Forest Biodiversity, Soil Functions and Human Behavior - A case study: the October 29 2018 catastrophe in North-East Italian Alps

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Abstract

A strong wind severely damaged the forests of 473 Italian Alpine municipalities at the end of October 2018. The affected forest area covers 42,500 ha. The president of one of the damaged regions asked for help from the TESAF department of the University of Padua. 27 international scientists (listed: 24; anonymous: 3) responded to the appeal and collectively wrote this article. At first, we discussed the value of ramial chipped wood; then of leaving or not the forest to its natural evolution; there was no lack of bark beetles; we estimated the biodegradation times of fallen trees according to the on-site humus systems and forms and also ended in political and social considerations. After eight months of discussion, with various reworkings and cuts, a controversial text was born, complete, and practical at the same time. There are several ways to read an article that seems too long:
a) Focus on Conclusions. In this report, there are two means to look at them: 1) Chapter 4. Conclusions: Response to Governor Luca Zaia, with concise considerations; 2) Chapter 3. Actions, in subchapter 3.3.1. Silviculture on 75% of the damaged area - Synthetic plan, with the practical items to do in the field; crucial pieces: Tab. 1 and figure 7;
b) Having some time left: pass through the answers reported in Chapter 2: Why not let Nature curing its wounds by herself? (for the complete authors' answers, refer to https://hal.archives-ouvertes.fr/hal-02342793, a CNRS site, France. Article code: hal-02342793);
c) Some idea of effective investigations in the chapter 3.3.2. Research on 25% of the damaged area;
d) while discussing, both traders and artists did not stop working. Just look at figures 8 and 9 or listen to Vaia's scream. The article displays an unusual Premise entitled "Should we doing science or politics?", and proposes a "Final suggestion" for rescuing the forests....of the whole planet!

***Keywords**: VAIA; Wind damages; Soil organic carbon; Humus; Climate change*

PREMISE: SHOULD WE DOING SCIENCE OR POLITICS? Augusto Zanella (IT), Nicolas Bernier (FR), Valter Giosele (IT), Cristian Bolzonella (IT)

Scientific and societal goals.

SADS (Soil As Digestive System) is a multinational group (the 24 authors of this article and an anonymous ecologist), composed of minds of diverse and co-evolving scientific opinions. The group took birth after a major storm over the North Veneto region (Italy) that came to the overall destruction of trees.
We know that forests generate from living soil. A forest ecosystem is composed of lasting organisms that use the soil as a secondary source of nutrients, the primary source being photosynthesis. The soil corresponds to a mandatory recycling center necessary for forest survival, in harmony with a local and relatively fixed climate and a geological substrate. Soil organisms digest dead organisms or parts of them, allowing reinvesting the products of past biological activities in living structures through the photosynthetic process. As for egg and hen, was soil born before photosynthesis or vice versa? The process of photosynthesis took probably place in the soil, at the origin, but in contrast with the digestive processes, the chloroplast activities are poorly diversified. Regardless of plant species, the photosynthetic function is taken in charge entirely unchanged. The digestive system is, in contrast, highly diversified and unequally distributed among the soil organisms. Fortuitously, it lies beneath the surface and remains quite invisible, and could be the Achille's heel of every ecosystem.
One among the authors claims that the management required after an event of such a high economic impact is not a task for university experts. That the present matter is not a question of biodiversity, biodegradation, litter, and worms, but of millions of cubic meters of lumber to be taken to sawmills for mountain inhabitant's sustainability. Are soil ecologists able to furnish indications on the soil of destroyed by wind forests, suggestions that can help to revive/sustain a mountain economy, respecting the ecological peculiarities of the damaged sites? Here down the collected opinions and recommended measures of intervention.
Given this general societal and natural context, and the current changing climate, even if the challenge that we would like to solve is locating in Italy, it could be an example of similar cases elsewhere. The issues would be the same in

other mountains. We would like to know how to manage correctly a forest knocked down by the wind. Would long term solutions be in agreement with short term ones? Have we to take away the fallen trees, eventually how much of them, or is it better to let them on the forest ground? Is it possible to transform this tragedy into economic wealth? Is there something at risk to be lost forever?

It is relatively easy to adopt a positive attitude and to believe that the forest will soon return as it was before the storm (a lot of people think like that). Can scientists believe that after a devastating hurricane, there is more timber available for human needs on a forest floor and that to take it away has no consequences on the forest becoming? Is this science or witchcraft?

Luca Zaia, president of the Veneto region, requested the intervention of the TESAF (Territorio E Sistemi Agro-Forestali) department of the University of Padua: "Please, send me directives as soon as possible".

We accepted with pleasure the challenge. Mixing science, philosophy, and even society ambitions, we found out some answers.

Doing science

Scientists have fewer and fewer choices other than engaging scientific knowledge in societal challenges. Yet, is it compatible with "doing science"? This question is worth asking since the future is not precisely fated, and ecological predictions may look like charlatanism. Strengths and weaknesses of ecology hold precisely in the unpredictable dimension of nature. The stochastic aspect brings considerable richness, allowing mechanisms such as interchangeability, founder effects, resilience, etc. System indeterminism is at the origin of ecologist discomfort when meeting requests for recipes. The duty of science holds probably more toward educating the glance than to manipulating nature. If society wishes more life, it should agree to lose some control over it to let every organism filling empty spaces and sharing a variety of ecological niches. In turn, every organism will be (or will construct) a habitat for adding a multitude of other species.

Consequently, the "letting go" philosophy or the will to let nature going by itself is at the core of the educational duty for scientists. Scientists must set up a back control of the way by which spontaneous dynamics serve humanity to check if this "letting go" philosophy brings some fruits, i.e., if the ecosystem goes in the direction of niche sharing and differentiation, that is a promise of biological richness. In this frame, scientists may play an active role in society, explaining the differences between natural wilderness and natural gardening. Both systems may hold a similar level of species diversity, but the former is self-organized while the second needs social skills to stabilize the ecological niche of each component. And the second alternative has an operational cost.

Sociology and ecology, a natural marriage?

Society and Nature must evolve together. Humans are an outcome of Mother Nature. Humans cannot live without Nature, but Nature can exist and live without humans. An entire artificial world cannot exist because we are unable to replicate the natural recycling of elements without producing trash. The cycle of plastic is a clear example (https://storyofstuff.org/the-story-of-plastic/the-problem-with-plastic). The dynamics of living systems occurs by jumps. Nature essays "prototypes". If they don't work, Nature tries other unlimited in number designs. We need to deconstruct our human-sided view of Nature because the "correct way" stays in the future, and it does not exist a priori.

Speciation is a natural mechanism that drives living beings to fill the gaps between occupied ecological niches. Nowadays, world ecosystems have to cope with mundialization that brings new flows and new channels. Increasing mobility brings upheaval in both ecology and society. Species and populations carried away from any places around the world bring disruption of local equilibria. Population dynamics, in an environment with limited resources, are known for a long time (Kingsland, 2015; Volterra, 1926). A new incoming population increases slowly first, then rapidly and finally reaches an overall equilibrium, oscillating around a relatively stable value of environmental resources. Invasive species may be considered as monopolistic (a factor depleting biodiversity) or on the contrary, as a means to increase local biodiversity. The exportation of a universal model of sociological development upset the equilibrium of a millennium share of resources between humans and Nature. The belief and the system value that support the search for new stability cannot overlook economic constraints and the fact that richness unequally distributes.

On the one hand, an ecological system is ultimately a biological solution to dissipate solar energy (Zanella, 2018). On the other hand, a sociological system is a solution to dissipate richness. Putting the analogy to the end, we know that an ecological system also has a hidden face that is soil as a digestive system (Sads), and we may wonder what a Sads could be for society.

Sads is the regulatory focus of every ecosystem. From an organizational point of view, the counterpart of Sads to the society could be the dissipative mechanism that corresponds to the process of economic goods consumption. Thus, the instruments of a social Sads regulation could consist of taxes and allow public services to control the consumer society. Unfortunately, this captivating representation may work only in a virtual and with unlimited resources world. As we *live in a real and limited resources world, we need to reconcile with Nature. Humans should limit their needs. Living and dead Nature should remain in a long-term balance. Social and natural Sads need to meet themselves and co-evolve.*

Humans struggle to distinguish between safe and dangerous progress. The "genetically modified organisms" are an example of ambiguous scientific attitudes: are these organisms the fruit of useful knowledge (a sort of intensified natural evolution) or models of unsafe progress? Back to the Vaia event, does the export of matter from a forest ecosystem influence its consistency in the future? Is it adequate to take away no more than the annual increment? Can we take away something from the wood without giving something in exchange for it? We can change the species composition of forests when economically advantageous. Is this a right or wrong move? When does a forest correspond to a group of living organisms? When does it, instead, correspond to a system of living organisms, with its functioning? Are we able to count the living organisms that make up a forest? Is it essential for humans to take care of this aspect of the story?

The authors of this article want to try a new formula for scientific articles. They propose to list the engaging opinions of a group of scientists (in the form of a lively dialogue) and to address them to politicians for putting the views into practice. After presenting official data on the catastrophe, we pondered several publications that suggest some recommendations. The main issues are listed in the Conclusions as a letter addressed to President Zaia, one of the rare politicians who asked for scientific support before making operational decisions.

INTRODUCTION

The Vaia event was quickly and well introduced (Motta et al., 2018). For this reason, we asked directly one of the authors, who preferred to remain anonymous, whether he could provide some updates on the catastrophe. We illustrated his contribution (1.1 and 1.2) by adding the "ecological" impressions focused chiefly on soil (1.3) of some of the authors of this paper.
On October 27-29, 2018, intense sirocco currents, boosted by their passage over the Mediterranean Sea (during a summer season much warmer than average), struck north-eastern Italy. Wind currents channeled along the slopes of many Alpine valleys reaching speeds of over 150 km/h (Fig. 1).
The Directorate General Forests of the Ministry of Agriculture, Food and Forestry and Tourism established a technical table with the Regions and Autonomous Provinces of Northern Italy affected by the storm. A few weeks after the disastrous event, the committee released the first quantitative analyses of the extensive damages to the national forest heritage. The analyzes base on local authorities' damage estimates, through field surveys and interpretation of aerial and satellite images, and with the support of numerous universities and forest research institutes (Fig. 1).
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Data

- *The forests of 473 municipalities were damaged. The affected forest area covers 42,500 ha, where an almost total knockdown of trees was observed, to which a similar surface having suffered partial damages should be added. Most affected areas are the Autonomous Province of Trento with over 18,000 ha of felled forests and Veneto with over 12,000, followed by Alto Adige, Lombardy and Friuli. Slight damages were noticed in Piedmont and Valle d'Aosta.*
- *The volume of timber on the ground in the 42,500 most damaged areas reaches about 8,300,000 cubic meters. Based on these estimates, the Vaia storm is the most destructive event ever recorded in Italian forests.*
- *This kind of storm in Central Europe is now quite common and is the cause of about 50% of forest damage in the last 100 years. The average rate of major or critical storms which hit Central Europe is two a year (the most famous cases being Vivian in 1990 and Lothar in 1999 with damages equal to about 200 million cubic meters).*

Criticalities

* *Downstream damaged forests, the function of protection of settlements, and human activities will be severely affected by falling rocks, avalanches, landslides for a period ranging from a few to tens of years. This situation will last until the post-storm renewal has been established.*
* *Risks of disease to surviving forest stands, primarily dominated by northern spruce (Picea abies (L.) Karst), are caused by the proliferation of Scolytidae's insects. They deposit eggs in fallen wood from which the populations can invade the surrounding forest stands, especially in the presence of a hot spring.*
* *The danger of spreading fires is caused by the high amount of deadwood mixed with grass and shrubs. This can give rise to highly flammable fuel and generates high flame front intensities.*
* *Significant economic damages to the chain of wood products are due to the low price at which wood is sold on the ground, an amount which still decreases rapidly over time because of the alteration of technologic quality. This sharply reduces the opportunity of public and private owners to benefit from the economic value of these highly productive forests. At the same time, harvesting all fallen timber will require 2-3 years, enough to bring down the price of wood in a period of excess supply, with adverse effects on the national forest sector of activity.*
* *Ordinary forest management is abandoned in non-damaged stands, as foreseen by planning tools, following commitment for emergency management of harvested timber.*
* *About the safety of the personnel employed in crashed forest site areas, where the felling and extraction of wood are complicated and dangerous due to strong wood tensile forces, there there is a high criticality. Some workers have already lost their lives on the worksites in progress. For these activities, the high professionalism of the operators is required.*
* *We expect a significant modification in the structure and composition of habitats of Community interest (Natura 2000 network), with inevitable repercussions on behavior, survival, and dispersal of animal and plant species.*

Figure 1. Left: Centre of Studies for the Alpine Environment (Belluno, Dolomites, Italy) on October 30, 2018, on the day after the event. Notice fallen trees on the roof of the building and part of the damages done in its vicinity. Right: Same position two months later (January 4, 2019), with the first restoration works (Photographs: Roberto Menardi).

Ecological impressions after Vaia

Immediate reaction. Roberto Menardi (IT), Jean-François Ponge, (FR), Augusto Zanella (IT)

From the beginning, the experts correlated the increase in temperature of the Mediterranean Sea with a higher quantity of energy and water vapor, which corresponded to the incredible virulence of the specific meteorological phenomena

occurring on October 29, 2018. Was the Vaia storm a perverse fruit of such a climate change on which so much people discuss? The soil "fluidized" reducing the root seal. The strong wind (about 100-130 km/h) produced localized whirlwinds due to roughness and micro-orographic peculiarities, which, allied to canopy rocking, caused the observed damages (Barcikowska et al., 2018; Cat Berro et al., 2018).
What percentage of vegetation would still be let in place if more responsible forest practices had favored a diversification of forest stands (Arts et al., 2013; Bormann and Likens, 2012; Motta et al., 2018)? Besides, great neglect was given meanwhile to the margins of forest stands: compactness of the border vegetation between a meadow and the forest is almost always lacking (Fig. 2, Left compared Right pictures).

Figure 2. Left: Forest without a mantel, easily subject to wind blows. Cadino Valley, Trento (photograph: Valter Giosele, July 8, 2019). Right: forest with shrubby mantel that resists strong winds. Boite valley, Belluno (Roberto Menardi, July 11, 2019).

You can enter immediately in the heart of the forest, too often thinned out by intensive use, more markedly in private forests. In most low and medium mountain forests, in search of higher economic rent, spruce has always been favored, "cultured" in even-aged pure populations (Gonzalez et al., 2010; Indermühle et al., 2005; Kauppi et al., 2018). This species has a superficial root system (Fig. 3 Right), and, in the event of a wind blow, its stands suffer from a domino effect (Merzari et al., 2018), as it also happened this time (Fig. 3 Left).

Figure 3. Left: In this population of spruce and larch destroyed by the Vaia storm, only some larches remained standing. The deeper, more solid root system and the lighter foliage probably made the difference (photograph: Roberto Menardi, November 9, 2018). Right: the root system of Picea abies does not allow isolated trees to withstand strong winds (photograph: Roberto Menardi, January 4, 2019).

In forest stands where trees were more diversified in age and species, devastating effects of the wind were more restricted, with a better resistance due to different morphology of the root system (white fir, larch, beech, and other deciduous trees). In damaged areas, only some larches (with little "sail effect" causing canopy rocking) and sometimes hardwoods remained standing. They survived the disaster for "intrinsic properties", not only because they bypassed by crashed vegetation (Fig. 3 Left). Merzari et al. (2018) reported: "Reasonably if we had mixed woods with different species (like spruce, fir, beech, and other species) of different ages able to better use the vertical space of the foliage, and with younger and more elastic plants, all this would have been limited to some portion of the forest". If true, Italian forest managers should end up in jail (there have been deaths and extensive damage). A more diversified forest was promoted for years, even in books of the founder of the Centre for Studies on Alpine Environment (Fig. 1) and President of the School of Forestry Science of the University of Padua (Giannini and Susmel, 2006; Susmel, 1980).

We hope that management errors will be recognized and, after having removed where and when possible fallen timber, management will follow the principles of close-to-nature forestry. We expect that foresters will concretely apply these principles according to the vocation of individual forest sites to spontaneously evolve in natural succession: from pioneer species of open spaces (for example larch) to the multi-layered uneven, multi-species high forest to which, where allowed by altitude, broadleaved trees like beech or maple conspicuously participate with adequate density.

The hydrogeological defense action of the forest and rainwater regulation can still be carried out, above all, on the steepest and most inaccessible areas where it is more difficult and dangerous to collect timber. Compared to an entirely denuded ground, trunks fallen on the ground may protect it (BAFU, 2008; Cislaghi et al., 2019). Infestations of xylophagous insects may undoubtedly happen in spring, but they can be opposed in turn by other competitors. So, in any case, it is preferable, when possible, to prevent landslides. In general, we suggest avoiding the use of forestry machinery that can affect the ground and cause irreparable secondary damages, resulting in gulling erosion figures (Fig. 4).

Figure 4. The passage of mechanical machinery necessary for the removal of fallen trees causes irremediable injuries to the soil. Near Perarolo (Belluno province) (photographs: Augusto Zanella, May 4, 2019).

Ecological catastrophes and "butterfly effect". Augusto Zanella (IT), Edoardo Costantini (IT)

Almost all wind-damaged areas were managed sustainably according to international standards of PEFC (Programme for the Endorsement of Forest Certification: https://www.pefc.org), a non-government organization that certifies the sustainable management of forests and forest products. Therefore, the cause of the lousy state of damaged forests is certainly not attributable to their abandonment. On the other hand, perpetual disturbance and disequilibrium could be a natural law (Motta, 2018). Indeed, without equilibrium, a system does not stand up, and this might contradict a thesis of perpetual disequilibrium. It could be the balance covering of a system in "unstable equilibrium", i.e., a continually evolving complex ecosystem. A forest displays century-old cycles, inserted in geological periods of several millennia. A forest includes trees with several-century growth cycles, plants, and animals with 10-yr, annual, or monthly cycles, up to the cycles of micro-organisms that are of days to hours or even minutes. Every sub-system is moving in a changing equilibrium. However, thinking that a world without balance exists, means disregarding ecology. If a catastrophe may stir the pot, there should be a trend, a force that allows recovering a momentarily lost original equilibrium (as in the aging of every natural system, like the growth of a child). Of course, the reference point of such evolution is in the future and remains theoretical. Nevertheless, this "final theoretical forest" will be mobile but measurable after the forest has started to regrow. We are talking about a concept attributable to the chaos theory (Lorenz, 1963; Mandelbrot, 1983; Gleick, 1988; Nottale and Schumacher, 1998; Nottale, 2003; Ponge, 2005; Zanella, 2018).

It is useful to refer to the term "catastrophe" as used in ecology, in the framework of the complexity epistemology.

Nature is a complex system whose components interact in multiple ways and follow local rules, meaning there is no reasonable higher instruction to define the various possible interactions (Nicolis and Auchmuty, 1974; Prigogine et al., 1974; Zeeman, 1976). René Thom in the 60ies firstly exposed a theory of catastrophes applied to different domains. For us, all this is relevant because we can formulate plans of actions, based on our various pieces of knowledge and experiences, but without having the presumption to provide solutions valid for everywhere. For this reason, we prefer to remain general in our approach and suggestions: i) use part of the accessible timbers, since there is an immediate economic and social interest, besides reducing the risks of fire and landslides, ii) leave all the rest on the ground to protect soil from water erosion. In the Actions chapter, we propose to harmonize this second solution according to the amount and kind of necromass left, the type of soil and humus profile, and other local factors. Possibly a sort of Decision Support System or guidelines is much more practically useful than lab experiments.

Why is soil so important after a catastrophic event like Vaia? Augusto Zanella (IT)

What soil is:

- *Soil corresponds to a vast digestive and accumulative system fed by organic and/or mineral compounds (Zanella et al., 2018d). The biological processes of demolition, selection, storage, reapplication of energy and building material from transformed mineral and organic matters occur in every living organism (belly, with the meaning of "internal and under control soil"). The evolution of life on Earth, expressed in increasingly complex natural ecosystems, is realized by breaking down mineral and organic structures and using the resulting elemental pieces and energy for assembling new organisms in new habitats and ecosystems (Gobat and Guenat, 2019).*
- *Earthworm communities are diverse in various types of European forests in coevolving soils (Wandeler, 2018); this fact supports the hypothesis that organisms and plants respond to the environment as a single system.*
- *Trees seem to speak to each other as in a big family that occupies a whole forest-ecosystem, review in (Wohlleben, 2018, 2016). The means of communication of trees are molecular signals that fly in the air or travel in the soil. This "chemical language" allows trees to face adversity and dangerous parasites as well as to find resources for feeding themselves and their progeniture. Wohlleben's books are founded on scientific truth and may recall the concept of Gaia developed by Lovelock and Marginus (Lovelock and Margulis, 1974).*
- *There is a French book entitled "Jamais Seul. Ces microbes qui constituent les plantes, les animaux et les civilisations" (Never Alone. These microbes that build plants, animals and civilizations). Its charming black and white cover exposes in a glance the content of the book (Selosse, 2017). Go and look at it here: https://www.actes-sud.fr/catalogue/sciences/jamais-seul .*
- *On the forest microbiome, curious and related to climate warming. Selected phrases from (Popkin, 2019). "Trees, from the mighty redwoods to slender dogwoods, would be nothing without their microbial sidekicks. Millions of species of fungi and bacteria swap nutrients between soil and the roots of trees, forming a vast, interconnected web of organisms throughout the woods. Now, for the first time, scientists have mapped this "wood wide web" on a global scale, using a database of more than 28,000 tree species living in more than 70 countries. Earth has about 3 trillion trees. Each tree is closely associated with certain types of microbes. For example, oak and pine tree roots are surrounded by ectomycorrhizal (EM) fungi that can build vast underground networks in their search for nutrients. Maple and cedar trees, by contrast, prefer arbuscular mycorrhizae (AM), which burrow directly into trees' root cells but form smaller soil webs. The researchers wrote a computer algorithm to search for correlations between the EM-, AM-, and nitrogen-fixer–associated trees and local environmental factors such as temperature, precipitation, soil chemistry, and topography. In cool temperate and boreal forests, where wood and organic matter decay slowly, network-building EM fungi rule. About four in five trees in North America, Europe, and Asia associate with these fungi. By contrast, in the warmer tropics where wood and organic matter decay quickly, AM fungi dominate. These fungi form smaller webs and do less inter-tree swapping, meaning the tropical wood wide web is likely more localized. About 90% of all tree species associate with AM fungi. The findings could, for example, help researchers build better computer models to predict how much carbon forests will squirrel away and how much they will spew into the atmosphere as the climate warms. As the planet warms, about 10% of EM-associated trees could be replaced by AM-associated trees. Microbes in forests dominated by AM fungi churn through carbon-containing organic matter faster, so they could liberate lots of heat-trapping carbon dioxide quickly, potentially accelerating a climate change process that is already happening at a frightening pace".*

Soil is an after storm available seed bank but:

- *Managers have to expect a shortage of tree seeds in old even-aged forests; on the contrary, a rich bank of tree seeds may be found in the juvenile phases of more natural uneven-aged forests (Alessio Leck et al., 1989; Rees, 1994; Thompson, 2000);*
- *Seed bank densities are higher in nutrient-rich soils (Berger et al., 2004);*
- *Nitrate treatments do not promote germination of viable buried seeds (Berger et al., 2004);*
- *The spruce forest regeneration starts where light reaches the ground; however, the sunlight will above all favor the development of grass seeds, and it will be necessary to cover the soil (with branches of fallen trees) to favor the growth of trees (Thompson et al., 2003) ;*
- *No matter how much biomass lies on the ground today, the soil-system will digest everything. Bark beetles can destroy the still living part of the forest system, especially if the standing forest has an anthropic origin and is not in equilibrium with the environment in which it developed. A healthy forest will not let the bark beetles dictate their law (Morris et al., 2018; Paoletti, 1999; Seidl and Blennow, 2012);*
- *If man intervenes as little as possible, the new forest will grow in harmony with the climate and environment of the region. By integrating the carbon of dead trees into new living organisms, the forest will even mitigate ongoing climate change, storing in the soil a part of the carbon that was in the fallen timber;*
- *The ramial chipped wood technique seems to be made for our case and deserves a large-scale attempt (Asselineau and Donenech, 2013). Why not try at least in areas where rehabilitation requires human intervention?;*
- *Specific composition of the tree population and humus forms are very correlated (Wandeler, 2018). The reason lies in the quality of the bedding produced by trees, which is related to soil biodiversity.*

Soils affected by VAIA storm

The soils of forest damaged by Vaia were identified by delimiting the boundaries of the forest area destroyed by the Vaia storm (Chirici et al., 2019) on the map of the soils of the Veneto (Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto, 2015).
The primary references to soil and humus affected by the event are listed in Table 1 (in Supplemental material). We have Leptosols, Cambisols, Phaeozems, Luvisols and Podzosols with Mull, Moder, Amphi, Tangel and Mor humus systems. In Chapter 4 we will use this knowledge to estimate the duration of biodegradation of wood material on different humus systems.

A CRUCIAL QUESTION: WHY NOT LET NATURE CURING ITS WOUNDS BY HERSELF?

Below we summarize the answers of several scientists. Following the indications of the Publisher, to reduce the size of the article, we reported the complete authors' answers and bibliographic references in Supplemental material, with a link to an external site (https://hal.archives-ouvertes.fr/hal-02342793).

Jean-François Ponge (FR)

a) *Do not chip fallen wood.*
b) *Wait at least 10 years before intervening, letting Nature to try something by Herself first.*

In response to a first hypothesis that wanted to transform the largest part of the fallen mass in chipped wood and to disperse it on the forest ground for nourishing soil and natural regeneration I am sure that there is a risk to destroy a large part of soil biodiversity just because ramial chipped wood is rich in phenols and terpenes (more especially in coniferous wood) which are toxic to fauna and microflora before being degraded by microbial enzymes (Machrafi et al., 2006; Taylor and Carmichael, 2003).
Second, you now that when suddenly applying a large amount of non-composted organic matter on the ground, this starts a thermophilic stage during which most indigenous organisms are killed by heat (Strom, 1985; Tang et al., 2004). Both reasons argue against such massive operations, which can be more aggressive than the present destruction of the forest canopy.
Better, it would be advisable to let the forest regenerate at its own rhythm, and wait for some years (say, no less than 10 years) before deciding to do something. This could be also a good occasion to increase biodiversity, in particular concerning wood-inhabiting fungi and animals (Stokland et al., 2012), and to hopefully give more chance to hardwoods to reconstruct the forest (Spurr, 1956). As I can see from the photographs thereby provided by other authors, it seems that most affected forests where even-aged coniferous forests resembling more to "agricultural" forests (as can be seen in Southwest France) than to "true" forests. Maybe something better could be hoped in the future, but please, let Nature try to do something by Herself before helping Her. Nature has no political feeling, just She likes to do things at their own pace.

Table 1. European soil regions and subregion (EDGI, 2016), altitude, soil references (IUSS Working Group WRB, 2015; Soil Survey Staff, 2015) and humus systems (Zanella et al., 2018e) examples. From (Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto, 2015), synthetic overview extracted by Augusto Zanella.

Soil region	Soil subregion	Soil subregion description	Altitude (m)	Examples of common soils	Soil diagnostic horizons	Humus system (diagnostic horizons)
37.1	MA1	Soils formed from moderately competent silicatic lithotypes. They are located on high slopes and at the top of the main mountain ranges, at medium energy of the relief, with common coverings of glacial and slope deposits.	1900-2500	Moderately deep, stony soils, with moderate profile differentiation and locally with moderate translocation of aluminum and iron sesquioxides in depth (Dystric Cambisols - Dystrudepts) and moderately deep, stony soils, with high profile differentiation, with deep sesquioxide and organic substance translocation (Entic Podzols - Humicryods)	A(AE)-Bs-CO; A-Bhs-Bs-BC-C	Moder (OL, zoOF, zoOH or szoOH, sgA) or Mor (OL, nozOF or szoOH, msA or sgA or absence of A horizon)
	MB1	Soils formed from moderately competent silicatic lithotypes. They are located on medium and low slopes of main mountain ranges and secondary chains, at medium energy of the relief, with extensive coverage of glacial and slope deposits	1000-1900	Moderately deep, stony soils, with moderate profile differentiation and moderate translocation of aluminum sesquioxides and deep iron (Dystric Cambisols - Dystrudepts)	AE-Bs-BC-C	Moder (OL, zoOF, zoOH, miA)
34.3	DA1	Soils formed from very competent carbonate lithotypes. They are located on high slopes and at the top of the main mountain ranges, high-energy relief, with common coverings of glacial and slope deposits.	1700-2800	Thin, very stony soils with low profile differentiation and accumulation of organic matter on the surface (Rendzic Leptosols - Cryrendolls)	OA-AC-C	Tangel (OL, zoOF, zoOH or szoOH, meA or absence of A)
	DA2	Soils formed from moderately competent silicatic lithotypes. They are located on high slopes and at the top of the main mountain ranges, at medium energy of the relief, with common coverings of glacial and slope deposits	1600-2500	Moderately deep, stony soils with high profile differentiation, with deep sesquioxide and organic substance translocation (Entic Podzols - Typic Humicryods) and moderately deep, stony soils, with moderate profile differentiation, with moderate translocation of aluminum and iron sesquioxides (Dystric Cambisols - Spodic Dystrudepts)	OA-Bhs-Bs-BC-C; OA-Bhs-Bs-BC-C	Mor (OL, nozOF or szoOH, msA or sgA or absence of A horizon) or Moder (OL, zoOF, zoOH, miA)
	DA3	Soils formed from moderately competent carbonate lithotypes. They are located on high slopes and at the top of the main mountain ranges, at medium energy of the relief, with common coverings of glacial and slope deposits.	1700-2500	Thin, very stony soils, with low profile differentiation, on steep and / or eroded surfaces (Rendzic Leptosols - Cryrendolls) and moderately deep, stony soils, with high profile differentiation, with leaching of clays on stable surfaces (Skeletic Luvisols - Inceptic Hapludalfs).	OA-AC-C; A-E-Bt-BC-C	Tangel (OL, zoOF, zoOH or szoOH, meA or absence of A) or Amphi (OL, zoOF, zoOH, meA or maA)
	DB1-2	Soils formed from very competent carbonate lithotypes. They are located on medium and low slopes of main mountain ranges and secondary chains, high-energy relief, with extensive coverage of glacial and slope deposits.	500-2100	Thin, very stony soils with low profile differentiation (Rendzic Phaeozems - Typic Haprendolls).	A-(AC)-C	Mull (OL, zoOF, maA) or Amphi (OL, zoOF, zoOH, meA or maA)
	DB3	Soils formed from moderately competent silicatic lithotypes. They are located on medium and low slopes of main mountain ranges and secondary chains, at medium energy of the relief, with extensive coverage of glacial and slope deposits.	1000-2000	Moderately deep, stony soils, with moderate profile differentiation and moderate translocation of aluminum sesquioxides and deep iron (Dystric Cambisols- Spodic Dystrudepts).	AE-Bs-BC-C	Mull (OL, zoOF, maA) or Moder (OL, zoOF, zoOH, miA)
	DB4	Soils formed from moderately competent carbonate lithotypes. They are located on steep surfaces and / or subject to erosive phenomena, of medium and low slopes of main mountain ranges and secondary chains, at medium energy of the relief, with extensive coverage of glacial and slope deposits	400-2300	Deep, stony soils with high profile differentiation, with deep clay accumulation (Skeleti-Cutanic Luvisols - Inceptic Hapludalfs) and moderately deep, stony soils with moderate profile differentiation (Haplic Cambisols -Typic Udorthents)	A-E-Bt-BC-C; (OA)-A-Bw-BC-C	Mull (OL, zoOF, maA) or Amphi (OL, zoOF, zoOH, meA or maA)

	DB5-6	Soils formed from competent carbonate lithotypes. They are located on stable surfaces of medium and low slopes of main mountain ranges and secondary chains, at medium energy of the relief and with extensive coverage of glacial and slope deposits	400-2000	Soils from moderately deep to deep, stony, with high profile differentiation, with accumulation of clay in depth (Cutanic Luvisols - Typic Hapludalfs), or with moderate profile differentiation with evident hydromorphy (Endogleyic Cambisols - Aquic Eutrudepts)	A-(BE)-Bt-C; A-Bw-(BCg)-Cg	Mull (OL, zoOF, maA)
	SA1-2-3-4	Soils on surfaces from sub-floors to undulating and slopes, in hard limestone, locally affected by karst phenomena	600-1800	Moderately deep soils, on rock, with high profile differentiation, with deep clay accumulation (Leptic Luvisols - Inceptic Hapludalfs) on wooded surfaces and thin soils, on rock, with moderate profile differentiation, with accumulation of organic substance on the surface (Leptic Cambisols - Typic Eutrudept); Soils on weakly concave surfaces affected by colluvial and alluvial troughs.	A-Bt-R; A-Bw-BC-R; A-(EB)-Bt	Mull (OL, zoOF, maA) or Amphi (OL, zoOF, zoOH, meA or maA)
				Deep, stony soils with high profile differentiation and deep clay accumulation (Luvic Phaeozems - Typic Argiudolls)		
	SD1	Soils on high-slope slopes formed by hard limestone with abundant debris deposits on the foot and in the watersheds.	300-1400	Thin soils, on rock, with low profile differentiation, with accumulation of organic substance on the surface (Epileptic Phaeozems - Lithic Hapludolls)	OA-A-R	Amphi (OL, zoOF, zoOH, meA or maA)
	SD2	Soils on slopes and on narrow ridges developed on marly limestone with medium-high slopes and dense drainage network.	300-1700	Thin soils, on rock, with low profile differentiation, with accumulation of organic substance on the surface, partial decarbonation (Endoleptic Phaeozems - Entic Hapludolls) on very steep eroded slopes and moderately deep soils, on rock, with high profile differentiation, with clay accumulation in depth (Cutanic Luvisols - Typic Hapludalfs), in stable situations	A-AC(AB)-(Bw)/R; A-Bt-BC-C	Amphi (OL, zoOF, zoOH, meA or maA) or Mull (OL, zoOF, maA)
	SI1	Soils on valley incisions in dolomite with predominantly steep slopes.		Thin soils, on rock, with moderate profile differentiation, with accumulation of organic substance on the surface (Haplic Cambisols - Inceptic Haprendolls)	A-Bw-(BC)-C	Mull (OL, zoOF, maA)
	SI2	Suoli his incision vallive and steep in rough limestones, with versatile moderately dirupati the strong pendency	200-2000	Very thin soils, on rock, with low profile differentiation, with accumulation of organic substance on the surface (Rendzic Phaeozems - Entic Hapludolls) on steep slopes, and moderately deep soils, very stony, with moderate profile differentiation, with accumulation of organic substance on the surface (Haplic Cambisols - Inceptic Haprendolls) on scree slopes	A-AB(Bw)-R; A-Bw-(BC)-C	Amphi (OL, zoOF, zoOH, meA or maA) or Mull (OL, zoOF, maA)
	SI3	Soils on valley incisions, escarpments, small basins in marly limestone (Biancone) and subordinately to marls with regular rounded slopes with strong slope.	300-1300	Thin soils, on rock, with low profile differentiation, with accumulation of organic substance on the surface, partial decarbonation (Epileptic Phaeozems - Lithic Hapludolls) on very steep eroded slopes and moderately deep soils, on rock, with high profile differentiation, with clay accumulation in depth (Cutanic Alisols - Ultic Hapludalfs) in stable situations	A-R; A-EB-Bt	Amphi (OL, zoOF, zoOH, meA or maA) or Mull (OL, zoOF, maA)

Oleg Chertov (GE)

c) *Eventually, re-create multiplane and multiage forests. We are now starting the activity that is also carried out in forest ecology and management under different names: sustainable forestry, ecological forestry and so on. However, as I understood, only to solve one concrete task: how to increase forest ecosystem resistance against wind damage?*

I am a person from flat lands but there was a great wind damage (actually tornado) on Karelian Isthmus about 20 years ago with the formation of a wide corridor of totally fallen trees from Ladoga Lake to Finnish border (about 50 km). The fallen wood was utilized, the damaged area remained for natural regeneration and sometimes for planting.

In the Karelian case, there was no danger of soil erosion, but I am sure that foresters in Italy have an experience of how to protect forests on upwind slopes. In the Russian case no wide information and discussions in media took place after this catastrophe.
My opinion, generally, is that it should be created "uneven-aged stands" having trees of all age classes from very young to very old as this takes place in "pristine, untouched, natural" forests. Local tree species with deep root systems should be planted on this upwind slope (for example, local oak species with shrub undergrowth). Soil preparation should be made by creating horizontal rows (following contour lines) only. This forest should be excluded from cutting and grazing but it should be under fire control.

Anonymous scientist (GE)

d) *Do not leave dead wood on the ground; a fast intervention that takes away the timbers will prevent bark beetle damage.*
e) *Mixed forests are the natural vegetation and are much more stable.*

I am not sure if it is a good idea to leave wood on the ground. Timber has a high market value and the money would compensate for some of the damage, but only if foresters are fast enough to secure the wood before bark beetles destroy it. In Germany wood was put on heaps and irrigated to prevent bark beetle damage until it was sold and transported off. Continuing bark beetle damage of still standing trees may happen in spruce forests because beetles are attracted by the volatiles emitted by sun-exposed tree trunks. Is spruce naturally occurring on the sites? North of the Alps spruce forests occur naturally only above 1000 m a.s.l. Spruce forests below 1000 m are man-made and prone to disturbance. They are fragile to wind, and on average every 80 years a strong storm would hit a forest (even before present-day climate change), but spruce is harvested after 100 years so there is always the risk of losing it. In the Bohemian Forest, and its Bavarian counterpart on the German side, huge (man-made) spruce forests were destroyed by wind and bark beetles but were left to natural succession, because beech or mixed forests are the natural vegetation and are much more stable.

Maria De Nobili (IT)

f) *no action is not a suitable option, but neither is log harvesting without soil conservation plans;*
g) *soil erosion must be prevented at any cost.*

The Alps are not the Rocky Mountains, but a heavily anthropized environment. Their much natural and even wild-looking landscapes have been shaped by centuries of human activities. Their beautifully diverse pastures and woods were created and assiduously maintained by local populations. Villagers did exploit all possible resources, but they were aware that survival also depended on the conservation of the environment, which often involved cutting rocks and moving stones by bare hands. It is their painstaking care that maintained the hydrology and the biodiversity of the Alps in the wondrous equilibrium that lasted up to these days. Alpine communities must therefore become directly involved in any future management plan.
No action is not therefore a suitable option, but the solution is not just log harvesting with heavy machinery without undertaking any action to conserve the soil. Truly, first of all, in this type of situation timber must be removed at all sites where slopes are steep, and valleys are narrow with creeks flowing at the bottom (a most common situation in these areas). The woody material might be transported further down by rainstorms and block the creeks with debris, forming dikes and unstable lakes that may suddenly collapse causing villages, which are often located at the bottom of valleys, to face violent uncontrolled flash flood waves.
The stronger risks, however, are erosion and landslides. Soil on steep slopes is shallow and unearthed trees leave bare patches were water will infiltrate and eventually freeze during winter, breaking down rock even more and destabilizing mountain slopes. Erosion will be severe, leaving only exposed subsoil or even bare rock. Heavy machinery should be employed with great care, as not only it is responsible for soil compaction, but also damages topsoil layers by creating preferential furrows which allow fast surface runoff.
The subsoil, in many parts, is not fit to allow the regrowth of trees. It is likely that the long unusual summer droughts, which are another typical feature of climatic changes that this part of the Alps has recently experienced, will repeat themselves. Erosion reduces the capability of soil to retain water. If erosion occurs, trees will never regrow for lack of water during summer months. Autumn rains will carry away what is left of the soil and, if not retained, will swiftly engross rivers with fast running floods, carrying over all type of debris.
How can we prevent soil erosion on cleared slopes? Chipping logs would not be good: chips are small, and light thus will be carried away by storms. It is better to secure intact branches to the slopes: they will protect the soil from erosion and seeds from being carried away. This seems easy but is not: how much branches should be left in place? It is enough to minimize rain impacts, but not so much as to hamper the emergence of seedlings. How should the branches be anchored to the soil (think of the terrible wind: no doubt it will come again)? Wood pecks and branches are abundant and cheap leftovers from logging operations and will be in the end assimilated in the soil. Certainly, neither metal or plastic materials should be used.

Climate change will increase the mineralization of soil organic matter, so it is important to preserve organic matter reserves in alpine soils. Indeed, last summer the humus layer suffered and thinned down terribly in many places. Just before the event I went to a field excursion with my students to the forest of Fusine where I used to show them some nice thick non zoogenic nozOF horizons, but they were reduced to patchy barely visible remnants. This is another aspect of the same problem, and we will have to deal with it as well. Even in places not affected by catastrophic events, erosion and mineralization will become faster and faster. Will Nature have the possibility to react? Most nutrients are stored within the organic-rich surface layers of the soil. When they have gone, recovery is slow and difficult. Sooner or later some soil will form again, woods will regrow, but the time scale involved might be of centuries. We cannot afford it.
All this is part of something happening much faster than predicted by even the worse scenarios. We should not be worried over by interfering with things such as nutrient balances and biodiversity which are already strongly endangered by climate change. Climate change is here: it will not go away. There is no way we can stop it: it is too late, but we can slow it up and this is no small thing. To gain time will make a lot of difference, not only in terms of preserved biodiversity, but even more in saved lives and containment of economic losses.

Dylan Tatti (CH)

h) *The context of such a problematic is essential; there's certainly no quick fix and it is important to consider a maximum of parameters (of course including ecological, socio-economical and historical parameters) before doing anything;*
i) *Everything is a question of quantity: mixed actions, in proportion to damage and considering each context;*
j) *Point zero for new scientific studies.*
In addition to all the scientific publications dealing with such a topic, it also seems of prime importance to contextualize the approach as much as possible and to keep in mind the different socio-economic and historical realities of the concerned areas. There's no "miracle" solution and everything is a question of quantity and spatial and temporal scale involved.

It may sound (very) trivial, but it is easy to lose sight of certain things and it is therefore important to learn as much as possible about the context before doing anything. What about forest policies of the different regions affected? What kinds of vegetation and soils are present? Are these areas strongly linked with tourism? What about the security for workers, hikers or other buildings nearby? Are also agricultural areas indirectly affected by such an event?
As strong as our scientific knowledge and experience is, it is important to remain humble and not to consider things as more trivial than they really are. There may always be a "little something" that we may have forgotten (due to a specific context), even if it can appear obvious afterwards.
For example, a few years ago, a small forest near the place where I worked was partially destroyed (should we rather talk of regeneration?) by wind. I remember some fellow biologists who then simply said something like "We have already seen something like this and one of the best things to do is certainly just to plant new trees while ensuring a sufficient soil coverage to avoid too much erosion". Then after an interesting discussion with the department forester we learned that it was more complicated and different from another situation that we first considered as similar. In the present case the fallen trees had opened a breach where the wind could rush more easily thus endangering the entire forest stand. In this context, it was finally decided to cut most of the affected area to avoid a "domino effect" (there were also several buildings nearby) and to insure an adequate forest regeneration.
Afterwards the choice made by the foresters seemed obvious (in this specific context), but this illustrates that even for aware people there can always be a "little something" that we did not think about (although sometimes appearing then as very logical) and that it is important to think on different scales, both local and global before going for any concrete action.
Another point is about what is sometimes called letting the forest regenerating itself in a "natural way". Such a think appears at first sight as very interesting, but the question also arises of the place of "naturalness" in some forests already strongly transformed by man. Is a "natural regeneration" always beneficial for a forest stand heavily managed by man for decades?
Finally, and as trivial as it could appears, it is important in such cases to keep in mind that everything is always a question of quantity and the good "approach" will probably be a mixed approach consisting of removing wood in some areas and leaving some "hot spots" (e.g. with a high concentration of dead wood) in other places.
Despite these many uncertainties and the difficulties to choose the "good" approach (somewhere between too much and not enough), it is sure that such an event (and as difficult it could be for many socio-economic reasons) can be a very interesting starting point for new scientific studies. This can allow us to learn new things and bring new knowledge about such an event in a specific context.

Herbert Hager (AU)

k) *The blowdown areas need to be assessed or classified according to their specific site condition and situation in the landscape (a concerted effort should be started to retrieve old records of local natural forest vegetation).*

l) *In a second time, differentiated site and landscape adequate reactions (soil potentiality in the context of sites and differentiated priorities) should be planned.*

I would like to throw some ideas which I see not adequately dealt with in this discussion. We have looked at humus and soil dynamics in the landscape and I think we should retain us from polarizing views like "let nature work and all will be fine", or "we have to immediately intervene and restore forest ecosystem functions". I think that for the first (no intervention) we may leave endangered communities which need the protective functions of forest ecosystems unattended, and for the second local government offices will not have all the necessary resources and manpower to deal with the problem, given the surface of wind-damaged areas. Therefore, I would like to plead for site and landscape differentiated reactions, like medical doctors do first an anamnesis before coming down with a diagnosis and, last but not least, a therapy or treatment. So, I think that blowdown areas need to be assessed or classified according to their specific site condition and situation in the landscape. Then possible geomorphological and hydrological risks (e.g. large sources of mobile sediment sources in the watersheds, avalanche risk, etc.) and forest pathological dangers should be considered. Furthermore, I would think that a concerted effort should be started to retrieve old records of local natural forest vegetation (e.g. pollen records), especially concentrating on broadleaved species fitted for montane and lower elevation zones. I do not want to abrogate the role of soils as digestive systems but let us see it in the context of site and differentiated priorities.

Raffaello Giannini (IT)

m) *Take example from other similar events (Fig. 5) and consequent results of given interventions.*
n) *Space (dimension of the damaged area) and time (forest cycle) should be considered as well as the origin of the species used in eventual plantations.*
o) *Coppices should be banned from the VAIA area.*

It is absolutely necessary to look at what already happened in the past, like the forest damages which occurred at the beginning of the first decade of the 20th century 20th along the Piave river in Valvisdende Valley (BL), or during the 1966 alluvium flood in Cadino Valley (TN): see what they have done and how things are moving forward.
From the net: Fig. 5 and translated text: L'alluvione del 1966 (The flood of 1966) (http://www.forestedemaniali.provincia.tn.it/forestedemaniali/cadino/pagina2.html).
It was an event that greatly changed the aspect of wooded slopes in the Cadino Valley and the environmental value that the population of Molina and the lower Val di Fiemme attributed to the forest and the cultural landscape. The current structure of the environment and of the wooded stands was modified, in addition to the productive management of natural resources, by the numerous destructive phenomena caused by the wind, the so-called crashes, from water and landslides.
From 1882 to today there have been at least 7 damage events caused by extraordinary meteorological events, of which the most catastrophic is undoubtedly coinciding with the historical flood of 1966. The 4th November cyclone struck above all the southern part of the forest, causing the loss of over 90,000 cubic meters of timber equaling 27% of the total mass. The damage to the infrastructures along the River Cadino was also very serious, with bridges, buildings and roads taken away or partially destroyed.
Recovering all fallen and uprooted timber took more than a year of intense work on more than 70 ha, employing men and vehicles of all kinds. These included some tugboats that were used to pull the fallen timber to Lake Stramentizzo, a particularly difficult operation, experienced by the population with trepidation and intensity.

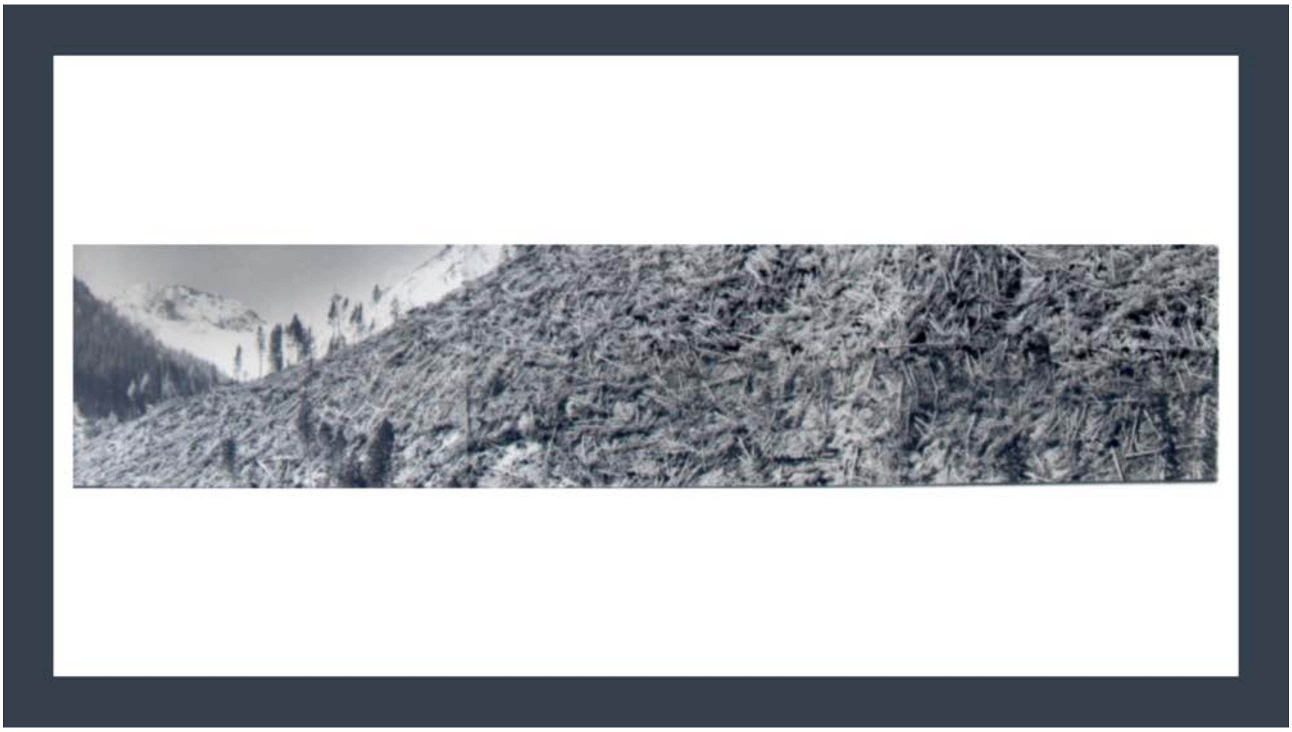

Figure 5. View of the state forest of Cadino Valley, resumed the day after the storm of November 4, 1966, taken from Aprie (http://www.forestedemaniali.provincia.tn.it/forestedemaniali/cadino/pagina2.html)

After census of the damage reforestation operations began immediately in the most affected areas, in order to avoid and prevent further damages caused by erosion. For an immediate recovery of forest vegetation more than 150,000 seedlings were planted in the period 1968-1971, almost all of spruce.

1. *Effects. What happens (happened) and what could happen? Numerous interacting factors are responsible; the joint action of these factors creates very different situations depending on wind speed, orography of the territory, naturalness and type of the ground, succession phase (this point seems neglected while the literature is rich, at least the old one!). I have some doubts about the effects of global change (the one caused by man), but it has to be considered. Among other things, it is necessary to remember what was written on the type of forestry or on forestry practices in Oregon Douglas fir forests. So, a good summary is possible by considering all forest ecosystem components.*
2. *Recovery strategies. Here is the dilemma! Two bottlenecks are space and time. Forest cycles are long because nature has limits that do not coincide with human goodwill. Of course, nature has to be followed. For a wind damage in Tuscany, an area of 2,000* m^2 *was considered a discriminating limit (Bottalico et al., 2016; Chirici et al., 2018; Motta et al., 2018). It could be, but to get what? A soil cover or a forest? Would it be different with an area of say 50,000* m^2*? Evolutionary dynamics are also conditioned by the dissemination phase: which seeds and when and how will they arrive? In subalpine areas mast years (years of greatest seed production on which you can count) happen every 15 years (Motta et al., 2006, 2002). What are the relationships between seed and soil? Then between tree seedlings and herbaceous vegetation? etc. These things already written need to be taken up again. Instead, if you plant the new forest with propagating material that nobody produces anymore in Italy (you can find it in Finland), you have to take care of it for the rest of your life! This too must be remembered.*
3. *About coppices. An extensive literature reports that the extent and intensity of wind damages on forests result from interactions between characteristics of the meteorological event and other components such as orography and site characteristics among which consistency and imbibition of the soil, species-specific typology, forest structure, forestry system (Gardiner et al., 2013), and today, not the least, climate change. For example, pure high natural forests, at high-density maturity (e.g. indigenous Canadian spruce forests), built by species with superficial root systems on permafrost, are subject to much more frequent wind damages. Mixed multi-layered forests exhibit a greater resistance than those characterized by a single crown layer. It may be asked whether coppices, which represent an extreme model of forest biomass use, can possess greater or lesser resistance and resilience compared to the high forest. A correct answer to the question must take into consideration and evaluate various collateral and temporal effects related to the type of management. This is the case of the erosive action of violent rains (cloudbursts, water bombs) that almost always accompanies wind in hurricanes and storms. In reference to this we remain perplex about the current and widespread management policies on the use of forests, even at European level, aiming at valorizing the coppice itself. This word, "valorizing", can take different meanings, whether it is understood from an immediate financial point of view, leading*

to a strong reduction of aesthetic-social and environmental services provided by the forests, or on the contrary from the point of view of stability and well-being for future generations (Clauser, 2018).

4.

Annik Schnitzler (FR)

p) *after events like VAIA, if forester let forests unmanaged, they recover rapidly, depending on soil and altitude (if VAIA forests were intensively transformed by humans, the "catastrophe" was not the windstorm, but the forest management).*

q) *Animals have a strong impact on plant regeneration: are large herbivores regulated by carnivores?*

I have read all the proposals for the 30th October story, and really enjoyed all the discussion. Before proposing some additional text to this interesting discussion, I would like to debate about the word "catastrophe". Is VAIA really a "catastrophe"? This word is not neutral, it is negative. I propose the word "event". Catastrophe is related to human disasters (death of humans, severe negative impacts on forest economy). Rather, in forest dynamics, there is no "catastrophe". Forests are adapted to windstorms, even at higher wind speed. For example, as far as I remember, in 1987 and 1990 successive windstorms reached more than 200 km/h, and forests recovered more or less rapidly, depending on soils and altitude, when forester had let them unmanaged. They are simply exceptional events, whose impacts on forest architecture and dynamics are greater than usual. Forests are adapted to such events, and forests have enough time to cope with them in particular if their surfaces are wide enough, which is the case here. Of course, affected patches do not recover exactly in the same manner, but this is perfectly natural: it depends on local characteristics which are shaped partly by nature, partly by human uses. For example, the impact of large mammals on regeneration depend on many factors, unnatural (hunting activity, predator presence or absence, plantations around, and further management) and natural (soil, exposure, slope).

That is why I propose to evaluate the vulnerability of Italian forests with regard to forest management: which kind of forestry was practiced here (either even-aged monospecific stands, or mixed uneven-aged forests with old trees with small roads and slow cutting rotation)? Which species were favored? Were the stem densities of spruce natural? Was the canopy closed or too opened by roads and clearings? If these forests were intensively transformed by humans, the "catastrophe" was not the windstorm, but rather the forest management. This question has been largely debated in Europe after the 1990s windstorms.

A second aspect could be added from the start: the integrity of the whole trophic network. Normally, these forests are a home for large mammals at relatively high densities, even when predators are present. So, what are the human practices? Are large herbivores still present? Are they regulated by Italian wolves? Animals have a strong impact on plant regeneration. In Italy there have been highly valuable efforts for restoring the wild fauna, which do not exist in France. But I do not know the situation in the Alps.

Nicolas Bernier (FR)

r) *When regeneration becomes improbable on the ground, it is very often vigorous on the trunks of decaying trees.*

s) *In case of fragile forests, it would be better to cut batches of trees and abandon them on the site to increase the dead wood mass on the ground.*

t) *Identify areas with pre-existing forest tree seedlings within the perimeter affected by the storm.*

u) *Identify patches of dense ground vegetation (of ericaceous type, Calamagrostis, etc.) which could in the near future show an explosive type of development and in this case avoid clearing the windthrow.*

v) *Take a close look at mounds and pits of uprooted trees because they are environments where the bare mineral soil is a micro-site favorable to regeneration. It can be beneficial to bring maximum light to these mounds.*

It should not be forgotten that when regeneration becomes improbable on the ground, it is very often vigorous on the trunks of decaying trees, so much that tens of years later, we can find tree alignments materializing the old windfall. Not sure that we get favorable seedbeds if we break branch wood into small chips. To regenerate the forest on windfall areas following a storm like VAIA, it is necessary that wood could rot for 20-50 years (according to altitude and degree of hygiene) unless rotten wood is already present on the site. The only thing that I see to be very similar is North American wave regeneration: windfall in wave lines and regeneration thereafter. Unfortunately, regeneration microsites and time scales are not specified in published studies (Attenborough, 1995; Fukasawa, 2012; Génot et al., 2011; Guo, 2016; Motta et al., 2006; Orman and Szewczyk, 2015; Szewczyk and Szwagrzyk, 1996; Tsujino et al., 2013; Zielonka, 2006; Zielonka and Piątek, 2004; Zielonka and Piątek, 2001).

When faced with an ecological event of the "disaster" type, such as this storm of great magnitude, we mistakenly tend to focus on what is most visible, i.e. a lot of dead trees. To be able reading between the lines we have to look for what remains alive and what will constitute bricks of the future forest. Clearly, when a storm occurs in a forest, damage is concentrated on large trees (first touching the least stable ones). In general, seedlings and young trees are almost spared. However, these seedlings are more or less overcome and hidden by the huge biomass of dead trees (Jane, 1986; Xi and Peet, 2011)

There is therefore an emergency at first to release seedings. If the demographic balance of the forest affected by the hurricane was good, then the identified areas should be large. A healthy forest must have an inverted J-shaped population, which means a high proportion of young trees and a small proportion of old trees. Paradoxically, the more a forest is of the "old-growth" type, the more the inverted J is marked (but with a long tail). On the other hand, an exploited forest is too often structured around a single cohort. In the Alps, given the industrial past of the economy, a large number of highland coniferous forests have cohorts centered on ages between 100 and 150 years. Many highland forests therefore display structural weaknesses that expose valleys to the risk of recurrent deforestation.
In summary, recommendations should focus on two levels:
1st (preventive): preventive measures to improve the demographic structure of forests before they are affected by hurricanes. The action can be summed up in group regeneration cutting aimed at mimicking small-scale storms with the creation of openings with or without the export of timber according to regeneration hazards (in case of fragile forests, it would be better to cut batches of trees and abandon them on the site to increase the mass of dead wood lying on the ground (Diaci et al., 2017)).
2nd (after the storm): identify, within the perimeter affected by the storm, areas with pre-existing forest tree seedlings. It is also important to identify patches of ground vegetation which could in the near future show an explosive type development (of ericaceous type, Calamagrostis, etc.) and in this case avoid clearing the windthrow (Fischer et al., 2002).
Also take a close look at mounds and pits of uprooted trees because these are environments where the exposed mineral soil is a micro-site favorable to regeneration. It can be beneficial to bring maximum light to these micro-sites. It is also necessary to be attentive to the slope which in this circumstance can be an additional destabilizing factor (Ilisson et al., 2007; Kuuluvainen, 1994). Notice that spruce has a pioneering habit on mineral soils which share some properties with Mull humus systems (Gensac, 1989).
A third idea to take advantage of this event is to perform experimental ecology by separating, for example, sectors without any intervention and other sectors where we would carry out experimental release interventions targeted on sowing in place in accordance with micro-topography, like this was reported in Martiník et al. (2014).

Eleonora Bonifacio (IT)

w) *many years (from 57 to 106 years) are needed to achieve an advanced decay for fir and spruce logs, while leaves, needles and small branches will provide an important input of organic matter at the soil surface in the short time.*
x) *lack of a forest cover will enhance nutrient losses because of lack of biological recycling of elements; 3) if a long time passes before revegetation occurs, the new equilibrium between forest and soil will favor a poorly fertile system.*

After such an intense disturbance, it is important to split what is likely to occur to the soil from the problems of revegetation dynamics even if forest cover affects the soil in many ways. Forest provides organic matter (OM) through root and leaf litter, it decreases soil water content through transpiration, it affects nutrient cycles as plants uptake elements from deep soil layers and give them back to the surface through litterfall. On mountain slopes, a forest cover protects the soil from being eroded, both through canopy cover and by protecting the uppermost soil horizons thanks to the mulching effect of litter. All these aspects should be considered when evaluating the best practice to be put in action after a catastrophic disturbance. The equilibrium that is present between the soil and the forest cover is affected in many ways, both if nothing is done and nature allowed to follow its course (e. g. no timber harvest, natural regeneration), and if anthropic actions intervene (e.g. wood harvest, tree plantation). In both cases it is important to realize that the soil must be protected as longer time schedules are needed for building soil than for revegetating a site, and if soil is lost then the forest cover will not find the same soil conditions as those that were present before the event.
After the Vaia storm, a patchy distribution of trunks and plant residues covers the slopes, originating in bare surfaces and areas of dead material accumulation. The decomposition of dead wood depends on the size of the material and on the environmental conditions, thus from 57 to 106 years are needed to achieve an advanced decay of fir and spruce logs (Přívětivý et al., 2016). During that time, inputs of organic matter to the soil will decrease, since the forest cover will not provide leaf litter and the slow decomposition of logs will decrease the quality of soil organic matter (SOM) towards a lignin-rich and N-poor composition (Spears and Lajtha, 2005), besides increasing the amounts of dissolved organic matter (Magnússon et al., 2016). Leaves, needles and twigs will instead provide an important input of easily available organic matter at the soil surface; when these materials are left on the soil after clearcutting an increase from 2.2 to 5 kg organic carbon (OC) m^{-2} in the topsoil layers has been reported two years later (Falsone et al., 2012). In case trunks are removed and smaller debris are left in the forest stand, the trend of OM input to the soil is likely to show a fast increase then a decrease before a new forest cover has developed and a new equilibrium is reached. In addition, while an equilibrium between inputs of OM to the soil surface (leaf litter) and within the soil (root litter) was present before, we can expect a decrease in root litter after the initial increase, with effects on soil structure and on mechanisms of OM stabilization through interactions with soil minerals (Jastrow et al., 2007; Liang et al., 2017). Even if trunks are harvested, the abundance of woody residues will increase the C/N ratio of soil OM (Smolander et al., 2008), with effects on the abundance and composition of microbial communities, and consequent effects on the nitrogen cycle (Strukelj et al., 2013).

Bio-cycling is the mechanism that provides most nutrients to forests and guarantees the growth of forest trees when no fertilizer is used. Elements taken up by plant roots are released back to the soil through litterfall and are made available again upon litter mineralization (Jobbágy and Jackson, 2001). This process is particularly effective in nutrient-poor forest soils, where it actively counteract the leaching of mobile elements (Bonifacio et al., 2013). The lack of a forest cover that uptake the elements released by litter mineralization leads to nutrient losses through leaching (Balogh-Brunstad et al., 2008) and the longer the time bare surfaces are exposed, the higher the losses. The level of soil development has an important effect on the magnitude of element losses; in well-developed soils, clay surfaces will provide an effective sink for Ca and K, while in sandy, less developed soils losses driven by fast drainage are further enhanced because of the lack of active surfaces. The weathering of minerals and the release of elements from unavailable pools in the soil solution occurs over much longer times, thus a new forest cover will develop under a new equilibrium on poorly fertile soils. The new equilibrium will also be determined by the extent of soil erosion on deforested surfaces. Some protective effects of forest cover effects are direct, such as the presence of the canopy cover that intercepts rainfall or of the litter layers that protect the upper mineral horizons from particle detachment. Others are indirect and related to the effects organic matter has in decreasing soil erodibility: well-decomposed organic matter incorporated in mineral horizons affects soil structure and soil aggregate stability. A change in the pattern of organic matter addition to the soil is likely to have a great impact, as OM is the main aggregating agent in mountain soils (Stanchi et al., 2012). Certainly, the removal of fallen trunks and any other machine operation will physically disturb the soil. The effects will depend on timing and weather conditions, and of course on soil type. It is probably during this phase that all measures to avoid soil losses have to be put into practice.

Jolanta Kwiatkowska-Malina (PL)

y) *Removing fallen trees as quickly as possible increases the possibilities of rational wood management and protects against pest degradation.*

z) *In managed forests, the adopted scheme of actions after hurricane disasters consist in "clearing up" damaged trees and artificially regenerate post-mortem areas, which from the point of view of natural forest ecosystems should be considered inappropriate.*

aa) *Attention should be paid to the role of the storms in the natural dynamics of the forest, a consequence of this should be a departure from the acute elimination of windstorm effects in favor of partially leaving the forest to natural succession and regeneration processes.*

In Poland, the biggest hurricane windstorm in the last 100 years was caused by a hurricane on August 11, 2017. According to the information of the (Directorate-General of the State Forests, 2017), losses were estimated to 7.7 million m^3 of felled trees and 80,000 ha of forests will require renewal. Crisis teams were established that dealt with the organization and coordination of activities aimed at securing the affected sites against forest damage, cleaning fallen trees mainly from forest roads, conducting a detailed inventory of damage (including using drones), and then developing activities allowing to export as quickly as possible wood from windbreaks and proceed with the renovation of damaged stands. Removing trees as quickly as possible increases the possibilities of rational wood management and protects against pest infestations, among others bark beetles which are a common pest in pine monocultures. After the degraded area has been cleared, a gradual introduction of a new generation of trees is planned. The species composition of the 'new' forest depends on the habitat and, above all, on the type of soil.
The hurricanes, from the point of view of raw wood production, cause economic losses, but ecologically they constitute natural processes increasing the biological diversity of forests (Wesołowski and Zmihorski, 2018). So far, in managed forests, the adopted scheme of actions after the hurricane disaster, consisting in "clearing up" damaged trees and artificial regenerate post-mortem areas, should be considered inappropriate from the point of view of natural forest ecosystems. On the basis of an analysis of studies on the effects of storms, it can be stated that in order to increase the resilience of forests for future hurricane winds, more emphasis should be placed on the role of natural processes in the restoration and regeneration of stands. This approach is particularly important now that forecasts predict that such extreme weather events will happen even more often and will become a new "norm" (Seidl et al., 2017).
The artificial renewal of windbreaks (planting large areas with mainly pine saplings) will result in the continuation of plantation monoculture and, as a consequence, in future exposure to economic losses caused by the intensification of the occurrence of extreme weather phenomena. By "cleansing" windbreaks, we reduce forest biodiversity by removing the habitats created by wind and the organism's dependent on them. Attention should be paid to the role of the storm in shaping the natural dynamics of the forest. The consequence of this should be a departure from the acute elimination of windstorm effects, in favor of partially leaving the forests to natural succession and regeneration processes.
I agree with Silvia Fusaro (see below), that it would also be interesting to proceed in different ways to study ecological recolonization in the field in various situations.

Silvia Fusaro (IT)

bb) *protected areas could not to be subjected to any interventions.*

cc) *In other managed state forests, it would be advisable to remove just a part of bigger logs.*

dd) *In cleared areas, leaving branch wood on the ground could be very useful to protect the soil ecosystem.*
ee) *The population should be informed with the production of leaflets and updated on the situation in itinere.*

After a detailed recognition and mapping of the forest situations, it is good to distinguish among different environmental protection grades, if there are protected areas such as natural parks, or managed state forests.
Taking the cue from a multidisciplinary approach which developed a growth simulation model for the management of a mountain spruce forest (Machar et al., 2016), protected areas should not to be subjected to any intervention. Therefore, every fallen tree should be left in situ, favoring the natural evolution of this climatic event, erroneously defined as "catastrophic" by some of us (see Annik Schnitzler's comments).
In other managed state areas, it would be advisable to remove just part of bigger logs, those interrupting pathways, streets or watercourses, but not all of them, since a fallen tree is a good natural resource for biodiversity (for food and microhabitats) and for long-term organic matter balance. Different possible management types in a similar climatic situation (windstorm but associated to wildfire) are described by Barančíková et al. (2018).
Removal of bigger logs should be done with care not to enter the forest with heavy vehicles (or limiting as much as possible their use) that induce soil compaction (Fig. 4), causing severe damages to the soil such as reduced porosity, oxygen and water supply and, in particularly problematic cases, preventing for a long time natural forest regeneration (Cambi et al., 2015). Examples of different harvesting machines, i.e. self-propelled cut-and-chip or tractor-pulled whole stems, can be found in Berhongaray and Ceulemans (2014). To use tracked vehicles may be advisable in order to reduce pressure on the ground, but it depends on soil texture, moisture and slope grade (Cambi et al., 2015).
In cleared areas, leaving the branches of removed logs on the ground could be very useful to protect the soil ecosystem. These branches could be beneficial in order to:
- *protect the soil from erosion and the impact of exogenous agents (rain, snow, wind, frost, etc.);*
- *maintain part of the biomass in situ;*
- *increase the number of microhabitats.*

Soil systems affected by the fall of trees and the in situ retention of logs and branches on the ground could be an excellent field of study for soil fauna, like soil nematode communities that Čerevková and Renčo (2009) analyzed in a similar situation (windfall associated to wildfire) that happened in 2004-2005 in a larch-pine forest in the High Tatras (Slovakia).
Surely it would be very interesting to follow community changes of xylophages, degraders and decomposers (Siira-Pietikäinen et al., 2001), even if microclimatic anomalies such as drought conditions caused by the lack of canopy cover could be a favorable situation for spruce bark scolytid beetle (Ips typographus) outbreaks. Monitoring of this pest, one of the most destructive insects infesting spruce forests (Faccoli and Bernardinelli, 2014), should be necessary.
To restore the forest ecosystem, it could be helpful to let free some areas, such as some clearings, in order to differentiate habitats, thus creating ecotonal zones: some of these areas could be kept free for lawn, others could favor the natural growth of trees and shrubs.
As regards the slopes most at risk of landslide, fallen and unsafe logs should be removed for public safety. From an ecological point of view Baran et al. (2018) and Barančíková et al. (2018) studied the botanical species composition and richness of ravine forests subjected to different management practices (protected areas or managed, that is with removal of single trees) and they concluded that low intensity forest management resembles natural disturbances, to whom these plant communities are adapted.
From a hydro-geological safety point of view, since plant roots can decrease soil water content and, meanwhile, increase its mechanical strength, then by suddenly lacking vegetation dangerous landslide phenomena could likely occur (Bischetti et al., 2009). To mitigate these natural hazards, it would be advisable to perform a controlled plantation to accelerate and guide slope consolidation according to the different roles of alpine forest species in stabilizing the slopes in terms of root cohesion (Bischetti et al., 2009; Cislaghi et al., 2019). Another concern to take into consideration for reforestation guidelines is the upper altitudinal limit of spruce bark beetles (Faccoli and Bernardinelli, 2014).
Meanwhile, other useful activities than the ecological-functional sphere sensu stricto would be advisable:
- *in order to involve economic activities of damaged areas, it would be positive to make the operators of timber exploitation aware for a responsible and sustainable use of the resource (wood) that will be taken out;*
- *as pointed out by (Sadri et al., 2017) about the consciousness of common people on the interactions between forest and climate change, the population should be informed, for example with the production of leaflets and updated on the situation in itinere thinking, in the near future, of some didactic-training thematic paths and thus promoting a responsible and sustainable tourism (so that our mountains are not abandoned);*
- *this "catastrophic" climatic event could be an opportunity for field ecological studies of recolonization, according to different types of management (Barančíková et al., 2018), as proposed by Magali Matteodo in the present paper.*

Safwan Mohammed (HU)

ff) *Climate change is considered as one of the big threats for forestry.*
gg) *Fallen trees should be removed.*

hh) *Soil nutrients increase in damaged areas due to reduction of biological demand; 4) the new forest should be adapted to incoming extreme events.*

In this decade, climate change was considered to be one of the big threats that faced forestry sectors, where extreme windthrow events increased rapidly resulting in big damages to the forest landscape (Andersson et al., 2018; Keenan, 2015). Therefore, forest management after any disaster is an essential tool for rehabilitation in terms of sustainability. Many researchers argue about the actions that should be taken after storm events (i.e. extreme windthrows and hurricanes). Valinger et al. (2019) indicate that after evaluating primary effects within damaged areas, removing felled trees from the forest are an important act to minimize secondary effects (i.e. insects).
On the contrary, McNulty (2002) reported that hurricanes had a good impact on nitrogen and other nutrient inputs to the forest soil even though the C/N ratio was high but increased nutrient availability was mainly due to direct effects of soil warming and reduction of biological demand. Nevertheless, Valinger et al. (2014) highlighted the importance of risk management awareness in forestry sectors as a key factor for resilience to and mitigation of extreme events, where adapted measures are the most crucial issue in the forestry sector (IPCC, 2014).

Cristian Bolzonella (IT)

ii) *A serious applied science should not be limited to the identification of guidelines but should give indications that are "scientifically proven" on how to act.*

Man is a gregarious animal and this behavior is reflected both in the scientific world and in the rest of human society. Human society tends to aggregate in lobbies according to common interests and objectives.
We also find similar behavior in the soil, where individual particles tend to aggregate into lumps. By ensuring the presence of air and water in the right balance, aggregates form a structure that allows life inside the soil. In soils without lumps an incoherent, anoxic environment is created that is incapable of sustaining life.
The current policy is the expression of lobby purposes, which go beyond traditional old ideologies, taking shape in similar stakeholders in various European countries (e.g. France, Italy, Spain, Hungary, etc.). A serious policy should not be based only on slogans (indispensable tools to reach a high level of consensus and reach the button rooms) but carry out an agenda of actions. Similarly, a serious applied science should not be limited to the identification of guidelines (slogans) but should also give indications that are "scientifically proven" on how to act.

Pascal Junod (CH), Augusto Zanella (IT)

jj) *The forest ecosystem is creative and adaptive.*
kk) *Are you producing wood as the primary goal? OK, but first ensure that the forest provides protective, ecological, and social benefits over the long term = design holistic forestry!*

The forest ecosystem is creative and adaptive. Forest managers should be patient and humble towards this living community and trust their ability to heal. After a storm, there is no place for either hectic or laborious cleanup works. The effort to be made is that of thinking to voluntarily not do the same thing everywhere, thinking about how it is possible to make the ecosystem more complex and imagine its evolution. Avoid simplifying, homogenizing, respecting surviving trees, accepting pioneer species, tolerating gaps. The higher the complexity of the forest - in terms of mix, structure, micro-relationship - the more resilient, adaptable, multifunctional, and productive in the long run.
In Switzerland, we knew Lothar, a powerful storm at the end of December 1999. In the 288 ha Creux du Van forest (canton of Neuchâtel), despite the fear and protests of neighboring forest owners (due to a possible rapid reproduction and spread of bark beetles), it was decided to leave all the fallen trees in place on a surface of 102 ha and to build a forest sanctuary (disturbances are opportunities to restore natural processes). Twenty years later, the renewal of this area (Abieti-Fagetum) shows unpredictable vigor (Fig. 6 Left), astonishing efficacy as well as perfect mixture and heterogeneity. Beech and spruce renew without a problem. Even the young white firs (Fig. 6 Right) regenerate much better than in areas in which fallen trees were removed. The ungulates hardly enter between disorderly overlapping trees (which could be a right hiding place for the lynx).
In general, it is essential to promote the use of wood in all its forms (home, furniture, equipment, flooring ...), to index the price of wood energy to that of other energy sources, to accommodate specific structures and to further develop the possibilities of biological and technical rationalization. The margins for maneuver are limited, and it will probably not be possible to return to forest management that brings consistent gains from the sale of timber. The exploitation of resources and conservation of these are in permanent opposition. There is also a need to sensitize beneficiaries of forestry services so that they participate more consciously in financing these services. In the canton of Neuchâtel as well as in the Veneto region, most of the drinking water comes from the mountains, where the forests act as filters and biological regulators of the quality and outflow. Forest owners receive no compensation from water distributors. How much does the quality of the water we drink (and the air we breathe) cost? What value can we give to the forest in which we walk, and which keeps us in shape? What value can we give to the song of the birds? They are around us even

in our towns thanks to the forest trees of the parks that welcome them. The time has come to give a respectful value to all these services related to the forest.

In Trentino Alto-Adige (Italian central-eastern Alps), we appreciate a mountain use system that could be an example to the whole world. It is an Austro-Italian recipe to populate mountains in a sustainable way. It endows on respect for natural resources considered as the founding basis of the design of the economic development. The latter operated to recover those values and lifestyles of the past that deserved to continue to exist: beauty homes, well-cared pets and forest animals, peasant clothes and festivals, healthy eating, a congruent deference also for proven and shared religious references that give the woman a position equal to that of man and great value to family, school and administration with well-safeguarded and respected roles, and agriculture equipped in a way adapted to the mountain (with high respect for the environment), an impeccable viability and well maintained, a trade of quality products and protected by brand, a tourism made up of small niches distributed over the territory and, finally, an attention to the political and administrative class of the area that has been able to control, distribute and allocate the financial resources coming from the Central Italian Administration. The same resources also given to other Special Italian Regions produced none or more mitigated effects. In reality, the economic system and society work only if supported by sound principles of respect for the environment and for citizens that are learned only in the family, at school, and following the example of citizens responsible for individual and societal well-being. It looks like a religious sermon. It might be a scientific observation, as in the story of the prisoner's dilemma.

From Wikipedia: (https://en.wikipedia.org/wiki/Prisoner%27s_dilemma):

The prisoner's dilemma is a standard example of a game analyzed in game theory that shows why two rational individuals might not cooperate, even if it appears that it is in their best interests to do so. It was initially framed by Merrill Flood and Melvin Dresher while working at RAND in 1950. Albert W. Tucker formalized the game with prison sentence rewards and named it "prisoner's dilemma", presenting it as follows:

Two members of a criminal gang are arrested and imprisoned. Each prisoner is in solitary confinement with no means of communicating with the other. The prosecutors lack sufficient evidence to convict the pair on the principal charge, but they have enough to convict both on a lesser charge. Simultaneously, the prosecutors offer each prisoner a bargain. Each prisoner gets the opportunity either to betray the other by testifying that the other committed the crime, or to cooperate with the other by remaining silent. The offer is:

If A and B each betray the other, each of them serves two years in prison;

If A reveals B but B remains silent, A will be set free, and B will serve three years in prison (and vice versa);

If A and B both remain silent, both of them will toil only one year in prison (on the lesser charge).

It is implied that the prisoners will have no opportunity to reward or punish their partner other than the prison sentences they get and that their decision will not affect their reputation in the future.

Because betraying a partner offers a greater reward than cooperating with them, all purely rational self-interested prisoners will reveal the other, meaning the only possible outcome for two purely rational prisoners is for them to betray each other. The exciting part of this result is that pursuing individual reward logically leads both of the prisoners to reveal when they would get a better personal bonus if they both kept silent. In reality, humans display a systemic bias towards cooperative behavior in this and similar games despite what is predicted by simple models of "rational" self-interested action. This bias towards cooperation has successfully experimented at RAND: the secretaries involved trusted each other and worked together for the best common outcome. Review in (Fehr and Fischbacher, 2003).

A recently published continuation of the prisoners' dilemma (Lambert et al., 2019), with political-practical consequences (primarily addressed to President Zaia): forced bargaining leads to more egalitarian agreements because forced to bargain players are more inclined to concessions within the negotiation than the pairs which freely bargain.

Figure 6. Left: the young spruce trees thrive between the trunks of fallen and decaying trees. The trunk on the left touches the ground and is more decomposed than the one on the right, which is held up above the ground by its branches. Right: A vigorous silver fir with 20 cm annual growth. Behind it, a decomposing trunk covered with mosses. Notice that behind the fir branches, beech and lime are composing a mixed forest. Soil: from Rendzic Phaeozems - Entic Hapludolls to Haplic Cambisols - Inceptic Haprendolls; Humus systems: from Amphi to Mull, respectively. The decomposition process appears to be in line with the provisions in Table 1 and Fig. 7, between the lines of Mull and Amphi-Moder systems.

ACTIONS

SHORT TERM ACTIONS (1-5 YEARS). Security, vulnerability/sensitivity analysis and maps. Klaus Katzenstein (AU)

Follow examples: https://www.wabo.boku.ac.at/fileadmin/data/H03000/H91000/H91200/Schriftenreihe/Band_21.pdf and http://www.bioone.org/doi/10.1659/MRD-JOURNAL-D-14-00094.1
In short:
1) Experts on Alpine Natural Hazards / Torrent- and Avalanche Control) can map critical zones for those disasters (there may be positive effects of residuals as they create surface roughness and prevent snow gliding, there may be negative effects by stems blocking streams, etc.) with priority ranking and, depending on the situation, advices on the degree of intervention.
2) Experts on area types (ownership, accessibility) can map forest type, structure and management, soil and humus types.
3) Bark beetle risk assessment, as in: http://ifff-server.boku.ac.at/wordpress/index.php/home/phenips-online/
4) Regeneration, the question of natural regeneration versus planting is an issue and will determine costs. How to make use of that potential?
5) Ungulate browsing will be a serious issue in the future. How to act on that?
I don't have time to come up with a careful DPSIR analysis by now, but I will continue to work along those lines.
6) Set up an Endnote-Web literature database.
7) Mapping: a) Critical zones and SECURITY, b) Accessibility (roads) and c) Regeneration and ungulate pressure.

SOIL POTENTIALITIES

Before presenting a project of forest recovery, let's spend another two words on the soil and specify the reasons that guide the development of such a type of reforestation plan.

Soil, humipedon, humus system and humus form

To operate respecting the soil potentialities, we need to map the "biological soil" and to forecast its response to the event. The soil may be parted in three main layers: Humipedon, Copedon and Lithopedon (Zanella et al., 2018d, 2018b). The top part is the more biological and the one that will first react to the event. To recognize the different forest humipedons (called "Humus systems", subdivided in "Humus forms"), we recommend the app TerrHum (free downloadable in the Education section of the App Store).

The main features that allow individuating the humipedons in the field are briefly resumed here down:

- ***Mull system: absence of OH horizon***
- ***Moder system: Presence of zoOH horizon pH (A horizon) ≤ 5***
- ***Amphi system: presence of zoOH horizon, pH (A horizon) > 5; thickness of A ≥ ½ thickness of OH***
- ***Tangel system: presence of zoOH horizon, pH (A horizon) > 5; thickness of A < ½ thickness of OH***
- ***Mor system: nozOF or/and szoOH present; pHwater of A or AE or E < 4.5***

Expected reactions on each humus system

On Mull system *[digestive system of temperate environment and neutral substrate, developed at the top of Cutanic Luvisols - Typic or Inceptic Hapludalfs or Haplic Cambisols - Typic Udorthents or Endogleyic Cambisols – Aquic Eutudents or Luvic Phaeozems – Typic Argiudolls (IUSS Working Group WRB, 2015; Soil Survey Staff, 2015)] areas: let 1/2 of the material (steams, branches...) to the natural digested;* ***estimated time of material digestion and transformation: 4-8 years*** *(Tab. 2, Fig. 7).*
A large (7-40 cm) A organic-mineral horizon is expected to be generated and/or enriched in OC.
A permanent or temporary switch to an Amphi system (formation of a zoogenic OH horizon) is possible under thick organic rests.

On Moder system *[digestive system of cold-temperate environment and acidic substrate, developed at the top of Dystric Cambisols – Spodic Dystrudents or Entic Podzols – Humicryods (IUSS Working Group WRB, 2015; Soil Survey Staff, 2015)] areas: let 1/3 of the material (steams, branches...) to the natural digestion;* ***estimated time of digestion: 14-28 years*** *(Tab. 2, Fig. 7).*
We expect the formation of a thick Organic OH horizon (3-20 cm) and a thin organic-mineral A horizon (< 7 cm). A permanent or temporary switch to a ***Mor system*** *is possible, with the formation of a thick organic layer in which a fungal biodegradation dominates;* ***estimated time of digestion: 28-56 years or more****.*

On Amphi system *[digestive system of cold-temperate environment and limestone or dolomite substrate, developed at the top of Skeletic Luvisols – Inceptic Hapudalfs or Epileptic Phaeozems – Lithic Hapudolls or Rendzic Leptosols or Cambisols – Cryendolls (IUSS Working Group WRB, 2015; Soil Survey Staff, 2015)] areas: let 1/3 of the material (steams, branches...) to the natural digestion; estimated time of digestion: 14-28 years (Tab. 2, Fig. 7).*
We expect the formation of a thick Organic OH horizon (3-20 cm) and a thick organic-mineral A horizon (7-40 cm). A permanent or temporary switch to a ***Tangel system*** *is possible, with the formation of a thick organic layer in which a zoogenic biodegradation dominates;* ***estimated time of digestion: 28-56 years.***

There are no tables with the duration of biodegradation of whole trees in the forest. Instead, the becoming of dead wood on the forest floor and the classification of the material in the evolving phases have been described and published by (Tatti et al., 2018; Zanella et al., 2018c). No estimates were made on the time needed for the biotransformation of wood because the factors that influence the speed of biodegradation are numerous and interdependent (Tatti et al., 2018): geological substrate, soil (pH, CEC…), climate, topography and contact surface between soil and deadwood, living organisms including microbial organisms, type of surrounding vegetation, tree/shrub species , initial decay stage of the woody material, quantity/volume, type, shape and size of the initial woody material.
We know that: a) there is a negative correlation between lignin content and tree wood formation (Novaes et al., 2010); b) in different tree species the lignin content varies from 15 to 40% (Sarkanen and Ludwig, 1971); c) in each species the content varies by only a few units (26% + / - 2% in Picea abies (Raiskila, 2008). Since Picea abies is the species that suffered the greatest damage, we think that the biodegradation times can reasonably be enclosed on the graph between the two lines of the Mull and Tangel-Mor, moving downwards in Mull more favorable conditions (high temperature and humidity) and upwards in opposite cases.
In 1966, McFee and Stone (1966) described a forest near New York where dead wood persisted in the soil long after being incorporated. After more than 100 years, the wood incorporated in the upper part of the soil was estimated at 15

or 30% of the initial volume. Even in the soil, these pockets of dead wood of more than 100 years show contents in N and P lower than the surrounding humus. Næsset (1999) states that the degree of contact with humus is one of the factors favoring the decomposition of wood. In particular, the author speaks of moisture rising from the ground ("Cross-section diameter, ground contact, soil moisture, and aspect were all found to have significant impacts on the decomposition rate constant. For different combinations of these characteristics the decomposition rate constant ranged from a minimum of 0.0165 per year to a maximum of 0.0488 per year"). This could mean that in a Mull (richer in organo-mineral aggregates and thus in water), the rise of moisture could be favored compared to a Moder.
However, a study by Bütler et al. (2007) assessed the relationship between the degree of decomposition of dead wood and the humus form but finds no link between the two. They take up the idea that only the rise of humidity counts.
With the study of Heilmann-Clausen (2001), a link between floristic wealth (which is probably associated with a soil richness gradient) and the diversity of wood decomposers, hence the rate of decomposition of wood. There is also talk of rising moisture, but also of pre-existing decomposers in the soil (Couture et al., 1983).
Culliney (2013) followed the decomposition of samples of wood included in different forms of humus and concluded the determining role of the macrofauna. This study shows that once integrated with humus, buried wood decomposes much faster in the mull than in the moder. This is one of the rare studies that goes in the direction of Figure 7 but unfortunately it lacks concrete elements to deduce a generalization to a forest context.
In conclusion, woody biomass generated by VAIA will mechanically increase the frequency of a very particular humus system, Legno, with all associated biological diversity. This "Para humus system" (Tatti et al., 2018; Zanella et al., 2018c) is usually "incorporated" punctually into another system. If the original system is a Mull, the biodegradation of wood may be faster than in a Moder (Fig. 7). The literature shows that even a hidden Legno humus system, which is incorporated under the soil surface, lasts a very long time and could even be a means of sustainably storing woody carbon in the soil to cope with global warming (Moroni et al., 2010).

It would be very interesting to see what happens with the VAIA material and to compare real data with the forecasts calculated in Fig. 7.

LONG TERM ACTIONS (1-100 YEARS)

To give a practical example, we decided to operate in a pragmatic way - a kind of classical method with greater importance assigned to the soil - on the three quarters of the area that suffered damage from Vaia, and to dedicate the remaining quarter to research.

Sylviculture on 75% of the VAIA surface. To support the forest regeneration.

The preconised measurements are adapted to the response of the biological soil. They can be reported in a few lines if together with the humus system we consider the naturalness of the damaged forest, the damaged surface in every type of forest and the quality of the natuiral renewal. The potential soil types and forms of humus in the areas that underwent the Vaia event are shown on Table 1. These parameters are coded as follows:

A. *Natural forests (reserves, parks…), not cut or very little, not for timber production*
B. *Forests submitted to natural forestry (no plantation, never clear-cut)*
C. *Forests subjected to more impacting cutting operations = wood production forests, band and spot cut*
D. *Forests from which fallen trunks have been removed and which have suffered damage to the soil and on the renewal due to the heavy means used for logging operations*
AND
1. *damaged by wind in spots or on less than 25% of coverage,*
2. *damaged on 25-50% of coverage and*
3. *damaged on 50% or larger surfaces;*

AND
y. *presence or potentially possible natural regeneration*
n. *absence or potentially difficult natural regeneration*

Examples:
A1y: *Natural forest (A), lowly damaged in spots (1) with potential or real natural regeneration (y);*
B2n*: Forests submitted to natural forestry (B), damaged on 25-50% of coverage (2) and absence or potentially difficult natural regeneration (n).*

The silvicultural measures that we recommend on the 75% of the surface that has suffered damage from VAIA are the following:

In A, *it is not necessary to detect the humus system:*
- A1: do nothing
- A2: remove only the stems easy to take out of the forest without damaging the soil (along the roads);
- A3: remove of the stems easy to take out of the forest without damaging the soil (along the roads and using a light and low-impact cableway);
In B:
- B1y and B2y: where possible with light soil damages, remove only the good-for-sawmill stems;
- B1n, B2n and B3y: do nothing;
- B3n: where possible with light soil damages, remove ½ or 2/3 of the steams in case of Mull or (Moder and Amphi) respectively;
In C:
As in B; in addition, where possible, fragment half the branches let on the soil.
In D:
Fragment half the branches and let the sites to natural evolution. In case of erosion danger, plants with native species in harmony with the surrounding natural forest.
The potential soil types and forms of humus in the areas that underwent the Vaia event are shown on Table 1.
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Table 2*. Estimation of the time necessary for a complete biodegradation of the fallen trees in three groups of humus systems. Mor and Tangel systems are very rare in the VAIA area*

Years for a complete biodegradation	*Litter (leaves, needles small branches)*		*Fallen trees (whole tree and visible strain)*	
	fast (1)	*slow (2)*	*fast (3)*	*slow (4)*
Mull	*0.1*	*1.9*	*4*	*8*
Amphi-Moder	*2*	*6.9*	*14*	*28*
Tangel-Mor	*7*	*14 or more*	*28 or more*	*56 or more*
(1) as good deciduous litter			*(3) = 2 * (2)*	
(2) as coniferous litter			*(4) = 2 * (3)*	

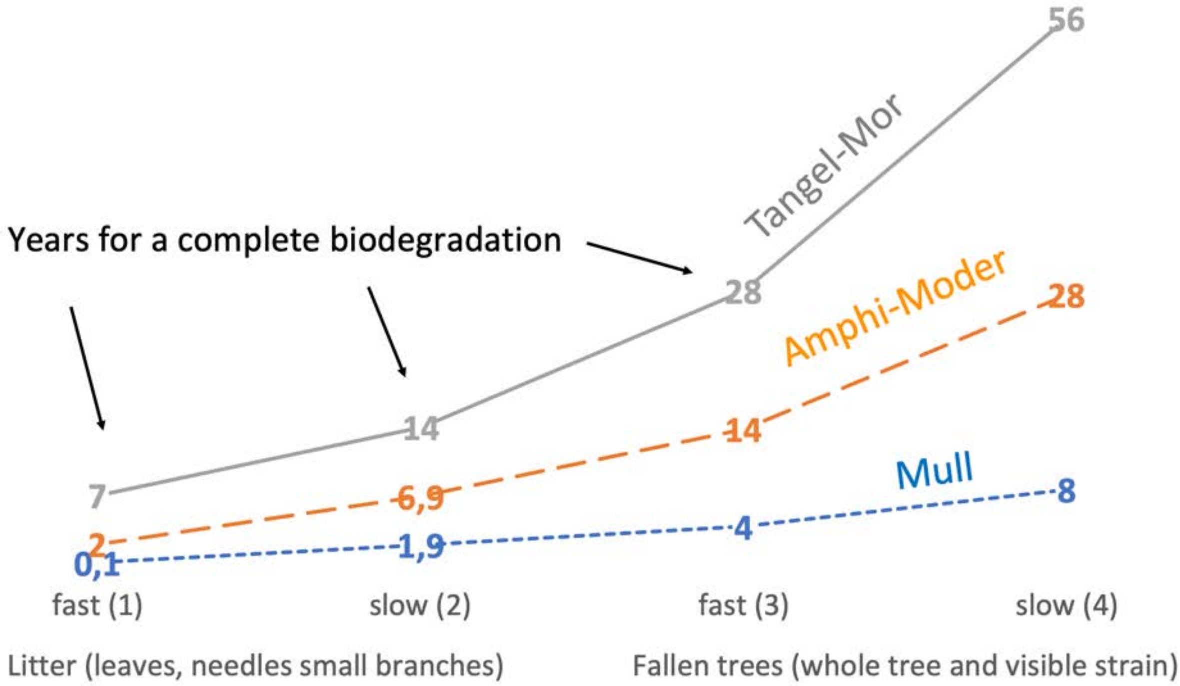

Figure 7. Estimation of the time necessary for a complete biodegradation of the fallen trees in three groups of humus systems. Mor and Tangel systems are very rare in the VAIA area and give an idea of what arrives in sites of slow biodegradation. We started with values published for litter, (1) good deciduous litter, (2) coniferous litter. As the time for lignin biodegradation is double compared to cellulose (Berg and McClaugherty, 2014; Zanella et al., 2018a), we used a factor 2 from column (2) to column (3) and from column (3) to column (4). Consider that: a) lignin nearly doubles in % from leaves-needles to wood; b) lignin is higher in coniferous than in deciduous material; c) from Mull to Tangel or Mor, coniferous increases and deciduous decrease in the population of trees.

Research on 25% of the damaged area

Why not using this destroyed forest as a long-term experiment? Anonymous scientist (IT)

Why not using this destroyed forest as a long-term experiment? By merely comparing two forest parcels, one in a damaged area and one in an undamaged one, with similar characteristics in terms of elevation, aspect, and vegetation community. Then, by monitoring the parcels over time. The hypothesis is that the patches will differ in terms of succession of micro- and macrofauna communities, forest regeneration success, the evolution of soil organic parameters, and changes in humus forms.
The study would certainly produce several scientific papers to publish in international journals and attract different forest ecologists to the Veneto region. Moreover, besides the evident scientific interest, this initiative will likely help policymakers, from Italy and abroad, to take appropriate measures of forest management. By the term "appropriate", we intend those measures that respect all ecosystem services furnished by the forest, such as wood production, place of leisure activities, biodiversity, and climate change mitigation.

Possible research on soil erosion, N cycle, biology and biodiversity. Michael Aubert (FR)

In slope erosion issues, Battany and Grismer (2000) and Stanko et al. (2011) in an experiment on soil erosion of vineyards, showed that below 16% slope, if erosive processes exist they are minors compared to steeper slopes. Holvoet and Muys (2004), Linser et al. (2018) and Rogers and Schumm (1991) specified that runoff in a forest context becomes intense from 20% slope if there is no ground cover. Runoff is slowed down as soon as 8 to 10% of the area remains afforested by bands parallel to the contours. A more recent synthesis (Gobin et al., 2004; Guerra et al., 2017) mentions that any landscape with a slope > 3-5% is subjected to soil erosion.
In detail, there are questions on the flow of nitrogen especially in the form of nitrates that enrich streams but impoverish forest soils. Törmänen et al. (2018) recently experienced the effect of the contribution of 40 kg/m^2 of exploitation residues on the N cycle in soil superficial horizons (0 and 0-5cm). They tested it for 3 species, Betula pendula, Picea abies and Pinus sylvestris. All species combined, 18 months after the intake, between 150 and 200mg/kg o.m. nitrate was produced. There was no nitrification in the control (now input of residues) for which the mineral N production was limited to ammonium. However, in a simple clear-cut without the addition of milling material, Smolander et al (1999), Finér et al. (2016) and Smolander and Heiskanen (2007), by comparing a clear-cut spruce stand with an existing stand, showed that the net N mineralization rate was low without producing NO_3^- in the stand in place while mineralization and nitrification rates were very high in the cut area. Net nitrification was 29 times higher in the clearcut, in line with Likens' work.
Then there are all the effects on soil biology, we export everything, we do not export everything, it's always the same question. The "cleaning" of the cut area with the export of slash is unfavorable to biodiversity. Indeed according to Landmann et al. (2009, 2014, 2015), wood debris are home to many living species, different from those of large dead wood. They are home to a large part of saproxylic insect and ascomycete communities. They provide shelter for amphibians, reptiles, small mammals, promote colonization by mycorrhizae, and maintain microclimatic conditions favorable to mosses. The few studies available in temperate forests show that compared to a conventional harvest leaving slash on the ground, the export of small wood remains decreases in the short term the diversity of saproxylic insect communities at plot scale, by modifying their composition (Canadian Instituite of Forestry, 2019).

Possible research on N and C cycles, erosion, leaching, evapotranspiration, nitrate concentration in forest soil solutions after windthrow. Anna Andreetta (IT)

Increased levels of nitrate concentration in the soil solution could be expected after forest damages following strong wind events. An increase in nitrate leaching into the deeper soil horizons was observed in previous studies on forests affected by storms (Hellsten et al., 2015; Legout et al., 2009) as well as by clear-cut harvests (Gundersen et al., 2006; Kreutzweiser et al., 2008). Diminished nitrogen uptake by plants and/or increased mineralization rates could be the driving process that explain nitrogen losses by leaching after forest disturbance (Ranger et al., 2007; Vitousek et al., 1979). Changes in the soil climate of forest gaps due to decreased transpiration and increased sun exposure (Kreutzweiser et al., 2008) favor organic matter decomposition and nitrate formation after nitrification. Nitrate *concentration in soil water has been found to reach a maximum a few years after the storm, up to 15 years depending on the study case. Indeed, the impact of windthrow on nitrate leaching is modulated by important factors such as the level of nitrogen deposition (Akselsson et al., 2004), the extent of ground vegetation cover (Hellsten et al., 2015; Legout et al., 2009) and the magnitude of the area affected by windthrow.*

Nitrate leaching below the rooting zone may potentially contaminate groundwater, cause eutrophication of surface water (Kreutzweiser et al., 2008) and contribute to soil acidification. This could further worsen the already critical situation of the VAIA forest ecosystems. European forests have been exposed to acidifying anthropogenic deposits for several decades and the Alps are still receiving high loads of atmospheric reactive nitrogen due to the proximity of emission sources in the Po Valley (Rogora et al., 2016). High inorganic nitrogen concentrations in soil solutions were found in sites with high N deposition loads (Andreetta et al., 2019), where a regular N flux out of the rooting zone can represent a risk of ground- and freshwater pollution. Increased nutrient availability could also affect tree carbon partition patterns, with a shift of carbon allocation from roots to aboveground woody biomass (Janssens and Luyssaert, 2009). This nitrogen-induced carbon allocation pattern could ultimately increase the sensitivity of trees to extreme windstorms, likely leading to an alarming positive feedback loop.

Studies on soil microbial communities. Adriano Sofo (IT)

In my opinion, before considering the whole forest soil as a digestive system or to subdivide the soil in parcels with different "managements", as an agricultural chemist I would recommend observing in the lab the degradation of the fragmented wood by endogenous microorganisms. It could be possible to identify and isolate at least the dominant ones and let them grow under controlled conditions using wood as a substrate. Soil respiration (IRGA), changes in wood composition (LC-MS) and composition of microbial communities (DGGE, 16S/18S-RNA fingerprinting) could be studied. This could be a preliminary basis before infield studies, in order to get an idea about the best strategy to be applied in the whole forest.

Soil microbial communities can play several important ecological and physiological functions in a forest (soil organic matter decomposition and control of its cycle; regulation of mineral nutrient availability for plants; atmospheric nitrogen fixation; formation of mycorrhizae; production of biologically active substances able to stimulate plant growth; etc.), ameliorating soil physical and chemical conditions, and consequently soil habitability for plants, as observed in many soil-plant systems (Sofo et al., 2014, 2012, 2010). There is a growing interest in the maintenance of forest functionality and its connected ecosystem services. It seems that the soil microbiota, particularly its biodiversity, allows forest systems to better overcome natural and anthropic perturbations by improving their recovering capacity (resilience concept). Thus, a survey on soil microbiological data of the forests of North-East Italian Alps, that were strongly damaged by wind on 30 October 2018, is urgent for planning the best strategies for their management in the next future. Particularly, attention should be given to changes in the structure, dynamics and complexity of soil microbial communities, in order to evaluate soil health status before and after planned interventions.

One of the easiest and reliable techniques for defining soil microbiological status is the determination of microbial metabolic/functional diversity by the spectrophotometric Biolog® method, that has a high discriminating power between microbial soil communities from different soil environments. Culture-based and genetic techniques have been used successfully in forests to ascertain the presence of some types of microorganisms. This is particularly important in damaged forests, where soil microorganisms, and particularly fungi, can play an important role for fast forest recovery, as both bacteria and fungi respond to forest perturbation already in the short term. Besides microbiological and genetic analyses, nowadays next-generation sequencing (NGS), coupled with bioinformatic tools and metagenomic approach, made it easier to comprehensively analyze microbial communities in any type of matrix, including soils.

On this basis, short-time effects on microbial functional and genetic diversity of different management systems after the 30th October disaster could be evaluated by a combination of culture-dependent and culture-independent methods, accompanied by microscopy. This is urgent for better understanding the degree of forest resilience in our case study.

For achieving this aim, it is possible to adopt the following methodologies:

1) *Total/specific microbial counts and microscopic analysis.*
2) *Polymerase chain reaction (PCR) and denaturing gradient gel electrophoresis (DGGE) of 16S rDNA amplicons (bacteria) and 18S rDNA amplicons (fungi).*
3) *Identification of specific microbial taxa based on a 16S rDNA- and 18S rDNA-based metagenomic approach*
4) *Microbial community metabolic profiles and calculation of related indices of microbial functional diversity using Biolog® 96-well microplates (AES Laboratory, France).*

The following activities should be carried out:

1) *Soil sampling. Composite samples of bulk soil (20 seven-cm-diameter cores pooled on site per each treatment) will be randomly collected from topsoil layers (0-30 cm) in different soil management system/location combinations. Soil physicochemical properties will be evaluated. Time: 1 week for each sampling date.*
2) *Microbial counts and microscopic analysis. Microorganisms grown on specific agar media will be counted after a period of incubation. Identification of isolates by a light microscope will be carried out and results compared with those deriving from genetic analysis (point 3). Time: approximately 3 months.*

3) Genetic analysis. After DNA and RNA extraction, PCR amplification will be performed at different conditions and temperature schemes in order to find the best amplification protocol. DGGE and bioinformatic/metagenomic analyses will be performed. Time: minimum 12 months.
4) Functional analysis. The appropriate observation period will be chosen as the time at which most of the substrate is used in Biolog® 96-well microplates, before color changes in control wells and by the rate at which color develops. The most important diversity indices (average well-color development, Shannon index, eveness and richness) will be calculated. Time: 4-5 months, excluding data analysis.
5) Statistical analysis. DGGE profile comparison and clustering will be performed by applying the Unweigthed Pair-Group Method using Arithmetic Average (UPGMAA) clustering algorithm, based on Pearson correlation coefficient. Principal component analysis (PCA) will be applied (PROC FACTOR) on Biolog® absorbance in order to characterize the structure of microbial communities on the basis of their substrate utilization patterns. The most abundant and long reads in each OTU (Operational Taxonomic Unit) will be selected as representative sequences. These sequences will be then used for taxonomic assignments using public, open-source databases. All results will be treated by analysis of variance (ANOVA) using SAS software (SAS Institute, NC, USA) and means will be separated according to Fisher's LSD tests at different p levels. Time: 4 months.

Soil studies as a basis for forest renewal. Augusto Zanella (IT)

A simple comparison between i) the soils prived of trees due to Vaia, ii) the soils now recovered with different species and processes by the silviculturist, and iii) the other nearby soils that instead continue to support the forest that survived Vaia.
We can make pedofauna inventories twice a year, with associated chemical-physical and biological (example: DNA) analyzes, for n years (the longer, the better). We could classify the forms of humus (with the app TerrHum), we could estimate the natural renewal (counting the seedlings in sample areas), we could collect soil samples, we could extract the animals and make chemical-physical and biological measurements. Then we will compare the data statistically, choosing the factors we want, such as the type of silviculture, the quality of the renewal, the altitude or the type of forest, but also the type of feeding of the soil (nothing, leaves, chips, branches, trunks ...).

CONCLUSIONS - Response to Governor Luca Zaia. All authors

Dear Luca Zaia, Dear Governor of Veneto Region,

Thank you for asking for scientific advice. In a democratic context, there is a divergence of opinions on the matter we are treating. Scientists do not have one but many solutions that depend on their inherited character, formation, experience, and economic situation. Consciously accept to enter into an "Anthropocene", maybe to admit that planet Earth could still be the typical single home for humans with very different identities and behaviors and for a long time. In line with this "precautionary principle", we propose below the average advice of the authors of this article concerning the part of the Alpine forest ecosystem touched by the storm VAIA.

Is it better to let nature treat its wound?

Yes, it would be better. Where possible, it is better to leave it to nature. In chapter 1.6 you will find the summary opinion of the authors of the article. Here (https://hal.archives-ouvertes.fr/hal-02342793) the whole discussion.
Un article in The Guardian, two years ago: From dead woods to triumph of nature, 30 years after the Great Storm. The devastating winds of 1987 felled 15 million trees but also prompted a radical change to the way we work with the countryside to let it heal itself. Author: Dan Glaister. Sun 15 Oct. 2017 :
"Scords Wood was left alone," says Tom Hill, the National Trust's trees and woodlands specialist. "There's been no intervention at all, and it's now a thriving woodland in terms of its diversity."
"Veteran trees have decay and growth happening at the same time. One of the biggest attitudes that changed was the process of decay being seen as an integrated part of life not just something dirty or rotten."
"Storms mix things up, they allow light to get in, which is a vital factor. Toys Hill is like a mosaic of different habitats and light and shade, and it has a very diverse structure. That's exactly what you want if you're seeking to maintain healthy woodland. Destruction is very important, and nature is self-destructive and self-healing at the same time."
Link: https://www.theguardian.com/environment/2017/oct/15/british-woodlands-30-years-after-great-storm

Short term actions (1-2 years)

For security, vulnerability/sensitivity analysis and maps, examples are reported in chapter 3.

Long term measures (coming 100 years)

In chapter 5.1., you dispose of a list of actions that allow renewing the forest on 75% of the damaged surface; in 5.2., you find a list of research projects to place on the remaining 25% of the damaged surface for collecting the necessary feedback and improve the forest restoration action.

Additional economical last-minute considerations. Cristian Bolzonella (IT), Lingzi Mo (CN), Augusto Zanella (IT)

Vaia market

From an economic point of view, VAIA had an interesting dynamic effect on the timber price. After VAIA, the prices of timber had literally dropped (Ebner, 2018; Talignani, 2019), with the consequent disadvantage of using most of the fallen timber. As a consequence, according to scientists, there were problems related to the spread of insects and fungi harmful even to the living woods that remained standing. However, in a second time the fall in the price of timber attracted unexpectedly forest companies and foreign European and Chinese buyers, arising the timber price which doubled. Market could be very efficient to use resources.
The figure 8 shows the dynamic of the standing timber price and the logs price in the Trento province.
The collapse of the prices hit in particular the standing timber that fell from 67,6 €/m3 to 29,36 €/m3 (-56.6%) from October to November 2018, while the price decline of logs has been more limited (-16%).
In the first months of 2019 there has been a recovery in the price of logs (64 – 67 €/m3) due to the effect of foreign buyers, while the price of standing timber remains at very low levels (19 – 20 €/m3).

Currently, the companies are removing all the woody material, without releasing wood on the ground, as if VAIA was an unexpected sylvicultural cut operated a large forest area (as it currently arrives in Canadian, Swedish, Russian woodlands).
If we want to let part of the material on the ground for stimulating the soil functionality, it is necessary to intervene rapidly raising artificially the timber price (imposing a minimum price) or establishing artificial constraints in the contract specifications (defined quantities of material to release in the forest), to guarantee the renewal of the woods in the long term.
Another exciting aspect ponders the dynamics of the free market. The storage of timber has a cost that risks not being compensated for by an expected price increase that remains unpredictable in a globalized market. It is sufficient that another catastrophic event arrives elsewhere to defeat the price forecasts.
It is, therefore, more prudent to store only the wood that can be used for local activities and to rely on a global market for the rest.

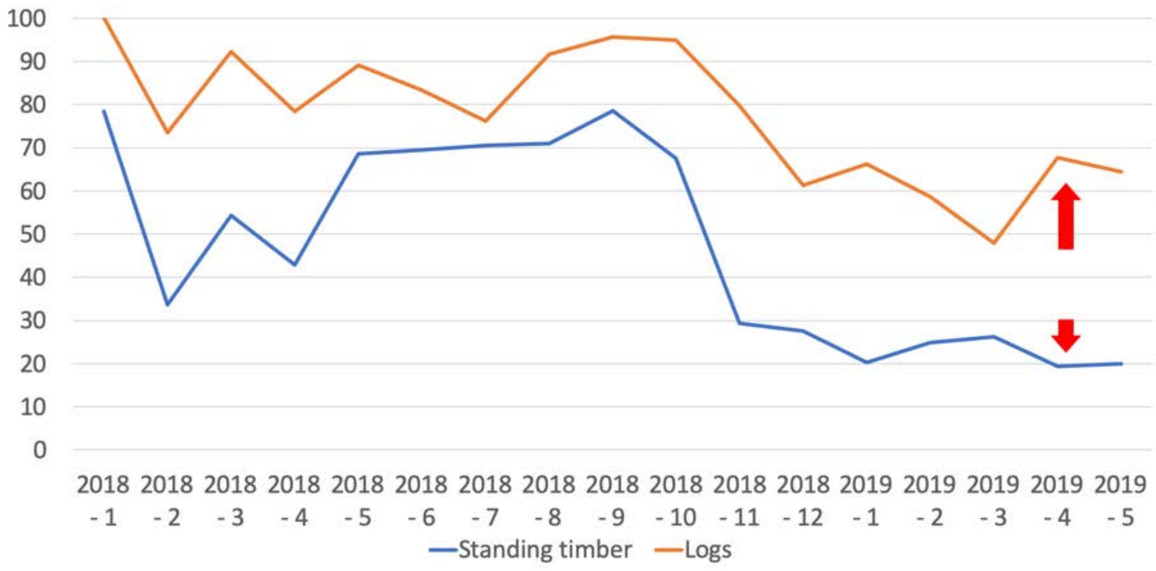

Figure 8. Dynamic of the monthly timber prices (€/m3) in the period January 2018 – May 2019. Source Commerce chamber of Trento (IT), www.legnotrentino.it/asteonline

The Chinese intervention in the VAIA timber market

It is, therefore, more prudent to store only the wood that can be used for local activities and to rely on a global market for the rest.
With growing domestic demand and booming export industry, China is both a major importer and exporter of wood products. Coupled with an environmental policy to protect the country's remaining natural forests and economic policy, China has not only increased its import of timber products but has tended to import less processed materials.
In 2018, China's logwood imports had increased by 8% compared to the previous year, rising to an overall of 60 million m³, of which about 42 million m³ (+ 9%) were softwood and 19 million m³ (+ 8%) were hardwood logs (Jauk, 2019).
Zhu (2019) shows (Tab. 3) that imported softwood logs quantity and price of China in 2018, 42% of softwood logs shipments arrived from New Zealand and 19% from Russia, followed by the US (12%), Australia (10%), Canada (6%) and Uruguay (5%), and the average price is about 139 $/m3 (around 125 €/m3).

Table 3. China imported softwood logs quantity and price in 2018 (Zhu, 2019)

Softwood	*Quantity (million m^3)*	*Price ($/$m^3$)*
New Zealand	*17.29*	*141*
Russian	*7.95*	*117*
The United States	*5.03*	*166*
Australia	*4.13*	*126*
Canada	*2.53*	*184*
Japan	*0.92*	*134*
Uruguay	*2.09*	*124*
Others	*1.64*	*-*
Total	*41.6*	*139*

The 8 million m3 of VAIA's timber correspond to a volume of softwood within reach of Chinese buyers, and the price fluctuations of Trento timber (Fig. 8: months 2019-3, 2019-4) could be related to their preferences. To avoid empty *export containers back to China, trading companies arrived in Europe would choose to transport logs back to China. Such logs are most likely used to produce medium grade furnishings sold in the country. Therefore, Chinese buyers were likely to buy logs and not standing timber whose prices remain low (Fig. 8). The fact that the cost of wood rose to avoid returning to China with empty containers (and not for reasons of competition with European companies) left everyone stunned. The unforeseeable is... not predictable. In this case, for example, timber extraction has become economically advantageous even in less accessible parts of the forest, with an additional consequent ecological impact to be taken into account. All this could be an example of unforeseeable behavior to have in mind if it were decided in the future to face global warming seriously.*

ARTISTIC INTERPRETATION

"Vertimus" and "Se planter", of Bonneval Karine (FR)

(Tree photographed by Eric Badel, INRA PIAF; composition, layout and color by Karine Bonneval)

Figure 9. Left: Vertimus. Instead of opposing the forces of nature, why not indulge their natural evolutionary tendency, inserting us into the mechanism as all other living beings do with innate mastery? And considering the soil as a source of life, as shown on the right part of the picture: "Se planter", "Plant yourself".

"L'urlo di Vaia", with the permission of the authors Vera Bonaventura (IT) and Roberto Mainardi (IT)

Inside Malga Costa (alpine hut for cows), it will be possible to relive, condensed in 5 minutes, what the populations and trees of Trentino have lived in 5 hours between 28 and 29 October 2018. "We probed the various forms of art we could use ... and we found ourselves with only a sound in our hands ... which, from interviews with people who lived Vaia, was an element tragically imprinted in our memory". A glimpse of this sound, from youtube: https://www.youtube.com/watch?v=SFGWU7gjQ48

WOULD YOU PROTECT AND ENTER THE AVERAGE AIR TEMPERATURE OF PLANET EARTH (mean surface air temperature = 15 ± 2 °C) IN THE UNESCO WORLD HERITAGE LIST? Augusto Zanella (IT)

Dear Reader,

To organize a first worldwide cell-phone referendum (Fig. 10) and to put the planet Earth's air mean temperature on the UNESCO list of World Heritage Sites might correspond to the first conscious and democratically determined step in the Anthropocene. We can arrange it during the Olympic Games in Tokyo. Would you help us and sign a petition addressed to the Japanese Premier Shinzō Abe? *https://secure.avaaz.org/it/petition/Toshiro_Muto_Tokyo_Organising_Committee_of_the_Olympic_Games_2020_As_planet_Earth_citizens_will_you_stop_the_climate_fro/* .

Figure 10. The figure illustrates the evolution of biodiversity on our planet. It develops between the molecular world of the organic substance in the soil and far away to the nearest galaxy clusters. The orange background corresponds to the threat of average rising air temperature. In the middle, the "Pioneer plaque" launched in 1972 by NASA in the space to indicate our position in the universe to other extraterrestrial living beings.

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