Jesús Rodrigo-Comino
Luca Salvati *Editors*

Fire Hazards: Socio-economic and Regional Issues

Springer

Fire Hazards: Socio-economic and Regional Issues

Jesús Rodrigo-Comino · Luca Salvati
Editors

Fire Hazards: Socio-economic and Regional Issues

Springer

Editors
Jesús Rodrigo-Comino
Department of Regional Geographic Analysis and Physical Geography
University of Granada
Granada, Spain

Luca Salvati
University of Rome La Sapienza
Roma, Italy

ISBN 978-3-031-50445-7 ISBN 978-3-031-50446-4 (eBook)
https://doi.org/10.1007/978-3-031-50446-4

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Paper in this product is recyclable.

Contents

The Cost of Forest Fires: A Socioeconomic Analysis

Zoran Poduška and Snežana Stajić

Abstract This chapter aims to show the phenomenon of forest fires from socioeconomic aspects to present the readers with a new perspective. We start from the assumption that fire in forest ecosystems has a positive and negative impact, which can be represented by an appropriate valuation system. The basis for such an assumption was found in the paradox of fire (in natural ecosystems), which has had human attention from the very beginning of the human population. From early views on social dependence on fire to a modern perspective, that fire is a catastrophic phenomenon in nature. Today, it can be assumed that our valuation system is set at a point where fire harms nature. This tacit acceptance has become commonplace in fire reporting where the importance of fire in removing biomass especially coniferous stands, maintaining open spaces for grazing and hunting, reducing catastrophic wildfires, in carbon balance and water regulation or scientific knowledge is almost completely omitted. Contemporary streams in nature and forest science and practice point out that fire is an ecosystem service providing many services with trade-offs between fire prevention and the provision of ecosystem services. Here, we explain why fire in natural ecosystems become relevant for science after the eighties. We present that the extent of fire damage is more than 0.012% of Worlds GDP in this decade. Major socioeconomic driving factors of forest fires are presented too. The chapter presents examples of ecosystem services and economic impacts provided by wildfires.

Keywords Wildfire · Natural disturbance · Ecosystem services · Valuation · Human well-being

Z. Poduška (✉) · S. Stajić
Department of Forest Management Planning, Organization and Economics, Institute of Forestry, Belgrade, Serbia
e-mail: zoran.poduska@forest.org.rs

Department of Forest Establishment, Silviculture and Ecology, Institute of Forestry, Belgrade, Serbia

S. Stajić
e-mail: snezana.stajic@forest.org.rs

J. Rodrigo-Comino and L. Salvati (eds.), *Fire Hazards: Socio-economic and Regional issues*, https://doi.org/10.1007/978-3-031-50446-4_10

1 Introduction

Socioeconomic analysis of forest fires is a two-way process. It could be analyzed by the role of socioeconomic factors in driving forest fire activities and analyzed as well in the allegedly opposite direction as the role of forest fire on society, economy and environment. But this is not the final division of forest fires from a socioeconomic aspect. Forest fires at the same time are considered occurrences with damages (Sil et al., 2019) and occurrences with benefits (Pausas & Keeley, 2019). Analyzing these opposite views, here, we primarily accepted the use of the term fire instead of wildfire. Term fire in socioeconomic and valuation studies enables a more balanced perspective of positive and negative contributions to human well-being (Shackleton et al., 2016; Pausas & Keeley, 2019).

Following such opposed attitudes regarding fire but with the orientation toward neutral analysis, it is justified to use the perspective that fire in natural ecosystems has dual effects on human well-being. In literature, this perspective is embedded in an ecosystem services–disservices perspective (de Groot et al., 2002; Shackleton et al., 2016; Depietri & Orenstein, 2019). This perspective indicates that fire can in some cases decrease human well-being and then we call it disservices (Shackleton et al., 2016) on opposite fire in some cases can increase human well-being and then we call it services (Pausas & Keeley, 2019). Following that perspective, our analysis is based on the assumptions that fire in forest ecosystems has a positive and negative impact, which can be represented by an appropriate valuation system.

The basis for such an assumption was found in the fire paradox (in natural ecosystems), which has had human attention from the very beginning of the human population. In the scientific community by fire paradox sometimes is understood as a situation when the results of research about fire are opposite of what scientists were going to find (Georgiou, 2022). Fire as a global and regular component of forest ecosystems consist of several paradox, too. The first and most recognizable paradox is placed in the traditional phrase[1] about fire as a master and a servant. This phrase carries a strong message that fire is useful when monitored and controlled however, left unattended, it is quite dangerous and destructive (Hills & MacGibeny, 2015). The next paradoxes are derived from the tacit acceptance that forest fires are destructive disturbances leading to very costly, extremely damaging effects on nature (Lynch, 2004). For example, newspapers and magazines report a catastrophic forest fire, but only 1% of all forest fires become catastrophic. It is completely justified to ask what the character of other forest fires is that gives us the epithet of catastrophic. The answer is not simple or is already contained in the view that the emergence of forest fires as a global and regular component of the forest ecosystem consists of paradoxes connected with the value of ecosystem products and services from a socioeconomic perspective.

---

[1] "*Fire is a good servant but a bad master*".

2 Valuation Studies Related to Forest Fire and Socioeconomy

Here, we analyze the phenomena of a forest fire from a socioeconomic perspective based mainly on valuation studies. The analysis starts with the search for appropriate documents in scientific databases. Scientific interest in fire in natural ecosystems is relatively new, which is presented in Fig. 1.

We used the Scopus (2020) scientific journal database that served us for the socioeconomic analysis of forest fires. We analyze scientific articles containing the terms fire/wildfire/cost in titles, abstracts and keywords. Most of the articles were published in the USA, Canada and Australia. In Asia, most of the papers were published in China and India and Europe in Spain, the UK, Italy and Portugal. Figure 10.1 presents the number of documents, mainly research papers in scientific journals with thematic of the valuation of the forest fires. The number of documents is presented per country, funding sponsor, subject area and year.

Increasing interest in fire is especially noticeable at the end of the '80s. This interest is explained by the occurrence of large fires that are broadcasted by media on a global scale. It is directly related to Ash Wednesday bushfire in Australia at the year 1983 and the forest fire in Yellowstone National Park (NP) at the year 1988. Forest fire in NP Yellowstone lasted longer than three months over an area of more than 1.400.000 ha with suppression cost of $120 million and 25.000 firefighters, until the evening of September 14, when approximately 1 cm of snow fell, extinguishing

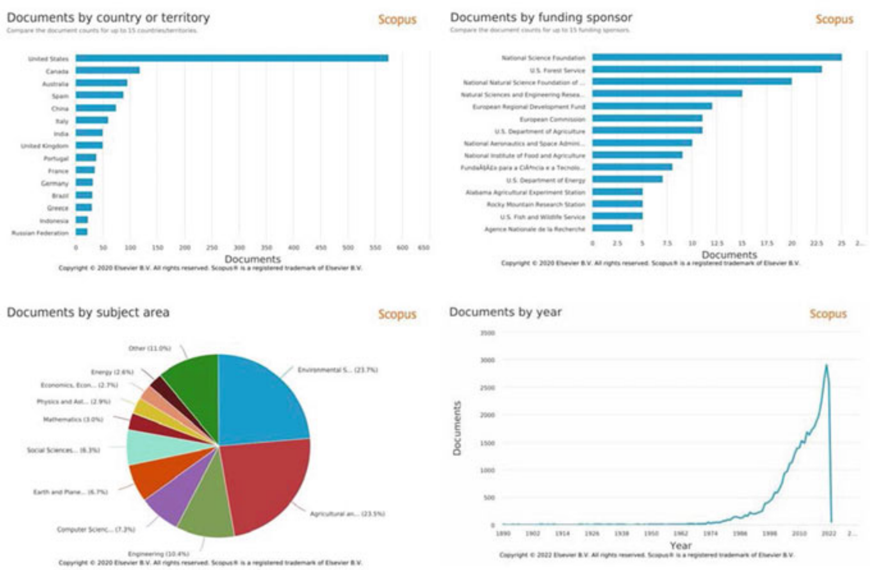

Fig. 1 Documents with thematic forest fire/wildfire and cost in Scopus

the fire (Keeley, 2009; Wallace, 2004). This sequence of events indicates that (this) fire in NP Yellowstone is a natural phenomenon that occurs every 300–400 years due to a specific meteorological phenomenon as a result of a combination of drought, temperatures and dry thunderstorms with lightning strikes and high winds (Wallace, 2004). After that, there was an almost exponential growth of published papers in scientific journals related to fires in the period 1985–1995 (Keeley, 2009).

2.1 Role of Forest Fire on Society, Economy and Environment

The growing interest of the scientific community in fires in natural ecosystems was followed by the formulation of several hypotheses and theories from a socioeconomic aspect. Such theories and hypotheses are (i) the grandmother hypothesis; (ii) the bipedalism hypothesis; (iii) the fire in nature as extraterrestrial origin hypothesis; (iv) the pyrodiversity–biodiversity hypothesis and (v) the Pyrocene theory.

One of the oldest social impacts of fire on humans is illustrated through the interpretation of the "grandmother hypothesis." It implicated that by softening food, the fire could have had a large effect on extending the human life span beyond the age of good-quality teeth which is related to child care by grandmothers and with social development and human evolution (Hawkes, 2004).

Bipedalism as a significant part of hominization is hypothesized to have some connections with fire-prone regions. The origin of human endurance bipedal could be connected with collecting underground plant structures widely spaced in fire-prone ecosystems (Lieberman, 2013). Such plants protect themselves from fire by growing belowground storing carbohydrates as a significant part of human dietary differences.

Among all other natural disturbing processes on Earth, fire has been hypothesized to have in some occurrences extraterrestrial origin, especially in Pleistocene megafauna demise (Firestone et al., 2007). Contrary to other natural hazards such as earthquakes or windstorms, wildfires are certainly among the most predictable ones (Birot, 2009). Multiple ecological hypotheses suggest that high pyrodiversity will lead to high biodiversity (Jones & Tingley, 2022). The hypothesis that "pyrodiversity begets biodiversity" still lacks in the synthesis of findings (Bowman et al., 2016) but there is an initial and contemporary theory. Fires as agents of biodiversity hypothesized that prehistoric fire regime promotes diverse biota but contemporary theory suggests that after many decades of fire suppression, we have reduced pyrodiversity which can lead to reduced biodiversity (Martin & Sapsis, 1992).

The Pyrocene theory reveals that Planet Earth is entering the age of mega-fire where there is no place for fire naivety (Nimmo et al., 2021). In today's fire-centric perspective, humans continue to shape the Earth in a specific pact with fire. Both fire and people exist in a mutual-assistance pact, but where humans could not

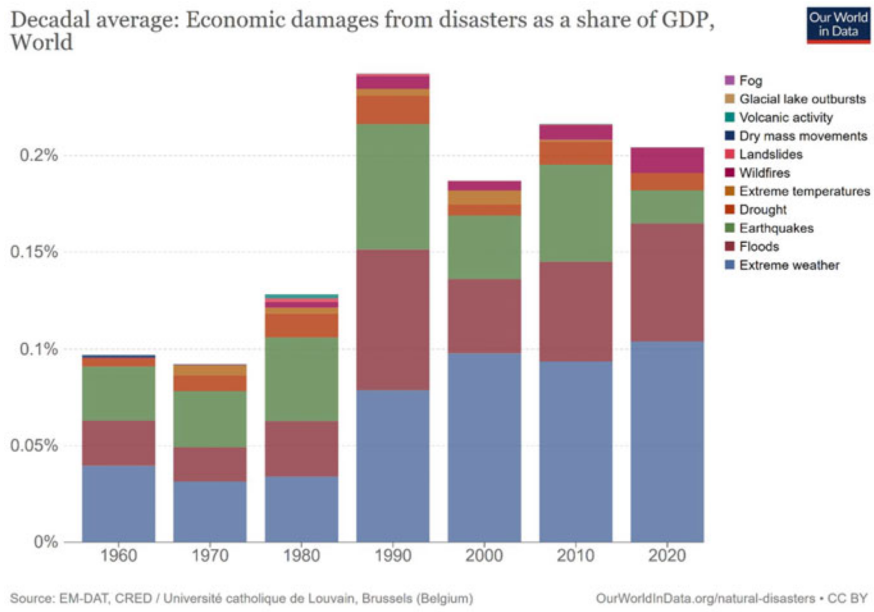

Fig. 2 Damages from fires among natural disasters as a share of GDP—world scale. *Source* (Ritchie et al., 2022)

exist without fire. Especially without the so-called "third fire" which is industrial combustion (Pyne, 2022).

2.2 *The Cost of Damages from Fires as Natural Disaster*

Today, it can be assumed that our valuation system is set at a point where fire harms nature. In that sense, reports about natural disaster damages from fires are presented too. The first global assessment of damages from fires counted from the decade 1960 and it is presented in Fig. 2.

The assessment indicates that the damage from the fire is $7.06B (Ritchie et al., 2022). According to the same source, the extent of fire damage varies across continents. In America (North and South), economic damages from wildfires are assessed at $6.65B, in Europe $282.67 M, in Asia $77.33 M, in Australia and Oceania $43.3 M, and without estimation for Africa. The damages from the fire are also assessed as a share of GDP.[2] The total share of damage from a fire disaster in GDP is highest in the ongoing decade 2020 and it is more than 0.012% of GDP, for the decade 2010 (> 0.007%). From 2000 to 2010, it reached > 0.005%, in the decade 1990 > 0.006%, and from 1980 to 1990 > 0.003. Finally, from 1960 to1970, the numbers reached <

[2] Gross domestic product.

0.001%. In more than 60 years, damages from fire as natural disasters increased by almost 12 times according to the share in GDP.

2.3 Socioeconomic Factors in Driving Forest Fire Activities

More than 90% of the forest fires in Europe are caused by human activities, behaviors and attitudes (Barbero et al., 1990; Martinez et al., 2009). In an econometric analysis, Michetti and Pinar (2013) revealed some major driving factors of forest fires (Table 1).

Specific patterns, frequency and affected area reveal that forest fires are not only related to meteorological and climate conditions (Ratknić, 2019) but also to socioeconomic causes (Birot, 2009). The ignition, in most cases, is related to human activities (agriculture, forestry, garbage removals or power lines) and behavior (recreation, delinquency or smoking) (Barbero et al., 1990; Catry et al., 2010; Martinez et al., 2009). Fire occurrence could be accidental too, although fires are considered catastrophic natural disturbances. However, human influence on fire is the greatest compared to all other natural disturbances. Regardless of economic and technological development, humans still have management authority over the fire, while storms, hurricanes, earthquakes and volcanic eruptions have no influence.

2.4 How (Fire in) Nature Always Works for the Benefit of Humans

The attitude toward fire in the sense that it is a benefit has its origins in the Utilitarian theory which addresses that nature always works for the benefit of humans. Based on similar premises, Pausas and Keely (2019) summarized the benefits to humans of living in a flammable world, even if it is well-known that forest fires are far from natural origins. These premises are criticized to be conceptually incorrect and misleading to policymakers and resource managers (Sil et al., 2019). Table 2 presents examples of ecosystem services provided by recurrent wildfires.

Fire as a tool for nature management is mainly related to primitive man who, when he "learned" to use it, provided himself with heat-treated food, increased soil fertility, regenerated natural vegetation for grazing and controlled competing vegetation (Damianidis et al., 2021). Contemporary streams in natural and forest science and practice point out that fire is an ecosystem service (Pausas & Keeley, 2019) providing many services with trade-offs between fire prevention and the provision of ecosystem services (Mavsar et al., 2013). Forest ecosystems fulfil a multitude of functions and services simultaneously including, producing timber and biomass, protecting the soil from erosion, and recreational tourist, spiritual and cultural experiences. In such an environment, the occurrence of various disturbances is expected. Fire is one of the most predictable disturbances that can be expected to have both

Table 1 Major driving factors of forest fires (Michetti & Pinar, 2013)

Cause	Impact on fire	Description of impact
Population density	Mixed	More urbanization reduces impact due to proper land management close to fully biomass removal as potential source of fire More human nature interaction increases possible accidental fire ignition
Infrastructures	Mixed	A greater number of roads and railways may put more pressure on wild lands raising possible ignition causes. Nevertheless, good communication routes may help fire prevention and suppression
Agriculture and pasture intensification	Mixed	Fire is often used by shepherds and farmers to (i) maintain herbaceous vegetation only; or (ii) eliminate wasting harvest in borders of croplands, (iii) remove pests
Education	Negative	More educated people may have a higher civic sense which helps containing the number of fires due to human perverse behavior or accidents
Unemployment total/ male/female; poverty level	Positive	Higher unemployment levels may provoke people from setting forests on fire for profit reasons
Depopulation of rural areas	Positive	It contributes to land abandonment and spontaneous colonization of natural vegetation with leading to increment in forest biomass, and consequently in greater forestland flammability
Tourism	Mixed	Tourism in forests areas could raise the probability of ignition by accident or negligence (campfires, smokers) From the other side management of forest recreation areas could decrease probability of forest fires
Presence of illegal activities	Positive	Initiation of forests fires to gain land for agriculture or pasture, tourism and recreation
Railway density	Positive	Improving safety in the railway network is expected to have a supportive impact in reducing fire events
Grazing activity by domestic animals (cattle, goats, sheep, horses, donkeys, pigs)	Mixed	Bovine grazing, which has almost no impact on reducing fire frequency, seems to help in containing the spread of fire The presence of caprine animals affecting positively both fire frequency and extension
Educational level in population	Negative	Increasing education levels decreases frequency and intensity of fires
Employment in the: agricultural/industry sector	Mixed	Agriculture activity puts pressure as well as generates protection against, forest fires Mixed effects but confirming a link between profit motives and forest fires

(continued)

Table 1 (continued)

Cause	Impact on fire	Description of impact
Criminal activities	Positive	Illegal activities have impact on fire frequency, but no impact on the total area burnt
Policy aspects/forest management plans	Positive	Coniferization increase possibility of fire occurrence and spreading

Source (Michetti & Pinar, 2013)

positive and negative impacts on possible objectives of ecosystem management (Silva et al., 2010; Keely & Pausas, 2022).

Supporting services are necessary for the production of all other ecosystem services (MA, 2005) where forest fires contribute to a range of ecosystem services. Some of these services are pollination, the evolution of a diversity of shade-intolerant plants, habitat heterogeneity, and breaking physical dormancy in forest tree seeds.

One of the oldest provisioning services lasting today, and as we mentioned above, it has been hypothesized that fires are agents of biodiversity (Martin & Sapsis, 1992). Humans can modify the landscapes through fires as a powerful ecological force that can positively or negatively affect the risk of economically disruptive fires by reducing catastrophic fires (Bowman et al., 2016). But reductions in burn probability are not always beneficiary. It depends on the site-specific consequences of fire (Thompson et al., 2017) and it might be desirable to increase the conditional probability of low-intensity fire for restoration objectives (Ager et al., 2013).

3 Economic Impact of Forest Fires

To better understand the economic impact of forest fires, Table 3 presents the costs derived from large fire occurrences based on Diaz's (2012) analysis.

The impact of large forest fires is presented in several cost types: natural areas, local community, business, suppression costs and post-fire rebuilding. Fire affects products and services in natural areas. The cost of timber affected by the fire is assessed at $2.995/ha. The cost of watershed protection as a regulatory ecosystem service is assessed at $311/ha.

Local communities as well lose significantly from forest fires through lack of tourist visits, infrastructure and property damages, and harm to residents and fire-fighters. Tourism losses are $682/ha when closing natural areas during and after the forest fires. Property losses calculated by damaged or lost homes are assessed at $59/ha. Effects of smoke on health are assessed through medical costs of $72/ha and suppression cost reaches $494/ha.

In an economic analysis of the impacts of wildfire, it is concluded that positive effects come from the economic activity generated in the community during fire suppression and post-fire rebuilding (Diaz, 2012). Besides suppression costs, local

Table 2 Examples of ecosystem services provided by recurrent (wild)fires

Type of ecosystem services	Examples of ecosystem services provided by (wild)fires	Used by human societies
Supporting	Formation of open habitats that enable the evolution of a diversity of shade-intolerant plants	Early
	Enables evolutionary processes (via natural selection and evolution) and ecological processes (via habitat heterogeneity) or breaking physical dormancy in forest tree seeds	Early; contemporary
	Species conservation, including the conservation of some ecological processes (e.g., pollination)	Early; contemporary
Provisioning	Provide open spaces for pastures, agriculture and hunting	Early; contemporary
	Stimulate germination of desirable annual "crops" post-fire	Early
	Provide carbohydrates from underground plant organs	Early
	Provide craft and basketry material (resprouts)	Early
	Maintain open spaces for grazing and hunting	Early; contemporary
	Provide essences, medicines, and flowers (ornamental)	Contemporary
Cultural	Spiritual	Early
	Ecotourism in open ecosystems	Contemporary
	Recreational hunting	Contemporary
	Scientific knowledge about the origin of biodiversity	Contemporary
	Information about ancestral fire management techniques	Contemporary
Regulating	Pest control for humans and livestock	Early, contemporary
	Reduce catastrophic wildfires	Early, contemporary
	Accelerate species replacement under changing conditions	Early, contemporary
	Enhance flowering and pollinator activity	Contemporary
	Water regulation	Early, contemporary
	Carbon balance	Early, contemporary

Source (Keeley, 2012; Pausas & Keeley, 2019)

Table 3 Economic impacts of (wild)fire (Díaz, 2012)

Type	Cost per ha in $
Timber	2.995
Fire suppression	494
Disaster relief	124
Property losses	59
Tourism	682
Watershed protection	311
Estimate of lost business economic activity	2.402
Home, business and property loss	7.658
Medical costs	72

economies affected by the fire can have future benefits fire has a positive influence on economic activities. These economic activities are building and maintaining fire lines in forests, which can be supported by Government funds, investments in wildfire education from the elementary school level (Đorđević et al., 2022), restitution of forests affected by fires (Ratknić et al., 2017, 2021) or by investments in agroforestry (Damianidis et al., 2021).

4 Conclusions and Final Remarks

In this socioeconomic analysis of forest fires, we first challenge the tacit acceptance of the catastrophic character of forest fires where the importance of fire as an ecosystem service is almost completely omitted. Official statistics include only the value of lost market goods and services, according to market prices (Mavsar, 2009) and this is not enough for a neutral assessment of the socioeconomic impact of forest fires. National perspectives of wildland fire patterns and challenges in Europe indicate that detailed studies on socioeconomic impacts are currently scarce (Fernandez-Anez et al., 2021). However, here presented analysis reveals that forest fires cause significant damage to natural products and services, but they can generate income for local communities. In a contemporary approach, the socioeconomic aspect of forest fires should answer the values we are protecting, rather than only the values lost (Mavsar, 2009). Only comprehensive information about the negative but also the positive impact of forest fires especially large ones can help public officials, community leaders and citizens understand the impacts on economies and society.

References

Ager, A. A., Vaillant, M. N., & McMahan, A. (2013). Restoration of fire in managed forests: A model to prioritize landscapes and analyze tradeoffs. *Ecosphere, 4*, 1–19.

Barbero, M., Bonin, G., Loisel, R., & Quezel, P. (1990). Changes and disturbances of forest ecosystems caused by human activities in western part of the Mediterranean basin. *Vegetatio/plant Ecology, 87*(2), 151–173.

Birot, Y. (Ed.). (2009). *Living with wildfires: What science can tell us* (Discussion Paper Vol. 15). European Forest Institute.

Bowman, D. M., Perry, G. L., Higgins, S. I., Johnson, C. N., Fuhlendorf, S. D., & Murphy, B. P. (2016). Pyrodiversity is the coupling of biodiversity and fire regimes in food webs. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1696). https://doi.org/10.1098/rstb.2015.0169

Catry, F. X., Rego, F. C., Silva, J. S., & Moreira, F. (2010). *Fire starts and human activities* (Research Report Vol. 23). In J. S. Silva, F. Rego, P. Fernandes, & E. Rigolot (Eds.). European Forest Institute.

Damianidis, C., Santiago-Freijan, J., den Herder, M., Burgess, P., Mosquera-Losada, M., Graves, A., & Pantera, A. (2021). Agroforestry as a sustainable land use option to reduce wildfires risk in European Mediterranean areas. *Agroforest Systems, 95*, 919–929. https://doi.org/10.1007/s10457-020-00482-w

de Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics, 41*(3), 393–408.

Depietri, Y., & Orenstein, D. E. (2019). Fire-regulating services and disservices with an application to the Haifa-Carmel region in Israel. *Frontiers in Environmental Science, 7*, 107.

Diaz, J. M. (2012). Economic impacts of wildfire. *Southern Fire Exchange Fact Sheet*, 2012–2017.

Đorđević, G., Ratknić, M., Rakonjac, L., & Dimitrijević, T. (2022). Sheme of organisation and procedures in the actions of entities on forest fire protection-prevention and suppression of forest fires. *Sustainable Forestry—Collection, 85–86*, 197.

Fernandez-Anez, N., Krasovskiy, A., Mülle, M., Vacik, H., Baetens, J., Hukić E., Atanassova, M. K. S. I., Glushkova, M., Bogunović, I., Fajković, H., Djuma, H., Boustras, G., Adámek, M., Devetter, M., Hrabalikova, M., Huska, D., Barroso, P. M., Vaverková, M. D., Zumr, D., … Cerda, A. (2021). Wildland fire patterns and challenges in Europe: A synthesis of national perspectives. *Air, Soil and Water Research, 14*. https://doi.org/10.1177/11786221211028185

Firestone, R., West, A., Kennett, J. P., Becker, L., Bunch, T. E., Revay, Z. S., & Wolbach, W. S. (2007). Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. *Proceedings of the National Academy of Sciences, 104*(41), 16016–16021. https://doi.org/10.1073/pnas.0706977104

Georgiou, M. (2022). Understanding the fire paradox: Why we need fire to prevent fire. https://www.newsy.com/stories/understanding-the-fire-paradox-fighting-fire-with-fire/

Hawkes, K. (2004). The grandmother effect. *Nature, 428*, 128–129.

Hills, P., & MacGibeny, A. (2015). Bibliography: Farlex dictionary of idioms 2015. (Eastman Johnson Catalogue Raisonné) Preuzeto April 12, 2022 sa https://www.eastmanjohnson.org/literature/entry.php?id=1197

Jones, G. M., & Tingley, M. W. (2022). Pyrodiversity and biodiversity: A history, synthesis, and outlook. *Diversity and Distributions, 28*, 386–403.

Keeley, J. E. (2009). A burning story: The role of fire in the history of life. *BioScience, 59*(7).

Keeley, J. E. (2012). Fire in mediterranean climate ecosystems—A comparative overview. *Israel Journal of Ecology & Evolution, 58*, 123–135. https://doi.org/10.1560/IJEE.58.2-3.123

Keely, J.E & Pausas, J. G. (2022). Evolutionary Ecology of Fire Annual Review of Ecology Evolution and Systematics 53(1) 203–225 https://doi.org/10.1146/ecolsys.2022.53.issue-1 https://doi.org/10.1146/annurev-ecolsys-102320-095612

Lieberman, D. (2013). *The story of the human body: Evolution, health and disease.* Pantheon Books.

Lynch, D. L. (2004). What do forest fires really cost? *Journal of Forestry, 102*(6), 42–49.
MA. (2005). *Millennium ecosystem assessment, ecosystems and human well-being: Synthesis*. Island Press.
Martin, E. R., & Sapsis, D. B. (1992). Fires as agents of biodiversity: Pyrodiversity promotes biodiversity. In *Proceedings of the symposium on biodiversity in Northwestern California 1991*.
Martinez, J., Vega-Garcia, C., & Chuvieco, E. (2009). Human-caused wildfire risk rating for prevention. *Journal of Environmental Management, 90*(2), 1241–1252.
Mavsar, R. (2009). Economics of wildfires. In Y. Birot (Ed.), *Living with wildfires: What science can tell us* (Vols. Discussion Paper 15, p. 59). European Forest Institute.
Mavsar, R., Japelj, A., & Kovač, M. (2013). Trade-offs between fire prevention and provision of ecosystem services in Slovenia. *Forest Policy and Economics, 29* 62–69 https://doi.org/10.1016/j.forpol.2012.10.011
Michetti, M., & Pinar, M. (2013). Forest fires in Italy: An econometric analysis of major driving factors. CMCC Research Paper No. 152. https://doi.org/10.2139/ssrn.2332068
Nimmo, G. D., Carthey, J. A., Jolly, J. C., & Blumstein, T. D. (2021). Welcome to the Pyrocene: Animal survival in the age of megafire. *Global Change Biology, 27*(22), 5684–5693. https://doi.org/10.1111/gcb.15834
Pausas, J. G., & Keeley, J. E. (2019). Wildfires as an ecosystem service. *Frontiers of Ecological Environment, 17*(5), 289–295. https://doi.org/10.1002/fee.2044
Pyne, S. J. (2022). The pyrocene how we created an age of fire, and what happens next.
Ratknić, T., Milovanović, J., Ratknić, M., Šekularac, G., Subić, J., Jeločnik, M., & Poduška, Z. (2017). Analysis of the profitability of the restitution of fire-affected beech forests in Serbia. *Applied Ecology and Environmental Research, 15*(4), 1999–2010. DOI: https://doi.org/10.15666/aeer/1504_19992010
Ratknic Tatjana, M., Ratknic Mihailo, B., Rakonjac Nikola, L., Živanovic Ivana, M., & Poduška Zoran B. (2019). Development of a national index for the purpose of forest fire risk assessments on the example of southern Serbia. Thermal Science *23*(6), 3307–3316. https://doi.org/10.2298/TSCI190412276R. https://thermalscience.vinca.rs/2019/6/2
Ratknić, T., Ratknić, M., Subić, J., Poduška, Z., Šekularac, G., Aksić, M., & Vještica, S. (2021). An analysis of the profitability of the restitution of sessile oak forests affected by wildfires in Serbia. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 49*(2). https://doi.org/10.15835/nbha49212260
Ritchie, H., Rosado, P., & Roser, M. (2022). Natural disasters. Published online at OurWorldInData.org. Retrieved: https://ourworldindata.org/natural-disasters [online resource].
Scopus. (2020). https://ezproxy.nb.rs:2071/results/results.uri?sort=plf-f&src=s&st1=Cost+Forest+Fire+Wildfire&sid=3fe1ee37c3ffe6cf2bdec525c38ed1c5&sot=b&sdt=b&sl=40&s=TITLE-ABS-KEY%28Cost+Forest+Fire+Wildfire%29&origin=searchbasic&editSaveSearch=&yearFrom=Before+1960&yearTo=Present. Accessed June 24, 2020.
Shackleton, M. C., Ruwanza, S., Sinasson Sanni, K. G., Bennett, S., De Lacy, P., Modipa, R., & Thondhlana, G. (2016). Unpacking pandora's box: Understanding and categorising ecosystem disservices for environmental management and human wellbeing. *Ecosystems, 19*, 587–600. https://doi.org/10.1007/s10021-015-99, https://doi.org/10.1007/s10021-015-9952-z
Sil, Â., Azevedo, J. C., Fernandes, P. M., Regos, A., Vaz, A., & Honrado, J. M. (2019). (Wild)fire is not an ecosystem service 17. *Frontiers in Ecology and the Environment*, 429–430.
Silva, J.S., Rego, F., Fernandes, P., & Rigolot, E. (2010). *Towards Integrated Fire Management – Outcomes of the European Project Fire Paradox*. Research Report 23. European Forest Institute
Thompson, M. P., Riley, K. L., Loeffler, D., & Haas, J. R. (2017). Modeling fuel treatment leverage: Encounter rates, risk reduction, and suppression cost impacts. *Forests, 8*, 469.
Wallace, L. L. (2004). *After the fires: The ecology of change in Yellowstone National Park*. Yale University Press.