



Incorporating economic valuation into fire prevention planning and management in Southern European countries

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Abstract

Aim of study: This article describes and analyzes the links between the fire-based scientific knowledge, the social perception of fire prevention and forest fires and the economic valuation requirements to assess social preferences for fire prevention measures.

Area of study: Southern European countries.

Material and Methods: For that purpose, we develop a critical revision of the existing literature on economic valuation of social preferences for fire risk reduction and fire prevention in terms of its links with fire science and social perceptions and the applicability of these results in fire management policies.

Research highlights: The assessment of social preferences for fire related issues is challenging due to the difficulty of setting sound valuation scenarios that can simultaneously be relevant for the respondents and derive conclusions useful for fire management. Most of the revised studies set up valuation scenarios focused on the final management outcome e.g. number of burnt hectares, what is easier for the respondents to evaluate but weakens the scientific relationship with fire management, making difficult reaching conclusions for sound management advice. A more recent set of valuation studies has been developed where risk perception of homeowners is further assessed as a key variable determining their preferences in valuation scenarios. These studies are relevant for managers setting fire prevention programs in wildland urban interface areas as understanding the factors that may promote or hinder the enrolment of these homeowners in fire prevention activities may have direct implication in addressing communication programs to promote fire prevention management.

Keywords: fire prevention; fire risk reduction; economic valuation.

Abbreviations: WTP- willingness to pay; CV- contingent valuation; CM- choice modelling.

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Introduction

Every year forest fires in the northern rim of the Mediterranean attract media attention and debate about forest management so as to minimize the losses; in particular when villages and infrastructure are affected too. The economic figures considered in elaborating fire prevention management plans usually reflect the private costs of these practices (e.g. unitary costs of machinery) while the social costs and benefits of implementing these measures are disregarded. Since these plans have a social impact, public preferences for fire management should be taken into account when design-

ing fire prevention strategies. However, these aspects are usually overlooked in the development of fire management plans. Improving the knowledge on these social preferences can contribute to filling this gap and promote the discussion on this topic that is largely absent, hopefully leading to more efficient and balanced debates on forest management policies (Holmes & Boyle, 2004; Mogas *et al.*, 2006). Economic valuation methods have been employed in non-Mediterranean countries as a tool to unveil social preferences for fire prevention management, allowing to estimate these social preferences and to evaluate how these are affected by changes in the management.

The Mediterranean is one of the hotspots of biodiversity at the global levels that is expected to suffer from extreme fire events due to climate change (FAO, 2013). However, its socio-ecologic systems and the underpinning causes of wildfires differ from that of other fire-prone landscapes. The Mediterranean has been subject to human presence during millennia, what makes some fire prevention approaches valid for other regions not directly transferable.

The objective of this paper is to discuss the challenges that practitioners may encounter in the design of economic valuation surveys to estimate the impact of fire prevention management. These challenges are discussed in the framework of the existing literature on economic valuation of forest fires and the lessons learnt from these studies that may be useful for future studies to be conducted in the Mediterranean.

Forest fires in Mediterranean countries

Wildfire has always played a major role in shaping many of the world ecosystems (Seijo & Gray, 2012), but fire frequency, extent, and/or severity have increased across the globe in recent decades (Bowman *et al.*, 2009). Mediterranean forests are recognized as a hotspot of biodiversity at the global level, providing a multiplicity of services (FAO, 2013). However, these services are under risk of degradation, where forest fires are nowadays the most important threat to Mediterranean forest ecosystems (Ministerio de Medio Ambiente, 1998; Valbuena-Carabaña *et al.*, 2010)

Large wildfires are relatively new in the recent history of the Mediterranean (Pausas *et al.*, 2008), being responsible for a significant percentage of the annual burnt area (Moreira *et al.*, 2011). Their severity and recurrence surpasses the capacity of these ecosystems to recover after the fire (Pausas *et al.*, 2008). As a result, a wide array of ecosystem services' flow to society will be interrupted or diminished due to the existence of wildfires (Barrio *et al.*, 2007).

The abandonment of farmland areas is assumed to be one of the main drivers behind the increase of the annual burnt area in the northern countries of the Mediterranean (Pausas, 2004; Duguay *et al.*, 2007; Loepfe *et al.*, 2010). The traditional rural mosaic that would make a sufficient fuel fragmentation is becoming scarce. Instead, the buildup of large and continuous fuelbeds facilitates fire spread (Pausas, 2004, Loepfe *et al.*, 2010).

Forest fires are also a severe problem in countries or regions such as the United States or Australia (Stephens & Ruth, 2005; Gill, 2005). However, one of the

most striking differences between those regions and these in the Mediterranean area is these millenary history of intensive and extensive land-use, resulting in strongly human modified landscapes that far from being wild (Pausas *et al.*, 2008), became cultural landscapes (Farina, 2006). Still and despite the socioeconomic changes that took place in the last decades in the European countries of the Mediterranean, fire is still linked to the persistence of traditional agrarian activities (Costafreda-Aumedes *et al.*, 2013), although the role of humans in fire danger is still to be clarified (Moreira *et al.* 2011). The strategies followed in those non-Mediterranean countries to reduce megafire occurrence are related to restoring pre-settlement fire regimes (i.e. forest fires regimes previous to the European colonization). The different socio-ecological setting in the northern Mediterranean countries determines the degree of exportability of these fire management strategies.

As a response to the fire problem that threatens not only ecosystems, but also human lives and infrastructures, southern European countries responded increasing their fire fighting budgets (Xanthopoulos *et al.*, 2006). However, despite the resources invested in fire prevention and suppression, the number of fires in recent decades has continued to increase remarkably (Moreira *et al.*, 2011). In fact, the reinforced funds on fire suppression policies observed in Mediterranean countries (especially after disastrous fire seasons) have shown their limited ability to remove the risk of major disasters if not coupled with appropriate fuel management strategies (Duguay *et al.*, 2007; Rigolot *et al.*, 2009; Moreira *et al.*, 2011). Furthermore, forest fire budgets have never been subjected to an objective and rigorous economic analysis indicative of the returns on investments in fire management programs (Rodríguez y Silva & González-Cabán, 2010).

The prevalence of extreme fire behaviour is however partly a consequence of effective fire suppression in the past century and it is nowadays a quite well known paradox (Pyne, 2001) resulting from fire policies that are focused in fire suppression and ignore or assign a minor role to fuel management. The term fuel management describes any mechanical, silvicultural, or burning activity whose main objective is to reduce fuel loadings or change fuel characteristics to lessen fire behavior or burn severity (Reinhardt *et al.*, 2008). Examples include mastication (e.g., flailing, chipping, and breaking), thinning, raking, prescribed fire used separately or in concert with the mechanical treatments (Reinhardt *et al.*, 2008). Fuels are the live and dead surface and canopy biomass that are burnt in wildland fire.

As Reinhardt *et al.* (2008) state, the primary objective for treating fuels is to make wildfire more acceptable (i.e. less severe), rather than to reduce wildfire extent or make it easier to suppress. Fuel treatments are therefore intended to help limit wildland fire sizes and severity by directly mitigating fire behavior and indirectly by facilitating suppression (Finney, 2001; Martinson & Omi, 2003). However the promise of fuel management has lately been loaded with the expectation of an array of benefits such as reducing suppression costs or acres burnt and preventing losses that would need an analysis of how effectively these benefits could be derived from the management action (Finney & Cohen 2003).

In the Mediterranean, fuel treatments have traditionally been based on forest compartmentalization by fuel break networks (Rigolot, 2002; Moreira *et al.*, 2011). These structures are effective stopping low intensity surface fuels. Contrary to what laypeople may think, these structures are mainly designed not to stop fires but to allow suppression forces a higher probability of successfully attacking a wildland fire (Agee *et al.*, 2000). These are intended to be safety areas providing quick access for fire fighters in wildfire suppression activities, playing an important role in controlling large fires (Syphard *et al.*, 2011).

Some studies conducted in the Mediterranean show that forest fires as an environmental problem attract much attention from the population (IESA/CSIC, 2007). Nevertheless, this high awareness is not coupled with a good understanding of the fire problem, with important disparities existing between statistics on forest fire causes and citizens' perception on forest fire causality (APAS & IDEM, 2004; De Castro *et al.*, 2007).

The role of economic valuation in fire prevention planning

Fire management plans developed by public agencies are mainly based on technical and budget criteria. This may be the best strategy in so far that the differences in management are small, technical and not visible to the general public. However, fire prevention has large impacts on the visual perception of the landscape, and wildfires affect many non-market forest goods and services that are important to society, including air quality, soil productivity, water quality and quantity, habitat for native fauna and flora, recreation opportunities, cultural heritage, and carbon sequestration and storage (Venn & Calkin, 2011). When these non-market values are under-recognised, forest management decisions tend to be suboptimal, with forests and the ben-

efits they provide often being lost or degraded (Holmes, 2004).

Economic valuation techniques allow the estimation in monetary terms of the expected benefits and costs resulting from the use or enjoyment of an environmental good or service, from an environmental enhancement or from an environmental damage. This section presents a revision of valuation studies aiming to incorporate social preferences for different aspects related to the influence of fire events and forest fire prevention on social preferences. A summary is also provided in Table 1.

Seminal economic valuation studies on the effects of forest fires focused on assessing their impact on the recreational demand function of the citizens (Vaux *et al.*, 1984). Loomis *et al.* (2001) examined the temporal effects of fires on the welfare of recreationists in Colorado and found that their annual consumer surplus was much higher after a crown fire than following a non-crown fire or for the pre-fire forest condition. Hessel *et al.* (2003) found that recreationists would experience decreases in annual consumer surplus following a fire from the year of the fire to 40 years post fire. In contrast, Montanan recreationists' welfare was not substantially affected by crown or prescribed fire (Hessel *et al.*, 2004). All these studies focus on the outcomes of forest fires, i.e. the scenarios that they evaluate are ex-post scenarios, in which the event has already taken place and the respondents are asked to provide their WTP for different post-fire scenarios.

More recent studies, presented below, have focused on assessing the WTP of the citizens for the implementation of preventive measures to protect certain ecosystems or their own properties from forest fires, i.e. ex-ante valuation scenarios, also considering both use and non-use values. Accordingly, contingent valuation (CV) and choice modelling (CM) techniques are employed for this purpose. The economic valuation of programs aimed at preventing forest fire occurrence is challenging since the surveyed population should be presented with credible scenarios that would allow for the desired decrease in fire risk. It contrasts with the non-predictable nature of forest fires, whose occurrence relies in probabilistic functions difficult to convey to the population. The CV or CM studies listed below address these aspects in different ways. Most of them present enhanced fire prevention scenarios with an expected decrease in burnt hectares.

The seminal study by Loomis & González-Cabán (1994) focused on depicting fire prevention programs to diminish the incidence of fire. They assessed the WTP for increased fire prevention in Colorado that would reduce the number of acres of critical habitat burnt from 11 square miles to 5.5 square miles. The high

Table 1. Summary of stated preference studies revised

Authors	Year	Aim of the study	Valuation technique	Region
Vaux <i>et al.</i>	1984	Temporal effects of fires on the welfare of recreationists	CV	California(US)
Loomis & González-Cabán	1994	WTP for increased fire prevention of old-growth forests	CV	Colorado (US)
Loomis & González-Cabán	1998	WTP for implementing a management plan to reduce acres of old growth forests	CV	California and Oregon (US)
Loomis <i>et al.</i>	2004, 2005, 2009	WTP for prescribed burning or mechanical fuel reduction programs	CV	California, Florida and Montana (US)
González-Cabán <i>et al.</i>	2007	Testing whether differences in WTP for fuel reduction programs exists between native Americans and general population	CV	Montana (US)
Riera & Mogas	2004	WTP to fund a fire prevention program that would reduce by half the annual burnt area.	CV	Catalonia (Spain)
Kaval <i>et al.</i>	2007	WTP for prescribed burning measures	CV	Colorado (US)
Walker <i>et al.</i>	2007	WTP for fuel treatment programs	CV	Colorado (US)
Winter & Fried	2001	WTP of homeowners for reducing fire risk in their homes	CV	Michigan (US)
Talberth <i>et al.</i>	2006	WTP for risk reduction options	CV	New Mexico (US)
Holmes <i>et al.</i>	2012	Evaluate the value to homeowners in Florida of public and private programs to reduce wildfire risk.	CM	Florida (US)
Varela <i>et al.</i>	2014a 2014b	WTP for changes in the management of fuel breaks	CM	Malaga (Spain)
Riera <i>et al.</i>	2007	WTP for a mitigation program to reduce the expected effects of global warming. Trade-offs between three climate-sensitive attributes of shrubland: plant cover, fire risk and soil erosion	CM	Catalonia (Spain)
Soliño	2010	WTP for a program to produce electricity from forest biomass that among other benefits would reduce the risk of forest fires	CM	Galicia (Spain)
Soliño <i>et al.</i>	2010	WTP for a forest-energy programme that would contribute to reduce the risk of forest fires	CV	Galicia (Spain)
Mavsar <i>et al.</i>	2013	WTP for forest management involving trade-offs between fire prevention and ES provision	CM	Slovenia

rate of protest responses was explained by the authors as due to the lack of trust of the respondents on the success of the fire prevention program. Loomis & González-Cabán (1998) tested WTP for implementing a management plan to reduce acres of old growth forests that burn in California and Oregon and are the habitat

for the spotted owl. A fire prevention and control program based on early fire detection, increased fire prevention and quicker and larger fire control response was presented to respondents. The program would reduce the acres of high intensity fires and total acres of old growth forests burnt by all intensities of fire by 20%.

This study estimated changes in social welfare arising specifically from the responses of animal species to wildfire, assessing this way the social preferences for changes in the provision of a natural amenity that may occur due to wildfires (Venn & Calkin, 2011). Loomis *et al.* (2004; 2005; 2009) and González-Cabán *et al.* (2007) tested the WTP of different populations in the United States for prescribed burning or mechanical fuel reduction programs expected to reduce forest fires in 25% and the houses destroyed by fire from 20 to 8. The advantages and disadvantages of the mechanical technique are presented while these were lacking for the prescribed burning. In their results they obtained a higher number of protest responses for the mechanical methods. The authors hypothesized that this may be due to the lack of information on pros and cons for the prescribed burning. Riera & Mogas (2004) estimated the WTP of Catalan population to fund a fire prevention program to reduce by half the annual burnt area. This program included biomass reduction, thinning along roads and inhabited areas and increased number of fire watching guards. Kaval *et al.* (2007) tested WTP for prescribed burning measures in public lands of residents living near the Colorado wildland urban interface. Respondents were told that the use of prescribed burning could reduce by half the frequency of a wildfire in the public land surrounding their homes. Kaval *et al.* (2007) found that the support of the respondents to adopt a fire risk mitigation policy depended on perceived fire frequency intervals. Walker *et al.* (2007) also employed a CV referendum format to test whether residents in Colorado were willing to pay for fuel treatments programs, i.e. thinning and prescribed burning. It seems that they did not specify the exact expected outcome of these programs. They compare WTP estimates between wildland urban interface (WUI) and urban residents and found similar results for both subsamples with mean WTP for thinning higher than for prescribed burning in all samples. Varela *et al.* (2014a, 2014b) conducted a CM survey in the province of Malaga (southern Spain) where respondents were asked to make trade-offs among fuel break management scenarios, each of them showing different combinations of fuel break cleaning technique, design of fuel breaks and density of the fuel break network (coupled with an expected decrease in burnt area). The density of the fuel break network is the attribute that determined preferences to a greater extent. This study also showed that although significant heterogeneity on preferences exists, being knowledgeable on fire causality and perceiving forest fires as an environmental problem are two of the features contributing to explain this heterogeneity.

A more recent set of valuation studies has been developed where risk perception of homeowners in the

WUI is further assessed. These studies have namely been conducted in the United States where the share of residents living in the WUI is quite significant. Protecting private properties and human lives from wildfires represents important costs for public administrations. Hence, private owners are encouraged to undertake fire prevention activities in their properties, setting defensive spaces where biomass is reduced, decreasing the probability of severe fires taking place. The subjective process of risk assessment that the homeowners go through and which may either amplify or dampen objective risk information, seems to play a key role in the willingness of homeowners to go through these activities (Talberth *et al.*, 2006).

Winter & Fried (2001) conducted a CV study to estimate the WTP of homeowners in Michigan to reduce the fire risk by 50% in their homes. They build a conceptual model on risk perception and how it affects the decision to participate in the hypothetical market. They found that forest owners rejected actions because the presence of vegetation outweighed the perceived danger (“*people live in the woods to live in the woods*”). Talberth *et al.* (2006) conducted a CV survey in New Mexico where participants made simultaneous choices between wildfire insurance and three types of averting activities. They found that insurance and averting activities are not substitutes but rather are purchased together to address both tangible and intangible losses. Holmes *et al.* (2012) conducted a CM survey with three attributes (risk, loss and cost) and employed a 1,000 square lattice to illustrate the probability of a wildfire damaging the home of the surveyed individuals. The level of risk varied from 1% to 5% and the alternatives offered public and private protection. They discussed the applicability of the prospect theory (Kahneman & Tversky, 1979). It states that individuals treat probabilities as decision weights and simplification rules are used to facilitate decision-making in complex situations. Accordingly, the value function proposed by prospect theory predicts that when faced with the risk of a loss of wealth, people are generally risk seeking. Kahneman & Tversky (1979) argue that this type of behaviour results because people overweight a certain loss (the payment) relative to a probable loss (the gamble). The results in Holmes *et al.* (2012) showed that while nearly all respondents had risk seeking preferences, a small segment of respondents were risk neutral or risk averse. Only respondents who had personal experience with the effects of wildfire consistently made trade-offs among risk, loss and cost and these respondents were willing to pay more for wildfire protection programs than were these respondents without prior experience of the effects of wildfire. These findings are in line with other studies that have stressed

the influence of current status quo perception in the obtained valuation estimates (Domínguez-Torreiro & Soliño, 2011).

Challenges faced when evaluating welfare change arising from wildfires as natural disturbances include insufficient scientific information to assess how non-market forest goods and services are affected by wildfire and a dearth of studies that have estimated marginal WTP to conserve non-market forest goods and services (Venn & Calkin, 2001). We would add the inherent difficulties in setting up valuation studies that convey simultaneously scenarios credible for the population and meaningful for the decision makers.

Finally an array of studies exists that show fire risk or burnt area reduction as an outcome of broader management policies, aimed at reducing global warming (Riera *et al.*, 2007), increasing the biomass share in energy production (Soliño, 2010; Soliño *et al.*, 2010; 2012) or assessing perceived trade-offs between fire prevention and provision of ecosystem services (Mavsar *et al.*, 2013).

Discussion

Forest fires can be considered as a public bad and hence the set up of fire prevention systems in public forests as a public good. All the population may benefit from fire prevention management without exclusion or rivalry, although the array of avoided costs (benefits) may differ among different citizens. The social concern that exists towards forest fires makes it reasonable to hypothesize that changes in the management of fire prevention systems may have an impact on the welfare of the population. This change in welfare is usually neglected and not accounted for, with management decisions most often based on financial and ecological criteria. As an example, the set up of fuel break networks, which is one the prevention measures undertaken by forest agencies, may produce a number of externalities, both positive (as these are expected to contribute to decrease the number of burnt hectares) and negative (negative impacts on the landscape or increased soil erosion).

A general problem in valuation studies is that the valuation scenario should be understandable and meaningful for the respondents, retrieving significant results for its analysis and at the same time the outcomes should be relevant for decision making and consistent with the management instruments employed. In setting up the valuation scenario, causality is a key aspect to consider when selecting the attributes/scenario to describe the environmental good or service to be valued. Upstream or causal scenarios depict fire prevention programs for their valuation by the respondents (e.g.

Walker *et al.*, 2007), i.e. prescribed burning or thinning activities to reduce biomass. In contrast, effect scenarios/attributes evaluate the social preferences for the effects of these prevention programs, i.e. reduction in burnt hectares or in burnt properties. The studies presented above can be assessed in relation to the way they approach causality issues.

The seminal studies presented at the beginning of the previous section are focused on ex-post scenarios, and hence more credible and easier to approach from a valuation point of view, as they are focused on effect scenarios that are already known. Hence the challenge on how to address causality relates to valuation studies focused on ex-ante approaches.

Causal attributes are often more policy relevant and measurable than downstream attributes (Blamey *et al.*, 2002). The drawback of adopting a causal approach is that respondents are left to reach their own conclusions on the benefits derived from the proposed changes, i.e. on the effectiveness or degree of success of such programs. This is something highly undesirable when respondents hold a low familiarity with the good to be valued. In contrast, respondents usually find it easier to choose these attributes or scenarios linked to the benefits or effects that can be obtained, e.g. number of burnt hectares. The second block of studies presented above uses a mixed approach, where respondents are asked to provide their preferences for a series of fire prevention management options (causal attributes), in presence of a fixed outcome in relation to the burnt area (e.g. Loomis *et al.* (2004, 2005, 2009) and González-Cabán *et al.* (2007)). The drawback of this approach is that the scientific link between action and end effects is many times uncertain and difficult to prove. The study by Varela *et al.* (2014a, 2014b) was developed in a Mediterranean context and conveys simultaneously information on fire prevention and outcomes related to the expected burnt area. Thus, respondents expressed their preferences both for causal attributes (design of fuel breaks and cleaning techniques) and for effect attributes (density of fuel breaks and expected burnt area). This approach allows to covering meaningful management attributes and securing that the respondents do not reach their own conclusions about the expected results of these prevention actions.

However, conveying concepts such as severity and uncertainty to the respondents is challenging, being the number of studies addressing these aspects still scarce. The studies conducted by Winter & Fried (2001) and Holmes *et al.* (2012) can serve as a good reference in this regards, as they present the respondents with scenarios closer to reality where the outcomes of a series of prevention activities are no longer precise but probabilistic.

Also these studies are relevant for managers setting fire prevention programs in WUI areas, that in the Mediterranean are becoming increasingly important for the challenges they pose to landscape managers and fire fighters (Badia *et al.*, 2011). The WUI that was not so relevant in the past is becoming increasingly important in the Mediterranean due to the expected increase in the likelihood of extreme fire events; the urban sprawl near forest areas makes WUI settlements extremely vulnerable to wildfires. Hence, understanding the factors that may promote or hinder the enrolment of these homeowners in fire prevention activities may have direct implications in addressing communication programs to promote fire prevention management in these areas.

To sum up, the dearth of studies conducted in areas other than the Mediterranean can provide useful insights in setting up valuation studies that are still scarce in the Mediterranean. Despite some common design features that can be learnt from these studies with specific consideration of causality aspects some Mediterranean specificities should be considered when designing fire prevention policies such as the broader context of the forest fires issues, the effects of climate change (Riera *et al.*, 2007), the active management of these forest and biomass use possibilities to reduce the incidence of fire (Soliño, 2010; Soliño *et al.*, 2010; 2012) or the social perception of forest fire causes and prevention structures (Varela *et al.* 2014a, 2014b).

Finally a pending issue in all these revised studies is to convey to the respondents the complex relationship between fire prevention and reduction of burnt area, affected by a wide array of other factors that interact in a non-linear manner.

Conclusions

Fire prevention measures may have a high visual impact on the landscape and forest fires raise a high social awareness. The effectiveness of fuel management should also take into account the benefits for fire suppression actions and the reduction of the environmental and the socio-economic impact of wildfires (Moreira *et al.*, 2011). Setting up valuation studies provides with additional criteria for decision makers and allows making more balanced decisions considering social preferences for these changes. These studies may represent a first step towards the public review of fire related policies, which are scarcely debated (Syphard *et al.*, 2011). However, the assessment of social preferences for fire related issues is challenging due to the misconceptions and disparities between

social perception and statistics regarding fire causality.

The primary criterion to select the attributes in a valuation study is that these attributes should be understandable and meaningful for the surveyed population. In addition the attributes should also retrieve results that are useful for managers and decision makers in the implementation of policies. The consideration of causality and effect in the election of attributes is relevant in the achievement of such a balance.

Climate change in Southern European countries will force institutions to acknowledge and embrace uncertainty in the future since we are moving into a time period with few analogues, being the strategic goal to encourage gradual adaptation and transition to inevitable change, and thereby to avoid rapid threshold responses that may occur otherwise (Stephens *et al.*, 2010). To incorporate local populations and foster co-responsibility in the management of natural resources, these messages should be appropriately conveyed to the general public as well as managers should have a better knowledge of social preferences for the different management options.

Valuation studies assessing social preferences can contribute to inform these new management trends in fire management. This type of studies, more developed in the United States where wildfires are very relevant, are still very scarce in the Mediterranean (see Table 1), existing an important room for their development. These studies may contribute to the decision making process that nowadays is largely driven by technical and ecological criteria.

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