expert analysis is done on each main road to identify the diversion road, its features (length, main speed) and then calculate the duration of travel with diversion $T_{\text{diversion}}$;

- Estimated value of damage to exposed covered areas issues determined through lost time ($C_{\text{lost}}$) following cost-benefit analysis economic approach. Cost in € for each hour of lost travel time is estimated according to the principles of CBA/Multicriteria analysis method (16);

- Assessment of the exposure through the volume and nature of disrupted traffic (traf). In practice, traffic information can be obtained on main roads from infrastructure managers (Figure 8-a);

**Table 1.** Evaluation of the road cut-off time based on expert assessments.

<table>
<thead>
<tr>
<th>Phenomenon intensity</th>
<th>Condition of the roadway (after event)</th>
<th>Snow avalanche</th>
<th>Torrential flood</th>
<th>Landslides</th>
<th>Rockfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>High phenomenon</td>
<td>Snow deposit greater than 1 m over several dozen meters in length</td>
<td>Scouring and/or covering by more than 0.5 m solid material thickness; gullying and ripping of road pavement</td>
<td>Covering by more than 1 m solid material thickness; road displacement; road drop or shoring greater than 0.5 m</td>
<td>Stopping and impact of isolated: cover grouped blocks greater than (0.5 m); aerodynamic height of the blocks greater than 1 m</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>Rehabilitation during several days with important means</td>
<td>Decollating, debris removal; undigging of bridges, hydraulic pipes and works</td>
<td>Rehabilitation time of several days with important means and/or reconstruction of roadway, drainage works</td>
<td>Rehabilitation time of several days with important means</td>
<td></td>
</tr>
<tr>
<td>Road closure duration ($D_c$)</td>
<td>48 hours (2 days)</td>
<td>24 hours</td>
<td>168 hours (7 days)</td>
<td>48 hours (2 days)</td>
<td></td>
</tr>
<tr>
<td>Medium phenomenon</td>
<td>Snow deposit between 0.5 m and 1 m over several dozen meters in length</td>
<td>Scouring and/or covering by more than 0.5 m solid material thickness; gullying or road pavement</td>
<td>Covering by more than 0.5 m solid material thickness or road displacement</td>
<td>Stopping and impact of isolated: cover grouped blocks greater than (0.5 m); aerodynamic height of the blocks lower than 1 m</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>Rehabilitation during one day with important means</td>
<td>Decollating, debris removal; undigging of bridges, hydraulic pipes and works</td>
<td>Clearing of obstructive materials from the roadway, spot repair works, management of water inputs to the roadway</td>
<td>Blocks removal and residual risk assessment</td>
<td></td>
</tr>
<tr>
<td>Road closure duration ($D_c$)</td>
<td>24 hours (1 day)</td>
<td>12 hours (half day)</td>
<td>24 hours (1 day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low phenomenon</td>
<td>Partial snow deposit under 0.5 m</td>
<td>Dispersion and spreading of flows</td>
<td>Covering by less than 0.5 m solid material thickness</td>
<td>Stopping and impact of isolated: cover grouped blocks lower than (0.5 m); aerodynamic height of the blocks lower than 5 m</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>Traffic disruption (transport and travel delays)</td>
<td>Roadway clearance with possibly reduced traffic or very temporary road closure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road closure duration ($D_c$)</td>
<td>0 hour</td>
<td>0 hour</td>
<td>0 hour</td>
<td>0 hour</td>
<td></td>
</tr>
</tbody>
</table>

*Source: adapted from ONF/RTM, 2022, StePRIM, CCPPG Risk diagnosis report.

Finally, for each frequency, the indirect damage (loss due to traffic disruption, access cut-off) is equal to $D_c$ (hours) x $t_{\text{lost}}$ (hours) x traffic (vehicles/hour). On this basis, the cost of loss in € due to traffic disruption could be calculated by $D_c$ (hours) x $t_{\text{lost}}$ (hours) x traffic (vehicles/hour) x $C_{\text{lost}}$ (€/hours.vehicle).
There are indeed two possible cases, depending on whether a diversion is possible or not: 1) without diversion, the time lost is the traffic outage duration (including event triggering, detection and repair time: $t_{\text{lost}} = D_c$; 2) with diversion, the lost time is the minimum between the additional time related to the deviation and the outage time: $t_{\text{lost}} = \text{Min} \{ D_c; T_{\text{diversion}} - T_{\text{normal}} \}$. This calculation is, of course, a simplified vision of reality since a natural phenomenon affecting a road network can lead to a total cut-off or a reduction in traffic (reduction in speed, number of vehicles). The total lost time is indeed for each part of traffic using them, the sum of the time lost due to traffic reduction on the disrupted road and the time lost due to the use of the diversion.

### 2.3.3 Main results

Table 3 shows the results of direct material and human damage for exposed people on roads for each category of phenomenon. Table 4 represents a synthesis of the direct damage over the whole territory given the assumptions and simplifications described above. Figure 10 shows the lost time in vehicle days on each section. Those results do not replace precise, local risk analysis but allow to have a quick overview on main threats on a large area and therefore to imagine and choose risk reduction strategies. Cut-off zones and duration have been identified for all phenomena on specific sections (Figure 10) using assumptions of Table 1) and show that tourist accesses at the bottom of the valley are highly exposed. It may provide useful information for infrastructures managers. A first estimation of the effect (loss of activity time) on remote activities is based on an arbitrary expert based cut-off duration as shown on table 2. However, the complete operational, simple assessment of indirect damage due to activity losses, somehow useful in a wide land-use planning vision extending results of Table 4, is still challenging.

<table>
<thead>
<tr>
<th>Impact on employement areas</th>
<th>Snow avalanche</th>
<th>Torrential flood</th>
<th>Landslides</th>
<th>Rockfalls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic activity continuity</td>
<td>Covered of facilities, technical zones with important amount of material, important structural damage to buildings, equipment preventing the continuation of the activity.</td>
<td>Covered of facilities, technical zones with important amount of material, important structural damage to buildings, equipment preventing the continuation of the activity.</td>
<td>Covered of facilities, technical zones with important amount of material, important structural damage to buildings, equipment preventing the continuation of the activity.</td>
<td>Covered of facilities, technical zones with limited amount of material, no structural damage to buildings, equipment preventing the continuation of the activity.</td>
</tr>
<tr>
<td>Nature of the operations necessary for a resumption of activity</td>
<td>Clearance and rehabilitation last several days with important means; Repair of structural damage.</td>
<td>Clearance and rehabilitation last several days with important means; Repair of structural damage.</td>
<td>Clearance and rehabilitation last several days with important means; Repair of structural damage.</td>
<td>Clearance and rehabilitation last several days with important means; Repair of structural damage.</td>
</tr>
<tr>
<td>Duration of interruption of activity</td>
<td>+/- 168 hours (7 days long)</td>
<td>+/- 168 hours (7 days long)</td>
<td>+/- 168 hours (7 days long)</td>
<td>+/- 168 hours (7 days long)</td>
</tr>
</tbody>
</table>

**Source:** adapted from ONF/RTM, 2022, CCPHG STePRiM, Diagnosis report
### 3 Conclusions

The STePRiM framework is a new and original tool for mountain risk integrated management and resilience for two reasons. First, the objective of the STePRiM framework is dedicated to promote an integrated vision of risk management (from risk awareness to protection works) which somehow allows being better prepared at a territorial scale to event management. Secondly, the analysis introduces a temporal aspect by looking at the delayed consequences of network outages. While risk assessment is done statically at a given time, indirect damage due to road networks disruption is characterized using practical expert assessment of effects and time to recover and repair.
The STePRiM also innovates in mixing both risk analysis and decision-making steps. Its territorial features emphasizes needs to combine assessment methods with specific decision support frameworks designed and adapted to various contexts in terms of actors, solutions, spatial and temporal scales. This constitutes a promising challenge for development of new progressive, integrated resilience assessment frameworks for critical infrastructures exposed to natural (or technological) threats mixing quantitative, qualitative assessment and decision-aiding methods. From a more general point of view, this kind of approach demonstrates gaps between theory and practice. The challenge will always consist in finding the best compromise between performance, precision, complexity and simplification, speed, imprecision (Figure 11) when choosing and applying assessment methods.

Acknowledgements: we thank the services of DDT (Departmental Directorate of Territories) of Haute-Garonne, DDT of Alpes de Haute-Provence, DREAL (Regional Directorate for Environment) of Provence Alpes Cote d’Azur and also the French National Forest Office/RTM of Hautes-Alpes for our fruitful discussions and collaboration.
Figure 11. Coping with complexity, accuracy and usability, the challenge of transfer from science to real decision-making contexts.

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