

Wildfire motivation survey through the Delphi Method

Jorge de las Heras¹, Rossella Salvatore², Maria Joao Rodrigues²,
Raffaella Lovreglio³, Vittorio Leone³, Patrizia Giaquinto³,
Alessandra Notarnicola⁴

Abstract

Forest fires are neither a natural calamity nor a fatality, but rather an anthropogenic phenomenon, which directly depends on social behaviour, whether voluntary or involuntary. Given the increasing number of fires on a world scale, the current piecemeal approach to fire which mainly concentrates on fire suppression must be integrated with better and more efficient prevention, embracing a wide range of measures and activities that either modify fuels, or try to reduce the human caused ignition risks and sources, also changing, when possible, human behaviour.

Understanding the reasons why fires start is, therefore, a crucial factor in order to prevent or reduce their incidence, to mount significant prevention efforts and to design specific fire prevention campaigns.

A promising technique for improving knowledge about causes and motivations behind them is the Delphi technique, a set of procedures for eliciting and refining the opinions of a group, usually a panel of experts.

With reference to case-studies in the South of Italy, the authors comment the results of the implementation of the Delphi method as a tool for the interpretation of the phenomenon of wildfires.

Results confirm the main nature of involuntary fires, often related to agricultural activities, giving emphasis to some motivations which are site and culture specific of the different study-cases.

Authors also propose a causality index, based on motivation assessed through the local Delphi survey.

The causality index is based on customized values of “weight” for each motivation, based on pair wise-comparison method, namely on the Saaty scale (1980).

The causality index considers both the frequency and the rank of each motivation, thus allowing a good geographical analysis of the phenomenon.

Key-words: Delphi method, fire causality index, fire motivations, fire prevention, panel of experts, Saaty scale, voluntary fires.

¹ University of Castilla-La Mancha

E.T.S.I.A., Campus Albacete s/n, 02071 Albacete; Spain

² *International PhD Course on “Crop Systems, Forestry and Environmental Sciences”*

University of Basilicata,

Viale dell’Ateneo Lucano 10, 85100 Potenza, Italy

³ University of Basilicata,

Department of Crop Systems, Forestry and Environmental Sciences

Viale dell’Ateneo Lucano 10, 85100 Potenza, Italy

⁴ University of Bari,

Department of Psychology

Piazza Umberto I°, 1 70122 Bari, Italy

Corresponding author: leone@unibas.it

Introduction

Forest fires are neither a natural disaster nor a natural calamity or a fatality, with the exception of those started by natural agents. They are, on the contrary, an anthropogenic phenomenon which exclusively and directly depends on social behaviour, whether it be voluntary or involuntary (LEONE *et al.* 2003).

Our knowledge of fire as a complex physical-chemical reaction is rather satisfactory and allows good prediction of its behaviour. We have adequate knowledge of how, when and where fire occurs: what we do not have is the capability of filling the gap between the advanced knowledge of the physical facets of the phenomenon and the very reasons of its genesis (LEONE & LOVREGLIO 2003b). We still do not know enough about who starts wildfires and why: on the subject we have mainly a list of credible (and sometimes obvious) motives for starting fires.

Fire Causes

Causes are more varied than is often assumed, and fire initiation is neither as random, nor, in some cases, as meaningless as some analysis suggest. Understanding the reasons why fires start is a crucial factor to prevent or reduce their incidence.

A rational approach is necessary to give an interpretation to this complex reality, which is site and culture-specific (LEONE *et al.* *op.cit.*), above all avoiding the piecemeal approach to fire which concentrates mainly on fire suppression (WILSON 1976), and hence mainly focuses on fighting fires and developing the infrastructure to detect and facilitate access to fires, whereas inadequate attention is given to addressing the underlying causes .

Knowing causes is critical to mount significant prevention efforts, which embraces measures that modify fuels and human behaviour so that the initiation, spread, and intensity of fires are reduced to such an extent that they can be controlled by the technical means available.

The Delphi Technique

A promising technique for improving the above mentioned knowledge is the Delphi technique, a method originally developed in the 1950s by Helmer and Dalkey, scientists at the Rand Corporation, as an iterative process for forecasting likelihood that certain events will occur (LINSTONE & TUROFF 2002).

Four elements are critical to the process: feedback in the form of individual contributions or responses; assessment of the group opinion; opportunity for individuals to revise their original responses following the initial assessment of group opinion; guaranteed anonymity for the individuals who participate in the process. In short, the method allows the best use of currently available formal and informal knowledge in a transparent and robust way.

The Delphi process tries to add value to experts' knowledge by achieving consensus between them over several rounds of investigation, on the assumption that combining the expertise of several individuals will provide more accurate results than consulting a single individual (DELBECQ *et al.* 1975).

Wildfire motivation survey through the Delphi Method de las Heras *et al.*

Delphi may be used in areas where there is an absence of sufficient data and/or an incomplete theory on cause and effect in regard to the phenomena under study. Sitting between knowledge and speculation, the informed deliberations of the panel of experts may best be considered an informed judgment.

The Delphi technique generally includes several steps: the specification of a topic to be investigated; the construction of an *ad hoc* questionnaire for data collection; the selection of experts; the weighting of the opinions of the experts by means of the questionnaire; the summary of the data resulting from the initial measurement; the communication of the results as feedback to all the respondents; a re-evaluation of the opinions of the respondents after they have been informed of earlier results; an analysis, interpretation, and presentation of the data and the writing of a final report. In the field of forest fires, Delphi has been used to explore the current state of wildland fire communication (CLUTE 2000); in analyzing the causes of fires in the Balearic Islands, in Spain (FAB 1990); in a survey of arson fires (ICONA 1995); in a survey on fire prevention and communication (MMA 1997); in a survey on the perception of forest fires by the Spaniards (APAS 2003; DOLZ REUSS & FRANCO IRASTORZA 2005). In Italy the only implementation of the technique is by the authors (LEONE & LOVREGLIO 2003a, LOVREGLIO *et al.* 2006).

This paper aims, therefore, to highlight further implementation of the Delphi technique in the Italian scenario of forest fires, which is characterized by a very scarce knowledge of motives.

Materials and Methods

Study area

The Delphi technique, for the assessment of fire motivations, has been implemented in the Basilicata Region, in the South of Italy, namely in the provinces of Matera and Potenza. Both study areas are southern mountain territories, with the typical Mediterranean climate pattern, where hot and dry summers are a predisposing fire factor.

They are rather different in terms of land-use pattern: the province of Matera is characterized by wide durum wheat cultivations, which occupies the best sites of territory; forests are concentrated on the most elevated sites. Forestry ratio is low (25.0 %). The province of Potenza is a rather rough, hilly and mountainous territory, with medium elevation creeks. Forestry ratio is rather high (41.1 %), much above national average.

Experts' panel

Experts in forest fires for our Delphi survey are the professionals working for governmental organizations, namely non commissioned officers of State Forestry Service, heads of the "Comandi Stazione Forestali", a sort of Forest District having a small jurisdiction (1 to 4-5 municipalities, 5.000 to 25.000 hectares total surface, on average). They must be therefore considered deeply knowledgeable and broadly experienced in the subject matter. The two provinces were surveyed through 49 and 16 sub-units, respectively for Potenza and Matera, each of them including one or more municipalities, through the response given by the State Forestry Service local officer. In both cases the number of experts exceeds the minimum: a group of about 10 individuals is considered appropriate for a Delphi expert panel (CRANCE 1987).

Wildfire motivation survey through the Delphi Method de las Heras *et al.*

One of the main problems with State Forestry Service, which has a strong hierarchical, military like organization, is avoiding negative group dynamics that may emerge, mainly superiority of rank, but also domination by key individuals, prestige of a certain participants, shyness of certain participants. The use of the questionnaire allowed for anonymous responses, giving the group members the freedom to express their opinions without feeling pressured by the wider group or dominant members.

Structured questioning

Structured questioning was achieved through the use of *ad hoc* questionnaires where all motives of forest fires, as recognized by the State Forestry Service (MIPAAF-CFS 2002) were reported. Such personnel, directly and permanently involved in forest fire control activities, were asked questions that specifically pertain to their respective areas of expertise, since motives and relative codes are very familiar to them when filling forest fire statistic forms.

A list of motives with their four-digit identification code is reported in Annex 1: it contains the 43 possible official motives behind the cause of fire in Italy, classified into five groups (natural, accidental, negligent, deliberate, doubt; MIPAAF-CFS 1992.). The motives maintain their original statement, but some explanatory notes are added by the Authors.

The panel was contacted via mail, receiving the form reporting the list of motives and identification codes (mail contact is considered acceptable; DUNHAM 1998) but did not accept any further meetings or questionnaire sending. Experts were asked to identify (“voting”) the eight most relevant motives and, subsequently, to rank them in order of decreasing importance, giving a score ranging from 1 (maximum) to 8 (minimum).

Results and their discussion

Table 1, here following, reports rank ordering, i.e. the modal value of rank-scores, going from 1 to 8. In rank ordering we did not use their arithmetic mean, which is not suitable for use with nominal or ordinal data (the scores are ordinal value only representing position of order, not quantity). It must be stressed that the same motivation can be repeated in different rank-ordering, due to different perception by experts.

Tab. 1 Rank-ordering (1 to 8) of most frequent fire motives in study-areas

Rank order	Prov. Matera Motivations code	Prov. Potenza Motivations code
1	3104 4108	3001 3102
2	3103 3104	3104 3101
3	3104 3101	3101 3102 3104 4108
4	3001 3103	3101
5	3102 4102	2002 3104
6	4101 4010 3002	4108
7	4102	2004 3103
8	1001	1001 3105

N.B. For codes explanation see Annex 1

Wildfire motivation survey through the Delphi Method de las Heras *et al.*

The majority of respondents converge towards a limited number of involuntary motives (codes 3101, 3102, 3103, 3104), namely negligent use of agricultural fire. Among voluntary motives, the most frequent one is referred to motive code 4108 (Fire caused by behavioural disturbances) followed by motives referring to: harvesting mushrooms and edible sprouts, converting forests into cultivable land, ownership conflicts. Low is the frequency of natural and accidental fires (sparks and wire-to-wire arcing).

The results are apparently in contrast with the current opinion that wants the majority of fires to be deliberate, but fitting with experts' point of view about a frequent overemphasis of voluntary causes of fire.

In regard to motives, defined as the inner drive or impulse that is the cause, reason or incentive that induces or prompts a specific behaviour, similar remarks can be drawn from the results of rank ordering, which is a measure of their importance as perceived by the experts.

Instead of the overwhelming majority of causes as arsonist or unknowns, the experts give answers which appear to be rather homogeneous and convergent despite the obvious difference of study areas.

In the first rank order, i.e. scored 1, the most relevant group is again referred to use of agricultural fire (mainly stubble burning, 3104), whereas a less important motive refers to deliberate fire setting (4108 pyromaniacs). Enlarging the comments, motives connected with negligent fires always refer to careless use of agricultural fires (codes 3101 to 3105)

The most frequent motive is 3104, stubble burning, i.e. systematic burning for the purpose of the preparation of the agricultural terrain for new sowing and the elimination of residue or thicket that hinders exploitation.

Taking a look at deliberate fires, the most relevant motives refer to groups 4101 and 4102. Motive 4101 (conflicts with Public Administration) could be interpreted as a sort of reaction against land use restrictions, which sometimes explode in violent ways. The motives which refer to ownership conflicts (code 4102) are ranked relatively low in terms of importance.

The popular and abused motive which usually refers to fire used as a tool to convert rural land into urban land (WWF 1993) is totally absent in the results.

A special remark must be made for motive code 4108 (pyromaniacs), which received rather high frequency and also ranked high in terms of importance in both provinces. It is a matter of fact that the term pyromaniac is largely misused as a synonym of arsonist, not only in Italy but also in other countries (APAS 2003; DOLZ REUSS & FRANCO IRASTORZA 2005).

No relevant problem appears in the provinces in connection with motives referring to voluntary fires set by fire-fighters as a way to maintain their job and increase their revenue, which on the contrary seems common in all Southern regions of Italy (LOVREGLIO *et al.* 2006).

The fire causality index

Information obtained through the Delphi method can be further processed through a *Fire Causality Index (FCI)*, which is the synthesis of various motivations,

Wildfire motivation survey through the Delphi Method de las Heras *et al.*

their role and relative importance. The index FCI, we here propose has the expression:

$$\sum_{i=1}^8 1/r_i * c_i / \sum_{i=1}^8 1/r_i$$

where:

$1/r_i = 8/8, 7/8 \dots \dots 1/8$ considers the rank order of each motivation;

c_i is the relative importance of each group of motivations ; its value can be simply assessed as (Velez, 2000) :

0,1 natural fires;

0,2 accidental;

0,5 negligent or involuntary;

1,0 voluntary (arson).

FCI has therefore a range 0,20 to 1,00. Values of FCI for the two provinces as above evaluated are respectively:

Province of Matera = 0.618

Province of Potenza = 0.531

whereas their fire statistics are:

<i>Fire causes (%)</i>	<i>Matera</i>	<i>Potenza</i>
<i>Natural</i>	-	3,70
<i>Accidental</i>	-	3,70
<i>Negligent</i>	16,40	14,82
<i>Deliberate</i>	52,45	61,48
<i>Unknown</i>	31,15	16,30

Much better, since each motivation has a different weight at a local perspective, we propose here to measure c_i through a scale of relative value, such as Saaty scale (1980), a linear scale 1, 2, 3, ..., 9 for the pair wise comparisons which is used to quantify how much important a criterion is compared to another one. The value 1 for instance means equally important and 9 means much more important. If the criterion is less important than another one, then the inverse preferences 1, 1/2, 1/3, ..., 1/9 are used.

Conclusions and Final Remarks

Causes of fires undoubtedly arise from many complex social, environmental, political, organizational and economic forces, whose importance is likely to vary by country or region and over time. The Delphi, which is ultimately a structured process for collecting and “distilling” knowledge from a group of experts, reveals very useful for this scope, since it exploits the accumulated experience and in-depth knowledge of territory by professionals, in a rather quick and simple way and allows using the limited information available in these forms, when full scientific knowledge is lacking. Understanding the motive behind the cause, may enhance investigative efforts and focus them on improving prevention and social behaviour modification.

In our study areas Delphi method allowed for placing the right emphasis on some motives, which can help to pinpoint appropriate preventive actions for the

Wildfire motivation survey through the Delphi Method de las Heras et al.

specific reality; it confirms that in Basilicata region fires are ultimately connected mainly with a general negligence in use of local agricultural practices.

The Delphi technique proves to be useful in helping fire managers in listing and identifying the most frequent and relevant human caused ignition risks and sources (AMATULLI et al. 2006)

Integrating Delphi with FCI, which is basically a *measure of the perception* of fire phenomenon by the experts, opens interesting perspectives, also in operative terms, in interpreting the phenomenon and the complex dynamics of fire in the rural space.

This phase is crucial to mount a significant prevention activity based on modification of social behaviour in concerned territories, where prevention must receive more attention than the improvement of fire suppression resources (FAO 2005), which do limit damages but at such a cost that possibilities to increase those resources are nearly exhausted.

References

- Amatulli G., Rodrigues M.J., Trombetti M. and Lovreglio R. 2006. **Assessing long-term fire risk at local scale by means of decision tree technique**. Journal of Biophysical Research-Biosciences, 111, G04S05, doi:10.1029/2005JG000133 .
- Clute O. 2000. **A Perspective from Wildland Fire Communicators**.
URL[online]:http://www.nifc.gov/preved/comm_guide/wildfire/fire_14.html
- Dunham R.B. 1998. **The Delphi technique** URL [online]:
<http://instruction.bus.wisc.edu/obdemo/readings/delphi.htm>
- Koutsias N., Kalabodikis K. D., and Allgöwer, B. 2004. **Fire occurrence patterns at landscape level: beyond positional accuracy of ignition points with kernel density estimation methods**. Natural Resource Modelling 17 (4): 359-376
- Lovreglio R., Leone V., Giaquinto P. and Notarnicola A. 2006. **Wildfire Cause Analysis through Delphi Method: Four Case-Studies in Southern Italy** (submitted, IJWF)

Book and chapters of books

- Delbecq A.L., Van De Ven A.H. and Gustafson D.H. 1975. **Group techniques for program planning: a guide to nominal group and Delphi processes**. Glenview, IL: Scott, Foresman and Company
- FAB CONSULTORES. 1990. **Estudio sobre la causalidad de los incendios forestales en la Comunidad Autonoma de las Islas Baleares**. Conselleria d'Agricultura I Pesca. Govern Balear, Impresrapit
- Leone V., Koutsias N., Martinez Fernandez J., Allgöwer, B., Vega Garcia C. and Lovreglio R. 2003. **The human factor in fire danger assessment**. In: Chuvieco Salinero E. (Ed) *Wildland Fire Danger Estimation and mapping. The role of Remote Sensing Data*. Vol 4, Series in Remote Sensing, World Scientific Publishing Co., New Jersey
- Linstone H. and Turoff M. 2002. **The Delphi Method Techniques and Applications** (digital version online) URL [online]: <http://www.is.njit.edu/pubs/delphibook/>

Wildfire motivation survey through the Delphi Method de las Heras *et al.*

MIPAAF-CFS (Ministero delle Politiche Agricole e Forestali, Corpo Forestale dello Stato). 2002. **Indagine conoscitiva incendi boschivi**. Stampa New Graphic snc, Roma.

Saaty Th. L. 1980. **The analytic hierarchy process**. Mac Graw-Hill, New York

Vélez R. 2000. **La defensa contra incendios forestales. Fundamentos y experiencias**. McGraw-Hill/Interamericana de España S.A.U., Madrid

Proceedings

Dolz Reuss M.L. and Franco Irastorza I. 2005. **State of the art of forest fire causes in Spain**. Centre Tecnologic Forestal de Catalunya, Proceed. II International Conference on Prevention Strategies of Fires in Southern Europe: Barcelona, 9-11 may 2005

Leone V., Lovreglio R. 2003b. **Human fire causes: a challenge for modelling**. In: Chuvieco E., Martin P. and Justice Chris (Eds) Innovative Concepts and Methods in Fire Danger Estimation (Proceed. 4th Intern Workshop on Remote Sensing and GIS Applications to Forest Fire Management)

Reports

APAS (Asociación para la Promoción de Actividades Socioculturales). 2003. **Estudio Sociológico sobre la Percepción de la Poblacion Española hacia los Incendio Forestales** (internal report)

Crance J.H. 1987. **Guidelines for Using the Delphi Technique to Develop Habitat Suitability Index Curves**. Biological Report 82. Fort Collins, CO: U.S. Fish and Wildlife Service National Ecology Center.

FAO. 2005. **Community Based Fire Management in Spain**. Forest Protection Working Papers, Working Paper FFM/4/E. Forest Resources Development Service, Forest Resources Division. FAO, Rome. URL [online]: <http://www.fire.uni-freiburg.de/Manag/COMMUNITY-BASED-FIRE MANAGEMENT-SPAIN.pdf>

Leone V., Lovreglio R. 2003a. Parco Nazionale del Gargano. Piano di Previsione e Prevenzione contro gli Incendi Boschivi. (Unpublished internal report)

MINISTERIO DE MEDIO AMBIENTE 1997 **Diseño y planificación de acciones de comunicación para la prevención de incendios forestales**. FAB Consultores, S. A. Madrid

Wilson C.C. 1976. **Detection and control of forest fires for the protection of the human environment**. Project 0206-74-003, Publ. M/LO788/E/1.78/1/70, FAO, Rome, Italy

WWF. 1993. **Fires in the Mediterranean**.
URL[online]:http://www.panda.org/about_wwf/where_we_work/mediterranean/publications/index.cfm?uNewsID=8022

Wildfire motivation survey through the Delphi Method de las Heras et al.

ANNEX 1 *Motives for forest fires in Italy, after the State Forestry Service (MIPAAF-CFS, 2002)*

1. NATURAL ORIGIN
1001 Fires started by lightning
1002 Spontaneous ignition or Fires caused by volcanic eruption
2. ACCIDENTAL ORIGIN
2001 Fire started by sparks from brake shoes of trains
2002 Fire started by hot vehicle or train exhaust pipes, hot car or truck mufflers
2003 Fire started by sparks from special locomotives or tractors
2004 Phase-to-phase (wire to wire) arcing shorting along power lines
3. CARELESS ORIGIN
3001 Carelessly discarded cigarette butts or matches on road banks
3002 Carelessly discarded cigarette butts or matches in countryside
3003 Carelessly discarded cigarette butts or matches in wildland areas
3004 Carelessly discarded cigarette butts or matches along railroad, cigarettes thrown by passengers.
3101 Fire set for cleaning on borders of croplands or in abandoned agrarian plots.
3102 Fire set by farmers for plantation cleaning after harvest or to eliminate pruning residues of trees/brushes.
3103 Fire set for pasture renovation
3104 Fire set for stubble burning
3105 Fire set for cleaning of road/railroad banks and railway embankments
3201 Fire caused by recreational and tourist activities: (e.g. negligent camp firing, barbecue etc.)
3202 Fire caused by the firing of fire-crackers and bottle-rockets, fireworks, bonfires, blasting of landmines or explosives
3203 Fire caused by the use of motor, flame, electric or mechanical devices
3204 Fire caused by military manoeuvres, shooting exercises or target practice
3205 Fire caused by the burning of waste in illegal dumps, negligent or imprudent waste or dump management
3206 Fires caused by poor maintenance of electrical lines or by the breakage or falling of wires
3207 Fire caused by negligent hunters (e.g. unattended heating fire, use of tracing bullets, setting a signal fire when lost, bullets ricochet off rocks creating sparks, target shooting sparks, discarding of used paper shells, burning embers from paper wad, sparks from gun powder explosion)
4. DELIBERATE ORIGIN
4001 Fire caused by the creation or renewal of pastures at the expense of forests (i.e. elimination of trees/brushes and wild land cleaning for pasture improvement)
4002 Fire caused by the will to regain agricultural terrain at the expense of forests for cultivation or to activate funding from European Union (e.g. conversion of forest areas into olive crops)
4003 Fire caused with the intent of earning from the removal of vegetation for the purpose of agricultural cultivation (i.e. employment of fire as a cultural tool to convert forest areas into agricultural areas.
4004 Fire caused with the intent of earning from the removal of vegetation for the purpose of building speculation, or fire set to change rural land into building land
4005. Fire set to save operations in the forest: opening of forestry trails, agricultural operations to save on labour, destruction of forestry mass, brush cleaning
4006 Fire set by the auxiliary workers who are retained by national forest fire services during the critical summer months; fires caused by occupational questions related to labourers hired by local administration (e.g. fire set to protest against termination of contracts, against notice of dismissal after the critical summer months etc.)
4007 Fire set with the intent of destroying by fire badly executed forestry operations (i.e. fire set to destroy defective plantations)
Fire set to conceal another crime, such as theft, murder
4008 Fire caused with the intent of being included in fire fighting efforts (e.g. fire set to be

Wildfire motivation survey through the Delphi Method de las Heras *et al.*

employed in seasonal crews or to force the creation of jobs in the forest, fire set to touch economic incentive provided by employment on seasonal fire fighting crews or in reconstitution post-fire activities) Syn.: fire industry (Italy only)
4009 Fire caused by inappropriate activity referable to poaching (e.g. revenge, protest against severe hunting control, protest against hunting fines)
4010 Fire set to obtain products deriving from fire passage (e.g. fire purposely set for gathering mushrooms or sparrowgrass' edible new sprouts)
4011 Fire set by organized crime (smuggling and other criminal activities)
4101 Fire set as revenge or retaliation against public administration
4102 Fire caused by conflicts between or revenge against owners, ownership controversies
4103 Fire caused as protest against limitations imposed in conservation areas (i.e. conflicts because of the creation of preservation areas, or declaration of protected spaces with restrictions on agrarian activity which conflict customs and traditional uses of the area)
4104 Fires caused for fun or games by minors (i.e. fires caused by curiosity and fire play, as well as those started by very young children who do not understand the dangers of fire)
4105 Fires set with the intent of devaluing tourist areas, retaliatory acts in tourist areas
4106 Fire caused by matters relating to political contrast (e.g. concrete political disputes, subversion of the political system or governor discredit)
4107 Fire set as act of terrorism
4108 Fire caused by behavioural disturbances, mental troubles and diseases (pyromania and mythomania)
4202 Fires caused by arson not otherwise defined
5. DOUBT ORIGIN
5001 Causes in which the motives that gave rise to the fire are not identifiable