Managing fire risk at the wildland-urban interface requires reconciliation of tradeoffs between regulating and cultural ecosystem services

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ABSTRACT

Forest fires at the wildland-urban interface are generating increasing losses due to the expansion of cities into adjacent forests. At the same time, urban green open spaces are highly valuable as sources of recreational, educational and aesthetic benefits. Tradeoffs may arise between the desire to preserve peri-urban forests for cultural ecosystem services and the need to manage them to enhance the regulatory capacity of the ecosystem and reduce fire risk. In this paper, we assess cultural services and fire regulating services in the urban forest of the city of Haifa (Israel) using participatory GIS mapping, and we look at tradeoffs between these services. We interviewed intensive users of the green spaces of the city and fire experts regarding the location of these services and preferences about selected vegetation management strategies to reduce fire risk. Green space users promoted the idea of a pristine environment and its conservation, mainly for recreational purposes, while fire experts suggested that vegetation management is needed although this would bring about changes in the landscape. Tradeoffs between cultural and regulating services can thus generate conflicts. We conclude by suggesting ways seemingly opposing objectives can be reconciled to reduce fire risk at wildland-urban interface and in a lasting way.

1. Introduction

Due to the urbanization of the world population, understanding tradeoffs and synergies among ecosystem services in cities is crucial (Turner et al., 2014). At the wildland-urban interface (WUI) (i.e. an area where built structures are in close contact and intermingle with the peri-urban forest and/or other vegetated areas) (Radeloff et al., 2005), unique land-use management conflicts arise as a result of fragmentation of habitats, introduction of exotic species and water availability (Radeloff et al., 2005). An additional challenge is that of forest fire risk. In densely populated, fire-prone areas, the impact of fire regimes is driven by the increased demand for living close to forested areas, land abandonment and by the widespread use of fire-exclusion practices (i.e. the prevention and suppression of forest fires which increases the accumulation of vegetation) (Burgess et al., 1988; Cohen, 2008; Cortner et al., 1990; Ganteaume et al., 2013; Keeley et al., 1999; Radeloff et al., 2005; Tal, 2013; Theobald and Romme, 2007). The main drivers behind this challenge are the desire of homeowners to be in proximity to nature and recreational opportunities, and the search for affordable housing and/or privacy (Ewert, 1993; Hendricks and Mobley, 2018; Stewart et al., 2007). These trends are further exacerbated by the increase of vegetation combustibility driven by anthropogenic climatic change (Bradshaw et al., 2011). Isolated clusters of development or areas of low to high housing density interspersed with wildland vegetation are thus particularly at risk from forest fires (Syphard et al., 2013). It is here that most of the human fatalities, economic losses and fire-suppression expenditures now occur (Moritz et al., 2014).

At the WUI it is a difficult task to manage a forest to simultaneously produce timber, conserve biodiversity, maintain other ecosystem services such as recreational opportunities, preserve a sense of pristine nature, all while reducing fire risk (Ager et al., 2010; Sturtevant et al., 2009). Policy makers, in this context, need to deal with new tradeoffs between different environmental objectives which might translate into conflicts. This quandary has been exemplarily expressed by an Israeli chief forester who manages forests adjacent to Jerusalem neighborhoods referring to his task of reducing fire risk at the WUI: “I risk being sued twice: once for ruining the landscape by cutting down the trees in the buffer zone between the city and forest and a second time for endangering residents and their homes by not cutting down the trees fast enough”.

In such conditions, public support is deemed critical for successful implementation of vegetation management programs at the WUI (Toman et al., 2011). There is a significant amount of literature on the factors determining the acceptance of different vegetation management
strategies to reduce fire risk (McCaflrey et al., 2008; McCaffrey and Olsen, 2012; McCaffrey, 2004; Moritz et al., 2014; Weisshaupt et al., 2005), and specifically at the WUI (Jacobson et al., 2001; Toman et al., 2011; Vogt et al., 2005; Winter et al., 2006, 2002). Less research has been done; however, on the case-based assessment comparing potentially competing priorities of a variety of cultural values relating to urban and peri-urban forests, on the one hand, and of maintaining or generating fire regulating functions in the forest for reducing fire risk, on the other.

Through the lens of the ecosystem services conceptual framework, we examine tradeoffs between cultural services (i.e. representing the value given by local inhabitant of living near and having access to open spaces for the aesthetic value and the recreational opportunities these offer) and fire regulating services (i.e. “the benefits provided by ecosystems in terms of reduction of fire intensity, magnitude, spread, and avoidance of catastrophic fires and associated damages for human beings and the environment”) (Depietri and Orenstein, 2019, p. 4). We use the context of the 2016 fire that occurred in the green spaces in the midst of the city of Haifa, in Israel. We adopt a participatory qualitative-quantitative approach to analyze how these services are perceived and articulated by frequent users of the green open spaces of Haifa, on the one hand, and by the local and national fire experts, on the other. We then look at tradeoffs and synergies between these services. The approach falls in the category of contextual applied policy research to investigate the attitudes and perceptions of the main stakeholders with purposeful strategic objectives (Ritchie and Spencer, 2002). In our case, the main question driving our policy-relevant research is: how can forest fire risk management at the WUI be made more effective in the long term by meeting other, potentially competing, social goals and needs?

In Section 1.1 we review the relevant literature on ecosystem service tradeoffs and synergies. In Section 1.2 we briefly describe what we intend for fire regulating services. In Section 2 we describe the Haifa case study and the methods used to assess cultural and fire regulating services and tradeoffs. In Sections 3–5, we present the results, discussion and conclusions, respectively.

1.1. Ecosystem services tradeoffs and synergies in the literature

While some types of ecosystem services correlate positively between one another, others show strong negative relationships (Brockheroff et al., 2017). The second case refers to the situation in which ecosystem management enhances the production and supply of one service, or group of services, while resulting in the decline in the supply of other ecosystem services, generating tradeoffs (Bennett et al., 2009; Eogh et al., 2008). Most of the literature on ecosystem service tradeoffs has concentrated on provisioning versus cultural and regulating services, as agriculture generally increases the supply of provisioning services while decreasing the supply of the other types of services (Chhatre and Agrawal, 2009; Johnson et al., 2012; Lee and Lautenbach, 2016; Martín-López et al., 2012; Power, 2010; Raudsepp-Hearne et al., 2010; Turner et al., 2014). Tradeoffs (and synergies) between cultural and other ecosystem services, such as regulating ones, are underrepresented in the literature (Howe et al., 2014). One case is presented by Nassauer (1995a), in which the construction of an artificial wetland for waste regulation was opposed by a local urban community because it was not considered aesthetically desirable and was perceived to cause other disservices (such as smell). Tradeoffs between regulating and cultural services may also result due to preferences of local inhabitants for aesthetic or recreational values to the detriment of regulating functions of ecosystems.

Among the ecosystem service studies that did consider competing environmental management objectives involving fire prevention management, Oteros-Rozas et al. (2014) studied the perceptions of ecosystem services provided by a transhumance social-ecological system. They found that respondents associated fire prevention, along with livestock, to transhumance lifestyles. The authors advocate the maintenance and support of transhumance lifestyles, both for the people who engage in that lifestyle, and in order to maintain the provision of associated ecosystem services, including fire prevention. Another relevant study is that presented in a technical report on forest management and ecosystem services prepared for the US Forest Service by Jaworski et al. (2018) who note that prescribed burns administered for ecological goals may diminish aesthetic values of the forest (e.g., the fall foliage), and therefore some sites need to restrict prescribed burns at least during the summer months.

Although ecosystem service studies tend to concentrate on tradeoffs, not all human interventions in the landscape generate conflicts. Indeed, they can also generate synergies (Howe et al., 2014). Synergies between ecosystem services are situations in which the amount of one service is positively correlated with the benefits supplied by another service. It has been documented that managers can learn how to manage natural areas to eventually craft solutions that provide for “win-win” interactions between provisioning, regulating, and supporting services (Bennett et al., 2009; Rodriguez et al., 2006; Smith et al., 2013; Swallow et al., 2009). Synergies more successfully emerge as the level of sustainability of the practice increases (Cumming and Peterson, 2005; Power, 2010; Pretty et al., 2006; Xue et al., 2015). Badly formulated policy could, instead, lead to tradeoffs and conflicts that need not have been (Smith et al., 2013). According to Howe et al. (2014), win-win solutions are also more likely to arise when managers avoid or overcome the main reasons for why tradeoffs generally arose in the first place, including: the failure to account for all benefits or stakeholders; failed management; and/or an assumption that provisioning services should always dominate any other services. To design successful win-win solutions, potential conflict situations first need to be identified (Galafassi et al., 2017). Participatory approaches to assess potential tradeoffs and identify synergies between different services are very promising tools (Galafassi et al., 2017), but they are underrepresented in the literature and need to be further investigated (Cord et al., 2017). Some examples are provided by Stosch et al. (2019), who assessed tradeoffs between agricultural production and freshwater ecological health by means of the participatory identification of the production possibility frontier, and by Galafassi et al. (2017), who assessed ecosystem service tradeoffs in a fishery located in Mombasa (Kenya) through participatory modelling and workshops.

1.2. Fire regulating services and disservices

In this section, we briefly review ecosystems services related to fire regulation, which has only recently been fully conceptualized (see Depietri and Orenstein, 2019). Most research concerning ecosystem services and fires focuses on the loss of services due to fire events (Hurteau et al., 2014; Inbar et al., 1997; Lee et al., 2015; Thom and Seidl, 2016). Other research looks at the ecosystem services provided by localized, intentionally set fires which increase agricultural land availability, hunting opportunities, fodder, pasture, pest management, wood, charcoal and some cultural services (Schmerbeck et al., 2015).

Some ecosystem conditions and functions can also reduce the risk of catastrophic fires. In the Mediterranean area, for instance, autochthonous plant species are generally adapted to fires, meaning that they have relatively less flammable biomass and are able to recover after a fire (Bond and Keane, 2017; Bradshaw et al., 2011). As such, they can reduce the spatial scale and intensity of a fire and are therefore considered to provide fire regulating services (i.e. the reduction of risk and potential impacts) in fire-prone social-ecological systems. Exotic tree species with abundant above-ground biomass (i.e. vegetation) and horizontal or vertical continuity, in contrast to autochthonous species in a patchier landscape, can increase fire intensity (Brooks et al., 2004; Nel et al., 2014) and provide fire regulating disservices (i.e. the increase of fire risk), as further detailed in Depietri and Orenstein (2019).
providing fire regulating services and those providing fire regulating disservices. Estimating fire regulating services and disservices generally demands a quantitative biophysical assessment. In this paper, we indirectly and participatory look at fire regulating (dis)services through assessing fire risk (chiefly co-determined by vegetation structure) and by looking at the potential role of five selected vegetation management strategies in producing fire regulating services benefiting the city of Haifa.

2. Methods

2.1. Casestudydescription

Haifa is the third largest city in Israel. It is in the northwest of the country on the Mediterranean Sea (32°49′0″N 34°59′0″E) (see Fig. 1) and hosts about 280,000 inhabitants as of 2017 (CBS, 2018). The climate in Haifa is typically Mediterranean. The temperature of the city ranges between 8.7 °C (average minimum temperature in February) to 31.4 °C (average maximum temperature in August), with high summer humidity levels. Precipitation averages 630 mm/year, almost all falling in the winter and spring. The city partially sits on Mount Carmel (elevation 0–525 m above sea level). The built-up area is interspersed with wadis (or ephemeral riverbeds). The wadis are undeveloped, vegetated and forested corridors that run up through the city, from the coast to the upper elevations. These open spaces host a rich vegetative community, including the common oak, terebinth, carob tree and mastic tree. Aleppo pine (Pinus halapensis) trees are also widespread in the area, principally due to past tree planting campaigns (Ne’eman et al., 1997). Aleppo pines were particularly attractive for afforestation efforts because of their adaptability to local climates, their shallow root system and the minimal care they require (Stemple, 1998). 80% of the planted conifers in Israel belong to this species (Ginsberg, 2006). The wadis provide habitat for wildlife, such as wild boars, salamanders, golden jackals, hyraxes, Egyptian mongooses, owls and chameleons. Many of the wadis of Haifa are marked by hiking paths, providing extensive recreational opportunities for the local population. The mosaic of wadis throughout the urban matrix often defines the city as green and forested. It also defines the city as having an extensive WUI due to the penetration of dense forested areas into the city.

In November 2016, the city was affected by a forest fire which spread through these green areas. The combination of the unmanaged vegetation, the wind direction, the dry weather conditions, and the topography produced a fast-spreading and intense fire which started in a green area adjacent to the city and then jumped from one green area to the other within the urban fabric (Tessler et al., 2019). 40,000 inhabitants (15% of Haifa’s population) were evacuated (Toledo et al., 2018). The fire destroyed 527 apartments in 77 buildings, leaving 1600 people homeless.

2.2. Methodology

This research applies spatial analysis and participatory research methodologies through semi-structured interviews to spatially locate and characterize places highly valued for aesthetic, recreational or ecological reasons, as well as places of high concentration of fire risk in

Table 1

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<tr>
<th>Characteristics of ecosystems providing fire-regulating services</th>
<th>Characteristics of ecosystems providing fire-regulating disservices</th>
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<tbody>
<tr>
<td>Native, fire adapted, low-biomass species</td>
<td>Highly flammable, high biomass, invasive species</td>
</tr>
<tr>
<td>Landscape heterogeneity and patchiness</td>
<td>Homogeneous landscape</td>
</tr>
<tr>
<td>Low forest density</td>
<td>High tree and canopy density and large number of young trees</td>
</tr>
<tr>
<td>Fire breaks and buffers</td>
<td>Continuous forest</td>
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Fig. 1. Location and satellite map of the city of Haifa.
Haifa. Bryan et al. (2010), applied a similar methodology to gather social and cultural values across a landscape, and to identify places of high interest, as well as places of high ecological risk. While, traditionally, tradeoffs are captured through costs-benefits analysis or through biophysical quantifications, a participatory methodology is more suitable to compare the range of social and cultural values of social groups (cultural services) with those suggested by experts groups (Galafassi et al., 2017). Participatory approaches for the investigation of ecosystem service tradeoffs allow research to benefit from specific expertise and from purposely targeting different understandings and perspectives that often go unnoticed with quantitative approaches (Stosch et al., 2019).

In our study, 40 in-depth interviews were conducted, allowing us to cover a targeted set of social and expert values deemed crucial for defining cultural and fire regulating services tradeoffs. The pool of respondents was expanded until significant redundancy in information emerged. Some researchers object, in fact, to a pre-determined sample-size, with ‘informational redundancy’ being the rule of thumb for determining sample size a posteriori (Sim et al., 2018). The first group of respondents represent intensive users of Haifa’s green open spaces. We sought locals who were particularly engaged in outdoors activities and whose interests were not limited to a single neighborhood, but rather to the entirety of the city. The information provided by these respondents thus allowed us to map hotspots of cultural value across the whole city. The respondents in this group were selected from colleagues, collaborators, students, as well as activists and NGOs members in Haifa who are or were highly engaged in recreational, educational and/or research activities in the green areas of Haifa. The initial group of potential interviewees was expanded through a snowball sampling technique (meaning that the respondents originally identified suggested other potential candidates for the interviews) (Johnson, 2014) and by posting announcements on relevant pages in social media of specialized groups, such as of hikers in Haifa or groups active in the environmental protection of the study area. The sample of 27 respondents thus represents residents with strong interest in Haifa’s green open spaces and with strong opinions regarding their ecological and cultural value. It also represents the group of stakeholders from which most intense opposition might emerge to the implementation of vegetation management strategies. Each interview lasted approximately 90 minutes.

Green open space users were each asked to identify and map up to five areas of special interest in terms of cultural services within the boundaries of the municipality (see Fig. 1). To do so, the respondents, together with the interviewer, drew polygons on a satellite image of the city embedded in the online tool “Scribble Maps” (www.scribblemaps.com). For each selected area, the respondents were then asked to explain why they chose it, what makes it special to them, and in what type of activities do they partake at each location. The second part of the interview aimed at identifying tradeoffs between the cultural services they derive from these areas and five proposed fire risk reduction strategies to be implemented in these same areas (potentially generating fire regulating services and disservices (high risk areas corresponding to lack of regulating services)). For an in-depth qualitative assessment, biophysical modelling would be needed, but we favored a participatory approach to gather contour information. The second part of the experts’ interviews inquired as to whether the five selected fire risk management strategies are suitable and potentially effective in reducing fire risk in Haifa (yes/no/effective under certain conditions), and why. Each interview lasted between 1 to 2 hours.

All maps produced by the two groups of respondents were downloaded in shape file format from “ScribbleMaps” to produce two separate maps (of cultural services and of fire risk), making use of the “QGIS” open source software. The cultural ecosystem service map was created by giving each drawn polygon a value of one and by summing up the values for the overlapping polygons’ areas, thus giving an estimation of the concentration of interest for each area. In this way, a hotspot map, showing classes of high interest for the selected areas, was produced. Similarly, the aggregate fire risk map was created by summing up the overlaying polygons drawn with the fire experts (each valuing one) and creating an intensity risk map expressing degrees of agreement amongst the fire experts regarding areas of high fire risk in Haifa. As emerged during the interviews, the risk map reflects the most important biophysical factors that determine fire risk, which include the vegetation structure and thus ecosystem (dis)services, but which at times are difficult to separate from other factors. The values of the two resulting maps were then normalized and the maps overlaid to create a third map displaying potential tradeoff areas where the need to reduce fire risk through the management of the vegetation might conflict with the maintenance and the enhancement of cultural services.

The qualitative information derived from the interview protocols were analyzed using “Atlas.ti” software, extracting major and recurring themes, key issues and concepts (Hagaman and Wutich, 2017). The objective was to identify the main reasons why users of the green open spaces of Haifa choose to visit or care for those sites and what makes them special. A second objective was to identify the kind and level of management of the vegetation for fire risk reduction that the respondents would tolerate and whether these preferences potentially conflict with the need for fire risk reduction. We also analyzed with the same approach the qualitative information provided by the fire experts to better characterize the potential effectiveness of the five fire management strategies selected in the context of Haifa, besides being able to further characterize the sources and factors determining fire risk in the city.

Overall, the qualitative-quantitative analysis facilitated the identification of instances of potential tradeoffs and synergies between enhancing the cultural value of the green open spaces of Haifa, on the one hand, and the need to implement vegetation management strategies to reduce fire risk, on the other. Co-production of knowledge (Galafassi et al., 2017) emerged during the semi-structured interviews as the respondents built mutual awareness of the potential competing objectives involved in the study area.
3. Results

3.1. Cultural ecosystem service assessment

Fig. 2 features the map derived from responses of green open spaces users, showing all areas of special interest, with hotspots of cultural value (in dark green). The most selected places were the wadis located in the north-west of the city as well as the coastal areas, although most of the green open spaces dispersed in the urban fabric appear to offer valued opportunities for recreational activities. The north-western wadis are areas of thick and dense vegetation hosting a variety of wildlife and crossed by multiple trails. Walking in these areas is also valued as it offers diverse and spectacular lookout points on the landscape, the sea and on the adjacent built-up areas. Some respondents noted the need for maintenance of the trails and clearing of the vegetation, given the density of the forest. Undergrowth and garbage clean-up campaigns are required in these wadis. Observing plants, flowers, animals and rock formations were cited as important opportunities for educational activities connected to experiencing nature. The north-western wadis host endemic species which should be the target of enhanced conservation efforts, according to the respondents. Aleppo pine forests (mostly planted forests) were also highly regarded as spots contributing to the positive experience of nature in Haifa and of sense of place. Most of these wadis were then valued because they offer access to beaches as they connect the upper part of the city to its coastal areas. Some open spaces are appreciated for the additional points of interest (other than the vegetation and wildlife) they offer, such as: the presence of springs with pools, historic orchards, agricultural terraces and monasteries. The forested areas of Haifa are thus also valued for their cultural heritage, which includes the remains of agricultural communities, and sites of historical and religious significance.

As mentioned, via the interviews, respondents provided additional information which allowed us to identify the main reasons that determine the cultural value of the designated open spaces of interest. These were fundamental in identifying specific sources of potential tradeoffs.

The main reason given by the respondents as to why they visit the open spaces of Haifa was the appreciation of being in nature while at the same time being so close to the city. The most highly valued aspect of living in proximity to forested areas was being able to experience a sense of wilderness and isolation in an environment mostly devoid of obvious human activities, while being only minutes away from home. The respondents noted that, at the national scale, Israel’s forested areas are concentrated in the north of the country and in the center, to the west of Jerusalem. The fact that Haifa is interspersed with forested, mostly unmanaged open spaces, which are perceived as wild, was considered as an asset and a unique situation found in almost no other city in the country.

More specifically, respondents suggested that visiting the open spaces of Haifa provided a similar experience to hiking in the (forested) Galilee (situated in the north of the country), without the need to drive that far. Some of the wadis start in the busiest neighborhoods of Haifa (e.g., the Carmel) but “soon you are immersed in the vegetation, and it feels like being in a nature reserve and you forget about the city” (according to a representative respondent). The forests of the wadis were even compared to a Swiss landscape. To further express the benefit of the closeness of the forested areas to the build-up areas in the city, some respondents described the wadis of Haifa as the “backyard of their house” as they offer close, walkable proximity to nature and a variety of recreation opportunities. This situation was considered important for the youth, and the hikes not particularly difficult and thus suitable for a wide range of users and age groups.

The open spaces of Haifa are also valued for providing multiple opportunities to observe wildlife (including endangered species like the fire salamander), relax and feel isolated. Respondents felt that this is an important source of well-being for the city residents, more so due to the proximity of the city to industrial sites. The forested areas are valued because they provide shade, allowing people to walk outdoors also during the warmer months, as they contribute to the reduction of temperature and pollution. Furthermore, green areas in Haifa provide a feeling of privacy by creating natural barriers between houses.

For all these reasons, the respondents expressed the desire that the
green opens spaces of Haifa be preserved for present and for future generations and that these areas should not be compromised by excessive and continuous urban development. It is the sense of wilderness that should be maintained, minimizing human intervention that would cause the degradation and loss of this valuable experience.

Overall, the main activities carried out in the open spaces of Haifa (including its beaches) are: strolling, walking, dog walking, hiking, doing exercise, enjoying the landscape, observing wildlife and plants, meditating, relaxing, spending time with the family and socializing with friends, educational activities, cleaning and monitoring of the natural resources, picnicking, site-seeing, swimming, running, boating and kayaking.

3.2. Green open space users’ preferences regarding the five selected vegetation management strategies to reduce fire risk

Users of the open spaces of Haifa were then queried about the perceived impact the implementation of the five selected fire risk reduction strategies would have on their experiences in Haifa’s green spaces. Regarding the possibility to implement thinning (explained as vegetation and biomass reduction through the mechanical removal of some plants, or parts of plants to reduce the forest density and increase the distance between trees), most of the respondents suggested that this would negatively affect their cultural experience in the green open spaces of Haifa. Reasons ranged from: the introduction of changes in the landscape that would make it overall less “natural” and thus less appealing; the potential damage to wildlife and vegetation and consequent potential losses in biodiversity; and the loss of shade, highly valued in hot climates like that of Israel. Some respondents thought however that thinning the vegetation could have the benefit to improve accessibility and offer more lookout points from the wadis to the surrounding landscape. Some others were willing to accept thinning if it would apply only to pine trees (see below for further details on this measure) and if ecological considerations (e.g., maintaining the forest ecosystem by planting more local and tall tree species that would provide shade, such as oaks and carob trees) were closely considered.

Regarding clearing firebreaks (explained as zones crossing the vegetated areas with a width of up to 70 meters in which the vegetation would be completely cleared), most respondents expressed that their experience in the wadis of Haifa would be strongly and negatively affected should this measure be implemented. The impacts were regarded as highly detrimental to the cultural, aesthetic value of the open spaces of the city. Some respondents felt that the areas would literally result as devastated should firebreaks be created. Furthermore, most did not see firebreaks as effective for preventing the spread of fires, while requiring high maintenance costs, efforts, and high ecological impacts (including favoring the spread of invasive species). A subset of firebreaks, buffer areas (explained as a zone around the built-up areas with no vegetation in close to the buildings up to 10 to 15 meters, followed by sparse vegetation and then more dense vegetation moving away from the buildings) were deemed less impactful for the environment and perhaps more effective in reducing fire risk. Despite this, some thought that buffers would also negatively impact the experience of the users, especially in the most narrow parts of the wadis and open spaces.

The possibility of introducing cattle and (especially) goats for grazing to reduce the density of the vegetation was regarded highly positively and enthusiastically by the respondents as a strategy that, aside from being potentially effective, would add positive elements to the experience in nature. It was considered as the most natural way to deal with fires and the most well-adapted strategy to the area. It was suggested that grazing could also be useful for maintaining buffers and fire breaks. On the other hand, some potential drawbacks linked to grazing were raised, such as the cultural connotation with past or undesirable lifestyles. The need for careful consideration on how grazing would affect the food chain in the ecosystem was also an important factor raised by the respondents. Overgrazing would need to be avoided and issues of safety and potential disservices (such as bad smell) would need to be considered.

The respondents were also asked specifically about the removal of pine trees (because of the high flammability of this species). Some were concerned by the fact that their experience might be worsened by the removal of these tall and green trees, feeling that these are an integral part of the landscape of Haifa. Despite this, some respondents were aware that dense and extensive pine forests do not occur naturally in this area, are mainly the result of afforestation efforts, have negative impacts on local ecosystems and are indeed very flammable. Overall, most of the respondents were willing to accept their removal provided that they were to be substituted with other local, tall tree species.

Diversifying the landscape and encouraging landscape patchiness (explained as obtainable by planting fruit trees, maintaining orchards and integrating other agropastoral activities in the area) received some support from respondents as an acceptable strategy to manage the risk from fires in Haifa. Some respondents considered it to be synergistic with the objective of improving the recreational experience of hiking in the wadis. These practices were considered as opportunities to clear and clean some degraded areas. Some other areas would however be needed to be preserved in a more “natural” state without intensive human modification (e.g., the core of the areas and the bottom of the wadis). Concerns for the large amount of resources needed to implement this strategy were also raised.

Fig. 3 summarizes the different attitudes of the users of the open spaces towards the five proposed fire risk reduction strategies. Grazing emerged as the most accepted strategy, while the implementation of fire breaks and then thinning would be the least appreciated interventions. Mixed feelings were expressed with respect to the removal of pine trees and the diversification of the landscape. In general, respondents stated that their desire was to keep the wadis and green open spaces of Haifa as untouched as possible due to the fear of destroying their attributes of “naturalness”. Thus, despite acknowledging that some vegetation management is required, the feeling of being in the wilderness, in areas with no or minimal intervention and so close to home, made respondents reticent to accept management strategies that were perceived as possibly diminishing those qualities.

3.3. Fire risk and regulating service assessment according to fire experts

Most of the fire experts interviewed agreed that the three main environmental factors determining the presence of fire risk in Haifa’s open spaces are: the type of vegetation (i.e. high density of tall, old trees, and the general presence of pine trees increase fire hazard); the orientation of the slope, wadi or green area with respect to prevailing wind directions; and the incline of the slope of the green area, also with respect to the location of buildings. Fig. 4 shows areas of high fire risk due to a combination of these main fire-risk factors, as drawn by the respondents. The map indicates a concentration of risk in the areas of the WUI of Haifa, as this further hinders access for firefighters.

Fig. 5 summarizes the considerations of the fire experts with respect to the effectiveness of each of the selected vegetation
management strategies. As the Figure illustrates, all of the strategies were considered as potentially suitable to reduce fire risk in Haifa, although they demand additional considerations, including budgetary and technical feasibility.

Regarding the strategy of thinning, most of the experts agreed that it should be implemented in the green open spaces of Haifa. However, several noted that this should be part of a broader plan that would also improve the network of roads to facilitated access for fire fighters. Thinning should be used as a strategy to maintain a buffer zone around the built-up area as well as to separate the ground and herbaceous vegetation from the crown of the trees. This last intervention would be particularly effective in preventing canopy fires, which are very difficult to control. The costs involved in implementing the strategy emerged as a significant challenge.

The community of fire 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 cleared of trash. Others thought that this strategy would not be effective since the fire jumps from one green patch to another across neighborhoods and streets, as it did during the 2016 fire.
Firebreaks might slow down 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 in Haifa, investing money and resources in firebreaks was considered by some as a potential waste of resources.

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

Some experts were in favor of introducing grazing, as it would separate the ground vegetation from the taller biomass, thereby reducing the risk of crown fires. Grazing could also be used for maintenance of buffer zones. Goats were considered preferable to cows, which create more nuisances. Experts, however, raised some potential challenges in the implementation of this strategy, including the need to employ and pay shepherds. Cultural aspects of grazing were raised implying that some residents would view the practice negatively. Bad smell and interference with traffic were considered. The question of the effectiveness of grazing on managing invasive species was also mentioned.

The experts gave relatively more support to the strategy of removing pine trees, as these had dominated the ecosystem, forming dense and homogeneous assemblages. The density of the pines, the distance between each pine, the number of pines and closeness to buildings 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 local tree species. Other respondents suggested keeping a few pine trees only for cultural reasons. Nonetheless, removing pine trees from within a distance of at least 20 m from buildings was deemed a key strategy to reduce fire risk in Haifa.

Diversification of the landscape appeared as an acceptable strategy and easy to justify. The experts suggested that, aside from reducing fire risk, investment in landscape diversification might also create opportunities for recreational activities (e.g., creation of pedestrian walkways, picnic areas, orchards, and agricultural fields with fruit trees) and it was also considered to be a potentially aesthetically desirable alternative. Again, implementation might be limited, especially if resources are lacking.

Overall, focussing on removing pine trees, especially close to buildings, and creating buffers around the urban core were suggested by experts as the most cost-effective strategies to reduce fire risk in Haifa and they recommended that this is where limited funds should be invested. Further information on the experts points of view on fire risk in Haifa are provided in Depietri and Orenstein (2020).

3.5. Analysis of the tradeoffs

Following the results of the spatial, quantitative analysis we superimposed both thematic maps to produce a third map (see Fig. 6) which enabled a spatial assessment of tradeoffs between cultural services, on the one hand, and fire risk (principally a result of fire regulating disservices), on the other. The Figure shows that areas with high cultural value and low fire risk are found in the north-western areas of the city, while areas with predominantly high fire risk are in the southern part of the city, close to the Carmel National Park. In these cases, there would seemingly be fewer conflicts resulting from managing for cultural and fire regulating services simultaneously: areas of high cultural value and low or no recreational value should be managed primarily to reduce risk. Areas that represent tradeoffs are marked in blue (low cultural interest and low risk) and yellow (medium cultural interest and medium risk) in Fig. 6. Here, prioritizing management strategies must consider potential emerging tradeoffs resulting from conflicting management decisions.

As mentioned, according to the first group of respondents, the green open spaces of Haifa provide an overarching benefit of creating a sense of being surrounded by wilderness, in isolation, only minutes from one’s home. Due to this specific attribute, any vegetation management intervention that would affect this experience or that would degrade or disturb the ecosystem is regarded as undesirable by open space users. This clearly emerged when this group of respondents was asked to discuss the perceived impacts of the five selected vegetation management strategies that would reduce fire risk, but which would also likely

![Fig. 5. Effectiveness of the five selected fire management strategies in the context of the city of Haifa, according to the fire experts.](image-url)
introduce visible anthropogenic elements in the landscape, thereby diminishing the sense of "naturalness" of it. Amongst the suggested strategies, only grazing (perceived as the most "natural" intervention) was accepted nearly unanimously by close to all green space users and was even thought by many to potentially greatly improve the cultural experience in the green areas of Haifa.

Overall, the respondents suggested that they would prefer minimal or no intervention. It would thus likely be difficult to convince stakeholders, such as those interviewed, to manage the forest to reduce risk, for instance by cutting down trees.

Table 2 lists: the five selected vegetation management strategies to reduce fire risk in Haifa (left column); a graphical synthesis of how the experience of users of the open spaces would be impacted should the five selected management strategies be implemented (middle column); and a graphical synthesis of the opinions of fire experts with respect to the appropriateness and the effectiveness of implementing the listed fire risk management strategies in the context of the city of Haifa (right column). Sources of tradeoffs between the assessed cultural value of the open spaces and the need to manage them to reduce risk are thus schematically identified by comparing responses along the rows.

While most strategies were deemed feasible (within certain conditions) by the fire experts, at the same time, most strategies (except for grazing and the diversification of the landscape) were considered as negatively affecting the cultural services of the open spaces in some ways by the users of the open spaces. Thinning was rejected by most users, while it is deemed potentially beneficial by most fire experts. Regarding fire breaks, there was some convergence of opinions between the two communities. These are considered as not fully effective and potentially significantly damaging to users' cultural experiences. Grazing was deemed very favorably by the green space users, while experts believed it would be effective, but raised different concerns over its applicability in the urban context. The removal of pine trees was considered as an important and effective strategy by fire experts (although not all) to reduce risk but was perceived somehow negatively by the users of the open spaces. The diversification of the landscape was seen overall positively by the two communities.

Despite these differences, there was awareness amongst the fire experts about the high cultural value of the open spaces of Haifa and amongst the users regarding the need to reduce risk following the 2016 event. Potential synergistic strategies, those that maintain cultural value while reducing risk, are presented in the next section.

### 3.6. Analysis of the synergies

As mentioned, despite their expressed desire to preserve the quality of the green spaces, awareness of fire risk and of the need to manage for it surfaced in interviews with green areas users, while the fire experts also acknowledged the unique contribution of the open spaces of Haifa to the quality of life of its citizens. This mutual understanding opened the door for the identification of synergistic solutions out of the potential conflict.
For instance, according to the users of the open spaces, thinning was considered as having a potentially positive effect on nature experiences by contributing in clearing the trails and keeping the forest in a more ordered state, which today is considered as poorly maintained. Respondents also expressed that this strategy could potentially ameliorate the view from the wadis by improving or creating look-out points to the sea and the surrounding open spaces. The fire experts suggested that buffers and unpaved roads located between the buildings and the forest to facilitate the access of fire fighters, could provide additional trails and more opportunities for walking and exercising close to home. Removing pine trees and substituting them with less flammable oak or carob trees would allow to restore the ecosystem by using indigenous species, which is also highly appreciated by most of the green area users interviewed. Most visitors were aware that Aleppo pine trees are primarily introduced in the area and that these increase fire risk, and they were more willing to accept the implementation of this strategy.

As an additional way of overcoming potential conflicts, both the communities suggested that, besides looking at the social and ecological aspects of fire risk, consideration should also be given to the role of technology. In the case of forest fires in Haifa, the distribution of heat and smoke could be used to promptly detect a fire and help concentrate efforts in a more restricted area. Other technology-based strategies would entail improving buildings codes (e.g., using less flammable materials), using sprinkles and improving the distribution of watch-towers and patrols. All these strategies would potentially reduce the need to intervene intensively in reducing forest vegetation to reduce risk.

4. Discussion

Though our spatial analysis suggests that areas of Haifa most at risk from forest fires (in the south of the city) are also often those less valued by green space users, we characterized how, at the WUI, the desire to preserve the forest for aesthetic and recreational purposes (cultural services) can conflict with the need to enhance its fire regulating functions through the implementation of vegetation management strategies. We thus strengthen the perception that tradeoffs can emerge, particularly in the urban and peri-urban context, in the attempt to enhance the cultural versus the regulating functions of the ecosystem, and vice versa.

Several tradeoffs were in fact identified in which cultural services, in the eyes of the beneficiaries, may be degraded should vegetation management strategies be implemented across the city to reduce fire risk. Concerns about the need to preserve the uniqueness and “naturalness” of the forested areas of Haifa were strongly expressed by the community of users. So, despite the awareness of the risk of fires of Haifa, the stakeholders favored preserving the cultural value of the ecosystem over the need to improve its fire regulating functions. They expressed this bias mainly through ecological arguments based on a specific understanding of what is “nature” and what is “natural”. This condition is not restricted to the case of Haifa in Israel. The desire to live in proximity to nature and the consequent increase of the exposure to forest fires at the WUI has been documented in Europe and US, as reviewed in the introduction. Failure to account for these conflicts could lead to the lack of success of policy measures to reduce fire risk (McShane et al., 2011).

Conflicting perspectives regarding land use management decisions that force decision-makers to solve tradeoffs may vary according, for instance, to the “knowledge, values, and beliefs of the stakeholders” (Galassini et al., 2017, p. 2). “Ideas of nature” and “nature preservation” expressed by the open space users, which convey the idea that existing vegetation near their homes is a natural state of affairs, can obstruct the necessary interventions and increase exposure to forest fires. Previous literature has identified how landscapes give expression to deeply held values and understanding about nature, and such aesthetic and cultural values can conflict with other landscape management objectives, including those considered more “ecological” by experts (Nassauer, 1995b).

In our study, the respondents were not given detailed ecological information. The green open space users largely related to the existing ecosystem structure as “natural” despite the fact that it is the product of millennia of human-nature interactions. In this way, the use of the term “natural” by our respondents as a synonymous of pristine might reflect the sense of being in the wilderness rather than ecological health (see also Lindenmayer et al., 2006). Considering the case from a political ecology perspective highlights how certain ideas of nature, preferences and collective choices about ecosystem management potentially can become determining factors contributing to natural hazards and the scale of their impacts (González-Hidalgo et al., 2014; Oliver-Smith, 1999).

Divergent ecological knowledge or perceptions between the actors involved in the decision making process can cause the process simply to fail (Rist et al., 2016). Strengthening ecological literacy through educational activities may provide great opportunities to reduce these negative tradeoffs (Hahn et al., 2006; Loomis et al., 2001; McCaffrey, 2004). In an experiment carried out in Massachusetts in the U.S., participants’ knowledge about specific vegetation management strategies proved to positively influence support for vegetation management to reduce fire risk (Blanchard and Ryan, 2007). Similar results were also reported by Weisshaupt et al. (2005). In the case of Haifa, if all the stakeholders could be uniformly made aware of the “unnaturalness” of the pine forest or about the “unnaturalness” of decades of fire suppression, negative tradeoffs, potential conflicts and risk might be significantly reduced. In fact, amongst those aware of the natural history of Aleppo pine and fire risk, the substitution of pine forests with more local, less flammable species (such as carob and oak) was deemed as an acceptable intervention in the landscape. This is in agreement with the literature reporting how the perceived sustainability of the measure increases its acceptance (Cumming and Peterson, 2005; Power, 2010; Pretty et al., 2006; Xue et al., 2015).

Previous experience about forest fire might also increase acceptance, although this was not assessed in our study. Perceptions of risk from wildland fire are the result of experience and by beliefs about site-specific conditions (Blanchard and Ryan, 2004). Despite this, in the past, some residents of the Carmel forest in Tivon, whose homes were directly affected by forest fires, opposed post-fire management of the vegetation involving thinning or buffers around houses (Tal, 2013). A conflict situation that was mentioned also by the Israeli chief forester cited in the introduction and by the fire experts interviewed.

On the other hand, fire experts and policy makers would need to develop and implement policies which enhance the cultural value of the ecosystem, for instance by concretizing interventions that produce synergistic situations, such as those identified in our study. A study that implements these principles within the context of a post-fire restoration project in Haifa is described in Tessler et al. (2019).

To note is that we compared and brought together two different types of knowledge (i.e. stakeholders’ knowledge and experts’ knowledge): the first usually considered as more subjective (opinion-based); and the second considered as more objective (science-based). These might appear as not comparable. However, previous research stated that, often, the “boundary between individuals who hold different types of knowledge is blurry, and that, […] policy-making stakeholders simultaneously employ several types of knowledge” (Negev and Teschner, 2013, p. 50). This was also suggested by one of our fire experts who, as a policy maker, felt compelled to mediate between two different types of knowledge, that of citizens and that of experts, without being able to systematically lean towards one or the other. In this sense, although two different types of knowledge might carry different weights (especially in the context of disaster risk where stakes are high), the identification of synergies might be fundamental for a successful and lasting reduction of risk. As expressed by Tal (2013, p. 10).
172), “successful fire management clearly needs to entail “dialogue” with the affected public as much as it needs to control the vegetation”. Trust in authorities and the need to be adequately informed through the planning process was raised by some of the respondents as fundamental to accepting the vegetation management strategies. Similar results were found by Toman et al. (2014, 2011) and Winter et al. (2006, 2004).

We thus stress that the identification of synergies in this context is possible and paramount to attenuate potential emerging conflicts between cultural and fire regulating services at the WUI. We also stress that the technological component of the systems is an important aspect in mediating the tradeoffs (besides the social and ecological components), as it offers solutions to complement our reliance on vegetation management strategies. Increasingly, holistic work on urban areas defines these systems as social-ecological-technological systems (SETS), highlighting how, in cities, technological considerations are often equal in importance to the social and ecological considerations (Depietri and McPhearson, 2017; Grimm et al., 2016; Keeler et al., 2019).

5. Conclusions

Tradeoffs between the need to manage the forest to reduce fire risk at the WUI and the desire of city residents to live in proximity to green open spaces may generate conflicts in managing the peri-urban ecosystem for fire regulating services or for preserving and enhancing cultural services. Such conflicts are increasing due to the expansion of cities onto the surrounding forest. Urban sprawl into natural areas and the growth of the WUI improve opportunities for recreational activities but also increase the exposure of local populations, buildings and infrastructures to forest fires. Conflicts might lead to the disaster risk reduction strategies to fail by meeting a strong opposition from local inhabitants.

Haifa offers a great opportunity to investigate these issues due to the close contact of the built up areas with large areas of unmanaged and dense forest. Potential tradeoffs indeed emerged around the need to manage the open green spaces of Haifa to reduce fire risk while maintaining the highly valued sense of wilderness these transmit to local visitors, as well as the opportunities for observing wildlife and for recreational activities. However, the discussion took place during the interviews also allowed to identify potential synergies towards successful implementation. In these cases, either both goals could be met, or compromises could be implemented that would be acceptable to all parties.

To conclude, we suggest that certain notions regarding nature and landscape preferences can lead to opposition to certain vegetation management strategies in the context of fire risk, which in turn can lead to the increase of risk (and vice versa, that managing ecosystems for risk can impinge upon cultural and aesthetic preferences in landscapes). Different views and types of knowledge thus need to be reconciled finding synergies in order to successfully and durably reduce fire risk at the WUI.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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