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Tradeoffs between regulating and cultural services as a sources of fire risk in Haifa

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Abstract: Urban areas are increasingly at risk of several natural hazards. In the Mediterranean area, the risk of forest fires at the wildland-urban interface are generating increasing losses. However, green areas in and around the city have traditionally been considered as a source of fresh air, recreational, as well as for educational and aesthetic purposes. Tradeoffs can then arise between the desire to preserve nature around cities for cultural ecosystem services and the need to manage the forest to reduce the risk of fires. Most of the literature on ecosystem services' tradeoffs has concentrates on provisioning versus cultural and regulating services. The potential tradeoffs arising from managing nature for recreational, spiritual, mental benefits and for hazard regulating functions in urban and peri-urban areas have rarely been explored. In this paper we assess cultural services and fires risk in the peri-urban forest of the city of Haifa (Israel) using participatory GIS mapping. We interviewed two groups regarding the spatial extent of these services and the management strategies to reduce risk: users of the green areas of Haifa and forest fire experts. We identified tradeoffs between cultural and regulating services for fire control in the green areas of the city. Green space users promoted the idea of a pristine nature and its conservation, mainly for recreational purposes, while experts suggested that improving fire regulating services would require intensive forest management with changes in the landscape such as the removal of pine trees and the creation of buffers around the urban core. We conclude that the tradeoffs between cultural and regulating services can generate sources of risk and must be reconciled when considering addressing it.

Keywords: ecosystem services tradeoffs; urban-wildland interface; fire risk; cultural services; regulating services.

1. Introduction

Urban areas worldwide tend to suffer from a greater number of fatalities and higher economic losses from natural hazards when compared to their rural counterparts. This is mainly due to the concentration of people, infrastructures and assets in cities, as well as to potentially inadequate management and urban planning with regard to hazard risks (Dickson et al. 2012). As the human population increasingly concentrate cities, these have expanded into hazard prone areas, leading to an overall increase in exposure to hazard risk (UNDESA 2014; UNISDR 2015). These processes have led some to speak of an "urbanization of disasters" worldwide (McClean 2010). This is also the case for fire risk. While the spatial extent of global area burnt appears to have declined over past decades (Doerr and Santín 2016), increasing attention has been paid to the economic and human losses caused by fires at the wildland-urban interface (WUI). In densely populated Mediterranean regions, such as California and southern Europe, the impact of anthropogenic pressure on fire regimes is in fact increasingly driven by the expansion of urban areas and by the increased demand for recreation activities in peri-urban areas (Ganteaume et al. 2013). It is here that most of the human fatalities, economic losses and fire-suppression expenditures occur (Moritz et al. 2014). Isolated clusters of development and low housing density alternated with clusters of wildland vegetation are, in fact, particularly at risk from forest fires (Syphard et al. 2013). These trends are further accentuated by the increase of the vegetation's combustibility happening due to climatic change in Mediterranean climate regions (Bradshaw et al. 2011).

In Mediterranean climates, the expansion of urban areas into woodlands and forested areas, together with the widespread use of fire-exclusion practices (the prevention and suppression of forest fires) which increases the accumulation of fuel, have increased the risk of fires at the WUI (Cortner, Gardner, and Taylor 1990; Cohen 2008; Keeley, Fotheringham, and Morais 1999). Fires at the WUI spread both through the vegetation and through the surrounding infrastructures and buildings (Mell et al. 2010). To adapt to this risk, specific fuel treatment strategies need to be implemented in these areas, while at the same complying with local regulations and the desires and preferences of urban inhabitants for the accessible and proximal green areas (Ager, Vaillant, and Finney 2010).

Urban green spaces, which can be the locale for fire ignition and spread, are, on the other hand, highly valued by urban planners and city dwellers for their contribution to quality of life in cities (Burgess, Harrison, and Limb 1988). Before the rise of industrialization, green areas in and around cities were crucial for supplying food and timber, cultural and aesthetic benefits, and their functions of providing fresh air and reducing air pollution (Barthel et al. 2005; Depietri et al. 2016). In the post-industrial era till nowadays, the range of services provided enjoyed by urban dwellers has shifted more and more towards cultural and regulating services, while provisioning services became less significant (Bolund and Hunhammar 1999).

In cities, tradeoffs may then arise between regulating and cultural services in different settings due to preferences of local inhabitants for aesthetic considerations to the detriment of regulating functions of ecosystems. One case is presented by Nassauer (1995b), in which the construction of an artificial wetland for waste regulation was opposed by a local community because it was not considered aesthetic and caused other perceived disservices). Thus, landscapes give expression to deeply held values and understanding about nature, and such aesthetic and cultural values can conflict with other landscape management objectives (Nassauer 1995a). As such, views of nature can become sources of risk. Looking at disasters from a political ecology perspective can elucidate how certain ideas of nature, preferences

and collective choices about ecosystem management are potentially determinant factors contributing to natural hazards and the scale of their impacts (González-Hidalgo, Otero, and Kallis 2014). In the case of forest fire, while one recognized principle for the healthy and sustainable conservation of nature is the use of disturbance regimes (Lindenmayer, Franklin, and Fischer 2006), nature conservation practices have long attempted to suppress natural disturbances from ecosystems. As a direct consequence of the conservation paradigm, low-severity surface fire regimes have been replaced with low-frequency, high-intensity crown fires which are outside the variability of ecosystems (Pausas and Keeley 2009), and which can have catastrophic impacts.

In this paper, we look at the social construction of risk of forest fires through the lens of the tradeoffs between cultural and regulating services in the context of the 2016 forest fire that affected the city of Haifa. We examine how preserving the forest of Haifa for the supply of recreational and educational opportunities conflicts with the need to manage the ecosystem for reducing risk from fires. We look at tradeoffs between cultural and regulating services by analysing how these services are articulated by users of the natural areas of Haifa, on one hand, and by the local fire experts, on the other and how tradeoffs can ultimately affect the resilience and vulnerability of local communities. We suggest that certain preferences towards nature can lead to unwanted, negative outcomes in terms of the increase of risk to natural hazards (and vice versa, that managing ecosystems for risk can impinge upon cultural and aesthetics preferences in landscapes) and different views and types of knowledge need to be reconciled in order to reduce risk.

2. State of the Art

2.1 Ecosystem services tradeoffs

Ecosystem management that enhances the production and supply of one service often results in the declines in the supply of other ecosystem services (Bennett, Peterson, and Gordon 2009; Egoh et al. 2008). Ecosystem service tradeoffs thus arise when the supply of one service is enhanced at the expense of reducing the supply of another service (Raudsepp-Hearne, Peterson, and Bennett 2010). Most of the literature on ecosystem services' tradeoffs has concentrated on provisioning versus cultural and regulating services (H. Lee and Lautenbach 2016; Martín-López et al. 2012; Power 2010; Raudsepp-Hearne, Peterson, and Bennett 2010). It is well explored, in fact, how the expansion of agricultural activities, specifically intensive agriculture, diminishes the capacity of the ecosystem to regulate water flows, purify the air and provide opportunities for recreational activities (Raudsepp-Hearne, Peterson, and Bennett 2010). While tradeoffs and synergies between cultural and other ecosystem services, such as regulating ones, are underrepresented in the literature (Howe et al. 2014).

Not all human interventions and agricultural activities generate tradeoffs. Indeed, they can also generate synergies, although studies tend to concentrate on tradeoffs rather than on synergies (Howe et al. 2014). Synergies between ecosystem services are situations in which the amount of one service and its associated benefits are positively correlated to the benefits supplied by another service. It has been shown that managers can learn how to manage natural areas to eventually craft solutions that provide for "win–win" interactions in provisioning, regulating, and supporting services (Rodríguez et al. 2006; Swallow et al. 2009; Bennett, Peterson, and Gordon 2009; Smith et al. 2013). Power (2010), for instance, refers to services or, conversely, disservices provided by agriculture depending on the level of

sustainability of the practice. Smith et al. (2013), also suggested that there are a number of potential policy 'win–win' options also between different regulating ecosystem services, but that badly formulated policy could lead to tradeoffs. According to Howe et al. (2014), win-win solutions are more likely to arise when managers have avoided or overcome the reasons for why trade-offs arose in the first place, such as: failure to account for all benefits or stakeholders, failed management, and/or an assumption that provisioning services should always dominate any other services. Pretty et al. (2006), found that sustainable agriculture enhances water use efficiency, carbon sequestration and water quality. Xue et al. (2015) also found a positive correlation between provisioning services from tea plantations and an array of regulating services, such as carbon sequestration, soil nitrogen protection, soil phosphorous protection, and water conservation. In the case of wetlands reclamation to control malaria in Africa, managers were able to produce solutions that provide both fresh water and malaria control through the implementation of adaptive management strategies at the local scale (Cumming and Peterson 2005).

2.3 Defining regulating services for fire risk

In this section, we briefly define ecosystems services related to fire regulation as this is a gap in the literature. Most research concerning ecosystem services and fires focuses on the loss of services following fire events, (Hurteau et al. 2014; C. Lee et al. 2015; Thom and Seidl 2016; Inbar, Wittenberg, and Tamir 1997), for example in terms of loss of recreational activities, loss of slope stabilization potential and increased erosion, loss of carbon storage potential and loss of biodiversity (Hurteau et al. 2014; Thom and Seidl 2016; Inbar, Wittenberg, and Tamir 1997). Other authors look at the ecosystem services provided by localized, intentionally set fires which increase agricultural land availability, hunting opportunities, fodder and pasture, pest management, fuel wood, charcoal and some cultural services (Schmerbeck, Kohli, and Seeland 2015). Little research is available on the characterization of ecosystem services that either alleviate or contribute to fire risk (Parthum, Pindilli, and Hogan 2017).

In the Mediterranean area, autochthonous species are generally adapted to fires, meaning that they recover after a fire (Bradshaw et al. 2011). Some species in fire prone ecosystems are also composed of less flammable biomass and possess a high capacity to withstand and better recover from fires (Bond and Keane 2017). As such, they can reduce the spatial scale and intensity of a fire and they are therefore considered to provide fire regulating services in ecosystems that are considered fire-prone. Exotic tree species with abundant above-ground biomass (i.e. fuel) and horizontal or vertical continuity, in contrast to autochthonous species, can increase fire intensity (Brooks et al. 2004; Nel et al. 2014).

The Common International Classification of Ecosystem Services (CICES) defines fire regulating services as those ecosystem features that contribute to "the reduction in the incidence, intensity or speed of spread of fire by virtue of the presence of plants and animals that mitigates or prevents potential damage to human use of the environment or human health and safety" or "the capacity of ecosystems to reduce the frequency, spread or magnitudes of fires. (e.g. wetland area between forests, or fire belt in woodland containing species of low combustibility)". We define fire regulating services as those ecosystem features and management strategies that contribute to lowering fire risk and avoidance of catastrophic fires. These are summarized in Table 1. In this way, we further stipulate that fire regulating services are coproduced by interacting social and ecological systems and emphasize the role of human intervention in the ecological landscape, thereby influencing the fire potential of a given ecosystems. We refer, for instance, to slash and burn vegetation management, diversification of the landscape and patchiness, and vegetation thinning as strategies that lead to better fire regulating potential of the

ecosystem. Conversely, other interventions in the system can introduce fire regulating disservices, raising the likelihood of the social-ecological system to experience catastrophic megafires (Stephens et al. 2014). For instance, fire suppression, changes in the mix of vegetation, an abundance of young trees and homogenization of the landscape are fire disservices, as these increase the risk of catastrophic fires megafires (see Table 1). For further information on this topic please see Depietri and Orenstein (2018).

Table 1. Fire regulating services (i.e. ecosystem characteristics that decrease the risk of catastrophic fire) and fire regulating disservices (i.e. ecosystem characteristics that increase the risk of catastrophic fire) (based on finding from Bond and Keane 2017; Pausas et al. 2008).

Fire regulating services	Fire regulating disservices
• Autochthonous, fire adapted species	• Highly flammable (often invasive) species
• Species with lower biomass accumulation	• High biomass species, high canopy density
• Patchiness, a mix or mosaic of land uses and vegetation	• Homogenization of the landscape, land abandonment
• Prevalence of grazing	• Large amounts of young trees
• Rivers, lakes, ice and snow, gravel beds, and other areas with sparse plant growth	

3. Methods

This research applies spatial analysis and social research methodologies to identification and locate highly valued places for aesthetic, recreational or ecological reasons and places of high concentration of fire regulating services or disservices in Haifa. Bryan et al. (2010), for example, applied a similar methodology to gather social and cultural values across a landscape, to identify places of high interest as well as places of high risk.

We spatially assessed cultural and regulating disservices through semi-structured interviews which entailed a participatory mapping exercise and open-ended questions with two groups of respondents: users of the green areas of Haifa (including beaches) and local as well as national forest fire experts. The respondents included members of NGOs, researchers, independent experts and local authorities. The first group of respondents was identified amongst colleagues and collaborators who included students and researchers of ecology or landscape architecture and those who were active users of Haifa's green spaces. This group was expanded using a snowball sampling technique to include members of hiking clubs, urban planners, residents, and environmental NGO representatives. 14 people participated in the study. Despite the small sample size, the respondents collectively represent the groups who are highly engaged across the city of Haifa and whose interests in the green spaces of the city are not limited to a single neighborhood, but rather to the entirety of the city. For the second group, 10 forest fire experts (researchers from various disciplines, independent experts and local authorities) took part in the study. This sample represents a large proportion of the rather small community of experts with knowledge about the local conditions found in Haifa and with in-depth knowledge of the different aspects contributing to fire risk.

The users of the green areas of Haifa were asked to map up to five areas of interest within the boundaries of the municipality of Haifa by drawing polygons on a satellite image of the city embedded in the online tool Scribble Maps (www.scribblemaps.com). For each area they chose, the respondents were additionally asked to explain why they chose it, what makes it special to them, and in what type of activities do they partake in each location. The second part of the interview aimed directly at identifying tradeoffs between their preferred characteristics of each site (i.e. cultural services) and the potential impact of implementing the common landscape fire management strategies that could be implemented in Haifa[1]. These strategies, derived from Pausas et al. (2008), Bond and Keane (2017) and Perevolotsky (2011), included: thinning of the vegetation; creating fire breaks and buffers; introducing grazing; removing pine trees; diversifying the landscape and introducing patchiness through other activities such as planting fruit trees. The respondents were asked if and how (in a positive way or in a negative way) these five vegetation management strategies would change their experience if implemented in the green areas of Haifa.

The second group of respondents (forest fire experts) where asked to identify up to five areas (also using a satellite image in Scribble Maps and drawing polygons) that were potentially at high risk of fire due to the type of vegetation, slope and/or wind direction. They were also asked to detail why they chose those areas. The second part of the interview inquired as to whether the above mentioned five management strategies of the vegetation were suitable and effectiveness in reducing fire risk in Haifa.

Two maps where derived from the two sets of interviews. The cultural ecosystem service map was created by overlaying the maps produced from each interview and for which to each polygon was assigned value 1 and summing up the total value of each delineated spatial unit creating an intensity map. Similarly, the fire risk map was produced by summing up the overlaying polygons and creating an intensity risk map. These two maps where then overlapped to produce a third tradeoffs-map which included: 1) areas at high risk and low recreational potential; 2) areas at low risk and high recreational potential; 3) and areas at both high risk and high recreational potential or low risk and low recreational potential. These last two cases were highlighted as areas where tradeoffs may occur between managing the vegetation for recreational activities and managing the vegetation for reduction of fire risk.

The interview protocols were analyzed for major and recurring themes. The objective was to identify main reasons why users of the green areas of Haifa choose to visit those sites, what makes them special on the one hand, and what level of management of the vegetation for fire risk reduction users of these areas would tolerate. Furthermore, the analysis of the information provided by the fire experts allowed to better characterize the main sources and factors determining fire risk in Haifa, especially with respect to the sample areas identified. The responses also allowed to outline tradeoffs and synergies between the desires of the users of the wadis of Haifa on one side and the need to implement risk reduction strategies in the research site.

4. Case study description

Haifa is the third largest city in Israel. It is located in the north west of the country on the Mediterranean Sea (32°49′0″N 34°59′0″E) and hosts about 280.000 inhabitants as of at the end of 2017

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[1] These strategies are widely discussed in Israel and experimented in neighboring areas of Haifa such as in the Ramat Hanadiv park (see https://www.ramat-hanadiv.org.il/en)

according to the Israel Central Bureau of Statistics (CBS)[2]. The climate in Haifa is typically Mediterranean. The average temperature of the city ranges between 8.8 ℃ (minimum temperature in January) to 30.8 ℃ (maximum temperature in July) with high humidity levels, while precipitation averages 630 mm/year, most falling in the winter and spring, with dry summers. The city sits on Mount Carmel (elevation 0 to 475 m above sea level), and the built area intermingles with wadis (ephemeral riverbeds). The wadis are undeveloped vegetated corridors that run up through the city from the upper elevations to the coast. Many of the wadis of Haifa are marked by hiking paths, providing extensive recreational opportunities for the local population. They also provide habitat for wildlife, such as wild boar, salamander, golden jackal, hyrax, Egyptian mongoose, owls and chameleons, as well as a rich vegetation, which include the common oak (*Quercus calliprinos*), terebinth (*Pistacia palaestina*), carob tree (*Ceratonia siliqua*) and mastic tree (*Pistacia lentiscus*). Aleppo pine trees (*Pinus halepensis*) are also widespread in the area, principally as a result of past tree planting campaigns (Ne'eman, Perevolotsky, and Schiller 1997). Aleppo pines were particularly attractive because of their adaptation to local climates, it's shallow root system and the minimal care required (Stemple 1998). 80% of the planted conifers planted in Israel belongs to this species (Ginsberg 2006). As a result, most of Israel high forests including the Carmel area, are planted and consist primarily of a small core group of native and exotic Mediterranean conifers (*Pinus halepensis, Pinus brutia, Cupressus sempervirens*) (Ginsberg 2006).

In November 2016, the city was affected by an extensive forest fires which spread through the vegetated natural areas and caused destroying 527 apartments in 77 buildings and leaving 1,600 people homeless. The combination of vegetation, wind direction, dry weather conditions, and topography produced a fast-spreading and intense fire.

Figure 1. Location and map of Haifa.
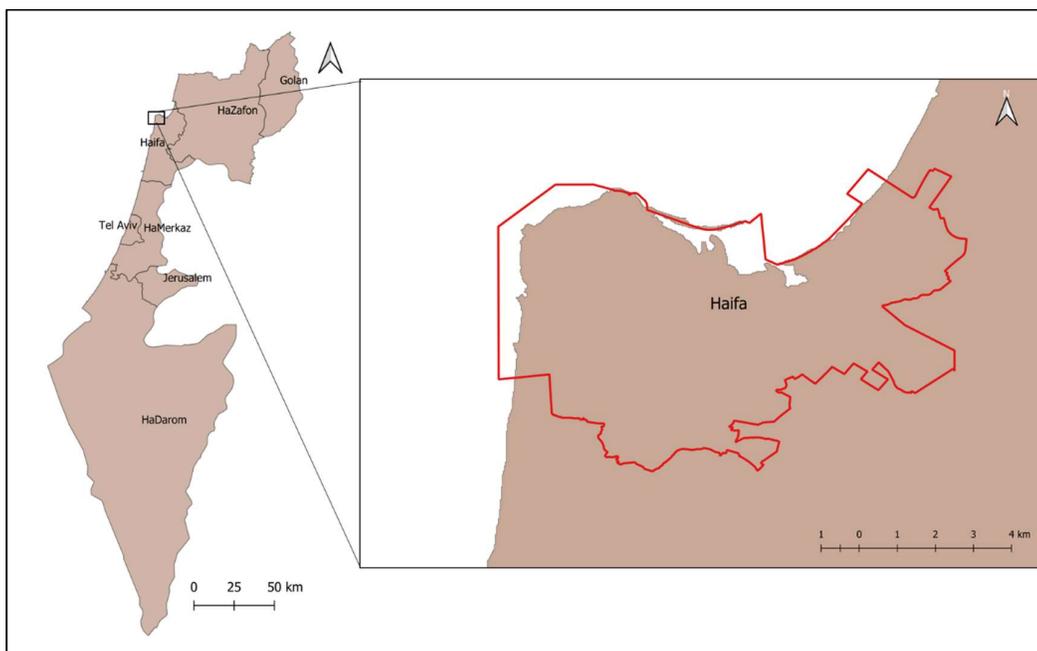
Source: own elaboration

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[2] http://www.cbs.gov.il/reader/shnaton/shnatone_new.htm (retrieved on October 30th, 2018)

5. Results

5.1. Cultural ecosystem services assessment

The main reason given by the respondents to why they visit the green areas of Haifa was the appreciation of being in nature while at the same time being so close to the city. Nationally, Israel's forested areas are concentrated in the north of the country and in the center, to the west of Jerusalem. The configuration of the city interspersed with green areas is perceived as an asset and a unique situation rarely found elsewhere in the country. Respondents listed numerous benefits of being isolated in nature and at the same time so close to home, a situation that further adds to the positive experience of being outdoors. They suggested that visiting the green areas of Haifa provided a similar experience to hiking in the [forested] Galilee, without the need to drive that far out of the city. The forest of the wadis was even compared to a Swiss landscape. To express the closeness of the green areas to the build up areas, some respondents described the wadis of Haifa as the "backyard of their house" offering close, walkable proximity to nature and recreation opportunities. This condition was considered as particularly important for the youth, although the hikes are perceived as not particularly difficult and thus suitable for a wide range of users and age groups.

The main activities performed in the green areas of Haifa (including its beaches) were: strolling, walking, hiking, dog walking, doing exercise in general, enjoying the landscape and its beauty (e.g. from the viewpoints of the wadis, from the Stella Maris Monastery lookout or the view from the Louis promenade), observing wildlife and plants, meditating, relaxing, spending time with the family and socializing with friends, opportunities for educational activities, cleaning and monitoring of the natural resources, picnicking and site-seeing, swimming, running, boating and kayaking. As shown in Figure 2, the most visited places were wadis located in the northern part of the city and connecting the top of the mount to the sea.

Figure 2. Map of cultural services in Haifa.
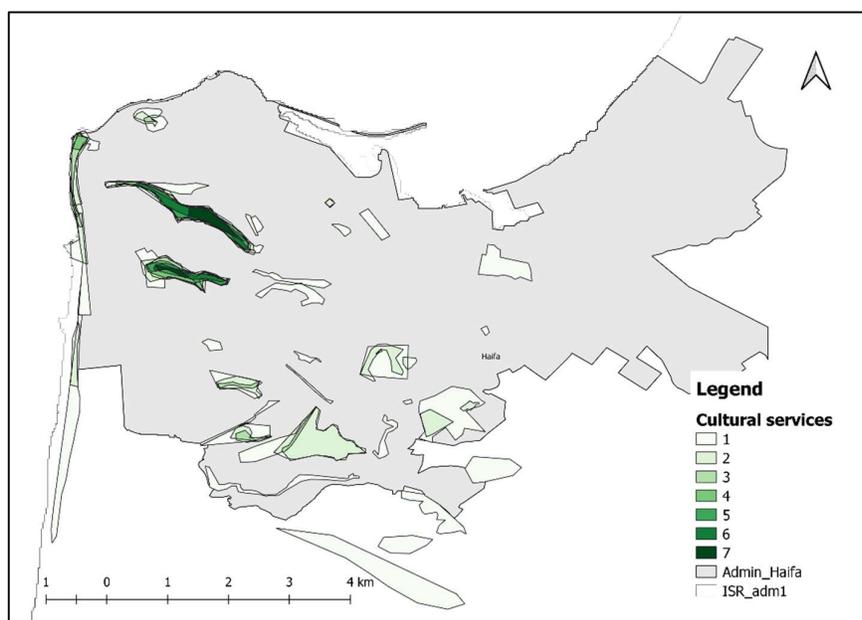
Source: own elaboration

5.2. Respondents preferences and fire management strategies

In this section, users of the green areas of Haifa were queried about the perceived impact various fire reduction policies, centered on the management of the vegetation, would provoke on the cultural experiences derived from visiting the green spaces. Regarding the possibility to implement *thinning* (explained as fuel and biomass reduction through the mechanical removal of some plants, or parts of plants to reduce density and increase distance between trees) in the green areas of Haifa, most of the respondents suggested that their experience of the green areas of Haifa would be affected and negatively. Reasons ranged from: the introduction of changes in the landscape that would make it less appealing; damage to wildlife, vegetation and consequent losses in biodiversity; a loss of the specific attributes of naturalness that make the wadis so pleasant; and the loss of shade. Others, on the other hand, thought that thinning could improve accessibility and offer more lookout points from the wadis. Most were willing to accept thinning if it would affect only pine trees.

The respondents were also specifically asked about the *removal of pine trees*. Some were concerned by the fact that their experience might be changed by the removal of these tall trees. However, most of the respondents were aware that dense and extensive pine forests do not occur naturally in this area, that they are mainly the result of afforestation efforts, that they have ecological impacts and also that these are very flammable species. Thus, most were willing to accept this strategy, especially in the case of the ill pines and if these are to be substituted with other tall tree species like oaks. Nonetheless some were concerned that their overall experience would be negatively affected with the removal of pine trees, seen as integral element of the characteristic landscape of Haifa.

About the possibility of building *firebreaks* (or areas near built space with a width of about 10 to 15 with no vegetation), most respondents expressed that their experience in the wadis of Haifa would be strongly, negatively affected. Furthermore, they did not see firebreaks as useful for preventing the spread of fires. These involve high maintenance costs and efforts, and have high ecological impacts, including the spread of invasive species. The aesthetic impacts were also regarded as highly detrimental to the cultural value of the green areas of Haifa. Some respondents felt that the areas would be destroyed should firebreaks be created. *Buffers* (or zoning around the built up areas with no vegetation close to the buildings, followed by sparse vegetation and then more dense vegetation) were instead deemed as less impactful for the environment and perhaps more effective in reducing fire risk. Still these would overall change negatively the experience of the visitors.

The possibility to introduce cattle and especially goat for *grazing* was regarded highly positively by the respondents as an effective measure which would add beneficial elements to the experience in green areas. It was considered as a "natural" way to deal with fires in Haifa and the most well-adapted strategy to the area. It was also considered to be useful for maintaining buffers and fire breaks. Careful considerations on how this would affect the food chain is also an important factor for consideration according to the respondents. Overgrazing should be avoided and issues of safety as well as disservices, such as bad smell, need also to be considered.

Diversifying the landscape, encouraging landscape patchiness (by planting fruit trees, having orchards and other agropastoral activities, for example), received strong support from respondence as an acceptable strategy to manage the risk of fires in Haifa. Respondents considered it to be synergistic with the objective of improving the recreational experience of hiking in the wadis. These practices were also seen as opportunities to clear and clean some degraded areas, if some would be conserved as much

"natural" as possible (e.g. core areas and the bottom of the wadis). Concern for the large amount of resources needed to implement this strategy, however, was expressed.

Overall, respondent stated their desire to keep the wadis of Haifa as untouched as possible due to the fear of destroying their "natural" attributes, despite the acknowledgment that some management will inevitably be required.

5.3. Fire risk and regulating services assessment according to fire experts

Most of the fire experts interviewed agreed that the three main environmental factors determining fire risk in Haifa's wadis are: the type of vegetation (high density of tall, old trees, presence of pine trees); the orientation of the wadi or the green area with respect to prevailing wind directions (a west-east orientation increases the risk; eastern facing slopes are most at risk e.g. due to the Sharav dry wind which can increase the temperature in few hours of up to 10ºC, drop the humidity as low as 5% with wind directions blowing from the east); and the slope of the area (if the built up area is located upslope and the slope is steep, the risk of fire increases). Another factors not considered in this analysis but mentioned by the experts was the of the green patch vicinity to a road, or to areas where recreational activities are concentrated and the presence of trash. We focus on the aspect of the vegetation because, of all the factors, vegetation is the only that can be possibly manipulated, and thus most relevant to our analysis.

Figure 4 shows areas of high fire risk due to the combination of the three main fire-risk factors mentioned above. The map shows a concentration of risk in the highest elevation parts of the city, especially those connected with the area of the park, and those areas with dense and thick vegetation. Dense forest and the presence of pine trees close to the built up areas were considered as the main risk factors connected to the type of vegetation. Oak forests are less a factor of risk. The absence of road access to the forest was also considered a worrisome aspect of the configuration of the WUI of Haifa, due to little access for firefighters.

Figure 3. Map of fire risk in Haifa.
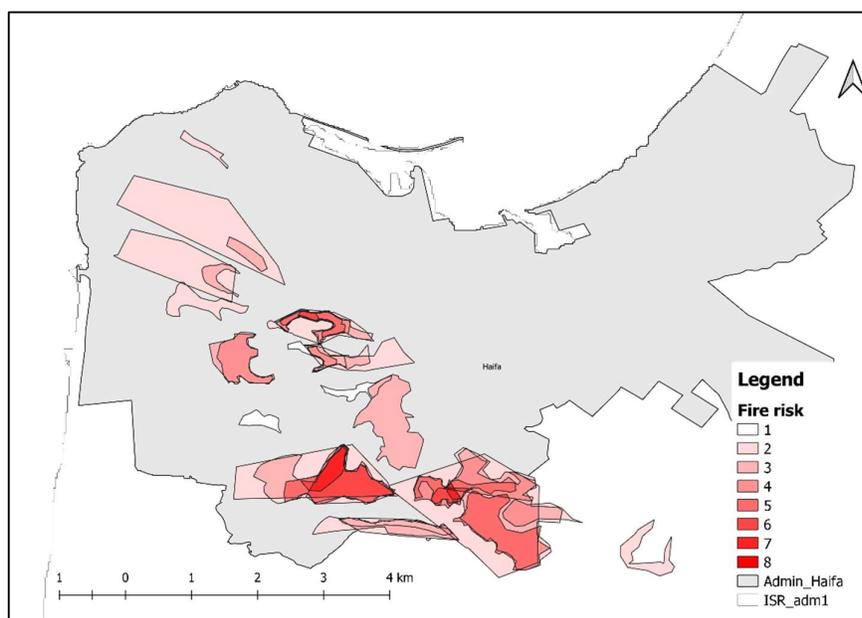
Source: own elaboration

5.4. Appropriateness of the management strategies of the vegetation according to the fire experts

Regarding *thinning*, most of the experts agreed that it is a fire management strategy that should be implement in the green areas of Haifa. But several noted that this should be in the context of a broader plan that would for instance improve the network of roads to facilitated access to fire fighters. Thinning should also be used as a strategy to maintain a buffer zone around the built-up area and to separate the herbaceous vegetation from the crown of the trees. This would be particularly effective in preventing canopy fires, which are very difficult to control in this area. Costs involved emerged as a problem to consider as well as the need to preserve the beauty of the forest. As a compromise, it was suggested to focus resources principally on removing pine trees.

The experts gave much support to the strategy of *removing pine trees*, as these trees had been planted and they dispersed across the ecosystem, forming dense, homogeneous assemblages in some areas. The density of the pines, the distance between each pine, the number of pines and closeness to the houses should all be assessed. Dense patches should be eliminated and the distance between the trees should be increased. In their place, expert respondents recommend a mix of tree species. Other respondents suggested keeping few pine trees only for recreational purposes. Nonetheless, removing pine trees from within a distance of at least 20 m from the houses was deemed a key strategy to reduce fire risk in Haifa and necessary by the quasi totality of the respondents.

The community of experts was divided regarding the creation of *firebreaks*. Some maintained that firebreaks might be useful only if roads are created to improve access for firefighters and if areas with dense forest were cleaned of trash. Others thought that this strategy would not be effective since the fire jumps from one green patch to the other across neighborhoods and streets, as it did during the 2016 fire. Firebreaks might slow fire but there was agreement that they would not stop it. Experts also considered firebreaks as detrimental in ecological terms. Due to their ambiguous contribution to reducing fire risk investing money and resources in firebreaks was considered by many as a waste of resources.

Buffers around the urban core, instead are necessary and should vary according to zoning, e.g. buffers close to building would have no vegetation, while further away, in an intermediate zone, vegetation would be kept low, sparse vegetation, while further afield, buffers would have tall, managed vegetation. This would also improve accessibility for firefighters at the WUI.

Most of the experts were in favor of introducing *grazing*, as it would separate the ground vegetation from the higher biomass, thereby reducing the risk of crown fires, and it could be used for maintenance of buffer zones. Experts focused on the technical aspects of grazing, such as employment and payment of herders. Goats were considered preferable to cows, which create more nuisances. Cultural aspects of grazing were raised regarding the significance of having herders and animals around the city, implying that some residents would view the practice negatively. Bad smell and interference with traffic were also pointed out. The question of the effectiveness of grazing on invasive species was also raised. A respondent suggested to have native gazelles, but others suggested that it would not be practical, as these are not domesticated animals.

Diversification of the landscape seemed be the most acceptable strategy and the easiest to justify. Investment in landscape diversification might create opportunities for recreational activities (e.g. creating pedestrian walkway, picnic areas, orchards, agricultural fields with fruit trees) and it is aesthetically desirable.

5.4. Analysis of the tradeoffs between cultural and regulating services

The map of tradeoffs between cultural services and fire risk is presented in Figure 4. It shows that areas with high recreational value and low risk are in the northern areas of the city, while areas with predominant high risk are located close to the Carmel national park. In these cases, there might be less interference between services: areas of high recreational value and low fire risk could be managed primarily to enhance recreational services; while areas of high risk and low recreational value will need to be management chiefly to reduce risk. Other areas which represent tradeoffs are marked in yellow in Figure 4. These show no clear priorities in terms of cultural services of fire risk, situations that can indeed lead to tradeoffs in terms of how to prioritize the management of these strategies.

Figure 4. Potential tradeoffs between cultural and fire regulating services in Haifa. It shows areas with high recreational potential and low fire risk in green. Areas of high fire risk and low recreational potential in red and areas of similar degrees of fire risk and recreational potential (low/low or high /high) in yellow. These are interpreted as area of tradeoffs between cultural and regulating services.
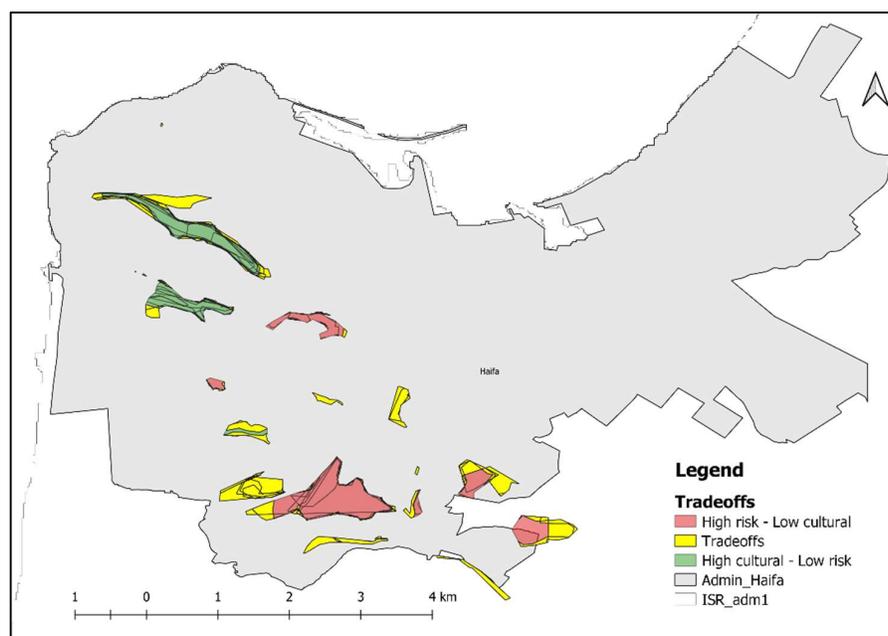
Source: own elaboration

Table 2 lists the management strategies of the vegetation considered to reduce fire risk (first column) and how the experience of interviewed users of the green areas of Haifa would be impacted should the five selected management strategies of the vegetation be implemented in these areas (second column). On the last column are summarizes the opinions of the fire experts with respect with the appropriateness and the effectiveness of implementing the listed fire management strategies to reduce fire risk in the green areas of Haifa. From Table 2 we clearly identify sources of tradeoffs with respect to thinning, buffers and the removal of pine trees which were considered to generally affect the experience of the users of the wadis of Haifa in a negative way while being effective to reduce risk according to fire experts. Some agreement was found instead around the building of firebreaks which were thought to be

not effective by fire experts as a strategy to reduce fire risk in the wadis of Haifa as well as highly impactful to the cultural experience.

Table 2. Summary about the responses given by the two groups of respondents (users of the green areas of Haifa and fire experts) related to their preferences on one side and retained effectiveness on the other, regarding the implementation of fuel management practices.

Activity	Users of the green areas of Haifa	Fire experts
Thinning	Slightly negative	Effective
Fire breaks	Negative	Community divided
Buffers	Negative	Effective
Grazing goats and or cows	Positive	Effective
Removal of pine trees	Slightly negative*	Effective
Diversification of the landscape	Positive	Effective

Despite these differences, there was awareness amongst the fire experts about the great potential of the green areas of Haifa. One interviewee summarized the situation as follows: "people like having trees close to houses while the city does not like fires". As a way out the tradeoffs, experts suggested the importance to create buffers with road to improve accessibility of firefighters around the buildings as well as removing pine trees as the most cost-effective strategies to the reduce risk in Haifa. Buffers and roads could offer new opportunities for recreational activities such as hiking.

7. Conclusions

Tradeoffs between the need to manage the forest to reduce fire risk at the WUI and the desire of city inhabitant to live in proximity of green areas is increasing due to the expansion of cities, urban sprawling into natural areas increasing the exposure to forest fires of local populations, buildings and infrastructures in these areas. In this paper we addressed this issue suggesting potential solution and strategies, based on the information collected in our quali-quantitative assessment, that can instead generate synergies.

We assessed cultural ecosystem services and fire risk in the green areas of Haifa and tradeoffs between cultural and regulating services in the wadis of Haifa. Regulating services can be enhanced by human intervention, especially in and around urban areas in the case of fire risk while leading to sustainable conditions. The case of the green areas of Haifa and fire risk clearly shows that there can be tradeoffs between regulating and cultural services, a little explored circumstance in the literature which generally concentrate on tradeoffs between providing services on one side and regulating and cultural services on the other side. Most of the tradeoffs emerged around the need to manage the green areas of Haifa to reduce risk while maintaining the excellent opportunities for recreational activities and to enjoy nature of local inhabitants which these areas offer. Most of the respondents showed in fact concern about the need to manage the "natural" areas of Haifa which is thought in many cases to impact negatively the experience in these densely forested areas so close to home. A solution to the conflict emerged in terms of building buffers principally around the built area as well as to reduce the amount and density of pine trees, particularly close to buildings. Synergies would emerge in this case also in terms of an enhanced

and improved network of trails for walking and hiking. By substituting pine trees with other tall trees such oaks also appeared as a common possible solution.

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