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FOREST VEGETATION AS AN ENVIRONMENTAL IMPACT INDICATOR FOR WATER RESOURCES

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Summary : *A multidisciplinary preliminary research\project was conducted on the impact of the new Fast Train Line between Florence and Bologna (Italy). Since about 60% of the train line is built below ground level even at considerable depth in the Apennine Alps, specific attention was given to the effects on the drainage of water resources kilometers from the railway line. While components of climate, geology and deep water bodies, hydraulic and related engineering systems were investigated, preliminary study on the distribution and health conditions of forest vegetation was approached in the attempt of establishing a range of samples to monitor eventual variations over time. According to a recent forest inventory and phytosociological classification completed by the Tuscan Regional Government (R.T., 1998), forest vegetation was classified as hydrophylous, meso-hydrophylous, and mesophylous. Forest health conditions were preliminarily approximated according to a formal classification published by the Tuscan Regional Government in 1995. The aim of the use of forest vegetation was to monitor eventual variations of forest vegetation composition and/or health relation to the distribution of potential impacts on water resources of the tunnels and related infrastructures of the Fast Train Line. Although chronological series of data were not or scarcely available, a first, preliminary remote sensing analysis showed negative trends of the N.D.V.I. (Normalized Difference Vegetation Index) in some relevant forest associations (i.e. Quercus pubescentis woods) at landscape scale. The N.D.V.I. (Tagliaferri, 2002a) appeared to worsen where an impact on water bodies (phreatic water) might have been occurred. However, other factors that may have affected forest health conditions were also explored. For example, annual rainfall showed a reduction over decades. At the forest unit level, a number of forest tree species showed symptoms of suffering or stress but no correlation with water drainage or lowering of water table/phreatic water was definitely verified at this stage. However, in some cases the disappearance of water in local creeks and small rivers was noted despite the surrounding vegetation was formed by highly water demanding species (i.e. Alnus glutinosa, Equisetum spp., Petasites spp., Salix alba, Salix spp., etc.). In general, these associations are classified as hydrophylous and need, at least in this area, no limiting water supply over the warm and dry summer. This means that they would not grow and establish in sites where water supply is somehow a limiting factor in any season. At the same time, various mesophylous species were found to grow within some river or creek beds, which would not be possible if water was present over the year. In particular, the biological cycle of those species (i.e. Viola spp., Geraneum spp., Rubus spp., Helleborus spp., Hieracium spp., etc.) may indicate a sudden or fast reduction or even disappearance of water resources or water flow in rivers/creeks. At the same time, a random sampling was initially made and 248 areas were described, photographed, and mapped. Distribution of hygrophylous, meso-hygrophylous, and mesophylous associations was then related to some site and topographical factors with the aim of verifying some possible influence on forest health and composition.*

Preliminary results indicate the need for both a continuation of the study through more accurate and specific analyses on different sectors, and the establishment of a definitive monitoring based on a deeper level of sampling areas and further statistical models. As is commonly known, variations on soil water supply and seasonal trends are in general likely to affect species composition, regeneration, growth, health, and dynamics of populations of forests. When such changes occur suddenly or in a few years and are consistent, water stress may become critical for a number of species and pathological problems may be serious. Silviculture and forest planning should take into account such an eventuality given the use of the forest as an environmental impact indicator.

1. Introduction

In the year 2000, the National Institute for Mountain Research (I.N.R.M., Italy) financied a national project on "Protection of Water Resources of the Mugello Mountains" (Tutela delle Risorse Idriche della Montagana Mugellana, T.R.I.M.M.). After, the National Environment Observatory (O.A.N., Italy) integrated the project with further financing. The Mountain Community of Mugello (Comunità Montana del Mugello, district of Florence, Italy) managed the project, which was assigned to the Dept. of Soil Science and Plant Nutrition (DSSNP) of the University of Florence, Italy (Prof. G. Rodolfi), the Dept. of Agriculture and Forest Engineering (DIAF) of the University of Florence, the Institute of Agrometeorology and Remote Sensing for Agriculture (IATA) of the National Council of Research (CNR, Florence), and the author as a consultant in forest impact evaluation, forest ecology and monitoring. Prof. G. Rodolfi of the DSSNP was the project coordinator.
The project interested a wide area in the province of Florence (Italy) where the national Fast Train Line (FTL) between Florence and Bologna was under construction, most of which is built in galleries even deep below the mountain surface. Possible impact on the conservation of water resources was hypothised and different fields of research such as water drainage at the geological scale, climate patterns and eventual changes over decades, techniques and methods for water conservation and deep water drainage reduction, restoration of water flow in some creeks, and so on, were investigated. The study below reports on preliminary results regarding forest health conditions and possible consequences of the impact on water resources due to various factors, in which the construction of the Fast Train Line.

The aim of the study was to preliminarily test the presence of stress symptoms of forest vegetation, in which water stress. This, to begin an investigation on possible relations of such symptoms with forest species distribution and forest typology. The possibility of identifying other processes, dynamics, or any phenomena apparently depending on modifications of some environmental factor, was not excluded. At this stage, no kind of causality was assumed. On this basis, the study provided preliminary results for further future use of methods and techniques able to start a check of relations with other sectors of investigation of the project, progressive screening of results in the forest investigation area, and for the identification of methods able to ascertain both simple and complex relationships between causes and response of the forest ecosystem, in which water stress and forest damage. However, the research was significantly limited by financial and technical constraints.

Thus, an estimation of the presence of forest stress or suffering with respect to species composition and distribution, phytosociological associations, and possible relations with environmental gradients, factors of impact, alterations of abiotical factors such as climate, hydrogeology, air quality, forest management, etc., was initiated. In this, eventual phenomena in the forest ecological and phytosociological ambits able to provide information or to indicate any change of the forest environment as a consequence of not well known causes, were considered.
The evaluation of forest vegetation was pursued without any information regarding the environmental, landscape, geology, probability distribution of impacts, and so on, in the attempt to avoid any possible direct or indirect influence on the survey.

2. Materials and methods

The research investigated variations of forest health condition, tree performance, and forest ecological stability with respect to environmental stress, and delimited areas susceptible of such variations with regard to possible (negative) alteration of soil water content caused by the FTL.

2.1 Constraints of research

Financial resources: Although the aim of the research required higher scientifical and technological levels, financial constraints limited the aplication of a number of methods and analyses. It affected both the possibility to develop and apply an optimal methodology and to achieve further results.

Timing: the project could not begin before July 1, 2001. It caused a delay in the timing of forest vegetation survey as in summer some water stress is likely to rise. Although this is a normal eco-physiological process in the Mediterranean climate, plant responses may produce some level of confounding with respect to crown and foliar symptoms that depend on diseases, pollution, and different kinds of environmental impacts (i.e. water drainage). Timing did not allow for monitoring of possible differentiate progression of symptoms in similar forest units with respect to the beginning of foliation.

Time length: the study had to be concluded in one year. However, time available for sampling, analyses, etc., was much shorter given the limited period from the beginning of the project (July, 1) and the length of the vegetative period, that is, until the end of September. Indeed, summer drought often shorts the time when to ascertain leaf colouration and fall, and morphological alterations. In spring, rainfall and soil water content are usually high enough to observe if such sympthoms appear anyway.

Availability of information: hystorical series of vegetation, various surveys, and similar information were little or poor; scale of soil maps was too high for a detailed (site level) description, given the purposes of the study. Similar difficulties affecting the other fields of research related to this project consequently affected this research.

These constraints allowed only for a preliminary investigation with the support of little data and information available, to be carried out. Hence, methods were only exploratory and recognitory, so as to identify what and whether problems related to environmetal stress, and in particular water stress, did exist. This, to define a methodological procedure to better identify and select research objects and causes that may be related to apparent alteration of water resources and effects on the forest.
Therefore, this study does not represent an optimal methodological procedure for the evaluation of similar impacts on both the forest and water resources but what was possible to achieve within the limits imposed by the above mentioned constraints.

2.2 Research objects

At this stage, a general perspection about the ecophysiological bases of water stress on plants, especially trees, and related phytopathological consequences and symptoms, was made (Amoriello *et* Costantini, 1999; AA.VV., 2000; AA.VV., 1992; AA.VV., 1990; AA.VV. 1991; AA.VV., 1987; Barbolani, *et al*., 1997; Barbosa and Wagner, 1989; Bottacci, *et al*., 1988; Ferretti, *et al*., 1999; GEA, 1991; Gellini et Clauser, 1986; Gellini, 1990; Gellini, *et al*., 1987; Ginter-Whitehouse, *et al*., 1983; Gravano, *et al*., 1999; Kozlowski, 1976; Lorenzini, 1983; Matta *et* Pennazio, 1984; Morselli, 1991; Provincia di Firenze, 2000; Ragazzi et Dellavalle, 2000; Stief, 1992; Schutt *et* Koch, 1983; Sturgiss, 1995). In particular, hydrophylous vegetation was considered. Then, preliminary results of the survey of vegetation and symptoms, distribution of hydrophylous and meso-hydrophylous vegetation, methods used, and data obtained were reported. Finally, a critical evaluation of the results produced at this stage by the other fields of research of the Project TRIMM, was made. This evaluation aimed to verify any data and information that may have been useful to the interpretation of the research objects.
This phasis contributed a first inventory of the presence and distribution of vegetation typologies and presence of stress sympthoms, which is an useful tool for future investigation of relations with environmental and site variables (indicators), monitoring of eventual changes that may occur over time as a consequence of both quantitative and qualitative variations of some of such factors.

Symptoms were classified according to the provisions of the "Programma MON.I.TO – Valutazione delle Condizioni degli Alberi - Manuale di Campagna per le Aree di I Livello (Program MON.I.TO (Intensive Monitoring of Tuscan Forests) – Evaluation of Tree (Health) Conditions – Field Handbook for First Level Plots)), which refers to the "Progetto per lo Studio dei Danni alle Foreste (Projects for the Study of Forest Damage) 92.60.IT.00.90, Reg. CEE 3528/86 e 2157/92". This program was realized by the Dept. of Agriculture and Forestry of the Tuscany Region (R.T., 1995). More detailed information about features of such symptomatologies is available in both this manual and the literature (Bussotti *et* Grossoni, 1999; Ferretti, *et al*., 1999; AA.VV. 1990; Amoriello *et* Costantini, 1999; Bartolozzi, *et al*., 1997; Borghetti, *et al*., 1997; Bussotti *et al*., 1997; Hartmann, *et al.*, 1990; Lorenzini, 1993; Matta *et* Pennazio, 1984; Moriondo, 1999; Paoletti, *et al.*, 1992; Pedersen, 1998) .

In this study, surveying and description of symptoms was not referred to any possible causality, any distinction nor selection was made between known or not well known causes of damage.
A first inventory of conditions and distribution of stress symptoms of the forest species followed a randomly distributed sampling with 248 points of survey. The descriptive analysys was made by directly

observing the presence – or less – of symptoms. Since the preliminary level of this approach as above introduced, symptoms were classified according to the criterion of presence/absence, given a class limit 10%, based on a scale relative to the above mentioned classification.
The distribution of points regarded both areas subject to potential impact of the Fast Train Line and areas with no or very low probability of impact. Points were recorded on topographical maps scale 1:10.000 edited by the Tuscany Region and the Province of Florence.

Random distribution of points was used without any consideration of other elements that could be influential in such kind of surveying. So, no possible gradients, physical factors, soil and geology data, etc., which could allow to suppose relations and effects on the parameters to be sampled, were initially consulted. Random sampling was choosen as it allows to observe a wide exploration range when no causes, gradients , environmental factors, etc., possibly related to stress, are known, at best, supposed. A stratified, systematical sampling appeared to be more appropriate to investigate known relations and factors with respect to the dependant variables (stress symptom classes). In other words, randomness seemed to give more chances to identify eventual processes, phenomena, symptoms, or else, of any interest for this research. Once further research will be able to describe correlations between various environmental factors, gradients, impacts, and composition, distribution, and presence of various stress symptoms of forest vegetation, different statistical tools can be used (Corona, 2000; Sokal *et* Rohlf, 1997; Weisberg, 1985).
Points provided first, initial information about the effective presence and general distribution of stress symptoms, so that a "First Level" surveying was completed. Insects, climate stress, pollution, cankers, silvicultural operations, impact of works, etc., were not considered but symptoms of suffering only.
Nonetheless, despite the constraints of the research, the total surface covered by sampling, variability observed, and number of samples taken described quite a significant picture.

In each point and photo-point the forest vegetation was classified as ecological groups based on water demand. Thus, hydrophylous, meso-hydrophylous, mesophylous, and meso-xerophylous associations were identified, paying attention to a recent Tuscan classification and the literature (Bebi, *et al*. 2001; Cappelletti, 1984; Corona, *et al*., 1998; D'Aprile, 2001; D'Aprile, 1999; Di Tommaso, n.d.; Larcher, 1993; Pignatti, Pranzini, 1995; R.T., 1998a; R.T., 1998b; Scarascia Mugnozza, *et al*., 1988; White and Harper, 1970; Zenner and Hibbs, 2000).

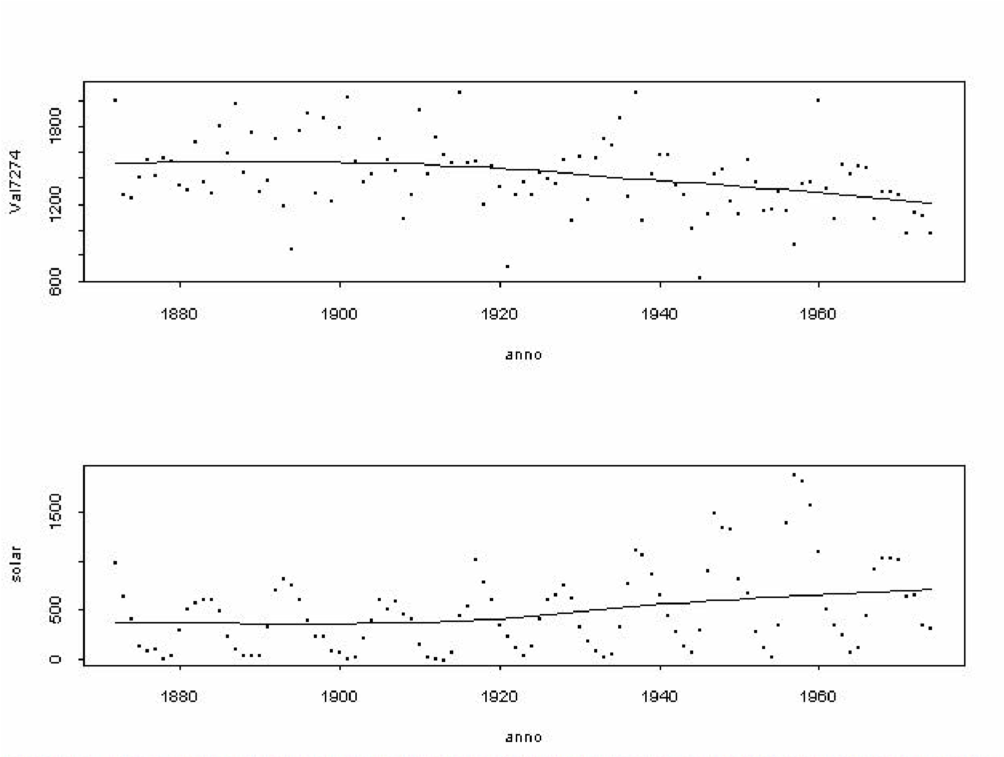
3. Preliminary results

3.1 Climate

Over 30 years, following climate modifications were observed in the area (Tagliaferri, 2002b):

- reduction of liquid and solid precipitation in winter (December, January and February), where winter dry periods show no variation of length but less apport of water during rainfall events; this phenomen reached its peak over the period 1989-1993, that is, before construction of the Fast Train Line;
- tendency of rainfall to increase in late spring (June) and autumn (November);
- increase of variability of rainfall in different seasons, such as surplus of rainfall followed by water deficit.

Furthermore, cycles of annual rainfall seem to occur every 11-15 years, where variation may be near 100% (D'Aprile, 1994). In particular, a significant trend of annual rainfall with respect to the amplitude of sunspots (King, 1975) was described (D'Aprile, 2001). According to this description, annual rainfall would slowly but progressively decrease over the period 1872-1974 while amplitude of sunspots cycles showed a similar but proportionally inverse trend (Fig. 1). These results would suggest the hypothesis of further reductuion of rainfall or climate change over next 10-15 years (Strachan and Harvey, 1996), which might alterate deep water resources.



Source: D'Aprile, 2001

Fig. 1. Annual rainfall (mm/yr) at Vallombrosa (province of Florence, Italy) over the period 1872-1974 (above). Number of sun spots (x 10) per year in the same period (below). The respective trends over time appear to be relatively similar but inversely proportional.

3.2 Plant species

The species (Pignatti, 1982; Gellini et Grossoni, 1997) found in the samples are reported in Table 1.

Table 1. Plant species found in areas sampled.

Trees	*Abies alba, Acer campestre, Acer pseudoplatanus, Acer opalus, Alnus nigra, Alnus cordata, Carpinus betulus, Castanea sativa, Corylus avellana, Fagus silvatica, Fraxinus ornus, Ostrya carpinifolia, Picea abies, Pinus nigra* spp., *Populus alba, Populus canescens, Populus nigra, Prunus avium, Pyrus pyraster, Pseudotsuga menziesii, Quercus cerris, Quercus pubescens, Quercus robur, Robinia pseudoacacia, Sorbus aria, S. domestica, S. torminalis, Ulmus campestris, Salix* spp. (i.e. *alba, apennina, capraea, eleagnus*, etc.)
Shrubs	*Crataegus monogyna, C. laevigata, Cornus mas, Cornus sanguinea, Euonimus europaeus, Prunus spinosa, Sambucus nigra, Vitis vinifera*
Small shrubs, suffrutices, herbs	*Artemisia* spp., *Arctium lappa, Arundo donax, Arundinaria japonica, Atropa belladonna, Brachypodium* sp., *Carex pendula, Carex* sp., *Clematis flammula, Clematis vitalba, Convolvolus* sp., *Coronilla emerus, Ciperaceae, Dactylis glomerata, Daphne lauoreola, Dentaria penthaphyllos, Digitalis lutea, Dipsacus fullonum, Dryopteris* spp., *Epilobium dodonei, Eupatorium cannabiunum, Equisetum* spp., *Euphorbia amygaloides, Euphorbia cyparissias, Euphorbia* spp., *Hellebours viridis, H. niger, Lonicera xylosteum, Pteridium aquilinum, Fragaria* sp., *Galium* sp., *Geranium robertianum, Glechoma hederacea, Sarothamnus scoparius, Hepatica nobilis, Hieracium* sp., *Holcus lanatus, Hypericum perforatum, Malva* sp., *Melilotus offcinalis, Ononis spinosa, Urtica dioica, Urtica* spp., *Petasites* spp., *Phyllostachys spp., Phytolacca dioica, Phragmites communis, Primula* spp., *Pulmonaria mollis, Rubus canescens, Rubus* spp., *Rumex* spp., *Salvia glutinosa, Sambucus ebulus, Solidago virga-aurea, Stellaria* sp., *Teucrium* spp., *Teucrium scorodonia, Thalictrum lucidum, Tussilago farfara, Typha* sp., *Verbascum niger, Viola* spp., *Viola reichenbachiana*

3.3 Stress symptoms

Aspect

Based on map distribution, stress symptoms were found on 46.8% on a total of 248 points (Neumann and Starlinger, 2001; Pedersen, 1998; Zenner and Hibbs, 2000; Kozlowsky and Pallardy, 1997). This percentage is composed as follow: 32.4% mainly hydrophylous species, 34.2% mainly meso-hydrophylous species, and 20.9% mesophylous species. The remaining 12.6% can be referred to various species associations, mainly meso-xerophytic (i.e. *F. ornus-O. carpinifolia*, *Quercus pubescens* woods, mixed *S. domestica*, *F. ornus*, *Q. pubescens*, etc.).

In general, all the forest species showed stress symptoms of different intensity, in the ambit of symptoms of known and not well known causes. At this stage, it was impossible to ascertain whether causes were primary or followed some kind of stress, disease, etc. Stress symptoms appeared to relatively vary with aspect. Most of relative frequencies occurred on the south-eastern exposure, decreasing toward South-West, South, East, and North-East. The minimum value was about 23% on the northern exposure, and it was above 48% in all the other directions, though a lower total number of samples occurred on the northern exposure. It seemed that stress symptoms were more frequent on warmer exposures (up to 78.6% of samples) and ranged in between 48% and 53% in the cooler and shadowed ones.

Stress symptoms in hydrophylous associations were present and appeared not to vary with altitude. In the meso-hydrophylous associations, such symptoms were more frequent but seemed to relatively decrease with altitude, and this was more evident at higher altitudes. Mesophylous associations did not seem to show relevant differences in the occurrence of symptoms between 200m and 600m altitude, apart from a slight increment of frequency above 600m, which might be also due to more difficult site and soil conditions.

In particular, preliminary results showed that frequency of highly water demanding, that is, *hydrophylous* forest vegetation was higher on south-western and southern exposures, diminished on the south-eastern (75.0%) and eastern (71.4%) ones, and further reduction was noted on north-eastern, northern, and western exposures. A slight increase occurred on the north-western direction.
Higher percentage of stress symptoms seemed to occur where frequency of highly water demanding forest associations is lower, which may be associated with more difficult site conditions, that is, stronger effects of stress factors. In general, presence of stress symptoms was noted in the southeastern (75%), southern (71.4%), northeastern (75%), northern (60%) and western (75%) exposures, and appeared to be lower but still relevant on the eastern, northwestern, and southwestern slopes.

Meso-hydrophylous forest vegetation showed a sharper distribution with respect to aspect than hydrophylous forest vegetation. Most of these associations occur on southern exposures, their frequency diminishes moving towards southeastern and eastern slopes, and it is relatively low on southwestern, western, northern, and northeastern directions. The lowest frequency was found on the northwestern exposure. Relative frequency of the presence of stress symptoms did not coincide with highest occurrence of meso-hydrophylous forest vegetation. Higher percentage was found on southwestern exposures, similar values were found from South to North-East, then a reduction appeared from North to West. The frequency of stress symptoms varied markedly, from about 20% at North to about 88.9% on the southwestern slopes.
In this, the highest occurrence of meso-hydrophylous associations was southern but the highest frequency of stress symptoms was southwestern, and remained quite high until South-Est. This would suggest that more intense or impacting stress factors mainly occur on sites located between West and South-West, though aspect did not seem to be a major factor in determining, or less, presence of stress symptoms.

A relative discrepancy between main occurrence of *mesophylous* forest vegetation and higher frequency of stress symptoms was also noted. These associations occur mainly on southwestern exposures, diminish from South to East, then further decrease at West, and in particular from North to North-East. Instead, main frequency of stress symptoms was noted on southeastern and eastern exposures, and relatively at North-East.Their frequancy is much reduced at South and South-West, and 50%-60% of frequency occurs at West and North-West.

The distribution of meso-xerophylous associations tends to coincide with stress symptoms distribution, which were found on all the exposures in this case also. Such forest association prevails on the eastern aspect, diminishes until North, were frequency is minimal. It appears relatively constant until South-West, then increases toward South. In these forest types the exposure appears scarcely associated with frequency of stress symptoms, and the distribution of species appears to be in line with their ecological features. The occurrence of stress symptoms did not seem associated with changes of water table, deep soil water, or phreatic water. Furthermore, such woods are often sited on tops, sunny slopes, shallow, sometime eroded or rocky soil, and in general water supply depends on rainfall. This would suggest that not well known causes stress dry and warm tolerant vegetation even more than less xero-tolerant or more water demanding associations . This seemed to correspond with previous results, which indicate that frequency of symptoms increase from hydrophylous and meso-hydrophylous forest types to mesophylous, and meso-xerophylous vegetation.

Altitude

The occurrence of hydrophylous, meso-hydrophylous, mesophylous, and meso-xerophylous vegetation types varies with altitude. The highest occurrence of hydrophylous associations was noted between 400m and 500m a.s.l., minimal between 600m and 800m, and relatively constant frequency occurred above 800m. Further, it was observed that both forest and ground hydrophylous associations occurred below 500m-600m but the latter, that is, suffrutices and herbs prevailed above 800m. In the 600m-800m range, hydrophytic forest vegetation disappears even along creeks and wet sites, and mesophylous forest species take place.

In the *hydrophylous* associations, relative frequency of stress symptoms appears little at low altitude but reaches the highest values between 400m and 500m, where the occurrence of such associations is also highest. Relative frequency of points with stress symptoms appears to be quite proportional to the total number of points sampled per class of altitude, and this would suggest that stress symptoms frequency is scarcely correlated to altitude. Actually, the percentage of points with stress symptoms seemed to vary with total number of points per altitude class (i.e. Equation (1); R^2 0.795, p-value 0.001233).

$$STR = -3.414 + 0.477PALT \quad (1)$$

where STR is percentage of points with stress symptoms, and PALT is total number of points per altitude class.

In other words, this may also indicate that some kind of stress occurs on a certain percentage of sites independently of altitude. Since frequency of rainfall and total rainfall increases with altitude, dry periods shortens, and average temperature diminishes, it was hypothised that rainfall might scarcely influence occurrence of stress symptoms. In facts, low variability of their frequency at both low and high altitude was noted, that is, areas with lower and higher amount of rainfall respectively. This preliminary result appears to be related with the need of soil water supply of hydrophylous associations rather than summer rainfall. In the Mediterranean area, many of such associations occur also in warm sites with summer drought, and their survival over time depends on soil water supply rather than else. This seemed coeherent with the hypothesis of relative independency from altitude, where this factor is an indirect indicator of rainfall distribution.

The *meso-hydrophylous* associations showed similar occurrences of hygrophytic types but a wider distribution, probably due to lower water demanding. The formers occur mainly in the 400m-600m range, the strip of minimal occurrence is reduced (700m-800m), and their presence above 800m is higher in comparison to the latters. In the mesohydrophytic associations, relative frequency of stress symptoms is higher at low altitudes, diminishes between 400m and 700m, and further decreases above circa 850m.
This would suggest a reduction of stress with altitude, that is, with increase of rainfall. Actually, meso-hydrophylous species tend to be more depending on rainfall than hydrophylous associations as they grow and/or expand on areas with lower water supply. In this case, the percentage of points with stress symptoms did not seem proportional with the number of points per altitude class, but a decrease with altitude appears.

The *mesophylous* associations appear to diminish with altitude, are more frequent between 500m and 600m, then decrease until 800m-900m, and over 1000m. The critical altitude above which such associations begin to decrease is about 700m. At this level, hydrophylous and mesohydrophylous vegetation showed an apparent minimum of presence while the mesophylous ones, which also start to reduce, are not at their minimum occurrence, which is above circa 850m. At about 850m, occurrence of beech increases relatively sharply, and other deciduous mesophytes and especially meso-xerophytes such as *Acer campestre, Acer opalus, Fraxinus ornus, Quercus pubescens*, etc., begin to rarefy. As noted earlier, beech depends mainly on total and summer rainfall and its roots do not deep much down the soil profile. Because of this, this species did not seem to provide significant information about monitoring of changes of the distribution and depth of water table or phreatic water, aprat from some particular circumstances.
In the mesophylous associations, the percentage of points with stress symptoms seemed proportional to total number of points per altitude class, though some decrease was noted at highest altitude. The correlation between the two variables appeared good (model (2) R^2 0.651, p-value 0.008604) but sligthly less than model (1).

$$STR = 0.563 + 0.578PALT \quad (2)$$

This preliminary result appears to confirm the hypothesis of a scarce influence of altitude, which is used as an indirect indicator of rainfall, on the presence of stress symptoms. Since similar results were shown by vegetation types with very different ecologic features, which grow in different site conditions, this would suggest that various stress factors act conteporaneously, though the impact on deep water resources may contribute at different levels.

The increase of frequency of hydrophylous associations with reduction of altitude may be influenced by different topography. For example, at low altitude the average slope is reduced in comparison to high altitude, water yield of creeks and rivers is more constant over time, alluvial areas and floodplains are wider and more common, and hydrography is more complex. Hydrophilous vegetation appears to follow such variations, and similar behaviour was noted with regard to meso-hydrophilous associations but more gradual and reaching higher altitude. Actually, hydrophytic associations show a wider variability of maximum and minimum relative frequency with respect to altitude than meso-hydrophilous associations.

4. Discussion

This preliminary stage shows the presence of forest ecological and health conditions that needs further research to determine any relationship between causes and effects.
The study was limited by lack or scarcity of data relation to soil, geology, pollution, deep soil water, aerial photos, maps at an appropriate scale with respect to various themes such as soil depth, texture, acidity, C/N, etc., local climate in the low strata of the atmosphere, and so on, which would allow to formulate investigations able to estimate factors influencing forest health, species distribution and forest composition, response of vegetation to different impacts (i.e. climate change, Fast Train Line, silvicultural management, etc.). The interpretation of landsat images might also have been affected by self selection and interspecific competition of forest species, which are common in these forest where the abandonment of traditional silvicultural activities began decades ago.

As noted earlier, a random sampling was implemented in the attempt to explore a high number of different situations with any specific subject but with the possibility to sample particular situations.

Actually, this method observed a number of different situations regarding forest ecology, health, stress symptoms, site, and impacts. It would allow to implement specific experimental designs and analyses on the basis of preliminary results, possibly activating also II level sampling areas (quote) with regard to the classification and initial diagnostics of forest stress symptoms. All of this is considered in the light of future possible monitoring of forest dynamics, development, and health of vegetational associations with respect to environmental factors, causes, and impacts.
At the same time, at this stage preliminary results appear to indicate that different factors (i.e. climate change, forest management, pollution, diseases and parassites) cause stress of forest vegetation but in any case water stress appears to be relevant, though it is not yet well known when it has to be considered as a primary, secondary, or tertiary factor. In particular, stress appears to be common to a range of different sites, species, and related ecologic features. Therefore, water stress on a large area caused by deep drainage due to the impact of the Fast Train Line, might be relevant to the problems observed.

The climate pattern would suggest a good rainfall distribution and recurrent re-charge of soil water yield depending on rainfall. Instead, the possible reduction of annual rainfall over such a long period might lead to a decrease or deeping of deep water bodies, and related water availability at the regional or landscape level. However, a slow reduction of water resources is likely to cause changes in forest composition, different phenotypes, and other kinds of ecological adaptment to new but constant and very gradual environmental modifications rather than intense and frequent occurrence of stress symptoms on vegetation with phenotypes and species composition indicative of higher water availability.

In the ambit of the classification of forest vegetation according to ecological groups based on water demand, namely hydrophylous, meso-hydrophylous, mesophylous, and meso-xerophylous associations, changes in the occurrence and distribution of more water demanding groups to less demanding ones cannot explain any causality unless further research and monitoring begin. Provisional or permanent disappearing of water bodies is a relevant phenomenon that may also be easily associated with changes in species composition and ecological regression but this alone cannot completely determine the causes of the problem. Monitoring of the process through vegetational indicators such as those above mentioned, and related frequency, distribution, and occurrence, is an useful tool but needs the contribution and coordination with other fields of research (i.e. geology, soil science, forest pathology, etc.). For example, apparent prevailing of natural regeneration of meso-xerophilous species such as *Fraxinus ornus* under cover of *Fagus sylvatica*, as noted in some cases, is likely a process that dependes on different factors, in which climate change may be considered. This, to screen possible impacts and causes of damage of the whole forest ecosystem.

At the level of preliminary results it was noted that meso-xerophilous vegetation growing on sites more exposed to wind, sun, on the tops, were frequently less damaged or with lower frequency of stress symptoms than mesohydrophylous and hydrophilous vegetation grown on valleys, bottomlands, along creeks, and on deeper soil. This would suggest a scarce influence of rainfall on the occurrence of forest stress symptoms, but a stronger association with soil water supply. In particular, meso-xerophylous species such as *Quercus pubescens*, one of most water stress tolerant species in the area, showed even dramatic levels of damage in bottomlands, valleys, and deep soils whereas underneath mesophylous species such as *Pteridium aquilinum* in the same sites did not dry over summer. A response like this allows to hypothise that such woods that are decades old and show well-developed oak trees, are suffering a relevant stress factor that might be related to deep lowering of phreatic water, given the deep rooting habit of the species. Actually, *Pteridium aquilinum* has shallow roots and only appropriate moisture availability can allow the plant to survive over summer. In this, *Pteridium aquilinum*, as well as other ground species, seems to indicate that water supply is not very limiting at soil surface level. At the same time, oak trees grown over decades apparently absorbing water from deep phreatic water may suffer for a sharp deeping of the water level due to deep drainage over a large area.
As noted above, such facts address further research toward environmental causes rather than bio-ecological ones, given the great difference of species, sites, and related eco-physiological needs and features.
All of this leads to consider the use of forest vegetation as an useful tool that can contribute relevant interdisciplinary information on environmental stress and impact.

The occurrence of stress symptoms on a good percentage on hydrophylous and mesohydrophylous associations other than mesophytes to meso-xerophytes, may indicate expansion of stressing conditions from areas with less soil water resources in summer to others with higher (soil) moisture availability, where established more water demanding forest vegetation represents a history of good water supply. This fact also, if confirmed in the future, would suggest the presence of one or more stress factors relatively independent from species, habitat, and site, that is, likely abiotical and spread over a wide area. In this case, deep water drainage for tens of kilometers below hills and mountains may be a relevant factor of impact. Furthermore, since such vegetation types that are so different in water demand and often sited near or even very close each other, unlikely climate or meso-climate can be considered as main factors of stress in a number of cases at the forest site level. Although climate change is considered a relevant factor influencing forests in a complex and significant way, in this case a number of situations that seemed to affect forest health and ecological stability appeared to depend more on geological, soil, ecological, and silvicultural stress factors. In this, surface hydrography, deep water bodies, and water flows related to both climate variability and impacts such as those caused by the Fast Train Line are likely to play a not negligible role.
In particular, the occurrence of even intense stress symptoms on various vegetation types indicative of good soil water supply over summer is likely to signal significant alterations that require further interdisciplinary research and thourough analysis of causes.

5. Conclusions

This study achieves the aims in consideration of the resources and means available. Based on preliminary results, the need for further and more specific research emerges. Field analysis confirms the presence of symptoms of forest suffering, which occur quite often. This may be related to mainly environmental casues as a number of plant species with different ecological features, response to stress, and susceptivity to environmenatl changes show such symptoms over wide areas.

This occurrence of forest stress symptoms is not negligible because of their intensity, frequency, and distribution. At the same time, possible modification of species composition into a more xerophylous profile requires specific investigations able to consider various factors that contribute to water supply and balance over time relation to soil, hydrogeology, geology, climate, and response to environmetal impacts such as the Fast Train Line. In this context, monitoring of distribution, intensity, dynamics of both forest vegetation and stress symptoms will contribute relevant information with respect to intensification and/or spread of damage at different level both in areas of potential influence and no (low probability) influence. Such information is particularly important in the light of the comparison with similar research regarding geology, climate, deep water flows and drainage, etc., Further research interests also the effects of reduction of annual rainfall on deep water resources over time. If deeping of the water table or phreatic water are ongoing on large areas because of climate change, deep water drainage caused by the Fast Train Line over a trait of tens of kilometers might cause relevant negative impacts. Maps of soil, geology, piezometers, hydrogeology, and hydrology maps at topographycal scale and related analyses, are also needed. Forest disease and pests require also to be investigated in their dynamics, density, and diffusion for a better screening of primary and secondary causes of forest stress.

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