

Review

Graffiti Paint on Urban Trees: A Review of Removal Procedures and Ecological and Human Health Considerations [†]

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Abstract: Mature trees play a fundamental role in nature and are crucial to maintaining good air quality in the urban ecosystem where they reduce air pollution, lower the surface temperature, and emit medicinal volatile organic compounds which combine to improve human health and mental wellbeing. From an aesthetic and cultural point of view, they are true living monuments to be preserved. In both rural and city environments, it takes numerous years for trees to become mature enough to have a significant impact on our health and the current global climate changes together with high levels of pollution in urban environments and other anthropic factors such as vandalism constitute important obstacles to new tree growth. This clearly makes existing trees, especially old growth, far more valuable than we often realize. Regardless of their artistic quality and in some instances their positive messages, graffiti are still unacceptable on living organisms, especially older urban trees. They also have a significant environmental impact due to the emissions related to graffiti that are primarily based on anthropogenic volatile organic compounds (VOCs) which contribute to the formation of ground-level ozone. We reviewed the literature on graffiti and paintings applied on tree bark and ultimately found that oil-based paints in particular can damage tree life support systems. We herein also discuss graffiti prevention, the potential impact on human health related with graffiti removal, as well as methods for tree bark cleaning including, as suggested by different urban forestry specialists, the application of citrus-based products for 20–60 min before rubbing and rinsing or multiple 1–2 h treatments, in the case of recent or old graffiti, respectively.

Keywords: graffiti; tree-bark: paintings; vandalism; nature conservation; volatile organic compounds; old-growth trees



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1. Introduction

By the word ‘graffiti’ one usually indicates messages, scribbles, patterns, or drawings written, carved, or painted on different types of surfaces including walls, monuments, and tree bark. Consequently, a ‘graffitist’ is a person who creates graffiti [1]. Graffiti has existed as long as human society but has become a public issue in recent decades, being often considered as a recurrent and unacceptable form of vandalism. The engravings and paintings of wild fauna in the Lascaux caves in the Dordogne region, France and the Romito grotto in Papisidero, Italy are said to date from more than 10,000 years before the Common Era [2,3]. Similar representations realized thousands of years ago on boulders, rock faces, and cave walls still exist in Australia, Africa, and Asia [4]. Ancient graffiti of various natures are found on the walls of the city of Pompeii, and on Egyptian monuments, to cite just a few examples [5]. Through the centuries, numerous people have left their

marks on walls, ancient monuments, tree trunks, and any other surface they found enticing. Nowadays, graffiti and paintings of the most diverse subjects are commonplace on building walls and are often tolerated as a new form of art, or so-called ‘street art’ when not previously approved or commissioned [6]. In fact, this type of graffiti has recently undergone noteworthy changes, with artists being inspired by new ideas coming from ‘street art’, particularly in depressed suburbs of New York and subsequently spreading to the capital cities of Europe; mainly London, Amsterdam, Berlin, and Paris, as well as others across the globe. The followers of ‘street art’, endowed with their own language, consider their work a form of genuine art and thus have artistic tags which identify them. However, tags should not be seen only as signatures used by writers to identify their own works; often, they are the preferred expression they use to leave a mark in the urban environment and are endowed with a number of legal, social, and personal implications. The artist Andy Warhol and one American graffitiist named Jean-Paul Basquiat worked together to produce a series of works that simultaneously filled three London galleries between the end of 1988 and the beginning of 1989 [7]. Many believe that anything made with a hand-held tool can legitimately be considered art, thus supporting initiatives that encourage graffitiists. Of course, for those whose property is targeted by graffiti—no matter the quality of the work—the unwanted markings are a form of vandalism, often upsetting to viewers and with significantly high cleaning costs. Media attention to ‘street art’ and its extensive use in advertisements, evening graffiti lessons in youth clubs and seminars, and other similar initiatives all serve to encourage the spread of graffiti in inappropriate places. It also does not contribute to deter the graffiti practice when courts show leniency and fail to declare graffiti a form of vandalism [1].

Old trees produce phytochemicals that have a wide range of medicinal applications. Additionally, several fungi with therapeutic potential live in symbiosis with old trees and can only be found living in old growth forests [8]. Our shared cultural legacy is greatly enhanced by the presence of large old-growth trees, which serve as historic, symbolic, visual, and religious cues [9]. Large old trees dominate the structure, function, and dynamics of temperate and tropical forests where large-diameter trees exert a central role in providing forest structural heterogeneity [10]. Due to their dynamics and sensitivity to environmental change, large old trees, which account for about half of the mature forest biomass worldwide, have the potential to exert a significant control over the global forest carbon cycling. Hence, ecosystem services can be preserved and possibly improved by managing forests to preserve old-growth trees that already exist or those that will reach the needed size in the next decades [11]. A protective effect on human populations by evergreen forests against pandemics was suggested recently due to trees not only reducing air pollution by collecting PM onto plant surfaces but also due to their ability to strengthen the human immune system by generating bioactive volatile organic compounds (VOCs) that when inhaled stimulate the body’s defenses [12,13]. This supports the development of ‘forest bathing’ [14,15] as a therapeutic technique, the creation of nasal sprays containing the most bioactive plant VOCs, the preservation of ecosystems, and most importantly, initiatives promoting an expansion of the areas covered by forests worldwide [16,17].

Urban forests can also be seen as green infrastructures that ensure a variety of environmental, health, social, and economic functions in urban areas [18]. More important to environmental quality and public health than oxygen production is the ability of urban trees to decrease air pollution by intercepting particulate matter on plant surfaces and absorbing different types of gaseous pollutants by the leaf stomata [19]. Urban green spaces contribute to attaining clean air standards in an economically sustainable and natural way [20–24]. Moreover, tree bark is a useful indicator used in studies that monitor air pollution, especially due to heavy metals, because of its structural porosity which makes this vegetal matter very effective for the accumulation and retention of aerosol particles [25–30]. In particular, mercury (Hg) is one of the most important elements to monitor through tree bark because it is typically not accessible in soils, and thus atmospheric transport is the primary cause of its presence in bark where this heavy metal can be kept both physically

and chemically [31]. Using biomonitoring techniques based on tree bark allows for the assessment of the dispersion of air pollution and to obtain accurate data for epidemiological research [32].

Tree graffiti is becoming an issue, especially in urban areas, where graffiti artists leave their mark at an increasing rate not only on building walls, metro trains, and monuments, but also on trees including urban patriarchs that are true living monuments. Sadly, in 2011 every tree on the 16th Street block in San Francisco, USA was sprayed in the colors purple, red, white, and black [33]. In light of the above considerations as well as the presented experience of urban forestry specialists in charge of removing paint from trees, the importance of protecting tree bark from graffiti is made clear as discussed below.

2. Graffiti, Paintings and Other Modifications of Tree Bark

According to English police [1], spraying graffiti is a major offense in a list that starts with littering and ends with vandalism and violence. When graffiti appears, the vast majority of local residents find it objectionable and want it to be permanently removed from the vandalized surface, especially when the victim is a mature urban tree. The hope that the vandalism will not reappear is frequently in vain, but this does not justify the renouncing of the difficult and onerous work of graffiti removal. Volunteers can accomplish a variety of environmental improvements efficiently and with enjoyment but graffiti cleaning from trees does not fall within this category of activities and should be regarded as a task for experts. In fact, it could require dangerous chemicals and, in some cases, it endangers tree bark and inner tissues, as well as environmental and public health as we discuss below.

2.1. Culturally Modified Trees (CMTs)

Trees that have been intentionally sculpted by a range of human activities are collectively referred to as Culturally Modified Trees (CMTs). The debarking of planks, felling of logs, testing of strength, and other operations may be shown in CMTs. Arborglyphs [34–39] are a subtype of CMTs that comprise pictures or text painted on or etched into tree bark or into wood after the bark has been removed from the tree. There are many distinct tree species that feature arborglyphs, and they are found on different continents at locations as disparate as some sites in Peru, Ecuadorian Andes, Hawaii, and New Zealand, where graffiti can be observed also on woody bushes or on the broad leaves or bodies of cactus, agaves, or other succulents [40]. The US is home to the carved quaking aspen (*Populus tremuloides*), whose reconstructed, white-colored bark offers a clean canvas. There is a lot of graffiti on well-known 20th-century poplars in the area that were made by Irish, Basque, and Hispanic shepherds. Additionally, since arborglyphs may date back to very early periods, there are numerous pre-Columbian CMTs in North America and other parts of the continent. As for European CMTs, there is a story about a shepherd carving his name into a beech tree in the *Bucolics* in the pastoral poems written by the Roman poet Virgil in the first century before the Common Era. On the other hand, native people, immigrants, pilgrims, and infatuated individuals are still carving graffiti into trees today [40]. Tree bark paintings produced and commercialized by the community living in Asei village, East Sentani District, Papua are an example in which artistic objects obtained from tree bark are used by local communities to sustain their economy. The quality of bark paintings coming from Asei village is considered high because these people, who still live in symbiosis with nature, have a clear identity, which is evident in their unique product motifs. The bark painting products of the Asei village community and a brief profile of the artists were also displayed on a website that can be accessed by the global community in order to promote them more effectively and efficiently with a larger coverage area [41].

2.2. Persistence of Paintings on Tree Bark: The Studies of Frank Nigel Hepper

Once painted, a tree's bark can show the signs of this anthropic intervention for a long time, as shown in the studies conducted by the English botanist Frank Nigel Hepper. In a work presented by Dr. Hepper in 1981, great attention was paid to the remarkable

longevity of white markings on several species of trees along Kew Road, in Kew, UK [42]. Interestingly, surplus tree stock was given away by the nearby Royal Botanic Gardens at the beginning of the 20th century, and this probably accounts for the wide range of tree species which Hepper found along Kew Road. To increase their visibility during the blackouts, these street trees were painted (white-washed with lime) with transverse white stripes during World War II (1939–1945). More precisely, the white lines on the street trees of Kew dated back to 1945 and were useful for both drivers and pedestrians because the streets were often unlighted and car headlights were obscured. The practice of tree-painting was discontinued once hostilities ended. After 35 years, the original banding's vestiges were still visible in Hepper's study, where his observations provided interesting insight into bark behavior according to the different tree species over these first 35 years; the trees having been under almost daily observation for 28 years. [42]. Trees showing white color were photographed in 1958 and re-photographed in 1979, i.e., 34 years after they were last painted. It was unlikely that anyone could have imagined the markings to persist for so long on tree bark, with some even lasting into the new millennium. By 1939 the street trees had trunks sufficiently large to be painted which led Hepper to estimate their initial age as 30 to 40 years. At the time of his study, published in 1981, these trees were likely 70–80 years old while during his last observations described in his publication of 2006 [43] they were about a century old and some of them still showed white markings. Looking at the findings in more detail, while no evident markings were present on *Acer pseudoplatanus* (Sycamore); *Castanea sativa* (Spanish Chestnut), *Platanus X hispanica* (London Plane), or *Platanus orientalis* (Eastern Plane), white lines could be clearly seen on trunks of *Acer platanoides* (Norway Maple), *Aesculus hippocastanum* (Horse Chestnut), *Fraxinus excelsior* (Ash), *Juglans nigra* (Black Walnut), and *Tilia x vulgaris* (x europaea) (Common Lime). This last species was particularly noteworthy with most of the 13 specimens still showing some paint, and one specific tree photographed in 1979 (Figure 1a) and then in 2006 (Figure 1b) showing bold markings even during the last observation. This is particularly evident in the inverted colors images of Figure 1.

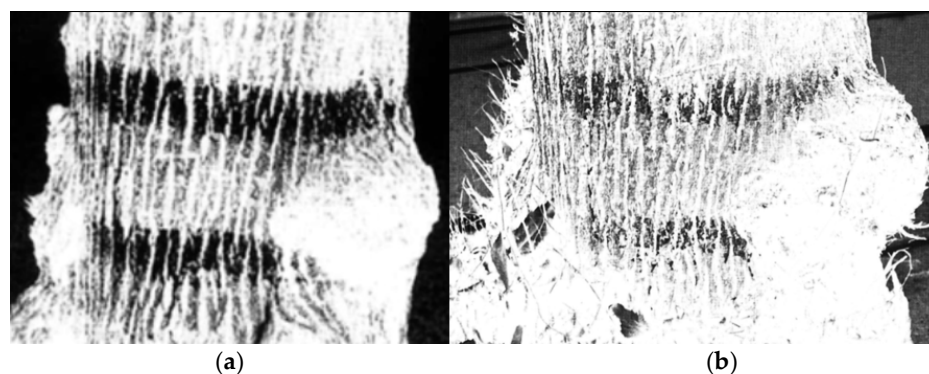


Figure 1. Stripes painted on the trunk of a *Tilia x vulgaris* European Lime examined by Frank Nigel Hepper in November 1979 [42] (a) and January 2006 [43] (b). Inverted colors are displayed for better clarity.

Remarkably, Hepper's work showed that after more than 60 years, all the white markings had persisted while one would have expected the disappearance of all signs of paint not only as an effect of general erosion but also by replacement of the bark by the tree itself. In this regard, even tree species with flaking bark retained small flecks of paint. Overall, the findings of these two studies led the author to conclude that a tree could be visually harmed for decades by 'a moment's daubing' [43].

3. Removal of Paintings from Tree Bark

Surprisingly, spots of paint may remain for several decades on tree bark [42] and this explains the need for the timely removal of paintings and graffiti by artificial but sustainable methods (Figure 2).



Figure 2. Images of the trunk and canopy of a Lebanese cedar specimen whose tree bark shows blue paint marks (photos taken in Naples, South Italy by V. Roviello in September 2022).

The removal of graffiti and the maintenance of cities in general are processes governed by specific laws and important regulations, but without workers, interventions, and extraordinary measures, especially for urban parks, they would fall by the wayside. The types of interventions must cope with urban environmental conditions, such as weather, that prevent the use of some graffiti removal methods. The cleaning practice is also susceptible to changes, with new graffiti removal methods being tested in the most difficult situations such as on porous surfaces [44]. Even though most graffiti do not harm trees, in some cases oil-based paints can damage tree life support systems by killing cambium tissue and clogging lenticels. In particular, paint and other chemical applications that reach cambium tissue can compromise tree health, while spray-derived coverings can clog the lenticels (tiny openings on the epidermis of different plant organs) which allow trees to release CO₂ and take in O₂ for respiration. In addition, paint may interfere with photoreceptors embedded in the plant stem, covering them and ultimately interfering with the plant's ability to sense changes in light intensity, duration, and quality, in turn disrupting the tree's natural biological processes. Just as importantly, the cambium layers and bark can be damaged by paint chemicals, especially those found in oil-based paints, which are able to heavily damage or even kill thin-barked trees [45]. Different methods to remove graffiti from trees were reported by the urban agriculturist Bonnie L. Grant, (<https://www.gardeningknowhow.com/ornamental/trees/tgen/graffiti-paint-removal-tips.htm>, accessed on 10 January 2023). These included both mechanical interventions, such as scrubbing or pressure washing, and natural methods. For the mentioned mechanical methods, pressure washing can be employed to remove graffiti paints on trees with large trunk girths and thick bark such as chestnut (*Castanea sativa*), hornbeam (*Carpinus betulus*), different oaks, and cottonwoods (*Populus deltoids*), while smaller trees need to be gently hand scrubbed or subjected to pressure washing using a washer on low

setting. In general, pressure washing, as suggested by Grant, should be accomplished with the washer on medium to low from a distance of at least 1 m away from the tree trunk, always assessing for any tree bark or cambium damage. Other than pressure washing and scrubbing, another method to clean tree barks is sanding using light abrasive papers, such as a 400-grit (20.6–23.6 μm) sandpaper, to hand sand the graffiti painted area. On the other hand, using a power sander is not recommended as more tree bark and other plant tissues will be damaged than necessary. Since mechanical methods can damage and remove the outer bark layer of trees, exposing the tree inner tissues to fungi and bacteria that may cause the plant to be irreversibly damaged, less invasive systems are clearly desirable. In this context, natural tree graffiti cleaners such as citrus-based graffiti removers or degreasers, whose active ingredients like orange oil are completely natural, have the advantage of cleaning the tree bark without doing harm to the plant or the environment and are commercially available (Figure 3; <https://www.gardeningknowhow.com/ornamental/trees/tgen/graffiti-paint-removal-tips.htm>, accessed on 10 January 2023).

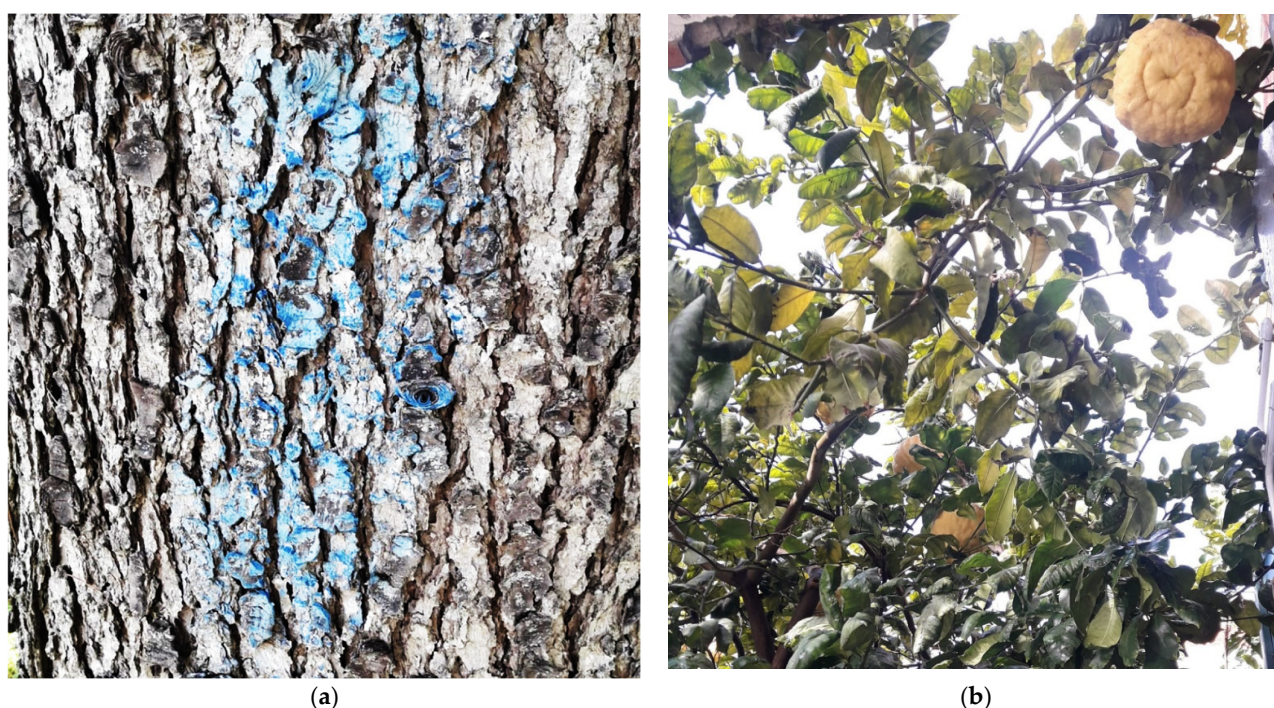


Figure 3. Close up surface of the tree bark with blue paint on the trunk of a Lebanese cedar specimen (a). Leaves and fruits of a specimen of *Citrus limon*. Note how citrus plants are important sources of ingredients used in graffiti cleaners which are effective in tree bark cleaning (b). Photos taken in Campania region, Italy by V. Roviello.

According to Grant, in case of recent paints, the natural removers should be applied on the painted tree bark area and allowed to react for up to 1 h, while older paints will require longer soaking times before rubbing and rinsing and possibly multiple treatments to fade the graffiti completely. The urban forestry specialist L. Purcell in 2012 also gave useful instructions on the removal of graffiti from trees [45]. As the author explains, graffiti should be removed from trees as soon as possible after their application. In fact, since the majority of paint formulations contain hazardous petroleum distillates and other chemicals, only a prompt removal may lower the potential for tree damage. Citrus-based graffiti removers, also indicated by the expert B. L. Grant, with ingredients such as natural orange extract as their main constituents should be given preferential status. Most retail stores have citrus-based degreasers, which are practically the same as graffiti removal products (<https://www.extension.purdue.edu/extmedia/fnr/fnr-474-w.pdf>, accessed on 9 January 2023) [45]. Products made from citrus are generally biodegradable, contain few

to no dangerous ingredients, and can be easily and safely rinsed off with water. Thus, tree damage from these degreasers is kept to a minimum. Nevertheless, before using any product, including the citrus-based ones, the specific cautionary remarks displayed on the product label should be duly noted. The graffiti itself should be left to soak for a suitable time after being covered in a citrus-based cleaning solution [45]. Depending on how long the graffiti has been on the tree, a cleaning agent may take different times to effectively penetrate. For instance, recently applied graffiti can be washed off with the application of a cleaning solution for 20 min. On the other hand, graffiti that is more than a few weeks or months old would need the removal solution to stay on the surface for a minimum of one to two hours [45]. The removal agent should typically be used at least twice before rinsing for the best results. Graffiti that has been treated with a removal agent should be rinsed and removed using a pressure washer or a hose with a high-pressure nozzle. To prevent damage, the pressure washer should be used carefully on tree trunks, especially those with thin and smooth bark. In fact, if used heavily in one area, high-pressure spray can harm the bark and other important parts of the tree. Using a stiff nylon or plastic brush to loosen the treated graffiti can help with graffiti removal when using a high-pressure hose nozzle and may help avoid the need for a pressure washer. If used carelessly, wire brushes can also harm the surface of the tree, which again reiterates the need for tree trunks to be treated with care when removing graffiti. If paint removal from the tree is initially unsuccessful, multiple applications may be required over time. As a last resort, writings can occasionally be covered or hidden with a straightforward, artistic aerosol paint combination if the graffiti area is limited. To match the color of the tree, natural, lengthy, vertical spray strokes should be applied. Oil-based paints are more hazardous than water-based paints, and so should be avoided [45]. Carla Short, an urban forester working for the San Francisco Department of Public Works, recommends the use of a wire brush and mild soap and water for the effective removal of graffiti for many species of trees. As referred by the same expert, it is generally easier to remove paintings from a tree than cleaning a building. However, certain trees endowed with smooth bark, such as *Ficus*, are more vulnerable to damage from graffiti removal, and in these cases steel wool would most likely be an effective methodology [33].

4. Tree Graffiti: Environmental and Human Health Considerations

Graffiti also has environmental consequences since the aerosol sprays used emit anthropogenic VOCs [46]. Since emissions related to graffiti are primarily VOC-based, the creation of these markings contributes to the formation of ground-level ozone. For example, it was estimated that during 2008 approximately 5000 tons of VOCs were emitted from the graffiti sector in US [46]. Tree bark is a fundamental source of traditional pharmacopoeia [47], and clearly painting tree bark makes it unusable for therapeutic purposes [47]. Graffiti removal [1,48–52] is of great importance nowadays for the preservation of our cultural heritage in the form of monumental trees. Showing these trees the respect they deserve as providers of a vast array of health benefits will go a long way in helping in their preservation. Such cleaning operations are also significant for the preservation of tree health as trees with smooth bark, and in particular *Ficus*, are especially vulnerable to damage from the removal of graffiti and other paintings. The importance of environmentally-friendly graffiti cleaners has received considerable attention in the recent literature as can be seen in a recent work by Roviello et al. which investigates new sustainable methods for the preservation of different materials from vandal graffiti, taking into consideration both their ecological characteristics as well as their effectiveness [53]. When looking for sustainable graffiti management tactics for green areas, particular attention should be paid not only to the efficacy but also to the socio-ecological effects of a range of contemporary graffiti removal solutions. Methods such as chemical-based graffiti removal, painting over graffiti, and anti-graffiti coatings are not only largely ineffective at deterring graffiti vandalism in public places, but are also unacceptable when the monument to protect is an old-growth tree as they are then even more detrimental to human health and local ecosystems. Other more

sustainable graffiti management tactics including green walls and landscaping techniques should be preferred to the above-cited more reactive management solutions that entail cumulative environmental risks [54]. In other words, not only should the effectiveness of graffiti management tactics, including the performance of several chemical graffiti cleaners, be considered in the development of sustainable strategies aiming at facilitating ecological and effective cleaning, but the short and long-term environmental implications of a given method must also be carefully examined. Several common graffiti cleaning products have non-negligible effects on human health and the environment. Thus, Craver et al. [55] analyzed 10 graffiti removal products and two spray paints using a scoring system called IRCHS (Indiana Relative Chemical Hazard Score) in which each hazardous component in a particular cleaning product was assigned an IRCH score for environmental hazard, worker exposure hazard, and total hazard. The same authors used the obtained scores to classify the graffiti removal products into different categories of varying environmental impact severities and found by their evaluative work that regardless of the hazard score, waste formed during graffiti removal still poses negative environmental impacts that stem from heavy metals contained in spray paints. These pollutants leech into soils and run off into aquatic environments with clear consequences on the local ecosystems. Overall, the main conclusion of this work is that only graffiti prevention is a sustainable solution that can avoid the environmental consequences of both graffiti and its removal [55]. Effects on human health during graffiti removal should also be given due consideration to prevent adverse effects on workers. For example, Langworth et al. demonstrated that graffiti removers reported a significantly higher prevalence of unspecific symptoms such as headache, fatigue, and irritative symptoms from the respiratory tract and eyes despite a low average exposure to organic solvents [56]. Anundi et al. estimated the level of exposure to organic solvents of graffiti removers and identified the chemicals used in different graffiti removal products finding that though the average exposure to solvents was low, some working tasks included relatively high short-term exposure. Remarkably, there was a significant correlation between the concentrations of *N*-methylpyrrolidone (NMP) in the air and levels of NMP and its metabolites in the blood and urine of graffiti cleaners [57]. In summary, environmentally-safe strategies should be adopted to remove paint marks from tree barks using methods which are safe both for humans and plants, whose key role in providing functional foods [58], bioactive compounds [59–62], and benefits to the environment [16], with remarkable protective effects on human communities especially in the current times of health [63] and ecological [64–68] crisis is well known in the scientific literature and should never be neglected.

5. Conclusions

Trees and particularly patriarch trees in urban areas have a unique role from both an environmental and sociocultural perspective and must be considered real living monuments that should be protected from vandalism of any type, including graffiti. In fact, more and more reports of tree bark painting and other forms of graffiti are being reported in the largest cities across the globe where urban trees are used as bulletin boards, from carving proclamations of love to posting notifications of sales and similar inappropriate messaging. Trees should be treated with respect in order to maintain their importance, endearment, and ensuing level of protection in the eyes of society. No matter the intent, any anthropic action on tree bark—although it may have a strong cultural or spiritual meaning—can be problematic, causing damages to trees, and paints or coatings on the bark could influence the whole CO₂ and O₂ cycle. Even though more scientific studies based on experimental analytical data are clearly needed, the experience of urban forestry specialists suggests that graffiti removal from trees should be performed by applying ecological products (especially citrus-based graffiti removers or degreasers) that are harmless to trees and can be removed in an environmentally-friendly way without causing health issues to graffiti cleaners. Graffiti removal should be performed as long as it does not provoke significant damage to the bark and living tissues of the tree. To prevent adverse health effects, the

most toxic chemicals should be excluded from the formulations of the removal agents, and the graffiti cleaners should be informed of all health risks as well as on the correct working procedures and encouraged to use all necessary personal protection equipment such as gloves and respirators. Creating purpose-built structures for the use of graffiti artists while enforcing the idea that trees are not the appropriate place for such activities due to their crucial role for human health should help bring back to trees the respect and reverence they so desperately need and deserve.

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